Conservation values and management of the Kongahu Swamp, Buller District

SCIENCE FOR CONSERVATION 124

Brian Sorrell and Trevor Partridge

Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

Keywords: wetland conservation, wetland vegetation, estuarine vegetation, wetland management, hydrological regime, Kongahu Swamp, Otumahana Estuary, Karamea Ecological District.

Science for Conservation presents the results of investigations by DOC staff, and by contracted science providers outside the Department of Conservation. Publications in this series are internally and externally peer reviewed.

ISSN 1173-2946
ISBN 0-478-21850-8

This publication originated from work done under Department of Conservation Investigation no. 2329, carried out by Brian Sorrell, NIWA Ltd, PO Box 8602, Christchurch, and Trevor Partridge, Landcare Research Ltd, PO Box 69, Lincoln. It was approved for publication by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

Cataloguing-in-Publication data
Sorrell, Brian K. (Brian Keith)
Conservation values and management of the Kongahu Swamp, Buller District / Brian Sorrell and Trevor Partridge. Wellington, N.Z. : Dept. of Conservation, 1999.
1 v. ; 30 cm. (Science for conservation, 1173-2946 ; 124)
Includes bibliographicalreferences.
1. Wetlands–New Zealand–Buller District–Management. 2. Wetland conservation–New Zealand–Buller District. 3. Kongahu Swamp (Buller District, N.Z.). I. Partridge, Trevor R. (Trevor Royce), 1952- II. Title. III. Series: Science for conservation (Wellington, N.Z.) ; 124.
333.918099373 20

CONTENTS

Abstract

An assessment of land use practices affecting wetland functioning in the Kongahu Swamp, Buller District, West Coast, has been made, based on historical and recent maps and information, discussions with local conservancy staff and landowners, and a site visit to the wetland in March 1998. Although quantitative sampling of vegetation and other biota was beyond the scope of this study, a general map of vegetation types in the wetland was prepared from aerial photographs and ground-truth correlation during the site visit.

Current vegetation in the wetland differs considerably from that in pre-European time, and varies considerably between individual properties, reflecting different management practices such as drainage, burning, grazing, and humping and hollowing of pasture. Present vegetation within the wetland is a mixture of kahikatea swamp forest, flax-dominated shrubland and rushland, and oligotrophic bogs with a diverse array of dominant species. Vegetation of the Otumahana Estuary downstream of the wetland includes rushland (salt marsh and freshwater seeps) and highly diverse herbfields. Areas of high conservation value remain, including remnants of kahikatea forest swamp, oligotrophic bog systems, and the Otumahana Estuary, which is in almost pristine condition.

Conservation issues in the wetland primarily reflect activities associated with drainage and other alterations of the water regime. There has been considerable shrinkage of the peat in the wetland due to drainage, together with increases in nutrient status due to run-off from grazing pasture, and invasion by weeds after burning. There is anecdotal evidence from landowners for increased siltation into main drains and Blackwater Creek, although water clarity and quality appear reasonable at present. There is no visible deposition of fine sediments in the Otumahana Estuary, although a layer of fresh marine sand suggests a recent intrusion near the mouth.

Future management options presented stress the need for co-operation with landowners and the importance of determining the desired management outcomes for a large, diverse ecosystem of this type. Possible mechanisms for protecting areas of high conservation value include land management strategies, co-operative management schemes with adjacent landowners, and purchase of some areas of high value.

The vegetation changes in the Kongahu system typify those seen in wetlands throughout New Zealand subject to drainage and other alterations to the hydrological regime. Restoration of such a degraded system may be difficult and require long-term planning, and depends on aspects of wetland functioning that remain poorly understood and require further research. These include the development of desirable hydrological regimes, the ways in which wetlands change over long time scales, and ecological processes such as trophic interactions and food web structure.

1. Introduction

Since European settlement, wetland areas in New Zealand have been subject to extensive modification from land management practices. Some 90% of the nation's pre-European wetland area has been lost to drainage, especially in lowland regions, largely through conversion to pasture (Cromarty & Scott 1995, McDowall 1998). While the economic benefits to New Zealand provided by agricultural activities are undeniable, the loss of wetlands is nevertheless of great concern, because of the important roles they provide in the landscape. These include erosion control, flood regulation, nutrient storage, waste treatment, habitat, and biodiversity values. A recent international study estimates the total global value of these wetland services to be US$4.9 trillion per year (Costanza et al. 1997); the figure for New Zealand is NZ$34,163 per hectare (Patterson & Cole 1999). In light of this, priorities for wetland management in New Zealand should focus on (i) maintaining and promoting these beneficial functions in our remaining wetland areas, to maximise their value to the public; and (ii) restoring and rehabilitating degraded wetlands, to compensate for the historical losses that have occurred.

Several obstacles currently inhibit our ability to manage and restore wetlands in New Zealand. First, the remaining wetland area is highly fragmented, and often under direct or indirect threat from practices such as burning, nutrient enrichment, and alteration of water regime. Second, there has been very little research in New Zealand into how particular wetland organisms respond to these factors. Hence, the management practices we need for maintaining wetland viability, and restoring wetlands, are poorly understood. Attempts to manage and restore wetlands without this information have often suffered costly delays or failed entirely (Basu 1997, Malakoff 1998). Research is therefore urgently needed to provide an understanding of how altered hydrology affects the conservation values of wetland areas. One approach to this is to look at how changes in water regime have affected particular wetlands, which can be used as models for management and restoration of other systems.

As part of this process, the Department of Conservation (DOC) contracted the National Institute of Water and Atmospheric Research Ltd (NIWA) and Landcare Research to assess the effects that land use practices within and around the Kongahu Swamp, West Coast Conservancy, have on wetland functioning. The project had two main objectives: first, to gain an understanding of the issues affecting the wetland through field assessment and interpretation; secondly, to focus on and prioritise those issues of greatest importance, for Kongahu itself and for wetlands elsewhere. While there is some information about certain management effects in New Zealand, such as the biodiversity values of wetlands and their response to water, little is known about other issues such as siltation and peat shrinkage in response to draining. Consideration of these issues will aid in the directing of future research priorities, for DOC and other organisations.

It must be stressed that the aim of this project is to provide advice and management options that can be used to benefit all parties with an interest in the Kongahu Swamp. With most of the wetland being in private ownership, it will be essential that mechanisms for wetland protection are put in place with the co-operation and involvement of the landowners. Experience in New Zealand shows that regulatory approaches to conservation generate antipathy from landowners (Cocklin & Doorman 1994), but that most do understand the importance of protection of wetlands and will undertake conservation activities on their land if this is based on advice and education rather than compulsion (Jones *et al.* 1995). Hence, in Kongahu and elsewhere in New Zealand, wetlands can only be protected and restored by an inclusive approach that maximises the benefits to all parties.

2. Site description

The Kongahu Swamp is a geologically recent peat bog (N. Moar, pers. comm.) lying between Karamea and Little Wanganui in the West Coast Conservancy (Fig. 1, Plate 1). It occupies a lowland coastal strip between a karst landscape to the east and the Karamea bight of the West Coast. The northern boundary is Granite Creek near the locality of Kongahu; the southern boundary is the Little Wanganui River. The main water inflow is Blackwater Creek from the hills behind, which after passing through the wetland exits to the north into the Otumahana estuary. The soil is a kini (i.e. a lowland organic soil comprising a clay base overlain with peat, Department of Scientific and Industrial Research 1964) that is deepest at the southern end of the wetland.

Early records described the vegetation as a diverse mixture of manuka, podocarp, flax, rush, sedge and reed swamps. Human effects have included intermittent flax milling from the 1890s to the 1950s, tree logging and milling, and more recently, extensive drainage and burning for agriculture. Water now flows through an array of lateral drains in each property, rather than the natural drainage channels, which are still visible in aerial photographs. Since 1985, on many properties farm management for maintaining productive pasture has included 'humping and hollowing', the practice of using a ditch digger to raise the level of the land in humps, interspersed at average distances of 30 m with hollows that act as water courses when water levels are high (Plate 2).

Most of the wetland is currently private farmland. The total area is approx. 400 ha; 51 ha at the southern end are a DOC-owned wildlife management reserve.

