SYMPOSIUM ON LLANGORSE LAKE: THE ECOLOGY AND CONSERVATION OF A LARGE NUTRIENT-RICH LAKE IN SOUTH WALES

A report from Dr Catherine Duigan (Countryside Council for Wales, Bangor) and Stuart Reid (Countryside Council for Wales, Abergavenny).

Introduction

A meeting to discuss the ecology and conservation of Llangorse Lake was organised by the British Ecological Society (Aquatic Ecology Group), in association with the Countryside Council for Wales (CCW), Brecon Beacon National Park Authority (BBNPA) and Environment Agency Wales. It took place on 22 October 1998 at the Castle of Brecon Hotel. Presentations were given by staff and researchers at the Countryside Council for Wales, University of Wales, University College London, University of Hertfordshire, Cheltenham and Gloucester College of Higher Education, National Museum of Wales, and the Royal Society for the Protection of Birds. Over 80 delegates attended and they included representatives of Brecknock Wildlife Trust, Llangors Sailing Club, Llangorse Lake Users Group, Plaid Cymru, Brecon Town Council and the organising bodies.

Malcolm Smith (Senior Director, CCW) welcomed all the participants and explained the background to the meeting. The British Ecological Society awarded CCW a grant to cover the majority of the costs associated with this meeting. This is the fifth freshwater symposium which has been initiated and organised by the Countryside Council for Wales. The assistance given by partner organisations - Brecon Beacons National Park Authority and the Environment Agency Wales - with this venture was gratefully acknowledged.

A special welcome was extended to the owner of the lake and representatives of the lake users and local community. It was reassuring to see that there is such a keen interest in the welfare of Llangorse Lake locally, as a partnership approach is essential for the conservation of lakes. It was acknowledged that all the people who live within or visit the catchment of Llangorse have a potential effect on the lake's environment (Fig. 1). This lake has been used and influenced by people since prehistoric times, and today it is important that people's enjoyment of the lake continues to go hand in hand with conserving the natural features found here. Indeed, if conservation measures are effective, everyone's enjoyment of the lake and its surrounding area will be increased.

The primary objectives of the *Llangorse Lake Symposium* were: (1) to carry out a comprehensive review of the ecological and conservation status of Llangorse Lake; (2) to assess the current environmental status of the lake, with a view to developing the future management of the site; and (3) to

provide a public forum for the presentation and discussion of recent scientific research on the lake, with the aim of reaching a consensus on some of the major issues.

Malcolm reminded us that some of the oldest records for algal blooms in Britain originate from Llangorse Lake. Giraldus Cambrensis passed this way in 1188 with Baldwin, Archbishop of Canterbury on a tour of Wales. He reported in his diary that "I *have determined not to omit mentioning those occurrences worthy of note which happened in these parts in our days. It came to pass before the great war in which nearly all this province was destroyed by the sons of Jestin, that the large lake and the River Leveni which flows from it into the Wye opposite Glasbury, were tinged with deep green colour. The old people of the country were consulted and answered that a short time before the great desolation caused by Howel, son of Meredyth, the water had been coloured in a similar manner".* It appears that this concern about the colour of the water in Llangorse Lake has spanned the centuries, and it is largely responsible for the organisation of the present symposium. However, the delegates were fortunate that they could apply scientific principles to understand what were considered to be the mysterious properties of Llangorse Lake water.

In 1993 the CCW and the other national wildlife agencies were asked to select sites as the best examples of a range of important and threatened habitats in Europe, for the Government to put forward as candidates for Special Area of Conservation (SAC) status under the EC Habitats Directive. Llangorse Lake is now on track to become a unique Welsh component of a series of internationally important sites which will stretch across Europe, referred to as the Natura 2000 series, and recognising Llangorse as one of Europe's most precious lakes. In addition, as part of the government's response to the Rio Convention on Biodiversity, a Habitat Action Plan for eutrophic (nutrient-rich) lakes has been produced. Llangorse Lake will feature as a flagship site for this particular type of lake in Wales. For many years, Llangorse has given rise to much concern and debate over impacts on its ecology from a variety of sources. This is still the case, and it was hoped that the symposium would allow a good airing of the issues and help to formulate views on management for the future. In particular, it will greatly assist with the development of a site-specific management plan in partnership with the owners and other interested parties.

