LIMITS OF THE EARTH BIOSPHERE
LIMITY BIOSFÉRY ZEMĚ

Karel KUDRNA, Marie ŠINDELÁŘOVÁ*

University of South Bohemia in České Budějovice, Faculty of Agriculture, Department of Agroecology, 370 05 České Budějovice, Czech Republic, Tel: + 420 387 772 414, Fax: + 420 387 772 402

ABSTRACT

Evaluation of the state of CO_2 accumulation in the atmosphere demands knowledge on possibilities of the biosphere – its photosynthetizing apparatus, conditions and limits of absorption. A decisive precondition is to determine relation of CO_2 accumulation by photosynthesis in dependence on the water balance, especially on its control quantity – transpiration, which is stabilized by supporting of underground waters.

KEY WORDS: CO_2 accumulation; biosphere; transpiration; photosynthesis

ABSTRAKT

Vyhodnocení stavu akumulace CO_2 v atmosféře vyžaduje poznání možností biosféry – jejího fotosyntetizujícího aparátu, podmínky a limity absorpce. Rozhodujícím předpokladem je stanovení vztahu akumulace CO_2 fotosyntézou v závislosti na vodní bilanci, zejména na její řídicí veličině – transpiraci, jež je stabilizována podporou podpovrchových vod.

KLÍČOVÁ SLOVA: akumulace CO_2; biosféra; transpirace; fotosyntéza

PODROBNÝ ABSTRAKT

Využití principů synergetiky k nalezení kritických hodnot – limitů v soustavě „Vodní bilance – fotosyntéza" vedlo k poznání zákonů, jimiž se řídí absorpce CO_2 v závislosti na transpiraci.

Definice rovnovážného stavu vodní bilance (Mb) umožnila rozdělit složku evapotranspirace na dvě – transpiraci a evaporaci a koncipovat rovnici

0,404 hstr / 0,176 hsp = (0,253 hsev / 0,167 hso)^2 [11]

a označit tak hstr a hsp jako zdrojové na sobě závislé veličiny. Obě složky jsou definovány na principu „dopravního zpoždění", tj. zpomalení evaporace (hsev) oproti transpiraci (hstr) a zpomalení odtoku (hso) oproti infiltraci do podpovrchových vod (hsp).

Z analýz světových výsledků uvedených v práci plyne, že účinnost fotosyntézy (FS) je při současné porušené hstr 0,3 (podle hodnot v rovnici Mb) [11] rovna 65,34 % podle absorbovaného CO_2.

V absorpci CO_2 existují dvě hodnoty pro využití CO_2; jedna je determinována stechiometrickým koeficientem 3,67 na jednotku C a druhá, která vyjadřuje nevyužitý CO_2, který se neúčastní transformace, vrací se zpět do atmosféry a jeho využití je určeno teprve přírůstkem organické hmoty a novým fotosyntetizujícím aparátem závislým na hstr a hsp. Pak dochází i k postupnému využití i tohoto objemu CO_2 až do limitního množství. Tak volný CO_2 (označený v práci jako Ms) klesá z 5,4 (v rovnovážném stavu 5,27) na 3,67, tedy z 1,73 k nule. Tato hodnota představuje limit nevyužitého CO_2, který může být využit zvýšením transpirace a tedy přírůstkem organické hmoty.

Tuto skutečnost dokazuje i analýza růstových funkcí a přírůstků stodvacetiletého porostu smrku, kterou jsme realizovali na základě pozorování V. Korfa [9]. Průsečík f'(t) a f(t) – jako růstových funkcí a přírůstků a tangenty vedené k růstové funkci f(t) (bod A) na obr. 2, který na y-ordinátě vytíná hodnotu Ms 4,95 tj. 5,27 - 3,67 = 1,6. Je zde tedy využito Ms 1,6 CO_2 při hstr 3,80 a dosaženo FS 91,67 %.

V těchto transformacích se výrazně prosazuje kvalita půd. Tak v našem případě 3 bonitních tříd smrkového porostu se prokázalo, že s nižší bonitní třídou se prodlužuje doba nástupu vrcholu růstové funkce f(t) i přírůstků f'(t), klesá účinnost FS. Snižující se objem aktivního uhlíku v půdě nedovoluje ani využití hstr a hsp a dochází k vyšší evaporaci.

INTRODUCTION

In the presented work we tried to explain the problems of CO_2 accumulation in the biosphere of mainland (dry land) and oceans. Many scientific works paid attention to CO_2 accumulation especially in the biosphere as one of the "greenhouse" gases, on which also the hypothesis of global warming of the Earth has been worked out. But we ask the question, what are in general possibilities of the biosphere of dry lands and oceans to bind CO_2 and release it back into atmosphere? We proceed from the assumption that it is the question of complicated connections between photosynthesis and biosphere [8] that must be explained clearly before this problem can be solved. That is why we used principles of synergetics to finding critical points – limits in the system "Photosynthesis – biosphere" and demonstration of conditions, under which the absorption by photosynthetizing organs of the biosphere is maximal. Counted equilibrium state of water balance (Mb) [11] offered the possibility to determine structure of the "Photosynthesis – water balance" system and its changing at its disturbing. In literature and engineering praxis, water balance usually is understood so, that the transpiration and evaporation are components of loss-making character and are expressed together as "evapotranspiration". But from aspect of the function of the biosphere it is not so. That is why we have divided these two components on a pair hstr/hsp and hsev/hso and marked them as source and not-source (dependent) components, and expressed their relation by the equation hstr/hsp = (hsev/hso)^2 [11]. The component hstr/hsp is then, in comparison with the component hsev/hso based on the principle of "transport delay", it is slowing down evaporation by transpiration and surface runoff hso by infiltration into underground waters (hsp). That is why it is necessary to consider both source quantities hstr/hsp, on which photosynthesis and thus absorption of CO_2 are dependent to a large extent. Analyses of results of Duvigneaud's works proved, that absorption of CO_2 on a C unit on mainland and oceans does 5.4 t CO_2 on 1 t C. This rather surprising result became a basis for determination of limits of CO_2 accumulation by the biosphere of the Earth.

