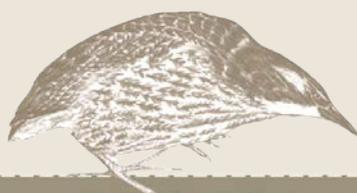




Arawai Kākāriki Wetland Restoration Programme

Whangamarino Outcomes Report 2007-2011



Arawai Kākāriki
wetland restoration programme

Whangamarino

Department of
Conservation
Te Papa Atawhai

Arawai Kākāriki Wetland Restoration Programme

Whangamarino Outcomes Report 2007-2011

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Cover image: Matthew Brady and Kathryn Duggan traversing Whangamarino Wetland (DOC)

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Executive Summary

Whangamarino Wetland is one of the largest swamp and raised peat dome wetland complexes in New Zealand. Located in the Waikato, the wetland encompasses an area of 6,912 ha, 5,690 ha of which has been recognised as a wetland of international importance under the Ramsar Convention. It is one of three significant wetlands in New Zealand to be included in the Arawai Kākāriki Wetland Restoration Programme, a flagship programme for the Department of Conservation initiated in 2007 that aims to: 1) undertake management to protect, maintain and restore the status of species and habitats at Whangamarino; 2) increase awareness, recreation and cultural use of wetlands in the community; and 3) undertake research to increase knowledge of the values and functions of Whangamarino Wetland and develop best-practice wetland restoration tools for application nationwide.

Whangamarino contains large areas of peat bog and is an important habitat for a high diversity of indigenous plants and fauna. In particular, it contains the largest known breeding population in New Zealand of the threatened Australasian bittern (*Botaurus poiciloptilus*) and is now the only known location for the tiny and nationally critical swamp helmet orchid (*Corybas carsei*). It is considered a stronghold for the 'at risk' black mudfish (*Neochanna diversus*). The wetland provided resources and sanctuary to Māori and its importance to Waikato-Tainui has been formally recognised as part of the Waikato River Settlement. Whangamarino is a popular game bird hunting location and a critical component of the Lower Waikato-Waipā Flood Control Scheme.

Areas of peat bog in the Whangamarino Wetland remain in very good condition, but swamp habitat is highly modified with impacts also extending into fen areas. The major threats to the wetland are increasing sediment and nutrient concentrations entering from the wider catchment, the impacts of the Lower Waikato Waipā Flood Control Scheme, the presence of mammalian predators, new incursions and expansion of weed species, and the effects of stock incursion within the wetland and surrounding catchment.

The Whangamarino Wetland restoration programme has invested in significant research and monitoring at the site, focusing on improving methods to monitor cryptic birds, developing techniques to undertake mammalian predator control in wetlands, and developing an ecohydrological model of the wetland to help elucidate the relationship between hydrology, ecology and wetland values. Considerable inventory monitoring has taken place resulting in updated knowledge of the species present in the wetland, particularly threatened species. This work, in conjunction with the adaptive management approach of the project, will play a crucial role in informing restoration and improving management of wetlands throughout New Zealand.

Key conservation outcomes under the Arawai Kākāriki programme to date include: extending and protecting wetland habitat by retiring grazing concessions, erecting 28 km of boundary fencing, repairing the Whangamarino weir, maintaining an extensive weed control programme, and enhancing the status of *Corybas carsei* plants through creation of a disturbance regime (controlled burns). The Whangamarino programme has also focused on; enhancing visitor experience by undertaking improvements to the Whangamarino Redoubt access track, upgrading boat ramps and installing interpretive signage, undertaking community engagement in conjunction with media releases and the distribution of a community newsletter.

This report describes the conservation outcomes achieved at Whangamarino Wetland from 2007-2011 using data/indicators to report on the status of the site, community engagement, and the research that has been undertaken. The report also provides key directions for future work at Whangamarino Wetland.



Start of a field day in Whangamarino Wetlands. Photo: DOC 2010

Acknowledgements

The Whangamarino Wetland restoration programme has benefited hugely from the input and enthusiasm of a great number of individuals and organisations. In particular, we would like to thank Wildland Consultants (especially Paula Reeves), NIWA, Landcare Research, SKM, the University of Waikato, Versus Research, James Blyth, Emma Williams, Waikato Tainui iwi and hapū, Waikato Regional Council staff, and all the dedicated people within DOC who have been part of this project.

1. Background

The Arawai Kākāriki ('Green Waterway') Wetland Restoration Programme began in July 2007 at three of New Zealand's foremost wetland sites, one of which is the Whangamarino Wetland. It is a flagship programme for the Department of Conservation (DOC, or 'the Department') aimed at protecting, restoring and understanding these ecosystems with the assistance of community¹.

There are 10 national objectives for the Arawai Kākāriki Wetland Restoration Programme under the themes; Biodiversity; Community; and Learning (Box 1)².

Box 1. Objectives of the Arawai Kākāriki Wetland Restoration Programme

Biodiversity

1. Maintain the extent of wetland habitat
2. Maintain and enhance water levels and water quality
3. Protect and restore wetland habitat
4. Maintain and enhance species diversity, including threatened species

Community

5. Conserve historic and cultural sites
6. Promote sustainable land use
7. Improve recreation and visitor facilities
8. Maximise community awareness and involvement

Learning

9. Undertake research to inform wetland management
10. Develop best-practice wetland restoration tools

This Site Outcome Report summarises progress under each national objective at Whangamarino, with reference to monitoring data and other observations that describe the current status of the ecosystems, species, and progress in working with the community. These national objectives are used to prioritise on-ground management and monitoring at the Arawai Kākāriki sites.

¹ For further background on the Arawai Kākāriki Wetland Restoration Programme and implementation at Whangamarino Wetland, refer to Robertson & Suggate (2011).

² These objectives were revised in 2012 (refer future directions).

2. Whangamarino Site Description

2.1 Vision

Our vision is that Whangamarino, one of New Zealand's largest wetlands, remains an outstanding site for promoting the value of wetlands and species conservation, especially Australasian bittern/matuku.

2.2 Location and History

Whangamarino Wetland is located approximately 45 km north of Hamilton and lies to the east of SH1, between Te Kauwhata and Mercer (figure 1). This falls within the operational area of the Department's Waikato Area Office. The wetland is contained within three shallow basins drained by the Maramarua and Whangamarino Rivers and the Reao Stream.

Its large catchment of 80,000 ha extends as far north as the headwaters of the Mangatangi Stream in the Hunua Ranges. To the east it is bounded by the Maungaroa Fault and on the west by low hills adjacent to SH1. Lake Waikare, one of the North Island's biggest lakes, flows into the wetland from the south and is a key feature of the catchment. The Whangamarino Wetland also receives water from the Waikato River catchment, via Lake Waikare, as part of the Lower Waikato Waipa Flood Control Scheme (hereafter referred to as the Flood Control Scheme). Land use in the catchment is predominantly pastoral and this has become much more intensive since the establishment of the Flood Control Scheme in 1965. The Scheme, managed by the Waikato Regional Council, utilises the Whangamarino Wetland and Lake Waikare for water storage in a much more controlled way. The scheme lowers the flood peak in the Waikato River by 40-60 cm, reducing the chance of serious damage to surrounding land, but in doing so periodically inundates Whangamarino Wetland.

The Whangamarino Wetland encompasses an area of 6,912 ha which consists of:

- 4,969 ha administered by DOC. Most of this area consists of Whangamarino Wetland Management Reserve (4,855 ha) and Whangamarino Government Purpose Reserve (323 ha) along with much smaller areas of Marginal Strips and Soil Conservation Areas;
- 737 ha owned by Fish and Game;
- 38 ha of the wetland which is protected by either Conservation Covenant or the Meremere Power Station Encumbrance; and
- 1,168 ha of privately owned land; as shown in Figure 2.

In December 1989, 5,690 ha of the wetland became formally recognised under the Ramsar Convention as a wetland of international importance. The wetland's Ramsar designation was inspired by the native species and ecosystem values that it supports, particularly, the diverse and numerous water birds, including herons, rails, waders and waterfowl.

The Whangamarino Wetland is located within the rohe (area) of Waikato-Tainui and local hapū continue to uphold and value their connection with this taonga (treasure).

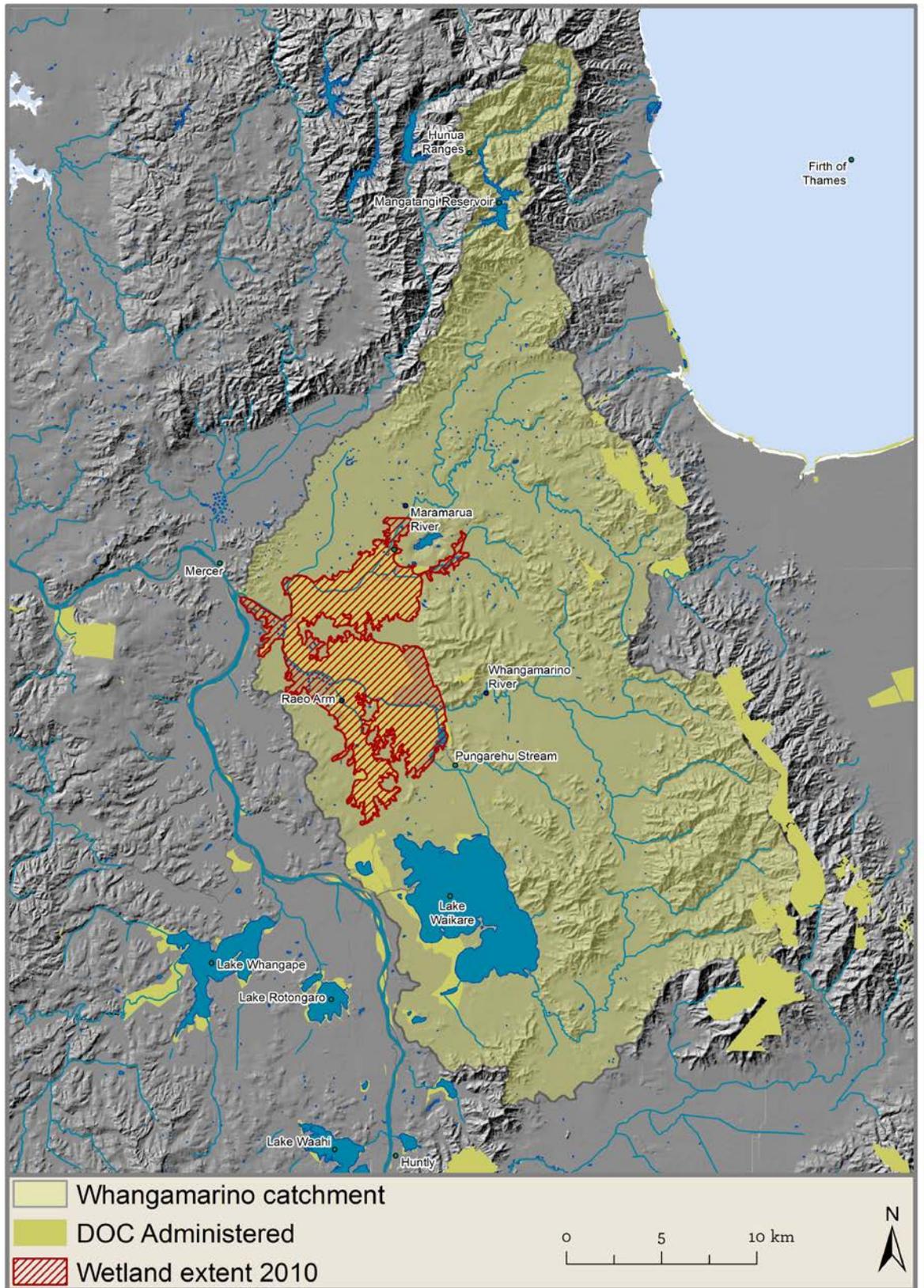


Figure 1. Location of the Whangamarino Wetland and its immediate catchment.

