the climatic changes, with the temporal resolution of the isotope signal in the order of several years.

3.7. MACROPHYTE VEGETATION OF NA JAZACH LAKES AND THE DISTRIBUTION OF THE SURROUNDING PLANT COMMUNITIES

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The complex of four lakes (Wierzchoń, Brzózka, Gościąż, and Mielec) called Na Jazach, and the stream Ruda connecting the lakes were the object of the floristic and phytosociological field research, together with the surrounding forest areas and the nearest peatbogs. The field studies were started in 1987 and continued until 1994.

The flora of the Na Jazach lake complex

The flora of the Na Jazach lake complex includes 560 species of vascular plants belonging to 81 families. Its richness is the consequence of the considerable diversity of habitats. An essential part of the flora is composed of species adapted to aquatic, submerged, and moist habitats. Another significant group is formed by species occurring in various forest and brushwood habitats. On the other hand, there are comparatively few representatives of xerothermic grasslands.

The most numerous components of the flora represent the following families: Compositae (60 species), Gramineae (49), Cyperaceae (39), Caryophyllaceae (32), Rosaceae (29), Papilionaceae (24), Scrophulariaceae (22), and Labiatae (20). 26 families of the plant list are represented by only one species, and 24 families by 2 or 3 species. Among the taxa found in the study area native species predominate, while alien species, including 42 archeophytes and 13 kenophytes, constitute only a low percentage of the flora.

The majority of the kenophytes come from North America, less frequently from Asia, and taxa coming from the Mediterranean area in a wide sense predominate among archeophytes. The fairly common kenophytes are *Acorus calamus, Solidago serotina, Senecio vernalis, Padus serotina, Erigeron canadensis*, and *Acer negundo*. To the most frequently occurring archeophytes belong *Capsella bursa-pastoris, Geranium pusillum, Erodium cicutarium, Herniaria glabra, Bilderdykia convolvulus, Spergula arvensis, Anchusa officinalis*, and *Scleranthus annuus*.

Many floristic rarities have been noted in the flora of the Na Jazach lake complex and the adjacent areas. They include plants under full protection (16 species) or partial protection (10 species), and 49 species are rare in the whole Płock Basin. The following species are fully protected: *Lycopodium annotinum, L. clavatum, Diphasium complanatum, Dianthus superbus, Pulsatilla pratensis, P. patens, Nuphar luteum, Drosera rotundifolia, Hedera helix, Chimaphila umbellata, Lilium martagon, Orchis fuchsii, Epipactis helleborine, E. palustris, Listera ovata*, and *Liparis loeselii*. Under partial protection are *Polypodium vulgare, Nymphaea alba, Ribes nigrum, Frangula alnus, Primula officinalis, Ledum palustre, Arctostaphylos uva-ursi, Viburnum opulus, Helichrysum arenarium,* and *Convallaria majalis.*

The following rare species are particularly interesting: *Ophioglossum vulgatum, Cystopteris fragilis, Dryopteris cristata, D. dilatata, Alnus incana, Salix nigricans, Viola epipsila, Agrimonia procera, Trifolium lupinaster, Angelica archangelica* subsp. *litoralis, Andromeda polifolia, Myosotis laxa* ssp. *caespitosa, Utricularia minor, U. intermedia, Teucrium scordium, Scheuchzeria palustris, Potamogeton praelongus, Rhynchospora alba, Cladium mariscus, Carex diandra, C. remota, C. limosa*, and *Sparganium minimum.* Other floristic peculiarities are some relict moss species: *Camptothecium nitens, Thuidium lanatum, Meesia triquetra, Paludella squarrosa*, and *Scorpidium scorpioides.*

Due to the absence of fields under crop in the area considered, the synanthropic species are very poorly represented in the present-day flora. The economically utilized plants are generally only forest trees. The most common tree species is pine (*Pinus sylvestris*), occurring in all kinds of forests. In extremely poor habitats this species develops dwarf forms.