Malcolm forewarned the audience that they would hear there have been recent positive environmental signs at Llangorse, and hoped that all would be able to leave at the end the day with more optimism for the future of the lake than there has been for some time. However, the signs of improvement do not mean we can be complacent and assume that a full recovery will follow. The diversion of sewage away from the lake appears to have been a critical and helpful factor, but it is not the only factor involved, and the symposium was

FIG. 1. Land-use adjacent to Llangorse Lake (9 July 1998). (Photograph by C. Duigan).

FIG. 2. Llangorse Lake, vegetational transition from open water through floating and emerged plant communities to woodland (9 July 1998). (Photograph by C. Duigan).

FIG. 3. *Potamogeton perfoliatus* in Llangorse Lake (9 July 1998). (Photograph by C. Duigan).

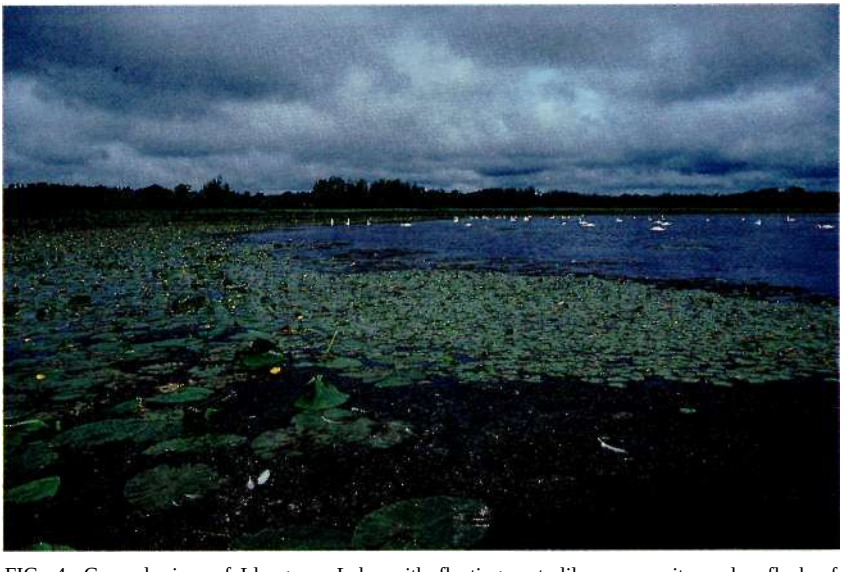

FIG. 4. General view of Llangorse Lake with floating waterlily community and a flock of moulting swans (9 July 1998). (Photograph by C. Duigan).

asked to address the parts played by all influences, with a view to making decisions for the future. Everyone's views were sought.

Session One: Yesterday and Today - Martin Fitton (National Park Officer, BBNPA) chairperson

