Appendix 2.2

AUTHOR'S REVIEW OF OWN SCIENTIFIC ACTIVITY AND ACHIEVEMENTS

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I. Personal data

1. Name and surname:

Danuta Drzymulska

2. Diplomas and scientific degrees:

- 1995, M.Sc. in biology, Institute of Biology, Faculty of Mathematics and Environment, Warsaw University, Branch in Białystok; master's thesis: "Anatomical analysis of shoulder belt bones of fossil penguins from Seymour Island, Western Antarctica", supervisor – prof. dr hab. Andrzej Myrcha

- 2005, Ph.D. in biological sciences, Institute of Biology, Faculty of Biology and Chemistry, University of Białystok; doctoral thesis: "Late Glacial and Holocene history of vegetation of selected mires of Knyszyńska Forest", supervisor – doc. dr hab. Andrzej Obidowicz from Władysław Szafer Institute of Botany, Polish Academy of Sciences in Kraków

3. Information about the employment:

15.IX.1995-30.IX.1996 – secretary in STM Promocje s.c. firm

1.IV.1997-31.VII.2006 – assistant in Department of Botany, Institute of Biology, University of Białystok (including 10 months of maternity leave)

since 1.VIII.2006 until now – assistant professor in Department of Botany, Institute of Biology, University of Białystok

II. Scientific achievement proposed as the basis for the application for the post-doctoral degree of „doktor habilitowany"

As the achievement in the sense of art. 16 par. 2 of the Polish law from March 14, 2003 about scientific degrees and scientific title as well as degrees and title in the arts (Dz. U. nr 65, position 595 with changes) I propose the series of five thematically related papers under the title **„Evolution of humic lakes in Wigry National Park from the decline of the last glaciation"**.

1. **Drzymulska D.**, Kłosowski S., Pawlikowski P., Zieliński P., Jabłońska E. 2013. The historical development of vegetation of foreshore mires beside humic lakes: different successional pathways under various environmental conditions. Hydrobiologia 703:15-31. IF_{2013} – 2,212; $MNiSW_{2014}$ score – 30

2. **Drzymulska D.**, Zieliński P. 2013. Developmental changes in the historical and present-day trophic status of brown water lakes. Are humic water bodies a uniform aquatic ecosysytem? Wetlands 33: 909-919. IF_{2013} – 1,444; $MNiSW_{2014}$ score – 20

3. **Drzymulska D.**, Fiłoc M., Kupryjanowicz M. 2014. Reconstruction of landscape paleohydrology using the sediment archives of three dystrophic lakes in northeastern Poland. Journal of Paleolimnology 51(1): 45-62. $IF_{2014/2015}$ – 2,120; $MNiSW_{2014}$ score – 30

4. **Drzymulska D.**, Zieliński P. 2014. Phases and interruptions in postglacial development of humic lake margin (Lake Suchar Wielki, NE Poland). Limnological Review 14,1: 11-18. $MNiSW_{2014}$ score – 5

5. **Drzymulska D.**, Fiłoc M., Kupryjanowicz M., Szeroczyńska K., Zieliński P. 2015. Postglacial shifts in lake trophic status based on a multiproxy study of a humic lake. The Holocene 25(3): 495-507. $IF_{2014/2015}$ – 2,283; $MNiSW_{2014}$ score – 40

total IF for the series of articles: 8,059
total scores of MNiSW for the series of articles: 125

III. Scope and results of scientific achievement presented for the habilitation procedure

Series of articles [1-5] entitled **"Evolution of humic lakes in Wigry National Park from the decline of the last glaciation"** comprises**,** essentially, results of the palaeoecological studies of sediments from humic lakes located in above mention park. Their conducting was possible, first of all, owing to research project of Ministry of Science and Higher Education nr N N305 085135 (realization period 2008-2011) under the title: „History of dystrophic lakes (*suchary*) of Wigry National Park in the light of Holocene succession of their vegetation" managed by me. To my knowledge, the problems discussed in the present series of papers and the methods used make these studies pioneer not only in our country.

INTRODUCTION

Humic (dystrophic) lakes are typically found in northern regions of the globe, with a cool, humid climate. In the territory of Poland, as well as in other areas of temperate zone, they occur much less. Hence especially great value of dozen humic lakes situated in Wigry National Park (WPN), so called *suchary*.

Humic lakes were carefully examined for the hydrobiological, microbiological and ecological aspects. Therefore their current state is well known, what is confirmed by the numerous literature data. This refers also to the dystrophic water bodies from the Poland territory, including *suchary*. However, little we know about the evolution of humic lakes. Generally, there are no palaeoecological data concerning development of these lakes during

thousands of years. *Suchary* do not constitute an exception. For this reason I undertook a study, which results, presented in this series of articles, seem to eliminate this deficiency, delivering data about development of dystrophic water bodies and conditions shaping this development in the period from the decline of last glaciation until now. We used the research methods which result from the specifics of humic lakes. Floating mat occurring in these water bodies is just a mire being the integral part of the lake. This provides an opportunity to collect the peat sediments for research from foreshores. Analysis of this material will deliver information about lake evolution. There is no such possibility in clearwater lakes.

Research of humic lakes from Wigry National Park had following aims:

1. Recognition when and how these water bodies formed, including verification of opinion about *suchary* as kettle holes.
2. Reconstruction of hydrological conditions during formation and functioning of these lakes in the past.
3. Recognition of directions of subfossil vegetation succession in the foreshores and statement if contemporary plant communities are their continuation.
4. Determine whether humic lakes remain uniform ecosystems both in the past and now.
5. Study if they arise directly from oligotrophic water bodies or if humotrophy could appear later, during evolution of lakes.

Both sediments of foreshores and central part of the lakes were studied. Following palaeoecological methods were used: analysis of macrofossil plant remains, determination of decomposition degree of peat, pollen analysis, subfossil cladocera analysis, geochemical analyses of sediments and radiocarbon datings. Furthermore, contemporary vegetation and water quality in selected lakes were investigated.