Plant communities

Basing on the analysis of 600 phytosociological relevés carried out in the area under study, 64 syntaxonomic units of 14 classes have been characterized (Tab. 3.17). The nomenclature and classification have been adopted mainly after Matuszkiewicz (1967, 1981), some other authors being also referred to (Pałczyński 1975, Jasnowska & Jasnowski 1983, Neuhäuslova & Neuhäusl 1985).

The full classification of plant associations distinguished is contained in Tab. 3.17. The simplified map of plant communities is presented in Fig. 3.23.

The vegetation is differentiated according to the prevailing habitat conditions (hydrologic conditions, types of soils and their nutrient resources, topographic features). Five basic groups of plant communities can be distinguished here, i. e. aquatic, reedswamp, mire, brushwood, and forest vegetation groups. In addition, "saum" and synanthropic, mainly ruderal, communities occur over small areas, developing in the vicinity of seasonally used human settlements and along roads and roadsides. One of the principal factors affecting the vegetation diversity of the area in question is water, deriving from the small (66 km^2) catchment area of the stream Ruda and stored in four lakes (Gościąż, Wierzchoń, Brzózka and Mielec) and in the stream flowing through them and discharging into the Vistula River near Dobiegniewo.

The distribution and development of the typical aquatic vegetation depend mainly on the configuration of the lake bottoms and their depth as well as on their fertility. The largest bottom surfaces occupied by vegetation are found in shallow lakes with little water motion, whose bottom sediments, rich in organic matter, favour intensive plant growth (lakes Wierzchoń and Brzózka). Much poorer development of aquatic vegetation is found in Lake Gościąż, where plants grow only in its shallowest parts. However, also in the shallow Lake Mielec (maximum depth 1.5 m), only small areas are occupied by aquatic communities, because its bottom is formed by thick beds of carbonate gyttja (Wicik & Więckowski 1991, Wicik 1993, Więckowski 1993), outgasing with great intensity. It is suggested that the poor development of aquatic vegetation in Lake Mielec is due to considerable water turbulence (gas), poor oxygen supply, and poor stability of the lake bottom.

In the lake complex Na Jazach 12 aquatic-plant associations of three syntaxonomic classes have been found. The associations *Ceratophylletum demersi*, *Myriophylletum spicati*, and *Ranunculetum circinati* occupy the largest areas in lakes Brzózka (90% of lake area) and Wierzchoń (more than 60%). They develop in well lighted, considerably shallowed places on muddy substratum. Their development and spread of *Elodeetum canadensis* and communities with *Potamogeton crispus*, *P. compressus,* and *P. pusillus*, is restricted to small areas only on the bottoms of these lakes. Comparatively small areas are occupied by the associations *Hydrocharitetum morsus-ranae*, *Lemno-Spirodeletum polyrrhizae*, and *Charetum fragilis*. Small stands of *Hydrocharitetum morsus-ranae* occur mainly in lakes Wierzchoń and Mielec and in low frequency in Lake Gościąż and the stream Ruda. *Lemno-Spirodeletum polyrrhizae* has been found in all the water bodies. *Charetum fragilis* occurs only in lakes Wierzchoń and Brzózka. Stands of the association *Potamogetonetum natantis* develop only in the southern part of Lake Wierzchoń, where it covers altogether the area up to 200 m^2.

In Lake Gościąż the aquatic vegetation develops only in its shallow offshore parts and in the very shallow bay Tobyłka. Besides *Lemno-Spirodeletum polyrrhizae* and *Hydrocharitetum morsus-ranae*, stands of *Elodeetum canadensis* and *Potamogetonetum pectinati* have been found there. Particularly interesting is the presence of the rare association *Potamogetonetum filiformis*, developed as a facies with *Potamogeton praelongus*. Stands of *Potamogetonetum perfoliati*, developed in its southwestern offshore part, have been also found in Lake Gościąż only.

The rather poor aquatic vegetation of Lake Mielec is represented by *Ceratophylletum demersi*, *Hydrocharitetum morsus-ranae* and *Lemno-Spirodeletum polyrrhizae*, growing only in its western part.

