12 Freshwater Ecosystems - Streams & Swamps

The origins of the coastal swamp ecosystems and their current vegetation have been covered in Chapter 9. Because alluvial systems and peat swamps accumulate pollen and other evidence of past environments sequentially in their sediments, they can provide valuable insights into environmental change, and the Great Barrier Island swamps have been studied in detail from this perspective[i]. In addition some aspects of current wetland ecology have been published[ii], but there is as yet no comprehensive study of any swamp or stream as an ecosystem – the inter-related functioning of plant productivity, hydrology, invertebrates and birds. In this section we concentrate on what is known of stream 'health' on Great Barrier Island.

Ecosystem health[iii]

One way of assessing the health of an ecosystem is to consider the 'food-web'. A food web shows what eats what. Plants are at the foot of the food web, with herbivores forming the next level. The animals which eat the herbivores (ie. carnivores) come next. Because there must be more plant biomass than herbivore biomass, and more herbivores than carnivores, such a food-web has a pyramidal shape. The 'top carnivore' sits on top of this pyramid, and is often one of the largest and least common animals. Consequently, top carnivores are very vulnerable to any changes occurring lower down in the chain. Counting the abundance of the top carnivores is thus one of the simplest measures of assessing ecosystem health. In the case of freshwater ecosystems this is complicated by the fact that some of the larger carnivorous fishes (such as eels) move between freshwater and the sea (are 'diadromous'). Consequently, choosing a species which is permanently present in the system, gives a better indication. The freshwater crayfish (koura), requiring well oxygenated water and a good supply of invertebrate food, is one such indicator of stream health.

Another way of assessing stream health is to measure amount of dissolved oxygen. Most macroscopic animals, such as fish or mayflies, require oxygen for life, so poorly oxygenated waters support few species. This condition often arises when organic pollutants enter the stream. The organic matter is 'attacked' by bacteria and protozoa, which multiply and use the available oxygen, thus depleting that in the water.

Finally water health can be assessed from a purely human perspective by counting the number of disease-causing bacteria in samples examined under the microscope. This is now done routinely by Auckland Council staff, who collects samples from six streams and count the number of *E. coli* present.

Fig 12.1 (a) 'Stamping battery stream'. This typical creek is crossed by the Hot Springs track. Although now apparently healthy, it would have been strongly impacted by toxic mercury and cyanide effluents from the Oreville stamping battery last century. (b) Debris dam – branches accumulated after a recent flood.

a.

b

Photos: John Ogden

Between Miner's Cove in the north, and Rosalie Bay in the south, there are seven major catchments on the west coast, and a further seven on the east. The former are mostly steep, while the east coast catchments generally have a flatter section with alluvial flats or swamps before they reach the sea. The largest catchments are those of the Awana, Kaitoke, Kaiaraara and Wairahi streams, which together drain much of the central mountainous block of the island. These larger streams were all dammed and utilised during the logging of kauri last century, so they have suffered some historical habitat modification. A further seventy-four smaller catchments are shown on the 1:50 000 scale topographic map series, many of these reaching the sea without passing through any farmland or being obviously influenced by human activity. However, bearing in mind the extensive erosion and habitat modification through fire last century, and the pervasive influence of introduced pests, it might not be accurate to call any of these streams 'pristine'.

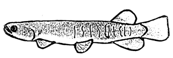
Table 12.1 Freshwater fish species present on Great Barrier Island. Based on a survey by R. McDowell (2000)[iv] With Additions From Windy Hill Records (2008).

Name	Latin	Status on Great Barrier Island
Eel short fin	*Anguilla australis*	Present in wetlands.
Eel long fin	*Anguilla dieffenbachii*	Nationally in gradual decline (Threat status 5) but common on Great Barrier Island.
Kokapu giant	*Galaxias argenteus*	? Extinct. Formerly present.
Kokapu banded	*Galaxias fasciatus*	Widespread.
Kokapu short jaw	*Galaxias postvectis*	Recorded at Windy Hill.
Short jaw Kokapu		
Koaro	*Galaxius brevipinnis*	? Extinct. Formerly present.
Inanga	*Galaxius maculatus*	Not abundant.
Bully Cran's	*Gobiomorphus basalis*	?Rare – only found at Windy Hill.
Cran's bully		
Bully common	*Gobiomorphus cotidianus*	Rare, but found at Windy Hill.
Bully redfin	*Gobiomorphus huttonii*	Recorded at Windy Hill.
Bully giant	*Gobiomorphus gobioides*[v]	Common at low elevations.
Bully bluegill	*Gobiomorphus hubbsi*	Found in 2000, one stream only.
Cockabully	*Grahamina nigripenne*	Estuaries; upper limits of tide.
Goby dart	*Parioglossus marginalis*	Found in 2000. First record for NZ!