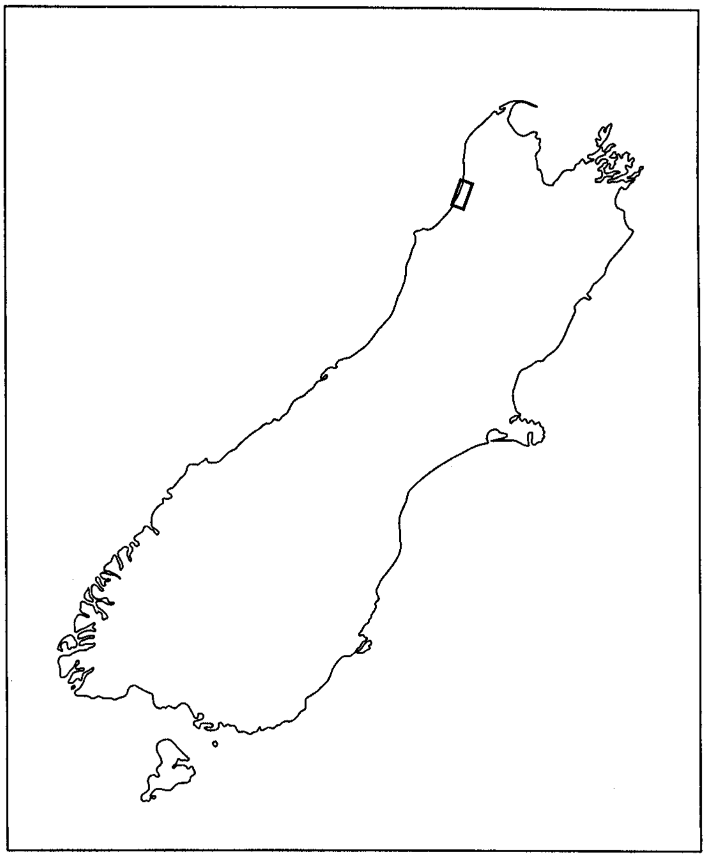

FIGURE 1. LOCATION OF KONGAHU SWAMP AND OTUMAHANA ESTUARY, BULLER DISTRICT, NEW ZEALAND.

3. Methods

The assessment of current vegetation in the wetland and its relationship to land management practices was made by analysis of historical maps and photographs, and a site visit was made to the area in March 1998. A vegetation map for the wetland (Fig. 2) was produced from recent aerial photographs after verification by ground-truth correlation along transects through the wetland during site visits. The map includes an overlay of the effects of management as assessed from land and vegetation condition, DOC records, and consultations with landowners, allowing the plant communities mapped to be linked to management effects. The wetland was also examined during the site visits for evidence of siltation, habitat changes and peat shrinkage, the major issues in the wetland, and these are discussed in the light of current understanding of how they are affected by land management.

4. Vegetation

4.1 LIST OF PLANT COMMUNITIES

The hierarchical classification system here has been designed to fit the system being developed for the description of wetland systems throughout New Zealand by a Working Group funded by a Ministry for the Environment Sustainable Management Fund project. As that system is still being refined (Ward & Lambie 1998), this list represents a broad interpretation of its status following a workshop held at Lincoln in March 1998, the week before the fieldwork was undertaken.

System: Riverine
Aquatics and marginal emergent plants

System: Palustrine

Function: Swamp

Structure: Forest

Swamp forest with emergent kahikatea

a. with tall understorey

b. with low regrowth understorey

c. no understorey (grazed beneath)

Structure: Shrubland

Swamp shrubland

a. manuka

b. flax-*Coprosma*

Structure: Rushland

Swamp

a. flax

b. flax-wet pasture

c. flax-bracken-blackberry

d. soft rush

e. *Carex virgata-Carex secta*

Function: Bog

Structure: Rushland—several variants including:

a. wire rush

b. *Baumea* mixtures

c. *Lepidosperma*

d. *Leptocarpus*

e. *Juncus canadensis*

Structure: Fernland bog

Gleichenia/Sphagnum

System: Estuarine

Function: Marsh

Structure: Rushland

Salt marsh

a. *Leptocarpus*

b. sea rush

Freshwater seeps

a. raupo

Structure: Herbfield

Salt marsh

a. *Sarcocornia-Samolus* lower marsh

b. *Selliera-Leptinella* middle marsh

Brackish marshes

a. *Triglochin*

b. three square

Systems: Non-wetland

a. humps in hump/hollows

b. other pasture

c. exotic tree plantings

d. tracks/raised access ways

e. ephemeral burn vegetation

4.2 DESCRIPTION OF VEGETATION TYPES

1. Aquatics and marginal emergent plants

The main drains and many of the hollows in the hump/hollowed areas provided suitable habitat for a range of aquatic plants (Plate 3). The commonest emergent species found throughout the shallower (<0.5 m) ditches and hollows, and at the margins of the deeper drains, were swamp willow weed (*Polygonum salicifolium*) and the introduced water purslane (*Ludwegia palustris*). Also present at this depth, especially at the northern end of the swamp, were floating sweet grass (*Glyceria fluitans*) and watercress (*Nasturtium officinale*). Starwort (*Callitriche stagnalis*) was common in the slower-flowing, shallow water at the southern end of the swamp. The development of all these species ranged from sparse, marginal plants in some areas to complete, dense bank-to-bank cover (especially in shallower areas). The introduced weed parrot's feather (*Myriophyllum aquaticum*) was found at one site on the Volckman property. The native floating-leaved pondweed (*Potamogeton subolongus*) was also widespread throughout the swamp, being most common in the deeper and wider drains with higher water velocities. Free-floating species included duckweed (*Lemna minor*), common throughout the swamp, and more rarely, azolla (*Azolla filiculoides*). Neither species developed dense cover.

Also present in several of the slow-flowing drains were extensive loose aggregations of filamentous green algae. These offered little resistance to flow, being fragile and readily broken up by mechanical disturbance.

2. Swamp forest with emergent kahikatea and tall understorey

This vegetation type comprises a tall emergent layer of kahikatea (*Dacrycarpus dacrydioides*) above a 4 m tall understorey of broadleaved shrubs. Rimu (*Dacrydium cupressinum*) is a minor emergent component. This vegetation is restricted to the large reserve at the southern end of Kongahu Swamp, with flax (*Phormium tenax*) swamp in the centre. It seems from anecdotal evidence that this patch was artificially created by Wildlife Service as an artificial wetland. The understorey is especially diverse, including pate (*Schefflera digitata*), pigeonwood (*Hedycarya arborea*), kamahi (*Weinmannia racemosa*), wheki (*Dicksonia squarrosa*), putaputaweta (*Carpodetus serratus*), black maire (*Nestegis cunninghamii*), puka (*Griselinia lucida*), and *Coprosma grandifolia*. Climbers include supplejack (*Ripogonum scandens*), kiekie (*Freycinetia baueriana*), kaihua (*Parsonsia heterophylla*), and bush lawyer (*Rubus cissoides*). Ferns are common as perching plants; these include *Phymatosorus diversifolius*, *Asplenium flaccidum* and *Hymenophyllum* sp. Together these form such a dense layer that the light intensity below is so low that there is minimal shrub layer (*Coprosma grandifolia*) or ground layer (*Polystichum vestitum*). This large patch of forest ends abruptly with only a narrow zone of margin shrubs where it abuts farmland, but there are extended sequences where it is adjacent to *Gleichenia–Sphagnum* bog inland, and manuka swamp shrubland on the coastal side.

3. Swamp forest with emergent kahikatea and low regrowth understorey

This type of forest occurs on the Simonsen property, and is characterised by tall emergent kahikatea above a dense regenerating understorey up to 2 m in height (Plate 4). It has occurred because the forest emergents, which were previously open and grazed beneath (see 4 below), have had their subcanopy species re-established following fencing. In the 1957 aerial photograph, it clearly comprised the tall standing kahikatea only. The regrowth comprises many species including *Pseudopanax arboreus*, mahoe (*Melicytus ramiflorus*), black maire, kohuhu (*Pittosporum tenuifolium*), putaputaweta, *Coprosma grandifolia*. Regenerating kahikatea was evident. Remnants of species that would have been present before the establishment of the subcanopy include *Astelia fragrans*, shining karamu (*Coprosma lucida*), *Coprosma tenuicaulis*, flax, and blackberry (*Rubus fruticosus* agg.), but these are expected to eventually disappear. Climbers such as supplejack are also establishing. Wineberry (*Aristotelia serrata*) is common around the margin. The fencing is along the margin of a deep drainage ditch.

