Table 9.5. Villages around Lake Gościąż (rent registers from 1557 and 1566, after Nowak 1991).

Village	Number of			
	sors	farmers	tenants	craftsmen
Dąb	6			
Dobiegniewo	1.5		1	
Duninów	17	12		2
Skoki	8			
Środoń	5.5	1		
Wistka Królewska	6	1	1	
Wistka Szlachecka	1			6

siderably and that the social differentiation of the inhabitants progressed (Tabs 9.3 and 9.5).

Totally two sors were prepared for settlement in both Wistka Szlachecka and Wistka Królewska at the time of their location (Tab. 9.3), but it is difficult to say how much of the land was actually used. In Wistka Królewska in the 17th century the rent was paid according to the area of 6 peasant sors (Tab. 9.5). In Wistka Szlachecka only one peasant sor was in use but 6 craftsmen paid rent (Tab. 9.5). In Dąb 6 peasant sors were in use. The particular farms, however, were rather small. In 16th and 17th centuries farms in Dobiegniewo were no more than 0.25 sor in size each (Nowak 1991). Duninów was a relatively big village at this time; 17 peasant sors were used, and 2 craftsmen and 12 farmers paid rents there.

Beside farming, other forms of utilization of the natural environment took place. Beside the mills existing at Dobiegniewo, Duninów, and Wistka Szlachecka in 15th century, new mills were built in the 16th century at Ruda and Wistka Królewska. The brewery at Duninów started to function already in 16th century. According to 17th century documents the inhabitants of some mentioned villages were engaged in fishing (Nowak 1991). Fishpools were often connected with mills, where the millers took care of the fish. By the permission of King Zygmunt I from 1521, the inhabitants of Dobiegniewo and Dąb were involved in wild-forest bee keeping. There were also bee keepers at Wistka Królewska and Duninów. Cutting trees for timber is mentioned in documents from the 15th century (Nowak 1991). Logs were worked in water sawmills at Dobiegniewo and Duninów. In the 16th and 17th centuries the inhabitants of Duninów worked also as raftsmen floating wood. From the end of the 15th century a woollen cloth-shearing manufacture functioned at Dobiegniewo (Tomczak 1963).

Manufacturing of iron at Ruda is confirmed from the end of 16th century. Near ironworks 10 houses were built then (Guldon 1974). At the same time 2 blacksmiths, 4 coal merchants, 4 miners, and 2 smelting-furnace operators paid rents at Ruda.

The above data suggest high professional differentiation of people living in the area between Wistka and Duninów during the 15th and 16th centuries. However, it is impossible to reconstruct the number of inhabitants of the villages near Lake Gościąż during that period. Information about rents and incomes from sawmills (Nowak 1991) implies that this region was intensively exploited economically.

In the 16th century the fishermen from Dobiegniewo paid a rent of 7 florens. Moreover, the inhabitants of villages situated along the Vistula River paid 4–8 bushels of hops (1 bushel = 36 litres). The cultivation of hops was probably connected with the brewery at Duninów. In 1564, the sawmill at Duninów gave a profit of about 60 florens.

The process of settling people in the region discussed continued in the 17th century, when the village Telążna came into being (Nowak 1991). All the previously mentioned villages were active at that time.

In the 17th and 18th centuries the royal stores of salt from Wieliczka existed at Dobiegniewo (Nowak 1991). In 1674, 55 people from Dąb paid rent. The brewery at Duninów worked throughout all that time, and some inhabitants of this village were engaged in fishing. The ironworks at Ruda were still functioning. Information is lacking about the sawmill at Dobiegniewo. Millers from Dobiegniewo and Wistka Królewska paid a conventional rent, and they were obliged to fatten hogs and do the carpenter services (Nowak 1991). Animal breeding in peasant farms then included cattle, horses, pigs, sheep, geese, and hens. In the Kowal district rye was the most commonly cultivated cereal. The population of Dobiegniewo parish in the 17th century is unknown, but in the Duninów parish 470 people lived at that time (Nowak 1991).

The distribution of archaeological sites confirms the above informations, and shows the general settlement patterns (Figs 9.1 and 9.6). In spite of the poor natural environment, which was not friendly to farming, the areas between Wistka and Duninów have been permanently inhabited during the Medieval Period and Modern Time.

9.1.3. Human impact on the vegetation of the Lake Gościąż surroundings in prehistoric and early-historic times

Magdalena Ralska-Jasiewiczowa & Bas van Geel

The Na Jazach Lakes region is a rather special and interesting area for tracing the participation of past human populations in the transformations of the natural environment. As an area of rather poor soils unsuitable for intensive farming, it has never been radically deforested. On the other hand, it is situated quite close to important habitation centres active during different crucial periods of cultural history, e.g. the chernozem region of Kujavia

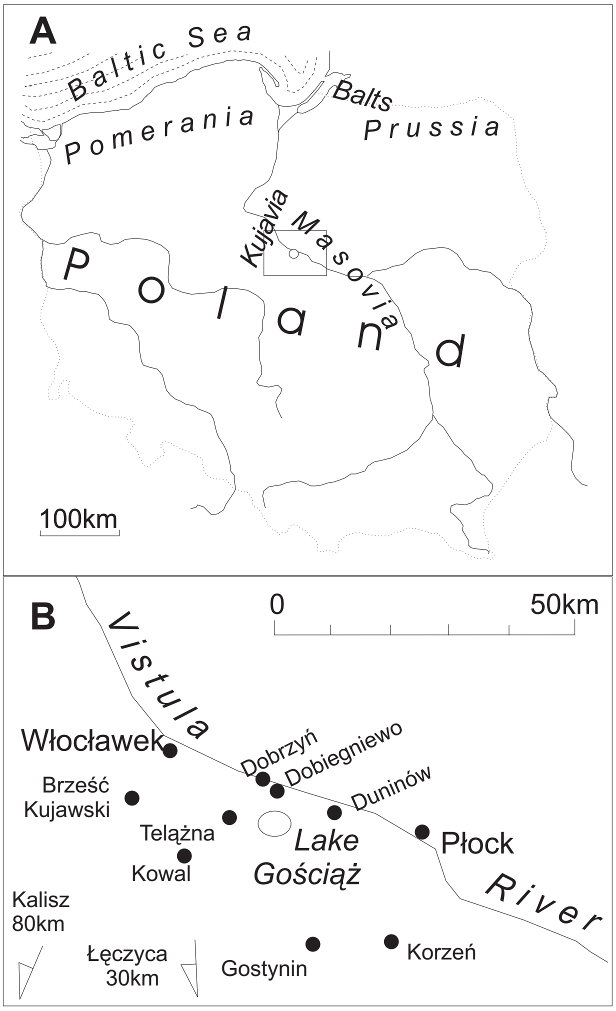

Fig. 9.7. Sketch maps of Poland (A) and of the Lake Gościąż region (B) showing the location of historical regions and localities mentioned in this chapter.

(Fig. 9.7), its borderlands lying hardly 30 km west from Lake Gościąż and inhabited intensively from early Neolithic since it became the earliest cradle of Polish Statehood in the 10th century. Still closer were important pre- and early historic strongholds at Płock, the capital of Poland in late 11th century AD (Szafrański 1983) and slightly younger one at Włocławek (Fig. 9.7). The study area is also located very near Vistula River, the largest and most important waterway in the history of Poland. Lying within the sphere of influences of those active areas, the Na Jazach lakes region was populated nearly continuously. However, because of the unfriendly environment, human impact could hardly develop intensively here, leaving possibilities for natural vegetation to keep its stands, although still subject to anthropogenic transformation.

The human impact on the vegetation as presented in this chapter is based on the interpretation of a pollen diagram for profile G1/87 from the centre of Lake Gościąż, discussed already for its records of Late-Glacial and Holocene vegetation history in Chapters 7.4 and 8.3. The pollen-analytic record from this profile is assumed to represent regional changes, i.e., in case of human activities, to reflect also some events taking place several kilometres away from the lake.

The basic data concerning the evidence of human activity in the Lake Gościąż region between ca. 7750–4550 cal BP (= ca. 6700–4100 ^{14}C BP) have been presented by Ralska-Jasiewiczowa and van Geel (1992), and data concerning the human-indicator value of some Cyanobacteria by Van Geel et al. (1994, 1996). These data will be also summarized here to make the settlement history complete.

To up-date the information published in 1992 the following questions must be mentioned:

1. The archaeological field-work carried out by Pelisiak and Rybicka during the years 1992–94 (Chapter 9.1.1) completed the fragmentary picture of human presence in the studied region that was formerly sketched on the basis of available sources for the Mesolithic and Neolithic periods.

2. The very detailed studies of the sediment chronology in the top part based on frozen cores (Goslar, Chapter 9.2.1), and the numerous AMS ^{14}C datings on terrestrial macrofossils from the central and bay cores (Goslar et al., Chapter 6.2) greatly improved the former floating chronology of the whole sediment sequence. It allowed us to correct and define more precisely the time spans attributed to particular cultural groups in the region.

3. The pollen diagram published in 1992 was based in its bottom part on pollen spectra counted with a time resolution of 100 yr. The ensuing complement of counts to 50 yr resolution revealed the evidence of humans in the area at least 200–300 years earlier than previously supposed (8000–8100 cal BP) (Fig. 9.8).

In describing the anthropogenic environmental changes we decided to use the calendar (varve) time scale as the primary time scale in accordance with the entire study on Lake Gościąż sediments, adding for convenience its conversion into the ^{14}C chronology (see Goslar, Appendix 1).

Mesolithic

Phase 1 (8100–7270 cal BP = ca. 7350–6400 ^{14}C BP)

The earliest changes in the pollen diagram interpreted as evidence of human activities (Phase 1, Fig. 9.8) occur within the older part of *Ulmus-Fraxinus-Quercus* PAZ, representing the Atlantic chronozone. The main vegetation types in the Na Jazach lakes region then were pine and mixed pine forests with substantial amount of *Betula*, *Quercus*, *Corylus*, and *Populus tremula* on the elevated sandy grounds prevailing in the region, their poorest forms overgrowing sand dunes. Mixed deciduous woods with dominant *Ulmus* and with *Fraxinus excelsior*, *Quercus*, both *Tilia* ssp. and *Corylus avellana* occurred on

Ralska-Jasiewiczowa M., Goslar T., Madeyska T. & Starkel L. (eds), 1998. Lake Gościąż, central Poland. A monographic study. Part 1.
W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

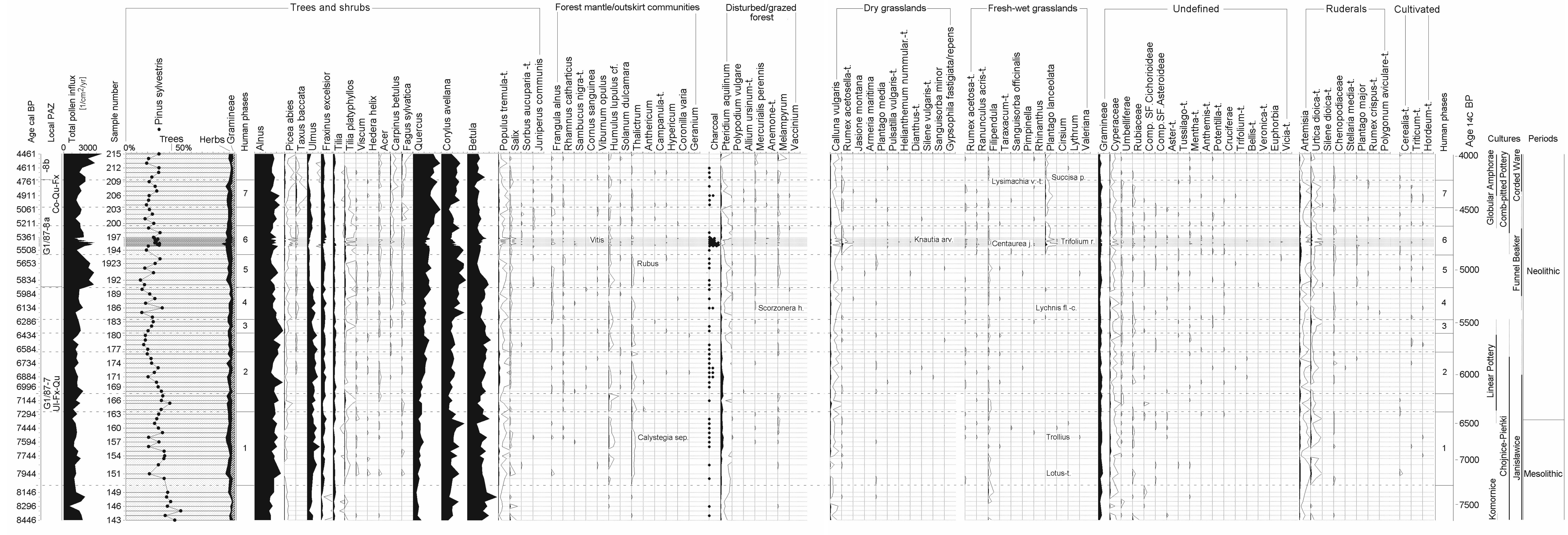

Fig. 9.8. Lake Gościąż, profile G1/87. Section of pollen diagram with evidence of Mesolithic and Neolithic settlements, selected pollen and spore taxa. Local PAZ's in the left side column follow the diagram zonation described in Chapter 8.3. Charcoal content (black dots) is estimated according to the 3-grade scale: one dot – present, two dots – frequent, three dots – abundant. The taxon grouping is approximate. The chronology of archaeological cultures follows Kozłowski (1989) and Czerniak (1994).

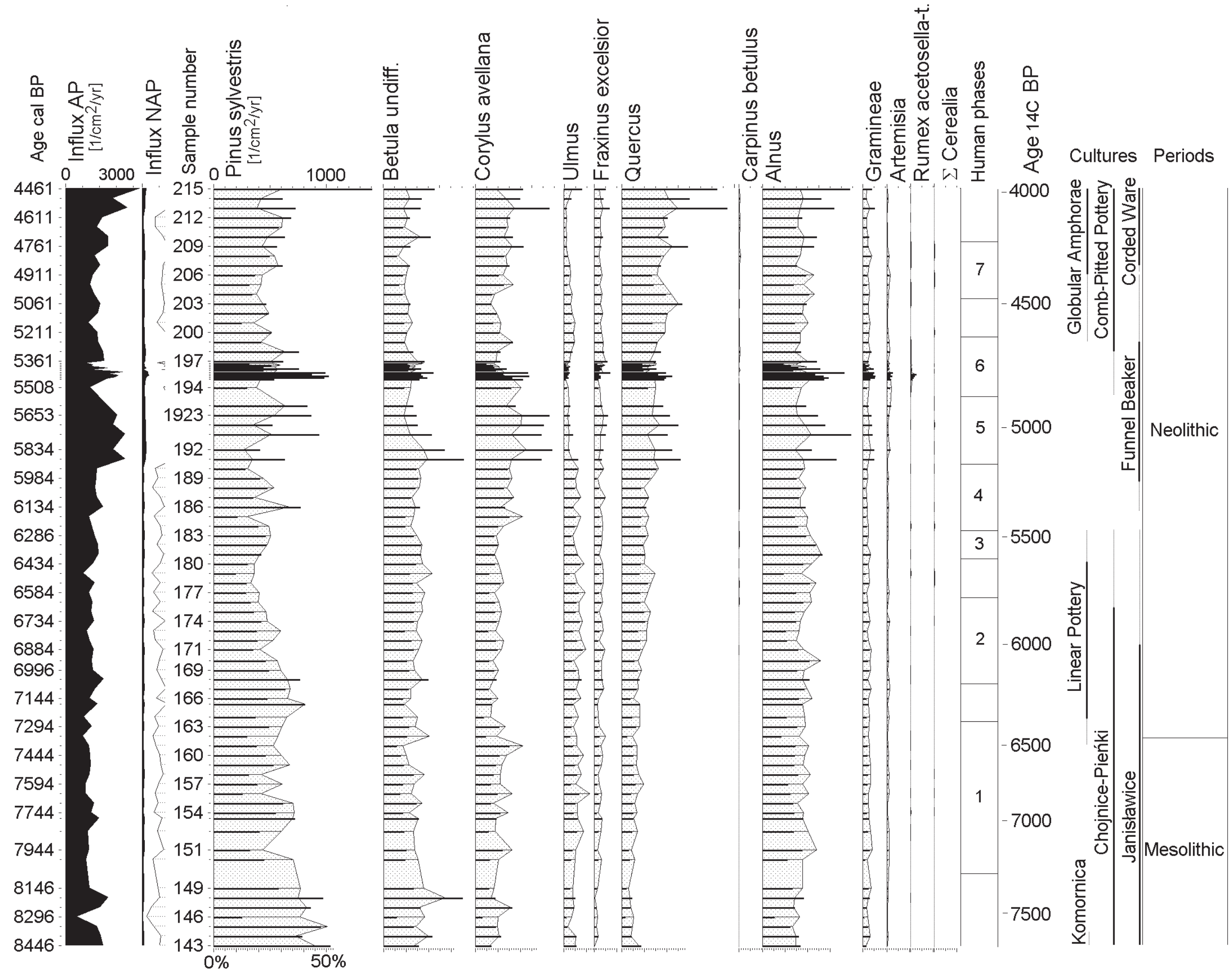

Fig. 9.9. Lake Gościąż, profile G1/87. Section of pollen-influx diagram (selected major pollen type) with evidence of Mesolithic and Neolithic settlements. Pollen-influx values (black bars) are superimposed on the percentage pollen curves (dotted). For other explanations see Fig. 9.8.

slopes and lower terrain of more fertile brown soils, passing gradually into alderwoods with different deciduous trees, *Picea, Salix*, and *Frangula* and with ferns. The generally high forest density is evidenced by low pollen influx (Fig. 9.9) and pollen diversity (Fig. 9.10), both around their lowest values for the entire Holocene (Chapter 8.3, Figs 8.23 and 8.24). Mixed pine forests were somewhat more open, with some patches of light-demanding vegetation (*Artemisia, Rumex acetosella, Calluna vulgaris*).

The changes recorded in pollen spectra from ca. 8000 cal BP may indicate the following effects of human interference in the natural vegetation:

The increased abundance and diversity of wood understory taxa (small peaks of *Corylus* and *Populus* cf. *tremula*, appearances of *Frangula alnus, Rhamnus cathartica, Viburnum opulus, Sambucus nigra* -t.) and also of herb-layer taxa provide evidence for some disturbance and creation of openings in different types of wood communities. The herb taxa document disturbance mostly in two types of woods: dry mixed pine forests (pronounced rise of *Pteridium aquilinum* curve, increased frequencies of *Melampyrum, Calluna vulgaris, Rumex acetosella*, appearance of *Polypodium vulgare*), and humid alderwoods (*Humulus lupulus, Urtica dioica, Thalictrum* (?), *Cirsium, Filipendula, Valeriana, Calystegia sepium, Mercurialis perennis*).