THE MOST IMPORTANT RESULTS OF THE PRESENTED SERIES OF PAPERS

Conditions of the biogenic accumulation in the humic lakes of WPN

The studied humic lakes are located in the territory of Lithuanian Lakeland, in the young glacial area. The oldest, connected with the Allerød, sediments from foreshores were recognised in Lake Suchar VI [1], L. Suchar II and L. Suchar Wielki [3]. In the other lakes biogenic sediments of marginal zones were formed in the different periods of the Holocene:

in Preboreal – L. Ślepe [3], in Boreal – L. Suchar III [1] and L. Sucharek [2], in Atlantic – L. Widne [1] and L. Wądołek [2], and even in the Subboreal period – L. Suchar IV [2].

Same as age of biogenic sediments from foreshore, their typology is a diverse. Solely peat profiles were found in L. Widne [1], L. Wądołek, L. Sucharek [2], and in L. Suchar Wielki [3, 4]. Whereas in five water bodies both peat and lacustrine sediments were recognised. Wherein following configurations of these sediments were stated (in direction from the bottom to the roof of profiles): peat → lacustrine sediment → peat, L. Suchar IV [2], L. Ślepe [3]; lake sediment → peat, L. Suchar II [3, 5], and several changes in sediment character, as in L. Suchar II and L. Suchar VI [1]. The latter scheme undoubtedly evidences fluctuations of the water table in studied lakes during their development. In L. Suchar III and L. Suchar VI they occurred repeatedly, and foreshore mires developed there in highly telmatic conditions, on the border of *terrestricum* and *limnicum*.

Regarding the beginning of sedimentation in the lake centres, the Allerød sediments were recognised in L. Suchar Wielki. In the case of this lake both marginal and central zones started to function at the same time. As we know, just in the Allerød melting of dead ice blocks took place on a large scale, what resulted in forming of numerous water bodies in the young glacial areas. In L. Suchar II and L. Ślepe bottom sediments are younger – Preboreal [3].

Detailed investigation of development of three above mentioned dystrophic lakes was possible thanks to determination isochrones – sediment layers of the same age. The results of pollen analysis were used for that purpose. The scheme of such layers reflects hydrological conditions during lake functioning in the past. **In L. Suchar II, L. Suchar Wielki, and L. Ślepe arrangement of isochrones indicates that each of three water bodies developed differently [3].** In the case of L. Suchar Wielki, already in the beginning of the Younger Dryas stadial, the decline of lake water table took place, therefore biogenic accumulation was interrupted in its foreshore. The hiatus present there embraced the Younger Dryas and the considerable part of the Holocene – up the Subboreal period, what is evidenced by the lack of isochrones. On the other hand, we possess radiocarbon data for sediment sample from foreshore profile and it indicates that this sediment accumulated in the Atlantic period. Therefore, the cessation of accumulation could be not such long, and sediments probably mixed as a result of slope processes in the foreshore zone. Such possibility was quite high because of the steep southern slopes of L. Suchar Wielki (region of drilling location), as well as the high precipitation noted in the territory of northern Poland in the first half of the Boreal period [3, 4]. Stabilization of water table on high level was noted in L. Suchar Wielki just in the beginning of the Subboreal period.

Development of L. Suchar II shaped in a different manner. Dead ice melted there unequally what resulted in the diverse age of the oldest sediments in the central part of the lake (accumulation in the Allerød) and in the foreshore (accumulation in the Preboreal period). In the centre of the future water body this ice block was very thick, so it melted slower. For this reason small, probably oligotrophic, lake grown by charophytes occurred just in the foreshore zone (in its present form). In the beginning of the Holocene L. Suchar II enlarged, taking contemporary shape. As scheme of isochrones indicates, water level in this water body was high until the Subboreal period. Then the inhibition of biogenic accumulation took place, what was, most likely, an effect of precipitation reduction, what caused decrease of water level in lake. Such phenomena were noted in this time not only in the territory of northern Poland, but also in the other regions of Europe. In the case of L. Suchar II, consequences of drop of precipitation could be particularly severe because of very small catchment and low catchment/lake area ratio [3]. From the second half of the Subboreal period water level increased in the lake.

The third object – L. Ślepe exists from the Preboreal period. The scheme of isochrones indicates the high water table throughout the Holocene [3].

According to above findings, **there is no synchronization in the changes of water table in studied lakes. This means that local conditions played a decisive role, such as parameters of catchment, ground water level, or morphometric features of lake basins.** Only in L. Suchar II decrease of water level was noted, what could be connected with the regional changes. The most ambiguous hydrological situation was concluded in L. Suchar Wielki.

The delimitation of isochrones was also used to verification of idea that humic lakes of WPN are potential kettle holes, such as objects known from Bory Tucholskie. In both cases we have to deal with small lakes located in the young glacial area, surrounded by coniferous forests. These indications were probably a basis for designation of *suchary* as kettles. However they are insufficient for justified using of that term. To form kettle hole, accumulation of sediments must to happen in the strict conditions, namely in situation when lake basin is sealed by organic materials, which isolate it from subsurface waters. In effect, sediments of the same age arrange parallel in relation to the lake surface, gradually filling the whole depression. **Investigation of isochrone scheme in L. Suchar II, L. Suchar Wielki, and L. Ślepe did not confirm kettle character of these lakes.** Development of *suchary* was connected with the ground water level, and sediments of the same age accumulated in the whole basin, what resulted in the concave scheme of isochrones [3].

Directions of subfossil vegetation succession in humic lakes of Wigry National Park

Reconstruction of subfossil vegetation occurring in the foreshores of humic lakes was done based on the results of analysis of macrofossil plant remains of peat sediments. As we fixed **there are three groups of lakes in the view of development directions of past vegetation.**

The first of them includes the water bodies with succession of subfossil vegetation driving to peat moss communities of bog. Wherein the following initial plant communities were recognised: brown moss phytocoenosis of fen, in L. Suchar Wielki [4], peat moss communities of poor fen, in L. Suchar III [1], or shrub communities of (moderately poor) fen. This latter were identified as the first stadium of succession both in L. Suchar IV and L. Wądołek [2]. In the case of L. Suchar II peat moss communities of bog existed practically from the beginning of the foreshore mire, what is evidenced by the presence of sphagnum peat, initially with a large number of pine remains [5].

