4.4.2 Some mineral wetland soils

Fig. 131 An ephemeral wetland soil. Profile (to 30 cm depth) beneath turf in a seasonally ponded depression, Arahaki Lagoon, Whirinaki, Volcanic Plateau (see Fig. 48). The upper horizon is firm silt, dark-stained by humus though only slightly organic. This grades down to compacted and then looser pumice gravels. Drainage is relatively good and this soil becomes moderately dry over summer.

Fig. 132 A pakihi soil. Profile from an outwash surface, German Terrace, near Westport, Buller (see Fig. 19). A relatively uniform silty soil, highly infertile, from beneath tangle fern (*Gleichenia dicarpa) - Baumea teretifolia* fern pakihi. This soil allows for only very slow water movement, but can become quite dry at times of low rainfall if the underlying water table is lowered. The sampled core is not of sufficient depth to show the probable underlying iron-humus pan that is the main factor in restricting drainage.

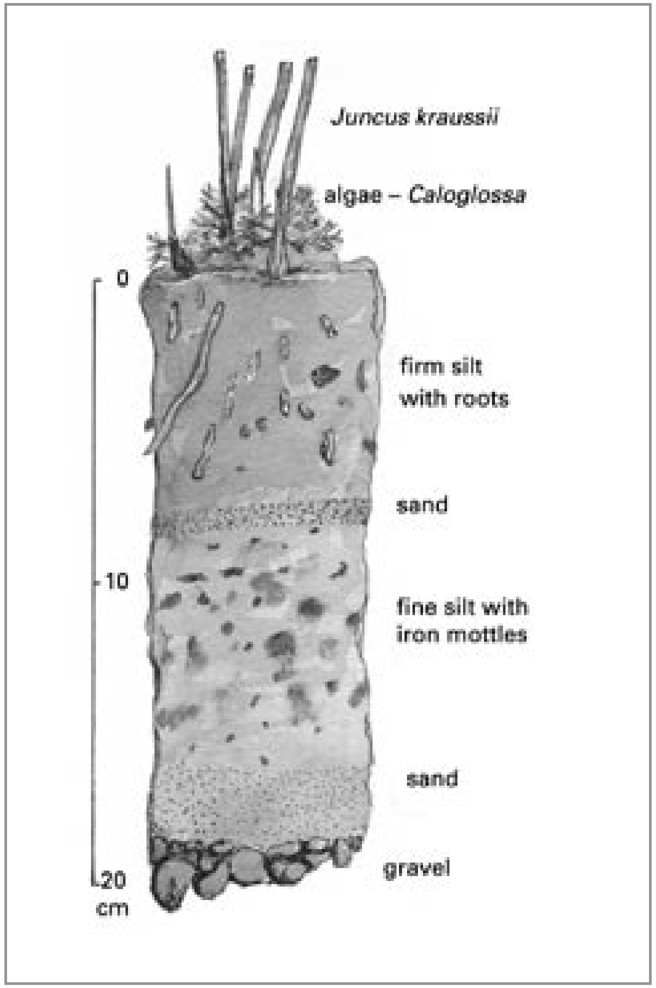

Fig. 133 An estuary soil from a tidal creek mouth. The varied deposition history is shown by layers of gravel, sand, and silt. The grey colour of the silt results from the process of gleying that occurs in wet soils where oxygen is scarce, and where iron compounds are present in their ferrous state, i.e. chemically reduced and often blackish. Rusty mottles and streaks are iron compounds in their ferric state, i.e. chemically oxidised. The mottles indicate places of better aeration. They can be common in soil horizons where the water table fluctuates. This soil, from Pauatahanui Inlet, Wellington, supports saltmarsh of sea rush (*Juncus kraussii* subsp. *australiensis*).