The reedswamp vegetation is most differentiated on the shores of Lake Gościąż, where it occupies comparatively large areas in its shallow, slightly muddy offshore parts. Stands of *Phragmitetum communis*, *Typhetum angustifoliae*, *Acoretum calami*, *Glycerietum maximae* and *Eleocharitetum palustris* occur solely in Lake Gościąż. The largest surfaces are occupied by *Phragmitetum communis* and *Typhetum angustifoliae*. They usually develop on slightly muddy mineral substratum, forming belts of various widths. Much smaller areas are occupied by *Glycerietum maximae*, *Eleocharitetum palustris* and *Acoretum calami*, which form patches of different size, usually within belts of other reedswamp communities. *Typhetum latifoliae*, sporadically found in Lake Gościąż, occurs frequently in the offshore, heavily muddy parts of lakes Wierzchoń and Mielec.

Patches of the rare association *Scirpetum tabernaemontanii* develop solely on the eastern shore of Lake Mielec, and *Scirpetum lacustris* have been observed only in the stream Ruda, at its outflow from Lake Mielec. Communities of sedge rush develop in all the lakes studied and along the banks of the stream Ruda. In Lake Gościąż the stands of *Caricetum rostratae*, *Caricetum paniculatae*, and *Caricetum gracilis* were most commonly found. Phytocoenoses of *Caricetum rostratae* develop as belts of varying width and poorly developed patches in the shallow offshore parts of the lake on mineral slightly mud-covered substratum. Small agglomerations of that association occur in lakes Mielec and Wierzchoń and sporadically on the banks of the stream Ruda. Patches of *Caricetum paniculatae* occur mainly in submerged places and are most commonly found in the vicinity of wet alderwoods, which are one of the more advanced links in the succession series. Stands of that association have been observed only on the northeastern shore of Lake Gościąż and on Mielec shores. Stands of *Caricetum gracilis* have been found only on the shore of Lake Gościąż, at the inflow of the stream Ruda. Patches of *Caricetum elatae* occur on the shores of lakes Wierzchoń and Brzózka, where they form very narrow belts in the shallowest places. The remaining associations of sedge rushes are found in most of lakes and on the river banks. *Thelypteridi-Phragmitetum* community shows a particularly luxuriant growth on the swampy shores of lakes Mielec and Wierzchoń. The associations *Caricetum ripariae*, *Caricetum appropinquatae*, and *Phalaridetum arundinaceae* and a small fragment of the association *Cladietum marisci* occur solely on the banks of the stream Ruda, while *Cicuto-Caricetum pseudocyperi* and *Iridetum pseudacori* (Kępczyński & Noryśkiewicz 1993) develop only on seasonally submerged shores of Lake Wierzchoń. In a shallow hollow near Lake Gościąż a small stand of *Sparganietum minimi*, rare in that area, has been found.

Aquatic and reedswamp communities occur also on

Table 3.17. Classification of plant communities of the Na Jazach Lake complex.

