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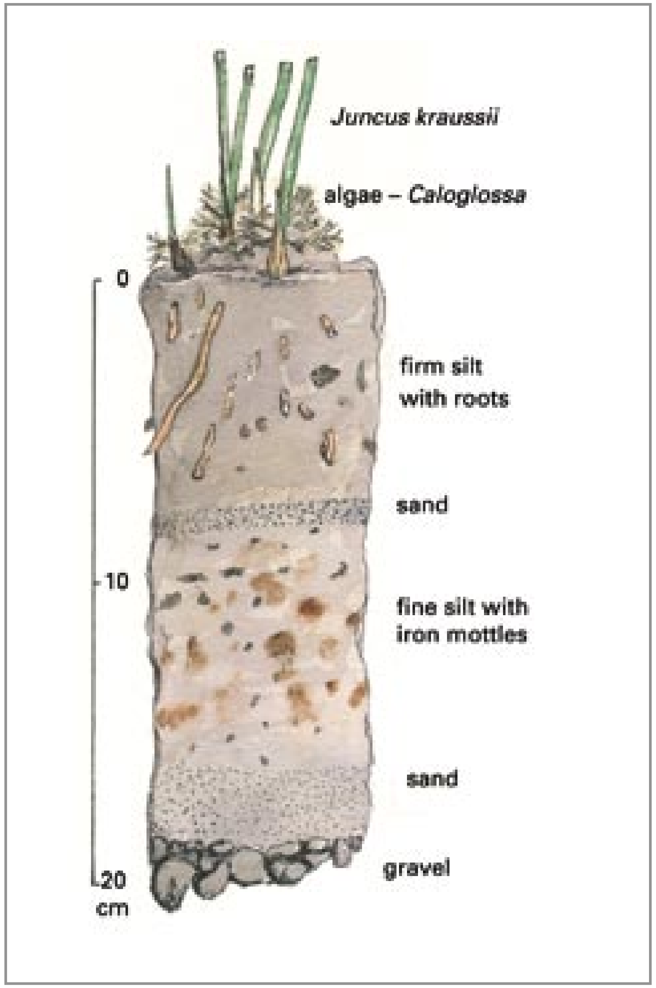

Fig. 133 An estuary soil from a tidal creek mouth. The varied deposition history is shown by layers of gravel, sand, and silt. The grey colour of the silt results from the process of gleying that occurs in wet soils where oxygen is scarce, and where iron compounds are present in their ferrous state, 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*).

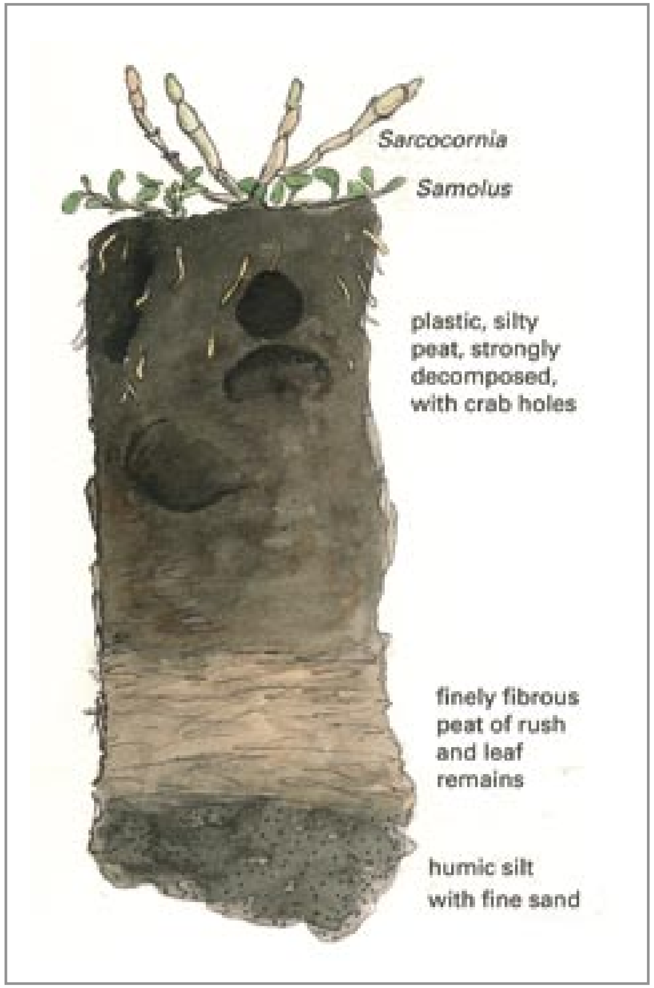

Fig. 134 A partly organic saltmarsh soil from an estuary margin behind a coastal dune. Note the large crab tunnels, a means by which much sand is continually mixed with the organic material. This is from a mid-tidal zone beneath glasswort (*Sarcocornia quinqueflora*) and sea primrose (*Samolus repens*)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

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4.6.1 Wetland change over millions of years

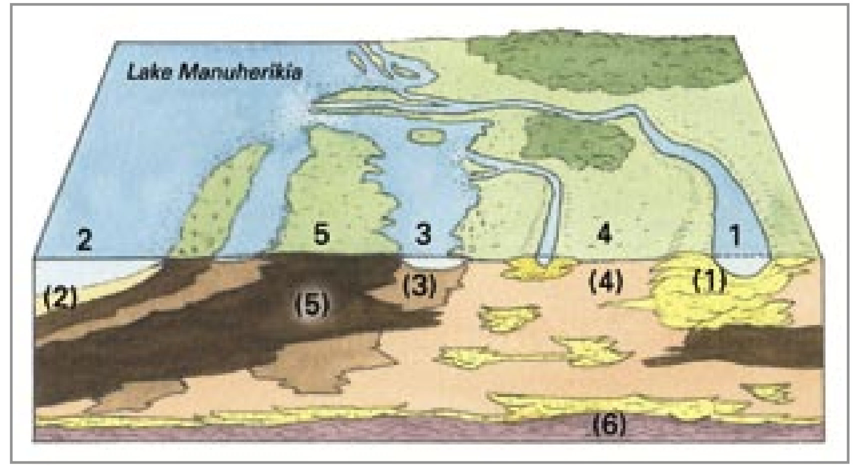

Fig. 139 A geologist's reconstruction (based on Douglas 1986) of part of the retrospectively named 'Lake Manuherikia' which extended across much of inland Otago in the mid-Miocene (c. 18–12 million years ago). This ancient wetland provides lessons for understanding modern wetland changes. Lake shore 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.