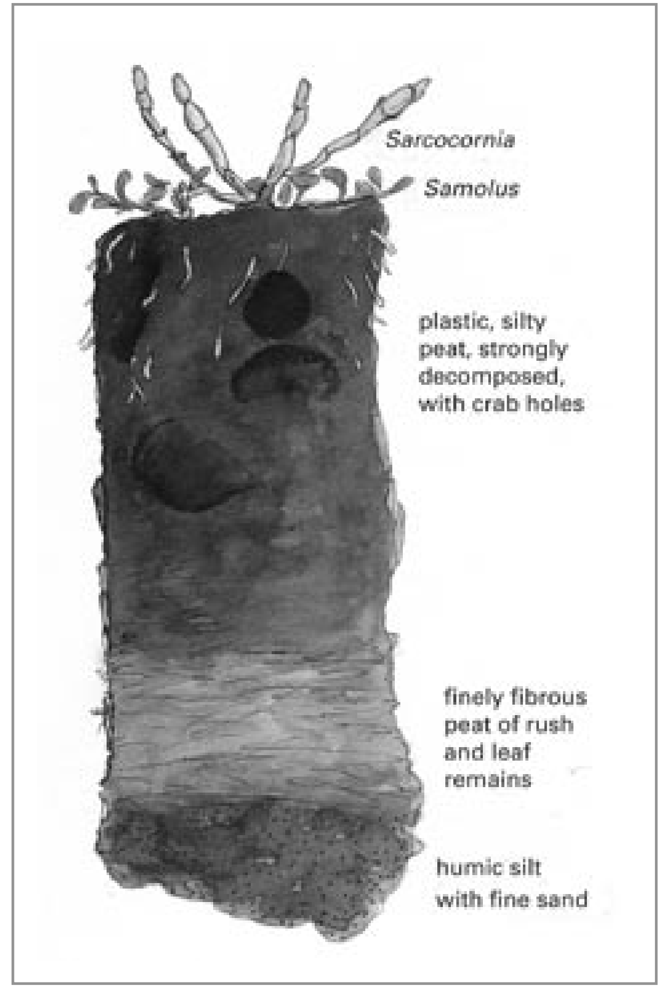

Fig. 134 A partly organic saltmarsh soil from an estuary margin behind a coastal dune. Note the large crab tunnels, a means by which much sand is continually mixed with the organic material. This is from a mid-tidal zone beneath glasswort (*Sarcocornia quinqueflora*) and sea primrose (*Samolus repens*) at Purakanui Inlet, Otago.

4.5 Sedimentation, deposition, and erosion

In places where sediment is carried by flowing water, any plant growth will act as an obstacle, reducing water flow and causing silt or sand particles to settle out. Most fens, swamps, and marshes receive ongoing inputs of water-borne sediment (Fig. 135). Submerged plants on a river margin can accumulate soft sediment around their stems, but this is usually liable to later erosion (Fig. 136). A saltmarsh can gradually elevate its ground surface with trapped sediment (Figs 33 and 137). Flowing water and wave action not only transport inorganic materials; but also deposit concentrations of organic matter (Fig. 138).

Fig. 135 Flooding of riverine marshes can bury and abrade the vegetation, yet provide fresh inputs of sediment and of nutrients. Here on the Tongariro River delta, Volcanic Plateau (see Fig. 106), recent disturbance clearly shows patterns of channel scouring and the deposition in different places of silt, sand, or gravel, creating microhabitats which will be reflected in the subsequent revegetating mix of sedge, rush, and grass patches.

Fig. 136 Sediment can have cycles of deposition and erosion. On the Clutha River, Otago, the Roxburgh Gorge was dammed for a hydro-electric lake, slowing both water flow and the carriage of sediment. Fine silt trapped by river-margin raupo (*Typha orientalis*) reedland is here being re-activated, for flushing downstream, by a deliberate lowering of lake level. Erosion reveals the thick rhizomes and the roots of the raupo, a reminder that wetland vegetation can produce much of its plant biomass underground and unseen.

Fig. 137 Sediment on a tidal river is moved by both the flood and the ebb tide. This is near the mouth of the Taieri River, Otago. Moving silt particles have settled out among the turf saltmarsh and oioi (*Apodasmia similis*) restiad rush saltmarsh, raising their platforms. The converse erosion part of the cycle is mostly by wave action undermining the miniature scarps, a process assisted by the burrowing holes of crabs, and by silt cohesiveness being weakened by the alternation of freshwater and seawater.