In this work we have analyzed results and estimates of many authors [15, 2, 4, 13] and tried to determine limit possibilities of the biosphere of mainland and oceans. We have used at this our former knowledge on the role of characteristics of Planck's radiation constants and the Boltzmann's constant as the criteria of limit values.

RESULTS AND DISCUSSION

Part 1. Block schema of CO2 absorption in the "Photosynthesis – water balance" system

From figure 1 is evident, that it is the question of three-phase aggregate system, which is divided to the phase

1. energetic
2. transformation

3. hydrologic

Numbers in hydrologic aggregates are values of relations of individual components in water balance, presenting its equilibrium state, data in % result from counted influences of individual aggregates on photosynthesis and CO_2 accumulation, and Ep aggregate then presents relation $C_{rs} : C_p$.

Part 2. Conditions of symmetry, reflexivity, antisymmetry and transitivity of observed system [14, 3]

We have applied the analysis to controlling quantity of water balance, hstr, and "FS-hstr" system we have defined as an automatic regulation circuit [10].

In connection with components of water balance we write these relations:

CO_2 ms / CO_2 hstr ≈ hstr / hsp ≈ CO_2 rs / CO_2 at

So we get pairs of relations, from which the first two present entry to the system, the third presents output. Each subset of the system forms a unary relation. Each element of the set has a certain property, which determines, whether it belongs to relation or is a complement. So in our case, CO_2 ms, hstr, CO_2 rs belong to relation, CO_2 hstr, hsp, CO_2 at are complements of the relation owing to the whole set. Determination the condition of symmetry, antisymmetry, reflexivity and transitivity we base on following thought: FS can't be realized without input of energy, which requires the whole process of transformation to be concurrently cooled and water to act concurrently as a reagens, it is a multipurpose role of water. In the case, that we call individual components of our pairs "classes" [3], then must exist connection of the classes CO_2 ms / CO_2 hstr with the class hstr / hsp. As hstr / hsp is according water balance equation 0.404 / 0.176 = 2.295 [11] and hstr is controlling quantity of the system, then the input quantity of CO_2 ms, determined by sun radiation, is determined by the quantity of transpiration water, which comes from the second class of relations of the system, it is CO_2 hstr, and that is why both classes must be equivalent. This equivalence has been found for Ms 5.27 CO_2 on 1 t. Then 5.27 / 2.295 = 2.295 and that is why both classes of relations are equivalent. As 5.27 – 2.295 = 2.975, then this rest expresses effect of