The meeting began with an account of the Quaternary history of Llangorse Lake, given by **Frank Chambers** (Cheltenham and Gloucester College of Higher Education). The Llangorse region was subject to repeated glaciation in the late Quaternary, and the lake catchment was completely covered with ice during the Last Glacial Maximum (ca. 22,000 BP). "Proglacial Lake Llangors" was a much larger lake than its current representative. The early shorelines are still visible at 190 m OD, which is approximately 37 m above the present lake level. It is also thought that this lake overflowed south at two points, into the River Usk. The accumulation of morainic debris, following further ice advances, eventually led to the formation of a new outflow to the north and a major drop in lake level. In the cold, steppe-tundra environment of the late Devensian, the lake basin started to fill with clay, sometimes in the form of laminated sediment sequences. Marls deposited within this period are thought to represent a relatively warm period but then there was a return to inorganic sediments, coincident with the Loch Lomond stadial. With the onset of warmer climate conditions in the early Holocene, catchment soils appeared to stabilise and organic mud and marls accumulated. Pollen data suggest that the open-ground communities were invaded by juniper *(Juniperus)* scrub and eventually by closed-canopy woodland, which included birch *(Betula)* and pine *(Pinus).* Immediately before humans arrived in the area, alder *(Alnus)* was a dominant component of the catchment woodland, in association with lime *(Tilia)* and ash *(Fraxinus),* and lake sediments then had a high organic content, a carbonate content of less than 10%, and a very slow accumulation rate (ca. 1.0 cm per 100 years).

Significant environmental changes were associated with the latter half of the Holocene. There is a major decline in *Ulmus* pollen, accompanied by records of plant taxa associated with humans (e.g. plantain and grasses). Although there were some changes in the ratio between arboreal and non-arboreal pollen, it seems that a diverse woodland existed during the Neolithic. Human impact increased during the Bronze and Iron Ages, which is reflected in an increased sediment accumulation rate. The period 2000 BP to AD 1700 can be summarised as a time of major human influence in the catchment, which involved large-scale tree clearance and soil cultivation primarily for cereals. These environmental changes are reflected in lake sediments, which change from black organic muds to red-brown silt clay that was accumulated at a relatively fast rate. Further evidence suggested that the rate of basin infill has accelerated even further in recent times - in the eastern basin, 90 cm of

sediment has been built up in the last 300 years, of which the upper ca. 65 cm accumulated in less than 150 years. Frank concluded his talk by stating that unless allochthonous inputs of sediment are reduced, the lake will not persist for the remainder of the Holocene.

Mark Redknap's presentation on the archaeology of Llangorse Lake, focused on findings from the partial excavation of the crannog which was carried out in 1989-1993 by the staff of the National Museum of Wales. Many early mysterious references to the wooden structures and houses within the lake seem to reflect a long cultural memory of the crannog. However, the first historical examination of the site was not carried out until 1867, when the remains of the site were revealed following a lowering in lake level caused by modifications to the channel of the Afon Llynfi. The earliest recovered artifacts included what are considered to be Mesolithic flint, chert and polished stone (ca. 8000 to 3500 BC) and Neolithic arrowheads (ca. 3500 to 2000 BC). Roman Age artifacts were shards of pottery, a tile, and a copper alloy Dolphin brooch. It was evident that wooden remains had preserved very well in the lake mud and it was established that the wood used in the palisades was felled between the years AD 889 and 893. The island had been periodically extended during the years of occupation but no house structures were discovered. Artifacts associated with the occupation of the crannog were found distributed throughout the sediments surrounding the island, and included fragments of high-quality textile, a Bronze Age hinge from an 8/9th century shrine, bone combs, beads, animal bones and other products of everyday life.

The natural materials found associated with the crannog also provide a valuable record of palaeo-environmental conditions. For example, the timber used is a reflection of the woodland resources available at the time - oak *(Quercus),* alder *(Alnus),* ash *(Fraxinus),* poplar *(Populus),* willow *(Salix)* and Hazel *(Corylus).* Plant macrofossils included a range of charred cereals, mainly wheat *(Triticum)* and hulled barley *(Hordeum).* The site is currently being eroded along its south and west margins by wave action, and sediments are being deposited on the north-east side. It is also subject to flooding and water-level drawdown.