Some taxa of humid habitats appear then in the pollen diagram, like *Sanguisorba officinalis, Trollius europaeus, Rumex acetosa, Lythrum*, etc., which are typical today of humid meadows. Some other plants showing increased pollen frequencies are clearly nitrophilous (*Urtica dioica, Artemisia*, Chenopodiaceae, *Sambucus nigra* -t., the latter evidenced for the first time) and indicate formation of nitrogen-enriched habitats arising around human camps.

The very characteristic maxima of *Pteridium* curve (Fig. 9.8) may indicate regular fires, most probably of anthropogenic origin (Bennett et al. 1990). *Pteridium* expands effectively not only by a good light supply but particularly so on soils enriched in ash, which highly im-

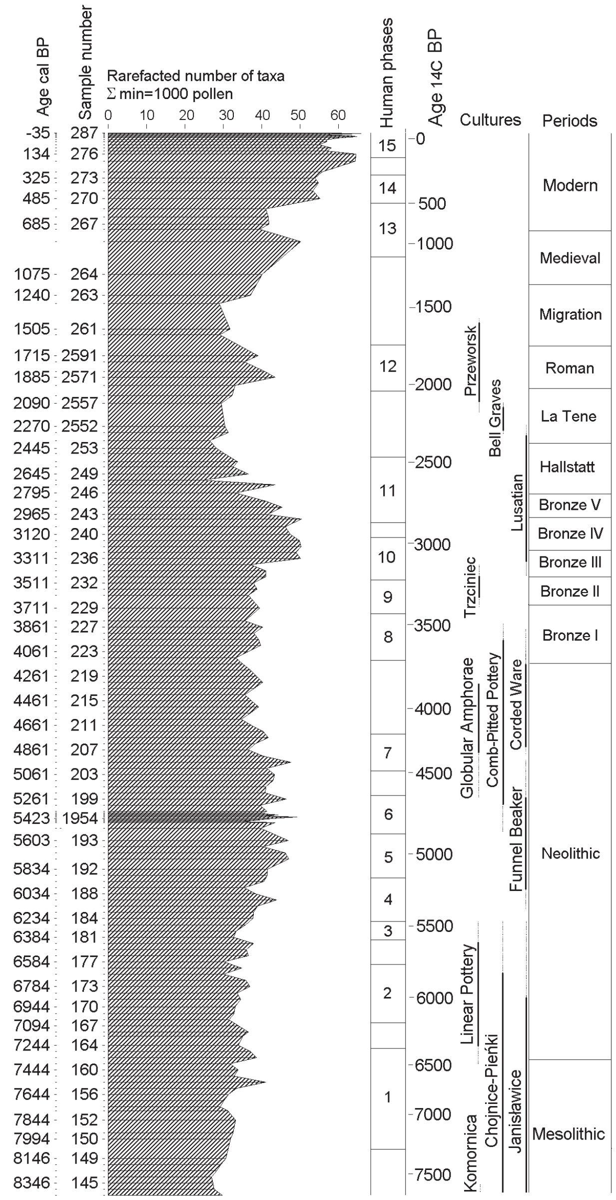

Fig. 9.10. Lake Gościąż, profile G1/87. Rarefaction analysis of the whole part of the Holocene pollen sequence with evidence of human impact (see Chapter 8.3, Fig. 8.24), to show correlation between the changes in taxa diversity and the pattern of settlement phases. Plot of expected pollen and spore taxa is based on the pollen count = 1856.

proves its spore production (Oinonen 1967, Latałowa 1992b). Behre (1981) considers it to be a cultural indicator of a broad ecological spectrum.

Melampyrum pollen often increases in frequencies in connection with the indicators of human activities (Behre 1986). It may represent species of different ecological affinities and however, several species are characteristic of woodland disturbances, including burning of forest herb layer and also of mire surfaces.

It was e.g. regularly found in mire profiles from North Yorkshire, UK (Turner et al. 1993) in connection with the evidence of Mesolithic man presencce. Its appearance there was interpreted as indicative of changes in forest herb layer following the lopping of branches and burning the ground vegetation.

During the following period of about 200 yr (ca. 7270–7065 cal BP) the indicators of human presence near the lake decrease in frequencies (*Populus* cf. *tremula*, *Urtica*, *Pteridium*) or partly disappear, possibly suggesting temporary departure of nomadic groups to other areas. However, after ca. 7070 cal BP the signs of their return to the region increasingly reappear.

Phase 2 (7070–6610 cal BP = ca. 6200–5770 ^{14}C BP)

The record of phase 2 (Fig. 9.8) starts with a brief peak of pollen influx, involving mostly *Pinus, Betula, Quercus* and *Alnus* (doubled influx) (Fig. 9.9). The consistently increased *Betula* and *Quercus* influx continues, suggesting some stabilization of human impacts in mixed pinewoods (Ralska-Jasiewiczowa & van Geel 1992). It is confirmed by the indications of wood disturbance similar to that in the previous phase as well as to some new ones. We can see again a maximum of *Populus* cf. t*remula* and an increased variety and representation of understory shrubs, including this time also *Cornus sanguinea* and *Taxus baccata*, and rises of *Pteridium aquilinum* and *Urtica dioica*. Different rather heliophilous herb taxa appear, some of them of xerothermic affinities, such as *Plantago media, Sanguisorba minor, Pulsatilla,* and *Anthericum*, documenting openings created in dry mixed pinewoods, together with ecologically undefined taxa like *Geranium, Dianthus, Trifolium, Hypericum, Anthemis* type, and others. The changes described are accompanied by the continuous record of charred tissues (Fig. 9.8) mostly of Gramineae epidermis and more rarely also of small wood fragments. The regularity of recorded fires speaks strongly for their anthropogenic origin. In the late part of phase 2 around 6600 cal BP the contribution of *Aphanizomenon* akinetes (Cyanobacteria) to the pollen spectra suddenly rises, interpreted by van Geel (Ralska-Jasiewiczowa & van Geel 1992) as evidence of increasing lake eutrophication.

Comparison of pollen-analytic and archaeological data on Mesolithic man in the Lake Gościąż region

As stated by Ralska-Jasiewiczowa & van Geel (1992) the two phases described, each lasting at least several hundred yr, correspond generally to the periods when "there was human activity in the regional pollen-source area". However, the shape of pollen curves such as *Populus* cf. t*remula* and *Urtica* suggests the occurrence of several short cycles of human activity within each phase, probably connected with the mobility of nomadic tribes.

The evidence of Mesolithic man long has been sought in pollen diagrams (Hicks 1972, Jacobi et al. 1976, Simmons & Innes 1987, Simmons et al. 1989, Simmons 1992, Latałowa 1992a, b, etc.), and some of records interpreted as consequences of human activities connected with those cultures are particularly suggestive (Kloss 1987, 1990, Innes & Simmons 1988). The records include, first of all, the evidence of frequent forest fires, interpreted most often as caused by Mesolithic hunters (Jacobi et al. 1976). Forests with dominant pine are the easiest to be set on fire, while the deciduous trees are rarely affected by natural fires (Rackham 1988), so the charcoal evidence from the Mesolithic including tree species other than pine is commonly assumed to be anthropogenic (Bennett et al. 1990). Latałowa (1992b) considers that regular fires on light sandy soils may produce favourable conditions for the development of a rich herb layer with dominant *Pteridium aquilinum*, limiting the regeneration of *Pinus* seedlings and favouring the advance of *Quercus*. This interpretation may explain very well the changes in the pollen record observed in phase 2 of Gościąż diagram.

In the G1/87 profile charred tissues start occurring much earlier than the noticeable pollen record of human presence (Fig. 9.8), and they may possibly be a signal of Mesolithic camps in a greater distance from the lake, for the archaeological data confirm the development of Mesolithic cultures in central Poland since the beginning of the Holocene.

The pollen/charcoal evidence, however, is rarely supported by the archaeological evidence found practically *in situ*. Out of 18 sites of flint artefacts found in the Lake Gościąż region (Pelisiak & Rybicka, Chapter 9.1.1) and recognized positively as Mesolithic, besides 47 poor flint assemblages, that at least partly may also represent Mesolithic, 5 sites were located on the sandy upland and on the ridge above the Lakes Na Jazach valley between the northern Lake Gościąż bay and Lake Mielec (Chapter 9.1.1, Fig. 9.1). One of them (site 11) contains the original undisturbed pattern of flint artefacts and suggests the tool processing executed *in situ*. This site is located very close to the lake, while the others follow the valley edge farther to the north-east.

According to Pelisiak and Rybicka (Chapter 9.1.1) two technological types of flints are represented here, one typical for the Komornica and Chojnice-Pieńki cultures, the other specific for the Gościąż microregion and connected possibly with the Wistka Szlachecka type of Janisławicka Culture (Schild et al. 1975, Więckowska 1975). The human-impact phases 1 and 2 as distinguished in the pollen diagram could then correspond to two different cultural phases of the Mesolithic, not to a single one, as previously supposed (Ralska-Jasiewiczowa & van Geel 1992).

The radiocarbon chronology for particular Mesolithic cultures in Poland (Kozłowski 1989) places the main development of the Komornica Culture between 9500 and 7200 ^{14}C BP (= ca. 10,500–8000 cal BP, see Appendix 1), its late stages persisting in western and northwestern Poland for the next two millennia. The Chojnice-Pieńki Culture in certain areas would be its successor from around 7000 ^{14}C BP (= 7800 cal BP), and Janisławicka Culture is presumed to spread only from ca. 6500 ^{14}C BP (= ca. 7400 cal BP). In this chronological context phase 1, dated between ca. 8000 and 7300 cal BP, could be well correlated with the presence of tribes of the Komornica/Chojnice-Pieńki cultural complex, and the younger phase 2 (ca. 7100–6600 cal BP) with the late-Mesolithic population of the Janisławicka Culture, producing flints of Wistka Szlachecka type.

It should be mentioned that from ca. 6500 ^{14}C BP (= ca. 7400 cal BP) the first early-Neolithic cultural groups started to penetrate the Kujavia region adjoining the study area to the west (Fig. 9.7). They could coexist within or more probably near the regions where Mesolithic populations persisted even until 5000 ^{14}C BP = 5900 cal BP (Kozłowski 1989). The landscape (soil, vegetation) qualities were the decisive factors here. The rich centres of early-Neolithic settlements within 30–40 km to the west from Lake Gościąż on areas of highly fertile soils are dated at ca. 6180 ^{14}C BP (= ca. 7145 cal BP), with the oldest uncertain dates of 6490±450 ^{14}C BP (= 7380±500 cal BP) for the Linear Pottery Culture (Grygiel 1984) and 5700±140 ^{14}C BP = ca. 6484±140 cal BP for the Lengyel Culture (Grygiel 1984, Grygiel & Bogucki 1997). The dates coincide with the age of younger Mesolithic phase 2 at Lake Gościąż, and some contacts between those different populations cannot be excluded. Single pollen grains of *Triticum* type are present in pollen spectra at that time too. However, both the type of habitat around Lake Gościąż and the type of environmental disturbance deduced from the pollen record speak against linking phase 2, or at least its youngest part, with the activities of early-Neolithic people. Nonetheless the single pollen grains of Cerealia -t., *Triticum* -t., and *Hordeum* -t., appearing sporadically from ca. 7300 cal BP on, might have been wind-transported from those early-Neolithic settlements.

The 200-yr section of the pollen diagram following Mesolithic phase 2 suggests a time of much reduced – if not totally ceased – human activities. *Artemisia, Urtica, Pteridium aquilinum* frequencies decline, single indicator herb taxa disappear. If late-Mesolithic populations were still present in the region at all, they certainly were rather scarce and not living close to the lake.

Neolithic

Phase 3 (6400–6260 cal BP = 5610–5450 ^{14}C BP)

The new signals of human presence in the study area start appearing from ca. 6400 cal BP (Fig. 9.8). Until 6250 cal BP they are rather indistinct and similar to the Mesolithic records. They include new increases in *Urtica dioica* -t., Chenopodiaceae, and Rubiaceae pollen, *Pteri-*

dium aquilinum spores, and also the appearance of *Campanula, Hypericum, Rhinanthus,* and *Potentilla* -t., which might suggest the formation of small open grasslands in woods. The first *Plantago lanceolata* pollen appears around the upper phase boundary. Some openings in alderwoods may be indicated by increases in *Alnus, Picea*, *Frangula alnus*, and *Humulus lupulus* frequencies. The pollen influx of dominant trees shows a temporary increase (Fig. 9.9), which altogether suggests some local activities generating forest disturbance. This might have been the time when the new Neolithic settlers migrated into the region, penetrating also the direct vicinity of the lake (fishing!), but still not dwelling there. It cannot be excluded that some delayed Mesolithic groups still appeared at the lake and were active for some time, but in light of the further gradual development of the settlement evidence showing the continuous presence of Neolithic tribes in the region it seems not very probable.

Phase 4 (6260–5910 cal BP = ca. 5450–5150 ^{14}C BP)

From ca. 6260 cal BP some distinct changes in the pollen record (Fig. 9.8) signal the new types of economic practices being introduced by newly arrived cultural groups.

The changes include sudden increase of *Corylus* pollen (nearly doubled in percentage), rising abundance of *Frangula alnus, Taxus, Picea,* and *Populus tremula*, and reappearance of *Cornus sanguinea, Viburnum opulus,* and *Sambucus* cf. *nigra*. The AP pollen influx shows a short maximum (Fig. 9.9) and maintains higher values, mostly due to the increased contributions of *Betula, Corylus,* and *Quercus*. Taxa diversity shows some increase (Fig. 9.10). These phenomena are typical for the early developmental stages of Neolithic settlement, when animal husbandry was based to a high extent on grazing in woods, and tree coppicing was used to let the light into the forest for improving fodder production in its lower layers. These questions are discussed much in the literature (Rackham 1980, Göransson 1988, Aaby 1988, Latałowa 1992b and many others). The beginning of the nearly continuous *Mercurialis perennis* curve documents the openings in deciduous woods, but richer are the evidences of pinewood thinning (*Coronilla varia, Scorzonera humilis, Jasione montana, Polypodium vulgare*, rise of the *Calluna vulgaris* curve), though clearly these taxa could not produce large fodder volume.

The first single *Plantago lanceolata* pollen appears at the phase onset, together with a rise of *Rumex acetosa* -t. frequencies, but altogether the indicators of any pasturelands are still very poor; the Gramineae curve also remains rather low. Some ruderals increase (*Artemisia*, Chenopodiaceae), and other new ruderal taxa appear (*Plantago major, Polygonum aviculare, Rumex crispus* -t. (?)). *Triticum* and *Hordeum* -t. pollen remain single, and their origin cannot be defined more closely. Altogether this phase documents the existence of primitive Neolithic settlement in the region, with animal breeding by grazing in the forest but with little developed pastureland husbandry and questionable early stages of agriculture. The economy of these populations must still have been based to a large degree on hunting and fishing. No evidence was found for their dwelling in the direct neighbourhood of the lake.

Phase 5 (5910–5550 cal BP = ca. 5150–4830 ^{14}C BP)

At ca. 5910 cal BP a classical *Ulmus* fall occurs in the pollen diagram (Fig. 9.8). It is accompanied by different indications of rather substantial ecological changes, not necessarily, however, of anthropogenic origin. The changes in the AP percentage diagram are not so drastic: they include a short lasting rise of *Betula,* followed by further increase of *Corylus* values, less distinct rises of *Quercus*, *Populus tremula* -t., and *Tilia platyphyllos,* small temporary declines of *Fraxinus* and *Picea*, and the first appearance of *Juniperus*. More expressive are changes in the AP influx (Fig. 9.9), which nearly doubles between 5934 and 5884 cal BP and remains high until ca. 5650 cal BP. Its first rapid rise is caused mostly by *Betula, Alnus, Quercus, Corylus,* and *Tilia*. In the later part of this stage *Corylus* influx is still high. A small but definite rise of NAP influx is first caused mostly by Gramineae, supported by *Artemisia*. The frequencies of other ruderals like *Urtica dioica*, *Plantago major,* and later Chenopodiaceae increase slightly too. Fresh/wet-meadow indicators are very scarce, except for slightly increased *Filipendula*. The latter may have come from the alderwoods, where the formation of openings is suggested by higher frequencies of *Frangula alnus, Rhamnus catharticus, Humulus lupulus*, *Solanum dulcamara,* and *Thalictrum*. The other wood types have been subjected to some disturbance as well, as evidenced by increased pollen occurrences of *Melampyrum* and *Mercurialis perennis* and substantial contribution of *Pteridium aquilinum* and *Calluna vulgaris.* Single pollen grains of *Anthericum*, *Gypsophila fastigiata*, *Armeria maritima*, and *Plantago media* document the formation of dry-land swards. The appearance of *Juniperus* is connected with that type of vegetation. The existence of small corn-fields cannot be excluded, as single cereal pollen mainly of *Triticum* -t. appear more regularly in this phase. However, all the evidence together speaks for grazing in the forest as the main economic activity for the population living near the lake.