4. Swamp forest with emergent kahikatea but little understorey (grazed beneath)

Patches of kahikatea forest occur along sections of Blackwater Creek through the Jennings property. Grazing occurs within this forest, so the vegetation is composed of a mixture of species that are grazing-tolerant and those that grow in inaccessible places (Plate 5). The past effects of grazing are responsible for the poorly formed subcanopy, which currently comprises mahoe, puka, black maire, kotukutuku (*Fuchsia excorticata*), and wineberry, and there are scattered smaller shrubs of putaputaweta, *Coprosma grandifolia*, *Coprosma areolata*, *Coprosma propinqua*, *Myrsine divaricata,* and mapou (*Myrsine australis*). Climbers include climbing rata (*Metrosideros diffusa*), kiekie, *Fuchsia perscandens*, bush lawyer, *Parsonsia heterophylla*, and supplejack. There is a diverse ground layer including many native ferns, beggars' ticks (*Bidens frondosa*), swamp willow weed, cleavers (*Galium aparine*), *Astelia fragrans*, *Acaena* sp., flax and others typical of both forest and open areas. This reflects the more open nature of the canopy.

5. *Swamp shrubland of manuka*

The older maps of Kongahu Swamp indicate that manuka (*Leptospermum scoparium*) was common throughout the area. At first it was suspected that this might have been an error for perhaps *Coprosma tenuicaulis*, but eventually one small manuka-dominated area was found coastward of the reserve at the southern end. There is an open canopy of large plants of manuka with occasional cabbage tree (*Cordyline australis*), wheki, kamahi, *Melicytus lanceolatus*, karamu (*Coprosma robusta*), pate, wineberry, rimu, mahoe and yellow silver pine (*Lepidothamnus intermedius*). Interspersed are tall herbs and scrambling climbers such as bush lawyer, flax, bracken (*Pteridium esculentum*), blackberry, pohuehue (*Muehlenbeckia complexa*), and *Cyathodes empetrifolia* (Plate 6).

6. *Swamp shrubland of flax–*Coprosma tenuicaulis

Intermediate between the shrublands and rushlands is the mixed vegetation dominated by flax and upright compact shrubs of *Coprosma tenuicaulis*. This mesotrophic swamp variant is scattered throughout in poorly drained fields and forest margins, so the more typical vegetation of those contributes some of the associated species. Common shrub associates are *Coprosma propinqua* and pohuehue, and common herbs include *Blechnum minus*, *Carex maorica*, and *Astelia fragrans*. Occasional cabbage trees are also a conspicuous feature.

7. *Rushland of flax*

Around the base of the hills inland from the Kongahu Swamp, adjacent to the oligotrophic bog systems, are mesotrophic swamps dominated by flax (Plate 7). They probably owe their existence to nutrient enrichment from hillslope flows and farming practices. Flax has >70% cover, with associated species including bracken, *Coprosma tenuicaulis,* and other minor species. The flax here is characteristically >1.5 m tall and virtually impenetrable. Some of these areas of flax may have been harvested for fibre over fifty years ago.

8. *Rushland of flax with wet pasture*

In the process of conversion of wetland to farmland, flax is one of the most resilient species. In many situations, isolated clumps of flax and occasional large patches persist in pasture, sometimes with stands of the unpalatable sedge *Carex coriacea*. Conversion to the hump and hollow farming system eliminates this type of vegetation during land stripping. There are occasional associated wetland species, but most common are adventive wet pasture grasses and herbs such as lotus (*Lotus pedunculatus*), jointed rush (*Juncus articulatus*), creeping bent (*Agrostis stolonifera*), kneed foxtail (*Alopecurus geniculatus*), and beggars' ticks.

9. Rushland of flax, bracken and blackberry

Thick impenetrable stands of these plants occur predominantly around the margins of the oligotrophic bogs where drainage allows the entry of these mesotrophic wetland invaders. Tall flax plants occur amongst tall arching bracken fronds, with blackberry scrambling over the top. Associated species are few and confined to areas adjacent to the ditches (aquatics and water-margin plants) and where this vegetation grades into the bog itself (bog species)

10. Rushland of soft rush

The most common invader of wet pastures following conversion to farmland is the widespread soft rush (*Juncus effusus*). This difficult-to-remove rush has also invaded the wet edges of the hollows in some of the hump and hollow situations as the only tall species. The similar native species *Juncus gregiflorus* is probably also present, and determining which species is present in such wetland situations is often difficult. From what was seen, it is considered that the introduced soft rush was the more common. Associated species are the typical grasses and herbs of wet pasture (see 7).

11. Rushland of Carex virgata and Carex secta

This kind of mesotrophic to eutrophic vegetation with *Carex virgata* and *Carex secta* is reliant on reliable waterflow, abundant nutrients and good soil aeration. It is therefore no surprise that it occurs only in a small area along the margin of Blackwater Creek where it flows from the hills behind. Associated species include flax, *Coprosma tenuicaulis, Isolepis prolifer*, beggars' ticks, *Carex coriacea*, lotus, and other species of fertile wet pasture.

12. Bog

The nutrient-poor (oligotrophic) bog communities are confined to two areas. The largest is on the Anderson property nearest the inland hills, and there is another inland of the forest at the southern end (Plate 8). The bog vegetation is highly mosaic, predominantly the result of patch forming by a number of dominants. Mixtures of these patch-forming species occur where they grade into each other. These types are covered separately below.

(a) Wire rush. *Empodisma minus* is not a major bog component, but instead occurs as round patches within which other species are rare. They are distinctive features because of their bright colour.

(b) *Baumea* mixtures. The two species of *Baumea*, *B. teretifolia* and *B. tenax,* constitute the background vegetation of most of the bog areas in which the other patch-forming species occur. There is a variety of associated species including *Gleichenia dicarpa*, *Coprosma tenuicaulis*, *Juncus canadensis*, *Isolepis prolifer,* and bracken. Pasture herbs also occur, especially creeping bent and Yorkshire fog. At the southern bog area there is a highly degraded form of *Baumea* bog vegetation as a result of grazing. Pasture species dominate with the *Baumea*, but there were small patches of other bog species including the native sundew *Drosera binata*.

(c) *Lepidosperma*. Clumps of *Lepidosperma australe* are found amongst the *Baumea* along with many of the associated species mentioned above.

(d) *Leptocarpus*. The presence of the typically estuarine species *Leptocarpus similis* amongst the other bog types in one area was something of a surprise, and it may represent the last remnants of a former lagoon vegetation. Such patches of *Leptocarpus similis* are found in similar situations elsewhere in coastal wetlands on the West Coast of the South Island. The most common associated species is *Baumea teretifolia*, but even that is uncommon.

(e) *Juncus canadensis*. Small patches of this typical introduced oligotrophic bog rush are scattered amongst the other oligotrophic communities.

13. Fernland of Gleichenia *and* Sphagnum

Sphagnum is a feature of much of the West Coast, but is rare at the Kongahu Swamp. The only situation where it is a component is a peculiar fernland bog variant in the triangle of land attached to the forest reserve at the southern end. Additional species include flax (unusual for bogs), bracken, *Baumea* (both species) and *Blechnum minus*. There are very few associated adventive species, with *Juncus canadensis* being the only frequent adventive seen.

14. Rushland salt marsh of Leptocarpus

This estuarine upper salt marsh community of almost exclusively dense *Leptocarpus similis* forms large patches at the upstream end of the estuary of Granite Creek and Blackwater Creek (Plate 9).

15. Rushland salt marsh of sea rush

Individual clumps and dense patches of sea rush (*Juncus maritimus*) occupy the lower salt marsh zones at both the upstream and downstream ends of the estuary, usually without associated species.

16. Rushland freshwater seeps of raupo

It seems somewhat incongruous that the freshwater eutrophic swamp species raupo (*Typha orientalis*) should be apparently absent from the freshwater parts of the Kongahu Swamp, but present in the estuary. It seems to owe its existence there to the presence of freshwater seeps or springs, and therefore it is confined to a single large patch along the margin.

17. Herbfield salt marsh of Sarcocornia *or* Samolus

The herbaceous variants of lower salt marsh are represented mostly by *Samolus repens*, but occasionally glasswort (*Sarcocornia quinqueflora*), but seldom mixed together.

18. Herbfield salt marsh of Selliera *and* Leptinella

The herbaceous middle to upper salt marsh variants constitute one of the few situations where there is more than just a single species. *Selliera radicans* is most frequent along with *Leptinella dioica*, *Triglochin striatum*, buck's horn plantain (*Plantago coronopus*) and *Apium prostratum*. Where this grades into more sandy areas of higher elevation, dune plants such as shore bindweed (*Calystegia soldanella*) and *Carex pumila* are found.