The second group refers to the water bodies with succession of subfossil vegetation of foreshores driving from fen communities to communities of fen/transitional mire. In the case of L. Suchar VI brown moss communities of moderately rich fen was replaced by peat moss communities of poor fen [1]. Whereas in L. Sucharek succession from reed rush to communities of moderately poor fen with peat mosses and deciduous shrubs was noted [2].

In the separate category of humic lakes there is only one object – L. Widne. Investigating development of its foreshore mire we noted functioning, from the beginning of its existence, of communities typical for fen, like communities of sedge-sphagnum and reed [1].

Our research showed that **differentiation in subfossil vegetation of humic lakes of WPN was reflected also in the results of geochemical analyses of sediments [1].** In connection with that, water body which is the most different in terms of subfossil vegetation, L. Widne, came off also in terms of values of chemical parameters (low content of nitrogen, the highest value of C/N parameter). A the opposite pole L. Suchar III ranked. While the results of the chemical analyses of sediments from L. Suchar VI placed this lake in the intermediate position, however with an indication of similarity to L. Suchar III.

In our study we wanted to go further. We were interested in if there is continuation between subfossil plant communities and contemporary vegetation occurring in the foreshores of investigated lakes, and then if there is continuation in the directions of subfossil vegetation succession in the lakes of three described groups. Analyses were done again in

L. Suchar III, L. Suchar VI, and L. Widne, so in water bodies complied with the above criterion [1]. Lake Suchar III representing the most numerous group of lakes, i.e. objects showing succession to peat moss communities of bog, also nowadays is devoid of vegetation connected with the more fertile habitats, possesses the good developed acid floating mat and could be named as typical humic lake. L. Suchar VI represents the water bodies surrounded in the past by communities connected with the average fertile fens and transitional mires. Also at present, in the foreshore there are plant associations typical for such kinds of mires. The third object – L. Widne was surrounded by communities connected with the fertile fen, therein the reed rush. Nowadays it also diverges from the image of typical humic lake. In its marginal zone *Sphagnum teres* (Schimp.) Ångstr. dominates, instead of *S. magellanicum* Brid. and *S. fallax* (Klinggr.) Klinggr., as in L. Suchar III. It concerns also the atypical for humic lakes values of chemical parameters of water, which is, in this water body, less acid, contains more calcium ions and less organic material, than water from L. Suchar III. Lake Suchar VI takes intermediate position in this regard. Therefore we stated that **directions of vegetation succession in the studied lakes in the past are continued nowadays.**

The existence of three directions of subfossil vegetation succession in the surroundings of *suchary* suggests that as in the case of water level changes in these lakes, it was shaped by local environmental conditions. Otherwise we would expect a uniform pattern of development, because we have to deal with objects located close to each other, functioning in the same climatic conditions. **The decisive impact on foreshore vegetation of humic lakes was exerted by the catchment parameters, as its size, value of catchment/lake area ratio, shoreline development index, catchment slope, or character of catchment** [1, 2]. It appears that these of *suchary*, which are characterised by succession of foreshore vegetation driving to peat moss communities of bog, like L. Suchar III and L. Suchar IV, have the highest value of catchment/lake area ratio (72,72 and 72,31, respectively) [1, 2]. We could suppose that as nowadays, also in the past catchments of these water bodies were forested, overgrown mainly by conifers. It promoted the considerable supply of humic substances from catchment to lake, affecting formation of peat moss communities of bog in its marginal zone. While in the case of L. Widne, perhaps like today, the past catchment was not densely forested, which with the conjunction with very low (8,03) value of catchment/lake area ratio, could lead to formation of lake with no all attributes of dystrophic water body [1].

Shaping of trophy in humic lakes over thousands of years

The preliminary recognition of typical humic lakes and lakes with atypical features became an incentive to further studies of humotrophy state in *suchary*, in the past. The

results of plant macrofossil and geochemical analyses of foreshore sediments from L. Suchar IV, L. Wądołek, and L. Sucharek confirmed that humic lakes are not uniform ecosystems. **Besides typical humic water bodies we recognised eutrophic-humic lakes** [2]. Following the development of studied lakes we stated that L. Suchar IV both in the past and nowadays demonstrates features of typical humic lake. Lake Wądołek – typically humic in the past, today is rather more fertile. In the case of the third of lakes – L. Sucharek we noted that in the past there was a shift from more fertile humotrophy to typical humotrophy and a return to the more fertile form in the present. **Therefore there is a possibility of shifts both from typical humic lake to eutrophic-humic and inversely. This lack of uniform model of development of dystrophic lakes results from the complexity of lake-catchment system, mainly** [2]. Once again we must to emphasise the impact of catchment on the lake history.

The studies conducted in L. Suchar II were the culmination of deliberation concerning the trophy shaping in humic lakes [5]. Their results show new data about evolution of these lakes. We stated that L. Suchar II was, after the initial stage of oligotrophy in the Late Glacial, the mesotrophic lake (during the Preboreal and Boreal periods), and next even eutrophic (in the Atlantic period) to reach finally humotrophy state in the Subboreal, what is continued to the present day. Therefore, there were three main shifts of trophy. The fundamental one – in the Subboreal period was a result of complete rebuilding of environment in the surrounding of lake, namely the appearance of pine and spruce forests in the catchment, which were a source of the huge amount of humic substances. Their supply induced humotrophy. The example of L. Suchar II showed that **dystrophic lakes could go through the developmental stages typical for the clearwater lakes. It is a complete *novum* in the previous limnology.** The trophic status of L. Suchar II changed so significantly, that this lake performed a peculiar shift from clearwater to disharmonic lakes. Wherein both developmental series were considered as completely independent until now (except initial oligotrophy). **Based on data about the trophy shaping in several humic lakes in the past, we proposed the scheme showing unknown, until now, directions of potential changes** [5]. **The obtained results demonstrate a new visage of humic lakes, presenting them as not uniform and changeable in time water bodies, what could be used in the expectations of their future.** Wherein **the main role in the shaping of the future of these objects should be assign to the catchment impact, namely to the coniferous forests overgrowing the surrounding.**

