24 EXPEDITION RESEARCH PROJECTS IN WETLANDS

Edward Maltby

Wetland is a collective term for a very wide range of ecosystems, the formation of which has been dominated by water and the processes and characteristics of which are largely controlled by water. A wetland is essentially a place that is wet enough for a long enough period to develop specially adapted vegetation and other organisms, and generally comprises mineral substrates or soils with particular morphological and physicochemical characteristics. Wetlands occur in a wide range of geographical locations and cover an estimated 6 per cent of the world's land surface (Maltby and Turner, 1983).

Investigation of the characteristics and functioning of wetlands is a high priority

Figure 24.1 *The mangrove environment is physically testing but offers exciting opportunities for research (© M. Huxham)*

not only because of the increasing evidence of their value in environmental support, but also because of the accelerating loss of the resource base. The physical, chemical, biological, hydrological and ecological processes that occur within these ecosystems are complex and sometimes difficult to measure and evaluate. However, many relatively simple and portable techniques are available for scientific study (e.g. Faulkner et al., 1989) and there is a particular need in less developed countries to evaluate more directly the relationships between wetlands and human use.

WETLAND DIVERSITY

Wetlands vary according to their genesis, size, geographical location, hydrological regime, chemistry, vegetation, and soil or sediment characteristics. Such diversity has complicated investigation of fundamental processes that may be common to many different systems, and has contributed to the lack of development of any unified discipline of wetland science (see Maltby, 1991a, 1991b). They include some of the most, as well as some of the least, productive ecosystems in the world; they occur from mountains to coasts, and range from freshwater to hypersaline systems, inorganic to organic, oligotrophic to eutrophic, acidic to alkaline, and from forested systems to those lacking any higher plants.

The main types of wetland are described in Maltby (1986). A comprehensive classification can be found in Cowardin et al. (1979) and an up-to-date review of wetlands can be found in Finlayson and Moser (1991). Conservation and management issues are covered in Dugan (1990) and more recently in Keddy (2000).

WETLAND FUNCTIONS, PRODUCTS, ATTRIBUTES AND VALUES

Wetlands perform functions as a result of the interactions among soil, water, plant and animal species. Products such as fisheries, wildlife and forest resources may be generated and attributes conferred such as biodiversity and cultural uniqueness. Functions, products and attributes are all valuable to society but the extent of this varies from wetland to wetland. A useful overview of this topic is given in Dugan (1990). Much more detailed discussion of functions can be found in Adamus and Stockwell (1983), Maltby (1986) and Mitsch and Gosselink (1986). An alternative view of functioning is found in Maltby (1991a) in which wetland roles are characterised as producer, store/sink, pathways and buffers.

WETLAND RESEARCH

Given the diversity of wetlands, there is a large scope for study which can either concentrate specifically upon functional values described above, or examine more specific processes and interrelationships of the biological, physical and chemical components of these ecosystems. A comprehensive account of the appropriate techniques cannot be given here; instead some suggestions are given for suitable areas of study with more detailed consideration of certain aspects of wetland research. It is hoped that this will serve as an introduction to the literature and the work that is possible.

A range of useful work might include:

- relationships between hydrological regime, vegetation and soil characteristics (e.g. water table–redox profile–vegetation distribution)
- investigation of zonation of use of wetlands by human communities and wildlife (patterns of use in space/time), e.g. Marchand and Udo De Haes (1989)
- assessment of the ecological/environmental functioning and values of products obtained from wetlands, e.g. wood products, animals, crops (Barbier, 1989; Nather Khan, 1990; Othman and Shalwahid, 1990; Maltby, 1991b, 1992). A good example of such on-going work can be found in the Royal Holloway Institute for Environmental Research's Darwin Initiative-funded project on wetland restoration in the Mekong Delta of Vietnam. For further details visit the Institute's website and follow links to the Darwin Southeast Asian Wetland Restoration Initiative
- effects of river regulation, irrigation and other human intervention on wetland characteristics (e.g. flooding extent, vegetation change, water table) (Drijver and Marchand, 1985)
- historical changes in wetlands (e.g. interviews, aerial photographs, maps, flood records) (Hollis, 1986).

WETLAND HYDROLOGY

Wetlands are by definition dependent on the presence of water for all or part of a year either just below the soil/sediment surface or above it. It is vital in the transport of materials to, from and within the wetland while providing the habitat for often rich, diverse plant and animal communities; as a result most wetland research and study require at least a fundamental grasp of the site's hydrology. Therefore the objectives of hydrological work can cross a spectrum from basic budget studies complementing other projects to self-contained research topics such as flood mitigation and water quality regulation. An excellent recent review is found in Bullock and Acreman (2003).