The real fall of *Ulmus* pollen influx (Fig. 9.9) is indicated only at 5834 cal BP, delayed compared with *Ulmus* pollen percentage fall. This shows that all the processes connected with the *Ulmus* reduction were more extended in time than the percentage diagram can show: the first thinning of the elm population let the light into the forest and enabled the remaining elm trees to bloom abundantly for the next few tens of years. However, the repeating reduction of elm resulted in its final very serious elimina-

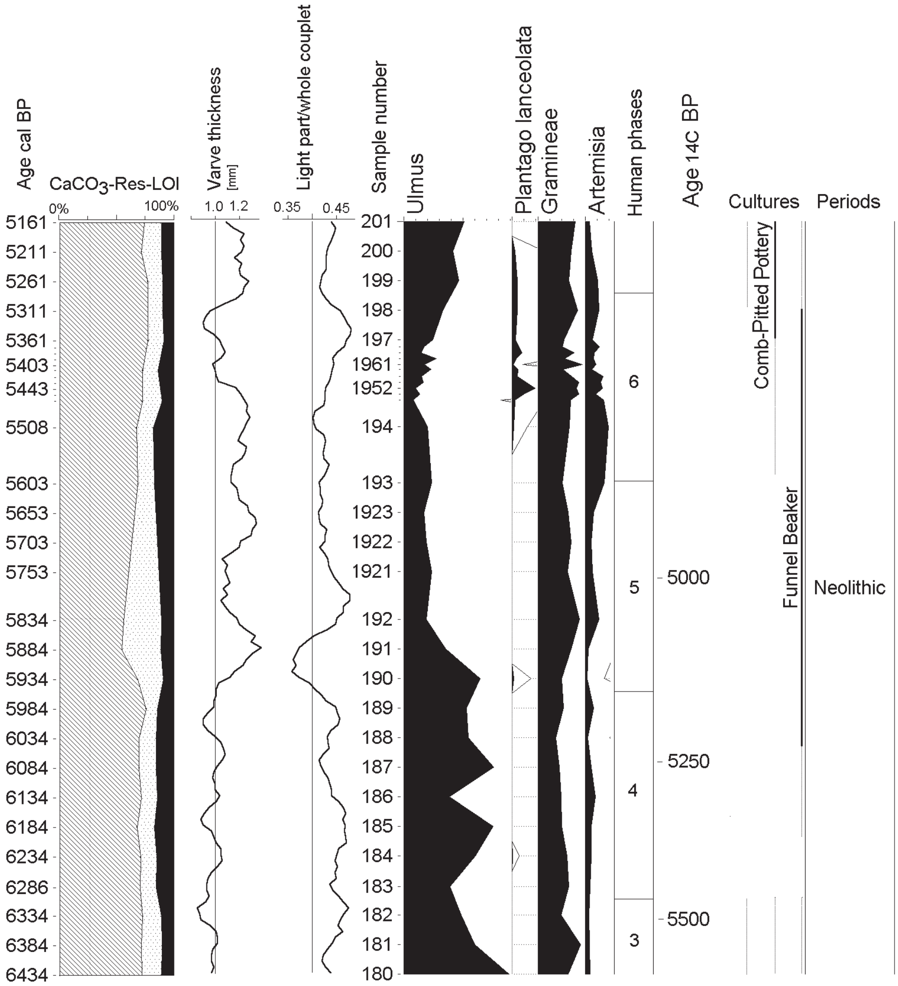

Fig. 9.11. Lake Gościąż, profile G1/87. Selected pollen curves illustrating changes around the *Ulmus* fall plotted against the curves of LOI analysis (Wicik 1993), varve thickness, and ratio of light part to whole couplet (Goslar, Chapter 6.3) to show a strict correlation between both groups of data.

tion from the area. The *Ulmus* fall is strictly coincident with the changes in sediment laminae (Fig. 9.11). The changes start with the drastically increased thickness of the dark parts of the couplets, the beginning of this change indicated slightly earlier than the onset of the *Ulmus* percentage fall (unfortunately no year-by-year pollen analysis was performed) and continuing for ca. 90 yr. It is followed by a sediment section with the dark couplet parts not so thick, but with the total couplet thickness distinctly though not regularly increased.

The above facts described also by Goslar (Chapter 6.3 and 8.2), were explained by Ralska-Jasiewiczowa & van Geel (1992) as increased soil erosion caused by the opening of woods surrounding the lake due to the *Ulmus* elimination (see Hirons & Edwards 1986). The primary cause of the *Ulmus* fall, however, was not discussed more thoroughly then. To support its possible interpretation the following facts should be remembered: the appearance of Neolithic people in the Lake Gościąż area during phase 3 is no more than very probable, but the records of phase 4 leave no doubt about the presence of settled populations, with animal husbandry by forest grazing accompanied by wood coppicing and pollarding (Rackham 1980, 1988, Göransson 1982, Pott 1986, and others). The evidences of those practices appear in the pollen diagram at least 300 years before the *Ulmus* fall, and though the increased human activities are indicated around the *Ulmus* fall itself, the strongest evidence of land occupation appear in the diagram only ca. 400 yr later, at the onset of settlement phase 6 (Fig. 9.8). This makes the purely anthropogenic origin of *Ulmus* fall highly improbable. Pathogenic attack as an important factor contributing to the *Ulmus* fall must be accepted as the most popular explanation of this episode in Holocene European forest history (Groenman-van Waateringe 1983, Birks 1986, Girling 1988, Molloy & O'Connell 1991, and many others). The hypothesis proposes the rapid spread of so-called Dutch elm disease caused by a fungus *Ceratocystis ulmi* by beetles of two *Scolytus* species – *S. scolytus* and *S. multistriatus* (Rackham 1980, Peglar 1993). In some cases *Scolytus* fossils were found in association with the elm decline (Girling & Greig 1985, Girling 1988). The year-by-year analysis of the *Ulmus* fall recorded in annually laminated sediment at Diss Mere described by Peglar

(1993) reveals a position of the *Ulmus* fall in the sequence of anthropogenic forest disturbance similar to that found at Lake Gościąż. Peglar accepts also an important role of elm disease in the loss of elm trees.

One cannot estimate to what extent the elm disease is responsible for the *Ulmus* fall recorded around 5900 cal BP in Lake Gościąż sediments, and how far human activities contributed to it. Most probably both factors were of substantial importance here. Similar are the opinions of different authors dealing with the problem of European *Ulmus* fall in detail, as presented very accurately by Peglar (1993), quoting Rackham's (1980) and Girling's (1988) considerations on the subject. In summary, it is assumed that the elm disease might have been present in the area already for some time before the main *Ulmus* fall, causing less serious attacks on elm trees (in case of the Lake Gościąż profile, the *Ulmus* curve depressions during phase 3 and possibly also between phase 2 and 3). However, as the Neolithic settlement developed, the damaging of elm trees by animal grazing and the different human activities in the forest weakened the elm trees, increased their susceptibility to infection and provided new habitats for *Scolytus* beetles contributing to the outbreak of a strong epidemic.

Phase 6 (5550–5230 cal BP = ca. 4830–4500 ^{14}C BP)

A new cycle of anthropogenic change beginning between 5600 and 5500 cal BP (Fig. 9.8) is signalled first by rising pollen frequencies of the ruderal taxa *Artemisia*, Chenopodiaceae, and *Plantago major.* The AP influx, rather low at the onset of the phase (Fig. 9.9), rises rapidly to reach a short maximum around 5370 cal BP, then decreases slowly. The percentage curves of *Corylus* and *Quercus* form then large depressions, and *Ulmus* and *Fraxinus* decrease to minimum values, later to rise again. On the other hand, percentages of *Betula, Populus tremula* -t., *Salix, Picea*, and *Pinus* show distinct increases. *Sorbus aucuparia* starts appearing continuously. At the time of the highest AP influx, the NAP influx rises too (Fig. 9.9), and the whole group of cultural indicators forms percentage maxima. In this central part of the phase the pollen spectra were counted with a finer time resolution (Fig. 9.12).

The deforestation for pasturelands becomes evident: formation of open grazed land on more humid soils is confirmed by regular occurrence of *Rumex acetosa*, presence of *Sanguisorba officinalis, Centaurea jacea, Trifolium repens, Cirsium*, and quite a few of ecologically undefined herb taxa like *Ranunculus acris* -t., *Rhinanthus, Potentilla* -t., *Anthemis* -t., *Campanula, Dianthus*, and others, strictly accompanying a sharp *Plantago lanceolata* peak up to 1.5% of the pollen sum. On the other hand, the similar and synchronous maximum of *Rumex acetosella* and the coincident appearance of heliophilous rather xeric taxa like *Jasione montana, Pulsatilla vulgaris* -t., *Helianthemum nummularium* -t., *Coronilla varia,* and *Knautia arvensis* document the deforestation of drier habitats. All those changes indicate the approach of Neolithic settlers closer to the lake and the occupation of adjacent grounds. The type of economy seems to be still based mostly on animal breeding – cereal pollen remains scarce, but by shortening the distance between the cultural activities and the lake shore the more local succession of changes could be recorded.

Together with the maxima of anthropogenic indicators one *Vitis* pollen grain was found, but the cultivation of grape-wine at that time is rather doubtful. This find contributes to the still not fully explained history of wild *Vitis* in the Holocene of Poland (see Chapter 8.3 and this Chapter p. 292).

Phase 6 seems to reflect the following land-occupation cycle (Figs 9.8 and 9.12):

1. arrival and settling (spread of the ruderals *Artemisia,* Chenopodiaceae, *Plantago major)*
2. extension of clearings, formation of pasturelands (high AP influx, percentage depression in deciduous trees, rises of pioneer trees, maxima of grasslands taxa and *Urtica*)
3. some recession of pastoral economy *in situ*, overgrowing of abandoned grounds (increases of *Artemisia, Pteridium, Taxus, Juniperus)* and starting regeneration of trees by sprouting (*Fraxinus, Ulmus,* later *Quercus, Corylus*).

The decline of local human activities is recorded in the diagram as a slow and gradual process, and it is difficult to define when indeed the population settled near the lake retreated from the area. The end of the phase is marked at the beginning of a distinct depression of ruderals and the temporary disappearance of *Plantago lanceolata* and *Rumex acetosella.*

The progress of a subsequent *Ulmus* decline during the land-occupation phase seems to show direct connection with human activities. Its minimum, concurrent with those of other deciduous trees and *Corylus*, must have been the effect of forest clearings as evidenced by maxima of grassland herbs. Its slow rise at the phase decline coincides with the decrease of anthropogenic indicators. This pattern confirms the opinion discussed earlier, that beside the Dutch elm disease the activity of Neolithic settlers played a very important role in the history of *Ulmus* in post-Atlantic times.

The short-lasting retreat of human populations from near the lake between ca. 5230 and 5080 cal BP is mostly expressed by a distinct reduction of some of culture-indicator taxa (*Artemisia, Urtica dioica* -t.) or even a temporary disappearance of others (*Plantago lanceolata, Rumex acetosa* -t., *R. acetosella* -t., Chenopodiaceae) and rising indicators of overgrown openings in pinewoods (*Calluna, Juniperus*). *Ulmus* and *Tilia* values rise slightly, and *Quercus* reaches its absolute Holocene maximum.

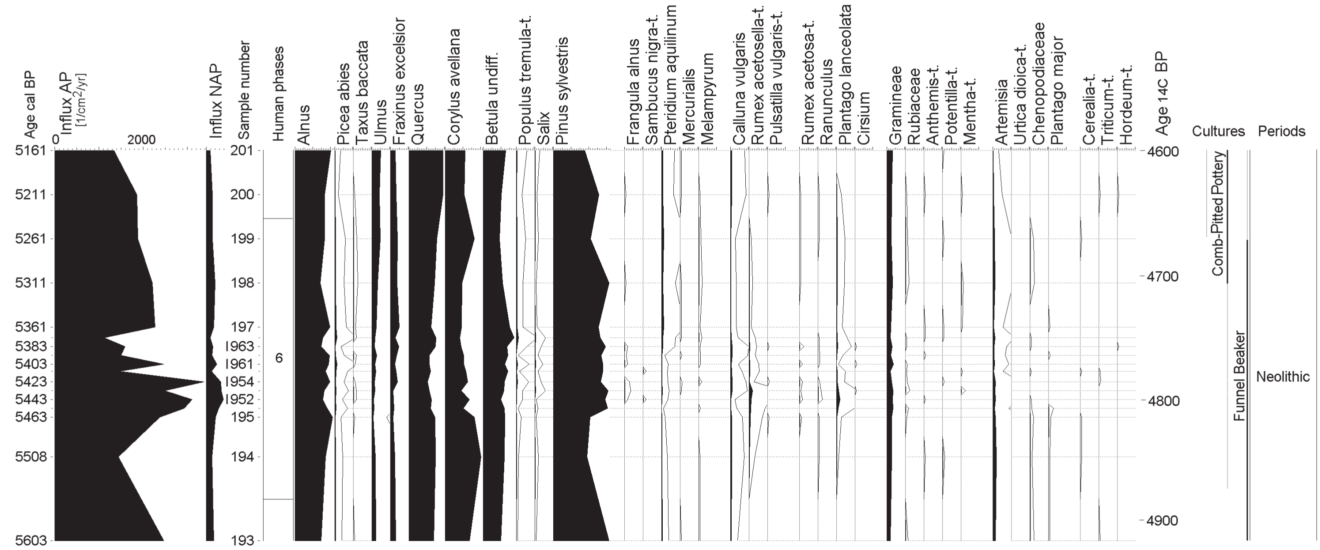

Fig. 9.12. Lake Gościąż, profile G1/87. Section of pollen diagram covering phase 6 of human impact with fine-resolution counts between 5463 and 5361 cal BP, when the land occupation activities were supposed to progress in the direct vicinity of the lake.

Phase 7 (5080–4730 cal BP = 4510–4160 ^{14}C BP)

The last settlement phase attributed to Neolithic population (Fig. 9.8) shows a similar set of NAP evidence as in phase 6, especially concerning the representation of ruderal and meadow taxa. The cereal pollen grains of *Triticum* and *Hordeum* types are slightly more frequent, suggesting small fields present not far from the lake. Some open places, particularly on drier sandy soils, were abandoned and subjected to natural succession, as documented by decreasing pollen values of *Calluna vulgaris, Rumex acetosella,* and *Melampyrum* and rise of *Populus tremula*.

The pollen influx of both AP and NAP is rather low (Fig. 9.9): *Quercus* pollen influx, making a sudden maximum at the onset ot the phase shows later a depression corresponding to the rise of *Corylus* influx and percentages and the steady declines of *Ulmus* and *Tilia platyphyllos*. This indicates progressive clearings of deciduous woods already disturbed rather heavily during the preceding Neolithic settlements.

As mentioned by Ralska-Jasiewiczowa & van Geel (1992), an interesting record is made by *Taxus* pollen, forming a distinct maximum in the middle of the phase. The explanation of this phenomenon in the above publication proposes *Taxus* expansion on abandoned pastures or fields. A small rise of *Taxus* frequency occurs also in the later part of the preceding settlement phase 6, where it coincides with a rise of *Picea*. A rise of *Picea* also follows *Taxus* maximum in phase 7. We can suppose that both trees were present in the understory of alderwoods surrounding the lake (*Taxus* appeared for the first time during the settlement phase 2), and that they expanded from there on the unused grounds, most probably the pasturelands (see also this Chapter p. 286).

Discussion of pollen and archaeological evidence of Neolithic settlements in the Lake Gościąż region

When we compare the palynological data with the archaeological information for the study area the following conclusions can be drawn:

The anthropogenic changes in vegetation ascribed to activities of Neolithic settlers must have been mainly connected with the tribes of the Funnel Beaker Culture (Pelisiak & Rybicka, Chapter 9.1.1). Their presence in the neighbouring Kujavia region (Fig. 9.7) on areas of podsolic soils on sandy substratum is dated at least from 6200 to ca. 5430 cal BP (= 5350–4650 ^{14}C BP), and on chernozem soils ca. 200 yr earlier, late populations surviving there until ca. 4800 cal BP (Czerniak 1994). The sites of the oldest FBC Sarnowo phase, which was first described from Włocławek region (Gabałówna 1968, 1969) have also been found in the Gostynińskie Lake District (Pelisiak & Rybicka, Chapter 9.1.1). Some doubts may then arise about the cultural attribution of phase 3, as its age seems slightly too old to correlate it even with the earliest FBC phase in the area, and the character of changes recorded in the diagram does not define it clearly as Neolithic. On the other hand its position in the diagram, as mentioned before, connects it continuously with phase 4, which is doubtless Neolithic. As proposed by Erny-Rodmann et al. (1997) for the Swiss Plateau, we may speculate about the possibilities of acculturation of autochthonous late-Mesolithic populations by early-Neolithic people of Danubian cultural cycle. In our case they were settled on neighbouring fertile soils of Kujavia (Czerniak 1994), e.g. from Brześć Kujawski centre (Fig. 9.7) (Grygiel 1984), but no evidence of such processes is available.

The population of Funnel Beaker Culture seems to have been most widespread in the study area (27 sites). The remains of their periodical encampments were found close to the lake and in other nearby places, but no permanent dwelling place was discovered as near by Pelisiak and Rybicka (Chapter 9.1.1, Fig. 9.3). The camps were situated on sandy terraces or in the transition zone between the terrace and the lake depression. It is then supposed by the analogy with the other FBC sites that the permanent settlement place of those people must have been situated on more fertile soils, possibly some 4–5 km to the west. Such interpretation agrees quite well with the palynological record of phases 4 and 5. It seems, however, that in phase 6 the land occupation reached terrains neighbouring the lake, where rather extensive forest clearings took place and pasturelands arose; therefore it is probable that the permanent dwelling place was also moved closer towards the lake.

The situation of phase 7 seems to be slightly different: it is distinctly separated in the diagram from phase 6 by an episode of ca. 150 yr suggesting the retreat of the former land-users from the lake region. The pollen record of phase 7 documents the formation of new open spaces exposed to grazing, a part of cleared surfaces being soon left unused and overgrown by *Populus*, *Taxus* and *Corylus*. Lots of habitats encouraging spread of ruderals was being created. This phase can most probably be linked to populations representing Comb-Pitted Pottery Culture. A relatively long-inhabited settlement of this culture, with a rich assemblage of artefacts and also a camping place, was discovered in excavations very close to the lake, together with the remains of FB Culture (Pelisiak & Rybicka, Chapter 9.1.1, Fig. 9.3), and two other sites of CPP Culture alone were found in some distance (Chapter 9.1, Fig. 9.3). The CPP Culture of rather poorly recognized economic background shows generally in the Polish Lowlands the distinct affinities to the local Mesolithic cultures, being strongly based on fishing and gathering (Wiślański 1979). Still the pollen-analytic data suggest quite a pronounced role of animal breeding in the economy of the population that dwelled near the lake during phase 7 including also possibilities of agricultural activities.

The presence of Comb-Pitted Pottery Culture in Poland is approximately defined by the dates of (4750) 4600 to 3700 (3600) ^{14}C BP (Wiślański 1979)= ca. (5480) 5300 to 4050 (3880) cal BP. The type of pottery found around Lake Gościąż (Linin type) delimits these dates to ca. 4450–4250 ^{14}C BP = 5020–4840 cal BP (Pelisiak & Rybicka, Chapter 9.1.1), which corresponds very well with the limits of phase 7 in the pollen diagram. Another suggestion of Pelisiak and Rybicka, to correlate phase 7 with the youngest Neolithic settlers recognized in the Lake Gościąż site 12 as Epi-Beaker horizon (*sensu* Kośko 1981), seems less probable, as the chronology of this culture is rather too young (4250–4050 ^{14}C BP = 4840–4460 cal BP), and the artefact representation is much less convincing than that of Comb-Pitted Pottery Culture. Still less probable, though theoretically possible in terms of chronology, is correlation of phase 7 with the people of Corded Ware Culture (1 recognized site in the area) or Globular Amphorae Culture (3 sites; Pelisiak & Rybicka, Chapter 9.1.1). In conclusion, we have to assume that the population of Comb-Pitted Pottery Culture was responsible for the environmental changes distinguished in the pollen diagram as phase 7.

