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Nutrients efficiency for biomass production of spruce and Beech

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Abstract: Bublinec E. 2015: Quantification of some components of geobiochemical element cycles in forest ecosystems. – *Beskydy,* 8 (2): 75–78

The paper assesses the major contribution of Prof Ing Emil Klimo, DrSc, done as part of research into geobiochemical cycle within the International Biological Programme and the Man and Biosphere scheme. It also explain findings of studying beech and spruce ecosystems. It is noted that spruce can make better use of stock of nutrients on the oligotrophic soils to generate biomass compare with beech. As a result, spruce is much more efficient at rather poor sites, even when it grows outside its natural range.

Keywords: Prof Ing Emil Klimo, DrSc; IBP, MaB, spruce, beech

Introduction

Despite the fact that our symposium discusses the biogeochemical cycle of chemical elements, particularly nutrients in the forest ecosystems, it is my welcome and personal commitment to recollect the beginnings of my connections with Prof Ing Emil Klimo, DrSc. They date back to my postgraduate study period.

Materials and Methods

Historia est magistra vitae

In the 1960s, a lively debate was underway in the then Czechoslovakia. Focusing on the characteristics of underlying soils of spruce monocultures in terms of ecology and production and the rate of podzolization of the soils, the discussion involved two barely reconcilable schools of thought headed by Prof Dr Ing J Pelíšek, DrSc of Brno and Ing R Šály, DrSc of Zvolen, each one being a luminary of soil science; the latter subsequently attained the Professor degree. It was the time when I first got in touch with Prof Klimo who has more than happy and ready to take me to his research area in spruce woods where he then carried out a challenging lysimetric study involving washout and movement of elements in the soil, actions typical of podzolization processes (Klimo, E. 1977: Migrace živin v lyzimetrických vodách v závislosti na průběhu podzolizačného procesu lesních půd. Vedecké práce VÚLH Zvolen, 1977, pp 75–92). Additionally, it is also an important component of the geobiochemical cycle of elements in the wood. It was pioneering work not only in our country, but also at the international level. Prof Klimo also provided me the first offprint which I quoted in my first candidate minimum (Klimo, E. - Pospíšil, J. 1963: Příspěvek k poznání vývoje a růstu semenáčku jednotlivých lesních dřevin na zeminách půdnich horizontů hlavních typů lesních půd. In: Sb. VŠZ, Series C 3, str. 207 –223). The authors investigated the seedling development and growth in spruce, pine,

European larch and aspen on, *inter alia*, nutrient-depleted and enriched soil horizons. The paper significantly influenced the focus of my own dissertation, which covered the influence of conifer monocultures on ecology-production characteristics of forest soils, in addition to the determination of the rate of podsolization.
During this initial period, Prof Ing E Klimo, DrSc, published other major papers; of these, let me mention at least the one released in 1973 and discussing recent soil processes as part of the research into the function, productivity and structure of forest ecosystems. It was ahead of its time in that it paid attention to the topic, which today is included among ecosystem services (Klimo, E. 1973: Studies on the recent soil processes as a part of the research of function, productivity and structure of individual ecosystems. Papers of the third Czechoslovak soil science conference. Part 1, Nitra, p 135–45).

Results and discussion

International Biological Programme

Another period of research – now a joint effort – arrived with a scheme under the aegis of UNESCO: International Biological Programme (IBP). This may be definitely called a period of collaboration. In Slovakia, the research was situated on the facility called Báb while in the Czech Republic it involved the ecosystem of alluvial forest in South Moravia. It needs to be noted that although these were cooperating efforts, I always felt that Prof Klimo was one step ahead each time. Yet, I never felt any superiority on his part. It each time involved selfless transmission of knowledge and experience, often as early as the manuscript stage; speaking of this, I still own multiple papers in this form that subsequently were released as printed articles. I shall indicate at least some of them:

- Klimo, E. 1973: Carbon cycling in the ecosystem of lowland forest in Lednice, Moravia; MS; which was published in Rostlinná výroba a year later. Both the manuscript and the published paper show my indication in the form of exclamation mark and a note saying „An example for element cycles!“

And there are more papers, such as:

- Klimo, E. 1974: Biogeochemický koloběh živin v ekosystému lužního lesa Jižní Moravy; again, it is a manuscript and was released as part a monograph entitled Funkce, produktivita a struktura ekosystemu lužního lesa Jižní Moravy, pp 117–136,
- Klimo, E. 1974: Spatial variability of chemical properties in the topsoil of the IBP study Lednice in Moravia PT – PP/IBP, p 321–328.