LEMNETEA R. Tx. 1955
LEMNETALIA R. Tx. 1955
Lemnion minoris R. Tx. 1955
1. *Lemno-Spirodeletum polyrrhizae* W. Koch 1954 em. Müll. et Görs 1960
2. *Hydrocharitetum morsus-ranae* Langendonck 1935
CHARETEA (Fukarek 1961) Krausch 1964
CHARETALIA Sauer 1937
Charion fragilis Krausch 1964
3. *Charetum fragilis* Fijałkowski 1960
POTAMOGETONETEA R. Tx. et Prsg 1942
POTAMOGETONETALIA Koch 1926
Potamogetonion Koch 1926 em. Oberd.1957
4. *Potamogetonetum pectinati* Carstensen 1955
5. *Potamogetonetum filiformis* Koch 1926
6. *Ranunculetum circinati* (Bennema et West.1943) Segal 1965
7. *Elodeetum canadensis* (Pign. 1953) Pass. 1954
8. *Ceratophylletum demersi* Hild. 1956
9. *Myriophylletum spicati* Soe 1927
10. *Potamogetonetum perfoliati* Koch 1926 em. Pass. 1964
Nymphaeion Oberd. 1957
11. *Potamogetonetum natantis* Soo 1927
12. *Nupharo-Nymphaeetum* Tomasz.1977
UTRICULARIETEA INTERMEDIO-MINORIS Den Hertog et Segal 1964 em. Pietsch 1965
UTRICULARIETALIA INTERMEDIO-MINORIS Pietsch 1965
Sphagno-Utricularion Müll. et Görs 1960
13. *Sparganietum minimi* Schaaf 1925
PHRAGMITETEA R. Tx. et Prsg 1942
PHRAGMITETALIA Koch 1926
Phragmition Koch 1926
14. *Scirpetum lacustris* (Allorge 1922) Chouard 1924
15. *Typhetum angustifoliae* (Allorge 1922) Soo 1927
16. *Eleocharitetum palustris* Sennikov 1919
17. *Phragmitetum communis* (Gams 1927) Schmale 1939
18. *Typhetum latifoliae* Soo 1927
19. *Acoretum calami* Kobendza 1948
20. *Glycerietum maximae* Hueck 1931
21. *Scirpetum maritimi* (Br.-Bl. 1931) R. Tx. 1937
Magnocaricion Koch 1926
22. *Thelypteridi-Phragmitetum* Kuiper 1957
23. *Cicuto-Caricetum pseudocyperi* Boer. et Siss. in Boer 1942
24. *Iridetum pseudacori* Eggler 1933
25. *Caricetum ripariae* Soo 1928
26. *Caricetum acutiformis* Sauer 1937
27. *Caricetum paniculatae* Wangerin 1916
28. *Caricetum rostratae* Rübel 1912
29. *Caricetum elatae* Koch 1926
30. *Caricetum appropinquatae* (Koch 1926) Soo 1938
31. *Caricetum gracilis* (Graebn. et Hueck 1931) R. Tx. 1937
32. *Caricetum vesicariae* Br.-Bl. et Denis 1926
33. *Phalaridetum arundinaceae* (Koch 1926 n.n.) Libb. 1931
34. community with *Calla palustris*
Sparganio-Glycerion fluitantis Br.-Bl. et Siss. in Boer 1942
35. community with *Berula erecta*
BIDENTETEA TRIPARTITI R. Tx. Lohm. et Prsg 1950
BIDENTETALIA TRIPARTITI Br.-Bl. et R. Tx. 1943
Bidention tripartiti Nordh. 1940
36. *Polygono-Bidentetum* (Koch 1926) Lohm. 1950
MOLINIO-ARRHENATHERETEA R. Tx. 1937
MOLINIETALIA Koch 1926
37. community with *Deschampsia caespitosa*
Molinion Koch 1926
38. community with *Molinia coerulea*
Calthion R. Tx. 1936 em. Oberd. 1957
39. *Epilobio-Juncetum effusi* Oberd. 1957
40. *Scirpetum silvatici* Knapp 1946
SCHEUCHZERIO-CARICETEA FUSCAE (Nordh. 1936) R. Tx. 1937
SCHEUCHZERIETALIA PALUSTRIS Nordh. 1936
Rhynchosporion albae Koch 1926
41. *Caricetum limosae* Br.-Bl. 1921
42. *Rhynchosporetum albae* Koch 1926
Caricion lasiocarpae Vanden Bergh. ap. Lebrun et all. 1949
43. *Caricetum lasiocarpae* Koch 1926
44. *Caricetum diandrae* Jon. 1932 em. Oberd. 1957
45. *Sphagno-Caricetum rostratae* (Steff. 1931) em. Dierss. 1978
46. community with *Eriophorum angustifolium*
47. community with *Juncus effusus*
CARICETALIA FUSCAE Koch 1926 em. Nordh. 1936
Caricion fuscae Koch 1926 em. Klika 1934
48. *Carici-Agrostietum caninae* R. Tx. 1937
49. *Calamagrostietum strictae* (Steff. 1931) Tołpa 1956
50. community with *Carex fusca*
OXYCOCCO-SPHAGNETEA Br.-Bl.et R. Tx. 1943
SPHAGNETALIA MAGELLANICI (Pawł. 1928) Moore (1964) 1968
Sphagnion magellanici Kästner et Flössner 1933 em. Dierss. 1975
51. *Eriophoro vaginati-Sphagnetum recurvi* Hueck 1929
PLANTAGINETEA MAIORIS R. Tx. et Prsg 1950
PLANTAGINETALIA MAIORIS R. Tx. (1947) 1950
Polygonion avicularis Br.-Bl. 1931
52. *Lolio-Plantaginetum* (Lincola 1921) Beger 1930
ARTEMISIETEA Lohm.
GALIO-CALYSTEGIETALIA SEPIUM (R. Tx. 1950) Oberd. 1967
Senecion fluviatilis R. Tx. 1947
53. *Eupatorietum cannabini* R. Tx. 1937 em. Faliński 1966
ONOPORDETALIA ACANTHII Br.-Bl. et R. Tx. 1943
Eu-Arction lappae R. Tx. 1937 em. Siss. 1950
54. *Tanaceto-Artemisietum vulgaris* Br.-Bl. (1931) 1949
ALNETEA GLUTINOSAE Br.-Bl. et R. Tx. 1943
ALNETALIA GLUTINOSAE R. Tx. 1937
Alnion glutinosae (Malc. 1929) Meijer Drees 1936
55. *Sphagno squarrosi-Alnetum* Sol.-Górn. 1975
56. *Ribo nigri-Alnetum* Sol.-Górn. 1975
57. *Salicetum pentandro-cinereae* (Almq. 1929) Pass. 1961
58. community with *Calamagrostis canescens*
VACCINIO-PICEETEA Br.-Bl. 1939
VACCINIO-PICEETALIA Br.-Bl. 1939
Dicrano-Pinion Libb. 1933
59. *Peucedano-Pinetum* Mat. (1962) 1973
60. *Querco roboris-Pinetum* J. Mat. 1981
QUERCO-FAGETEA Br.-Bl. et Vlieg. 1937
FAGETALIA SYLVATICAE Pawł. 1928
Alno-Padion Knapp. 1942 em. Medw.-Korn. ap. Mat. et Bor. 1957
61. *Circaeo-Alnetum* Oberd. 1953
62. *Carici remotae-Fraxinetum* Koch 1926
Carpinion betuli Oberd. 1953
63. *Tilio-Carpinetum* Tracz. 1962
RHAMNO-PRUNETEA Rivas Goday et Carb. 1961
PRUNETALIA SPINOSAE R. Tx. 1952
Rubion subatlanticum R. Tx. 1952
64. *Pruno-Crataegetum* Hueck 1931