19. Herbfield brackish marshes of Triglochin

In the uppermost reaches of the estuary, adjacent to river inflows, there are brackish marsh variants. One of these is the herbaceous vegetation of virtually pure *Triglochin striatum*.

20. Rushland brackish marshes of three square

The other type of brackish marsh comprises almost pure stands of the creeping sedge, three square (*Schoenoplectus pungens*, Plate 9).

21. Humps in hump and hollow farmland

Whereas some of the hollows in hump and hollow farmland have attracted adventive and native wetland plants, there is little invasion of anything on the humps other than the typical pasture species (Plate 10). On some of the older humps, however, the weed beggars' ticks was sometimes found.

22. Other pasture

Pasture species contribute to many of the communities of the wetlands, but they are also a feature of non-wetland areas as well. Indeed there are within the basin high-quality very productive pastures.

23. Exotic tree plantings

Extensive exotic plantations occur at the northern inland end of the basin. Elsewhere trees are used mostly for shelterbelts.

24. Tracks/raised access-ways

Tracks that have been constructed through the wetland areas are colonised by a wide variety of pasture species and weeds of land environments. The common weed beggars' ticks is a feature here.

25. Ephemeral burn vegetation

Much of the Kongahu Swamp has been burnt at some stage. The typical long-term coloniser is bracken, but there are a number of shorter-lived species that enter immediately after burning, but disappear later. On areas recently burnt, the weed black nightshade (*Solanum nigrum*) was particularly evident (Plate 11).

4.3 VEGETATION MAP

Figure 2 is a map showing the vegetation of the wetland following the list of communities above as closely as possible. As much of the swamp has been highly modified, this map emphasises those areas dominated by communities with highest conservation value as described below. It should be noted that many of the boundaries between vegetation types follow fencelines, owing to different management practices by the various landowners.

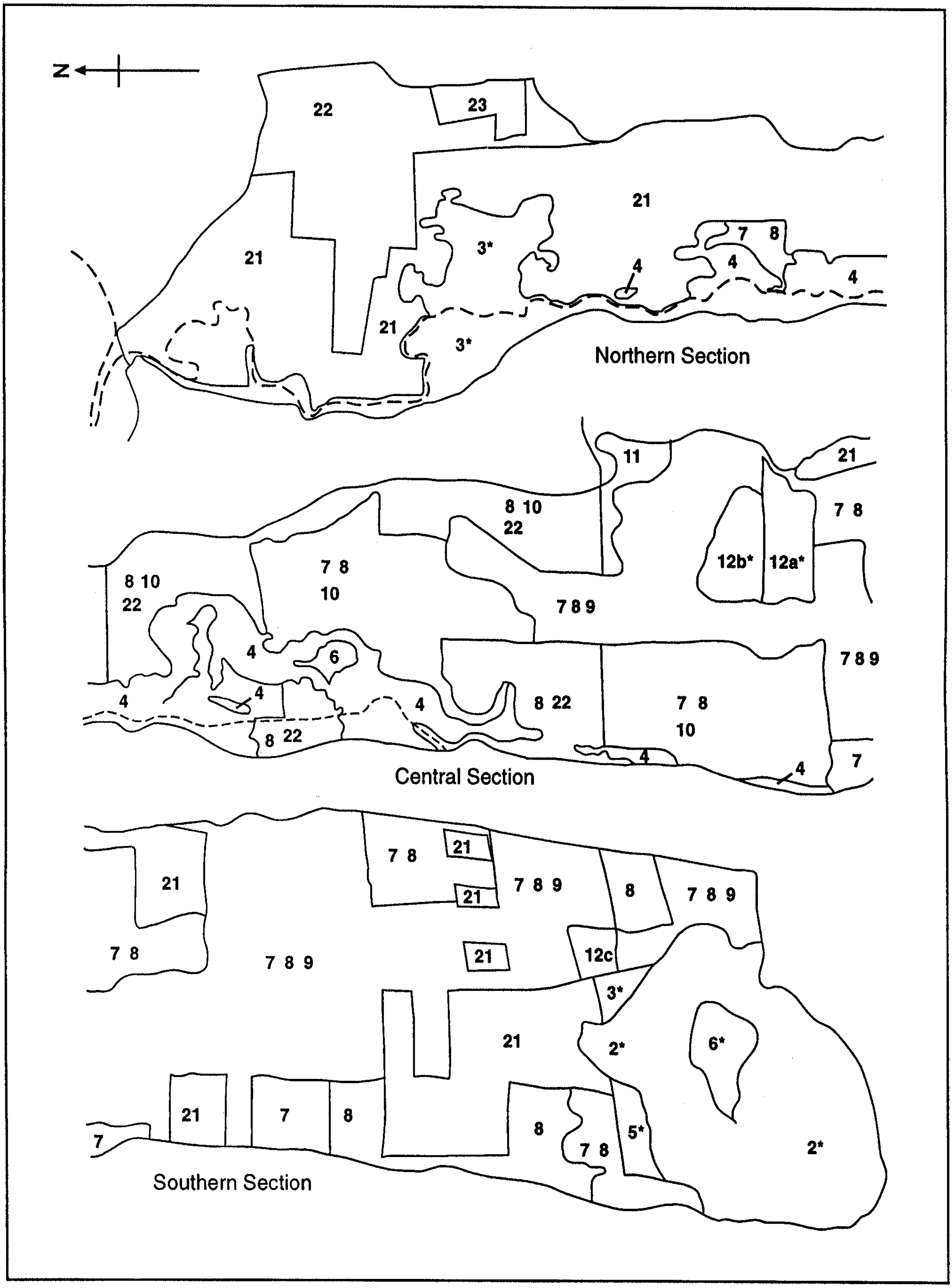

FIGURE 2. VEGETATION MAP OF MAJOR COMMUNITIES AT KONGAHU SWAMP. COMMUNITY NUMBERS ARE AS IN SECTION 4.2. E, ESTUARINE COMMUNITIES; * PRIORITY AREAS FOR CONSERVATION.

5. Conservation values of vegetation

5.1 VEGETATION TYPES

1. Aquatic communities

The true aquatic species have probably become more widespread during development, reflecting creation of the many deep drains in the area. Species in the deeper drains are mainly native, and are common throughout New Zealand. It should be noted that the drains currently contain few exotic weed species and that attention should be paid to early identification and removal of these if they arrive (see Section 6.5). Most of the shallow emergent species (e.g. water purslane, starwort) are adventive.

2. Kahikatea forest with tall understorey

The structure and composition of the vegetation are largely in their natural state. It includes all canopy layers and good tall kahikatea, although this would have once been logged. Weedy adventive species are virtually absent. This area is already reserved as a Wildlife Management Reserve.

3. Kahikatea forest with regrowth understorey

The conservation values of this forest are increasing as the understorey, shrub and ground layers re-establish following fencing and removal of grazing. Kahikatea regeneration is also evident. Any adventive weedy species are disappearing. This area is therefore passing from moderate value (as in 4 below) to one of high value (as in 2 above).

4. Kahikatea forest with no regrowth beneath

The conservation values of this forest are limited by the stock damage to the understorey layers. Adventive weeds are a feature of the ground layer. The tall kahikatea is similar to that found in more natural forests, but the poor condition of the native components of the other layers reduces its current conservation value. Experience as in 3 above shows that exclusion of cattle by appropriate fencing can considerably improve ecological values of this area.

5. Manuka shrublands

This vegetation has apparently declined from a significant feature of the wetland vegetation and now occupies one small area. Good healthy stands of manuka are now hard to find in many areas of the country, owing to a combination of changed management and manuka disease. Although this vegetation is not in the best condition, there is a diverse array and structure of associated species. It therefore has considerable conservation value. Although some nuisance weeds are present, and ideally should be removed, they contribute little to the cover and have little impact. It is currently part of the reserve, so it is already protected.

6. *Flax*–Coprosma

Of all the flax-dominated communities, this has greatest conservation value. Although not particularly diverse, it comprises mostly native species and is in excellent condition. It is, however, rather uncommon, so those areas that are in best condition are of special value.

7. *Flax*

The dense stands of flax have been somewhat modified by fire, and many of the associated species are weeds. If left, however, the flax cover is so great that the native vegetation components are likely to recover to a more natural state. The weeds will most probably disappear, although gorse may still have to be managed. The conservation value of this vegetation is therefore limited at present by weed species, but its potential to recover is considerable.