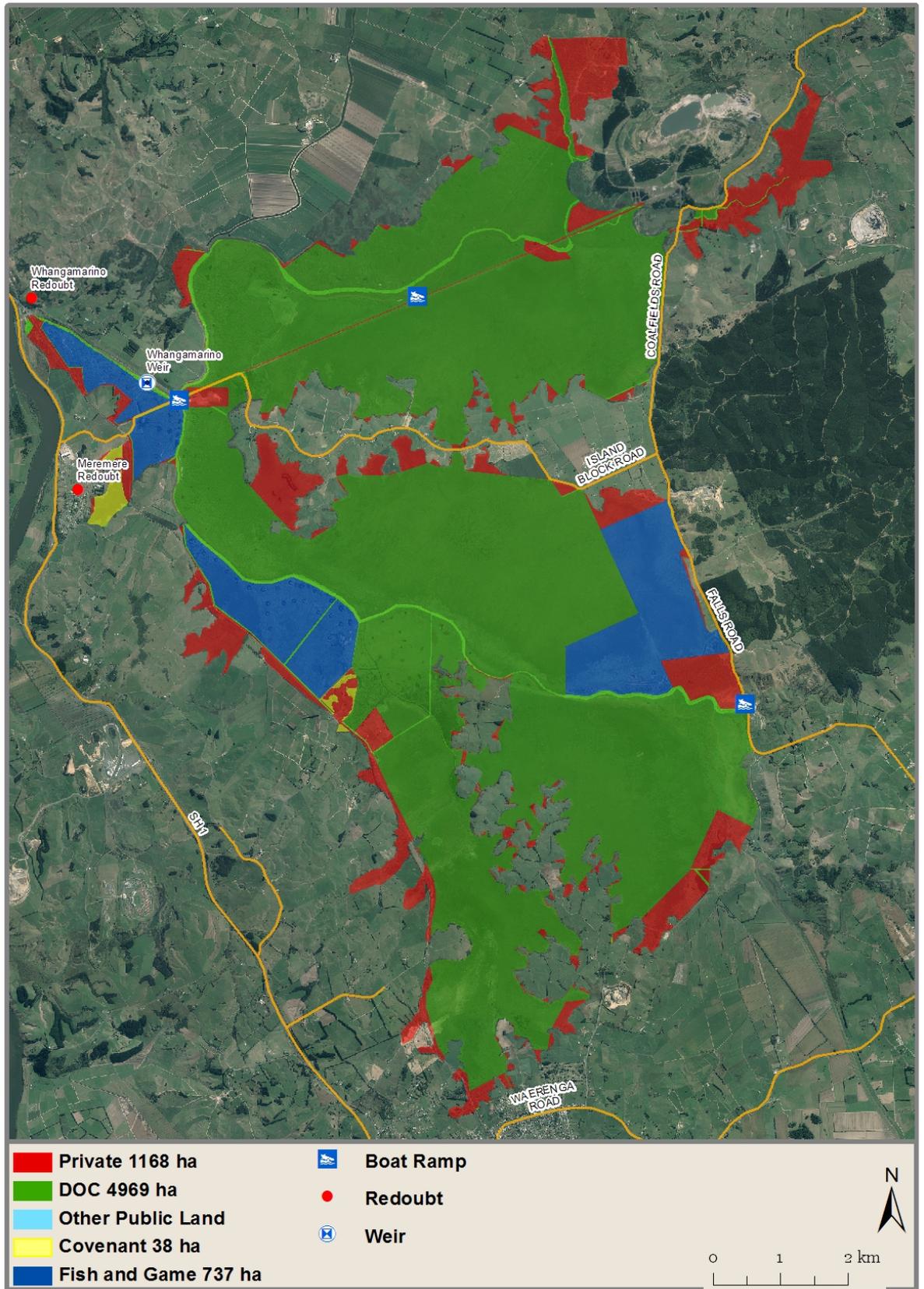


Figure 2. Whangamarino Wetland land tenure and points of interest

2.3 Wetland values

Whangamarino Wetland is one of the largest swamp and raised peat dome wetland complexes in New Zealand. The low nutrient, ombrotrophic (rainwater fed) regions of Whangamarino are largely still intact.

The size and combination of wetland types at the Whangamarino Wetland confer significant conservation values. In 1989 it was recognised under the Ramsar Convention as a wetland of international importance. It is important habitat for a high diversity of indigenous plants and fauna, including ten threatened plant species (Reeves 2009), and contains the largest known breeding population in New Zealand of the threatened Australasian bittern (*Botaurus poiciloptilus*, Ogle & Cheyne 1981). It is also a significant site for other uncommon wetland birds including marsh crake (*Porzana pusilla affinis*), spotless crake (*Porzana tabuensis plumbea*), North Island fernbird (*Bowdleria punctata vealeae*), and NZ dabchick (*Poliocephalus rufopectus*), as well as the 'at risk' black mudfish (*Neochanna diversus*).

Whangamarino Wetland contains large areas of peat bog, a comparatively rare wetland type in New Zealand (Ausseil *et al.* 2008). The Whangamarino contains approximately 26% of the peat bog area found in the Waikato region, which is considered a stronghold for bogs with around 19% of the historic extent remaining (though less than 5% of other wetland types remain; *ibid.*). Peat bogs are derived from the remains of plants that have built up over hundreds of years, and their surfaces can be several meters higher than surrounding fen and swamp (Johnson & Gerbeaux 2004). Their main source of water is from rainfall and they are therefore dominated by plant species that are adapted to live in very low nutrient environments. Eight out of the ten threatened plant species found in the Whangamarino Wetland occur within the peat bogs.

Early Māori utilised the resources of the wetland, including tuna (eels), birds and harakeke (NZ flax) for cultural and traditional purposes and the rivers were used for transport and recreation. Dense vegetation limited use of much of the wetland, but provided sanctuary during times of war. Māori used peat margins to preserve taonga such as waka, tools and weapons. The Whangamarino area was the site of several major battles during the Waikato War of 1863-1864 including New Zealand's most fierce land battle at Rangiriri.

Whangamarino Wetland is a popular game bird hunting location, with 748 ha of the wetland owned by the Auckland/Waikato Fish and Game Council. Thousands of game birds utilise the wetland attracting hunters from Auckland and the greater Waikato region. Recreational fishers frequently visit Whangamarino targeting coarse fish and the wetland is renowned throughout New Zealand for bird watching.

Whangamarino plays a vital role within the Flood Control Scheme of the Lower Waikato River. Its floodwater storage capacity was valued at \$3.8 million per annum (in 1998 dollars) alone (Waugh 2007), and has avoided costs in public works and reduced damage to surrounding farmland during large floods, of which there have been several in the last decade. Other wetland ecosystem services include carbon sequestration, nutrient/sediment filtering, and the provision of water for irrigation during dry periods within strict water take limits. The wetland also acts as a habitat refuge during dry periods as water is released more slowly from the peat substrate than other soil types.

Modification of catchment land use and the hydrological regime are the overriding threats to the Whangamarino Wetland. Inclusion within the Flood Control Scheme, land clearance and agricultural intensification has dramatically changed wetland hydrology and increased the ingress of nutrients and sediment into sensitive low-nutrient habitats. The establishment and spread of a range of weeds and pests is also threatening many of the species, ecological communities and habitats that make up the Whangamarino Wetland.

3. Conservation Outcomes

In all conservation projects it is essential to have clear measures of success that indicate whether the investment is achieving the desired outcomes. A key element of the Arawai Kākāriki programme was the development of specific indicators and measures to monitor and report on each of the programme objectives. Development of the indicators was initially based on the Department’s Natural Heritage Management System (NHMS) framework, and overtime has expanded on the NHMS indicator sets to incorporate freshwater environments.

A reporting framework was developed to link high-level objectives, with specific goals, management actions, monitoring and reporting (Figure 3). This established a process for reporting on the management and monitoring at each site (Implementation Report, see Robertson & Suggate 2011), and for evaluating conservation outcomes (as in this report).

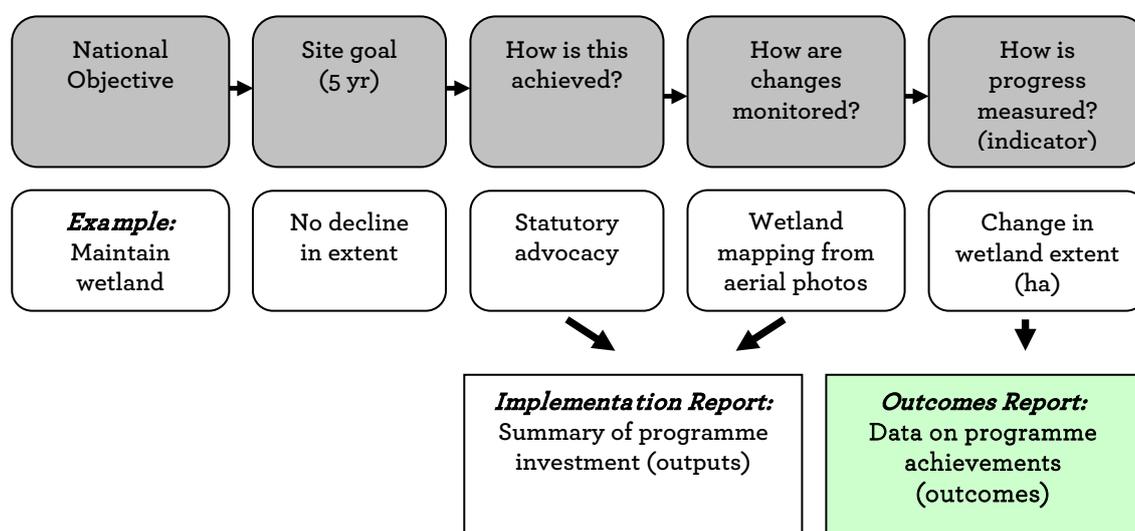


Figure 3. Reporting Framework for the Arawai Kākāriki programme that links national objectives with specific indicators to measure progress at each site.

The focus of this Outcomes Report is to describe the ecological condition of Whangamarino as recorded from our wetland monitoring, and to detail the programme’s effectiveness in promoting recreation, engaging with community, and improving our knowledge of wetlands.

The Outcomes Report is based on 56 indicators identified for reporting on changes in biodiversity, community involvement and the other national objectives of Arawai Kākāriki programme (Appendix 1). However, not all indicators are relevant to each site, and a subset of data is presented here that is most appropriate for reporting on the Whangamarino Wetland.

3.1. Biodiversity

Objective 1: Maintain the extent of wetland habitat

Loss of wetland habitat has been well reported across New Zealand. This is correlated with a decline in biodiversity and a reduction in the ecosystem services they provide such as maintaining water quality.

Whangamarino incorporates a diverse range of habitats including bogs, fens, swamps and lowland rivers. While maintaining the overall extent of wetland habitat is important, of greatest relevance at Whangamarino, is the proportion of wetland extent that is made up of high value bog habitat compared with fens and more modified swamp habitat.

Under this objective, management is focused on protecting wetland habitat through both statutory measures (e.g. Resource Management Act 1991 (RMA)) and non-statutory advocacy. A review of DOC-administered grazing concessions around the margins of the wetland has also been included in the management approach, with the intention of determining the most appropriate use to ensure net conservation value is achieved in these areas.

Outcome monitoring

Wetland extent and composition at Whangamarino is monitored using vegetation maps developed using Geographic Information System (GIS) software.

In 2008 Wildland Consultants were contracted to produce a GIS based vegetation map of the wetland founded on aerial imagery gathered in 2007 (Reeves 2011a). This map was developed using a similar methodology to that used in previous vegetation mapping projects undertaken at Whangamarino and completed in 1994 and 2003 (Reeves 1994; Reeves & Haskew 2003). The vegetation map was then overlaid on property boundary layers to calculate the size of wetland types (bog, fen, swamp or other) across four categories of tenure (DOC, Fish and Game, Private Covenants and Private Other).

Progress is measured using the following outcome indicators:

- Extent of wetland habitat [AK 1.i, AK 1.ii]
- Extent of wetland habitat protected in covenants and reserves [AK 1.iii]

Results

The total area of Whangamarino calculated using the 2007 vegetation map was 6,912 ha (Reeves 2011a). Swamp was the most common habitat making up approximately 35% of the wetland with both fen and bog making up a slightly smaller proportion of around 28% (Table 1). Most of the bog and fen habitat were found on public conservation land (PCL), however, there were still 274 ha (4%) of bog and fen habitat present on private land.

The 2007 vegetation map sets the baseline extent of Whangamarino at the start of the Arawai Kākāriki programme. Since that time the overall extent of the wetland habitat within the management area has slightly increased. This increase is due primarily to the retirement of grazing concessions around the margin of the wetland (approximately 80 ha).

Of the concessions that have been retired, most were selected for retirement to allow permanent fencing to be constructed above winter flood levels. This protects seasonally flooded wetland habitat and also increases the life span of the fences themselves. Fencing was required in many areas to comply with Regional Council stock exclusion rules which came into effect in 2006. In some instances grazing concessions were also known to be having a significant impact on wetland

habitat. Some of these areas have undergone restoration planting and/or been developed into seasonally flooded open water habitats.

Table 1. Extent of wetland habitat (ha) at Whangamarino in 2007.

Wetland habitat type	Public Conservation Land	Other land in Management Area			Total
		Fish & Game	Private Covenants	Private - Other	
Swamp	1504	373	20	559	2456
Fen	1526	218	12	210	1966
Bog	1808	119	1	64	1992
Other*	132	26	6	334	498
Total	4969	737	40	1167	6912

*includes treeland, shrubland and open water.

Management implications

A comprehensive assessment of changes in wetland extent since 2007 will be achieved once an updated vegetation map is developed. The updated vegetation map will be based on the next set of aerial photography which is scheduled for 2013.

Over time, the conservation value of retired grazing concessions will be enhanced through native wetland re-vegetation and/or conversion into open water habitats. However, given the large areas that have been retired there is a need to implement some form of interim management until re-vegetation can take place. This will include allowing grass cutting and weed control while preventing application of fertilisers. Future opportunities to purchase or protect wetland habitat will be considered as they become available, especially for high value bog and fen habitats.