The following period, when human populations retreated from the lake surroundings, lasted up to 600 yr (ca. 4730 - 4130 cal BP). It is shown in the pollen diagram by a strong reduction of anthropogenic indicators (*Plantago lanceolata* maintains a continuous curve), rise of *Melampyrum* and *Calluna*, but not much change in the tree composition. By the end of this period the next *Ulmus* fall is compensated by rises of *Alnus* and *Fraxinus* pollen values, which may suggest a new attack of Dutch elm disease, affecting mostly the elm trees contributing to alderwoods.

From ca. 4130 cal BP the human groups started reappearing and were active in the region studied more or less continuously for the next ca. 1500 yr, though with different intensity and changing land-use tendencies and with short-lasting retreats. Both archaeological and palynological evidence shows that we have to do with the activities of at least two main cultural cycles, each of them represented by two pollen phases.

Early Bronze Age

Phase 8 (4130–3760 cal BP = ca. 3780–3480 ^{14}C BP)

The phase beginning is indicated by returning higher frequencies of most common ruderal plants like *Artemisia*, *Urtica dioica*, and Chenopodiaceae, the appearance of *Polygonum aviculare* and *Plantago major*, and the rise of *Rumex acetosella*, Gramineae, and some other ecologically undefined taxa (Fig. 9.13). No cereals except for a single pollen grain of *Hordeum* type appear. A distinct increase of AP and small one of NAP pollen influx start from the middle of phase (Fig. 9.14). The changes in AP composition are more significant: the early part of the phase shows clearly a regeneration of deciduous woods, as documented by small maxima of *Fraxinus*, *Ulmus*, and *Tilia* following a maximum of *Alnus*, recorded still before the onset of the phase. This sequence could suggest some natural succession proceeding synchronously with the retreat of *Betula*, its pollen curve declining to very low values. On the other hand, massive peaks of *Pinus* at the

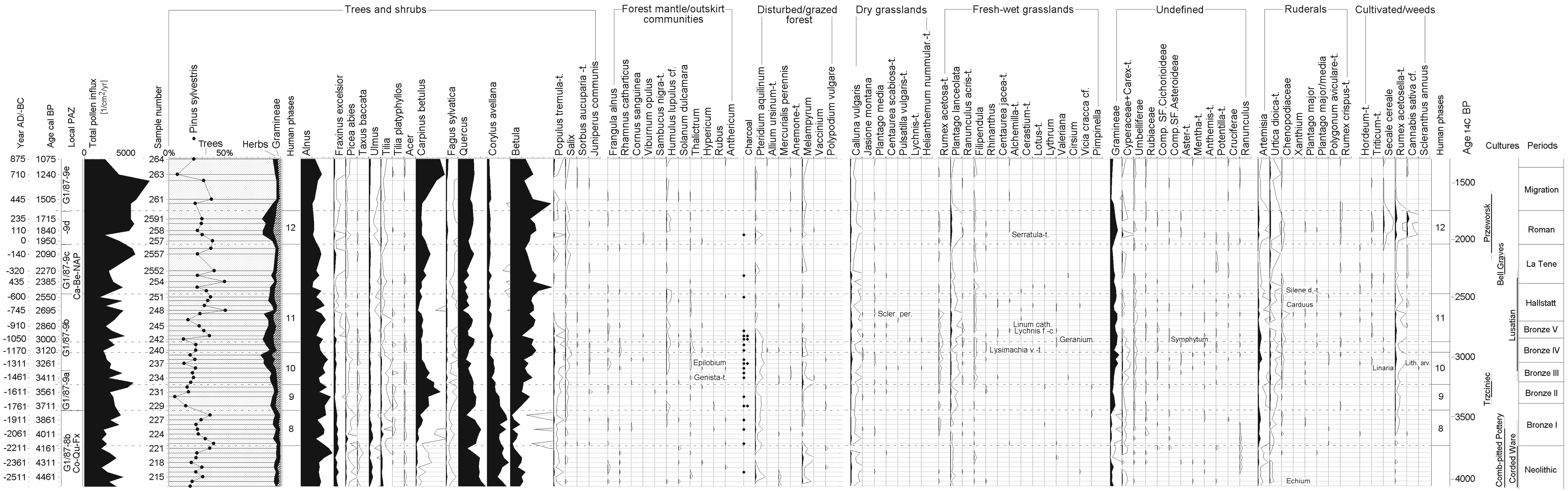

Fig. 9.13. Lake Gościąż, profile G1/87. Section of pollen diagram with evidence of settlements of Trzciniec and Lusatian Cultures, Bronze Age, and Roman Iron Age Culture, selected pollen and spore taxa. The chronology of archaeological cultures follows Godłowski & Kozłowski (1979), Dąbrowski & Gardawski (1979), Bukowski (1979), Węgrzynowicz (1979), Godłowski (1989). For other explanations see Fig. 9.8.

beginning and end of the phase coincide with the depressions of *Quercus*, *Tilia*, and *Ulmus* and with a minimum of *Betula*, all reflected also in pollen influx (Fig. 9.14). This pattern of changes is very difficult to explain without involving a human factor (clearings). The *Carpinus* curve rises consistently throughout the whole phase to ca. 7% at its decline. According to Huntley and Birks (1983) *Carpinus* pollen values above 5% indicate that hornbeam is a “prominent tree in the regional forests”.

Altogether the changes described above cannot be clearly explained in forms of the development of human settlements at least in the older part of the phase. In its younger part the rises of *Corylus* and *Populus* when *Ulmus* and *Tilia* decline and both AP and NAP influx rise may possibly be connected with human activities.

In conclusion we can suppose that some cultural interference in the lake surrounding, expressed mostly by the formation of nitrogen-enriched ruderal habitats and some grassland patches, proceeded from the beginning of phase, but the coincident changes in wood communities, if at all connected with human activity, could only progress in a significant distance from the lake. Around the middle of phase at ca. 3960 cal BP (ca. 3650 ^{14}C BP) more distinct indications of anthropogenic disturbance of deciduous woods, possibly not so far from the lake, are to be seen. This would facilitate the *Carpinus* invasion into those communities. It seems, however, that neither pasturage nor agricultural activities took place close to the lake at that time.

Phase 9 (3760 – ca. 3480? cal BP)

The most characteristic feature of the following ca. 300 yr is a rapid expansion of *Carpinus*, coincident with the spread of *Betula*, expressed in rises of both pollen percentage and influx values (Figs 9.13 and 9.14). The low-percentage *Fagus*, *Populus*, and *Taxus* pollen curves increase slightly; *Corylus* and all other deciduous trees still present in the area are clearly in retreat. *Pinus* decline, distinct in the percentage curve, is not so pronounced in pollen influx. The changes in the NAP composition, including especially rises of Gramineae, *Plantago lanceolata*, and *Rumex acetosa* -t. curves, and later appearance of single pollen of diverse wet and dry grassland taxa (*Rhinanthus*, *Lythrum*, *Pimpinella*, *Jasione*, *Plantago media*, *Centaurea scabiosa* -t.), suggest formation of open meadow-like surfaces used probably for cattle grazing. Ruderals were not widespread (slight rise of *Urtica; Artemisia* distinctly declines!?). No cereals appear at all. The interpretation of changes in wood communities during this phase in terms of human impact is still difficult, because of persisting strong imbalance between intensities of both records – the evident profound transformation of woods is out of proportion to the rather slight evidence of land-use. The expansion of *Carpinus* during this phase might be explained by its general migration, the anthropogenic forest disturbance being here only a stimulating factor. However, it is coincident with the spread of *Betula*, clearly a pioneer tree indicating in prehistoric times an extensive anthropogenic disturbance of natural woods. Symptomatic is also a progressive retreat of still remaining deciduous taxa, especially *Fraxinus* and *Corylus.* We are not able to give a reliable interpretation of the vegetational changes proceeding during the phases 8 and 9.

Archaeological data on Early to Middle Bronze Age cultures in the Lake Gościąż region versus pollen-analytical record

The archaeological data available do not help us too much to understand the real role of people in the transformation of landscape during the phases 8 and 9, corresponding chronologically to the early to middle periods of the Bronze Age. Pelisiak and Rybicka (Chapter 9.1.1) found 21 sites of this age, most of them located several kilometres east of Lake Gościąż, but only 2 of them situated very close to the lake. One such site was excavated, and its chronology was estimated approximately as period III of Bronze Age with the probable attachment to Trzciniec Culture. Another one, though very poor, represents a classical phase of Trzciniec Culture. The precise chronology and cultural classification of all other Early Bronze Age sites found within the study area and in other parts of Gostynińskie Lake District (archival data, see Pelisiak & Rybicka, Chapter 9.1.1) are unclear.

The Trzciniec Culture was formed in the catchment areas of the middle and upper Vistula by unification of older, rather differentiated Early Bronze Age cultures (Iwieńska, Unietycka Culture) probably during the 16th cent. BC = from ca. 3850 cal BP (Godłowski & Kozłowski 1979). This time corresponds approximately with the decline of phase 8 in the pollen diagram. The economy of Trzciniec populations was mostly based on animal husbandry, exploiting for grazing all open spaces available and dwelling in small encampments situated on drier rather sandy soils; agriculture was of minor importance (Godłowski & Kozłowski 1979). This type of economy should not provoke such essential changes in the forest structures as those observed during the phases 8 and 9.

Late Bronze/Early Iron Age

Phase 10 (ca. 3480–3150 cal BP)

This phase develops gradually from phase 9, and its lower boundary is hardly seen in the percentage pollen diagram alone (Fig. 9.13). However, the transitional zone between phases 9 and 10 is marked by 2 short peaks of AP influx, formed mostly by *Carpinus*, *Quercus*, and *Alnus* pollen, and by a smaller rise of NAP influx (Fig. 9.14). All those taxa show at that time rather decreasing tendencies in percentage values. Such a pattern is a char-

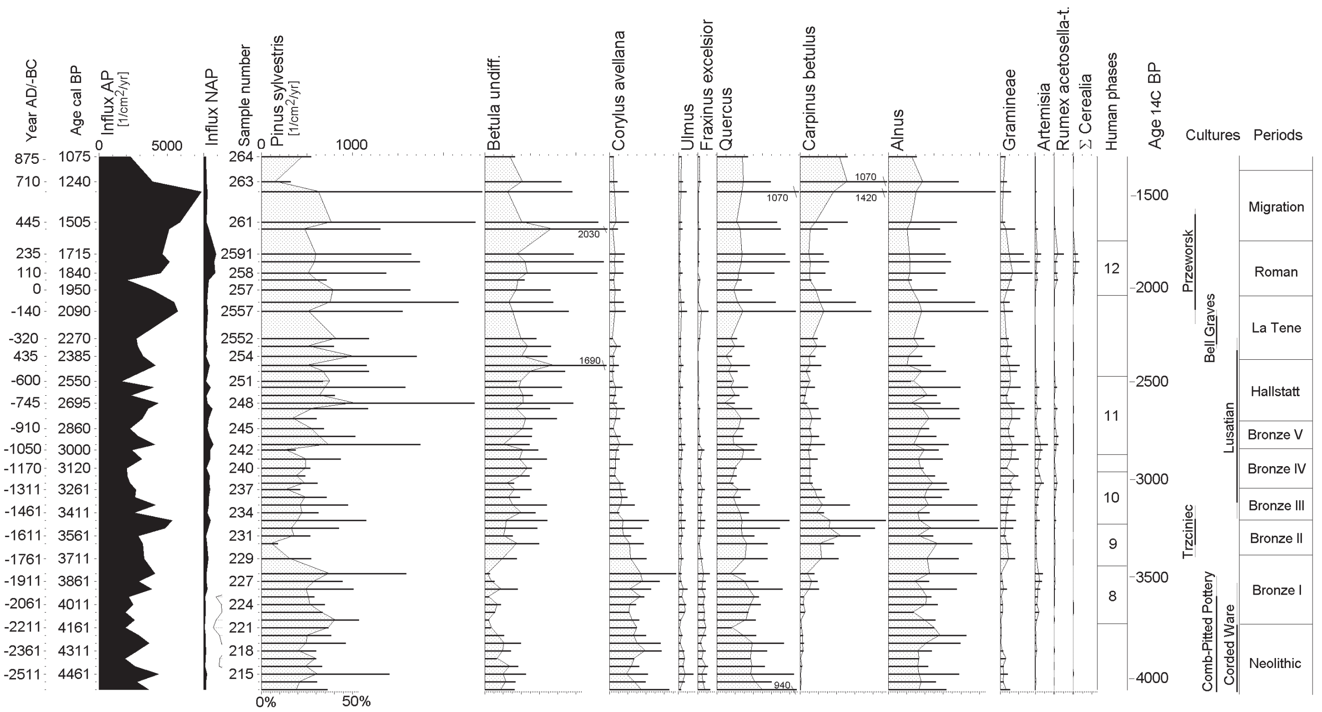

Fig. 9.14. Lake Gościąż, profile G1/87. Section of pollen-influx diagram with evidence of Trzciniec, Lusatian, and Roman settlements, selected major pollen types. For other explanations see Figs 9.8 and 9.9.

acteristic indication of the beginning of wood felling, and, indeed, it is followed by the evidence of progressing extensive clearings expressed first by a strong decrease of *Carpinus,* and then of *Quercus* and *Corylus* percentage and influx pollen curves, a decrease of *Pinus* pollen influx, and a general deep depression of AP influx, with the coincident rise of *Populus, Juniperus*, and *Salix*. NAP influx increases too, as the cumulative effect of a substantial rise of Gramineae and small rises of different low-frequency pollen taxa connected in many ways with human activities.

The woodland communities of different types were then affected by human activities. Open surfaces were created in pine woods on dry sandy habitats (*Pteridium, Melampyrum, Calluna vulgaris, Rumex acetosella, Jasione montana, Pulsatilla vulgaris* -t.) and on more alkaline grounds (*Plantago media, Centaurea scabiosa* -t., *Helianthemum nummularium* -t.). Humid and fresh grasslands were developing and extending due to grazing (*Plantago lanceolata, Rumex acetosa* -t., and *Rhinanthus, Potentilla* -t., *Ranunculus acris* -t., *Anthemis* -t., *Centaurea jacea* -t., *Cirsium* species, and many other meadow plants represented by family/genus type pollen taxa). The rises of *Frangula alnus, Humulus, Thalictrum, Filipendula,* and Cyperaceae pollen frequencies evidence disturbances in alderwoods. The increasing frequencies of ruderal plants (*Artemisia*, Chenopodiaceae, *Urtica dioica, Plantago major, Polygonum aviculare*) document the formation of nitrogen-enriched habitats. The most significant evidence of the small-scale agricultural activities not far from the lake is the appearance of cereal pollen (*Hordeum* -t., *Triticum* -t.) together with the first sporadical field weeds like *Scleranthus annuus*, *Lithospermum arvense,* and *Linaria* (*L. vulgaris*?).

The NAP percentage curve, rising consistently from the beginning of the phase, reaches in its later part ca. 20%, based mostly on Gramineae, *Artemisia, Rumex acetosella,* and *Calluna* contributions. The quantitative input of herb anthropogenic vegetation, though still not quite adequate for the scale of human activities suggested by changes in tree pollen curves, is certainly expressive enough to signal the first real change of forest/open land ratio. The taxon diversity rises abruptly, reaching values similar to those found in early historical times (Fig. 9.10).

A not very distinct episode of reduced human activities in the Lake Gościąż region, lasting slightly over 100 yr, separates phase 10 from the following phase 11 (Fig. 9.13). It is indicated mostly by somewhat decreased herb pollen influx and percentages, by rises of *Betula, Populus,* and then *Quercus* pollen values, and by depressions in anthropogenic indicators (*Rumex acetosella, Plantago lanceolata, Artemisia,* Chenopodiaceae). No evidence of agriculture beside the first single pollen grain of *Secale* was found in that diagram section. This episode probably documents some movements in the settlement pattern within the region and the temporary abandonment of grounds situated closer to the lake.

Phase 11 (3020–2500 cal BP = 2910–2480 ^{14}C BP)

This settlement phase (Fig. 9.13) is distinguished by the record of changes in forest communities comparable in scale to that of early historical times. The changes progressing continuously throughout the whole phase include declines of *Fraxinus* and *Ulmus*, and reduction of *Taxus* and *Acer* to single occurrences. *Populus* disappears in the middle of phase, and *Carpinus*, *Quercus*, and *Corylus* decreases progressively, especially in its later part. *Betula* and *Pinus* together with *Alnus* dominate absolutely, as confirmed by pollen influx (Fig. 9.14).

The record of changes in herb vegetation is rather striking: NAP influx, higher in the early and middle parts of phase, lowers towards the end, resulting from the progressively decreasing input of *Artemisia, Rumex acetosella,* and *Plantago lanceolata* pollen. Sporadic dry-grassland pollen taxa present at the beginning of the phase and later disappearing gradually include *Lychnis viscaria* -t., *Helianthemum nummularium* -t., then *Centaurea scabiosa* -t., *Pulsatilla vulgaris* -t., *Scleranthus perennis* and finally *Jasione montana* and *Scleranthus annuus*. *Pteridium* spores become scarce. This succession seems to reflect a progressive reduction of openings in dry pine and mixed pinewoods, which probably served earlier for animal grazing. Otherwise, the abundance of low-frequency pollen taxa originating probably from the fresh to wet grasslands is distinctive of the whole phase, in addition to substantial curves of *Plantago lanceolata, Rumex acetosa* -t., and *Filipendula*. This group includes *Centaurea jacea* -t., *Alchemilla* -t., *Ranunculus acris* -t., *Rhinanthus, Cerastium* -t., *Valeriana,* and sporadic *Linum catharticum*, *Geranium*, *Vicia cracca*, *Lotus,* and *Lychnis flos-cuculi*. Most of them disappear around the end of the phase or shortly later. A similar occurrence is shown by the majority of “ecologically undefined” pollen taxa, rather frequent during the phase (Compositae SF Cichorioideae, Compositae SF Asteroideae, *Aster* -t., *Anthemis* -t., *Potentilla* -t., and others), suggesting their probable connection with the fresh-wet meadow communities.

This pattern may suggest some essential change in the ways of animal breeding; the shift from grazing mostly in different types of mixed pine forests dominant in the area to the intentional formation of the grasslands – “meadows” on selected surfaces more effective in fodder production – on more fertile, fresh to humid habitats. The grassland communities, formed gradually then, could be of a type of meadow communities classified nowadays within *Molinio-Arrhenatheretea* class.