The conducted studies allowed verifying the previous knowledge about character of sediments accumulated in humic lakes [5]. *Dy* is considered as sediment typical for these

water bodies. Its principal features are: dark brown colour, homogeneity, semi-liquid consistency, a lack of $CaCO_3$. Such sediment was identified in studied water bodies. However micro- and macroscopic analysis of samples originating from the different depths of both cores collected in L. Suchar II did not show expected difference, which should be a consequence of the deposition in different trophic conditions. Only geochemical analysis evidenced that sediment previously described as *dy* [1, 2] is differential, in fact. Samples connected with the eutrophy state are characterised by increase of TKN (*Total Kjeldahl Nitrogen*) content, and decrease of this parameter was noted in sediment samples accumulated in the conditions of humotrophy. This suggests that **we must to use the *dy* term very carefully, and sediment should be geochemically analysed before its classification. Visual and microscopic investigations are insufficient.**

Issues of trophy status in the past of humic lakes need further studies. In 2015 I applied for funding to National Science Centre. In planned project I'm going to focus on problems of humotrophy in geographical aspect.

SUMMARIZE

1. Humic lakes of WPN originated in the Late Glacial, and in the beginning of the Holocene. However we also stated the presence of foreshore sediments which accumulated in the younger Holocene. The beginning of the biogenic deposition in the lake basins and in the marginal zones not always were convergent in time.

2. The delimitation of isochrones in the deposits of studied lakes allowed investigating hydrological conditions in which these water bodies functioned in the past. There was no synchronization of changes between objects, what shows the domination of local condition impact.

3. The pattern of isochrones in the studied deposits did not confirm the idea about humic lakes of WPN as kettle holes.

4. In terms of directions of subfossil vegetation development in the foreshores, *suchary* represent three main groups of lakes. Succession towards bog communities was stated in the first group of lakes, towards fen/transitional mire – in the second one, and invariable development of fen communities, therein reed rush, characterised the third group of them. This showed that besides typical humic lakes there are also more fertile water bodies. Such tendencies were confirmed by geochemical analyses. They are continued nowadays, what is indicated by contemporary vegetation and water quality.

5. Besides typical humic bodies we recognised eutrophic-humic lakes. According to the results of our studies there is possibility of shift both from typical humic lake to eutrophic-humic and inversely.

6. The changes of trophy in these lakes could extend beyond the humotrophy state. We stated that lake presently humic, in the past was clearwater, passing from oligotrophy (in the Late Glacial) by mesotrophy (the Preboreal and Boreal periods) to eutrophy (the Atlantic period). Radical changes in the surrounding of the lake in the beginning of the Subboreal period, namely appearance of coniferous forests being a source of humic substances and their supply to the water body, caused beginning of the humotrophy, which remains until now.

7. The conducted analyses indicated the necessity of careful classification of sediment as "*dy*". The correct identification could be difficult if we analyse only macro- and microscopic parameters of sediment. The geochemical analyses seem to be vital.

8. The biggest impact on the evolution of humic lakes of WPN was attributed to the local conditions. The catchment features decided about conditions of sediment accumulation, fluctuations of water table level in lakes, directions of subfossil vegetation succession and their trophic status.

IV. Research activity prior to a doctorate

The first experience in work with palaeobiological material I gained during preparation of my master's thesis, which was carried in Department of Animal Ecology, Institute of Biology, Faculty of Mathematics and Environment, Branch of Warsaw University in Białystok, under the supervision of prof. dr hab. Andrzej Myrcha. I analysed in detail anatomy of coracoids, scapulae and breastbones of fossil penguins occurring on Seymour Island (Western Antarctica). Numerous fragments of these bones were found in Tertiary geological formation named La Meseta, which age was determined as Eocen to early Oligocen. Conducted studies showed, among others, that fossil penguins were much more diverse in terms of body size, than contemporary. Whereas scheme of bone structure did not change, except for coracoids, which were more medially bent and broader at the base. For this reason they more resembled the bones of modern flying birds, than modern penguins. In 1995 I have obtained Master of Science degree in biology with dissertation "Anatomical analysis of shoulder belt bones of fossil penguins from Seymour Island, Western Antarctica". Fragments of bones studied by me are now a part of collection of bones of fossil Antarctic

penguins, which is deposited in Prof. Andrzej Myrcha University Museum of Nature under the care of dr hab. Piotr Jadwiszczak from Institute of Biology, University of Białystok.

In 1995 I obtained formal teacher's qualifications required to teach biology at school. The gained skills are useful during teaching courses for students of Biology and Environmental Protection at University of Białystok.

After almost two years from obtaining the master's thesis, in April 1997, I started to work as an assistant in Department of Botany, Institute of Biology, University of Bialystok and I began to deal with the problems of plant ecology, more precisely, the competition among plants. For this purpose I started the regular observations on experimental plots located on several sites in Knyszyńska Forest, cooperating with dr Ewa Pirożnikow. Then two review articles concerning plants as competitors were prepared [6, 7].

However, already in 1999 I decided to return to palaeobiological theme. I took action to complete a scientific internship in terms of analysis of plant macrofossil remains, in Department of Palaeobotany, Władysław Szafer Institute of Botany, Polish Academy of Sciences in Kraków. The first such internship took place in April 1999. I was supervised by doc. dr hab. Andrzej Obidowicz, the approved specialist of macrofossil analyses and palynology. In sum, I stayed several times in above mention Institute to improve my skills in terms of both vegetative and generative analyses of plant macrofossils and determination of peat decomposition degree by microscopic method.