8. *Flax–wet pasture*

This is a highly modified remnant vegetation, in which flax and other native species have been reduced to minor components in the extended process of conversion to farmland. The opportunities for repair, which would require water table restoration at least and return of other species of value, are limited, so this community is regarded as being of limited conservation value.

9. *Flax–bracken–blackberry*

As this community owes much of its origin to fire, the cessation of burning might result in some recovery, provided that bracken, and blackberry are reduced. Gorse may become a problem. This community therefore has minimal value for conservation.

10. *Soft rush*

This community is of minimal conservation value except if there are areas including some *Juncus gregiflorus*.

11. Carex virgata–C. secta

This rare type of vegetation may never have been common. It comprises plants of the two species of *Carex* amongst other natives but mostly with adventive species. It is of limited conservation value, and would require considerable restoration to improve its values.

12. *Bogs*

Bogs, especially those of lowlands, have been one of the most degraded wetland systems on the West Coast. Of all the communities at Kongahu, these have suffered most, being reduced to three small areas (along with the *Gleichenia-Sphagnum* fernland). They all show signs of decline, and as they are all different will be treated as areas which form mosaics, rather than as communities.

a) Southern Anderson bog

This bog is partly modified but still has a good species assemblage. There are some weed problems, especially around the edges. The present drainage patterns seem to be the cause of the decline, so to maintain the considerable conservation values of this bog, at the very least natural water regimes would have to be restored.

b) Northern Anderson bog

This makes up a fairly large area, so even though the margins and the inland end have been considerably modified, the central areas are still in good condition. They comprise predominantly native cover, and illustrate the bog mosaic pattern at its best. This area therefore has considerable conservation value, but could show greater improvement if appropriate water regimes were restored.

c) H. Keys bog

This bog has been highly modified by fire and intensive grazing, and, with the obvious exception of *Baumea teretifolia*, most native species have been replaced by adventive grasses and weeds. One plant of conservation value still there, however, is the sundew *Drosera binata;* this was absent from the other bogs. The bog has very limited conservation value otherwise, and would require considerable changes in water table and grazing management to even start to improve its condition.

13. Fernland of **Gleichenia–Sphagnum**

This small area of rather different bog contains an assemblage of almost exclusively native species and is in almost pristine condition, as it appears to have been little modified by the changes that have caused bog decline elsewhere. It is already protected as part of the reserve.

14–20. Salt marshes

The many estuarine salt marsh communities have been grouped together, as the conservation values of this area apply equally to all. The estuarine vegetation is in excellent condition, with minimal impact of those weedy salt-tolerant species that invade especially the marginal upper marsh communities. These values are maintained despite the highly dynamic nature of some of the communities. It therefore has considerable conservation value and requires no management at present.

21–25. Land communities (humps and dry hollows, pasture, exotic trees, tracks, recent burnings)

Apart from occasional native species around track margins, these land vegetation types have no conservation value.

5.2 PRIORITY AREAS FOR CONSERVATION

Wildlife management reserve

Three communities of the highest conservation value occur here, and the opening in the centre of the forest (this was not visited) probably has the same. The forest is the least disturbed of the Kongahu Swamp, the manuka-dominated stand is the last remnant of a once significant community, and the fernland bog is in superb condition and of unusual composition.

Simonsen fenced forest

The fenced kahikatea forests and associated flax/*Coprosma* community are showing such recovery of vegetation following stock removal, that this area is improving to become one of considerable conservation value. Any weeds that were previously present are in the process of being displaced.

Anderson bogs

The two paddocks on the Anderson property that comprise predominantly bog vegetation are of considerable conservation value as the last remnants of vegetation that was once common in the Kongahu Swamp. This is despite their condition, especially round the drainage ditches. The areas are quite different, but together contribute a diversity of bog communities representing the range of dominant species typically found there. They do, however, need some action to halt the decline in their biological values, such as water table management, weed control, fire control, and stock management. Exactly what is required here is currently uncertain and should be the subject of some future research.

Estuary

The vegetation of the estuary is in excellent condition and contains few of the weedy adventive species that commonly invade disturbed marshes elsewhere in New Zealand. There are therefore no current management priorities, but continued protection of this area is essential. In contrast, recent marine sand intrusions have made the estuarine intertidal zone quite barren, but only near the estuary mouth. This may be a result of natural, periodic events causing infill with marine sediments, or it may have been accelerated by changes in the tidal regime of the estuary arising from the increasing use of floodgates to separate the freshwater wetlands from the downstream salt marshes.

5.3 AREAS OF INTERMEDIATE CONSERVATION VALUE

Flax communities

These areas were not specifically identified, but there is an area of flax adjacent to the bogs on the Anderson property that is readily identifiable as being in good condition and worthy of some conservation interest.

Carex secta–C. virgata

The small area of this swamp community where Blackwater Creek enters the basin is of some minor conservation value.

Jennings kahikatea forest

The ribbons of kahikatea forest are of current conservation value because of their trees and some associated native species, but because of the understorey modifications from grazing do not compare with the other forest areas. However, the return of these values on the Simonsen property shows that simple management can improve them.

6. Issues for conservation

6.1 WATER MANAGEMENT, DRAINAGE, AND PEAT SHRINKAGE

The present hydrological regime of the wetland differs greatly from that in pre-European times. Historical maps from the early twentieth century indicate wetland vegetation dominated by flax, manuka, and kahikatea forest prior to development. Moreover, there is evidence to suggest that Kongahu was a low-nutrient raised peat bog—a type of community once common on the West Coast. The alteration in water regime has been responsible for much of the change to the current vegetation described in Section 4.2 above. The effects of drainage are the conversion of wetland communities to farmland, the gradual degradation of other vegetation, especially in the bogs, and accentuation of the effects of fire.

Peat soils have very high water contents (normally 80–90% by volume) and hence are susceptible to shrinkage when drained. This is evident in Kongahu from the presence of exposed stumps, some protruding more than a metre above the current soil surface (Plate 12). These were seen in two areas, but only provide qualitative evidence for shrinkage. The current rate of shrinkage in Kongahu is unknown but could easily be measured. Rates of shrinkage in New Zealand peats are typically up to 1.5 m over the first ten years after drainage begins and, for lowland peat such as Kongahu, 20–30 mm per year in subsequent years (Waikato Peat Management Advisory Group 1996). It should be noted that peat shrinkage is continuous following drainage and is difficult to reverse due to oxidation of the exposed carbon and loss of ability to re-absorb water. This is a probable constraint on any attempt to restore farmland in Kongahu to its pre-drainage status, and highlights the need for sound management strategies to protect soils in the Wildlife Management Reserve and other areas not yet heavily drained. Humping and hollowing activity will accelerate this peat loss as it will increase rates of oxidation by lowering the water table. It is likely to increase drainage in adjacent unmodified areas, so possible edge effects on areas such as the reserve should be monitored.

6.2 FARMING PRACTICES

Dairying has been the major farming activity in the wetland, although there is also some sheep farming. Direct effects of animals in the wetland that have affected the vegetation include pugging of soils, grazing of the forest understorey, and removal of palatable species, especially *Lepidospermum*. The changes in vegetation in the wetland, especially the invasion of vigorous species such as Yorkshire fog, flax, and bracken, provide clear evidence of a shift from the original low-nutrient (oligotrophic) status to the present mesotrophic status. Much of the increase in fertility is no doubt related to run-off from grazing pastures, and this can be expected to progress to an even more nutrient-rich status if the wetland continues under current management practices. Again, this is accentuated by the hump-hollow activity, which has further increased the fertility of the humped areas. Fortunately, however, most of the dairy sheds associated with the properties are located outside the wetland, so the very concentrated fertilisation produced in dairy shed waste has not been an issue. Keeping dairy shed waste out of the wetland should be a management priority.

The other main impact is fire (Plate 13). It has exacerbated peat loss and led to the invasion of bracken, blackberry, and, to a lesser extent, gorse. It may have also eliminated intolerant species, e.g. *Thelymitra* orchids, which were not seen but would be expected in an area of this type.

6.3 CATCHMENT ISSUES AND SEDIMENTATION

The management of the Kongahu Swamp area should not be viewed in isolation, but rather in the wider context of the surrounding catchment and the larger wetland–estuary system downstream. Increased drainage and run-off has the potential to increase sediment input into the Otumahana Estuary downstream of the wetland. Current stream flow into the estuary consists of a continuous outlet and an overflow; these flow separately under the main road. The only sign of sediment load in the upper estuary occurs in the first 20 m below the overflow outlet (Plate 14). This sediment has minimal impact on the salt marsh communities. The constant flow channel seems to carry little sediment from the river.