The Department will continue to work with stakeholders such as Waikato Regional Council (WRC), Fish and Game and Waikato-Tainui to ensure new areas of wetland are used wisely. This may include the creation of bird habitat or the provision of cultural resources for harvest such as planting harakeke (flax). Retirement of additional concessions blocks are currently pending.

Objective 2: Maintain and enhance water levels and water quality

Changes in water quantity/hydrology and quality can have significant and lasting impacts on wetland ecosystems. Water regimes can be altered by drainage or the diversion of surface water and groundwater. Decline in water quality, due to increased nutrient and sediment loads, is generally associated with changes in land use and particularly the intensification of agriculture.

The Whangamarino's hydrological regime has been altered dramatically from its natural state. Much of this change is due to its incorporation into the Flood Control Scheme and the construction of the Pungarehu Canal between Whangamarino and Lake Waikare. Whangamarino now experiences much more sudden increases and decreases in water levels than would have occurred naturally.

In addition, lowering of the Waikato River bed for sand mining and to improve navigability once threatened to drain large areas of the wetland. The Department and Fish and Game constructed a weir on the Whangamarino River in 1994 to maintain minimum water levels in the wetland. This became operational in 2000. Repairs to the weir were completed by DOC early in 2010 to avoid potential failure of the structure which could have had significant effect on the ecology of the wetland.

The quality of water entering the Whangamarino Wetland is also a major concern. The connection to Lake Waikare results in regular influxes of sediment laden water. In combination with other rivers, streams and drains feeding into the wetland, this has increased levels of sediment and nutrients. This is having an adverse effect on conservation values with the low nutrient bog and fen habitats particularly sensitive.

Through the Arawai Kākāriki project the Department has invested in research to understand the effects of altered hydrology, sources of poor water quality, and the level of threat that these factors have on the wetland ecosystem. The Department has focused on investigating key knowledge gaps through application of three dimensional (LiDAR) modelling to assess changes in water levels over time and aid the development of a dynamic hydrological model for the wetland. This information will be used to inform statutory avenues, such as the development of better conditions in RMA consents and guide future management by the Department, other agencies, and the local community.

Outcome monitoring

Hydrological and water quality monitoring is undertaken by the Department and WRC in collaboration with key research organisations.

Progress is measured using the following outcome indicators:

- Changes in wetland hydrology [AK 2.i]
- Trend in water quality of wetlands, lakes and rivers [AK 2.iii, AK 2.iv]
- Trend in wetland soil nutrient levels, soil pH, and sediment accumulation [AK 2.ii, AK 2.v, AK 2.vi]

Hydrological monitoring is carried out through a combination of river level recorders managed by WRC and a series of water level loggers deployed by the Department across the southern section of the wetland. Wetland hydrology was assessed by analysing water level fluctuations and supporting a Master of Science (MSc) student to complete ecohydrological research at Whangamarino. Water quality is monitored in the Whangamarino River by WRC. The Department has also installed a turbidity logger in the Pungarehu Canal to monitor suspended sediment loads entering via Lake Waikare.

In addition, the Department collected soil samples from 37 plots where vegetation was also assessed in March 2011 (see Objective 3). Assessment of sediment accumulation rates (SAR) in the southern part of the wetland were carried out through analysis of series of sediment cores sediment cores.

Results

WETLAND HYDROLOGY

Since 2007 the water levels in Whangamarino have fluctuated from 2.9 m to 5.7 m above sea level. With the weir set at 3.2 m summer water levels rarely fall below 3 m, ensuring a minimum water level is retained in the wetland (Figure 4). At 3 m, water is largely confined to the rivers, streams and main water bodies with fen areas drying out. Flood events and in particular the use of the wetland for flood storage result in water levels above 5 m.

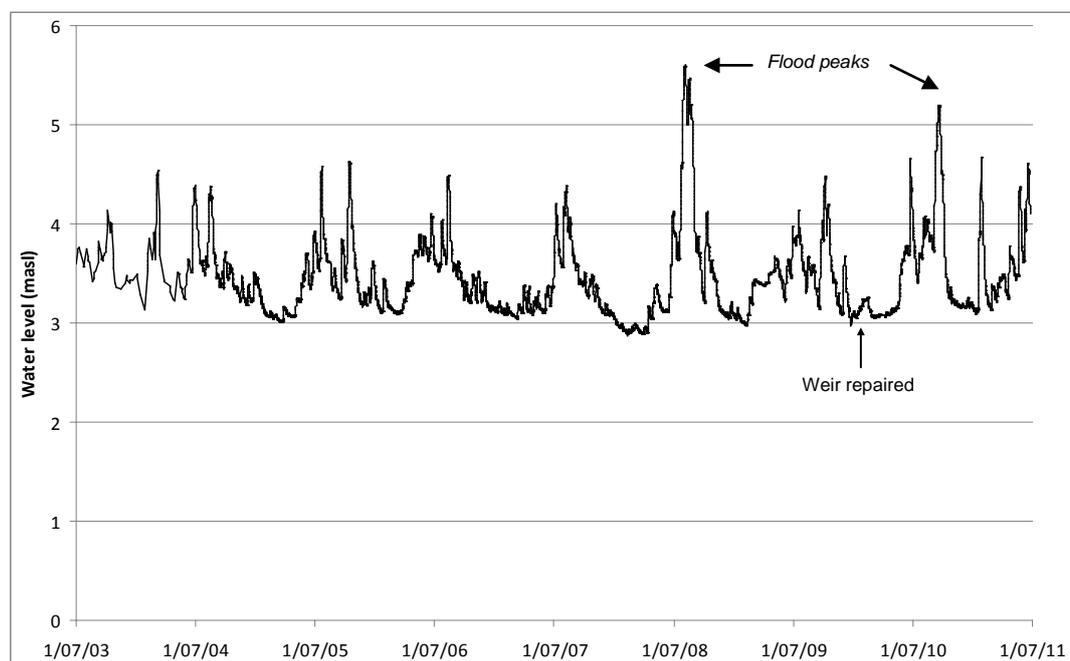


Figure 4. Variation in water level (meters above sea level) in the Whangamarino River between 1 July 2003 and 2011. Levels taken from the Ropeway on Island Block Road. Source: Waikato Regional Council.

Initial analysis of the water level loggers installed in the southern section of Whangamarino was carried out by James Blyth, an MSc student, as part of research to characterise the ecohydrology of the wetland (Blyth 2011). A 3.3-year flood event in September 2010 impacted on wetland water levels up to 1.4 km from the Whangamarino River. 100-year floods were estimated to extend 1.75 km away from the river. Frequency analysis indicated sites up to 500 m from the river are likely to be inundated by flood waters every year (Figure 5). Flood events result in transfer of sediment, nutrients, and weeds to the low-nutrient bog and fen areas. Monitoring of water levels is ongoing and is a key input into a hydrological model being developed for the wetland and its catchment (Thornburrow 2010).

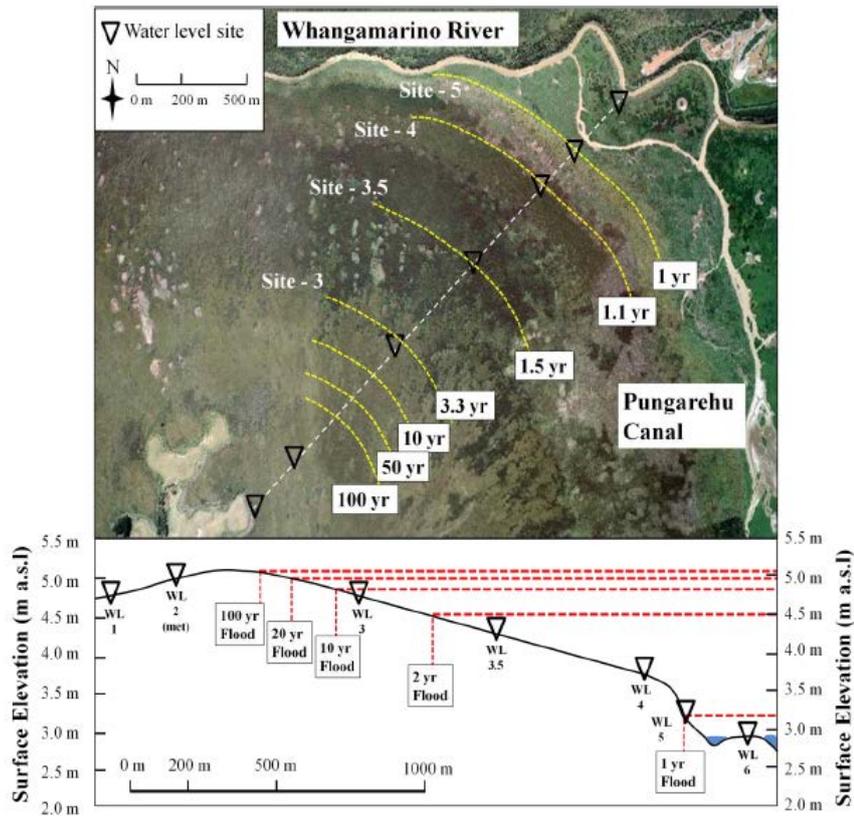


Figure 5. Predicted flood inundation return periods (years) along the transect line from the Pungarehu Canal (Blyth 2011).

WATER QUALITY

Waikato Regional Council regularly monitors stream and river water quality at a number of locations in the wider Whangamarino catchment. One of these, the Whangamarino River at Island Block Road is within the wetland (near the outlet). Average water quality at this site has been assessed as 'Unsatisfactory' over 50% of the time between 2007-2011, as defined by ecological standards set by WRC (Waikato Regional Council 2012a). Nutrient, turbidity levels and dissolved oxygen concentrations were 'Unsatisfactory' over 90% of the time (Waikato Regional Council 2012b). The site was considered 'Unsatisfactory' for swimming 100% of the time. It is important to note that the criteria used by the Council to assess stream and river quality may not be as relevant to wetlands.

Water samples collected during the flood event in September 2010 showed the concentration of total suspended solids peaking within the Whangamarino River at 260 mg/L, more than double the concentrations from the Pungarehu Canal (Blyth 2011). However, the total load of sediment transported down the Pungarehu Canal is still likely to be significant.

The turbidity meter installed on the Pungarehu Canal in 2010 shows turbidity reached a peak daily average of 957 NTU (turbidity measurement scale) at the end of December 2010 and did not drop until the 23rd of January 2011. This was likely due to unusually high rainfall and water flow. Following this event, turbidity averaged 127 NTU through to the end of November 2011. Turbidity levels greater than 5 NTU are classified as being unsatisfactory for supporting plant growth (Waikato Regional Council 2012a).

SOIL AND SEDIMENT

The results obtained from the soil sample analysis undertaken at vegetation plot sites were used to establish baseline condition in the wetland. Changes in soil characteristics in response to existing pressures or future management actions can now be assessed. When analysed by habitat type, bogs

have lower total nitrogen and phosphorus with high organic carbon levels, while swamp and fen habitats are more fertile. This difference in fertility is reflected in the vegetation composition (discussed further below).

The National Institute of Water and Atmospheric Research (NIWA) were commissioned to investigate sediment accumulation rates where the Pungarehu Canal enters Whangamarino (Reeve *et al.* 2010). Samples were taken from four sites between the canal and a point 1.3 km away to the west (Figure 6).



Figure 6. Core sediment sample sites investigated by Reeve *et al.* 2010.

Sediment accumulation rates were found to have substantially increased at two sites since the commissioning of the Pungarehu Canal. Accumulation rates increased from 2.9 to 14.9 mm/year at the canal margin and from 2.2 to 7.9mm/year at a site located 150 m from the canal. Accumulation rates in the canal and at the furthest distance from the canal remained steady at approximately 16.3mm/year and 2.5mm/year respectively.

The study also showed a change in the composition of sediment from low density organic matter to high density inorganic matter at sites 1 and 2, attributable to the change in the main sediment source. The deeper (older) sediment was primarily made up of sediment from the Waerenga catchment and decomposed mānuka, as well as grass in variable proportions. The shallower (younger) sediment comes predominantly from the Pungarehu Canal, with a greater contribution from maize becoming apparent (Figure 7).