The island was abandoned in the early 10th century and vegetational succession has taken place. This has led to some concern with regard to the impact of natural processes on the historic features. For example, *Phragmites* root growth is damaging the archaeological deposits; there is evidence of desiccation and collapse of some of the remains, following periods of low water levels, and the action of moles *(Talpa europaea)* has the potential to disturb and contaminate the archaeological deposits. Modern human activity has also caused damage, e.g. breaking of palisade timbers by boats. Reference was made to a management plan under development, which is seeking to control vegetation, animals and humans, and the action of water, in order to

protect the archaeological deposits while still maintaining aspects of the ecosystem. An unsuccessful attempt to create a protective barrier from the effects of erosion, using barley-straw bales, was described. The use of a geotextile cover is now being evaluated with a view to wider consultation with interested parties. Mark concluded his talk with a reiteration of the archaeological importance of Llangorse Lake crannog, which is unique in Wales and considered to be of international significance.

The objectives of the next talk, given by **Catherine Duigan** (Countryside Council for Wales), were: (1) to give an introductory account of the current ecological and conservation status of Llangorse Lake, (2) present the findings of a recent limnological survey carried out by ENSIS Ltd for CCW, and (3) to identify and discuss some of the management issues. Catherine described how a combination of ecological features, such as the aquatic flora, transitions of vegetation (Fig. 2), and rare species of plants and animals, makes Llangorse Lake an important conservation site. Above all, it is a shallow, nutrient-rich lake system with a large number of plant and animal species, and can therefore be described as a "biodiversity hot spot". It was first designated as an SSSI in 1954 (renotified in 1983) and the citation focuses on the lake's nutrient-rich character and high biodiversity and productivity. More recently the lake has become a candidate Special Area of Conservation under the EC Habitats Directive, as an example of a natural eutrophic lake with Magnopotamion-type vegetation (i.e. broad-leaved pondweeds).

A limnological survey was carried out in 1995-96. The lake has two basins; maximum depth is ca. 7.5 m but a substantial proportion of the lake is less than 2 m deep; the surface area is 139 ha.

In a Welsh context, the lakewater is particularly alkaline (pH 8; alkalinity 2446 microequivalents per litre annual mean), nutrient-rich (total phosphorus 117.8 μg P per litre, annual mean) and productive (chlorophyll-a 31 μg per litre in April 1996). Complete deoxygenation of the water below 5 m was recorded. The epilithic diatom assemblage was very diverse and composed of 23 taxa, including *Amphora pediculus, Cocconeis placentula, Fragilaria pennata, F. brevistriata* and *Nitzschia dissipata.* In general, this assemblage was considered indicative of alkaline conditions with a good supply of nutrients. In contrast, the epiphytic diatom assemblage was less diverse (9 taxa) and dominated by *C. placentula* and *Achnanthes minutissima.* The surface-sediment diatom community was dominated by planktonic taxa that are also indicative of nutrient-rich, alkaline waters; *Aulacoseira subarctica* was the dominant species. *Phragmites australis, Scirpus lacustris* ssp. *tabernaemontani* and *Typha latifolia* were represented in the fringing emergent vegetation. *Nuphar lutea, Nymphaea alba, Nymphoides peltata* and *Polygonum amphibium* were the most frequently found floating-leaved taxa. The presence of *Potamogeton perfoliatus* (Fig. 3), *P. lucens* and *P. crispus* confirmed the lake's importance as an example of a lake with Magnopotamion

vegetation. *Sida crystallina* was the most abundant component of the zooplankton in the littoral, and this species is known to prefer well vegetated habitats with clear water. *Daphnia galeata* (in association with 5 copepod taxa) dominated the open water zooplankton community. A diverse assemblage of macroinvertebrates with a large number of individuals was found, with oligochaetes being most abundant. The general conclusion from the survey was that Llangorse Lake is an alkaline, nutrient-rich system as reflected in its flora and fauna.