The alderwoods might have been affected to some extent by these activities too; the distinct evidences of their disturbance, such as increases in frequencies of *Frangula alnus, Rhamnus cathartica, Humulus, Solanum dulcamara,* and *Thalictrum* (?), begin to decline still during the later part of phase 10.

The evidence of agriculture during this phase includes, beside a single *Secale* grain, pollen of *Hordeum* -t. and *Triticum* -t., regularly occurring throughout the whole phase, and some typical field weeds (*Lithospermum arvense, Scleranthus annuus*) appearing together with the increase of *Rumex acetosella,* which might grow in primitive cereal cultures as well as on other open sandy surfaces (Behre 1981). Striking is also the shape of *Plantago lanceolata* curve, forming peaks coincidently with *Rumex acetosella*. *Plantago lanceolata* may be an indicator species not only for fresh grasslands but also for fallows (Behre 1981), or may grow as a weed on arable grounds (Groenman-van Waateringe 1986, Regnéll 1989).

The accompanying frequent fragments of charred tissues suggest that slash-and-burn techniques were still in use for the woodland clearance by the Lusatian population that settled then probably around the adjacent Telążna Lake (Figs 9.1 and 9.5, Chapter 9.1.1).

The ruderal vegetation, in spite of the *Artemisia* pollen curve being distinctly lower in the upper part of zone, has a good representation all the time (*Plantago major*, *Polygonum aviculare, Xanthium, Carduus,* and continuous Chenopodiaceae and *Urtica* cf. *dioica* pollen curves, as well as possibly some species of *Rumex crispus* -t.).

Some discrepancy in pollen record again exists between the evidence that wood-felling intensity clearly increased towards the end of the phase and the consequences of these activities. The latter seem altogether not very strong and, as shown by the main anthropogenic indicator taxa, start decreasing before the end of the phase. No better explanation could be found for this imbalance than the assumption that we have to do with a record of regional location of settlement. In the older part of the phase the grounds used by man would then be situated closer to the lake, but later on the centre of activities would move towards more distant areas, where more fertile soils, still bearing remnants of deciduous woods, survived earlier waves of land occupation. This may be a good example of the relationships between the particular groups of pollen indicators we find in the centres of rather big lakes. The speculation presented above can find some grounds in archaeological evidence.

Anthropogenic phase 11 is followed in the pollen diagram by a ca. 500 yr record of forest regeneration documenting the retreat of people from the area (Fig. 9.13). The pollen record of this period documents a typical long-term succession of forest on post-farming grounds, starting with a maximum spread of *Betula* (up to 40% of total pollen), followed by a still more extensive development of dominant *Pinus* (up to 50%), and leading to some local regeneration of deciduous multispecies woods (small rises of *Fraxinus, Ulmus,* and *Fagus* pollen values) but with a distinct prevalence of *Carpinus* and *Quercus*. A very high AP influx by the end of the phase (its main components being first *Betula,* and *Pinus* and later *Alnus*, *Carpinus*, and *Quercus*) may suggest not very dense forest structure. The NAP decline drastically both in percentages and diversity of taxa, all previously well represented human indicators falling to minimum values and the sporadical ones almost totally disappear.

All this means a strong reduction of grounds exploited by farmers and of all other open-land vegetation followed by intensive overgrowing processes. Noteworthy, however, are the regular occurrences of different cereal pollen types, including *Hordeum* -t., *Triticum* -t., *Secale*, and *Cannabis sativa* cf., in numbers similar to those during settlement phase 11. They suggest the existence of at least a small agricultural settlement through the whole time at a distance within the reach of the cereal pollen rain.

Comparison of pollen evidence with the archaeological data on the development and decline of Lusatian Culture in the Lake Gościąż region

The time span of phases 10–11 (3480–2500 cal BP = 3290–2480 ^{14}C BP) (Fig. 9.13) corresponds in the archaeological classification with the cultures of Middle to Late Bronze Age (III to V periods) and Early Iron Age. The most important culture of those times in central Poland, occurring here through the whole period in question, was the Lusatian Culture (Gardawski 1979, Dąbrowski & Gardawski 1979). The study area was also temporarily reached by populations of Bell Graves Culture and possibly also by East Pomeranian Culture (Bukowski 1979, Godłowski & Kozłowski 1979, Węgrzynowicz 1979). During the field search by Pelisiak and Rybicka (Chapter 9.1.1) 59 sites of Lusatian Culture, a few of them containing also some not very typical artefacts of Bell Grave and East Pomeranian Cultures, were found in the study area. Most of them were located around Lake Telążna (Fig. 9.7), forming a distinct centre ca. 7 km west of Lake Gościąż, and only 2 were located within the Na Jazach Lake complex (Chapter 9.1.1, Fig. 9.5). Pelisiak and Rybicka (Chapter 9.1.1) argue that the areas closest to the lake were probably temporarily exploited but not permanently settled during the times when Lusatian populations inhabited the region. Their permanent settlements must have been concentrated on more fertile grounds, e.g. centred around Lake Telążna.

According to the pollen record, the lands close to the lake were exploited during the time of Lusatian settlement at least twice. It is evidenced first from the phase 10 (ca. 3270–3150 cal BP), when some small corn fields and grazed open spaces must have existed close by. Later during the early to middle parts of phase 11 (ca. 3000–2730 cal BP), it is documented again by rises of ruderals and of indicators of diverse grassland types and of cereal cultivation. However, the devastation of deciduous woods within the region *sensu lato* reached its maximum only by the end of phase 11.

The following ca. 500 yr in the pollen diagram records the regeneration of forest, caused undoubtedly by the retreat of the settlement. This depopulation was a part of generally observed decline of Lusatian Culture in Poland around 2500–2400 cal BP (Godłowski & Kozłowski 1979, Niewiarowski 1995, and others). Its composite reasons include the invasion of Scythian tribes from the south, the expansion of Pomeranian and Baltic Cultures from the north (Fig. 9.7), and generally also the climate and water-level changes. During the last centuries BC the eastern part of Masovia was reached by tribes of Pomeranian and Bell Grave Cultures, both mixed with the impoverished remnant populations of the Lusatian Culture and degraded. On that basis the new Przeworska Culture started to arise, in some places already in the 2nd or 1st cent. BC, in other areas much later, as broadly discussed in the archaeological literature and not presented here in more detail.

Roman Period

Phase 12 (1990-ca. 1600 cal BP = 2050-ca. 1700 ^{14}C BP)

This rapid and brief settlement episode differs distinctly in its pollen record from the earlier phases (Fig. 9.13). It started about 40 yr before 1 AD (if not slightly earlier); its end has not been exactly defined because the sample interval was too large. The beginning is indicated by a rise of *Betula* and decreases of *Fraxinus* and *Ulmus*, followed immediately by a sharp reduction in *Carpinus* and *Alnus* pollen values.

The increases of the main human indicators occur in a succession, starting directly above the onset of the phase, with rises of Gramineae, *Plantago lanceolata,* and *Calluna vulgaris*, coincident with the appearance of *Triticum* -t. and beginning of the continuous *Secale* pollen curve; the increases of ruderals (*Artemisia, Urtica*, Chenopodiaceae, *Rumex acetosella*) and of *Secale*, and the occurrence of *Cannabis sativa* cf. starting ca. 50 yr later. This may mean first the exploitation of nearby grounds for grazing and later the movement of the settlement towards the lake. Between 1890 and 1715 cal BP the NAP influx reaches high values (Fig. 9.14), similar to those recorded in the 18th and 19th centuries. The taxa diversity, however, though distinctly higher than during the preceding and following forest regeneration phases, is substantially lower than during the periods of Lusatian and Neolithic settlements (Fig. 9.10).

The lists of taxa associated with both dry-sandy and fresh to humid grassland communities are much poorer than in the earlier settlement phases, though Gramineae and *Plantago lanceolata* form distinct maxima. Clearly increased is only the variety of pollen taxa undefined ecologically.

Rumex acetosella values rise substantially to levels higher than ever before (up to 1.8%). This increase, how-

Ralska-Jasiewiczowa M., Goslar T., Madeyska T. & Starkel L. (eds), 1998. Lake Gościąż, central Poland. A monographic study. Part 1.
W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

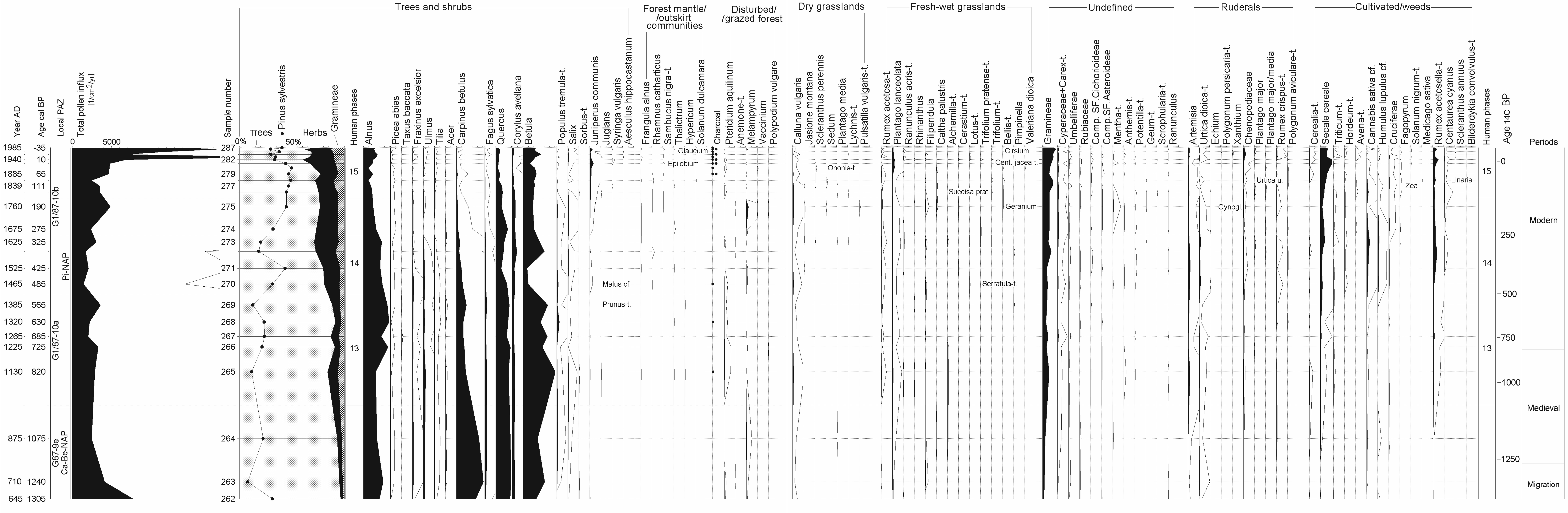

Fig. 9.15. Lake Gościąż, profile G1/87. Section of pollen diagram with evidence of Medieval and Modern settlements, selected pollen and spore taxa. The chronology of historical events follows Szafrański (1983). For other explanations see Fig. 9.8.

ever, may have a new meaning here, as the most important and distinguishing feature of this phase is a conspicuous record of developing agriculture. Besides the regular appearance of *Triticum* -t. pollen, *Secale* forms a continuous curve up to 1%. *Rumex acetosella* might have then entered rye cultures, becoming a common grain-field weed on sandy soils (Behre 1981, 1992). Phase 12 gives the first undoubted evidence of rye cultivation. Sporadically occurring *Secale* pollen was observed much earlier, in diagram sections between phases 10/11 and 11/12, both documenting reduced human activities *in situ*. More or less continuous evidence exists for cereals grown probably some distance from the lake. *Secale* might have accompanied those cultures as a field weed. Another important cultivated plant at that time was *Cannabis sativa*, its pollen values reaching nearly 2% (for a wider discussion on *Cannabis* and *Secale* see p. 292 and 293).

The rises of most typical ruderals (*Artemisia*, *Urtica dioica* -t., and Chenopodiaceae) form a distinct phase. As a whole it is the record of a rather intensive though short land-use period, starting with a pre-phase when the settlers appeared within some distance from the lake. The maximum of farming activities lasted slightly more than 100–120 yr, and focused on agriculture rather than animal breeding. It was probably connected with the shift of settlement towards the lake.

Discussion of pollen and archaeological data on settlements from Roman period in the Lake Gościąż region

According to the archaeological chronology the settlement phase 12 corresponds with the Roman period (Roman Iron Age, AD 1–375). At that time the Przeworska Culture was already strong and widespread, occupying southern, eastern, and central parts of Poland. However, in the late-Roman period the populations of Przeworska Culture retreated southwards, pushed from the north and north-east by the expanding tribes of the Wielbark Culture. The Vistula valley in its middle course was then a borderland between those two cultures. A cemetery with cinerary urns originating from that time was found at Korzeń (Fig. 9.7), east of Gostynin town (Godłowski & Kozłowski 1979).

However, the archaeological information from the study area itself is scanty and hardly supports the palaeoecological data. All except one of the 28 sites of Przeworska Culture found by Pelisiak and Rybicka (Chapter 9.1.1) are dispersed >5 km from Lake Gościąż, and most of them are situated on the right side of Vistula valley (Pelisiak & Rybicka, Chapter 9.1.1, Fig. 9.5). The authors suggest their possible connection with the Late La Tene period (the results of excavations at Telążna site 36). This could partly explain the regular presence of cereal pollen during the forest regeneration phase between phases 11 and 12. However, the sites may as well originate from different phases of the Roman period. The only fragment of ceramics found close to Lake Gościąż, representing most probably Przeworska Culture pottery, can only confirm the penetration of the lake surroundings by people of those tribes, but it cannot help in any further interpretations of pollen data.

Unfortunately, the successional processes recorded in this and the next phases could not be followed in the diagram with the precision comparable to that in earlier sections because of deficient sediment sampling. The time intervals between samples are irregular and generally too large. In consequence also the age definition for the boundaries between recorded events is sometimes approximate.

Migration Period

Judging from the pollen record, during 600–700 years following phase 12 (approximately AD 300–900/1000), the region of Na Jazach Lakes seems to have been almost depopulated (Figs 9.13 and 9.15). This enabled the processes of forest succession to reproduce different types of woodlands in the area: the total AP influx is initially very high on account of successively occurring maxima of *Betula* and then of *Carpinus*, *Quercus*, and *Alnus*, but later it decreases drastically because of increasing woodland density (Fig. 9.16).

The expansion of pioneer copses on abandoned grounds documented by a huge peak of *Betula* (ca. 40%) was followed by the development of *Carpinus*-dominated woods, with some contribution of other deciduous trees. Alderwoods regenerated around the lakes. The pinewoods seem not to follow those forest regeneration processes to a higher extent. The percentage contribution of *Pinus* pollen is then lower, its pollen influx remains mostly similar to that during the preceding phase 12, and later it decreases significantly.

The NAP influx is very low, the pollen curves of nearly all human indicators are reduced to minimum values, or sporadic grains, some of which disappear periodically. The only exception is a substantial pollen curve of *Urtica dioica*, which, together with *Melampyrum* and *Calluna vulgaris* overgrew abandoned lands.

The depopulation period recorded between phases 12 and 13 (Fig. 9.15) coincides roughly (ca. AD 350-after 875) with the Migration period. The settlement recession seems to have been prolonged in the study area by at least 200 yr, or more within the early Early Medieval time (Fig. 9.15). The deficient samples resolution leaves only one pollen spectrum (sample 264, AD 875) to support such supposition, but the slow and poor economic development of the area during the next centuries (phase 13) makes it probable.

There are no archaeological findings from the Migration period in the study area. The central part of Poland was then probably very scarcely populated; the nearest

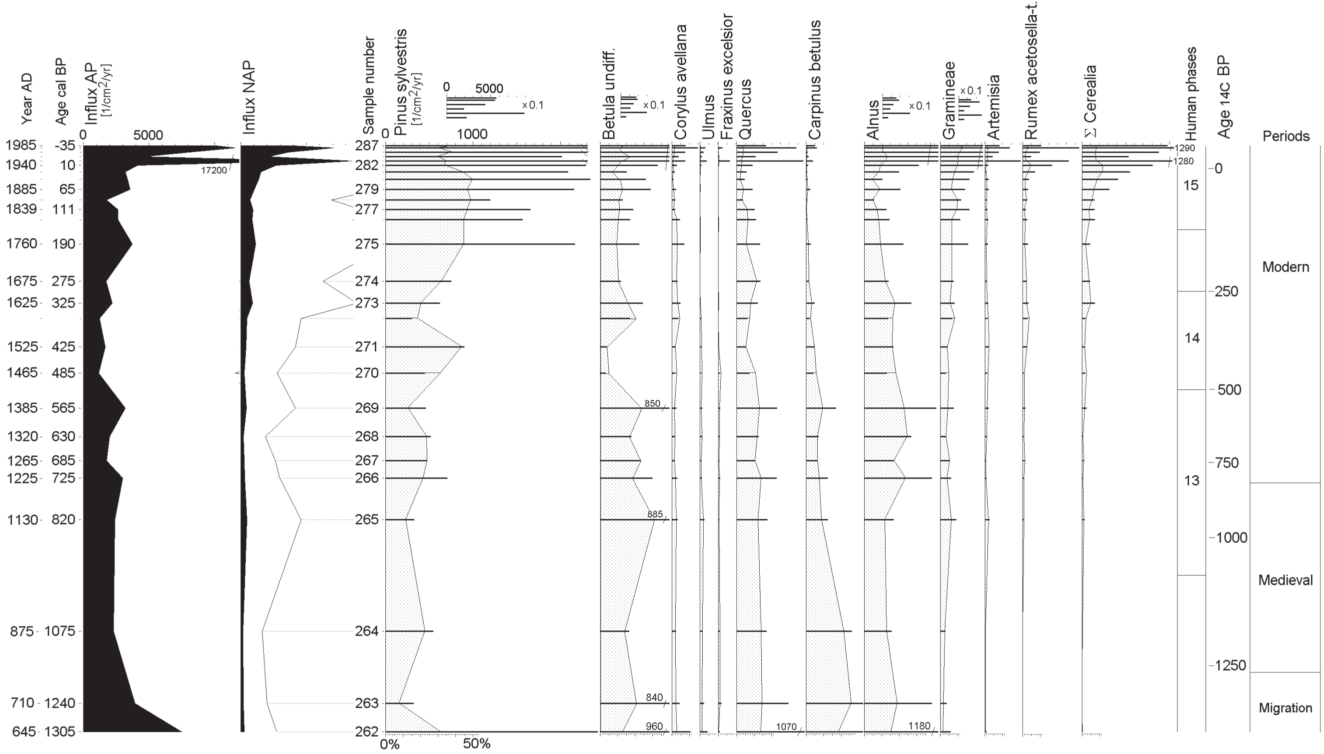

Fig. 9.16. Lake Gościąż, profile G1/87. Section of pollen-influx diagram with evidence of Medieval and Modern settlements, selected major pollen types. For other explanations see Figs 9.8 and 9.9.

sites of late Przeworska Culture from the decline of 5th century are known from Łęczyca and Kalisz region (Godłowski 1989) (Fig. 9.7).