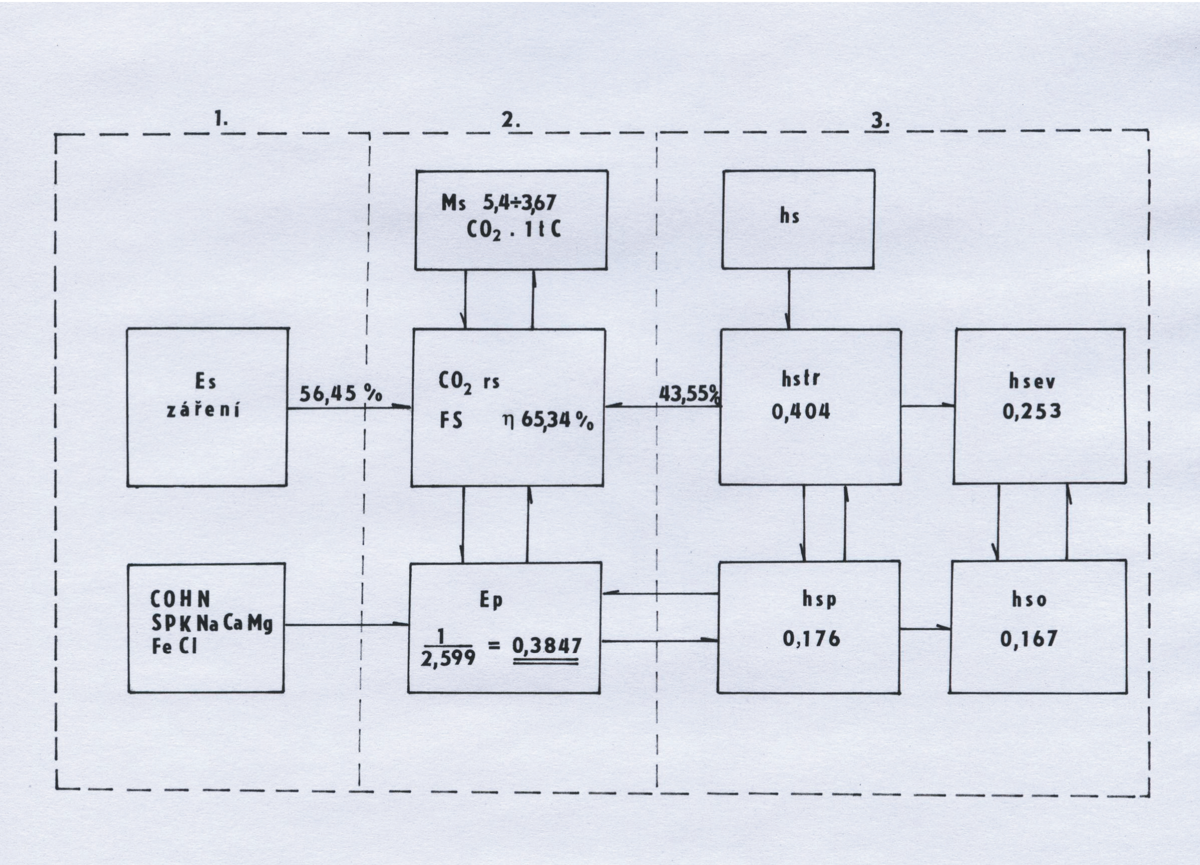

Figure 1: Block scheme of the "Photosynthesis – water balance" system
Obr. 1: Blokové schéma soustavy „Fotosyntéza – vodní bilance"

sun radiation on transformation of CO_2 at FS and does 56.45 %, while hstr shares by 43.55 %, as we also have expressed in block scheme.

Finally for the class CO_2 rs / CO_2 at, we can derive from coefficients: 3.67 / (5.27 - 3.67) = 3.67 / 1.6 = 2.294, where 3.67 is stoicheiometric coefficient of reduction C to CO_2. As again 3.67 – 2.294 = 1.376, it is 37.5 %, then this quantity leaves back into the atmosphere. Then all classes are equivalent one another and the structure is symmetric. If we mark CO_2 ms = a, hstr – b, CO_2 rs – c, we can derive the other conditions, which determine functionality of the system. The condition of reflexivity is given, that every element in operation of relations R agree with itself, it is CO_2 ms must correspond to CO_2 absorbed as influence of hstr, thus if element CO_2 ms is regulated by hstr, then also CO_2 ms regulates CO_2 taken by the influence of hstr. It is agreement of elements in their own class: a R a.

Antisymmetry is a decisive factor for development of the system. Systematic input of CO_2 ms disturbs present structure of the system and its symmetry determined by equivalence of individual classes, and input of energy and transpiration water re-establish it, but always on a higher energetic level, as always a higher quantity of CO_2 is fixed by photosynthesis and transformed to CO_2. The condition of antisymmetry defines demands on the class hstr / hsp, as it limits transformation of CO_2. Axiom of antisymmetry is then based on these relations: if a R b and b R a, then also a = b.

Condition of transitivity is an expression of entirety of the system and characterizes relations between absorption of CO_2 ms and CO_2 rs. If there are equivalent elements a = b and also c = b, it is CO_2 ms = hstr and hstr = CO_2 rs, then also a = c, thus CO_2 ms = CO_2 rs. Then a direct relation exists of absorbed CO_2 ms and CO_2 rs – transformed by plants.

Part 3. Degree of disturbing of water balance

Already in the work [11] we warned about considerable disturbing of water balance of the Earth, and on the principle of symmetry and invariance we counted its equilibrium state. If we consider average hs 730 mm, we get: hstr / hsp = 2.295 = $(hsev / hso)^2 = (0.253 / 0.167)^2 = 1.51^2 = 2.295$

For 730 mm:

0.404 * 730 + 0.253 * 730 + 0.176 * 730 + 0.167 * 730

294.92 + 184.69 + 128.48 + 121.91

hstr + hsev + hsp + hso

Real:

0.3 * 730 + 0.355 * 730 + 0.111 * 730 + 0.234 * 730

219 + 259.15 + 81.03 + 170.82

hstr + hsev + hsp + hso

hstr /hsp 2.7 hsev / hso 2.28

Mb 2.295 2.295

Balance

Source quantities

219.0 hstr (- 75.92)

81.03 hsp (- 47.45)

- 123.27

Non-source

259 hsev(+ 74.36)

170.82 hso (+ 49.01)

+ 123.37

Thus source quantities are lacking markedly.

Part 4. Primary production of mainland (dry land) and oceans

For calculation, we have used qualified estimations, calculations and data of many authors according Duvigneaud [2, 4], especially results of J. H. Rythera, some American authors (Whittaker, Lieth, 1975), Russian authors Baziljevičova, Rodin and Rozov (1970), which we present in following table (table 1) (data in Gt, in dry mass Ys)

Presented values have been reduced by limit coefficients derived from characteristics of Planck constants:

Yz to Ys 0.267 1 / C1 1 / 3.74

Ys to C 0.3847 C2 / C1 1.438 / 3.74

C to CO_2 3.67 stoicheiometric coefficient

As from analysis of results [2] results, that at symmetry of structure is true 5.27 t $CO_2 \approx 1$ t C, then by comparison with stoicheiometric coefficient 3.67 we get values in table 2.