The overall water budget is a very useful approach to studying wetland hydrology and is described in Mitsch and Gosselink (2000). It provides an overall view of the transfer of water in a system over a year; subsequent division of the budget into smaller time periods will describe the hydrological regime, especially when coupled with knowledge of a site's water storage capacity (see later). Knowledge of a wetland's

Figure 24.2
Collecting sediment samples as part of a mangrove impact assessment study on Rodrigues Island (© RGS–IBG/Tom Hooper)

hydrological regime is important in the understanding of functions such as flood alteration, groundwater recharge/discharge, nutrient dynamics, food chain support and habitat provision.

The following is an equation describing a wetland's overall water budget (Mitsch and Gosselink, 2000):

$$\mathrm{d}V = P\mathrm{n} + S\mathrm{i} + G\mathrm{i} - ET - S\mathrm{o} - G\mathrm{o} \pm T$$

where V is the volume of water storage in the wetlands, $\mathrm{d}V$ is the change in volume of water storage in the wetlands, $P\mathrm{n}$ is the net precipitation, $S\mathrm{i}$ is the surface inflow, including flooding streams, $G\mathrm{i}$ is the groundwater inflow, ET is the evapotranspiration, $S\mathrm{o}$ is the surface outflow, $G\mathrm{o}$ is the groundwater outflow, T is the tidal inflow (+) or outflow (-).

Obviously completion of the formula requires a considerable input of data. These can be collected in the field using standard hydrological techniques (Wilson, 1983). However, it is rare to find a study that does monitor the entire hydrological suite. Often the "missing" data can be obtained from government sources, previous studies at the site or recording stations in a similar climatic region. LaBaugh (1986) gives an overview of these problems and Hollis (1986) provides a good example of their application.

Some wetland functions are purely hydrological in their nature, such as flood storage. Wetlands often serve as natural storage or collecting points for run-off or river discharge; therefore the potential exists to prevent or reduce flood peaks moving downstream, by temporarily detaining the water, by retaining the water from surface run-off or by the reduction of floodwater velocity. This is potentially of great socioeconomic value (see US Army Corps of Engineers, 1972; Novitzki, 1979). Larson et al. (1989) provide a useful overview of this function and list a number of predictors of opportunity and effectiveness, based on map-and-field observation techniques. Quantitative techniques range from direct measurement of flood events to more morphological assessments of a wetland's capacity to mitigate floods. Outlet condition is a key indicator. A comparison of the wetland inlet cross-sectional area with that of its outlet gives an indication of the wetland's capacity to attenuate upstream discharges. Standard surveying techniques and cross-section measurement can be used; if discharge measurements can be made at the inlets and outlets then, using the Manning "n" equation, a rating curve can be constructed enabling regular run-off measurements to be taken using a stage reading (Wilson, 1983 gives a clear description of this technique). Using maps and field surveying, the volume of the wetland basin or its storage capacity can be estimated and compared with expected volumes of floodwater. Alternatively trash lines of previous flood events can be mapped at the edge of the wetland and used as reference points for previous floodwater levels.

The water quality of resident and discharging water is intimately linked to a wetland's hydrology. Considerable influence on local and even regional water supply quality may be exerted by a wetland receiving nutrients from run-off and groundwater sources. Interactions of wetland ecosystems with groundwater are often very important to their chemical budget. Good overviews of wetland hydrogeological relationships are provided by Carter and Novitzki (1988) and Brown et al. (1985). Larson et al. (1989) again give a useful rapid functional assessment of the hydrogeological wetland function, which helps to provide an initial overview for a study. It is important to establish the quantity, quality, direction and regime of groundwater flow. Already published hydrogeological and geological data can (where available) provide a history of change and display annual trends. More specific variation can be investigated by sampling water in the field using existing wells and field installation of piezometers (see Siegel, 1988a, 1988b; Faulkner et al., 1989; Roulet, 1990) and comparing these with other hydrological data collected.

Water quality is also dictated by surface interactions between water and sediment/soil. The examination of these interactions has been covered by workers in wetland wastewater treatment as well as natural systems. If only an establishment of the net change in the water quality is required, a "black-box system" of monitoring inlet and outlet water quality variation coupled with discharge measurement can be considered. If more detailed process studies of the spatial and temporal relationships is required, sampling along transects within the wetland and the measurement of direction and discharge of surface water is necessary. Hill and Warwick (1987, 1988) and Kadlec (1988, 1990) describe these techniques.