Medieval and Modern Periods

Phase 13 (ca. AD 875/1130 – ca. AD 1420)

The age of the lower phase boundary, contained between the levels dated at AD 875 and 1130 (Fig. 9.15) approximates the beginning of the Polish State.

The changes in pollen record express first the renewed felling of the deciduous woods (declines of *Carpinus*, *Quercus*, *Fraxinus*, and *Tilia*), followed from AD 1130 by the disturbance in alder and pinewoods (declines of *Ulmus* and *Salix*, rises of *Alnus*, *Pinus*, and *Populus*, and of *Calluna* and *Pteridium*), a part of cleared grounds being left unused (*Betula* rise).

The indicators of agriculture reappear but in low frequencies, the only continuous curves are formed by *Secale cereale* and *Cannabis sativa* cf., with *Rumex acetosella* possibly contributing as a weed to the cornfields. *Triticum* -t. and undefined cereal pollen are sporadic. A slight rise of ruderals (mostly *Artemisia*) is indicated, but more distinctly the rise in the frequencies and diversity of fresh-wet meadow taxa (*Plantago lanceolata*, *Rumex acetosa* -t., sporadic appearances of *Ranunculus acris* -t., *Alchemilla* -t., *Filipendula*) together with taxa undefined ecologically (Gramineae, Cyperaceae, sporadic Compositae both SF.'s, *Anthemis* -t., *Potentilla* -t.). Because of poor time resolution the described changes in the lower part of the phase may only be treated as a signal of some economic activation of the region.

From AD 1225 pollen spectra have better time resolution (ca. 50 yr or less), and confirm some development of agriculture. However, the most evident changes of that time, such as a change in the ratio of deciduous forest trees to *Betula* or the increasing values of anthropogenic indicator taxa of high pollen productivity such as *Secale* or *Rumex acetosella* may document human activities in the region *sensu lato*, not necessarily in the lake surroundings.

Pollen data versus Early-Medieval sources

The general historical knowledge about the Early-Medieval development of eastern Masovia seems to corroborate the conclusions based on pollen-analytical evidence. The region was inhabited by Masovian ethnic groups from the time preceding the official foundation of the Polish State (AD 966) by ca. 180 yr (Szafrański 1983). Płock functioned already in the 9th century as the main centre of pagan rites for those tribes until it came to an end by the Christian conversion in AD 968. At the beginning of the 11th century Płock and Włocławek functioned as important strongholds ca. 45 km from each other, but Płock belonged to the estates of the Polish king, and Włocławek was in possession of a noble family. The study area was probably situated within the borderland between those two estates. In the last decades of the 11th century Płock was the capital of Poland. During all those times the settlement must have existed in the region between those two active centres close by, with economic and trade routes crossing it.

During the 12th and 13th centuries the area in question was repeatedly invaded first by Pomeranian and next by Baltic and Prussian tribes (Fig. 9.7), and it was set in war and fires, but in spite of that the local settlement in the part of Gostynińskie Lake District discussed started to develop at least in the early 13th cent.: Dąb village is first mentioned in written sources from AD 1228 (Rybicka & Pelisiak, Chapter 9.1.2), and two other villages from the turn of 13/14 cent. These data correspond in time with evidence of economic development recorded in the upper part of phase 13.

Phase 14 (ca. AD 1420–1650)

From the beginning of the 15th cent. the pollen record reveals the drastic changes in the forest cover of the Lake Gościąż region (Fig. 9.15). It starts with the deep depression of the *Betula* pollen curve between ca. AD 1450 and 1550 (1600?), suggesting total clearings of birch-overgrown (postfarming?) grounds, followed after AD 1465 by more gradual declines of *Carpinus*, *Fagus*, *Ulmus*, *Fraxinus*, and *Tilia*, the latter three genera vanishing temporarily from pollen spectra or appearing only as single pollen grains by the end of the phase. The *Quercus* curve forms also a distinct depression, but its pollen maintains a substantial though minor role. The decreasing AP influx is composed mostly of *Pinus* with subdominant *Alnus*. Such a record documents total clearings of all still existing fragments of deciduous woods that persisted on more fertile grounds in this generally poor region. The NAP percentages rise, exceeding 20%. Most characteristic for this phase is the rise of indicators of agrarian activities, starting at the beginning of the phase and culminating from ca. AD 1625, after an episodic rise of *Betula*, *Corylus*, and *Salix* by the end of the 16th cent., connected possibly with some shift of land-use. The most pronounced are indicators of cereal cultivation: the dominant *Secale cereale* pollen, reaching ca. 3% around AD 1625, is accompanied by high values of *Rumex acetosella* and from AD 1525 by a continuous occurrence of *Centaurea cyanus*. *Hordeum* and *Triticum* -t. are also continuously represented. The cultivation of *Fagopyrum* is documented from AD 1625, and from AD 1675 *Avena* -t. starts appearing as a probable evidence of oat-growing. Besides cereals, *Cannabis sativa* was also grown at that time, its small peak around AD 1650–1625 suggesting possibility of hemp retting in the lake. The coincidently increased *Humulus* pollen frequencies might result from some difficulties in separation it from *Cannabis*, however the archival data support the probability of hops cultivation at that time as well.

The spread of ruderal vegetation is distinctly indicated through the whole phase. The diversity of fresh-wet meadow and ecologically undefined taxa increases (*Trifolium pratense*, *Trifolium* -t., *Pimpinella*, *Cerastium* -t., *Lotus* -t., *Serratula* -t., *Geum* -t.), and such main meadow taxa as Gramineae, Cyperaceae, and *Plantago lanceolata* show increased frequency from ca. AD 1650, but generally no particular extension of open grazed land is evidenced. It is highly probable that in view of a shortage of fertile grounds the grazing in the forest was still practiced, as is reported by Szczepański (1990).

Pollen record from historical times compared with the archival data

The economic activation of the study area recorded from the early 15th cent. coincides in time with the occupation of the Dobrzyń land by Teutonic Knights in AD 1409, when the Vistula left-bank terrains were included in the Kowal Castellany. The written sources document the development of population between Wistka and Dobiegniewo, location of new villages on Teutonic law, and building of new churches and mills (Rybicka & Pelisiak, Chapter 9.1.2).

Of special interest is the first mention about Ruda village as an “industrial settlement” (Ruda means ore in Polish) in AD 1565 (Tomczak 1963, Guldon 1964, Goslar, Chapter 9.2.1), which proves that smelting works existed there at that time. The need for timber for that primitive industry caused undoubtedly an intensive tree-felling, as described from the changes in pollen diagram. The other demands for timber were provided by at least two known local water sawmills; the timber was also floated (Rybicka & Pelisiak, Chapter 9.1.2).

The brewery functioning at Duninów in 16th century (exact date of its foundation unknown) needed hops, resulting in the imposition of a tribute on peasants partly to be paid in hops to encourage its cultivation in the area. The tributes paid then also in hemp are reported from the neighbouring Gostynin Land (Szczepański 1990).

Woollen cloth manufactures functioned at Dobiegniewo (Tomczak 1963) and Duninów (Szafrański 1983) from the end of the 15th cent., for the prevalence of poor soils started sheep-breeding in the area. There existed also dye-works (Szafrański 1983); the production of the purple dye was a speciality of the whole Masovian region, started probably as early as in Medieval times, with an optimum in the 15th cent. and lasting at least until the 17th cent. (Bystroń 1976). The dye was exported to many countries, e.g. Italy, The Netherlands, Turkey, and others. It was produced from the maggots of a beetle *Porphyrophora polonica* feeding preferably on roots of *Scleranthus perennis* (Gloger 1958), but also on other Ca-

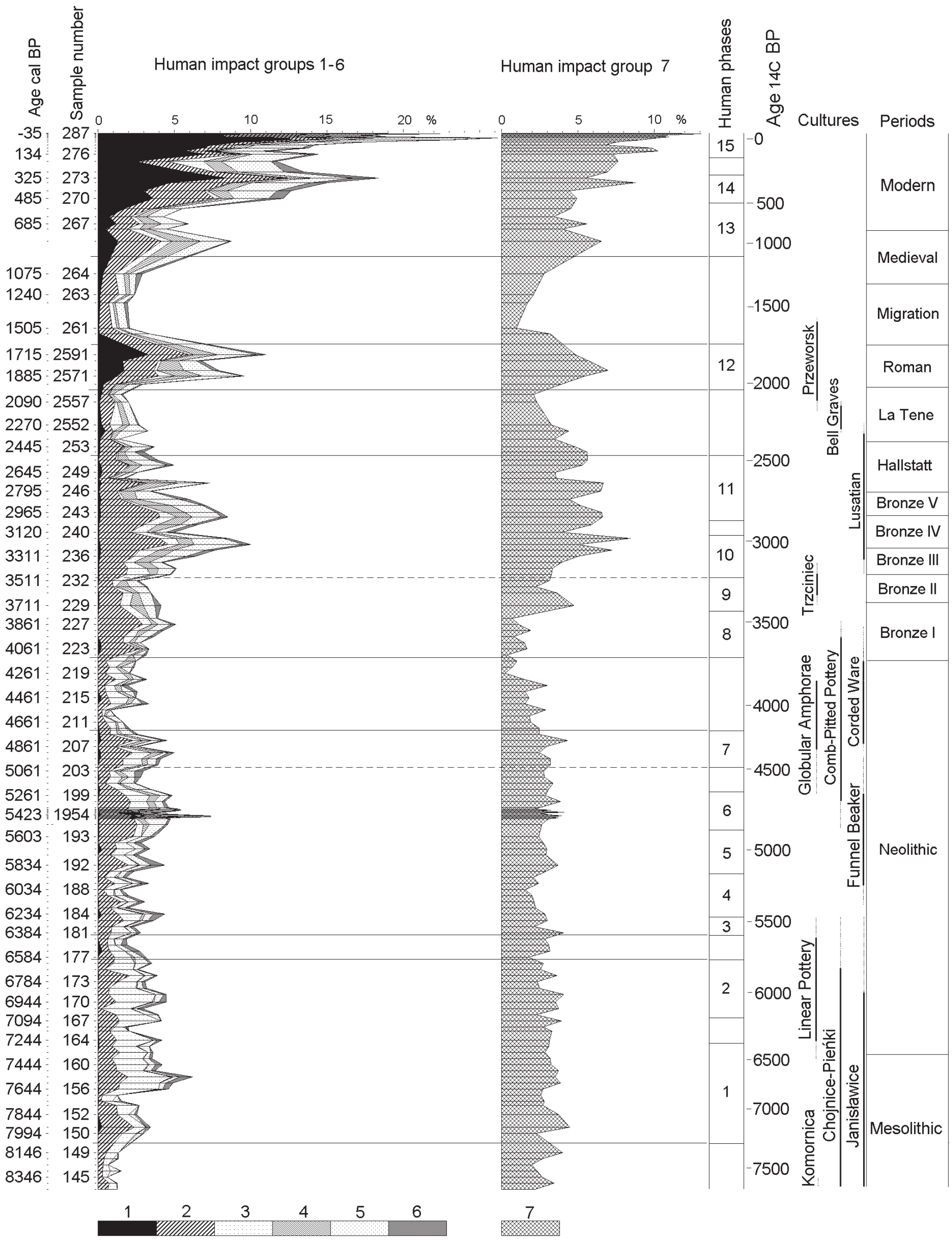

Fig. 9.17. Lake Gościąż, profile G1/87. Synthetic pollen diagram showing the contribution of different types of anthropogenic vegetation in the successive human phases. The grouping, following roughly Behre (1981) and Berglund & Ralska-Jasiewiczowa (1986), has been slightly modified to fit the vegetation types distinguished in this chapter. However no taxa are included in two different groups as in the case of the tables. The following taxa groups are represented: 1 – cultivated land, 2 – ruderals, 3 – grazed woodland, 4 – fresh-wet grasslands (meadows), 5 – dry grasslands (pastures), 6 – mantle/outskirt shrubs, 7 – taxa ecologically undefined (family or genus type rank mostly), but favoured for human use.

ryophyllaceae. In this respect the abundance of sandy soils in the area was an advantage. The occurrence of *Scleranthus perennis* is confirmed by pollen from AD 1625, and later.

Generally, the time of a rather good situation in the rural economy in the Gostynin and Kowal Lands lasted till the end of the 16th cent., and during the 17th cent. it started to deteriorate. The degradation of the country had complex reasons: not only tributes were too high, but also the relation between the agriculture and animal husbandry was wrong; poor soils were overexploited by corn cultivation, for because of too low animal stock they were not fertilized enough and could no more yield enough crop. Peasants began to leave for towns (Szczepański 1990), and this situation affected in turn the towns too by reduction of trade and handicraft. The deepest crisis was reached after the Swedish invasion in 1665–60, when army troops brought pests and epidemics devastating the population. However, local villages survived, and in AD 1674 55 inhabitants in Dąb paid rents, and brewery and iron-works of the region were functioning (Rybicka & Pelisiak, Chapter 9.1.2). The time of reduced economic activities is indicated between AD 1675 and 1760 by a depression in NAP curve caused by declines of all cultivated, weed, and ruderal pollen taxa and by rises of *Quercus, Salix, Populus,* and *Juniperus* pollen values as well as of herbs overgrowing forest openings (like *Melampyrum* and *Calluna*).

Phase 15 (ca. 1800–1985 AD)

The distinct signs of economic restoration of the study area only appear in pollen diagram around the beginning of 19th cent., but the section of the pollen diagram between 1625 and 1816 has again a very poor time resolution (Fig. 9.15). The next pollen spectra up to 1887 register the rise of “economic boom” (in proportions adequate for the regional possibilities), until the time of the 2nd World War, and the following recession in consequence of depopulation and reforestation of Na Jazach Lakes surroundings. However, the youngest period of settlement history in this area from 1663 till today has been reconstructed with a very fine time resolution basing on data from the cores collected by the technique of freezing *in situ* (Goslar, Chapter 9.2.1). This story is presented and discussed in detail by Ralska-Jasiewiczowa and van Geel in Chapter 9.2.4.

Development of different anthropogenic vegetation types through consecutive settlement phases, and comments on some selected taxa

This chapter aims to trace the development of particular anthropogenic vegetation types recorded in the Lake Gościąż profile G1/87 through the subsequent phases of human activities from Mesolithic till modern times. Some discussion on more interesting or controversial pollen taxa is also included.

The pollen data are presented in tables listing taxa typical for the particular vegetation types. The authors are fully aware of the deficiencies of such tables. The grouping, especially when taxa of different taxonomic rank are concerned, could only be very approximate and simplified, as the majority of taxa, even those treated as main cultural indicators, can occur in fact in several different vegetation types (Behre 1981). In some such cases, when we have to do with a species of a broad ecological spectrum (e.g. *Rumex acetosella*), or a higher-rank taxon covering species of different ecological attachments, this taxon is placed parallel in different tables. But, even then, only the most common ecological settings of a taxon are pointed out.

The picture we get in this way is rough and generalised, but it makes the long-term changes of anthropogenic vegetation easily readable, though with inevitable lack of precision.

The subdivision into phases used in tables has partly been simplified as compared with the human phases distinguished in pollen diagram (Figs 9.8, 9.13, and 9.15). The Neolithic phases are grouped in 3 columns: phases 3/4 (human presence weakly indicated, in some distance from the lake), phases 5/6 (human impact distinct, close to the lake), and phase 7 (another Neolithic culture). Also both Early Bronze phases (8/9), Lusatian phases (10/11), and phases of historical to modern times (14/15) are treated jointly.

Vegetation of disturbed/grazed forests (Table 9.6)

Table 9.6 includes taxa overgrowing places within the forests of different types (from mixed deciduous woods on moderately fertile and humid soils to mixed pine and pine woods on rather poor and dry soils), disturbed by man in many ways – e.g. by tree pollarding/coppicing, felling, burning, and forest grazing.

The taxa diversity does not change very much in subsequent columns. It is richer during the later stages of the

Table 9.6. Vegetation of disturbed/grazed forests.

Taxa / Arch. periods / Human phases	BO-early AT		Mesol		Neol			EBr	Lus	Rom	EMed	His/Mod
			1	2	3/4	5/6	7	8/9	10/11	12	13	14/15
Melampyrum	+	+	X	+	+	X	X	+	●	X	+	+
Pteridium aqulinum	+	+	●	●	X	X	X	X	X	+	X	+
Mercurialis perennis			+	+	X	X	X	+	+			
Allium ursinum -t.				+			+		+			
Anemone -t.						+	+	+	+	+		+
Polypodium vulgare	+		+		+	+		+	+		+	
Taxus baccata				+	X	X	●	X	X	+	+	+
Taxa number	3	2	4	5	5	6	6	6	7	4	4	4

+ – sporadic occurrence, X – regular occurrence, ● – abundant occurrence, ( ) – cultivated?
Mesol – Mesolithic, Neol – Neolithic, EBr – Early Bronze, Lus – Lusatian, Rom – Roman, EMed – Early Medieval, His/Mod – Historical to Modern

Table 9.7. Vegetation of forest mantle and outskirt communities (*Rhamno-Prunetea*, *Trifolio-Geranietea*).

Taxa \ Arch. periods	BO-early AT		Mesol		Neol			EBr	Lus	Rom	EMed	His/Mod
Human phases			1	2	3/4	5/6	7	8/9	10/11	12	13	14/15
Frangula alnus	+		+	+	X	X	+	+	X	+	+	+
Rhamnus catharticus			+	X	X	X	+	+		+		+
Viburnum opulus			+	+	+	+	+		+	+		
Sambucus nigra -t.			+	+	+	+		+				X
Sorbus aucuparia			+			X	+		+			
Cornus sanguinea				+	+			+	+			
Rubus						+		+				
Genista -t.									+			
Humulus	+	+	X	+	X	X	X	+	X	X	+	(●)
Melampyrum	+		+	+	+	X	X	X	X	+	X	+
Calystegia sepium			+									
Anthericum	+		+	+		+			+			
Hypericum				+	+	+	+	+	+	+	+	
Geranium				+	+							
Coronilla varia					+	+						
Campanula -t.					+	+	+					
Pimpinella	+				+		+	+				+
Knautia arvensis						+			+			
Anemone -t.						+	+	+	+	+		+
Epilobium									+			+
Taxa number	5	1	9	10	12	14	10	10	12	7	4	(8)7

For explanations see Tab. 9.6

Neolithic (5,6,6) and Lusatian settlements (7) and lower in the Mesolithic (4,5) and Roman and historical times (4,4,4). However, the frequencies of particular taxa are distinctly differentiated.