If we consider these values as an average, we get primary production of mainland and oceans per year:

734 Yz = 196 Ys = 75.4 C = 276.83 Gt CO_2 * $year^{-1}$

We have used these values as a basis for determination of limits of biosphere. The difference 30.36 % CO_2 shows, that photosynthezing

Table 1: Primary production of mainland and oceans (Gt Ys)
Tab. 1: Primární produkce pevnin a oceánů (Gt Ys)

Production (Produkce)	J. H. Rythera (1969)	American authors (1975) (Američtí autoři)	Baziljevičová et al. (1970)
Mainland (Pevniny)	139	∅ 175	172
Oceans (Oceány)	42	-	60
Mainland and oceans (Pevniny a oceány)	181	175	232

Table 2: Difference of primary production for coefficients 5.27 and 3.67
Tab. 2: Diference primární produkce pro koeficienty 5,27 a 3,67

1.	181 * 0.3847 = 69.63 C	* 5.27 = 366.95 Gt CO_2	
		* 3.67 = 255.54 Gt CO_2	
		-----------------------------	
		dif 111.41 Gt CO_2	30.36 %
2.	175 * 0.3847 = 67.42 C	* 5.27 = 354.78 Gt CO_2	
		* 3.67 = 247.43 Gt CO_2	
		-----------------------------	
		dif 107.35 Gt CO_2	30.36 %
3.	232 * 0.3847 = 89.25 C	* 5.27 470.35 Gt CO_2	
		* 3.67 327.54 Gt CO_2	
		-----------------------------	
		dif 142.81 Gt CO_2	30.36 %

Table 3: Values of hstr, Ms and their difference
Tab. 3: Hodnoty hstr, Ms a jejich diference

hstr	0.3	0.315	0.329	0.345	0.359	0.374	0.391	0.404
Ms [t CO_2]	5.4-3.67	5.27-3.67	5.05-3.67	4.71-3.67	4.36-3.67	4.02-3.67	3.74-3.67	3.67-3.67
Ms [t CO_2]	1.73	1.60	1.38	1.04	0.69	0.35	0.07	0.00

organisms receive more CO_2 than they need and return it back into the atmosphere, and so this quantity remains unused. But it is not the quantity, which returns at respiration (at darkness breathing), but the quantity, which changes – decreases with growing hstr. That is why we have divided this circuit of CO_2 circulation into two ones – internal one (small), which is regulated by rotation of the day and night, and external one (big), which is regulated by changes of hstr.

Annual increase in CO_2 into Rs was growing according to Le Quéré [15, 13] in 80th and 90th by 1 t C per year on mainland and oceans. From this, oceans have absorbed 1.101 Gt CO_2 and mainland 2.6 Gt CO_2 per year. In the atmosphere the increase was 12.11 Gt per year. From this follows, that the increase on mainland and oceans did only 30.55 % of the increase in atmosphere. The mentioned values were determined in a period of disturbed state of water balance, which also was determined in this period, thus approximately at hstr 0.3 of the equation of water balance. As at 0.3 hstr the primary production is 196 Gt Ys, then at full equilibrium 0.404 it would do 264 Gt Ys. This corresponds to: 988.76 Yz ----- 264 Gt Ys -----101.45 Gt C ----- 372.32 Gt CO_2

As the product of converting coefficients

0.267 * 0.3847 * 3.67 = 0.37696

1/3.74 1.438/3.74

1/C1 C2/C1 then 376.96 / 0.37696 = 1000 Gt Yz

Thus we get limit year value of primary production of the biosphere of mainland and oceans:

1000 Gt Yz	267 Gt Ys	102.73 Gt C	376.96 Gt CO_2
	1/0.267	1/0.10273	1/3.77
	3.74	9.73	0.265

Part 5. System "FS – hstr" as an automatic regulation

circuit

If we term Es – const, and FS = f(Ms, hstr), and the state of this circuit we express by a set of numbers, which enables in time $t > t_0$ to determine its behaviour and development, then, if at a certain moment a certain quality of CO_2 will be taken as Ms, then we get a response, which we can express by a transition characteristic (figure 2). Values of hstr, Ms and their difference are in table 3.

The coarse of transition characteristic is aperiodic and shows, how limit values of CO_2 absorption in the biosphere occur, from unstable state to stabile one. The highest stability is achieved, when specific consumption Ms is quite utilized (under these conditions ηFS would achieve 100 %). Stability of this system can be determined using Thom's theory of catastrophes, or, in our case, when we can determine conditions of a sudden qualitative change, Donocik's theory of functional analysis can be used [1, 5], as it does not matter, how such state has set in, but there is here a condition, that it will end in a point of the state plane. As hstr = f(t), we can choose functional