At the time of the study, a brief visit was made to the northern part of the estuary, near to its opening to the sea. There the situation in regard to sedimentation is rather different. Large amounts of both water- and wind-derived sediment abound, and the salt marsh vegetation is very patchy and discontinuous. The taller vegetation of *Juncus maritimus* and *Leptocarpus similis* has been overwhelmed by this sediment, and only dominates along the inland margins. Most of the area that should comprise salt marsh is either moving bare sediment or patches of the creeping salt marsh herbs *Samolus repens* and *Sarcocornia quinqueflora*. On the east coast of the South Island, the succulent native herb *Suaeda novae-zelandiae* might be expected to dominate this situation, but it is absent from the west coast.

The sediment material is almost exclusively derived from coastal sediments, and not from Kongahu Swamp, although some may also come from Granite Creek. The process of infilling may have an indirect effect on the salt marshes adjacent to Kongahu Swamp by affecting water flows, and making the system fresher. Such an impact was not, however, visible at the time of visit as the salt marsh indicates a truly estuarine series of vegetation types. Conservency staff have also noticed that large floods from Granite Creek tend to flush this sediment periodically from the system, reducing its build-up.

There has been no monitoring of suspended sediment loads released from the wetland during its development; however, during the site visit, landowners provided anecdotal evidence of increases in sediment in major drains over time. A record of black disc visual water clarity obtained by the West Coast Regional

Council (14 April 1998) in Blackwater Creek at the Jennings property was 420 mm. This indicates moderately low water clarity, most likely because of dissolved colour rather than suspended sediment. However, sediment loads in rivers are highly variable due to changes in flow, and a more detailed programme of measurements of water clarity and sediment loads would be essential to determine how much material is being transported to the estuary. The vegetation and sediment in the estuary showed no obvious signs of excessive siltation from Kongahu, even at the outflow of Blackwater Creek. This is because the sediment contribution from this relatively small creek is minor compared with the much larger adjacent Granite Creek. Whether more serious siltation problems arise in the future will depend on the future land management practices. If drainage and conversion to pasture continue, increased rates of sedimentation from the wetland into the creek are possible. However, many owners of swampland have taken care in the past to retain spoil from drain-clearing operations on their land, and this may well have assisted in preventing higher amounts of siltation. Continued assessment of water clarity in the creek may be desirable to cover this possibility, and should include measurement of suspended solids, to allow sedimentation to be distinguished from dissolved colour. The situation at the outflow channels suggests that high sediment loads are only deposited during times of flood. Restoration of marginal vegetation in some areas could reduce sedimentation if it became excessive.

6.4 WATER QUALITY

In common with many other issues, relatively little is known about how land use practices have affected water quality as it passes through the wetland. Current water quality data are being collected by the Regional Council and single readings taken just after our site visit were kindly provided (T. James, West Coast Regional Council, pers. comm.). The values for nitrate (0.047 g/m^3), total nitrogen (1.4 g/m^3), dissolved reactive phosphorus (0.039 g/m^3), and total phosphorus (0.17 g/m^3) are relatively low. Biological oxygen demand (1.0 g/m^3), and fecal coliforms (measured as *E. coli*) in Blackwater Creek (560 cfu per 100 ml) are also not excessively high. These nutrient and fecal coliform values are typical of New Zealand lowland streams in landscapes used for pastoral agriculture. However, ammonium concentrations in Blackwater Creek are relatively high (0.057–0.82 g/m^3 during March–April 1998), and within the range that is toxic to some fish species. These high ammonium concentrations may result partly from run-off from farmland in the wetland, as they apparently increase downstream. Another possible source of ammonium is groundwater from acidic soils further upstream, as low pH and low oxygen conditions favour high ammonium concentrations. It should also be noted that these data were collected in late summer; at times of higher rainfall there could be dilution by higher flows. Further monitoring of water quality over longer time periods is advisable.

6.5 WEED PROBLEMS

Like many wetland areas subject to drainage for agriculture, the Kongahu area has been invaded by several important weeds along with other exotic aquatic, wetland and pastoral species.

Parrot's feather

The identification of parrot's feather (*Myriophyllum aquaticum*) at one site in the swamp (Plate 15) is of extreme concern. This aggressive and troublesome introduced species is a common weed of drainage systems and ponds in many areas of the North Island, and continues to spread rapidly through the country. This is the first record of it occurring on the West Coast, and although it was only found in a single drain during this study, more extensive surveys by conservancy staff have shown it to be widespread in drains south of the swamp. Considering the climate of this region, this species has the potential to spread and become a widespread nuisance if not eradicated as a matter of utmost urgency. There are two possible methods. Covering with black polythene, and follow-up visits to confirm eradication, could destroy a small infestation such as the patch seen in the Volckman property. More extensive patches should be destroyed by an initial spraying with Roundup in November-December during the period of most vigorous growth, followed by further spraying of any remaining growth at three-week intervals (any longer between spraying will allow the damaged weed to recover). This method has recently been used to successfully eradicate parrot's feather infestations in the Bay of Plenty.

It would also be advisable to continue checking for other infestations in the area, and for all landowners in the swamp to be made aware of its presence and of the need to identify and eradicate any that appear in future.

Low-growing marginal aquatics

The main exotic species of this type were water purslane (*Ludwegia palustris*) and starwort (*Callitriche stagnalis*). Together with the native swamp willow weed, these plants can provide valuable habitat for invertebrates and fish when present as moderate stands, but become a nuisance if they spread to form a dense bank-to-bank sward that can impede water flow (Plate 16). This was evident in some parts of the wetland, especially the southern properties. The appropriate management strategy here is partial mechanical harvesting rather than complete eradication.

Beggars' ticks

The invasive species beggars' ticks (*Bidens frondosa*) is showing signs of becoming a major problem in many of the partly modified communities of the Kongahu Swamp. It is already a nuisance in many of the disturbed areas of wetlands of Waikato, and appears to be a relatively recent arrival at Kongahu. Although an annual, it does have the ability to form dense stands each year and thus affect both the survival of native lower-growing species and the visual appearance of the vegetation. Its spread is aided by its effective dispersal, and it is unpalatable to stock. Beggars' ticks is therefore a weed of considerable concern for the future of the wetlands.

Invasive pasture weeds

Grazing of the wetlands has facilitated the invasion of many exotic pasture species, e.g Yorkshire fog, kneed foxtail, creeping bent, giant buttercup, lotus, etc. These seldom affect taller species such as upright rushes, sedges, and flax, but can have considerable impact on low-growing native herbaceous species, which they can displace through overtopping.

Bracken

Although a native fern, bracken must be regarded as a weed in the context of the Kongahu Swamp. Here it is predominantly a fire weed, invading after repeated firing to become a major component of such vegetation. Its management is therefore highly dependent upon the restricted use of this management tool.

Blackberry

Blackberry is a nuisance to both farming and conservation values. It scrambles over taller vegetation where present, smothering other native species and degrading visual values. Control of its spread needs to be maintained by spraying, although some areas have difficult access.

Soft rush

This species is mainly a nuisance to farming, as it is more likely to invade pasture than native vegetation in good condition. Its greatest nuisance value is its similarity to so many native rushes, making identification of conservation values difficult.

Juncus canadensis

This species is scattered throughout Kongahu but has had little impact so far. However, elsewhere on the West Coast it has become a major vegetation component, so any future spread of this rush should be viewed with alarm.

Gorse

Vast areas of modified wetland vegetation of Kongahu Swamp vegetation are vulnerable to invasion by gorse, especially as fire has been such an important management tool. However, it is only a minor component of the vegetation, apparently because all the landowners are especially vigilant in controlling it whenever and wherever it occurs.

Black nightshade

Large stands of this weed were seen on areas that had recently been burnt. It is, however, considered to be ephemeral, and likely to disappear completely within a short period. Other species may play this role of ephemeral fire weed elsewhere in Kongahu.

Alarm weeds

These constitute species that are currently absent, or are rare, but which would be of concern if they were to arrive, or suddenly expand. An important consideration here is the climate of the Karamea lowlands, which is very much like that of the North Island, and which provides ideal conditions for a variety of northern weeds. Despite its isolation, this region has already turned up species such as parrot's feather (Kongahu) and kikuyu (Little Wanganui), so others can be expected to first appear here. Beggars' ticks is probably the best example of a northern weed becoming a nuisance here.