Pine forests on poor soils were then mostly affected (*Pteridium aquilinum*, *Melampyrum*, *Polypodium vulgare*; see also *Calluna vulgaris* in Table 9.8). The highest amounts of *Pteridium aquilinum* spores in phases 1 and 2 together with *Melampyrum* shows clearly that Mesolithic populations used fire as a main tool in forest "management" (Jacobi et al. 1976, Latałowa 1992a). *Pteridium* never appeared again in such abundance. Deciduous woods might have also been penetrated (*Mercurialis perennis*, *Allium ursinum*). During the later stages from Neolithic II till the Roman period, the nearly continuous and sometimes quite abundant (Lusatian phases) occurrence of *Melampyrum* together with *Pteridium* and *Calluna* may document animal grazing in the pine and mixed forests but burning of forest herb layer as well (Turner et al. 1993). The Neolithic populations disturbed also humid deciduous forests, as is suggested by regular presence of *Mercurialis perennis* during all Neolithic phases. The last appearances of *Mercurialis* and *Allium ursinum* are noted during the Lusatian phase.

An interesting connection with the anthropogenic forest disturbance is shown by *Taxus*. Its pollen, recorded first in the Mesolithic phase 2, occurs rather regularly but in small amounts during the earlier Neolithic phases, rises slightly at the decline of "land occupation" phase 6, and then forms a distinct maximum in the middle of phase 7. In the Early Bronze and Lusatian phases *Taxus* pollen still occurs regularly but never increases in frequencies. Later it appears only rarely.

A similar *Taxus* spread was observed in connection with Neolithic settlements in several pollen diagrams from the British Isles (Watts 1984, Bennett 1988, O'Connell et al. 1988, Peglar et al. 1988). A simple comparison of successional processes in areas belonging to different climatic regions, may cause many doubts. However, such processes are known from Poland still today: *Taxus baccata*, growing mostly in the understory of Fagetalia and Alnetalia forests, can escape from the wood to overgrow an abandoned pastureland. Pfabe (1950) reports such a case from the northern margin of Kraków-Częstochowa Upland in SW Poland, where *Taxus* thickets of ca. 200 specimens covered an old pasture in a wood clearing.

From Roman time on, the indicators of forest grazing are sporadic during the phases of active settlement; their values increase rather when human activities weaken, e.g. during the Migration period, the early Early Medieval time, or in 18th cent. (Figs 9.15 and 9.16). Only *Calluna* abundance increases in the Lusatian and historical times as the indicator of the spread and stabilization of poor acidic pastures and heaths.

Vegetation of forest mantle and outskirt communities (Table 9.7)

Table 9.7 contains taxa belonging to the undisturbed forest communities as well as those that may participate in the advanced overgrowing stages of forest openings. All those taxa are typical today for the forest mantle and outskirt vegetation formed at the forest/open-land ecotone (*Rhamno-Prunetea* Rives Goday et Carb. 1961, *Trifolio-Geranietea* Müll 1962 (Brzeg 1989)). Table 9.7 may therefore illustrate the development of such type of vegetation in connection with prehistoric human activities.

This problem, taken up by Troels-Smith as early as 1955, was then extensively discussed by Groenman-van Waateringe (1976). Neolithic people were assumed to make use of natural growth of forest understory shrubs in places where trees were felled down or coppiced in order to form enclosures to protect arable grounds or pastures from wild animals. Natural hedges would be formed in that way, their specific herb vegetation originating mostly from the forest herb layer. They gave an additional profit by production of edible fruits. Such plant communities have been widespread in Poland till recent times (Matuszkiewicz 1981, Brzeg 1989). Some of their characteristic plants are repeatedly documented as pollen, seeds, or charcoal in connection with the Neolithic settlements (e.g. *Rhamnus catharticus, Cornus sanguinea, Frangula alnus, Viburnum opulus, Sambucus nigra, Sorbus aucuparia, Acer (campestre), Rubus* ssp., *Humulus lupulus, Hypericum, Geranium, Allium ursinum, Anemone nemorosa,* etc.) (Groenman-van Waateringe 1986, Wasylikowa et al. 1991). These taxa occur also in the Lake Gościąż pollen diagram. They are listed mostly in Table 9.7 but also in Table 9.6, and most of them start appearing coincidently with the earliest evidence of prehistoric man. Strikingly, a substantial increase of their diversity starts in connection with the appearance of Mesolithic populations (5 taxa in BO/early AT, before Mesolithic penetrations, 9 during the phase Mes 1, and 10 during Mes 2 – see also Tab. 9.6). This may raise again the discussion of a possible “woodland management” by Mesolithic tribes in order to get a more abundant herb/understory browse for wild animals (Jacobi et al. 1976). The repeated burning is supposed to be used to obtain this effect, but the deciduous wood is not so easy to burn, so the girdling of trees might have been another way to let the light penetrate down to the forest herb layer (Göransson 1986 and earlier papers, Latałowa 1992b). The question of method applied cannot be answered here, but the essence of the problem seems to be evidenced by our pollen data.

During the Neolithic settlement phases the diversity of forest-mantle taxa still increases (Neol. 3/4 – 12 taxa), especially when settlement was supposed to approach the lake (Neol. 5/6 – 14 taxa), and some taxa became also more frequent then (*Frangula alnus, Rhamnus catharticus, Sorbus aucuparia, Humulus, Melampyrum*). However, to fit the image of thorny hedges protecting fields and pastures of Neolithic settlers, such taxa as *Prunus, Crataegus, Rosa* (Rosaceae undiff.?) would be required, but evidence is lacking.

This type of vegetation might have been still relatively widespread during the Early Bronze and Lusatian settlements (10 and 12 taxa), but less and less common later, in connection with changing management methods, and perhaps also in consequence of strong soil degradation.

Vegetation of grasslands on xeric/alkaline to sandy soils (Table 9.8)

Table 9.8 includes pollen taxa that might represent xeric grasslands and swards of habitats on more alkaline (recent *Festuco-Brometea* Br.-Bl. et T. Tx. (1943) class) to rather acidic, poor sandy soils (*Sedo-Scleranthea* Br.-Bl. 1955 em Müll. 1961 and *Nardo-Callunetea* Prsg. 1940 classes, Matuszkiewicz 1981).

The list, particularly in its part concerning more alkaline soils, contains some genera or species types that cannot give any direct ecological information, and their value is rather approximate. However, they may form the ecological setting for such plants as *Sanguisorba minor, Helianthemum* ssp., or *Centaurea scabiosa*. *Plantago media* can occur in the fresh grassland communities as well, but just xeric grasslands were the type vegetation assumed to persist on special habitats in the early-Holocene expansion of forests, and *Plantago media* can be traced in the pollen diagram all the way from the Younger Dryas up. The group of taxa discussed cannot be well separated from those forming the herb layer in the forest mantle and outskirt shrubs (Tab. 9.7). The number of taxa rises first in phase 2, when Mesolithic people created more openings in the woods, then once again in connection with the middle Neolithic “land-occupation” close to the lake (phase Neol 5/6). During the Lusatian phase (10/11) *Plantago media* might have also entered the increasing meadow-like fresh grasslands. Following the processes of soil degradation the vegetation type discussed later lost any meaning.

The group of grassland taxa of poor acidic soils shows somewhat different pattern. Evidently the patches of heliophyte vegetation containing such taxa were naturally present in Boreal forests of looser structure (7 taxa), and they later were limited by the development of dense deciduous woods (AT – 2 taxa). The only taxa of this group documented through the phases 1 and 2 are *Rumex acetosella* and *Calluna vulgaris.* It is rather astonishing that the late Mesolithic populations, which are known to prefer camping in rather open and dry pine woods did not contribute more to the extension of this vegetation type. The number of heliophyte taxa of sandy soils reaches a

Table 9.8. Vegetation of grasslands on xeric/alkaline (*Festuco-Brometea*) to sandy soils (*Sedo-Scleranthea, Nardo-Callunetea*).

Taxa \ Arch. periods / Human phases	BO-early AT		Mesol		Neol			EBr	Lus	Rom	E Med	His/Mod
			1	2	3/4	5/6	7	8/9	10/11	12	13	14/15
Festuco-Brometea												
Plantago media	+	+	+	+	+	+	+	+	X	+		+
Helianthemum num.-t.			+			+			+			
Dianthus -t.				+		+						
Sanguisorba minor				+								
Silene vulgaris -t.				+		+						
Knautia arvensis						+						
Centaurea scabiosa	+							+	+			
Lychnis viscaria -t.									+			+
Ononis -t.												+
Sedo-Scleranthea												
Rumex acetosella -t.	+	+	+	+	+	●	X	X	●	●	●	●
Jasione montana	+				+	+	+	+	+			+
Silene dioica -t.						+	+					
Armeria maritima	+					+						
Gypsophila fas./rep.	+					+						
Scleranthus perennis									+			+
Sedum												+
Nardo-Callunetea												
Pulsatilla vulgaris -t.	+			+		+	+		+			
Scorzonera humilis					+							
Calluna vulgaris	+	+	X	X	X	X	X	X	●	+	●	●
Juniperus communis	+					+	+	+	+	+	+	●
Taxa number	9	3	4	7	5	13	7	6	10	4	3	9

For explanations see Tab. 9.6

maximum in the middle Neolithic phase 5/6 (8) and decreases only slightly in the following late Neolithic phase (6), whereas the heliophyte taxa of richer soils practically disappear then. It might be the effect of a different economy of the Comb-Pitted Pottery population that settled at the lake during phase 7 (less cattle grazing??). In the younger phases, besides some rise during the Lusatian settlement (phases 10/11), the number of acidic grassland taxa is low, although the frequencies of the few remaining ones rather increase. This concerns again the same species: *Rumex acetosella*, which expanded as well in other types of poor soil communities (e.g. segetal weed communities), and *Calluna vulgaris* which together with *Juniperus communis* document the spread of heath patches. The appearance of taxa characteristic for the *Sedo-Scleranthea* class (*Scleranthus perennis, Sedum, Jasione montana*) in historical time (phase 15) could have some relationship with the development of dye-manufactures connected with woollen-cloth production. The commonly used purple dye was then obtained from beetles feeding on sandy soil Caryophyllaceae species (see p. 283, 284).

Vegetation of fresh to wet grassland communities (Table 9.9)

Table 9.9 is meant to represent the fresh to humid grassland communities, which were the nuclei of subsequently formed meadows of *Molinio-Arrhenatheretea* Tx. 1937 class (Matuszkiewicz 1981). Many genus-type or species-type taxa placed here may represent meadow grassland species as well as species of other affinities, but their behaviour in the diagram (e.g. coincident rises of *Plantago lanceolata* and of *Anthemis* -t., *Potentilla* -t., etc.) suggests their essential connection with the communities of meadow type.

The number of taxa in particular phases is rather variable. It apparently rises during the Mesolithic (10 and 10 in phases 1 and 2), and earlier Neolithic (9 in phase 3/4) as compared to the earlier times (5 in BO and 2 in early AT), suggesting the creation of gaps in the forest where light-demanding herb vegetation could develop. During the Neolithic phases 5/6 following the *Ulmus* fall and the land occupation at the lake, the number of taxa is doubled (18), and it is nearly as high as recorded later during the Lusatian phases (20). It is hard to define the differences between middle Neolithic and Lusatian taxa assemblages. The Lusatian list contains some new taxa like *Linum catharticum, Vicia cracca* cf., *Symphytum* (?) or *Cerastium* -t., and some of them (e.g. *Alchemilla* type) appear then regularly in all younger human phases. However, the taxa pattern of the Lusatian phase is substantially different from the middle Neolithic because of increased frequencies of many broad, ecologically undefined taxa in the rank of family or genus type, known as largely contributing to meadow communities (Gramineae, Umbelliferae, Compositae SF. Cichorioideae and SF. Asteroideae, *Filipendula*, and a few others (see the bottom of Tab. 9.9 and Fig. 9.13).

The widely discussed history of meadow formation (Knörzer 1975, Greig 1984, and others) is still not well recognized. If we strictly use the species combination of

Table 9.9. Vegetation of fresh to wet grassland communities (*Molinio-Arrhenatheretea*).

Taxa \ Arch. periods / Human phases	BO-early AT		Mesol		Neol			EBr	Lus	Rom	EMed	His/Mod
			1	2	3/4	5/6	7	8/9	10/11	12	13	14/15
Trollius europaeus			+									
Sanguisorba off.			+			+	+					+
Trifolium -t.				+		+	+		+			+
Rumex acetosa	+	+	+	+	+	+	+	+	+	+	+	+
Rhinanthus			+		+	+	+	+	+	+	+	+
Anthemis -t.			+	+	+	X	+	+	+	+	+	+
Ranunculus acris -t.		+	+	+		+	+	+	X	+	+	+
Potentilla -t.	+			+	+	X		+	X	+	+	+
Geranium				+	+							+
Dianthus -t.				+		+						+
Bellis -t.				+		+			+			+
Lychnis flos-cuc.					+	+			+			+
Lotus -t.									+			+
Lysimachia vulg. -t.							+		+			+
Succisa pratensis							+					+
Plantago lanceolata					+	X	X	X	●	●	X	●
Campanula -t.					+	+	+					
Centaurea jacea -t.						+		+	+			+
Cirsium			+			+			+			+
Trifolium repens						+						
Linum cathart. -t.									+			
Symphytum									+			
Vicia cracca cf.									+			
Cerastium -t.									+			+
Alchemilla -t.								+	+	+	+	+
Taraxacum -t.			+	+	+	+						
Pimpinella	+			+		+		+				+
Serratula -t.										+		+
Lythrum	+		+					+	+			+
Polygonum bistorta												+
Valeriana	+		+			+		+	+			
Taxa number	5	2	10	10	9	18	10	10	20	8	7	23
Undefined:												
Gramineae			X	X	X	X	X	●	●	●	●	●
Umbelliferae	+	+	+	+	+	+	+	+	X	+	+	+
Comp. SF. Asteroid.			+		+	+		+	+		+	+
Comp. SF. Cich.	+	+	+	+	+	+	+	+	X		+	X
Filipendula	X	X	+	+	+	+	+	+	X	+	+	+
Taxa number	3	3	5	4	5	5	4	5	5	3	5	5

For explanations see Tab. 9.6

the present hay-meadows as an indication of meadow formation, the macrofossil evidence of meadows in the Neolithic is practically absent from central Europe (Behre & Jacomet 1991). However, the presence of macrofossils of wet marsh/meadow species being reported from Neolithic sites, e.g. from Switzerland or The Netherlands (van Zeist 1991) and the pollen records often suggest extensive Neolithic clearings for animal grazing. The information on macrofossils of grassland species from the Bronze Age archaeological sites is sparse, the hay-meadow species are still absent, and the species spectra resemble often those of Neolithic sites (van Zeist 1991). Behre & Jacomet (1991) explain it by the long-lasting transformation processes succeeding from pastures to hay-meadows, stimulated later by mowing. The pre-Roman Iron Age is assumed as the time when hay-meadows began to arise (Knörzer 1975, Greig 1984).

All the above listed taxa in the rank of family, genus -t., genus, or species t. showing increased frequencies in Lusatian phase 11 may represent the fresh-wet grasslands of *Molinio-Arrhenatheretea* type. Their rises are signalled already in phase 10, and their presence continues till the end of phase 11 or only a little longer. In the authors' opinion this might express the formation of grasslands in the type of fresh-wet meadows already during the time of Lusatian settlement, though mowing was not necessarily practised then.

The number of wet/fresh grassland taxa becomes distinctly impoverished in the records of the Roman period and Early Medieval time. This might result from the occupation of more fertile grounds by agriculture, the progressive degradation of soils, and a weak population density around the lake. In the later (historical to modern) times, when the lake surroundings were deforested and settled, the number of meadow taxa is at its maximum.

Vegetation of ruderal/field-weed communities (Table 9.10)

Table 9.10 contains taxa of former *Rudero-Secalinetea* class (Braun-Blanquet 1936), later divided into several

Table 9.10. Vegetation of ruderal/field-weed communities.

Taxa — Arch. periods	BO-early AT		Mesol		Neol			EBr	Lus	Rom	EMed	His/Mod
Human phases			1	2	3/4	5/6	7	8/9	10/11	12	13	14/15
Plantaginetea majoris												
Plantago major	+			+	+	X	+	+	+	+	+	+
Polygonum aviculare					+			+	+		+	X
Rumex crispus -t.					+	+	+	+	+	X	+	X
Artemisietea												
Artemisia	+	+	X	X	X	●	X	●	●	X	●	●
Urtica dioica	+	+	X	X	X	●	X	X	X	●	X	●
Silene dioica -t.					+	+			+			
Echium												+
Carduus									+			
Cynoglossum												+
Cirsium			+						+			+
Chenopodietea												
Chenopodiaceae	+	+	+	+	X	X	X	X	X	X	X	●
Stellaria media cf.				●								
Xanthium									+			+
Linaria									+			
Urtica urens												+
Secalietea												
Rumex acetosella	+	+	+	+	+	●	X	X	●	●	●	●
Scleranthus annuus									+			+
Lithospermum arv.									+			
Polygonum persic.												+
Centaurea cyanus												X
Bilderdykia con. -t.												+
Anthoceros punctatus												+
Taxa number	5	4	5	6	8	7	6	7	14	6	7	17

For explanations see Tab. 9.6

different classes: annual or biennial ruderals and root-crop weeds (*Chenopodietea* Oberd. 1957 em. Lohm., J. et R. Tx. 1961), segetal weeds (*Secalietea* Br.-Bl. 1951), vegetation of foot-paths and of other trodden places (*Plantaginetea majoris* R. Tx. et Prsg. 1950), and communities of big perennials of different nitrogen-enriched habitats forming often the more advanced overgrowing stages on ruderal habitats (*Artemisietea* Lohm., Prsg. et R. Tx. 1950) (Matuszkiewicz 1981).

The table is strikingly poor and stable except for the Lusatian phase and historical times. The foot-path vegetation (*Plantaginetea majoris*) is documented by three taxa only, from the earliest Neolithic phases (3/4) (stable occurrence of *Plantago major* and *Rumex crispus* -t. with occasionally appearing *Polygonum aviculare*) till recent times.

The main taxa of *Artemisietea* class (*Artemisia*, *Urtica dioica)* were present in natural communities through the entire Holocene and earlier. They show distinctly increased though oscillating frequencies in all human phases from Mesolithic on, accompanied by a small enrichment of taxa number during the Lusatian settlement and historical times.