$$\xi = \lim_{\Delta t \to \infty} \frac{1}{\Delta t} \int_0^{\Delta t} F(t)dt$$

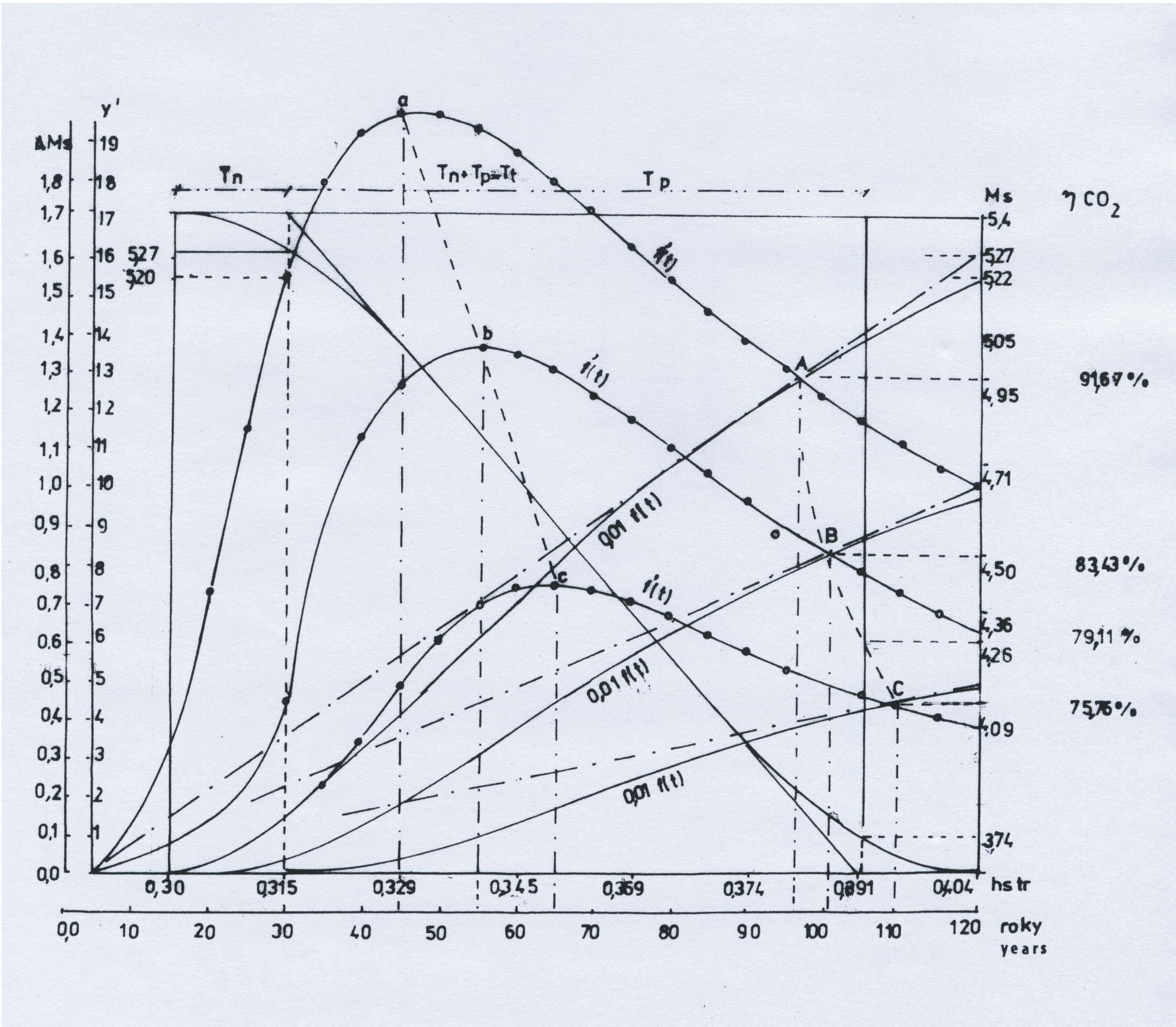

Figure 2. Transition characteristic of dependence of Ms on hstr in regulation circuit "FS – hstr"
(In the graph there is also expressed comparison of growth functions of forest stands, which will be analyzed in next part of the work)

Obr. 2: Přechodová charakteristika závislosti Ms na hstr v regulačním obvodu „FS – hstr"
(V grafu je rovněž uvedeno porovnání růstových funkcí lesních porostů, které bude analyzováno v další části práce)

Table 4: Levels of absorbed CO_2 in dependence on hstr
Tab. 4: Hladiny absorbovaného CO_2 v závislosti na hstr

hstr	Level of CO_2 (Hladina CO_2) [Gt]	Unused CO_2 (Nevyužití CO_2) [%]	Unused CO_2 (Nevyužití CO_2) [Gt]	FS [%]
0.300	279.95	34.66	97.05	65.34
0.315	293.94	28.35	83.06	71.65
0.329	307.00	22.80	70.00	77.20
0.345	321.94	17.39	56.00	82.61
0.359	335.00	12.53	42.00	87.47
0.374	345.27	9.18	31.73	90.82
0.391	364.86	3.32	12.14	96.68
0.404	377.00	0.00	0.00	100.00

Table 5: Homogenization of Ms series
Tab. 5: Homogenizace řad Ms

5-member series (5-členná řada)	Ms	6-member series (6-členná řada)	Ms
5,4 – 1,38/4	5.05	5.4 – 0.5 (1.38/5)	5.27
5.4 – 2(1.38)/4	4.71	5.4 – 1 (1.38/5)	5.12
5.4 – 3(1.38)/4	4.36	5.4 – 2 (1.38/5)	4.84
5.4 – 4(1.38)/4	4.02	5.4 – 3 (1.38/5)	4.57
5.4 – 5(1.38)/4	**3.67**	5.4 – 4 (1.38/5)	4.22
		5.4 – 5 (1.38/5)	4.02
		5.4 – 6 (1.38/5)	**3.74**

Regulation circuit is stabile, when with growing hstr (t) → ∞ there is general solution ΔMs (t) → 0, that is, in this circuit forced state stabilizes. In case of observed system lim ΔMs (t) = 0.

If we draw tangent in inflection point of transition characteristic, then in plane x_2 of state coordinates locates point 5.27, from which we derived symmetry of the system. It presents beginning of the draft of the curve Tp, while in the end it locates point 0.391 hstr, what corresponds to projection 3.74, thus again to limit value. Point 5.4 – 5.27 presents rise time Tn, and so Tn + Tp = Tt, where Tt is time of transition. Rise time and time of draft are of extraordinary importance in the system as limit values for determination the coefficient of stability.