Fig. 138 Organic material can be carried and concentrated by moving water in many types of wetland. This is the shallow coastal lagoon of Waituna, Southland. Dislodged aquatic plants are being deposited by waves as a natural mulch among three-square (*Schoenoplectus pungens*) sedgeland and oioi (*Apodasmia similis*) restiad rushland.

4.6 Changes over time

All wetlands are dynamic, not static: they change naturally over both short and long time scales, and at rates that are not necessarily constant. Water channels change course, or become dammed. Land drainage can become impeded. Lakes and basins can fill with sediment. All these events are influenced by changes in climate. Peat accumulates and can raise the ground surface above the surrounds. The nature of a substrate and indeed a whole wetland can be determined by the plants that grow on it. A sequence of many stages may occur, for example a pond may infill with sediment, develop marsh vegetation, accumulate peat to become a swamp, then a fen, and finally a domed bog. As ground conditions change, so too does the vegetation: the process known as plant succession. Processes of vegetation change, including in wetlands, are described by Burrows (1990).

The following examples illustrate wetland change over three very different time scales.

4.6.1 Wetland change over millions of years

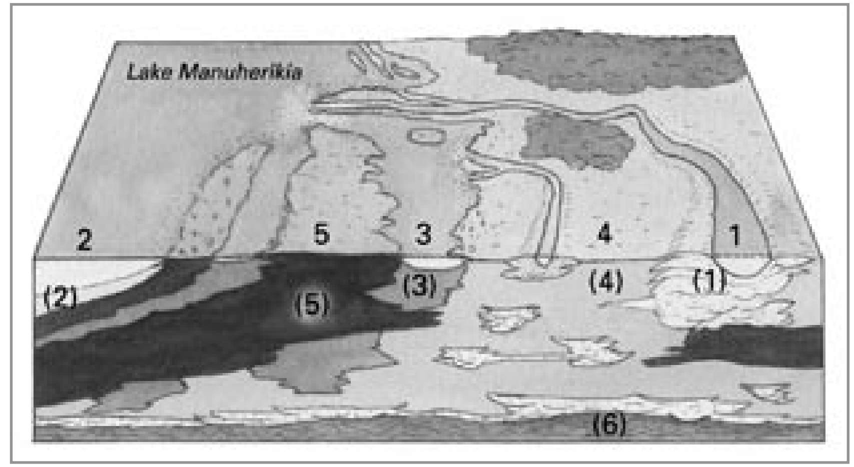

Fig. 139 A geologist's reconstruction (based on Douglas 1986) of part of the retrospectively named 'Lake Manuherikia' which extended across much of inland Otago in the mid-Miocene (c. 18–12 million years ago). This ancient wetland provides lessons for understanding modern wetland changes. Lake shore and alluvial plain wetlands have deposited peat and sediments in patterns which include: (a) pulses of sand deposition in riverbeds and on their levees; (b) lenses of sand where delta channels have changed course; and (c) diagonal patterns of organic beds caused by fluctuation and gradual rising of lake level.

Depositional environment	Materials
1. River beds and levees	(1) Sand and gravel
2. Open lake	(2) Non-carbonaceous mud, silt, sand
3. Lake bays	(3) Carbonaceous mud, silt, sand
4. Backswamps behind levees	(4) Carbonaceous mud / shale
5. Swamps (lake margin, alluvial plain)	(5) Peat turned to lignite
	(6) Underlying basement of weathered schist

Although 'Lake Manuherikia' and its wetlands existed for several million years, only fragments of their deposits remain today. Leaf and animal fossils tell a story of a period when New Zealand's climate was much warmer. However, the wetland cycle continues: parts of the ancient sedimentary sequence shown above are now again underwater; flooded by the man-made Lake Dunstan.