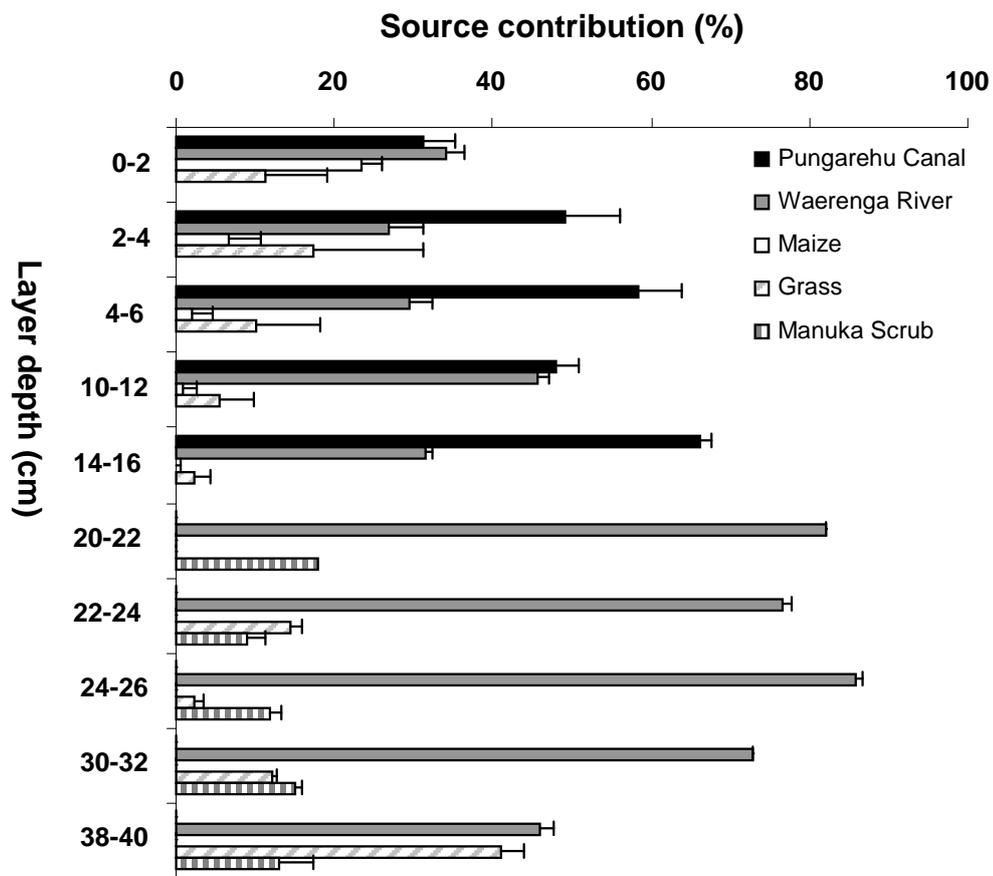


Figure 7. Histogram of proportional source soil contributions to the sediment at different depth layers in Core 2B. (Error bars are ± 1 SD).

Management implications

The management implications are far reaching because hydrology and nutrient status are the main drivers of wetland ecology. The Whangamarino is under significant pressure due to changes in hydrology and an increase in the influx of sediment and nutrients into areas that were previously low nutrient habitats.

The change in wetland ecology is illustrated in the aerial photography based vegetation maps (Figure 8) below. Between 1942 and 2007 bog vegetation retreated back from the Pungarehu Canal, replaced with mānuka dominated plant communities. Mānuka dominated communities are more tolerant of higher nutrients and altered water levels than bog vegetation. They are also more susceptible to weed incursions and are a less valuable habitat type in terms of conservation status.

Blyth (2011) suggests that a lower water table may have caused expansion of the mānuka prior to the construction of the weir. However, the deposition of sediment and nutrients associated with increased flood inundation is now the most likely factor driving continued mānuka expansion and wetland degradation.

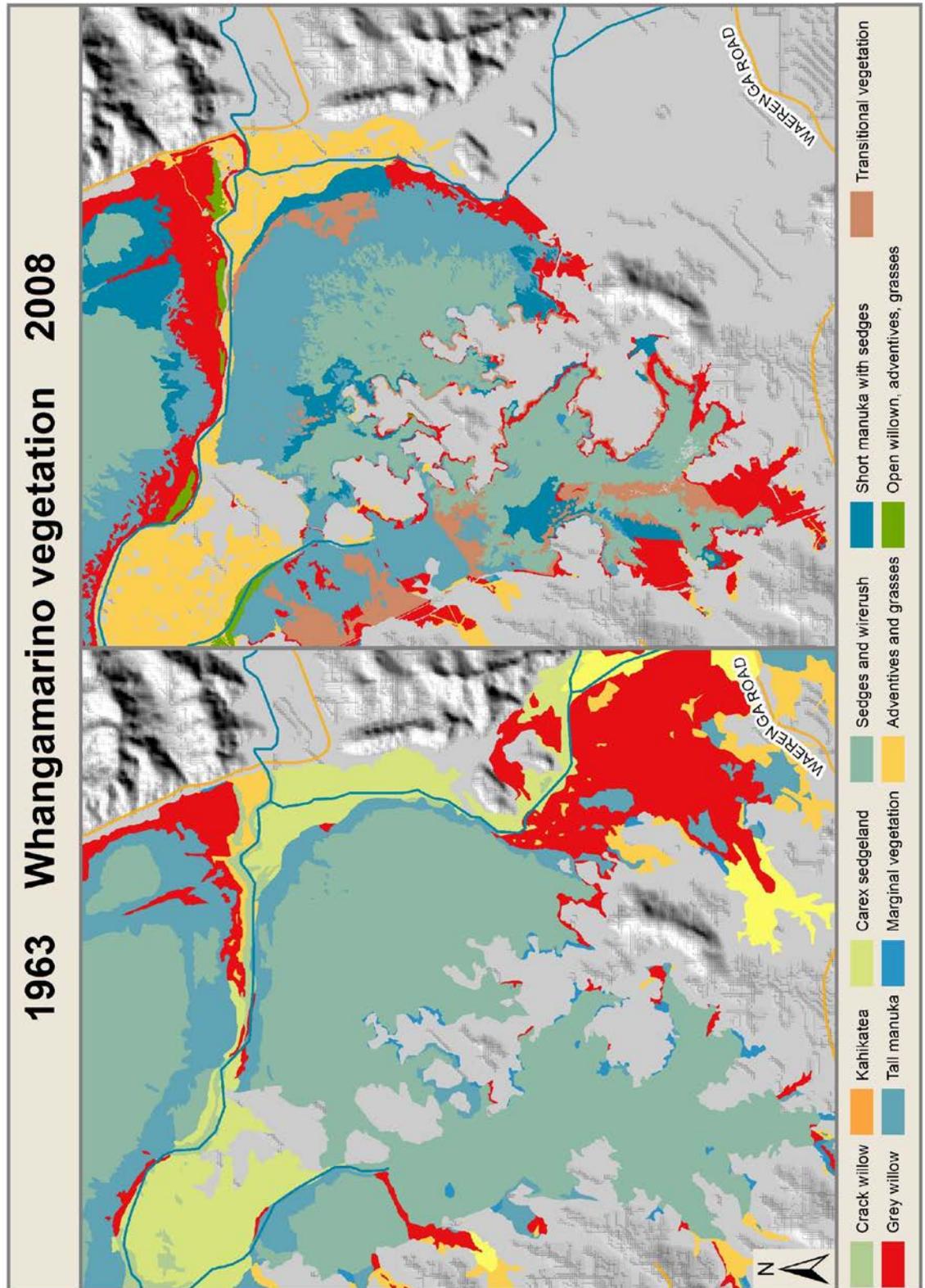


Figure 8. Vegetation map showing the expansion of mānuka dominated vegetation within the Southern area of Whangamarino between 1963 and 2008.

Historically there have been large fluctuations in water levels in the Whangamarino Wetland. However, fluctuations are now much more rapid than they would have been under natural conditions because of wetland conversion, land use change, and the operation of the Flood Control Scheme. The Whangamarino weir, while maintaining minimum water levels, also slows the rate of water level changes.

To ensure the integrity of the peat bog in the southern part of the wetland it is important to reduce the nutrient and sediment rich flood waters reaching the bog areas. While there are catchment-wide measures that can be introduced to influence this, such as supporting the agricultural and horticultural industries to implement the recommendations of the Clean Streams Accord, the volume and quality of water entering Whangamarino is largely outside the control of the Department. Some options may exist to influence hydrology within the wetland, and potential options to mitigate the impacts of the Flood Control Scheme on the Whangamarino Wetland have been explored (Reeves & Hancock 2012). Wetland ecohydrology will continue to be investigated to inform decisions on these options.

Effective management and restoration of the Whangamarino Wetland relies heavily on obtaining a detailed understanding of hydrological and sedimentation processes. The Department worked with consultants such as Sinclair Knight Merz (SKM) to produce detailed hydrological modelling. The model will continue to be improved as more data is collected and will be used to test various management scenarios, providing a stronger platform to lobby for improved catchment management. SKM are also developing a source catchment model to improve understanding of sediment and nutrient loads being deposited in Whangamarino.

The complex nature of the Whangamarino and the number of external factors influencing the ecohydrology of the wetland mean that a collaborative management approach, including councils, industry, local community and landowners, is essential. A working group with WRC has been formed; a critical partnership as WRC has the lead role in catchment management as well as the operation of the flood scheme. Initially this will enable the Department to work more effectively with the Regional Council around the impacts of the flood control scheme. It is hoped that this group will go on to work together to address wider catchment issues alongside the community and key stakeholders.

At a regional level, collaboration takes place through forums such as the Waikato District Lakes and Freshwater Wetlands Memorandum of Agreement. These will be used to advocate for integrated catchment management, farm nutrient budgets and better protection of riparian margins.

Objective 3: Protect and restore wetland habitat

Whangamarino is one of the most significant wetland habitats found in New Zealand. The significance of the wetland habitat is directly related to its condition (i.e., its ecological integrity). Both the protection and restoration of wetland habitat is a management priority at Whangamarino. Primary causes for habitat degradation include the ingress of nutrient rich flood waters, incursions of livestock and other grazers, increased abundance of invasive plants and changes in the frequency of fires.

At Whangamarino, as with all wetlands, the hydrological regime is the primary driver of ecological processes within the wetland (see Objective 2).

Weed control is ongoing, guided by a strategy that incorporates both site-led (focused on maintaining the integrity of high quality habitat) and weed-led (focused on containing or eradicating specific weed species that have the potential to greatly increase in numbers, distribution and level of impact) approaches. Containing incursions of the most serious weed threats is our focus, such as alligator weed (*Alternanthera philoxeroides*), classified as an eradication pest plant under the current Waikato Regional Pest Management Strategy (RPMS), and yellow flag iris (*Iris pseudocorus*), classified for containment under the RPMS. Surveillance is carried out in the wetland and immediate catchment so that weed threats can be controlled as they are identified.

Cattle incursions have major effects on the wetland habitat, contributing to nutrient input, trampling and grazing. There is an ongoing fencing programme in place to exclude grazing stock and an annual aerial cull of red deer. Restoration planting continues to be carried out at a number of sites.

Outcome monitoring

The Department employs a number of techniques to monitor the protection and restoration of wetland habitat at Whangamarino. Progress is measured using the following outcome indicators:

- Extent of indigenous-dominated habitat [AK 3.i, AK 3.ii]
- Ratio of indigenous : exotic species [AK 3.vi, AK 3.vii]
- Extent of wetland habitat impacted by fire [AK 3.ix]
- Distribution of weed species considered a threat [AK 3.x, AK 3.xii]
- Abundance of pest species (herbivores) considered a threat [AK 3.xi]

Vegetation maps developed using aerial photography dating back as far as 1942 were used to monitor changes in extent of key habitat types within Whangamarino (Reeves 1994; Reeves & Haskew 2003; Reeves 2011a). The vegetation mapping is further augmented by the establishment of permanent vegetation plots (

Figure 9) set up to monitor changes in the structure and condition of wetland vegetation and the ratio of indigenous : exotic species. The plots were surveyed in 2011 using a modified Reconnaissance (Recce) plot design (Bodmin & Robertson 2010).