Part 6. Levels of absorbed CO_2

Unused CO_2 leaves to the atmosphere. In connection with the different grade of utilization, levels of absorbed CO_2 in dependence on hstr are forming. In table 4, they are calculated according to the limit 377 Gt CO_2.

Error does 1.07 % and proceeded basic data correspond very well with evaluated series. At present, ηFS is corresponding by the value of absorbed CO_2 to hstr 0.3.

Part 7. Homogenization of Ms series for calculation of CO_2 in dependence on changes hstr

There was necessary to homogenize Ms series by converting from values Ms on limit 3.74 and stoicheiometric coefficient 3.67. As it concerns a thermodynamic process, we have used characteristic of Boltzmann constant K = 1.38, which expresses relation of energy of molecules to heat supply. That is why we outlined two series of 5 and 6 elements, supposing, that they must end with the value of 3.67 and 3.74.

Values 5.27 and 3.74 belong to the 6-member series, 3.67 to 5-member one. In both cases, characteristic of Boltzmann constant has led the series to the values of limit Ms 3.67, 5.27 and 3.74. Mutual shift enables their arrangement on the only line, and so it is possible to match values hstr to them. Generally then for limit values holds true:

Ms max – n * K / (n – 1) = 3.67 where n = 5, K = 1.38

Ms max – n * K / (n – 1) = 3.74 where n = 6, K = 1.38

Ms max – 0.5 * K / (n – 1) = 5.27 where n = 6, K = 1.38

Part 8. Comparison of limit transition characteristic with growth and growth increase function of forest stands (see figure 2)

Grows and grows increase functions of long-lived stands (spruce) have been counted by V. Korf [9] for I. – V. bonity class. We have drawn their trajectory and put into the graph of limit transitive characteristic. Time f(t) is 120 years and growth increase function is expressed by its derivation (figure 2).

DISCUSSION

Determination of limit possibilities of the biosphere to bind CO_2 gives preconditions to specify considerably CO_2 balance in the atmosphere. CO_2 absorption is bound from the great part to changes of hstr / hsp as a controlling quantity of stated system as an automatic regulation circuit. The biosphere takes up by 30.36 % more CO_2, than it is capable to transform and returns it back to the atmosphere. Utilization of this quantity, which we have called specific consumption (Ms) depends on mainland on the state of hstr / hsp; while this unutilization at hstr 0.3 does 34.66 %, it is 97.05 Gt CO_2, it decreases at achieving hstr 0.404 to zero. In this way increases also FS from 65.34 to 100 %. That is why a precondition of this utilization is the equilibrium state of water balance, which determines the course of FS.

The whole process is expressed by limit transitional characteristic, which expresses limit values of Ms as well as hstr by delimitation of Tn and Tp. CO_2 volume, absorbed by the biosphere yearly has this limit value:

1000 Gt Yz = 267 Gt Ys = 102.4 Gt C = 376. 96 Gt CO_2 (377 Gt)

For each level hstr, a level of absorbed CO_2 is formed, round which the value fluctuates according to change of hstr. In limit value the biosphere would become stabile. It has proved, that disturbed water balance of the Earth, especially of source quantities hstr / hsp, is a limiting factor of CO_2 absorption by photosynthesis.

Limit value of transitional characteristic enables comparison of all trajectories of growth and growth increase functions based on photosynthesis and thus CO_2 absorption. This comparison has brought following knowledge:

All points of intersection f'(t) of growth function f(f), which we have expressed as 0.01 f(t) are a quotient of time and the value of characteristic of Planck radiation constant C1 3.74. Thus t/3.74 = n, where n is an integer, and create an arithmetic series, as it is stated in the following table 6. Values of f'(t) and f(t) have been counted by V. Korf [9].

Rise time Tn and draft time Tp of the transitional characteristic have a special task, as they present limit values, according which it is possible to determine ηFS in % according absorbed and transformed CO_2. In the following table 7, times of intersection points of