mires situated around the lakes. Only one aquatic community with *Nymphaea alba* has been found there, while reed vegetation is represented by different communities such as *Typhetum latifoliae*, a community with *Phragmites australis* and *Acoretum calami*, *Thelypteridi-Phragmitetum*, *Iridetum pseudacori*, *Caricetum paniculatae*, *Caricetum acutiformis*, *Caricetum vesicariae*, *Caricetum rostratae*, *Caricetum elatae*, and a community with *Calla palustris*.

Among the least frequent mire associations in the surroundings of lakes Na Jazach are those usually occurring on transitional peatbogs: *Rhynchosporetum albae*, *Caricetum limosae*, *Caricetum lasiocarpae*, and *Caricetum diandrae*. They develop on acid peat substratum in places submerged during the periods of heavy rainfall and spring thaw. On transitional peatbogs develop also rare phytocoenoses of *Sphagno-Caricetum rostratae* and *Eriophoro vaginati-Sphagnetum recurvi*. Patches of the latter association usually occur in complexes of raised bogs; in the investigated transitional moors (Kępczyński & Noryśkiewicz 1992) they form one of the developmental phases. The association frequently found in the 11 studied mires was *Carici-Agrostietum caninae*. It usually develops on fens, with a steady horizontal water supply, but is also found in marginal parts of transitional peatbogs. Drier parts of peatbogs are overgrown by communities from *Molinio-Arrhenatheretea* classes (*Epilobio-Juncetum effusi*, *Scirpetum sylvatici*, and communities with *Molinia coerulea* and *Deschampsia caespitosa*).