Photo: Short Jaw Kokapu, R. McDowell. NIWA web site; Crans Bully, S. C. Moore. NIWA web site.

Freshwater fishes

Most of the fishes in Table 12.1 belong to three families:

 eels,  galaxiids, and  gobies.

Of these, both eels have a marine phase (ie are diadromous), as do all the galaxiids (the young galaxiids are 'whitebait'). Cran's goby is definitely non-diadromous, so it must have got to Great Barrier Island when the island was attached to the mainland during the Last Glacial phase of lowered sea-level. Most of these fishes are endemic to New Zealand. The galaxiids and gobies are all small and predominantly nocturnal, hiding under stones and banks during the day. Consequently they are generally not seen. More details can be found on the NIWA website (www.niwa.co.nz: search for 'fish atlas'). The Department of Conservation holds a distribution map for freshwater fishes on Great Barrier Island.

The tiny dart goby (*Parioglossus marginatus*) was found in the Kaitoke wetland on Great Barrier Island in March 2000, being previously known only from coastal New South Wales. In Kaitoke it appears to live in the saline water underlying the out-flowing freshwater. Later in the same year it was found in a stream near North Cape.

Stream health at Windy Hill

Between 2005 and 2008 (continuing), seven streams in the rat-controlled area comprising the Windy Hill-Rosalie Bay catchments were surveyed (Fig 12.2). Common bully, long-finned eel, red-finned bully, Cran's bully and short jaw kokapu were found in one or more streams. Koura (*Paranephrops planifrons*) were present in all streams. Invertebrates were not specifically looked for, but mayfly larvae and 'shrimps' – fish food - were seen in several streams. Overall these preliminary data suggest that the streams at Windy Hill have retained considerable biodiversity and are in a healthy condition. By inference other small, forested catchments throughout Great Barrier Island should also be healthy, but the effects of higher rat predation elsewhere must be considered – no comparative data on stream health in trapped and untrapped catchments are available.

Fig 12.2 (a) Koura (*Paranephrops planifrons*) - One feeler missing. (b) Stream survey work at Windy Hill.

a

b

Photos: Kevin Parsons, Windy Hill Collection

Stream geomorphology and history

Prior to forest clearance the stream valleys of Great Barrier Island would have been generally V-shaped in section, and forested. Although occasional floods would have occurred, run-off would have been controlled by the dense vegetation cover, so that streams would generally have been held within mossy banks. Coarse woody debris due to tree-falls would have been a feature of the streams, forming small dams and creating a sequence of pools and riffles.

Forest clearance by fire exposed soil to erosion and increased run-off following storms. The increased velocity of the streams greatly increased their erosive power. Gully bottoms were scoured out, moving debris dams and fine sediment downstream, and exposing bedrock and boulders in the upper parts of the stream valleys. In the first phase of this process, following Maori fires 700 years ago, sediments accumulated in the lower parts of valleys, swamps, alluvial flats, and estuaries[vi] . In the second phase, initiated by European logging and burning, the scouring was renewed, and earlier sediments were cut into and moved further down valleys into estuaries and swamps. Commenting on the settler's practice of burning forest to establish pasture Winklemann (1889) wrote "vain hope! The heavy rains now pour down the hillsides and carry the seed away". As a consequence, mangroves spread in the Whangapoua estuary, and raupo (*Typha orientalis*), invaded the tangle fern (*Gleichenia/Baumea*) community in Kaitoke swamp; vegetation responses which are still in progress (Fig 12.3).

Fig 12.3 (a) Tangle fern (*Gleichenia dicarpa*). (b) Raupo (brown, middle of picture) invading tangle fern and *Baumea* (rush-like, foreground) in Kaitoke swamp. Te Ahumata (White Cliffs) behind.

a

b

Photos: John Ogden

The scale of flooding events during the kauri logging era is exemplified by the deaths of three 'Austrians' washed from their camp site by the flooded Awana creek in 1907[vii]. Other 'floods' in the 1920s and 30s were deliberate, due to the release of water held in the kauri dams, but were equally destructive to valley bottom soils, vegetation and other biota. Species such as Hochstetter's frog, which lives in small stream-side populations, and chevron skink, which seems to require debris dams, must have been eliminated from many streams and held on only as isolated populations (see Chapter 11). Although the logged catchments are now regenerating, forest biomass is much less than formerly, and floods are still a feature of many streams.