4.6.2 Wetland change over thousands of years

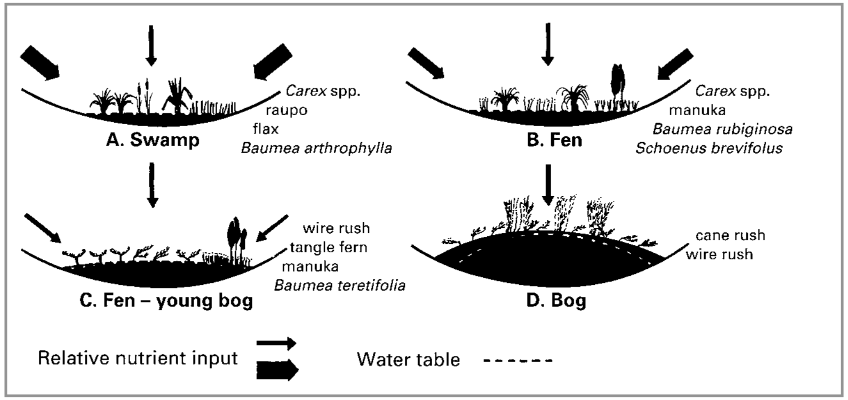

Fig. 140 Generalised sequence of bog development in the Waikato region over c. 10 000 years (based on Clarkson 2002).

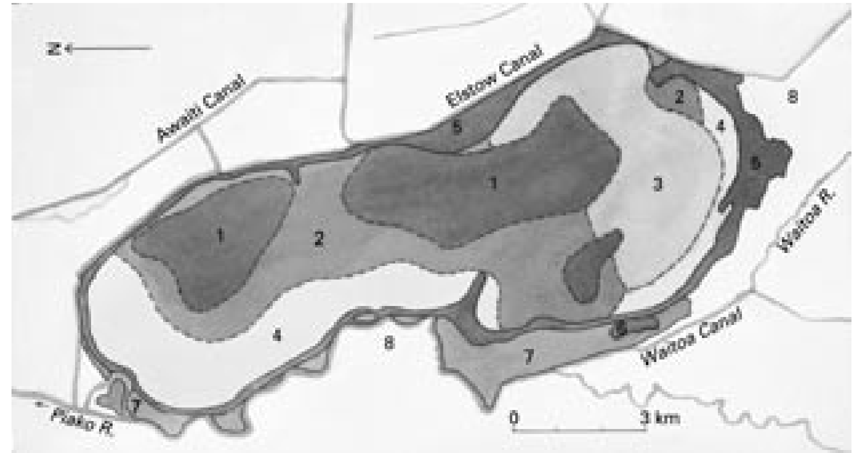

Fig. 141 Vegetation map (simplified from Irving et al. 1984) showing the modern wetland pattern on the Kopuatai Peat Dome. This is the largest New Zealand domed bog still in natural condition. The peat base lies at least 4 m below present sea level, and the highest point of the dome is only some 6 m above sea level. Although now surrounded by drainage canals and farmland developed from former peatlands, Kopuatai still shows a vegetation pattern that reflects water source, water movement, and hence nutrient status of the wetland types. The main vegetation types and habitats are:

1. *Sporadanthus ferrugineus* restiad rush bog on the rain-fed and least fertile dome crests;
2. *Schoenus brevifolius* - wire rush *(Empodisma minus)* rush bog surrounding the *Sporadanthus* communities;
3. *Baumea teretifolia* - *Empodisma* rush fen, typical of very wet areas in the south-east;
4. *Baumea teretifolia* - tangle fern (*Gleichenia dicarpa*) rush fen, fringing many margins of the dome and grading to the following;
5. Manuka scrub fen around the somewhat more fertile fringe of the peatland; this zone may be partly induced by the surrounding drainage and maybe also by fire;
6 Kahikatea forest swamp: one of the last remnants of a formerly widespread community;
7. Willow forest swamp, mainly grey willow (*Salix cinerea*), but also crack willow (*S. fragilis*) on wet mineral floodplain soils that were originally kahikatea forest swamp or flax - *Carex secta* swamp;
8. Surrounding farmland.