Catherine then showed how this type of lake tends to exist along an environmental gradient between a plant-dominated, clear water state, and a phytoplankton-dominated turbid water state. It was highlighted that any management of the site would need to pay particular attention to the environmental factors (e.g. herbicides, mechanical damage to plants, and exotic fish species) which can cause the lake to switch to the phytoplankton-dominated condition. *Nymphoides peltata* and *Elodea canadensis* were given as examples of non-native plant species present in the lake. It is believed that bream *{Abramis brama)* were introduced in the early 1970s. The debate about the effects of waterborne recreation at Llangorse extends back to 1925, when a member of the lake's management committee suggested that motor boats were detrimental to fish and birds. Under the present recreational levels it was acknowledged that there has been a significant recovery of the lake ecosystem from the effects of enrichment. The people and organisations with a role in the management of Llangorse Lake were identified (e.g. BBNPA, local people, CCW and EA). It is anticipated that aspects of the management of the lake will be advanced through the Biodiversity Action Plan process, as a requirement for maintaining its status as an SAC, and through an SSSI management plan and the Local Environment Agency Plan for the Wye catchment.

In summing up this session, Martin Fitton expressed his concern about the increased sedimentation rate in the lake (as presented in the talk by Frank Chambers) and he asked if it would be appropriate to consider dredging Llangorse Lake. In response, Catherine Duigan stated that our objective should be to slow down this natural process if it is being exacerbated by human activities. Dredging would cause large-scale disturbance to the lake system and its wildlife, and it would not be compatible with the conservation management of the site.

Session Two: The Aquatic Environment - Ray Woods (Area Officer, CCW) chairperson

Ray Woods introduced the next speaker - **Kathryn Benson-Evans** (University of Wales) - as the person who probably knows more about the ecology and functioning of Llangorse Lake than anybody else, as she has been

working on aspects of the site for thirty years. Kathryn's paper focused on physico-chemical and algal studies carried out at Llangorse, at intervals from 1961 to the 1990s, in order to establish seasonal variations and effects of climate fluctuations and interference by humans on the lake ecosystem. In particular, intensive fortnightly sampling was carried out from 1972 to 1975, when treated sewage from Llangorse Village, agricultural runoff, and power-boat disturbance, could have been affecting water quality. Studies after this period assessed the response to the diversion of the sewage.

In this shallow lake system, algal blooms were found to be positively correlated with increased dissolved silica, orthophosphate, ammonia, BOD, pH, wind action and rain. Thermal stratification occurs only in brief, windless, hot periods in summer. The lake has remained alkaline throughout the 30-year study period, varying from pH 7.5 to 9.2, with higher readings usually in the warmer months. Dissolved ammonia values were relatively low in the 1960s; they increased in the 1970s, particularly in the autumn and early winter months and, in general, they decreased again in the 1980s. It was evident from the cell counts of phytoplankton from the surface waters that the greatest algal production was in summer and early autumn. In the 1960s the Cyanobacteria (Myxophyta) were the most common, together with the Bacillariophyta. Representatives of the Chlorophyta increased over the years, as did those of the Bacillariophyta. The Cynobacteria decreased in the 1980s. The main conclusion was that the overall water quality of the lake has improved since the diversion of the sewage away from the lake. However, the lake water is likely to remain rich in nutrients for some time, partly as a consequence of the large nutrient store in the sediments.

Max Wade (University of Hertfordshire) began his talk on the aquatic macrophytes of Llangorse with some remarks about the long history of botanical interest in this lake (Fig. 4). The earliest records of plants are those of Edward Lhuyd who visited the site in 1698; he referred to Chara being present and a "pellucid plant Subularia" which is now thought to be *Potamogeton lucens.* The first recorded impact by humans on the aquatic flora of Llangorse was the introduction of *Elodea canadensis* and *Nymphoides peltata,* probably in the early 1900s, which brought about a shift in the dominance of both the submerged and floating plant communities.