Crack willow and grey willow

A remarkable feature of the Kongahu Swamp is the rarity of willows (not identified during site visit but reliably reported from the Jennings property). Willows, especially crack willow and grey willow have considerable effects on wetland values. The first usually dominates along stream margins and affects mostly marginal communities, but grey willow, which is currently absent from the West Coast, has the ability to spread across many wetland areas, including bogs. Considering how little there is currently present, removal of willows and treatment of regrowth would be well worth the effort before spread becomes a problem.

Spartina *and tall fescue in estuary*

The risk of *Spartina* invasion is high, as it has been reported to be present north of Karamea. As with estuaries elsewhere, any appearance of any species of *Spartina* in the estuary should be followed by its complete removal. This salt-tolerant grass can have considerable impact on sediment movement and native flora and fauna. As long as the upper marsh zones are undisturbed, tall fescue (*Festuca arundinacea*) will remain the minor component it is currently.

Oxygen weeds

Blackwater Creek and the drains in the wetland were notable for the absence of invasive oxygen weeds such as *Lagarosiphon major* and *Egeria densa* that are severe nuisances in creeks and drains in the North Island. Both of these species have now spread to the South Island and have been identified on the West Coast, and there is therefore a high danger of them arriving in the Karamea district. The choking of streams by their excessive growth is a costly problem in many North Island regions, and vigilance to their arrival is therefore strongly recommended. If these weeds are noted in Kongahu at any time they should be eradicated immediately. Early detection of these weeds is important because small infestations can be removed by hand weeding, whereas herbicides may be needed for extensive infestations.

7. Management options for Kongahu

Because wetlands are such a diverse grouping of ecosystems, it is essential that management options are tailored for the system under consideration. Given the size of the Kongahu system, the range of disturbance levels across the wetland, and the array of vegetation condition from near-pristine to completely degraded, a single management strategy for the entire system is not appropriate. Instead, management practices will be needed that are designed in keeping with the current status of the system and desired end-points.

Involvement of the landowners will be essential here. The following list of options is designed to identify the likely consequences of potential actions.

Maintain current management

The current protection and management of the DOC reserve and the forest on the Simonsen property has been favourable for regeneration and should be maintained. However, other areas in the wetland, e.g. the bog systems, will continue to decline if there is not some intervention. Humping and hollowing will cause continued loss of wetland communities and is likely to lead to further invasion of weeds, as seen with the recent arrival of beggars' ticks.

Areas with high conservation values

Identification of particular areas with high conservation values, and encouraging landowners of the benefits of retaining, expanding, and protecting these, would lead to their improvement while other areas lose conservation components. The implication of this is that landowners are able to exchange high-value areas for low-value areas that they can then develop. A patchwork of high- and low-value areas would result.

Strategy for large areas irrespective of conservation value

The advantage of this strategy would be the possibility of improvement of all areas of the wetland, and the ability to obtain a balance between productive agriculture and wetland protection. It should be stressed here that agriculture and conservation are not necessarily conflicting activities in wetland systems. Many of the valuable functions of wetlands (e.g. erosion control, nutrient trapping) can be beneficial for farming activities, and education and advice to landowners about these aspects may help obtain this balance. Some possible mechanisms to consider for areas suitable for restoration are:

- Land management: For areas to restore to wetland status, a combination of weed control, reforming of soil, increasing of water level, stock removal, and planting of wetland species would be necessary.
- Interaction: Co-operation with owners of land surrounding restored areas would be valuable in their protection, e.g. by not burning or hump-hollowing buffer zones.

- Purchase of specific areas with high value may be necessary to prevent them being developed into farmland.
- As noted earlier, regulation is usually counterproductive in wetland conservation, unless it is accompanied by some kind of compensation to landowners. In our opinion, it should be a strategy of last resort.

8. Research needs for wetland management

The issues identified here for the Kongahu system are also relevant to wider wetland management strategies elsewhere in the conservancy and throughout New Zealand. The responses of the vegetation to land management are typical of those occurring in wetlands elsewhere. Because wetlands exist in the terrestrial/aquatic interface in landscapes, they characteristically have very precise semi-aquatic regimes and are very sensitive to changes in patterns of water supply and level. Drainage shifts the system towards a more terrestrial environment, typically causing loss of aquatic biota and vegetation that cannot compete with more vigorous terrestrial species. At the other extreme, prolonged high water levels, a serious and neglected issue for riparian and lake-edge wetlands in New Zealand, can destroy the wetland ecotone between land and freshwater ecosystems.

Hence, although there are numerous biotic and abiotic factors that can affect community structure in wetland ecosystems, the primary forcing factor that overrides all other management considerations is hydrology (Mitsch & Gosselink 1993, Bunn et al. 1996). This includes water flow rates through wetlands, and water retention times; soil water contents control almost all other factors that affect biota. Changes in water regime alter the nutrient sources, rates at which materials exit, and sediment properties such as nutrient availability, pH, and sediment porosity and anoxia (Faulkner & Richardson 1989). These abiotic characteristics affect vegetation patterns, because wetland plants have different nutrient requirements and tolerances to stresses associated with flooding (van den Brink et al. 1995, Ewing 1996).

Appropriate water management is therefore the key to successful protection of relatively unmodified high-value wetlands, and for restoration of degraded wetlands. However, providing the appropriate water regime in the face of community pressure for competing requirements for land and water is extremely difficult, especially if there is a lack of reliable information on the regimes needed by particular biota. This understanding of the linkages from hydrology to soil and water edaphic factors and the biota they control is the predominant handicap for wetland management and restoration in New Zealand. Although there is some understanding of broad tolerances of individual species preferences for water and nutrients, responses of plant communities remain unpredictable.

Examination of failed wetland restoration and creation projects elsewhere highlights this need for understanding of basic wetland ecology and its application in management as factors that need to be considered in restoration strategies (Mitsch & Wilson 1996). These authors identified three critical issues that need to be addressed for all successful wetland conservation and restoration work. These are all aspects that are poorly understood in the New Zealand context:

1. Hydrological regimes need to be consistent and suitable for the vegetation desired. Provision of water to the wetland needs to be flexible enough that soils are not too dry during low-flow conditions (i.e. during summer), and water level fluctuations should not be greater than the wetland plants can tolerate.

2. Systems need to be given time to develop, and the likely changes over time should, where possible, be predictable in advance. It can take many (>10) years for viable plant communities to develop, or for species that have been eradicated to achieve stable re-colonisation. The more degraded the system is before intervention, the longer it will be before reaching a steady state after restoration attempts are begun (Jørgensen 1994). Long-term interactions between management and monitoring are needed to achieve this, and implicit in this is sound experimental design of studies to ensure that any changes observed are significant (see Connell & Sousa 1983; Likens 1985; Brinsen & Rheinhardt 1996).

3. Provision of appropriate hydrology and allowing long time scales for wetlands to recruit species can assist in minimising costs, as it reduces the amount of human intervention needed. The ability of the system to achieve this can only be determined from holistic understanding of the ecosystem desired, i.e. of water retention and mixing, water quality, sedimentation, vegetation development, aquatic metabolism, and finally fish and bird re-colonisation.

Understanding trophic interactions and food webs could be critical in setting priorities for restoration strategies. One of the first consequences of drainage, the main threat to lowland palustrine wetlands in New Zealand, is the disappearance of standing water and hence the aquatic component of the ecosystem. Even if drainage is only moderate, so that the water regime remains suitable for retaining existing emergent aquatic vegetation, conditions will no longer be suitable for development of epiphytic periphyton on the vascular plants. Periphyton and phytoplankton are now emerging as the major direct food sources for invertebrates and hence the entire food web in both freshwater and estuarine wetlands (Hamilton et al. 1992, Kwak & Zedler 1997), so maintaining water levels suitable for their development may be essential if high biodiversity is a management goal.

Further drainage leads to degradation of the type seen in Kongahu, where wetland plant communities gradually disappear and are invaded by disturbance weeds. This is more evident if areas are subject to additional effects such as burning and eutrophication. The management strategies needed to reverse these changes could also benefit from a better understanding of the conditions desirable species prefer during restoration programmes.

Finally, it should be noted that while drainage (i.e. loss of water) is the main cause of loss of palustrine wetlands in New Zealand, flooding and excessive water level fluctuations are a more important threat to riverine (riparian) and lacustrine (lake-edge) wetlands. This issue has received little consideration in the past, so that we currently know very little about the water level changes these wetlands will tolerate, which will be critical for protecting them from human disturbance.