4.6.3 Wetland change: short-term cycles in an upland fen

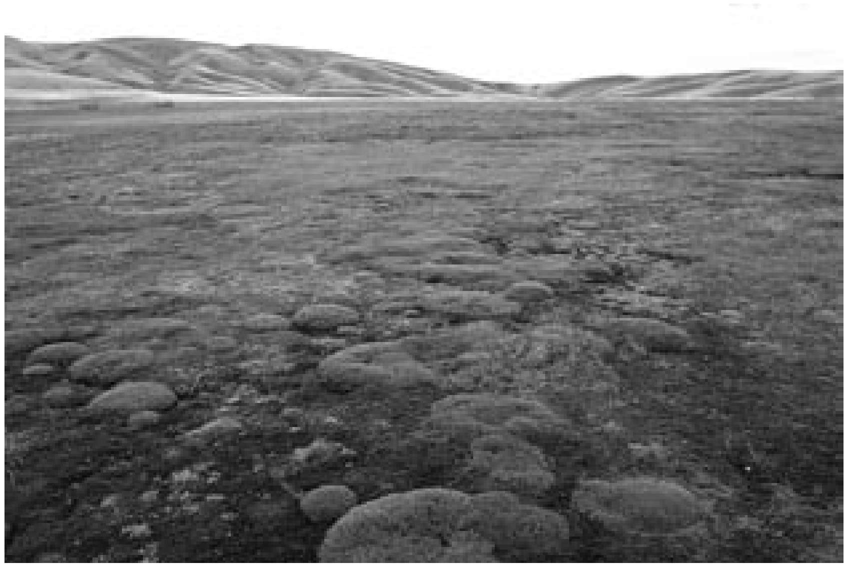

Fig. 142 Part of Teviot Swamp, Otago (see Fig. 24), a gently sloping fen nourished by groundwater that seeps from surrounding hills, and where slight changes in the rate and direction of downslope water movement cause short-term cycles in the dominant vegetation. At this site a slowing of drainage and a slight rise in water table have resulted in the demise and browning of sheets of *Sphagnum cristatum* moss, and their colonisation by young cushions of comb sedge (*Oreobolus pectinatus*). These cushions will rise above the water table, and themselves be invaded by other plants and lichens (see Fig. 88) during a phase when the hummocky ground becomes more bog-like.

Fig. 143 A portion of Teviot Swamp, where, in contrast to that in Fig. 142, the fen surface is receiving a re-invigorated supply of water. In response, *Sphagnum cristatum* is growing actively as a broad sheet, its vertical growth overwhelming an earlier phase of cushion plants, so that the foreground patches of *Phyllachne colensoi*, once convex cushions, are becoming saucer-like at their margins as the *Sphagnum* engulfs them. This phase of *Sphagnum* vigour is of benefit to the abundant flowering plants of *Gentiana amabilis*, growing upon the moss.

FIVE

Interpreting wetlands

Fig. 144 Working in a wetland; working out what it is: Shearer Swamp, Westland.

5.1 Use and application of the classification system

The New Zealand wetland classification system is designed for practical use by specialists and non-specialists alike. It seeks to circumscribe the units of classification, define terms, and standardise the naming of wetland types, in order to help unify wetland survey and management nationwide. As a scientific, functionally based classification system it is neither a taxonomic classification nor a regulatory one and does not focus on site evaluation related to environmental, social, cultural, or economic importance. The classification system is intended to complement the handbook on monitoring wetland condition by Clarkson et al. (2003) which outlines methods for recording wetland composition and for assessing condition and the impacts of changes.

The earlier sections of this book describe the units of classification and the ways in which wetlands function, at a level of detail intended to assist field workers to carry out relatively rapid survey and description of wetland sites, using mainly visual observations and simple recording techniques that are mostly qualitative or semi-quantitative, rather than involving systematic sampling or detailed analyses of data. The comments that follow are intended as additional introductory hints for efficient field studies of wetlands.

5.1.1 The question of scale

The sequential tiers of the classification allow for wetlands to be recognised and described at different levels of detail, depending on what applications are intended. The higher levels in the hierarchy apply to large regions and are most applicable to broad-scale inventory, survey, or mapping, to sort wetlands into meaningful groupings for data storage, retrieval, and interpretation, for example for State of the Environment monitoring. The lower levels are most useful for the evaluation of wetland values and benefits, the management of hydrology and wildlife habitat, and the conservation of threatened organisms.