The review undertaken in this presentation concentrated on the results of surveys and observations made over the period 1961 to the present, during which the flora has remained largely the same in terms of species composition but has undergone significant changes in the abundance of some species. These changes were especially noticeable over the period 1961 to 1982, which saw a dramatic decline in both number and extent of submerged species. This was followed by a recovery phase. A marked change in species composition had taken place by 1972-73 when *Potamogeton pectinatus* and *Zannichellia palustris* were most abundant, having displaced *Myriophyllum spicatum.* Both

of the former species are characteristic of eutrophic conditions, *P. pectinatus* often being an indicator of community change, especially where the species is dominant. The continued enrichment of the lake led to further declines in the condition of the submerged flora until, by 1982, only *M. spicatum* and fragments of *Potamogeton crispus* were found in the lake. Following the diversion of sewage away from the lake, a recovery in the submerged flora was quickly evident. A survey carried out in 1985 revealed that *M. spicatum* and *P. pectinatus* were the most abundant species, and they occurred in association with four other taxa, including Z *palustris.* Successive surveys in the 1990s have shown a continued increase in the number of submerged macrophyte taxa; thirteen were recorded in the most recent survey (1995).

A similar analysis of the survey data on emergent and marginal fen concluded that although there have been some changes in the distribution of the taxa, there have been few overall losses or gains in the extent of the stands. The only species which have shown a significant contraction in distribution are *Phragmites australis* and *Equisetum fluviatile.* In particular, it has been estimated that there has been a reduction in the cover of reedbeds, by ca. one hectare, from the **11.2** ha present in 1952. The reduction of nutrient loads and recreation control (e.g. zoning of waterborne activities) were identified as the key elements in the future management and conservation of the aquatic and marginal wetland flora of Llangorse Lake.

Tony Prater (Royal Society for the Protection of Birds) began his talk with the observation that some of the environmental problems at Llangorse (e.g. nutrient enrichment and recreational pressure) extend to other sites in the UK. He proceeded to outline the case for the regional importance of Llangorse Lake for birds. The priority conservation wetland species at the lake are the aquatic warbler *Acrocephalus paludicola,* reed bunting *Emberiza schoeniclus* and, to a lesser extent, the lapwing *Vanellus vanellus.* A number of other important species (e.g. skylark *Alauda arvensis,* song thrush *Turdus philomelos,* linnet *Carduelis cannabina* and spotted flycatcher *Muscicapa striata)* are associated with the habitats around the lake. The bird species of Welsh and local importance at Llangorse include the great-crested grebe *Podiceps cristatus,* cormorant *Phalacrocorax carbo,* reed warbler *Acrocephalus scirpaceus* and sedge warbler *Acrocephalus schoenobaenus.* Data were presented which compared the population changes for all wetland birds at Llangorse with overall Welsh and UK trends. It was evident that despite positive environmental improvements in the lake, the bird populations were declining. The major factors influencing the bird population were identified - habitat change, water-based recreation, land-based disturbance by people, and predation by mink *(Mustela),* pike *(Esox lucius),* crows (Corvidae) and gulls (Laridae). Habitat change was related to alterations in land-use in the surrounding fields (e.g. pasture improvement and increased grazing pressure) and changes in water quality. In particular, the reedswamp

community was considered vulnerable to grazing by Canada geese *Branta canadensis*, and it was estimated that 10% of this habitat resource has been lost to jetty construction. Tony concluded his talk with an analysis of craft-type and bird disturbance incidents at Llangorse Lake. It was suggested that power-boating was the most important disturbance factor in relation to other forms of water recreation.

Session Three: Environmental Management and Open Forum Discussion - Madeline Havard (University of Wales and Chair of the Wye Management Advisory Group) chairperson

Unfortunately, **Janet Dickinson** (University of Hertfordshire) could not attend the symposium but her paper on land-use change in the Llangorse Lake catchment was presented by Max Wade. It provided an overview of land-use change in the catchment based on existing data which were related to water quality and other environmental impacts on the lake system. Change was examined in the catchment from the late 1930s to the present day, based on previous studies, existing land-cover studies and recreation statistics. The Land Utilisation Survey of 1937, the Second Land Utilisation Survey in the 1960s, and the Phase I Habitat surveys, were the main sources of data which were analysed using the Idrisi Geographical Information System. Parish summaries of livestock numbers were also used. The recreational statistics were based on car and boat counts which were collected by volunteer wardens and compiled by the Brecon Beacons National Park Authority from 1975 to the present day. These data were organised into time and date categories so that consistent annual comparisons could be made between years.