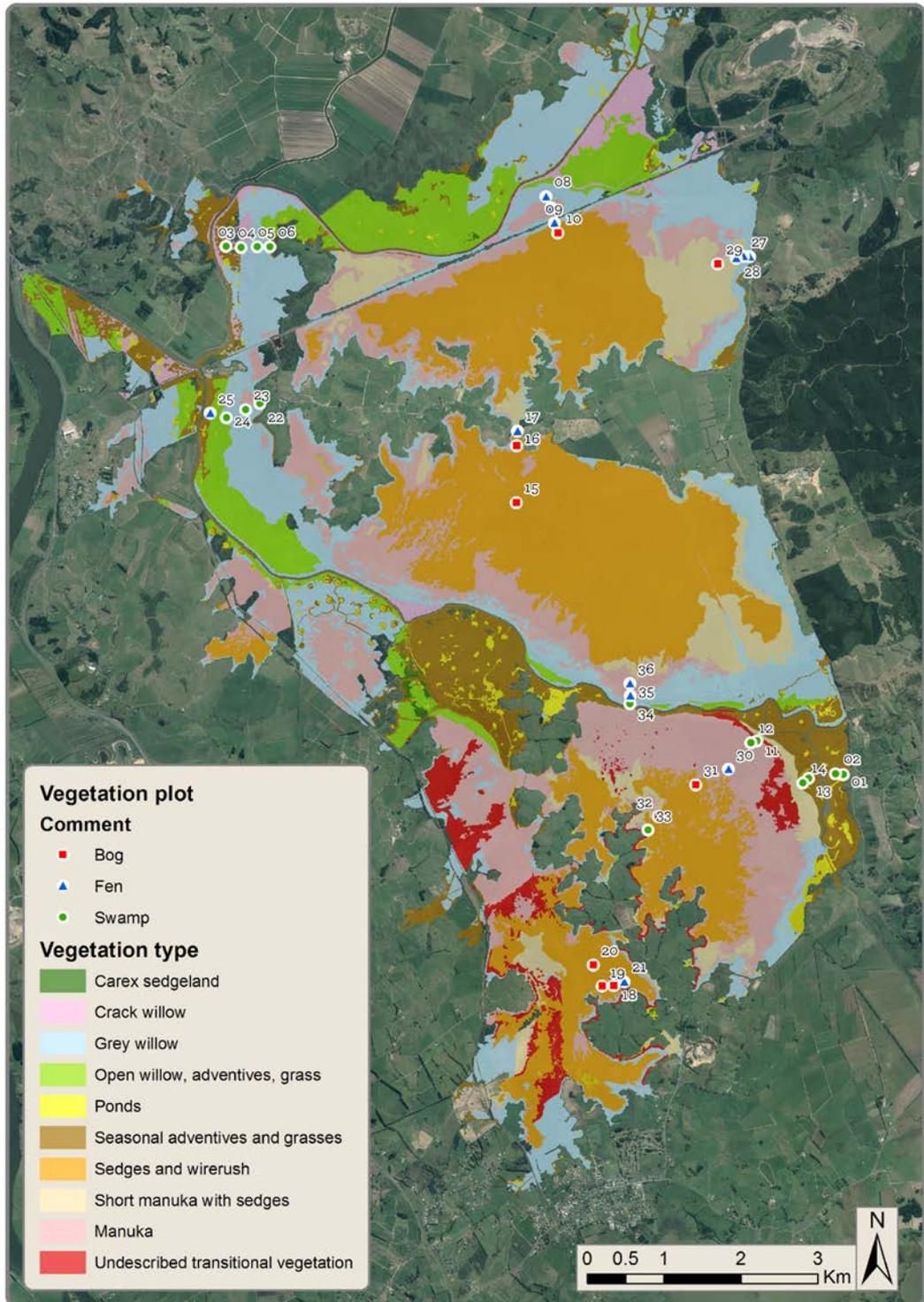


Figure 9. Map showing the location of vegetation plots established in Whangamarino in 2011.

The distribution of key weed species has been determined by analysing vegetation maps in conjunction with data from the permanent vegetation plots. Yearly surveillance for new weed incursions is conducted throughout the wetland using GPS and used to update weed mapping.

The threat posed by pest herbivores is monitored by recording the extent of boundary fencing and completing an annual search/cull helicopter flight targeting red deer.

Results

EXTENT OF INDIGENOUS DOMINATED COVER

The 2007 vegetation map of the Whangamarino Wetland identified 16 vegetation types. Each vegetation type was categorised as being either native or exotic dominated based on descriptions provided by Reeves (2011a). Just over half of the vegetation in the Whangamarino vegetation is made up of native dominated vegetation classes (Table 2). Most of the exotic dominated vegetation consists of grey willow swamp forest.

Table 2. Area of exotic and native dominated vegetation classes calculated from the 2007 Whangamarino vegetation map (Reeves 2011a). The ‘Ponds or Open Water’ vegetation class has been excluded.

Vegetation Classes ¹	Dominance	
	Native (ha)	Exotic (ha)
Bog		
Sedge and wirerush	1882.9	
Short mānuka with sedges	439.3	
Undescribed transitional vegetation		172.8
Fen		
Grey willow forest		1472.4
Tall mānuka	1198.2	
Swamp		
Bolboschoenus reedland	4.6	
Carex sedgeland	13.2	
Crack willow forest		120.0
Eleocharis reedland	4.5	
Eleocharis-Baumea reedland	1.1	
Harakeke flaxland	8.9	
Kahikatea forest	1.2	
Open willow, seasonal adventives, and grasses		521.9
Raupō reedland	0.6	
Seasonal adventives and grasses		581.5
Other		
Exotic treeland and shrubland		59.5
Total area (ha)	3554.5	2928.1
Total area (%)	54.8	45.2

¹ There is some overlap in vegetation types across wetland types. For example, grey willow forest occurs in both fen and swamps.

RATIO OF INDIGENOUS TO EXOTIC SPECIES

The proportion of native plant species varied across the three main habitat types. Vegetation plots located in bogs were almost exclusively made up of native species (Figure 10), with many plants having unique adaptations to the rainfall-fed, low nutrient bog environment. For example, the carnivorous bladderwort (*Utricularia delicatula*) and sundews (*Drosera binata*, *D. spathulata*) are adapted to gain additional nutrients by trapping and ingesting small invertebrates (Clarkson *et al.* 2002). *Empodisma robustum* (wire rush), a major peat-forming plant, is adapted to conserve water through strictly controlled transpiration and the formation of a dense, mulch-like litter that helps prevent water loss from the bog surface (*ibid.*). These factors make the now rare bog habitat valuable for conservation management.

On average native species made up the greatest proportion of plant species found in fens, however, exotic species did dominate in some plots. Exotic species dominate the swamp areas (Figure 10).

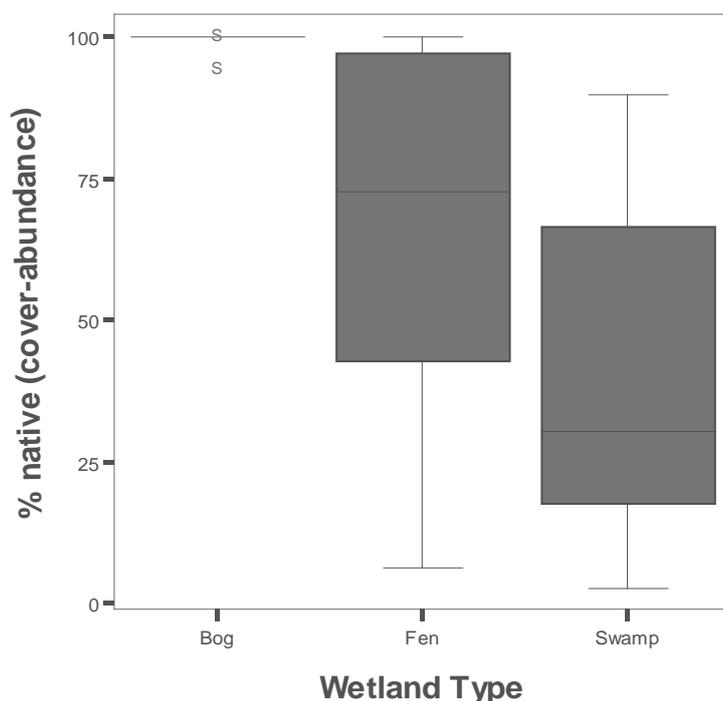


Figure 10. Mean (and range) abundance of native species found in each wetland type in Whangamarino. Data from vegetation plots surveyed in 2011.

EXTENT OF WETLAND HABITAT IMPACTED BY FIRE

Historically there have been numerous fires in Whangamarino, particularly during the period when steam-driven trains travelling between Auckland and Hamilton passed alongside the wetland. Whilst fire remains a concern there have been only a few fires in recent years and these have caused minimal damage. Fire has also been used by the Department to (re)create a disturbance regime to promote the growth of the endemic swamp helmet orchid *Corybas carsei* (see Objective 4).

DISTRIBUTION OF WEED SPECIES CONSIDERED A THREAT

The key weed species present at Whangamarino are summarised in Table 3 and the distribution of major weed species are mapped in Figure 11. Grey willow (*Salix cinerea*) and royal fern (*Osmunda regalis*) have been present for many years and range expansion is continuing. Grey willow expansion has continued despite an aerial spraying programme conducted between 1999 and 2008 and is expected to reinvade areas that have been sprayed (Bodmin & Champion 2010).

Royal fern was first recorded in Whangamarino in 1958 and is now widespread (Champion 2006). Because it usually occurs below dominant canopy species the extent of royal fern has not been picked up in vegetation maps, however it is becoming an increasing threat.

Crack willow (*Salix fragilis*) appears to have reached its maximum range and has retracted in recent decades through aerial spraying programmes (Bodmin & Champion 2010). European alder (*Alnus glutinosa*) was first identified in Whangamarino in late 2009 and does not appear to be spreading.

Yellow flag iris (*Iris pseudocorus*) and alligator weed (*Alternanthera philoxeroides*), both significant pest species, have established at several sites during the late 2000s and are major threats to wetland habitat. Incursions of new weed species are likely to continue to occur through introductions by catchment inflows, human visitors and transfer via waterfowl.

Table 3. Historic and current extent of major weed species at Whangamarino. Data derived from the 2007 vegetation map and weed incursions maps.

Weed species	Historical information	2007 (Ha)	2011 (Ha)
Grey Willow	36 ha in 1942	1390	No data available*
Crack Willow	313 ha in 1942	449	No data available*
Yellow flag iris		24	49 [#]
Alder		0	0.25
Alligator Weed		0	1.8 [#]

*to be updated after next vegetation map completed in 2013

[#] DOC Rangers have actively controlled incursions which has restricted invasion of these species.

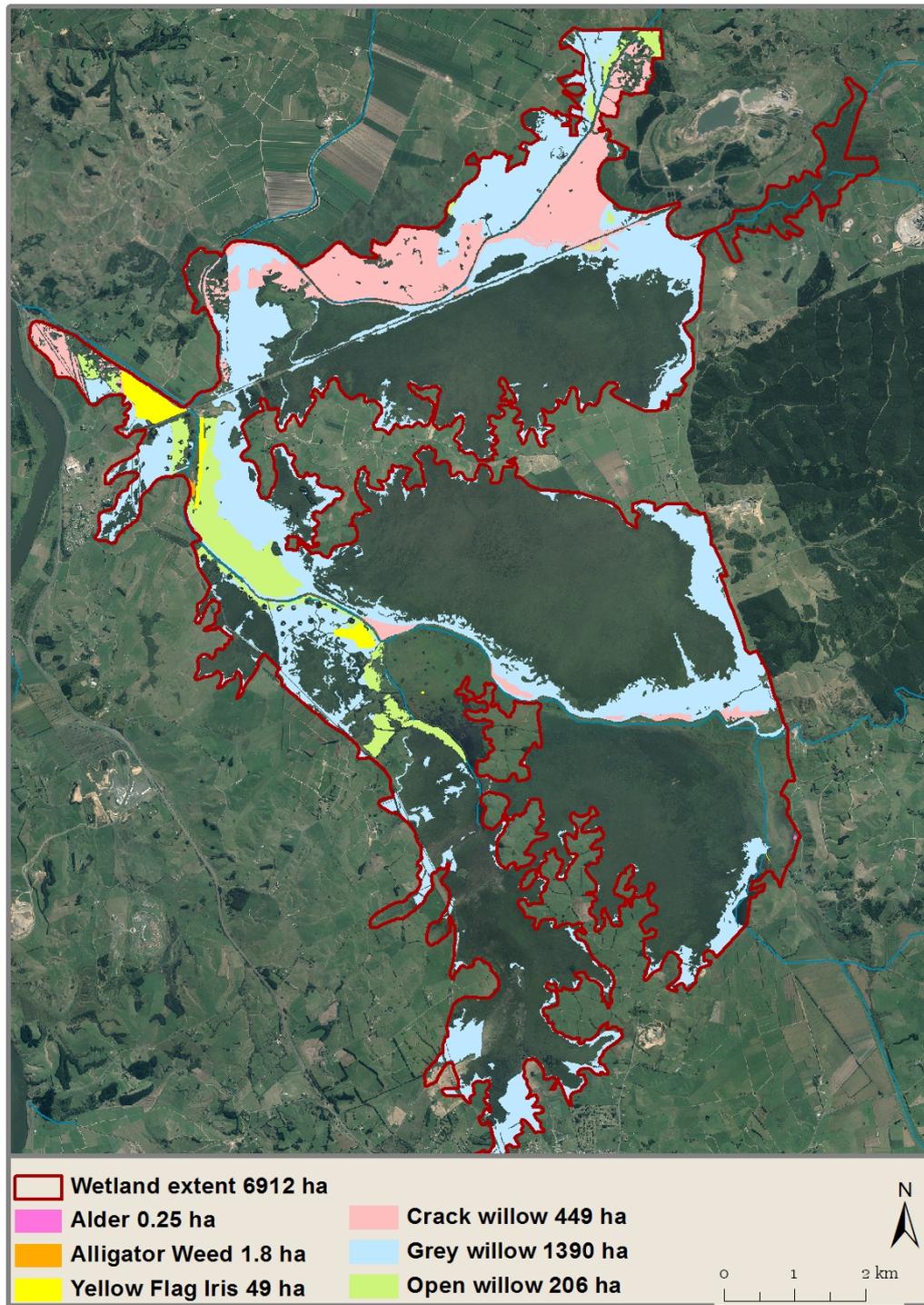


Figure 11. Map of extent of major weed species at Whangamarino in 2011. Data from aerial photographs, vegetation plots and GPS surveillance.