Mapping scale is closely linked to the levels of wetland classification that can be mapped. A map scale of 1 : 100 000 would be appropriate only for hydrosystems. The scale of 1 : 50 000, as used for the topographic map series NZMS 262, is sufficient for showing location of wetland sites, and large areas of wetland classes. For many wetland systems a scale of 1 : 10 000 will be appropriate for mapping vegetation classes and also some degree of detail of vegetation structural classes, but note that at this scale it is often considered difficult to label areas smaller than 0.1 ha. For mapping vegetation types based on composition and structure of vegetation, a scale of 1 : 500 may be most useful, at least for a small wetland, or else to portray a selected window of detail of a larger mapped wetland.

5.1.2 Sources of background information

Field study of wetland sites for description and mapping will be most informative if available information is gathered beforehand. Location of wetland sites will be assisted by consulting topographic maps, aerial photographs, and GIS (Geographic Information System) information, as is available from the New Zealand Land Cover Database Version 2 (Thompson et al. 2004). The LENZ (Land Environments of New Zealand) database should prove to be a valuable tool for future wetland studies (Ministry for the Environment 2003). This enables individual sites to be evaluated within the context of a wider ecosystem classification based on climate, landform, and soil variables. Other sources of information include geological and soil maps, site field reports, and historical data, such as can often be obtained through discussion with local agencies and people.

5.1.3 Aerial photos

Aerial photos are a great help in planning a field inspection. Modern vertical aerial photos tend to be in colour, but older black-and-whites are equally or even more informative, having often been taken at relatively low altitude. Study of aerial photos taken in different years and seasons can reveal changes that have taken place in a wetland over time, and features such as fire boundaries, or patterns of surface water, that may be present only at certain times of year or after climatic events. The use of stereo pairs of photos, viewed in 3D under a stereoscope, is much more informative than looking at single photos.

Aerial photos help with understanding the landform setting, the surface catchment and drainage system, and often also, by inference, the nature of subsurface water movement. Patterns of vegetation can be identified by different tones, textures, and colours, though each of these can differ with the season of photography.

5.1.4 Field survey

Be prepared to get wet in a wetland! The margin of a wetland is often the wettest and most forbidding part, but also least representative of the main body of the wetland. Most wetlands can be walked or waded through; the main challenge is usually climbing through dense vegetation rather than extricating yourself from the wet or the muck.

It is often informative to visit the same site in different weather conditions. For instance, you are more likely to identify levels of inundation after heavy rain, or extreme low levels during dry spells. It is preferable to visit the site

during the same season that the aerial photo you are using was taken. Some plants, sedges in particular, are easier to identify when they are flowering or fruiting, during summer.

Wetland surveys do not require a great deal of equipment unless specialist studies are being pursued. Besides normal outdoor gear, useful items include compass, GPS, camera, notebook with waterproof paper, plot recording sheets, shovel and probe for looking at soil structure, pH and conductivity meters, field guides for identification of organisms, and plastic bags for soil or plant samples. When collecting plant specimens for identification, either later by yourself or for an opinion by an expert, make a point of collecting not just a foliage sample but also material that includes diagnostic features such as flowers or fruits, and in the case of many grasses, sedges, and rushes, a basal portion of stem that shows the growth habit.

5.1.5 Water regime

Observations on hydrology are essential for defining wetland classes. The source of water is a key criterion, for which landform setting and slope are the main indicators as to whether a wetland is fed by rain only, receives surface water or groundwater, or is associated with a lake, river, tidal river, or estuary. Direction of flow and drainage characteristics are useful features to assess on-site, and the nature of ground surface micro-topography can assist with this. Water table level can be gauged after it has reached equilibrium in an excavated hole. Water fluctuation regime can often be estimated by checking the level reached by debris or silt accumulation along river or lake margins and also within palustrine wetlands, and this can help in allocating boundaries between hydrosystems.

The firmness or otherwise of a peatland site is broadly correlated with degree of water content of the substrate. Jumping on a wetland surface can result in a quaking movement of up to several metres in radius, and this can indicate a substrate charged with moving groundwater, having unconsolidated sediments, or the presence of well-decomposed peat.