It was demonstrated that there has been a net loss of moorland, heathland and upland vegetation since 1937 and an increase in improved grassland. The area of arable land, woodland and scrub has remained relatively stable throughout the period, but there has been a slight increase in the area of coniferous plantations. Llangorse Parish has the highest proportion of improved pasture; Cathedine Parish had the largest conversion from moorland/upland vegetation to improved pasture. The analyses of land cover within 100 m and 500 m "buffer" zones around the lake were complicated by differences in the land-cover classifications used in the separate studies. Livestock figures from 1940 to 1988, for the three parishes in the catchment, indicate a substantial increase in numbers of cattle and sheep and an overall doubling of productivity. Overall decreases in numbers of poultry and pigs were reported.

The principal visitor activities at Llangorse Lake were (in order of popularity) picnicking, sunbathing/relaxing, walking to scenic points, row boats, sightseeing, informal games, photography and canoeing. On the busiest summer Sundays in the 1970s more than 600 vehicles were observed on the

common. Fishing, canoeing, rowing, sailing, power-boating, water-skiing and windsurfing are still carried out on the lake. The use of the lake for sailing and power-boating reached a peak in the late 1970s. No clear trends in the recreational data are visible from the 1980s onwards, with the possible exception of a decline in fishing since the beginning of the 1980s. It was concluded that land-uses in the Llangorse catchment have not changed dramatically since World War Two, but a number of factors indicate that a more intensive agriculture system has been adopted which is likely to have had an effect on the trophic status of the lake. The use of the lake for power-boating seems to have stabilised since the 1970s but further research is required to establish any causal links between power-boating and changes in the ecology of the lake. Suggested management solutions included the use of buffer zones around the lake and watercourses, the control of fertiliser applications, and some form of temporal and spatial zoning of the water craft.

Helen Bennion (University College London) concluded the series of presentations with an assessment of recent environmental change in Llangorse Lake, using palaeolimnology. Fossil diatom assemblages were analysed in 13 samples of a dated sediment core from the eastern lake basin, in order to reconstruct the post-1850 nutrient-history of the site. A diatom-based transfer function was applied to the fossil data to generate a quantitative reconstruction of in-lake total phosphorus (TP) concentrations. The sediment analyses revealed that diatom assemblages were dominated by non-planktonic taxa (especially *Fragilaria* spp.) until ca. 1950. Then there was a switch to an assemblage dominated by planktonic taxa, including *Stephanodlscus* spp. and *Cyclotelld* spp. It was suggested that this change was a response to reduced light conditions and the decline in submerged macrophytes in the lake, following nutrient enrichment. The increased use of fertilisers, agricultural intensification, afforestation and tourism/recreation developments were implicated as possible nutrient sources. The most recent diatom assemblages were associated with mesotrophic conditions and implied a degree of lake recovery. The quantitative TP reconstruction showed that Llangorse Lake has experienced a decline in TP concentration since the mid-1980s, following at least half a century of high and stable TP levels of ca. 150 µg TP per litre. This decrease was coincident with the major sewage diversion in 1981, followed by a smaller diversion in 1992. Helen recommended that monitoring should be carried out in order to observe whether the improvement in water quality is maintained or indeed further improved upon.

Open Forum discussion

Madeline Havard began the discussion session by extracting some of the main points derived from the earlier presentations. It was acknowledged that Llangorse Lake was a very important wildlife and conservation site, but it was

also important for the local economy. Environmental impacts occurring in combination need to be considered. Water quality and the aquatic vegetation appeared to be improving but could still not be regarded as back to previous historic levels. A special plea was made for local information and insight into the environmental factors involved.