ABUNDANCE OF PEST SPECIES (HERBIVORES) CONSIDERED A THREAT

Domestic cattle on farms adjacent to Whangamarino are the most significant herbivore threat to wetland condition. It is difficult to directly measure the abundance of cattle as they only temporarily reside in the wetland. However the incursion of cattle can be indirectly assessed by considering the length of wetland boundary fenced. Prior to 2007, 86 km of the Whangamarino boundary that required fencing was unfenced. Since 2007, 28 km has been fenced by the Department or by private landowners (Table 4). This represents a significant decline in the numbers of stock able to access the wetland.

Table 4. Length of wetland fencing constructed between 2007 and 2011.

Funding Source	Length of fence (m)
DOC Funded Wetland Boundary Fencing Since 2007	23,586
Privately Funded Wetland Boundary Fencing Since 2007	4,351
TOTAL	27,937

Apart from the cattle, red deer and possum are the only mammalian herbivore species known to utilise the wetland. Deer numbers are very low in the wetland and are controlled by annual aerial culls. Eleven deer were culled between 2006 and 2008. None have been shot since that time despite an ongoing investment of 1-2 hours of flying time annually. Possum numbers are high but this is thought to have little impact on native vegetation as the population is concentrated on the fringes which are dominated by exotic vegetation.

Management Implications

The most intact vegetation communities occur in the bog and fen habitats. Most swamp habitat is highly modified and dominated by exotic species. The ingress of nutrients into low nutrient bog and fen habitats is the greatest threat to these habitats because it precipitates a shift in vegetation towards communities that are more readily invaded by weeds. Regression of bog and fen areas to less valuable, higher nutrient habitat is a negative outcome for the site, even if the area remains dominated by native plants, as it reflects a change in ecosystem type. It takes thousands of years for a peat bog to form from swamp land and if the bog habitat is lost, we are unlikely to be able to restore it. Hydrological management is discussed in more detail under Objective 2 and in Future Directions.

Weeds will continue to be a threat to wetland habitat at Whangamarino. A site-led weed management plan was developed in 2010 in consultation with wetland experts and external contractors in response to the increasing weed threats. The plan identified key management areas within the wetland and recommended control methods based on weed density and site sensitivity to herbicide use. The plan also recommended further research on the environmental drivers of royal fern as evidence suggests this plant has the potential to become as widespread as grey willow. The Department is currently focusing attention on preventing further incursion of grey willow into high value bog and fen areas rather than a more widespread approach. Effective methods for large-scale grey willow control in wetlands are currently being investigated by Landcare Research and DOC Science and Technical.

The weed management plan was structured to work in conjunction with the Whangamarino weed surveillance plan (Champion & Bodmin 2009). The surveillance plan recommended regular monitoring of key inflow sites, as well as commercial fishing and recreational access sites to target both current weed species and potential weed species not found in the wetland. Areas of weed surveillance will also be influenced by the findings of Reeves (2011b), which identified significant areas vulnerable to invasion by alligator weed and yellow flag iris. It is timely to review the Whangamarino Wetland weed management plan in light of this report.

Fencing is an effective way to exclude herbivore grazing and more fencing is planned as part of the Arawai Kākāriki Programme. Of the 58 km of wetland margin currently unfenced, 27 km is considered to be high priority and mostly occurs in the southern Whangamarino. The Department will seek to work with landowners whose boundaries with the wetland are currently unfenced to achieve stock exclusion, and this will be addressed as part of the rural engagement strategy (discussed in Objective 6).

Annual aerial red deer operations will continue. The flights provide an opportunity to continue to monitor the small deer population known to be persisting in the area. They also help discourage further deliberate introductions of animals.

Objective 4: Maintain and enhance species diversity, including threatened species

Halting the decline of native species from wetlands and other freshwater environments presents a challenge. The historic loss of wetlands, increased abundance of mammalian predators, and reduced habitat connectivity has, in combination, reduced the diversity of native plants and animals in New Zealand wetlands. Whangamarino Wetland supports a number of rare and threatened species dependent on wetland habitat for at least part of their life-cycle.

In particular, the Whangamarino is considered to be the stronghold for both the nationally endangered Australasian bittern (Figure 13) and the black mudfish, which is considered to be 'at risk' (Allibone *et al.* 2009). It is the only known location for the tiny and nationally critical swamp helmet orchid *Corybas carsei* (Figure 12), as well as the home to many other threatened or at risk plants, birds and fish species. Species management has focused primarily on Australasian bittern and *Corybas carsei*.

The major threats to these species are predation and habitat degradation. A suite of mammalian predators occur in Whangamarino and will be having a significant impact on populations of wetland birds and other fauna. Habitat degradation at the wetland is mainly due to nutrient enrichment of low nutrient bog and fen habitats as well as the reduction in water quality and extent of aquatic habitat. Wetland vegetation has also been impacted by weed expansion and incursions of herbivore grazers; management of these impacts is discussed in Objective 3.



Figure 12. *Corybas carsei* in flower at Whangamarino Wetland. Photo by Craig Purvis 2009.



Figure 13. Australasian bittern in flight. Photo: Peter Langlands 2010.

Outcome monitoring

A range of biodiversity inventory surveys and monitoring programmes have been established at Whangamarino over the past four years to assess changes in the abundance of the indicator species Australasian bittern and to better understand the population dynamics of some threatened species. Monitoring has primarily focused on *Corybas carsei*, Australasian bittern and black mudfish, alongside a major investigation of predator monitoring methods. Inventory surveys have also been carried out for other threatened plant (*Lycopodiella serpentina*, *Myriophyllum robustum*, *Cyclosorus interruptus*, *Pterostylis paludosa*, *Utricularia australis*; Reeves 2009), birds (spotless crake, fern bird, marsh crake, banded rail), fish (shortfin eel, longfin eel, grey mullet, common smelt, inanga, common bully, redfin bully, banded kōkopu; Lake *et al.* 2011) and terrestrial invertebrate species (Watts 2009).

Progress is measured using the following outcome indicators:

- Diversity of indigenous species [AK 4.i, AK 4.iii]
- Abundance of indicator animal species [AK 4.iv]
- Number of threatened species that rely on the site [AK 4.v]
- Population status of rare and threatened species [AK 4.vi]
- Distribution and abundance of predators considered a threat [AK 4.vii].

Results

DIVERSITY OF INDIGENOUS SPECIES

Whangamarino Wetland illustrates the importance of wetlands as an ecosystem type as it provides food and habitat for approximately 400 different animal and plant species (Table 5). Whangamarino is renowned for the native wetland and game birds it harbours; a key reason for its inclusion as a Wetland of International Importance under the Ramsar Convention. However, for many guilds native species are outnumbered by exotic ones, as is often the case in modified habitats.

There was a higher diversity of native fish species than exotic ones in the surveys conducted by Lake *et al.* (2011). However, many of the native species were found in tributary streams rather than in the wetland itself. Koi carp (*Cyprinus carpio*) comprise the highest biomass of fish. Koi are pest fish species known to have significant impacts in wetland systems worldwide. The wetland does support a significant eel population, mostly comprised of shortfin eels. These eels support a commercial fishery and, to a lesser degree, recreational and cultural fisheries. The information provided below provides a baseline for future species monitoring.

Table 5. Summary of the diversity of wetland plant and animal guilds recorded at Whangamarino Wetland.

Plant / animal guild	Diversity (number of species)			Source
	Native	Exotic	Total	
Freshwater fish	9	5	14	Lake <i>et al.</i> (2011)
Lizards	2	1	3	DOC unpublished
Mammals	0	10	10	DOC unpublished
Birds	32	20	52	DOC unpublished, Ogle & Cheyne (1981), Bull <i>et al.</i> (1985)
- Waterfowl	6	3	9	
- Cryptic	3	0	3	
- Other	23	17	40	
Invertebrates	43	151	221*	Watts (2009)
Vascular plants	32	72	104	Reeves (2009), DOC unpublished
Total	118	259	404*	

*includes 27 unknown species

ABUNDANCE OF INDICATOR ANIMAL SPECIES

The key indicator species monitored at Whangamarino is the nationally endangered Australasian bittern. This species is considered an indicator of a suite of cryptic wetland birds including spotless crane, marsh crane and fern bird. The Australasian bittern is widespread throughout Whangamarino and is thought to constitute a large proportion of the total New Zealand population. The result of three years of monitoring using listening stations is presented in Table 6.

The highest detections of Australasian bittern appear to occur in the southern area. While it has been possible to record the number of sites where bittern are heard calling we cannot yet translate that to actual numbers of birds. Methods for determining relative abundance of Australasian bittern are in development through the Arawai Kākāriki Programme (see Objective 10). Once this research has been completed it will be possible to back-calculate bird numbers.

Table 6. Proportion of listening stations where Australasian bittern were heard in Whangamarino between 2008 and 2010.

Location	Site Occupancy (% of sites)			
	2008	2009	2010	Mean
Whangamarino north	5.2	4.6	9.5	6.77
Whangamarino central	5.2	7	7.8	6.67
Whangamarino south	7.8	11	11	9.33
Total	18.2	22.6	28.3	23

NUMBER OF THREATENED SPECIES THAT RELY ON THE SITE

Whangamarino is home to at least 17 species whose threat status range from gradual decline to nationally critical (Table 7). Whangamarino is considered to be the stronghold for some of these species; the 'at risk' black mudfish are widespread in the wetland and are often abundant where habitat is optimal (DOC unpublished). Once widespread throughout wetlands in the upper North Island, the Whangamarino is now the only known location for *Corybas carsei*.

Table 7. Species of conservation concern present at Whangamarino in 2011.

	Species	Conservation status	Estimated no. individuals	Source
Fish ³	Black mudfish	Relict	Very abundant	DOC unpublished data
	Longfin eel	Declining	Unknown	Lake <i>et al.</i> (2011)
	Redfin bully	Declining	Unknown	Lake <i>et al.</i> (2011)
	Inanga	Declining	Unknown	Lake <i>et al.</i> (2011)
Birds ⁴	Australasian bittern	Nationally Endangered	100-200	DOC unpublished data
	Marsh crane	Relict	Unknown	DOC unpublished data
	New Zealand dabchick	Nationally Vulnerable	6	DOC unpublished data
	North Island fernbird	Declining	Common	DOC unpublished data
	Spotless crane	Relict	Unknown	DOC unpublished data
Plants ⁵	<i>Corybas carsei</i>	Nationally Critical	204	Reeves (2009)
	<i>Cyclosorus interruptus</i>	Declining	70 (clumps)	DOC unpublished data
	<i>Lycopodiella serpentina</i>	Nationally Vulnerable	10 (plants)	DOC unpublished data
	<i>Myriophyllum robustum</i>	Declining	8 (locations)	DOC unpublished data
	<i>Prasophyllum hectorii</i>	Relict	34 (plants)	DOC unpublished data
	<i>Pterostylis paludosa</i>	Declining	860 (plants)	DOC unpublished data
	<i>Utricularia australis</i>	Nationally Endangered	24 (small patches)	DOC unpublished data
	<i>Utricularia delicatula</i>	Relict	500+	DOC unpublished data

³ Conservation Status determined after Allibone *et al.* (2009)

⁴ Conservation Status determined after Miskelly *et al.* (2009)

⁵ Conservation Status determined after de Lang *et al.* (2009)

POPULATION STATUS OF RARE AND THREATENED SPECIES

Threatened species activities has focused on three species: *Corybas carsei*, Australasian bittern, and black mudfish.

The Department has been conducting management by fire (Figure 14) in small areas of the wetland to increase numbers of *Corybas carsei* plants by recreating the disturbance regime the plant needs to thrive. Controlled burns took place in 2007, 2009, 2010 and 2011. The numbers have increased in our monitoring areas from a low of 77 in 2008 to 195 in 2011 (Figure 15). This method has also proven beneficial for the bog clubmoss *Lycopodiella serpentina* (nationally vulnerable), *Utricularia delicatula* (relictual), and *Drosera* species.

Monitoring of *Corybas carsei* occurred sporadically until 2008, when permanent monitoring plots and an annual monitoring regime were established. There are now 28 permanent monitoring plots (seven plots at each of four sites) in the wetland, with a weed control programme focused around key threatened plant sites.



Figure 14. Controlled burn of *Corybas carsei* habitat in 2010.
Photo: DOC 2010.

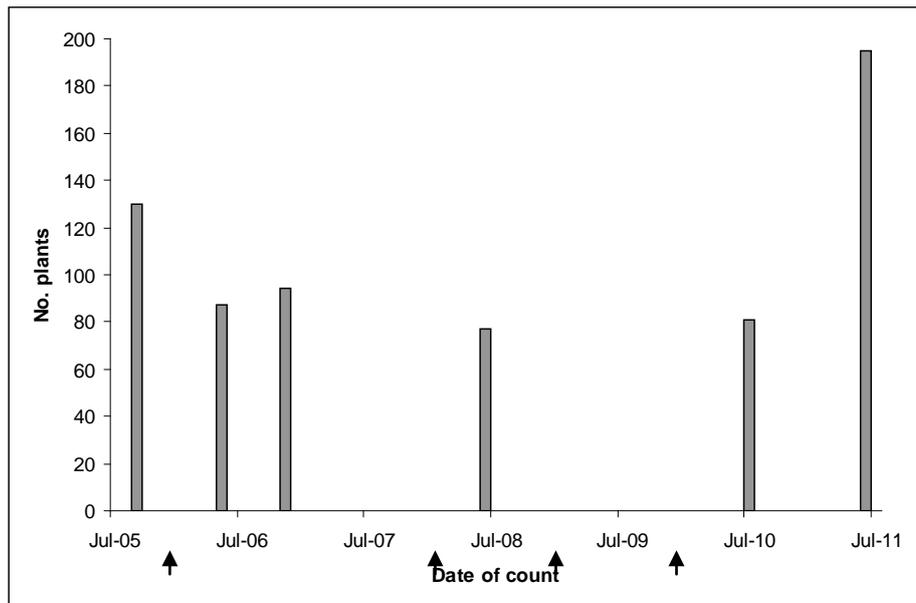


Figure 15. Number of *Corybas casei* plants recorded in plots at Whangamarino between 2005 and 2011. The arrows represent the timing of the controlled burns.