The annual ruderals/rootcrop weeds group is practically represented by chenopods only, with very few other taxa (*Xanthium*, *Urtica urens*, *Stellaria media* cf.), appearing in the Lusatian phases and in the youngest historical period.

The group of segetal weeds practically does not exist till the Lusatian phase, as earlier its only representative is *Rumex acetosella*, a species of a broad ecological spectrum. The appearance of some segetal weeds *(Scleranthus annuus*, *Lithospermum arvense*) just during the Lusatian phase is astonishing, as most probably the fields were then mostly located at some distance from the lake, and the evidence of cereal growing is rather poor. Those weeds do not reappear with the well documented development of *Secale* cultivation in the Roman period. The corn-field weeds are best represented in the historical up to recent times by abundant *Centaurea cyanus*, sporadic *Bilderdykia convolvulus, Polygonum persicaria,* and few other pollen taxa together with spores of the therophyte liverwort *Anthoceros punctatus,* which lives in moist field depressions.

The overall representation of weeds and ruderals during the time of Lusatian settlements approximates the numbers (14) noted again in historical times only (17), while it is much lower in all other phases (5–8).

Cultivated and planted plants (Table 9.11)

Table 9.11 contains pollen taxa ranging from field crop plants to fruit and decorative trees and shrubs. Four taxa susceptible to various interpretations have been included here, because of their position in the diagram and way of occurrence. These are *Solanum nigrum* -t., including *S. tuberosum*, which appears exactly at the time when potatoes were introduced in the study region (see also Chapter 9.2.4); *Humulus lupulus* cf., placed also in Table

Table 9.11. Cultivated and planted plants.

Taxa / Arch. periods / Human phases	BO-early AT		Mesol		Neol			EBr	Lus	Rom	EMed	His/Mod
			1	2	3/4	5/6	7	8/9	10/11	12	13	14/15
Cerealia -t.		(+)	(+)			+	+				+	X
Triticum -t.			(+)	(+)	+	+	+		+	X	+	X
Hordeum -t.			(+)		+	+	+	+	+			X
Secale cereale									+	●	X	●
Avena -t.												X
Vitis vinifera ?						(+)						+
Cannabis sativa cf.								+	+	●	+	●
Fagopyrum												X
Juglans										+		+
Malus cf.?								+				+
Medicago sativa												+
Zea mays												+
Solanum nigrum -t.												X
Syringa vulgaris												+
Aesculus hipp.												+
Glaucium flavum												+
(*Humulus* ?)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	+	+	●
(Cruciferae ?)			(+)	(+)	+	+	+	+	+	+	+	X
Taxa number	(1)	(2)	(5)	(3)	3(4)	5(6)	4(5)	4(5)	5(6)	6	6	18

For explanations see Tab. 9.6

9.7, but showing a distinct rise in the historical time; Cruciferae, their only substantial increase occurring in historical time too, and *Vitis vinifera*.

The record of Cerealia starts with sporadic big Gramineae pollen grains of the type of *Hordeum, Triticum,* and Cerealia undiff., found in both Mesolithic phases and also earlier. As mentioned by Ralska-Jasiewiczowa and van Geel (1992) those pollen grains, especially *Hordeum* -t., may originate from wild grass species (see Beug 1961, Andersen 1979). "Cereal-like" Gramineae pollen was sometimes observed in pre-agricultural zones of pollen diagrams; speculations on its origin include possibilities of polyploid forms or of wild Gramineae species not identified palynologically so far.

In Mesolithic phase 2 the transport of single cereal pollen from the nearest early-Neolithic settlements cannot be excluded (Chapter 9.1.1). This possibility should also be taken into account regarding Neolithic phases 3/4. In the following Neolithic phases 5/6 and 7 the representation of cereals is substantial enough to suggest agricultural practices proceeding in the study region.

From Early Bronze phases the cereal evidence is practically absent, and only the Lusatian and Roman phases give a rather reliable evidence of cereal cultivation. This includes *Triticum* -t. and *Hordeum* -t. during the Lusatian settlement, in agreement with the general palaeoethnobotanic knowledge about the grain cultivation during this period (Wasylikowa et al. 1991).

During the Roman phase 12 *Triticum* was grown and *Avena* -t. pollen appears for the first time, but *Secale cereale* undoubtedly became the dominant cultivated cereal.

Increased pollen frequencies of *Secale* were observed in pollen diagrams from different parts of Poland in sections corresponding to the Roman period (Noryśkiewicz & Ralska-Jasiewiczowa 1989, Bińka et al. 1991, Latałowa 1992b, Ralska-Jasiewiczowa & Latałowa 1996), and in some sites from S-Poland even earlier (Ralska-Jasiewiczowa 1980, Szczepanek 1982). The hypothesis assuming the change of rye status from weed to cultivated plant was discussed in detail by Behre (1992). On the basis of macrofossil finds he specifies the time of this change from the pre-Roman to the Roman periods, but the main expansion of *Secale* cultivation in central Europe assuming in Medieval time only. Some of his data, however, document the cultivation of rye as a main crop on poor soils in NW Germany since the Roman period. The macrofossil data from Poland compiled by Lityńska-Zając (1997) suggest that rye was grown in South Poland as early as the late pre-Roman period, it was present (?) in the grain-fields of middle-Polish areas occupied by the Przeworska Culture during the Roman period, and its role was substantial in the territories of the West Balt Culture (NW Poland) in the late Roman period. Wasylikowa et al. (1991) concludes from both macrofossil and pollen evidence that rye cultivation, also as monocultures, was practiced in the Roman period in all of Poland. The data from Lake Gościąż fit this pattern quite well. The Early-Medieval record (phase 13) gives evidence of rather poorly developed agriculture with the continuous occurrence of *Secale* alone, and only the later historical and modern phases (14 and 15) document the presence of all cereal types in cultivation, with *Secale* being still the dominant crop.

The origin of a single *Vitis* pollen grain found in middle Neolithic phase 6 is unclear. It seems rather well documented by now that wild *Vitis vinifera* ssp. *sylvestris* occurred in different parts of Poland during the warmest periods of the Holocene, growing in the humid forests, probably of alderwood type (Latałowa 1976, Ralska-Jasiewiczowa 1980, Madeyska 1989, Bińka et al. 1991). At Błędowo Lake (central Masovia, ca. 100 km to the east of Lake Gościąż, Bińka et al. 1991, see Chapter 8.3), two of *Vitis* pollen finds coincide with Neolithic phases, as in the Lake Gościąż profile. No evidence from the archaeologic sites of Poland exists, however, about the cultivation of wine until Early-Medieval times (Wasylikowa et al. 1991). Some more evidence is still needed to try to find any explanation to those pollen finds.

Malus cf. pollen in Early Bronze phase (Fig. 9.14) possibly could have been brought from a wild *Malus* stand. *Malus sylvestris* seeds are often found in archaeological sites from former Czechoslovakia and also from Poland since Neolithic times (Wasylikowa et al. 1991). One *Juglans* pollen grain around the onset of Przeworska Culture phase 12 at ca. AD 1 has no explanation, as the earliest data about the cultivation of *Juglans regia* in Poland comes from the Early-Medieval time (Wasylikowa et al. 1991).

Table 9.11 includes also the record of *Humulus lupulus* cf. and *Cannabis sativa* cf. pollen. *Humulus*, as a native component of humid woods, was present in the area from the beginning of the Holocene, well before the formation of alderwoods. However, a distinct rise in its pollen curve in historical times only (phase 15) was probably the effect of its cultivation, connected with the large-scale production of beer. The common macrofossil finds and written sources evidence the cultivation of hops in Germany from early-Medieval times (9/10 cent. AD, Behre 1984). According to Nowiński (1970), on the territories inhabited by Slavs beer-brewing was known much earlier, in pre-Christian times. It seems reasonable to assume that hops were then gathered from their wild stands, in our case abundant in alderwoods surrounding the lakes. At any rate our pollen data give no grounds for speculation about intentional growing of *Humulus* before the 15th century.

The identification of *Cannabis sativa* cf., which in fact means its separation from *Humulus lupulus* pollen, was based mostly on pore protrusion, with the pollen-grain size and wall thickness treated as complementary diagnostic features (Godwin 1967, French & Moore 1986). Though always difficult (see Whittington & Gordon 1987, Whittington & Edwards 1989), it seems in this case to be reasonably reliable, giving at least approximate contribution of both taxa to the pollen spectra. In the Lake Gościąż profile *Cannabis* type begins to appear sporadically from the later part of Lusatian phase 11 (ca. 2700 cal BP = 2500 ^{14}C BP, Halstatt C/D), including the following depopulation time during the La Tene period. These are very early finds and may concern untypical *Humulus* pollen. The first substantial *Cannabis* maximum occurs during the Roman period, and after a break during the Migration time, it is noted continuously, though with low frequencies throughout the Medieval and Modern times, forming another maximum only between AD 1420 and 1650. In Bjäresjö, southern Sweden (Gaillard & Berglund 1988), the pattern is different, the Cannabaceae (?) make the first small rise during the Roman period and a massive maximum during the Early Medieval (Vendel/Viking time). The authors quote the data suggesting the introduction of hemp cultivation in Sweden in the first centuries AD. Dörfler (1990) in his synthetic work on *Cannabis* history in central Europe assumes the possibility of its local introduction in Germany (Hochdorf) as early as in the Pre-Roman period, and documents the spread of *Cannabis* cultivation from the areas south of the Alps far northwards during the Roman period.

In some pollen diagrams from Poland *Cannabis* appears coincidently with the first rise of *Secale* pollen at the time of the supposed Roman period (Ralska-Jasiewiczowa 1981, Szczepanek 1987, 1989, Bińka et al. 1991, Noryśkiewicz 1995), but not all profiles are well dated. On Wolin Island (NW Poland) it was found in small quantities during the pre-Roman period (Latałowa 1992b).

Macrofossil finds of *Cannabis sativa* were reported from South Poland, Cracow area, from La Tene and Early Roman periods (Wielowiejski 1981), but its common cultivation in Poland is documented only from the Medieval time (10th century AD), as in Czech Republic and Slovakia (Wasylikowa et al. 1991). According to Nowiński (1970), hemps (*C. indica*) were first known as hashish and later used for fibre and oil, but still prepared dry; the retting was discovered much later, and probably only since then *Cannabis* cf. pollen was found in the pollen spectra from lacustrine sediments more often and in higher frequencies. Nowiński assumes an essential role of pre-Slavonic populations in the transference of *Cannabis* cultivation from Asia westwards; the Scythian invasions would be an important stage of this process.

The data above show that the first substantial spread of *Cannabis* cultivation during the Roman period is well documented, not only from the south, but also from lowland Poland. We cannot exclude its first appearance in connection with the Scythian incursions into Poland that reached also the Kujavia and Toruń regions around 2600–2500 cal BP (Godłowski & Kozłowski 1979).

The Cruciferae pollen curve was also listed in Table 9.11. This, of course, must be controversial, because there is no possibility to separate the pollen of cultivated crucifer species from the wild ones. Cruciferae, occurring sporadically from the time of Mesolithic settlements, might have originated from any type of open herb vegetation. However, a massive rise of Cruciferae curve late in historical times resulted undoubtedly from the cultivation mostly of edible oil or medical crucifer plants (e.g. *Raphanus*, *Brassica*, and accompanying weeds like *Sinapis*, *Capsella*, *Sisymbrium*, and other genera). It is shown more precisely in the fine-resolution pollen diagram of the last 330 yr (Chapter 9.2.4).

Syringa vulgaris, *Aesculus hippocastanum* were first planted, and *Glaucium flavum* appeared in late-historical times.

The indicator value of remains of Cyanobacteria

In an early stage of our analysis of pollen and other microfossils of the Gościąż-material it became evident that two types of – at that time still unknown – characteristic, grey-coloured, cigar-formed, 15–60 μm long microfossils often were abundant to extremely abundant, especially during the second half of the Holocene. Our efforts to identify these fossils with the help of colleagues were successful, and Ralska-Jasiewiczowa & van Geel (1992) could illustrate one of these ‘Types’ as the akinetes of *Aphanizomenon* (Cyanobacteria, formerly called Blue-green algae). In first instance it was already evident that the phases of high representation of these akinetes had to be interpreted as an indication for eutrophication of the lake water, but the mechanism was not yet completely understood by us. With the records of the late Holocene deposits it became even more urgent to fully understand the increases of Cyanobacteria, especially because curve matching showed that the curves of akinetes of *Aphanizomenon* and *Anabaena* paralleled the pollen curves of herbaceous upland taxa that are human impact indicators. The full interpretation of blooms of Cyanobacteria as reflected in our fossil record could be given by Van Geel et al. (1994, 1996), after having consulted Dr L.R. Mur, who is an expert in the study of blooming of Cyanobacteria in relation to pollution of fresh-water lakes.

The first rise of *Aphanizomenon* frequencies in pollen samples that could be connected with some human interference into the natural ecosystem of the lake appeared at the decline of the late-Mesolithic (phase 2, around 6600 cal BP = phase II in Ralska-Jasiewiczowa et al. 1992). Its much higher values (approaching 1000 %) were then reached during the time when the terrains very close to the lake were occupied by the population of the Neolithic Funnel Beaker Culture (phase 6 = phase IIId in paper quoted above, ca. 5500–5200 cal BP). Once again the high rise of *Aphanizomenon* occurred during the Late Neolithic (ca. 1200 %, phase 7 = phase IV in paper quoted above, ca. 4800–5000 cal BP). The settlement of Comb-Pitted Pottery Culture was situated directly at the lake then, and inhabited this area during a fairly long time. Throughout the Bronze and Early Iron Ages, and the Roman Iron Age, the frequencies of Cyanobacteria remain low (Van Geel et al. 1994), suggesting lack of strong anthropogenic influences on the lake itself. Considerable blooms of Cyanobacteria started only during the Early-Medieval times, after AD 1000.

The interpretation of the fossil Medieval record does not differ from the present situation in polluted lakes: phosphorous enrichment from effluent and excreta in the catchment area of the lake can at times become so high that nitrogen-limited growth conditions occur. In such conditions Cyanobacteria, capable of active nitrogen fixation, became very efficient in the competition with the green algae and they showed strong increases, often with negative effects for other organisms as a consequence of the production of toxic substances by the Cyanobacteria. However, in the deposits representing the last ca. 330 years (Goslar et al. in print) there was a decline of Cyanobacteria and Chlorophyta (green algae) took over the dominance. This is interpreted as the effect of a change from nitrogen components as a limiting factor (as a consequence of phosphate eutrophication) to light as a limiting factor, under conditions of extreme eutrophication and increased turbidity as a consequence of dense algal populations. The process of nitrogen fixation is an energy (light) consuming process and in conditions where Chlorophyta are able to survive and to live in water with a dense population of algae, the Cyanobacteria lose their strong position in the competition as a consequence of lack of sufficient light.

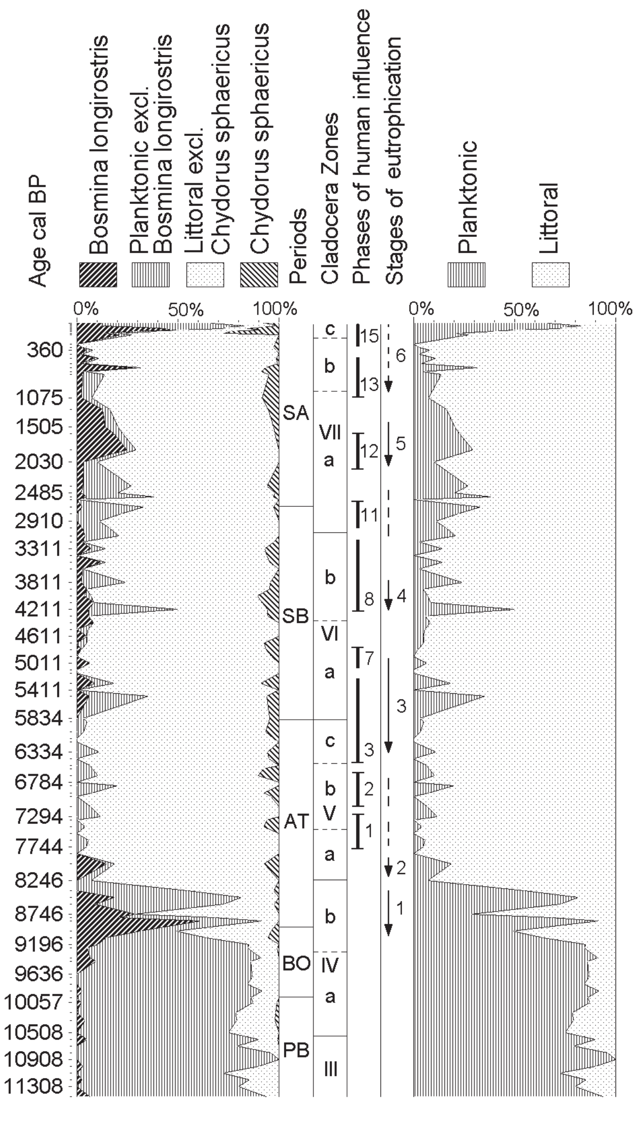

Fig. 9.18. The planktonic/littoral ratio in the cladoceran stratigraphy and eutrophication in profile G1/87 (Holocene) in comparison with the pollen zonation and phases of human influence (after Ralska-Jasiewiczowa & van Geel, Chapter 9.1.3).

9.1.4. Correlation between human activity and trophic stages in Lake Gościąż development based on cladoceran analysis

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Results of Cladocera analysis are very important and useful for reconstruction of the history of lakes and of lake trophy, usually connected with human activity. Cladocera remains have been present in Lake Gościąż from its initial period until the present day.

According to concentration and percentage diagrams of species composition (Figs 9.18, 9.19 and Fig. 8.30 in Chapter 8.4), and in particular the curves of *Bosmina longirostris*, *Alona rectangula*, and *Alonella exigua*, increased trophy existed in Lake Gościąż in periods: 9100–8500, about 8000, 5800–5200, 4200–3800, 1800–1400, and 600–100 cal BP.

A considerable increase of trophy was noted before the record of human impact begins, in the sediments accumulated during the time 9100–8500 and about 8000 cal BP. It was registered by a drastic expansion of the eutrophic species *Bosmina longirostris*. This increase of trophy was probably a result of changing climate.

The stages of increased trophy partly correlate with phases of human activity identified on the basis of palynological analysis, partly supported by results of archaeological research (Pelisiak & Rybicka 1993, Pelisiak & Rybicka, Chapter 9.1.1. and 9.1.2., Ralska-Jasiewiczowa & van Geel, Chapter 9.1.3). Therefore, it may be supposed that the increase of trophy in the lake was provoked by the activity of people settled near the lake. Such a relation was also confirmed in the studies by Alhonen