The first macrofossil analyses I did in cooperation with dr hab. Mirosława Kupryjanowicz, prof. UwB. We studied the Eemian and Early Vistulian sediments from Michałowo site (Gródek-Michałowo Depression, NE Poland) [8] and Żelechów (E Poland) [9]. In both cases the obtained results allowed confirming the existence of local overrepresentation of pollen grains of: *Alnus* and Cyperaceae – in the case of sediments from Michałowo and *Pinus* and *Picea* – in the case of sediments from Żelechów. This was the important supplement of knowledge about vegetation development and allowed confirming supposed age of the studied sediments.

In 2003 I analysed plant macrofossils and peat decomposition in sediments of five profiles collected at Rabinówka deposit (Gródek-Michałowo Depression, NE Poland). Their results [10] indicated the presence of several dry phases during the mire development, what was evidenced by humopeat layers. In the case of older sediments this was connected with climatic changes, whereas in the roof – with human activity, which interrupted peat forming in the youngest stage of mire functioning. Among interesting taxa recognised during studies there were: *Scorpidium scorpioides*, *Meesia triquetra*, *Helodium lanatum*, and *Carex* cf. *flava*.

At the same time, the idea of my future doctoral thesis shaped. It was prepared under the supervision of doc. dr hab. Andrzej Obidowicz from Department of Palaeobotany, Władysław Szafer Institute of Botany, Polish Academy of Sciences in Kraków. Three hydrologically different mires from Knyszyńska Forest (North Podlasie Lowland, NE Poland) were selected to the study: Taboły – soligenic fen/transitional mire, Kładkowe Bagno – peat bog, and Borki – soligenic fen supplied by waters from the deep aquifer. I collected in total 36 cores of sediments (Taboły – 20, Kładkowe Bagno – 11, and Borki – 5), analysing 686 samples of peat and lacustrine sediments. Peat was investigated by methods of plant macrofossil remains (vegetative and generative) and decomposition degree of peat, whereas lacustrine sediments – studied for carpological remains. The age of sediments was determined by radiocarbon method. Altogether 50 datings were done, in laboratories from Poznań, Gliwice, and Kiev. The oldest sediments of Taboły deposit were connected with the Older Dryas stadial, in Kładkowe Bagno – with the Younger Dryas, and in Borki – with the Preboreal period of the Holocene. In total I recognised 116 plant taxa of different rank (species, genus, family, order, and class). Among them – 16 taxa, which do not occur nowadays in the territory of Knyszyńska Forest, like *Betula nana*, *Scheuchzeria palustris*, *Cladium mariscus*, *Sphagnum centrale, and Scorpidium scorpioides*. Altogether 24 peat units of different rank were also described, therein 15 which are not included in the classification of Middle European peats by Tołpa, Jasnowski and Pałczyński. I reconstructed then 22 subfossil plant communities, including those which analogues occur now only in North-Western Europe and in Western Syberia, like community recognised in Taboły and similar to contemporary *Menyantho trifoliatae-Sphagnetum teretis* Warén 1926, or in North-Western Russia, where *Sphagnetum betulo-pinosum* Filatov et Yurev 1913 association occurs, which subfossil analogue – *Sphagnetum betulo-pinosum-eriophoreto fruticuletosum* community was described by me in Kładkowe Bagno. The investigation of vegetation succession of three studied lakes allowed recognising its two main directions. In the first one, known from Kładkowe Bagno, succession drove, by mineralogenic phase, towards peat bog. The second one, in Taboły and Borki, was characterised by the occurrence of vegetation forming fen and transitional peat. However this direction is not uniform. In Borki signs of oligotrophy were clearer. The study was notably realised based on research project nr 3 P04C 066 24 financed by KBN: “Succession of vegetation on hydrologically various mires of Knyszyńska Forest (NE Poland)” (realization period 2003-2004), managed by me. In 2005 I obtained Ph.D. degree in biology in Institute of Biology, University of Białystok, with the thesis entitled “Late Glacial and Holocene history of vegetation of selected mires of Knyszyńska Forest”.

The results of studies done during preparing the doctoral thesis were published in reviewed English- and Polish-language journals. In each of them I focused on the concrete

problems, like: development of subfossil water bodies in Taboły and Kładkowe Bagno [11], subfossil plant communities reconstructed in Taboły, Kładkowe Bagno and Borki [12], history of Kładkowe Bagno deposit in context of different development of its both basins [13], succession of subfossil vegetation of Borki mire [14], identification of new, unknown so far peat units [15], development of Taboły deposit in the Late Glacial and Holocene [16], processes during formation of Taboły deposit in the Late Glacial [17], changes in flora and vegetation in the territory of Knyszyńska Forest from the last glaciation [18], detailed analysis of occurrence and decline of *Betula nana* in NE Poland and in the adjacent areas, in the postglacial period [19].

V. Post-doctoral scientific activity and achievements, other than these presented for the habilitation procedure

Soon after obtaining the PhD degree I undertook research concerning development and functioning of mires located nearby Lake Wigry (cooperation with prof. dr hab. Jacek Rutkowski, Department of Environmental Analyses, Cartography and Economic Geology, AGH University of Science and Technology in Kraków and with prof. dr hab. Sławomir Żurek, Department of Quaternary Palaeogeography and Nature Conservation, Institute of Geography, Jan Kochanowski University in Kielce). The study was conducted in 2006-2011. I analysed altogether 32 cores of peat and lacustrine sediments, using method of plant macroscopic remain determination. These sediments were gradually collected in the surrounding of Lake Wigry, and on Ostrów island. In total I analysed 187 samples of peat and gyttja. The one of the considered problem was the development of limnogenous mires in the southern coasts of Lake Wigry [20]. During the study of these objects I recognised 31 plant taxa and 8 peat units, therein both mineralogenic and mineralogenic-ombrogenic peats. As expected peat accumulated on lacustrine sediments, mainly on the lacustrine chalk. Only in the region of one drilling of Zakąty peat-forming process started on mineralogenic substratum. The characteristic feature of succession of subfossil vegetation in the southern coast mires of Lake Wigry was multidirectional. Therefore succession drove in several ways, even in the small area, like Ostrów island, where communities with *Sphagnum magellanicum* appeared only in the north region, while in the southern one communities of fens and transitional mires occurred in the past. The results of macrofossil analyses of sediments collected in the region of Lake Wigry were presented in some articles [21-24]. During these studies I analysed, for the first time, sediments from the foreshores of humic lakes of Wigry National Park, so called *suchary*. Their development became in the near future a theme of my detailed studies, conducted under managed by me research project of Ministry of Science and Higher Education nr N N305 085135 (realization period 2008-2011): „History of