Work is underway to establish the population status of the suite of cryptic birds at Whangamarino, particularly Australasian bittern (see Objective 10). Current monitoring techniques and the cryptic nature of many of the animal species make it difficult to estimate precise numbers. The Waikato Area Office has carried out bittern monitoring bi-annually since 1997. New methods being developed will allow us to better indicate relative abundance of bittern and other cryptic birds beyond the baseline determined in Ogle and Cheyne (1981).

The fish survey undertaken by the Department and the University of Waikato in 2007/2008 (Lake *et al.* 2011) found that black mudfish were widespread in the wetland, though restricted to the seasonally inundated areas around the peat bog areas.

DISTRIBUTION AND ABUNDANCE OF PREDATORS CONSIDERED A THREAT

Whangamarino Wetland is home to a suite of mammalian predators including cat (*Felis catus*), ferret (*Mustela putorius*), stoat (*M. erminea*), weasel (*M. nivalis*), Norway rat (*Rattus norvegicus*), ship rat (*R. rattus*) and hedgehog (*Erinaceus europaeus*). A large-scale study of wetland predator monitoring and control methods is taking place at Whangamarino (see Objectives 9 and 10 for more detail on the research and learning aspects of this study).

Predator trapping trials were run from 97 different trap locations over a period of 15 months. Different trapping sites (along the wetland margins, river banks and the causeway) and baits were trialled using DOC200 kill-traps. Ship rats were the most common species caught using this method, followed by hedgehogs (Table 8). Ferrets were the most abundant carnivore, although DOC200 traps are not considered large enough to target this species.

Following this, predator monitoring trials took place that included live-capture trapping using Edgar traps and cat cages. Live-capture trapping revealed a larger proportion of cats and ferrets than from data obtained using DOC200 traps, possibly reflecting the issue of trap size. Norway rats also featured more prominently in these trials (Table 8). An intensive adaptive management trapping regime aimed at reducing predator numbers will be established in 2013.

Table 8. Results of predator trapping research at Whangamarino 2008-2011.

Order	Species	Kill trapping (2008-2009)		Live trapping (2010-2011)	
		Total	%	Total	%
Carnivora	Cat	10	2.2	25	11.4
	Ferret	71	15.8	93	42.5
	Stoat	25	5.6	1	0.5
	Weasel	37	8.2	10	4.6
Rodentia	Norway rat	62	13.8	36	16.4
	Ship rat	160	35.5	27	12.3
Other	Hedgehog	85	18.9	27	12.3
Total		467	100	219	100

Management implications

The 2007/2008 freshwater fish survey carried out by Lake *et al.* (2011) provided an up to date fish species inventory for Whangamarino Wetland and its tributary streams. A key finding was that a range of different sampling techniques should be used to compensate for different gear bias when undertaking fish community inventories.

Koi carp comprise the highest biomass of fish in the wetland, and their impact on the wetland environment is a concern. Control of pest fish species using existing methods in large systems like Whangamarino is costly with little chance of sustained success. Waikato Regional Council (who have responsibility for koi carp under the RPMS) and Waikato University are currently developing new control methods, including the installation of a fish trap at the Pungarehu Canal.

Black mudfish are prevalent in the wetland, although the Whangamarino is known to be one of only two strongholds for the species. Future monitoring of black mudfish will be considered if new significant threats are identified or to establish up to date information prior to further manipulation of hydrological regimes.

Management of threatened native wetland birds is challenging because their cryptic nature makes it difficult to establish population numbers or distribution. Reliable and standardised monitoring of these birds, and Australasian bittern in particular, has been a key aim of the Arawai Kākāriki programme at Whangamarino.

Monitoring of Australasian bittern as a key indicator species for the Whangamarino Wetland (as identified through the NHMS ecosystems prioritisation) will be ongoing to assess the response of the Whangamarino population to predator control and other management actions. Detailed understanding of the status of the species is dependent on research (see Objective 10), which will inform future monitoring.

Corybas carsei has been identified as a priority species by the NHMS optimisation process. Monitoring and management of *C. carsei* has been very successful to date. As orchid numbers have increased in recent years, the feasibility of translocation to appropriate habitats both within the Whangamarino and other nearby wetlands will be explored. Time-lapse photography is now being trialled in an attempt to ascertain *C. carsei* flowering and seed set times to help inform future management. The controlled burning regime will be continued.

There is ongoing monitoring of mapped threatened plant species and, where practical, weed maintenance at the sites. The major threat to our native plant species is the habitat loss caused by increased sedimentation, nutrient enrichment and weed invasion. Management of these threats is discussed in more detail under Objectives 2 and 3.

Our understanding of mammalian predators has increased through a pilot trapping programme and research (see Objectives 9 and 10). A number of predatory species were identified and all are likely to have significant effect on native fauna as well as game bird populations. An intensive adaptive management trapping programme will be initiated in 2013 to reduce numbers of predators in the northern part of the wetland. The success of this programme will be measured by monitoring predator numbers and the responses of wetland fauna. The findings of this will be used to inform mammalian predator management approaches in wetlands nationwide and will be shared with all organisations and community groups undertaking wetland restoration.

3.2. Community

Objective 5: Conserve historic and cultural sites

Places of cultural and historic significance to tangata whenua and local communities are often located close to freshwater lakes, rivers and wetlands. It is important these sites and their historic values are protected and made available to the community to maintain their heritage for future generations.

The Department has been working in partnership with iwi, the New Zealand Historic Places Trust *Pouhere Taonga* (NZHPT) and local communities to identify the location and significance of cultural and historic sites within the Whangamarino area. To date, two key sites have been identified on public conservation land:

- The Whangamarino Redoubt
- Whataroa Pā⁶

The Whangamarino Redoubt is located alongside Te Teoteo's Pā at the confluence of the Whangamarino River and Waikato River, south of Mercer. The Whangamarino Redoubt Access Track is part of the Te Araroa long distance pathway, stretching from Cape Reinga in the north of New Zealand to Bluff in the south. The elevated redoubt and walking track provides an excellent opportunity for interpreting the history of the area, the Whangamarino Wetland and the Waikato River.

Whataroa Pā is a medium sized pā site located on a prominent knoll off Falls Road, recently (re)discovered by DOC staff. This pā site provides excellent opportunities for interpretation and visitor awareness of the cultural and ecological history of the wetland. However, local hapū are deeply concerned that the cultural history of the site is not well understood and further work is required before potential development of the site as a visitor facility can take place.

Outcome monitoring

As well as utilising Departmental records on the protection and condition of public conservation land, DOC has been working with Ngā Muka Development Trust (Ngā Muka), a collective of local hapū, to identify sites and values of cultural significance to iwi. Progress is measured using the following outcome indicators:

- Level of protection of cultural and historic sites [AK 5.i]
- Condition of important cultural and historic sites [AK 5.ii; AK 5.iii]
- Identified iwi cultural values adequately protected, restored, or enhanced [AK5.v]

Results

LEVEL OF PROTECTION AND CONDITION OF SITES

The protection status and current site condition of the two cultural and historic sites identified at Whangamarino are summarised in Table 9. Whangamarino Redoubt and Te Teoteo's Pā are in good condition due to an ongoing maintenance programme managed by the Visitor/Historic Assets team. The access track was upgraded in the winter of 2010 and a new electronic track counter was installed. The PCL component of Whataroa Pā is currently managed as a grazing concession.

⁶ The site has also been referred to as Pukerua Pā; however, records held by NZHPT identify Whataroa Pā to be the correct name.

Table 9. Summary of important cultural and historic sites at Whangamarino.

Site Name	Protection status	Site Condition	Currently actively conserved
Whangamarino Redoubt/Te Teoteo's Pā	Sites and access track a mixture of PCL, WRC, and NZHPT ownership	Good	Yes
Whataroa Pā	60% PCL, 40% privately owned and unprotected*	Features being eroded by cattle	No

*Full extent of site is not currently known.

CULTURAL VALUES ADEQUATELY PROTECTED, RESTORED OR ENHANCED

A cultural values assessment was commissioned with Ngā Muka in early 2009. The Department guided kuia and kaumātua around Whangamarino wetland to assist the gathering of historical and current information on cultural values. This report has not been completed; strengthening of the relationship between Ngā Muka and DOC are required before further work on the cultural assessment can occur.

Ngā Muka has also been engaged to carry out a Mohiotanga Tuku Iho ('knowledge from above') assessment for Whataroa Pā. The report from this assessment is currently in a draft stage.

With the cultural values assessment remaining under development, the Department has limited information on cultural values specific to the Whangamarino Wetland. However, in a general sense, Ngā Muka identifies the protection, quantification and restoration of the mauri (life-force) of the wetland and its surrounds as a key concern. This correlates well with the outcomes achieved under the biodiversity objectives of Arawai Kākāriki (Objectives 1-4).

Following the discovery of Whataroa Pā, the Department contracted Thorne Archaeology to inspect and map the site and comment on the proposal to develop it as a visitor attraction. We are currently working with Ngā Muka and NZHPT to guide future management of the site.

Management implications

The Department manage Te Teoteo's Pā and the Whangamarino Redoubt Access Track, while NZHPT manage the Redoubt itself. The site is inspected monthly and maintained when necessary. Track counter data indicates relatively low numbers of visitors to the site (see Objective 7). Improved awareness is planned and should increase visitor numbers.

The site is being upgraded as a key feature in the NZHPT Waikato War driving trail⁷, and is the only location on the trail where both Māori and European features are evident. Interpretive signage will be installed to complement the NZHPT interpretation of the cultural history of the site. The Department's panels will highlight the view offered by the Redoubt (Figure 16) to focus on the biodiversity significance of the Whangamarino Wetland and the Waikato River Conservation Accord.

Effective management of the cultural values of the wetland is not able to take place while the cultural values assessment is collated. Progressing this is a high priority for the Department through a strengthened relationship between DOC, iwi and mana whenua. While this management approach takes time, it is fundamental to achieving appropriate conservation of local historic and cultural sites while also working towards the ultimate goal of wetland co-management.

⁷ For more on this see <http://www.thewaikatowar.co.nz>



Figure 16. View over Whangamarino Wetland (top) and the Waikato River (bottom) from Whangamarino Redoubt and Te Teoteo's Pā. Photos: 2013.

Objective 6: Promote sustainable land use

Freshwater ecosystems are directly influenced by their surrounding catchments. Increased sediment and nutrient loads associated with the intensification of land use is linked to a decline in ecological integrity, and may lead to rapid shifts in species composition. At Whangamarino, the surrounding land use is predominantly cropping and dairy farming with sheep and beef farming limited to the steep rolling country further back in the catchment.

Since 2007, the Department has evaluated all concessions in and around the wetland. As a result, some grazing concessions have been retired, and others converted to cropping and grass cutting systems or beehive concessions where appropriate.

Collaboration with local government, industry groups and private landholders is critical to promoting sustainable land use. The Department can manage the condition of concession land, but does not have the mandate to work on improving effluent management in agricultural areas upstream of high conservation value wetlands and outside of public conservation land.

Sustainable land use includes the use of cultural resources by iwi on public conservation land. The cultural harvest of flora resources at Whangamarino will be included in the Cultural Flora Harvest Plan being developed as part of the Waikato River Conservation Accord.

Outcome monitoring

Changes in land use practices at Whangamarino were examined by collating information on the compliance of concessions and mapping the extent of wetland on private land. Progress is measured using the following outcome indicators:

- Condition of conservation land managed under concession activities [AK 6.i]
- Extent of indigenous wetlands on private land; covenants [AK 6.iii, AK 6.iv]
- Satisfaction of iwi on the availability and use of cultural resources [AK 6.v]

Activity on concession land is observed as part of the general daily operational management at Whangamarino, and staff are regularly in communication with concession holders. As concession terms near expiry staff visit the licence area and evaluate the concessionaire's performance. Methods used by field staff to measure farmers' performance include assessing ground condition (e.g. evidence of pugging during wet weather), turf condition and density (e.g. % ground cover), weed abundance, evidence of fertiliser/lime application, infrastructure condition (e.g. state of fences, including whether electric fences are being powered) and compliance with Regional Council rules (e.g. fencing and stock exclusion). This information is provided back to concessions staff to assist in the processing of new concession document.