5.1.6 Substrates

The ease with which you can sink a probe will help to differentiate organic from mineral soils. A probe or auger will indicate depth of a substrate, and also the nature of underlying basement (e.g. rock, silt, sand) or the presence of buried wood or a hard pan in the profile. Peat can usually be recognised by its black or brownish colour. Its decomposition stage can be assessed using the von Post index (see Table 4). Inorganic matter in a substrate is usually paler, but may be dark from humus staining. Material that is of sand or larger particle size can be felt by its grittiness between the fingers. Finer silty material can be detected by its smooth and soapy feel, while clay is characteristically sticky, at least after some moistening and kneading. Soils that experience waterlogging may be detected by the presence of gleyed (greyish) horizons, various types of iron-mottling, and by sulphurous smells that indicate anaerobic processes.

Field measurement of conductivity is a general indicator of salinity and/or nutrient status, and field measurement of pH will help with assigning a wetland class name to a site (see Table 2). Sampling of soils for laboratory analysis of carbon and nutrient values will further confirm the class of wetland. Taste is a fair indicator of salinity. Hypersaline conditions, which occur in parts of estuaries subject to much evaporative drying, may be indicated by visible salt encrustations.

5.1.7 Describing and mapping vegetation

For the purposes of mapping wetland vegetation and undertaking rapid survey, the classification system provides the lowermost tiers of structural class (Section 2.7) and composition of vegetation (Section 2.8). Recognition of structural classes, i.e. the general growth form of vegetation or else the leading type of ground surface, is a straightforward exercise that does not require any detailed knowledge of plant identity. Likewise, composition of vegetation can be named with this system by being able to recognise just the dominant plants present in the canopy. So the entity we loosely refer to as a wetland type, being the combination of dominant plant with structural class, as in *Carex* sedgeland, is quite easy to recognise, and the system of Atkinson (1985) provides the diagnostic criteria and standard procedure for naming.

In practice, any vegetation study of a wetland, even at a general survey level, will involve recording vegetation at a level of detail somewhat beyond that required for naming and mapping wetland types. Thus the plot forms designed for use in assessing wetland condition (Clarkson et al. 2003)

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prompt the recording of plant cover not only of canopy dominants, but also of subcanopy and ground layers.

Plant cover, usually expressed as a percentage, is one of several measures used for recording the composition of vegetation. Other measures include density (number of plants or stems per unit area), frequency (proportion of occurrences in a total number of samples), and biomass. There are several ways of measuring cover precisely, but for rapid survey it is simply estimated 'by eye'. This can be done to a moderate degree of accuracy only, but a quick check can be done, before moving on from a study site, to see whether the recorded cover values add up to the 100% total expected of canopy cover, this being what one would see in 'bird's-eye' view (see appendix VII in Clarkson et al. 2003). Note that if vegetation is being considered across several tiers of vegetation it is quite valid for the cover values of plant species to come to a total exceeding 100%. Note also that a subcanopy tier, considered alone, will very often have less than 100% cover, and that cover recorded for the ground tier is likely to include a proportion of unvegetated surface such as bare ground, litter, or standing water. Beware of the tendency to over-estimate the cover of plant species that are especially conspicuous, such as cabbage trees scattered through a sedgeland, and of plants having erect foliage or stems, such as some sedges and reeds, for while these may appear dense when seen from the ground in side view, the vertical view would show them to be less so.

Detailed ecological studies of wetlands would aim to use rigorous sampling and recording procedures, to produce data capable of statistical analysis. Such methodology is beyond what we are describing, but it should be noted that the wetland classification system can also be applied to the results of such studies.

Many wetlands are nearly flat so their features can be difficult to locate on the ground. A few wetlands can be viewed from adjacent high ground. Prominent landmarks are worth identifying before entering a wetland, and these can be located, with grid references, upon a laminated copy of an aerial photo, topographic map, or sketched base map, upon which annotations can be made with a wetland-proof marker pen. GPS (Geographic Positioning System) technology provides a modern aid to navigating around a wetland.