Contrary to intuition, wetlands burn easily. This is because they carry large quantities of dead biomass, which dries out in summer even when the underlying substrate is waterlogged. Extensive fires, over most of the Kaitoke swamp occurred in 1887, 1938 and 1965, and there have been lesser fires at other times[viii]. These fires must have added large quantities of nutrients to the swamp surface, and will have contributed to a shift from the low nutrient requiring species such as *Gleichenia* and *Baumea*, to more 'eutrophic' species such as raupo (*Typha*) mentioned earlier.

Coastal wetlands

The vegetation of the wetlands has already been described. Here we draw attention to their role in water storage and carbon sequestration[ix] and storage. Extensive areas of wetlands were formerly present behind the dunes at Medlands, Kaitoke and Awana. Fifty percent or more of these areas have been drained and converted to farmland, and recent submissions to the District Plan indicate that this trend is continuing[x]. However, at c.320ha, Kaitoke swamp is the largest remaining wetland anywhere close to Auckland. Although some drainage has occurred, this wetland still acts as a huge water-storage system, with > 3m depth of saturated peat and silt throughout the year, and water c. 0.5m deep above that for most of the winter. A conservative estimate is that it holds seven and a half million cubic metres of water.

The water-level of the rear-dune lagoons and swamps, draining seaward under the dunes, probably determines the base-level ('ablation surface'[xi]) of the inter-dune flats. This in turn determines the growing conditions for plants. Lowering of the dune water-table, through drainage of the rear-dune swamps, combined with grazing on the dunes, probably lead to destabilisation of dune vegetation, blow-outs and inland sand-drift at Kaitoke, as occurred elsewhere on the coastal dunes of the North Island. This was 'remedied' at Kaitoke by planting pines and marram grass (*Ammophila arenaria*). Both these species have subsequently changed the native vegetation on the dunes.

Wetlands have declined drastically in New Zealand. Since European arrival wetlands have been drained for farms, filled with trash or soil, had towns or roads built on them, or been otherwise removed. In 1976 the Wildlife Service calculated that 264,000 ha had been drained in the preceding 22 years. A further 15% of the remaining wetlands disappeared between then and 1983, and the trend has continued. It is generally accepted that at least 90% of the original wetlands of New Zealand have now been lost. This is particularly so in coastal areas of the North Island. With the loss of these wetlands these have been declines in many biota, especially endemic water-birds, freshwater fish species such as eels and whitebait, and many invertebrates of which we know little.

The national concern for the decline of wetlands is pointed out in the New Zealand Biodiversity Strategy (2000), and arises from several causes. The most frequently stated concern is probably "loss of native biota" – birds, aquatic creatures, plants etc. However, from a landscape and land-use perspective, their role in controlling run-off and acting as a 'sponge' is probably more significant. They can also act as purifying filters – this role having been recognised by the use of semi-natural wetlands in sewage treatment. Last, but not least, wetlands are highly productive in terms of dry-matter per hectare – much more so than pasture or even mature forest. In the *Gleichenia/Baumea* vegetation type on Kaitoke Swamp, 40 – 70% of the dry matter produced is retained in the system as peat[xii], arguably making swamps one of the most efficient way of sequestering carbon. For example, the highest rate of sequestration measured in kanuka stands on Great Barrier was fifteen CO^2equivalent tonnes/ha/annum, compared to eighteen tonnes for *Baumea* stands on Kaitoke swamp (Table 12.2).

Table 12.2. Estimated productivity and carbon sequestration in Kaitoke Swamp[xiii]

Species	**Productivity: dry matter in tonnes/ha/year**	**% added to peat**	**Accumulation in swamp in tonnes/ha/year**	**CO^2 equivalent sequestered in tonnes/ha/year**
Typha	30	6.5	1.95	3.6
Gleichenia	5	42.8	2.14	3.9
Baumea	14	71.6	10.02	18.4