dystrophic lakes (*suchary*) of Wigry National Park in the light of Holocene succession of their vegetation", and in the effect – a theme of my paper series proposed as the basis for the application for the post-doctoral degree of „*doktor habilitowany*" (see point III). The preparing of chapter in the monograph of Lake Wigry was the culmination of these several years of studies [25]. The monograph was edited by prof. J. Rutkowski and dr L. Krzysztofiak. Together with prof. S. Żurek I presented there the results of plant macrofossil analyses of 118 peat samples from 23 cores located around the lake. I recognised remains of 72 plant taxa of different rank, and 9 peat units, therein sphagnum peat which is not present in classification of Tołpa et al.. This sediment is characterised by a significant share (not less than 60%) of peat mosses remains, with domination of *Sphagnum teres* and species from other sections: *Cuspidata* (*Sphagnum fallax*, *S. angustifolium*, and *S. cuspidatum*), *Palustria* (mainly *S. plaustre*), *Subsecunda*, and *Acutifolia*. Reconstructed successive ranks of subfossil vegetation indicated the presence of numerous schemes of its changes. However we could recognise two main developmental tendencies. In the central-southern region of Lake Wigry subfossil vegetation oscillated towards *Sphagnetum megellanici* association, whereas in the north succession drove mainly towards sedge communities. Analyses of peat macrofossils indicated that each of two main kinds of mires recognised in the region of Lake Wigry are characterised by domination of the different kind of peat in the deposit. Therefore, mires of coasts and islands are dominated by fen peats, while mires of melt depressions, farther off the lake, are dominated by bog and transitional peats.

Our studies contributed to broaden the previous, quite general knowledge about the development of numerous mires located around Lake Wigry. This is the first, so particular palaeobotanical recognition of these objects. We indicated that succession of subfossil vegetation was multidirectional, what must be connected with the variability of environmental conditions in which mires existed in the past.

In 2007-2008 I conducted studies of peat collected in the roof layers of mires overgrown by boreal bog-birch forest *Thelypteridi-Betuletum pubescentis* Czerwiński 1972 (cooperation with dr Beata Matowicka, Department of Environmental Protection and Management, Białystok University of Technology). Their goal was to reconstruct the way of origin of boreal birch forests occurring on protected mires of North Podlasie Lowland, then recognition of subfossil plant communities, which occur under contemporary boreal birch forests. To detailed studies, we selected forests overgrowing seven mires located in three mesoregions of NE Poland: Biebrza Basin, Białystok Plateau, and Bielsk Plain [26]. Sediments from 16 cores were analysed, in total 164 samples of peat and gyttja. I recognised remains representing 51 plant taxa of different rank, therein remains of species

which do not occur there nowadays, like *Scheuchzeria palustris, Cladium mariscus*, and *Betula nana*. In six from seven objects, in the roof layer connected with the youngest stage of the Holocene, I described peats of forest phase of mires (forest-herbaceous peat or forest-herbaceous-peat moss peat). They were accumulated by subfossil forest-brushwood+*Carex* community, eventually its variant with peat mosses, so forest-brushwood+*Carex–Sphagnum* community. Only at Czerwone Bagno mire (Biebrza Basin) boreal bog-birch forest appeared as the first forest stadium at mire occupied earlier by rush vegetation. I stated also that appearance of birch forests in the type of *Thelypteridi-Betuletum pubescentis* Czerwiński 1972 was connected with the climatic changes, namely with the occurrence of drier periods, what caused the depletion of habitats. Consequently, birch shrubs appeared at open mires, and then trees – pine and spruce. This was happened in the Subatlantic perid, or even in the decline of the Subboreal, as on mires of Knyszyńska Forest (Białystok Plateau), what was confirmed by radiocarbon datings.

The studies of origin of specific plant communities are the rarity in the palaeobotanical investigations. Until now we knew more only about succession directions towards the peat bog communities. The results of my analyses showed how pine-birch forests could arise. This community is a relic of cool climatic periods of the Holocene, and it reaches its western border of extent in Poland.

In 2008-2009 I again studied the Eemian and Early Vistulian sediments originating from Northern Podlasie (the first such analyses were done before a doctorate, see point V) (cooperation with dr hab. Mirosława Kupryjanowicz, prof. UwB, Department of Botany, Institute of Biology, University of Białystok). I analysed plant macrofossils in peat and lacustrine sediments from Haćki site (Bielsk Plain), where they occurred in very untypical localisation – on the top of the kame hill. In about 20 sediment samples I identified remains (vegetative and generative) of 26 plant taxa, what was an important supplement of the pollen analysis results. In effect, four stages of vegetation succession in studied lake were recognised:

I stage – lake was overgrown by shallow-water vegetation with domination of *Nymphaea alba*
II stage – shallowing of water body and capture of its surface by floating mat consisted of fern *Thelypyeris palustris*
III stage – palaeolake covered by alder shrubs
IV stage – flooding of mire and transformation into water body.

The macrofossil analyses of peats older than Holocene are quite rare. This is probably a consequence of strong decomposition and, sometimes, physical deformation of remains, caused by the compaction of biogenic sediments, which usually lay under the thick mineral

sediments. These both factors efficiently impede difficulty of macrofossil analyses. However they are necessary for reconstruction of mire/mire-lake vegetation succession at any site.