Brushwood communities, represented mainly by *Salicetum pentandro-cinereae*, occur on submerged shores of the lakes, by the stream Ruda, and in the surroundings of peatbogs. Stands of a community with *Calamagrostis canescens*, without trees or shrubs, occur in the vicinity of willow brushwoods and wet alderwoods.

The distribution of forest communities depends mainly on the character of soil and on hydrologic conditions. Wet alderwoods (*Carici elongatae-Alnetum sensu lato*) develop in submerged habitats in direct contact with surface water. They are distinctly differentiated into two association types: *Sphagno squarrosi-Alnetum* and *Ribo nigri-Alnetum*. The first one occurs in places without drainage and occupies comparatively small land surfaces, and the other occupies large areas in the surroundings of all the lakes and of the stream Ruda. In recent years the area occupied by the black current alderwood (*Ribo nigri-Alnetum*) decreased due to the lowering of groundwater level. Similar but slightly more elevated habitats are occupied by various forms of the association *Circaeo-Alnetum*. Particularly interesting are patches with numerous occurrences of *Orchis fuchsii* and *Listera ovata*. Those phytocenoses grow on the southern shores of all the lakes, and they are particularly well developed near lakes Brzózka and Mielec. In places of seepage water flowing from the southern elevated slopes (mainly by lakes Gościąż and Mielec), impoverished forms of *Carici remotae-Fraxinetum* have developed. That association is rare in northern Poland.

At some distance from the lakes, associations of *Tilio-Carpinetum* and *Querco roboris-Pinetum* adjoin the carr communities. Stands of *Tilio-Carpinetum* cover larger areas on the southeastern side of Lake Wierzchoń (Fig. 3.32), and on the slope on the southern side of Lake Gościąż they form a narrow belt bordering upon *Carici remotae-Fraxinetum* towards the lake and on *Querco roboris-Pinetum* forest on the other side. Northwest of Lake Gościąż on elevated slopes small fragments of *Pruno-Crataegetum* occur. It is a vicarious communities for *Tilio-Carpinetum* developing after the forest stand has been destroyed by man.

The surroundings of lakes Na Jazach are dominated by pine forests. Their composition depends on the fertility of the habitats. In more humid places richer in nutrients near water bodies, stands of *Querco roboris-Pinetum* develop, and dry dunes are overgrown by *Peucedano-Pinetum.*

The distribution of vegetation around the lakes Na Jazach depends mainly upon the natural conditions. There are no apparent damages resulting from human activity to be observed there nowadays. Most natural features can be found in aquatic, reedswamp, and mire plant communities, and among forest communities in wet alderwood and riverside forests.

To the contrary, a distinct effect of human management is visible in the formation of pine forests. During forest management pine has been protected for many years, being introduced even on mixed deciduous forest habitats. That is evidenced by the species composition of understory and herb layer in many stands of mixed pine forests.

During several years' studies we observed the gradual decrease of the area occupied by alderwoods to the advantage of the alder carr. That process can be observed distinctly on the southern shores of lakes Wierzchoń, Brzózka, Gościąż, and Mielec. It is the result of the gradual lowering of the groundwater level, caused mainly by the low annual rainfall in recent years.

From the present-day patterns and diversity of plant communities as well as from their continuous dynamic transformations it can be presumed that in the past the water bodies occupied larger areas than recently. Such a conclusion is substantiated by the present-day development of plant communities, particularly spectacular in the eastern and western parts of the lake complex, where a large area is occupied by *Ribo nigri-Alnetum* and *Circaeo-Alnetum*, developing on a substratum formed of peats. The presently observed intense shallowing of lakes Wierzchoń, Brzózka, and Mielec will soon result in complete disappearance of those water bodies and in the de-

velopment of reedswamp and mire vegetation, and finally of wood communities in their place. The pattern and succession of plant communities in the area of the lake complex Na Jazach does not basically differ from those observed in other areas of lowland Poland with little human interference.