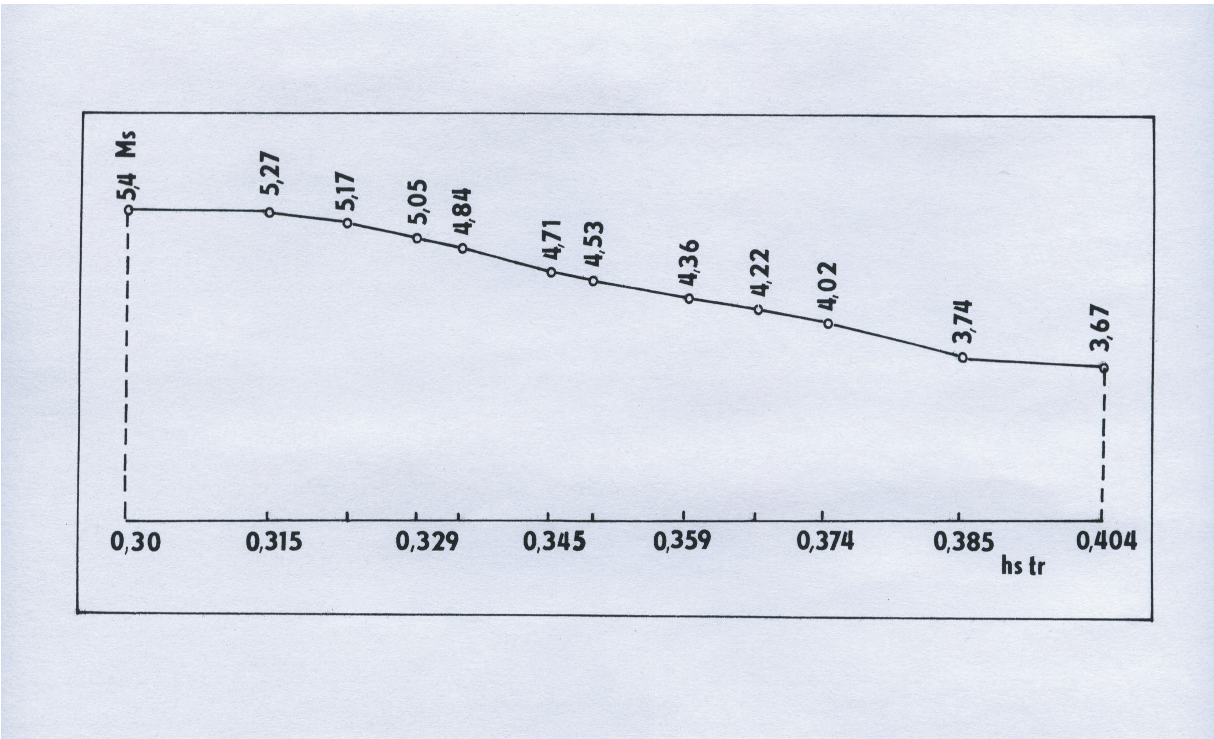

Figure 3: Trajectory of Ms with values counted from 5- and 6-members series
Obr. 3: Trajektorie Ms s hodnotami vypočítanými z 5- a 6-členné řady

Table 6: Ascensional and descensional values of growth curves on different bonities
Tab. 6: Vzestupné a sestupné hodnoty růstových křivek na různých bonitách

Bonity (Bonita)	Ascensional branch (Vzestupná větev)		Descensional branch (Sestupná větev)	
	t_1 [years (roky)]	Number of units C_t (Počet jednotek C_t)	t_2 [years (roky)]	Number of units C_t (Počet jednotek C_t)
I.	47.4	47.4 / 3.74 = 12.67 (13)	93.7	93.7 / 3.74 = 25.0 (25)
II.	52.0	13.90 (14)	99.5	26.6 (26)
III.	55.0	14.7 (15)	102.1	27.2 (27)
IV.	60.0	16.0 (16)	108.8	29.0 (29)
V.	64.9	17.3 (17)	114.1	30.5 (31)
End of vegetation (Konec vegetace)			120.0	32.0 (32)

Table 7: Time of intersection point of f'(t) with Tn and Tp and transformed Ms CO_2
Tab. 7: Doba průsečíku f'(t) s Tn a Tp a transformovaná Ms CO_2

Bonity (Bonita)	t_n [years (roky)]	C_t	Tn Ms	Top point of f'(t) (Vrchol f'(t) [years (roky)]	C_t	Tp Ms	t [years (roky)]	C_t	FS [% CO_2]
I.	30	8.0	5.20	45.0	12	- 4.95	97	26	91.67
III.	30	8.0	4.17	55.0	15	- 4.50	101	27	83.43
V.	34	9.0	3.82	65.0	17	+ 4.09	110	29	75.75

Table 8: Dependence of photosynthesis on hstr and hsp in different bonity classes
Tab. 8: Závislost fotosyntézy na hstr a hsp v různých bonitních třídách

Bonity (Bonita)	FS [%]	hstr [mm]	hstr [%]	hsp [mm]	hsp [%]
I (A)	91.67	- 19.71	- 6.7	- 8.6	- 6.7
III (B)	83.43	- 41.02	- 13.9	- 17.87	- 13.9
V (C)	75.75	- 51.92	- 17.6	- 22.62	- 17.6

derivation f'(t) of growth function f(t) with Tn and Tp for the I., III. and V. bonity class are stated.

According the evaluated ηFs % CO_2, conditions can be determined, under which the growth function proceeded (table 4). Considering hs 730 mm, then the dependence of photosynthesis on hstr and hsp can be presented as it is in table 8.

From the given is evident, that the V. bonity class already exceeds Tp (point C), and so, in this case, holds true:

□ A, B, C □ f'(t), f(t) : Ms $\geq$ 4.26 Tp □ $\eta FS_{CO2} > 79$ %

For all intersection points A, B, C, which are elements of growth function, stands, that specific consumption of CO_2 higher or equal to the value 4.26 Tp implicates ηFS_{CO2} higher than 79 %. These limits range from Ms $1/\sqrt{3}$ to $\sqrt{3}$.

CONCLUSIONS AND RECOMMENDATIONS

The presented work is one of analyses of Earth biosphere, by which we tried to explain principles of biosphere development, its photosynthetizing elements in dependence on controlling component of water balance – transpiration and underground waters. We tried to warn, that water balance of the Earth is disturbed and that is why the effectiveness of photosynthesis and absorption of CO_2 is low. We had also in view the necessity to suggest some new ways to solution of so important problem as it is to stop extending deserts, necessity to extend forest stands on known principles of hydrogeomorphology, solution of delimitation of agricultural and forest fund with the aim to secure the equilibrium of water balance and thus substantially strengthen the absorption of CO_2 by photosynthesis.

ACKNOWLEDGEMENT

This study was supported by the Grant Project of Ministry of Education of the Czech Republic, identification code

MSM 6007665806.

REFERENCES

[1] Donocik R., Functional stability, its concept, theory and application, Academia, Rozpravy, 87, 1977.