Approximately the same period saw us releasing multiple papers based on the Báb research facility; these aimed at element importing via precipitation, washing from vegetation organs and movement through soil (In: Biskupský, V; 1972, IBP/Báb Colloquium I), followed by decomposition of litter and ecology- production characteristics of soils. The research work included the accumulation of nutrients and micro elements in aerial biomass of trees in the oak-hornbeam vegetation of the Carpathians (Research project Báb/IBP, Progress report II , Veda Publishing House, Bratislava, 1975, pp 475–486, 493–496). Like outlined above, both of these as well as other publications were influenced and the research initiated by scientific activities of Prof E. Klimo.

Man and Biosphere Programme

The UNESCO's scientific scheme was a follow-up of the IBP. Studying and determining the productivity, stability and functioning of ecosystems affected by human activity was the underlying concept and made use of the analysis of primary and secondary production. For this reason, the spectrum of the elements normally tracked in cycles, i.e. macro nutrients (C, N, P, K, Ca, Mg, S) and biologically important trace elements (Fe, Mn, Cu, Zn, Mo, B), where appropriate, became extended with added toxic or even some other elements with a larger concentration in tree species (Cl, Pb, As, Cr, Cd, Ni, Si, Al, Na, Ti and Co & ash content).

In Slovakia, the scheme was underway as part of multiple transects in the Small Carpathians. Of these, most work was done within transect I, an area with good accessibility by road. It is located in close proximity to Bratislava. The territory is heavily affected by the industrial background as well as tourism. The transect is found at the junction of navigation points Rača - Biely Kríž - Košariská - Lozorno. The research into geobiochemical cycles was carried out on an area with artificial planting of spruce and beech vegetation. The plots are very well comparable, benefitting from being placed in each other's immediate vicinity and belonging to a group of forest type of Querceto - Fagetum tiliosum, type Melica-Mercurialis beechwood with linden. In the concept of Zürich-Montpellier school of thoughts, it is the Dentario - Fagetum community. In any of the cases, acidic cambisol is the soil representative.

Tab. 1: Quantification of some components of geobiochemical element cycles in forest ecosystems

	Increment	N	P	K	Ca	Mg	S
Beech forest	1713	112.5	10.2	50.0	67.6	13.8	6.6
Increment of dendromass per 1 kg of bio element		15.2	167.9	34.2	35.3	124.1	259.5
Spruce forest	1129	28.7	2.9	10.0	35.2	3.6	2.9
Increment of dendromass per 1 kg of bio element		39.3	389.1	112.8	32.1	313.5	389.1

The results of this research can be interpreted in various ways (Bublinec, E. 1974: Koncentrácia, akumulácia a kolobeh prvkov v bukovom a smrekovom ekosystéme. In: Acta dendrobiologica, Veda SAV Publishing, 132 pp). Here we will do it a bit unconventional in terms of production of both the ecosystems. Ask yourself the question: How do beech and spruce stands manage the primary offer of nutrients in the soil? What amount, how much biomass will they produce per kilogram of nutrients consumed. In doing so, let the current average increment of dry matter per hectare and the nutrient required for this be the basis; all figures are kg. ha^{-1}:

The conversion to the common base shows that while 1 kg nitrogen produces 152 kg dendromass in beechwood, it generates up to 393 kg in spruce forest, for instance. A similar situation is seen even with the other nutrients. These coefficients of efficiency, which we might refer to as nutrient coefficients as well, are certain analogies of transpiration rate, presenting in fact a quantity of wood produced by 1 kg of bio element and making it obvious that spruce is rather economical in managing nutrients and its production is more efficient than that of beech. The interpreted outputs thus demonstrate that spruce can make a better use of supplies of nutrients from the soil compared with beech. As a result, spruce is much more efficient at rather poor sites, even when it grows outside its natural range, while there is the assumption that for richer soils, spruce will not utilise the entire production potential of these to produce biomass. Richer soils require mixed vegetation with a more complex structure while beech ecosystems, in contrast, have a more intense element cycle, hence a greater ameliorative effect on the soil.

Conclusion

Completing the picture may need including the other activities in which Prof E Klimo became involved. After the completion of the international schemes, i.e. IBP and MAB, the Institute of Forest Ecology in Zvolen started to build its own scientific programme. It includes the renowned Beech ecology field research station in the hills of Kremnické vrchy (Barna, M., Kulfan, J., Bublinec, E. (Eds) Buk a bukové ekosystémy Slovenska/ Beech and Beech Ecosystems of Slovakia, Veda, Vydavateľstvo, Bratislava 2011, 634 pp). The good relations with the Institute of Forest Ecology of Mendel University in Brno remained to be kept under the management by Prof Ing Jiří Kulhavý, CSc, and are hoped to continue under the leadership by Doc Ing Luboš Purchart, PhD. To conclude, I need to mention that I am grateful to Prof Emil Klimo, DrSc, that it was he who stood with me as an opponent as part of both the habilitation and inauguration procedures, whether as a member of appointment committees or as a direct reviewer of my scientific and research activities. Professor Emil Klimo, many thanks for everything!

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