In 2008-2011 I conducted palaeobotanical analyses of calcareous tufa and peats from Middle Pomerania sites, what was the huge challenge. Studies were carried out, in a large extent, under two projects of Ministry of Science and Higher Education: nr 2PO4G 03530 and nr N N304 396638 (cooperation with dr hab. inż. Zbigniew Osadowski, prof. AP, Department of Botany and Nature Protection, Institute of Biology and Environmental Protection, Pomeranian Academy in Słupsk and with dr hab. Radosław Dobrowolski, prof. UMCS, Department of Geoecology and Palaeogeography, UMCS in Lublin). The presence of peat and tufa layers was the characteristic feature of the studied profiles. The cores consisted of firmly diversified fractionally (from coarse grains to muddy) calcareous tufa and strongly decomposed sedge peats. The thickness of singular layers was from several millimetres to dozen centimetres. I analysed plant macrofossils in sediments originating from 4 profiles: Bobolice 1 (65 samples), Ogartowo 7 (56 samples), Opatówek 1 (75 samples), and Porost 8 (140 samples), in total 336 sediment samples. I identified remains of 28 planta taxa in Bobolice 1 profile, 12 – in Ogartowo 7, 32 – in Opatówek 1, and 21 – in Porost 8. I described the following peat units: in Bobolice – sedge peat, sedge-brown moss peat, sedge-sphagnum peat, *Sphagnum sec. Acutifolia*-peat, and *Sphagnum sec. Palustria*-peat; in Ogartowo 7 – sedge peat; in Opatówek 1 – sedge peat and sedge-sphagnum peat; in Porost 8 – sedge peat, sedge-sphagnum peat, sphagnum peat, sedge-brown moos peat, sedge-brown moos-sphagnum peat, and wood peat. I also described local macrofossil zones in each profile, and then I reconstructed subfossil plant communities.

The difficulties in identification of plant macrofossils present in calcareous tufa cause that such studies are often ignored and pollen and especially malacological analyses are preferred. For this reason plant macrofossil data are only known from several sites (mainly from Carpathians). Therefore analyses done by me are the rarity in the scale of not only our country.

The results are now elaborated to prepare article treating about the Late Glacial and Holocene vegetation succession in the record of sediments of spring mires from the Chociela river valley. They are the one of the proxies in multiproxy studies, which are conducted on spring mires of Poland [27].

I also conducted analyses of plant macroscopic remains of sediments from Białowieża Forest (cooperation with prof. dr hab. Małgorzata Latałowa and dr Marcelina Zimny, Laboratory of Palaeoecology and Archaeobotany, Department of Plant Ecology, Faculty of

Biology, Gdańsk University). Studies were performed under research project of Ministry of Science and Higher Education nr N N305 167839. A goal of it was to reconstruct history of forest communities of Białowieża Forest and an attempt of connection of changes in their species composition and long-term dynamics with anthropogenic and natural factors. The analyses of plant macrofossils were carried out to reconstruct palaeohydrological changes at studied sites. In 2011-2014 I analysed the peat samples from 8 mires located in the different regions of Białowieża Forest, in total 265 sediment samples. I recognised vegetative and generative plant remains representing 56 taxa of different rank. Local macrofossil zones were determined for each profile. On this basis I reconstructed subfossil plant communities. This particular research allowed concluding that a common feature of the most studied deposits was the presence of mesotrophic and oligotrophic phase as well humid and drier episodes during their development [29]. The ombrotrophy of habitats noted in the youngest stadium of mire development was evidenced by the presence of *Eriophorum vaginatum*, and peat mosses *Sphagnum magellanicum*, *Sphagnum fallax*, and *Sphagnum rubellum*. The lack of the distinct bog phase was recognised in three sites.

Macrofossil plant remain analyses conducted by me in Białowieża Forest are the first so detailed source of knowledge about mire vegetation succession in this area, in the youngest Holocene. Description of stages dominated by different hydrologically relative species contributed to description of dry and humid periods during the history of studied mires. The results of these palaeoecological studies are now prepared for publication.

I was also involved in palaeobotanical analyses of sediments from Mrągowo Lakeland (cooperation with mgr Marta Szal, Department of Botany, Institute of Biology, University of Białystok and with mgr Mariusz Wyczółkowski, Wojciech Kętrzyński Museum in Kętrzyn), done under two research projects of National Science Centre: nr N N304 280540 and nr UMO-2011/01/B/HS3/04167. The aim of these studies was to recognise lithology and conditions of biogenic accumulation at two sites: Lake Ruskowiejskie and Poganowo. Analyses of organic sediments were conducted by me in 2012-2014. In the case of Lake Ruskowiejskie 26 sediment (peat, lacustrine sediment, and sediment from the border of peat and gyttja) samples were analysed. I recognised plant remains of 13 plant taxa. The character of studied sediments indicates that its accumulation followed mainly in the lacustrine environment. I recognised also water-weed peat-like sediment Potamioni, which is included both to fen peats and to lacustrine sediments, exactly it is named coarse detritus gyttja. The presence of tissues and astrosclereids of Nymphaeaceae is the characteristic feature of this sediment. Then I stated that in Lake Ruskowiejskie after short period of

sedentation (what is evidenced by a thin peat layer in the bottom of profile), accumulation followed in lacustrine conditions.

Whereas at Poganowo archaeological site I analysed 46 sediment samples and I identified plant remains representing 19 taxa of different rank. Alnioni fen peat dominated in the deposit, what evidences the dominance of shrub communities with *Betula pubescens* (presence of nuts and catkin scales) and *Alnus* sp. (presence of nuts, periderm and wood) in this area, in the past.

In some cases microscopic analyses of biogenic sediments are need to identify sediment character, and then to confirm or refute assumptions about its accumulation environment. The visual evaluation of sediment is often false in fact, what could cause the incorrect result interpretation. I just made such conclusions regards typology of sediments both from Lake Ruskowiejskie and Poganowo.