She then handed over to Norman Lowe, who made a statement partly on behalf of the Brecknock Wildlife Trust, which has ca. 1000 members. He reinforced the degree of local interest in Llangorse Lake and asked if it was possible to bring the information derived from the symposium to a local centre. He also referred to a recent meeting between the Lake Users Group, CCW, BBNPA and the Wildlife Trust to discuss the continued use of the lake for recreation and wildlife conservation. He stated that the community needed to have a sense of common ownership of the lake's management problems and their potential means of resolution. The need for a coordinated monitoring approach in relation to the use of the lake for wildlife and recreation seemed evident. In particular, he suggested that the bird disturbance data needs to be re-examined.

Another member of the audience suggested that although there is only a small amount of forestry within the catchment, it could be a significant source of sediment/nutrient runoff after planting and felling. A question was asked about the likely Special Area of Conservation management and monitoring requirements. Stuart Reid replied that this level of information was not available yet. In addition, Catherine Duigan stated that the EU Water Framework Directive could bring additional catchment management implications. Madeline Havard reminded the audience that Llangorse Lake is being included in the Local Environment Agency Plan for the Wye catchment. It was suggested that it might be possible to set up a local body or "Authority", so that all interested parties could be involved in the management of the lake; a comparison was made with the Norfolk Broads.

A representative of Plaid Cymru mentioned a recent television programme which featured an archaeological investigation of Llangorse crannog, and suggested that it was carried out in an insensitive manner. Mark Redknap provided reassurance that the works were supervised by staff from the National Museum of Wales and that no damage had been done. Some discussion followed on the best means to protect the crannog and associated remains from erosion. It was agreed that there was a need for further consultation between the conservation and archaeology bodies on this issue. An extreme measure would be to remove the vegetation and to provide an artificial cover for the island.

Stuart Reid asked Max Wade to comment on the "quality" of the open water plant communities, as his presentation focused on the diversity of species. Max replied that this type of information was not available and any inferences can only be made from people's memory of conditions. He went on to say that

the current indications of recovery from enrichment were a very positive sign and likely to continue, with the noticeable exception of the continued lack of *Equlsetum fluviatlle* beds where waterlilies are absent. However, other forms of pollution (e.g. pesticides) remained a potential threat to the health of the lake.

Frank Chambers brought us back to the scenario of increasing sedimentation, and estimated (on the basis of current rates) that in less than 400 years the eastern lake basin would be infilled. A member of the County Council described a situation where a drain has been blocked with an accumulation of silt and this causes the water to overspill onto surrounding land during high water conditions. He suggested that this type of situation may be a source of sediment to the lake. He also remarked that he thought the people of Llangors village would wish to have access to the information exchanged at this meeting. John Davies (CCW, geologist) believed that the two basins within the lake were separated by a fault zone. He also thought that the red plumes of sediment in the water, occasionally observed by local people, may be the result of turbidite flows in steep areas of the basin. Helen Bennion replied that there was no evidence for turbidite flows from the sediment core analysis. John also suggested that the crannog was built on a natural delta in the lake.

With regard to the future management of the lake, there seemed to be a consensus that the sediment loading to the lake needs to be reduced, with the use of sediment traps on in-flow streams as a possible option. An up-to-date nutrient budget was also considered necessary to determine enrichment sources. Information on the recycling of nutrients from the sediments could also be very important.

Madeline Havard drew the meeting to a close with the observation that the ecological direction of natural freshwater systems is difficult to predict, especially in combination with the effects of human activity. No single answer can be considered as the complete solution and no single organisation has ownership of the issues, problems and solutions. There is a need to pool knowledge and involve the local community. Often we tend to think about immediate concerns when we should be considering the future.

Written accounts of the presentations at the *Llangorse Lake Symposium* will be published in *Aquatic Conservation: Marine and Freshwater Ecosystems*, Volume 9 (4 and 5).