9. Summary and conclusions

1. The Kongahu Swamp is now a highly modified system, with a mosaic of vegetation types ranging from near-pristine to highly degraded. This results from different management practices employed on properties in the wetland, with loss of conservation value in many areas caused by lowered water table, fire, grazing, and hump-hollowing. There are several important weed issues.
2. Associated with these vegetation changes has been extensive shrinkage of the peat soils, and possibly an increase in suspended sediment in Blackwater Creek, due to drainage and hump-hollowing. The Otumahana Estuary immediately downstream of the wetland is unaffected by these practices at present, and is therefore of high conservation value.
3. Future management of the wetland should be based on strategies that integrate across properties and provide an optimum balance between agriculture and promotion of wetland values in the landscape. Co-operation with landowners will be essential to achieve this.
4. The effects of land management on the Kongahu system are similar to those seen in many other areas of New Zealand and highlight gaps in research knowledge for wetland protection and restoration. In particular, responses of biota to water management are poorly understood, especially over long time scales.

10. Acknowledgements

We are grateful to staff of the West Coast Conservancy, especially Philippe Gerbeaux and Natasha Grainger, and landowners in the wetland for their hospitality, assistance, and useful discussions during the site visit. The report benefited greatly from the constructive criticism of Alastair Suren and two anonymous referees.

11. References

Basu, J. 1997. Spotlights on science: Mooney calls on scientists to find how biodiversity protects ecosystems. *Science International 64*: 10–11.

Brinson, M.M.; Rheinhardt, R. 1996. The role of reference wetlands in functional assessment and mitigation. *Ecological Applications 6*: 69–76.

Bunn, S.E.; Boon, P.I.; Brock, M.A.; Schofield, N.J. 1996. National wetlands research and development program scoping review. Land and Water Resources Research and Development Corporation, Australia.

Cocklin, C.; Doorman, P. 1994. Ecosystem protection and management in New Zealand: A private land perspective. *Applied Geography 14*: 264–280.

Connell, J.H.; Sousa, W.P. 1983. On the evidence needed to judge ecological stability or persistence. *American Naturalist 121*:789–824.

Costanza, R.; d'Arge, R.; de Groot, R; Farber, S; Grasso, F.; Hannon, B; Limburg, K.; Naeem, S.; O'Neill, R.V.; Paruelo, J.;Raskin, R.G.; Sutton, P.; van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature 387*: 253–260.

Cromarty, P.; Scott, D.A. (eds) 1995. *A directory of wetlands in New Zea*land. Department of Conservation, Wellington.

Department of Scientific and Industrial Research 1964. Soil Survey Map. Department of Scientific and Industrial Research, Wellington.

Ewing, K. 1996. Tolerance of four wetland plant species to flooding and sediment deposition. *Environmental and Experimental Botany 36*: 131–146.

Faulkner, S.P.; Richardson, C.J. 1989. Physical and chemical characteristics of freshwater wetland soils. P. 41–72 in D.A. Hammer (ed.). *Constructed Wetlands for Wastewater Treatment*. Lewis Publishers, Chelsea, Michigan.

Hamilton, S.K.; Lewis, W.M.; Sippel, S.J. 1992. Energy sources for aquatic animals in the Orinoco River floodplain: evidence from stable isotopes. *Oecologia 89*: 324–330.

Jones, D.;Cocklin, C.; Cutting, M. 1995. Institutional and landowner perspectives on wetland management in New Zealand. *Journal of Environmental Management 45*: 143–161.

Jørgensen, S.E. 1994. *Fundamentals of Ecological Modelling*. (2nd edn) Elsevier, Amsterdam.

Kwak, T.J.; Zedler, J.B. 1997. Food web analysis of southern California coastal wetlands using multiple stable isotopes. *Oecologia 110*: 262–277.

Likens, G.E. 1985. An experimental approach for the study of ecosystems. *Journal of Ecology* 7: 381–396.

Malakoff, D. 1998. Restored wetlands flunk real-world test. *Science 280*: 371–372.

McDowall, R.M. 1998. Once were wetlands. *Fish and Game New Zealand 20*: 32–39.

Mitsch, W.J.; Gosselink, J.G. 1993. *Wetlands*. (2nd edn.) Van Nostrand Reinhold, New York.

Mitsch, W.J.; Wilson, R.F. 1996. Improving the success of wetland creation and restoration with know-how, time and self-design. *Ecological Applications 61*: 77–83.

Patterson, M.G.; Cole, A.O. 1999. Assessing the value of New Zealand's biodiversity. *Massey University occasional paper 1*. 88 p.

van den Brink, F.W.B.; van der Velde, G; Bosman, W.W.; Coops, H. 1995. Effects of substrate parameters on growth responses of eight halophyte species in relation to flooding. *Aquatic Botany 50*: 79–97.

Waikato Peat Management Advisory Group. 1996. Facts about peat and protocols for peatland management. *Water Research Unit occasional report 2, University of Waikato, Hamilton*.

Ward, J.C.; Lambie, J.S. 1998. Coordinated monitoring of New Zealand wetlands. Report of Classification of Wetlands Workshop 1, Ministry for the Environment Sustainable Management Fund. UNEP/GRID, Christchurch.

12. Plates

PLATE 1. KONGAHU SWAMP FROM COASTAL RIDGE, LOOKING EAST: DRAINAGE DITCH THROUGH FLAX-DOMINATED PASTURE AND RUSHLAND.

PLATE 2. RECENTLY CREATED HUMPS AND HOLLOWS IN KONGAHU SWAMP, SHOWING HOW THE HOLLOWS INCREASE DRAINAGE FROM HUMPED PASTURE.

PLATE 3. AQUATIC VEGETATION. MAIN DRAIN, WITH SWAMP WILLOW WEED AND WATER PURSLANE AT MARGINS, AND NATIVE PONDWEED IN DEEPER WATER (COMMUNITY 1).

PLATE 4. SWAMP FOREST. TALL KAHIKATEA WITH REGENERATING SUBCANOPY AND FLAX MARGINS (COMMUNITY 3).

PLATE 5. SWAMP FOREST. TALL KAHIKATEA WITH GRAZED UNDERSTOREY ALMOST ABSENT (COMMUNITY 4). FOREGROUND OF PASTURE SPECIES (COMMUNITY 22).

PLATE 6. SWAMP SHRUBLAND OF MANUKA AND OTHER LOW-GROWING SHRUBS WITH BRACKEN (COMMUNITY 5). TALL KAHIKATEA FOREST (COMMUNITY 2) IN BACKGROUND.

PLATE 7. RUSHLAND OF FLAX AND ASSOCIATED SEDGES AND SHRUBS (COMMUNITY 7).

PLATE 8. BOG OF *Baumea* spp. AND *Gleichenia dicarpa* (COMMUNITY 12b). BRACKEN AND BLACKBERRY IN FOREGROUND ADJACENT TO DITCH.

PLATE 9. *Leptocarpus similis* RUSHLAND (COMMUNITY 14) AND SHORTER-GROWING THREE SQUARE (COMMUNITY 20) IN THE OTUMAHANA ESTUARY.

PLATE 10. HUMP (BACKGROUND) AND HOLLOW (FOREGROUND) WITH MIXTURE OF PASTURE AND WETLAND SPECIES (COMMUNITIES 1 AND 21).

PLATE 11. EPHEMERAL BURN VEGETATION OF BLACK NIGHTSHADE AND DEAD *Coprosma* SHRUBS (COMMUNITY 25).

PLATE 12. VISUAL EVIDENCE FROM EXPOSED TREE STUMP FOR PEAT SHRINKAGE IN BOG. THE TREES WERE BELIEVED TO HAVE BEEN CUT AT A FORMER GROUND LEVEL.

PLATE 13. RECENT BURN (AT RIGHT) IN FLAX PASTURE AT EDGE OF BOG.

PLATE 14. BLACKWATER CREEK SEDIMENT DEPOSITED CLOSE TO OVERFLOW OUTLET VALVE IN OTUMAHANA ESTUARY.

PLATE 15. THE SINGLE OBSERVED INFESTATION OF PARROT'S FEATHER IN A DRAINAGE DITCH.

PLATE 16. SPRAWLING SPREAD OF WATER PURSLANE ACROSS THE SURFACE OF A MAJOR DRAIN.