My contemporary scientific interests concern problems of the trophy shaping in humic lakes depending on the latitude of their occurrence. The target is to study lakes both from Poland and Northern Europe, therein from boreal zone. In 2015 I applied for funding to National Science Centre.

The next theme is the development of two relic lakes located in Gródek-Michałowo Depression. Both Lake Gorbacz and Lake Wiejki are the one of the last natural water bodies, which endured to nowadays in the area not embraced by the last glaciation. Besides succession of subfossil vegetation I schedule to study the past trophic status of both objects, especially that, as hydrobiological data show, the trophy state in Lake Gorbacz raised quite distinctly over the last half-century.

In the nearest future I also intend palaeobotanical research of Beretnica mire. Its aim will be to recognise the development of this one of the most interesting peat bog of Knyszyńska Forest. In fact this is the overgrown lake with clear zone arrangement of vegetation. This is also the only known site of *Rhynchosporetum albae* Koch 1926 occurrence in Knyszyńska Forest.

VI. Scientific cooperation

In my previous scientific work I had the opportunity to cooperate both with palaeoecologists and researches representing other scientific disciplines, like botany, hydrobiology, geography, geology, archaeology. My co-operators represent the following research centres, organizations and institutions:

- University of Białystok

Department of Botany, Department of Hydrobiology, Department of Environmental Protection, Department of Genetics and Evolutionism (Institute of Biology)

Department of Modern History of Poland (Institute of History and Political Sciences)

- Władysław Szafer Institute of Botany Polish Academy of Sciences in Kraków

Department of Palaeobotany

- Białystok University of Technology

Department of Environmental Protection and Management

- North Podlasie Society of Bird Protection
- AGH University of Science and Technology in Kraków

Department of Environmental Analyses, Cartography and Economic Geology

- Jan Kochanowski University in Kielce (previously Świętokrzyska Academy in Kielce and Jan Kochanowski Humanistic-Life Sciences University in Kielce)

Department of Quaternary Palaeogeography and Nature Conservation (Institute of Geography)

- Warsaw University

Department of Plant Ecology and Environmental Conservation (Institute of Botany)

- Pomeranian Acedemy in Słupsk

Department of Botany and Nature Protection (Institute of Biology and Environmental Protection)

- Maria Curie-Skłodowska University in Lublin

Department of Geoecology and Palaeogeography

- Gdańsk University

Laboratory of Palaeoecology and Archaeobotany (Department of Plant Ecology)

- Wojciech Kętrzyński Museum in Kętrzyn
- Institute of Geological Sciences, Polish Academy of Sciences in Warsaw
- Institute of Geography and Spatial Organization, Polish Academy of Sciences in Toruń

I am in close cooperation with dr hab. Mirosława Kupryjanowicz, prof. UwB. The main themes of our long cooperation were: development of mires of Knyszyńska Forest during the Last Glacial and Holocene, the Eemian and Early Vistulian history of vegetation in North Podlasie Lowland and the development of humic lakes in Wigry National Park.

The person who had an impact on my scientific work is doubtless prof. dr hab. Sławomir Żurek. For several years we studied together mires located around Lake Wigry. The effects of that cooperation are numerous papers as well as oral presentations and posters presented during both internal and international conferences.

VII. Summarize of scientific achievements

Total impact factor of my post-doctoral publications, according to Journal Citation Reports (JCR) and a year of publication, is 16,571. MNiSW score is 394 for all papers, therein 25 – before a doctorate and 369 – after a doctorate. Total number of citations (for 16.X.2015) according to Web of Science, Scopus and Google Scholar: 19, 37 and 100, respectively; h-index (for 16.X.2015) according to Web of Science, Scopus and Google Scholar: 3, 3 and 6, respectively.

My scientific output comprise 76 publications in total (therein 5 papers indicated as habilitation achievement) published in Polish- and English-language journals. There are: 9 chapters in monographs, 34 articles (therein 9 published in journals indexed in Journal Citation Reports), and 33 conference abstracts. I also prepared about 20 palaeobotanical and peat-knowledge expertises.

The results of my studies were presented during conferences: 12 international (8 oral presentations and 7 posters) and 26 internal (17 oral presentations and 12 posters). I participated in 7 international conferences (among others in Tampere, Bonn, and Novosibirsk) as well in 21 internal conferences. I was a member of Organizing Committee and a Conference Secretary of IInd Nationwide Scientific Conference „Wetlands and freshwater ecosystems – existence, hazards and protection" in Augustów, in 2009. Twice I co-organized and co-led palaeobotanical field session during meetings of Polish Botanical Society (PTB): in 2010 on Białystok Plateau (55th Meeting of PTB) and in 2013 in Mrągowo Lakeland (56th Meeting of PTB). In 2011 I organized and led field session on Białystok Plateau under XXXVth International Moor Excursion. I also co-organized and led Symposium of Palaeobotanical Section of Polish Botanical Society in Warsaw, in 2014.

I managed two research projects (financed by MNiSW and KBN) and I participated in five others (financed by MNiSW and NCN). I also realised project of EkoFundusz and North Podlasie Society of Bird Protection. I was a reviewer in five journals, therein in three from Philadelphia List. I a member of International Peat Society (IPS), Polish Limnological Society (PTLim), and Polish Botanical Society (PTB). In term of office 2013-2016 I am a vice-chairman of Palaeobotanical Section of PTB.

I am a Secretary of Faculty Committee of Enrolment for the Doctoral Studies on Biology at Institute of Biology, UwB, as well as a member of Program Board at Institute of Biology, UwB and a member of Examination Committee for Bachelor Exam on Biology course of study. In 2009-2012 I was a member of Scientific Board of Institute of Biology UwB and a member of Scientific Board of Faculty of Biology and Chemistry UwB. I got an award of Rector of University of Białystok fivefold (both for scientific work and organizational activity).

Since the beginning of the work at University of Białystok I teach students of Biology and Environmental Protection, also a supervisor of master's and bachelor's thesis. I am also involved in popularization activity, among others under Podlasie Festival of Science and Art.

Detailed information was given in Appendix 3.2.

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