REFERENCES

Bloesch J. 1994. Methods how to measure bottom sediment resuspension. In: J. Bloesch (ed.), *Sediment resuspension. Hydrobiologia* 284: 13–18.

Blomqvist S. & Håkansson L. 1981. A review on sediment traps in aquatic environments. *Archiv für Hydrobiologie* 91: 101–132.

Błędzki L. A. 1993. Zooplankton of Lake Gościąż. *Polish Botanical Studies, Guidebook Series* 8: 49–54 (in Polish with English summary).

Brunksill G. J. 1969. Fayetteville Green Lake, New York II. Precipitation and sedimentation of calcite in a meromictic lake with laminated sediments. *Limnology and Oceanography* 14: 830–847.

Carlson R. E. 1977. A trophic state index for lakes. *Limnology and Oceanography* 22: 361–369.

Choiński A. 1995. Zarys limnologii fizycznej Polski. Wydawnictwo Naukowe UAM, Poznań.

Churski Z., Marszelewski W. & Szczepanik W. 1993. The dynamic and conditions of sedimentation in Lake Gościąż. *Polish Botanical Studies, Guidebook Series* 8: 15–28 (in Polish with English summary).

Davis M. B. 1973. Redeposition of pollen grains in lake sediment. *Limnology and Oceanography* 18: 44–52.

Davis M. B., Moeller R. E. & Ford J. 1984. Sediment focusing and pollen influx. In: E. Y. Haworth & J. W. G. Lund (eds), *Studies in palaeolimnology and palaeoecology in honour of Winifred Tutin*. Leicester University Press, Leicester.

Emerson S. 1975. Gas exchange rates in small Canadian Shield lakes. *Limnology and Oceanography* 20: 754–761.

Fabianowski W. & Olczak H. 1988. Mapa Hydrologiczna Polski 1:200000 ark. Płock, Wydawnictwa Geologiczne, Warszawa.

Geyh M. A., Merkt J. & Müller H. 1971. Sediment-, Pollen- und Isotopenanalysen an jahreszeitlich geschichteten Ablagerungen im Zentralen Teil des Schleinsees. *Archiv für Hydrobiologie* 69: 366–399.

Gierszewski P. 1993. Chemical denudation within the drainage basin of the Ruda River in 1990 hydrological year. *Zeszyty Instytutu Geografii i Przestrzennego Zagospodarowania PAN* 12: 29–45 (in Polish with English summary).

Giziński A. 1978. Significance of benthal fauna as indicator of eutrophication degree in lakes. *Verhandlungen der Internationalen Vereinigung für theoretische und angewandte Limnologie* 20: 997–999.

Giziński A., Błędzki L. A., Kentzer A., Rejewski M., Wiśniewski R. & Żbikowski J. 1991. Hydrobiologiczna charakterystyka jeziora Druzno. Rozpoznanie i ochrona ekosystemów (RPBR 28). *Wiadomości Instytutu Melioracji i Użytków Zielonych (1991)*: 151–164. Falenty/Elbląg-Olsztyn.

Giziński A., Błędzki L. A., Kentzer A., Wiśniewski R., Zawiślak W., Żbikowski J & Żytkowicz R. 1992. Abiotic and zoocenotic conditions for the functioning of selected lake ecosystems with various trophic levels. In: R. Bohr, A. Nienartowicz & J. Wilkoń-Michalska (eds), *Some ecological processes of the biological systems in north Poland*, pp. 437–479. Nicolaus Copernicus Univ. Press, Toruń.

Glazik R. 1978. Wpływ zbiornika wodnego na Wiśle we Włocławku na zmiany stosunków wodnych w dolinie. *Dokumentacja Geograficzna* 2–3: 1–119.

Gliwicz Z. 1977. Food size selection and seasonal succession of filter feeding zooplankton in an eutrophic lake. *Ekologia Polska* 25: 171–225.