WETLAND SOILS AND VEGETATION

Wetland soils and vegetation interact to produce the biological uniqueness of a site as well as performing socioeconomically valuable functions such as the removal of nitrogen compounds from run-off, the trapping of sediment from waterways, and the provision of local medicines, foodstuffs and building materials. Mitsch and Gosselink (2000) provide useful introductions to the physical functions whereas Marchand and Udo De Haes (1989) provide good insight into the social values of wetlands. A few of the projects that might be attempted are outlined briefly below.

One of the most interesting features of wetlands is the remarkable zonation that occurs in plant communities. This is particularly well illustrated in the case of coastal and river-marginal wetlands, especially in the tropics, e.g. zonation occurs in mangrove species and these species often give way in succession to nipa forest and peat swamp forest communities. We still know relatively little about the exact environmental relationships in these successions and of the dynamics of plant communities and change. Despite the relative inaccessibility of densely vegetated areas such as these, some locations exhibit change over short distances and therefore lend them-

Figure 24.3 *Using ground-penetrating radar to measure soil density in peat. Remember, if you are using sophisticated equipment in wetland environments it is absolutely essential that this is tested thoroughly beforehand and if necessary protected from the wet (© Jo Holden)*

selves to more complex investigation. Studies can range from simple mapping exercises to more complex investigation of the successions and their relationships to soil parameters (e.g. pH, salinity) or hydrological regime (e.g. degree of inundation, periodicity of flooding).

Soils often provide important clues to wetland processes, character and history. Waterlogged soils have classic morphological features, such as the presence of a surface peaty layer and distinct mottling in the mineral horizons. The latter is caused by variations in the oxidation/reduction state of the soil, which affects the chemical status of particular elements resulting in distinct colour changes. The most notable is that which occurs between ferric and ferrous; in reduced pockets the Fe^{2+} is often bluish/green in colour which contrasts sharply with the rusty red/brown of the Fe^{3+} oxidised state. The depth and degree of development of such "mottling" patterns give a good indication of water table regime in the soil and particularly the depth to permanent water table (the mottling regime generally disappears in permanently saturated horizons). Investigation is relatively simple using an auger and soil colour chart. The extent and depth of such horizons can be mapped and related to hydrology, vegetation and the impact of anthropogenic alterations to a system.

WETLAND FIELD LOGISTICS

All environments pose logistical problems to expeditions and wetlands are no exception. At all stages of planning it is wise to keep these in mind. In wetlands they are generally caused by one or a combination of the wet and boggy conditions, and the temporal variation of these, the often dense and sometimes impenetrable vegetation, the lack of good communications to and within a site, and often the remoteness of these ecosystems from civilisation. The more common problems being:

- site accessibility
- mobility of expedition equipment
- the availability of portable and sufficiently rugged (and waterproof) equipment
- the availability of basic data representative of the site, e.g. rainfall, river discharge, maps (soil, vegetation and geology) and even indigenous population statistics
- the presence of local accommodation or even land to camp on; risk of diseases such as schistosomiasis
- local facilities for the storage of degradable samples (e.g. cold storage for soils being analysed at a later date)
- local facilities for sample analysis.

Despite these problems, much help can be gained from non-governmental organisations and local agencies involved or associated with wetland research, conservation and management. Examples of the former are the Royal Society for the Protection of Birds, Wetlands International and the WWF International Mire Conservation Group. The latter are often government agencies involved in agriculture, forestry, fisheries, hydrology/water resources and conservation, or very often universities. Contact with these, preferably before the arrival of the main expedition (either indirectly or directly during a reconnaissance trip) will often yield much help in background data collection, field logistics, local information and sometimes even liaison in the field.

FURTHER INFORMATION

Useful websites

EVALUNET project web page: http://www1.rhbnc.ac.uk/rhier/evaluweb/index.shtml
DARWIN SEAWRI web page: http://www.rhul.ac.uk/Environmental-Research/Research/Darwin/Darwin.html
International Mire Conservation Group: www.imcg.net
Ramsar Convention on Wetlands: www.ramsar.org
River Basin Initiative: www.riverbasin.org
Royal Holloway Institute for Environmental Research: http://www.rhul.ac.uk/Environmental-Research/index.html
Society of Wetland Scientists: www.sws.org
US Fish and Wildlife Service National Wetlands Inventory: www.nwi.fws.gov
US Wetlands Regulation Center: www.wetlands.com/regs/tlpge00a.htm
Wetlands International: www.wetlands.org
Wetlands of the Central and Southern California – a methodology for classification: http://lily.mip.berkeley.edu/wetlands
Wetland definitions from American and Canadian Agencies: www.ecn.purdue.edu/agen521/epadir/wetlands/definitions.html
Wetland links – sorted by category: www.mindspring.com/~rbwinston/wetland.htm
Wildfowl and Wetlands Trust: www.wwt.org.uk

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