i Horrocks, M., Ogden, J., Nichol, S. L., Alloway, B. V. & Sutton, D. G. 1999. The palynology and sedimentology of a coastal swamp at Awana, Great Barrier Island, New Zealand, from c. 7000 yr BP to present. *Journal of the Royal Society of New Zealand* 29(3): 213-233. /Horrocks, M., Ogden, J., Nichol, S. L., Alloway, B. V. & Sutton, D. G. 2000. Palynology, sedimentology and environmental significance of Holocene swamps at northern Kaitoke, Great Barrier Island, New Zealand. *Journal of the Royal Society of New Zealand* 30(1): 27-47. /Horrocks, M., Ogden, J., Nichol, S. L., Alloway, B. V. & Sutton, D. G. 2000. A late quaternary palynological and sedimentological record from two coastal swamps at southern Kaitoke, Great Barrier Island, New Zealand. *Journal of the Royal Society of New Zealand* 30(1): 49-68. /Horrocks, M., Deng, Y., Ogden, J., & Sutton, D. G. 2000 'A reconstruction of the history of a Holocene sand dune on Great Barrier Island, northern New Zealand, using pollen and phytolith analyses', *Journal of Biogeography* 27:1269-1277. /Deng, Y., Ogden, J., Horrocks, M., Anderson, S. & Nichol, S. L. 2004. The vegetation sequence at Whangapoua Estuary, Great Barrier Island, New Zealand. *New Zealand Journal of Botany*.42**:** 565-588*. /* Deng, Y., Ogden, J., Horrocks, M. & Anderson, S. 2006. Application of palynology to describe vegetation succession in estuarine wetlands on Great Barrier Island, northern New Zealand. *Journal of Vegetation Science* 17: 765-782. /Deng, Y., Horrocks, M., Ogden, J. & Anderson, S. 2006. Modern pollen-vegetation relationships along transects on the Whangapoua estuary, Great Barrier Island, northern New Zealand. *Journal of Biogeography* 25 (4): 592-608. /Ogden, J., Deng, Y., Horrocks, M., Nichol, S. & Anderson, S. 2006. Sequential impacts of Polynesian and European settlement on vegetation and environmental processes recorded in sediments at Whangapoua Estuary, Great Barrier Island, New Zealand. *Regional Environmental Change* 6: 25-40.

ii Rutherford, G. N., 1998. The current vegetation of Kaitoke Swamp, Great Barrier Island. Unpublished MSc. Thesis. University of Auckland. / Anderson, S. H. & Ogden, J. 2003. The bird community of the Kaitoke wetland, Great Barrier Island. *Notornis.* 50(4): 201-209. /Deng, Y., Ogden, J., Horrocks, M., Anderson, S. & Nichol, S. L. 2004. The vegetation sequence at Whangapoua Estuary, Great Barrier Island, New Zealand. *New Zealand Journal of Botany*.42**:** 565-588./ Pegman, A. P. McK. & Ogden, J. 2005. Productivity-decomposition dynamics of *Typha orientalis* at Kaitoke Swamp, Great Barrier Island, New Zealand. *New Zealand Journal of Botany* 43: 779-789./ Pegman, A. P. McK. & Ogden, J. 2006. Productivity-decomposition dynamics of *Baumea juncea and Gleichenia dicarpa* at Kaitoke Swamp, Great Barrier Island, New Zealand. *New Zealand Journal of Botany* 44: 261-271.

iii See also the NIWA website for practical tools in assessing stream health.

iv R. M. Mcdowell. 2000. Great Barrier Island freshwater fishes – a microcosm of the mainland fauna. *Report to Department of Conservation*. Port Fitzroy Office.

v This is incorrectly called redfin bully in McDowell's (2000) report.

vi Ogden, J., Deng, Y., Horrocks, M., Nichol, S. & Anderson, S. 2006. Sequential impacts of Polynesian and European settlement on vegetation and environmental processes recorded in sediments at Whangapoua Estuary, Great Barrier Island, New Zealand. *Regional Environmental Change* 6: 25-40.

vii New Zealand Herald, Jan 25th 1908

viii Rutherford, G. N., 1998. The current vegetation of Kaitoke Swamp, Great Barrier Island. Unpublished MSc. Thesis. University of Auckland.

ix Sequestration refers to the removal of CO2 from the atmosphere and keeping it in long-term storage.

x Proposed Hauraki Gulf Islands District Plan (2008). In the Hearings Panel Document relating to Part 10c in "Amendments to Planning Maps", (p 334-376), there are 12 cases dealing with wetlands on Great Barrier Island. Of these, ten involve the reclassification of the wetlands as some other (less restrictive) land-use category.

xi The level to which the sand dries out and can be blown away; the permanently wet surface.

xii Pegman, A. P. McK. & Ogden, J. 2005. Productivity-decomposition dynamics of *Typha orientalis* at Kaitoke Swamp, Great Barrier Island, New Zealand. *New Zealand Journal of Botany* 43: 779-789./ Pegman, A. P. McK. & Ogden, J. 2006. Productivity-decomposition dynamics of *Baumea juncea and Gleichenia dicarpa* at Kaitoke Swamp, Great Barrier Island, New Zealand. *New Zealand Journal of Botany* 44: 261-271.

xiii Based on data in: Pegman, A. P. McK. & Ogden, J. 2005, 2006. Above (11).