Golachowska J. 1971. The pathways of phosphorus in lake water. *Polskie Archiwum Hydrobiologii* 18: 325–345.

Golterman H. L. 1988. Reflections on fractionation and bioavailability of sediment-bound phosphate. *Archiv für Hydrobiologie. Beihefte Ergebnisse der Limnologie* 30: 1–4.

Goslar T. 1993. Seasonal component changes found in the youngest part of the Lake Gościąż. *Polish Botanical Studies, Guidebook Series* 8: 189–202 (in Polish with English summary).

Goslar T. & Wachniew P. 1995. Evidence for the climatic and anthropogenic changes inferred from the youngermost section of laminated sediments of Lake Gościąż, Poland. In: *Extended synopses of International Symposium on Isotopes in Water Resources Management,* IAEA-SM-336, pp. 188–189. Vienna, Austria.

Håkansson L. 1977. The influence of wind, fetch, and water depth on the distribution of sediments in Lake Vänern, Sweden. *Canadian Journal of Earth Sciences* 14: 397–412.

Håkansson L. 1994. A model to predict gross sedimentation in small glacial lakes. In: J. Bloesch (ed.), *Sediment resuspension. Hydrobiologia* 284: 19–42.

Håkansson L. & Jansson L. 1983. Principles of lake sedimentology. Springer Verlag, Berlin.

Herczeg A. L. & Fairbanks R. G. 1987. Anomalous carbon isotope fractionation between atmospheric CO_2 and dissolved inorganic carbon induced by intense photosynthesis. *Geochimica Cosmochimica Acta* 51: 895–899.

Hilton J., Lishman J. P. & Allen P. V. 1986. The dominant processes of sediment distribution and focusing in a small, eutrophic, monomictic lake. *Limnology and Oceanography* 31: 125–133.

Hollander D. J. & McKenzie J. A. 1991. CO_2 control on carbon-isotope fractionation during aqueous photosynthesis: A paleo-pCO_2 barometer. *Geology* 19: 929–932.

Jaczynowski J. 1929. Morfometria Jezior Gostynińskich. *Przegląd Geograficzny* 9: 35–66.

Jasnowska J. & Jasnowski M. 1983. Szata roślinna torfowisk mszarnych na Pojezierzu Bytowskim cz. III. Ogólna klasyfikacja fitosocjologiczna zbiorowisk torfowiskowych. *Zeszyty Naukowe Akademii Rolniczej w Szczecinie, Rolnictwo* 30: 49–57.

Kelts K. & Hsü K. J. 1978. Freshwater carbonate sedimentation. In: A. Lerman (ed.), *Lakes: Chemistry, Geology, Physics*, pp. 297–323. Springer Verlag, New York.

Kentzer A. 1995. Cumulation of phosphorus and nitrogen in bottom sediments of Lake Gościąż. *Acta Universitatis Nicolai Copernici. Limnol. Pap*. 19: 37–47.

Kentzer A., Giziński A., Wiśniewski R., Błędzki L. A., Żbikowski J. & Żytkowicz R. 1990. Gospodarka fosforem w eutroficznym jeziorze Wlk. Partęczyny. In: Struktura i funkcjonowanie wybranych ekosystemów jeziornych poddanych antropopresji. *Szkoła Główna Gospodarstwa Wiejskiego-Akademia Rolnicza* 41: 156–166. Warszawa.

Kentzer A. & Żytkowicz R. 1993. The formation of recent bottom sediments in Lake Gościąż. *Polish Botanical Studies, Guidebook Series* 8: 39–48 (in Polish with English summary).

Kępczyński K. & Noryśkiewicz A. 1992. Pflanzenwelt der gewählten Torfmoore im nördlichen Teil des Gostynińsko-Włocławski-Schutzgebietes. *Acta Universitatis Nicolai Copernici, Biologia* 40(79): 59–120 (in Polish with German summary).

Kępczyński K. & Noryśkiewicz A. 1993. Wasser- und Schilfvegetation