[2] Duvigneaud P., Ekologická syntéza (Ecological synthesis), Academia, Praha, 1988.

[3] Faure R., Heurgonová E., Uspořádání a Booleovy algebry (Structures ordonnées et algebres de Boole), Academia, Praha, 1971, 1984.

[4] Field C. B., Behrenfeld M. J., Randerson J. T., Falkovski P. G., Primary production of the Biosphere: Intergrating terrestrial and oceanic components, Science 281, (1998): 237-240.

[5] Hudec L., Synergetika a teorie stability (Synergetics and theory of stability), Academia, Praha, 1983.

[6] Kalinin G.P., Globalnyj vodoobmen, Nauka, Moskva, 1975.

[7] Kalman R., Falb P., Arbib M., Očerki po matematičeskoj teorii sistem, Mir, Moskva, 1971.

[8] Krasnovskij A. A., Biologičeskoje preobrazovanije solnečnoj energii, Vestnik AN SSSR (1979): 83-96.

[9] Korf V., Zákonitosti růstu lesních porostů, Doktorská disertační práce (Principles of growth of forest stands), VŠZ Praha, 1972.

[10] Kubík S., Kotek Z., Šalamon M., Teorie regulace, SNTL, Praha, 1974.

[11] Kudrna K., Šindelářová M., Equilibrium of water balance as a basic precondition of progressive development of land area, J. Cent. Eur. Agric. (2004) 4: 273-280.

[12] Manabe S., Strickler R. F., Termičeskoje ravnovesije v atmosfere s učetom konvekciji, Sb. Teorija klimata, Gidrometizdat, Moskva (1967): 61-103.

[13] Nátr L., Země jako skleník, Proč se bát CO_2? (Earth like a greenhouse, Why to be afraid of CO_2?), Academia, Praha, 2006.

[14] Ovčinikov N. F., Principy sochranenija, Nauka, Moskva, 1966.

[15] Le Quéré C., Aumont O., Boop L., Bousquet P., Ciais P., Francey R., Heimann M., Keeling C. D., Keeling R. F., Khesghi H., Peylin P., Piper S. C., Prentice I. C., Rayner P. J., Two decades of ocean CO_2 sink and variability, Tellus 55 B (1966): 649-655.

Symbols and indications used in the work
Použité symboly a označení

Symbol	Meaning	Význam
FS	Photosynthesis	Fotosyntéza
ηFS	Coefficient of effectiveness of FS	Koeficient účinnosti FS
Mb	Equilibrium state of water balance	Rovnovážný stav vodní bilance
hstr	Transpiration, k hstr – coefficient of transpiration	Transpirace, k hstr – koeficient transpirace
hs	Precipitation	Srážky
hsp	Underground waters, k hsp – coefficient of hsp	Podpovrchové vody, k hsp – koeficient hsp
hsev	Evaporation, k hsev coefficient of evaporation	Evaporace, k hsev – koeficient evaporace
hso	Runoff waters, k hso – coefficient of runoff waters	Odtokové vody, k hso – koeficient odtokových vod
Ms	Specific consumption of CO_2 on 1 t C	Měrná spotřeba CO_2 na 1 t C
CO_2 ms	Input quantity of CO_2 from Ms	Vstupní množství CO_2 z Ms
CO_2 hstr	Quantity of CO_2 dependent on hstr	Množství CO_2, závislé na hstr
CO_2 at	Quantity of CO_2 coming into atmosphere	Množství CO_2 vstupující do atmosféry
CO_2 rs	Quantity of CO_2 bound by plant associations and algae (photosynthetizing organs)	Množství CO_2 vázané rostlinnými společenstvy a řasami (fotosyntetizujícími orgány)
C1	Characteristic of the 1st Planck radiation constant – 3.74	Charakteristika 1. vyzařovací konstanty Planckovy – 3,74
C2	Characteristic of the 2nd Planck radiation constant – 1.438	Charakteristika 2. vyzařovací konstanty Planckovy – 1,438
C3	Relation C2/C1 – 0.3847, conversion coefficient Ys to C	Poměr C2/C1 – 0,3847, převodní koeficient Ys na C
3.67	Stoicheiometric coefficient of conversion C to CO_2	Stechiometrický koeficient převodu C na CO_2
K	Characteristic of Boltzmann constant 1.38	Charakteristika konstanty Boltzmannovy 1,38
∑Yz	Green matter volume	Objem zelené hmoty
∑Ys	Dry matter volume	Objem suché hmoty
∑C	Carbon volume	Objem uhlíku
Gt	Unit in gigatons (milliard tons)	Jednotka v gigatunách (miliarda tun)
f(t)	Growth function	Růstová funkce
f´(t)	Derivation of growth function – growth increase function	Derivace růstové funkce – přírůstková funkce
Es	Energy of sun radiation	Energie slunečního záření
Ep	Bioenergetic potential of soil	Bioenergetický potenciál půdy
rs	Plant associations	Rostlinná společenstva
C_{akt}	Active carbon	Aktivní uhlík
C_{rs}	Carbon contained in plant associations	Uhlík obsažený v rostlinných společenstvech
C_p	Carbon contained in soil	Uhlík obsažený v půdě
ξ	Designation of functional	Označení funkcionálu
Tn	Rise time of transition characteristic	Doba náběhu přechodové charakteristiky
Tp	Time of draft	Doba průtahu
Tt	Time of transition	Doba přechodu