Histories of **underwater**

Close your eyes and imagine this. It is the year 1800 and you are in a rowing boat drifting across a shallow pond in East Anglia. As you gaze down through the crystal clear waters of the pond at first you see a tangle of submerged plants. Then as you row from place to place you notice changes in plant architecture and varying shades of green indicating different species. You might even see some stripey perch and a lurking pike. Isn't it great! This is what pristine shallow lakes should probably be like. They should have clear waters and an underwater vegetation composed of several species that together form a mosaic of different underwater habitats.

Sadly, however, high quality shallow lakes are quite a rare commodity today. In fact over the last century in particular, few lakes have avoided pollution of one sort or another, with eutrophication—the enrichment of our fresh waters by phosphorus and nitrogen compounds—one of the most widespread threats. In many areas of the UK, lakes have experienced large reductions in plant diversity and in some cases they have become green with algae, with the result that submerged vegetation has been completely eliminated. The loss of aquatic plants from shallow lakes and ponds has several negative consequences for aquatic ecosystems including reductions in biodiversity and undesirable changes to food-webs.

Conservation agencies and lake managers want to restore submerged vegetation in shallow lakes. But before spending lots of money, one question looms: what to restore? What species did a lake contain before it was polluted? For some lakes old historical records can be gleaned from the notebooks of Victorian botanists, but such records are rare for the vast majority of UK lakes.

All is not lost. In the Environmental Change Research Centre (ECRC) at University College London, we have been studying cores of sediment extracted from the lake bed to help answer these very questions. In the muds that accumulate at the bottom of a lake are preserved the fossil remains of several water plants—seeds, spores, leaves and spines—that in many cases are highly resistant to decay. Thus collecting a core, dating the mud layers and careful analysis of these so-called 'plant macrofossils' can provide detailed information on the plant species that used to live in a lake. But there are several questions about what these remains can actually tell us. For example: how many species are represented by macrofossils? And what can macrofossils tell us about the distribution and extent of different plants within a site?

To answer these questions, our research at the ECRC aims to improve the accuracy and reliability


1


2

Nigel Willby

weeds

To restore a lake to its original pristine state, you need to know which plants grew there before pollution took its toll. **Carl Sayer** investigates.

of plant reconstructions based on macrofossils. At one shallow English lake (Groby Pool, Leicestershire) there is a detailed historical record of water plants that extends as far back as 1747. This seemed like an opportunity that was too good to miss. In 2000 we collected several sediment cores from around the site, with the aim of comparing our macrofossil results with the historical plant records.

Our mud cores showed dramatic and dynamic changes in the submerged vegetation of the lake over at least the last two centuries. Comparing these results with the historical record, we inferred that mud cores accurately reflect changes in the dominant water plants of small lakes. But because not all historically-recorded species left macrofossils in the mud, we also concluded that core sequences can not be used on their own accurately to reconstruct past changes in plant diversity.

At another small shallow lake (Green Plantation Pond, Norfolk), we studied modern spatial relationships between plants and their fossils. In June 2000 we made a detailed modern vegetation survey of the site. This included 87 sample points carefully located along fixed lines. Then, after plant die-back in November 2000, we collected samples of the upper 1.5cm of the surface mud from 30 of these points and analysed them for macrofossils. In this study we found that a single sediment core best reflects vegetation within a 20-30m radius of a core site. Therefore, in most cases, macrofossils are best at indicating local vegetation change.

Together these studies of the relationships between plants and fossils allowed us to be a little more critical in our interpretation of mud cores, and in the shallow lakes of the Norfolk Broads we have been putting what we have learnt into practice.

The Norfolk Broads comprise a system of 50-60 shallow lakes formed from the flooding of medieval peat workings. Over the last few centuries many of the Broads have been badly polluted, culminating in the widespread loss of open water vegetation since at least the 1960s. To understand these changes in detail, we analysed the macrofossils in sediment cores from several Broads to try to reconstruct long-term changes in their underwater vegetation.

Plant macrofossils from all of the sites we have looked at show dramatic, often step-like, changes in water weed communities over time. Before the 1900s we have evidence of meadows of charophytes (commonly known as stoneworts), a group of larger algae frequently found in unpolluted lakes. In this case our vegetation reconstruction comes from the occurrence of large numbers of stonewort oospores (tiny female fruiting bodies).

From 1900 to around the 1950s or 1960s, several changes can be noted. In almost all cases, we see a decline of stonewort species and increases in water lilies, water soldier, milfoils and several pondweeds. In this phase diversity may have been at its highest. Finally, from around the 1960s onwards, in many sites, we see indications of a dramatic reduction in the number of plant species present and in some cases a complete loss of submerged vegetation.

But the more lakes we look at, the more we are realising that the story of vegetation change is complex, and while there are consistent patterns across lakes there are also interesting idiosyncrasies. There is still a great deal that we don't know!

Our research is being used by the Broads Authority to inform management and to set restoration targets for individual lakes. We hope that one day all of us will be able to head out onto the Broads to see the clear waters and plant species of old. Until then, we must look at our cores, close our eyes and imagine what it was like.

1 *A fossil seed.*

2 *Several varieties of water weed.*

3 *Example of a sediment core.*

3

The UCL team includes Carl Sayer, Tom Davidson, Helen Bennion, Dan Hoare, Dave Emson, Genevieve Madgwick and Yan Zhao.

Dr Carl Sayer, Environmental Change Research Centre, University College London, Gower Street, London WC1E 6BT, email: c.sayer@ucl.ac.uk. *This work was funded by NERC, The Royal Society, Broads Authority, English Nature, Norfolk Wildlife Trust and the Environment Agency.*