Results

CONDITION OF CONSERVATION LAND MANAGED UNDER CONCESSION ACTIVITIES

The concession activities that take place at Whangamarino Wetland are summarised in Table 10 below. Four non-compliant grazing concessions have been retired, and two further retirements are pending. Two concession areas remain non-compliant. Overall, compliance has improved in the last five years, assisted by boundary fencing facilitated by the Department as well as greater involvement and communication with the community and wetland user groups.

Bee keeping on conservation land continues to have poor compliance with Department regulations. A potentially lucrative highly mobile business, hives can be easily hidden from roads and access ways and as a result many operators do not have the required license to keep bees on public

conservation land. While this does not effect wetland management to any great extent it is of concern to the Department in general.

Table 10. Summary of the concession management at Whangamarino 2007-2011.

Concession type	No. concessions	Compliance assessment
Grazing/cropping	11	4 retired 2 retirements pending 2 non-compliant 3 compliant
Bee keeping	8	Poor compliance

One of the retired concessions received a Waikato Catchment Ecological Enhancement Trust (WCEET) grant, with the assistance of Auckland/Waikato Fish and Game Council, and an ephemeral wetland was created and planted over a two year period. This is an example of the increase in net conservation value the Department hopes to achieve through evaluating concessions, and has the potential to become a showcase example of a constructed wetland in future.

EXTENT OF WETLANDS ON PRIVATE LAND

The extent of indigenous wetland present on private land, including that which is protected by covenants, is summarised in Table 1 (page 14). A total of 1,207 ha of Whangamarino is located on private land but only 3.3% (40 ha) of this is protected by some form of covenant. Most of this privately owned wetland consists of swamp habitat but a significant portion (274 ha) of high value fen and bog habitat is also privately owned.

SATISFACTION OF IWI ON THE AVAILABILITY AND USE OF CULTURAL RESOURCES

As discussed in Objective 5, the Department has limited information on the cultural values of iwi relating to the Whangamarino Wetland. However, a Cultural Flora Harvest Plan is being developed as part of the Waikato River Conservation Accord (discussed further in Objective 8), and this will include the cultural use of flora resources at Whangamarino.

Management implications

The Department will continue to monitor concessions, modifying their management to meet Arawai Kākāriki objectives. To ensure the Whangamarino Wetland Concessions Strategic Plan remains up to date and relevant, Wildland Consultants will be commissioned complete a thorough ecological assessment of concessions to ensure all grazing concessions provide net conservation value. In addition, our current approach to evaluating concessions will be reviewed, with the intention of undertaking evaluation on an annual basis with regular record keeping.

The Department has also been investigating ways we, in partnership with WRC, can better communicate with rural landowners to support and encourage them to achieve sustainable land use and protect wetland habitat. For example, some adjoining land owners have agreed to more wetland-friendly changes in grazing techniques, including “flash grazing” (using a high concentration of livestock to briefly graze a paddock) and low density stocking of young animals, which help to keep grass/weeds down and reduce fire risk while lessening negative impacts on the wetland.

Research carried out with local community recommended developing a Landowner Engagement Plan, taking into account the needs of the rural land owners. This plan will focus on collaboration with adjacent landowners on catchment management and providing better information on our work in the wetland. This approach will be particularly important as the Department heads into a model increasingly focused on inter-agency collaboration and empowering communities to look after their natural assets.

Work is underway on a Cultural Flora Harvest Plan through the Conservation Accord, which will identify key plants and sites on all public conservation land within the rohe of Waikato-Tainui, including Whangamarino Wetland. Waikato-Tainui are leading the process, with the support of the Department, which will include consultation with iwi, particularly weavers, carvers, and practitioners of Rongoa Māori (the use of plants for medicinal medicine).



Figure 16. Meremere Primary School planting day. Photo: DOC 2012

Objective 7: Improve recreation and visitor facilities

Promoting public use and enjoyment of the recreation opportunities and scenic values at Whangamarino is one of the key aims of Arawai Kākāriki. The establishment of facilities for visitors such as walking trails provides a mechanism to inform public of the issues that threaten wetland ecosystems. The main recreational activities at Whangamarino are game bird hunting and fishing, mostly for coarse fish such as koi carp. A small number of people also utilise the wetland for kayaking and bird watching activities.

At Whangamarino, the Department has focused on maintaining existing visitor facilities and investigating new opportunities to allow sustainable recreation and attract visitors to public conservation land. A number of options to provide visitor access by foot have been and continue to be investigated. Due to the complex nature of the site and potential for long term damage to the bog habitats, this is yet to be resolved.

Outcome monitoring

A comprehensive survey of visitor use and satisfaction has not taken place at Whangamarino; however, the Department has recorded a snapshot of visitor numbers and satisfaction at various locations and times. Progress is measured using the following outcome indicators:

- Number of visitors [AK 7.i]
- Visitor satisfaction, and visitor awareness of wetland values [AK 7.ii, AK 7.v]
- Use of wetlands for game bird hunting and fishing [AK 7.iii]

The numbers of visitors using walking trails has been monitored by establishing track counters at the Whangamarino Redoubt access track. Visitor satisfaction was recorded following a DOC-led guided kayak tour with 18 participants from the local community in 2011. Whangamarino game bird hunters were surveyed in 2011 as part of the yearly Fish and Game telephone survey.

Results

NUMBER OF VISITORS

Visitor numbers throughout much of the Whangamarino are not well known. A visitor survey proposal has been developed but the Department has not had the resources to implement this to date.

Visitor numbers have been recorded by electronic track counters at the Whangamarino Redoubt (Figure 17). Ranging between 14 and 29 visitors per month with a mean average of 20, these are considered relatively low for the site. This is attributable to a lack of awareness of the network of historic sites that exists in the Waikato and is likely to change in 2013 following significant plans for the 150 year commemoration of the Waikato War led by NZHPT.

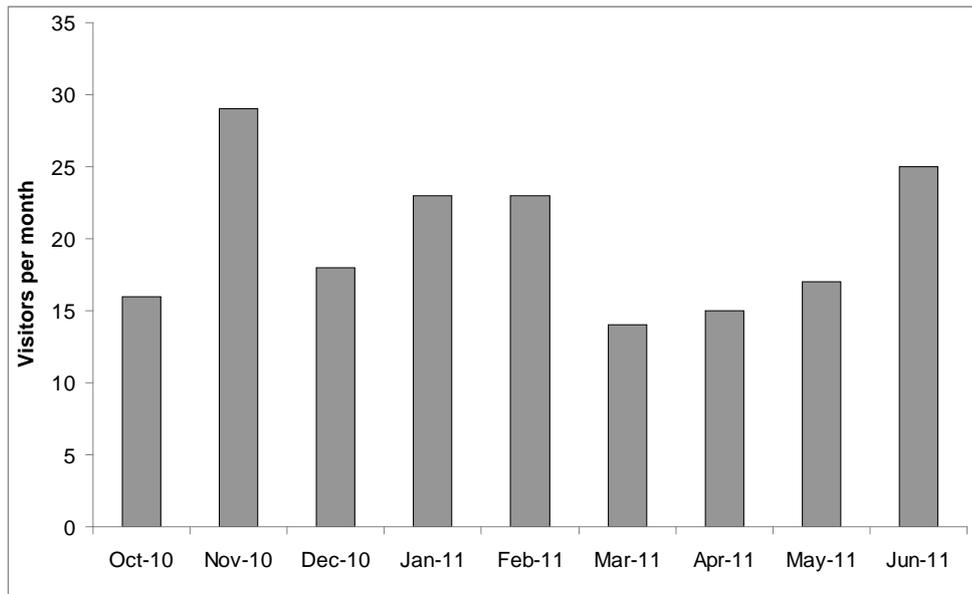


Figure 17. Visitor numbers recorded at the Whangamarino Redoubt/Te Teotēo Pā following the upgrade of the access track.

VISITOR SATISFACTION, AND VISITOR AWARENESS OF WETLAND VALUES

Visitor satisfaction and awareness of wetland values is not well known at Whangamarino. The proposed visitor survey aims to address the lack of information. However, limited information has been gained through an exit survey of participants of a guided kayak tour through the wetland and by additional questions added to the annual Fish and Game telephone survey of game bird hunters (discussed further below).

Nineteen people participated in the guided kayak tour run by the Department in 2011. These were a combination of members of the local community, including iwi, and local politicians.

The objectives of the event were to:

- Enable the local community to experience the wetland from another perspective;
- Update people on conservation progress during the Arawai Kākārīki project; and
- Explain the importance and value of wetlands, highlighting their uniqueness.

Participants were asked how they would rate their enjoyment of the event, how effective the event was in meeting its objectives, how the event could have been made more effective, any changes they would like to see for future events, and if they had any further comments. On a scale of 1-5, where 5 is highly effective, participants rated the effectiveness of the event in meeting its objectives 4.4 on average. Participant satisfaction was very high (Table 11), with an average enjoyment rating of 4.8 using the same scale, with 5 being very enjoyable.

The Department has worked to enhance visitor experience by upgrading three boat ramps and associated signage since 2007 as a large portion of the wetland is only accessible by boat. Other resources developed to improve visitor experience include the erection of an interpretation panel in the nearby township of Te Kauwhata (Figure 18) and distribution of an informative brochure.



Figure 18. Kaumatua Pat Kingi at the unveiling of the Whangamarino Wetland interpretation panel in Te Kauwhata. Photo: DOC 2010.

USE OF WETLANDS FOR GAME BIRD HUNTING AND FISHING

Game bird hunter satisfaction was measured by adding the following two questions to the annual Fish and Game game bird hunter telephone survey when respondents indicated they hunted in the Whangamarino:

1. On a scale of 1 (poor) to 10 (exceptional), how satisfied are you with the recreational experience in the wetland?
2. Has your hunting success increased or decreased over the past five years?

Seven respondents had hunted in the Whangamarino. Five hunters ranked their satisfaction levels between 7-10; the remaining two rated their satisfaction 1 and 2 (Table 11). Two respondents stated their hunting success remained unchanged over the past five years, while five ranked their success as having decreased over the same period. When asked about what contributed to their ranking of their hunting experience at Whangamarino, interviewees were reasonably happy but identified high water levels, poor signage, increased hunting pressure in the wetland and a lack of communication between the Department and hunters as areas that could be improved.

Table 11. Summary of visitor satisfaction at Whangamarino, recorded from exit and telephone surveys respectively, in 2011.

Visitor group	Satisfaction			
	Very High	High	Moderate	Low
Kayak tour participants	13	2	0	0
Game bird hunters	3	2	0	2

Management implications

The Department currently has limited information to report on Objective 7. Monitoring can be improved by better tracking of visitor numbers and implementation of the proposed visitor survey that recommended targeting boat ramps users, angler counts, and more intensive surveys of game bird hunters. This will be initiated during the next phase of management over the coming five years.

Whangamarino Redoubt visitation is low but is expected to improve with increased awareness provided by the 150 year commemoration of the Waikato War and the concurrent launch of the driving trail in 2013. The Department has an opportunity to capitalise on the increased infrastructure interpreting the cultural history of the site by adding interpretation relating to the Whangamarino Wetland and the Waikato River at key viewing points atop the redoubt and pā site.

The guided kayak tour was very successful. The model could provide opportunities for visitor access in the future, either led by the Department or run by a concessionaire.

Game bird hunting and coarse fishing are the most common visitor activities currently carried out in the wetland. The effects of recreational use on wetland habitat are unknown; although the transfer of wetland weeds remains a significant concern.

Game bird hunters' satisfaction is influenced by deteriorating success. This is likely to be linked to ecological factors in the wetland and is a region-wide trend. The diverse waterfowl present in the Whangamarino is one of the key reasons the wetland was designated a Ramsar site, with game birds and native wetland birds alike requiring good ecological conditions to thrive. This deterioration is reflected in changes to the game bird hunting season signalled by the Auckland/Waikato Fish and Game Council in 2013. These include reducing the game bird hunting season from eight to four weeks, setting a three shell total shotgun capacity limit, and removing the exemption allowing waterfowl baiting so it is not allowed one month prior to or during the hunting season.

Encouragement of coarse fishing is complicated by the fact that some aspects of the sport practiced by some individuals are illegal (i.e., the catch and release of koi carp) and represent a potential, albeit low, biosecurity risk (the transfer of live koi). Good coarse fishing success is not necessarily linked to good ecological health in the wetland and control of some species like koi carp is likely to be supported by Department.

Objective 8: Maximise community involvement and awareness

Without the support of local community it is often difficult to achieve the goals for biodiversity conservation and improved recreation. Successful engagement requires an understanding of community values and the interest of individuals in contributing to wetland conservation. The development and maintenance of partnerships with iwi, Waikato Regional Council and other stakeholders is a priority. Promoting awareness of the unique features and vulnerability of wetlands to a wider audience through media and other communication tools is equally important.

The key aim of this objective is to increase local community awareness of and engagement in the Whangamarino restoration programme. A variety of strategies have been employed to achieve this, including:

- Regular media releases in local and regional newspapers;
- Distribution of the Whangamarino Natter, an intermittent newsletter dedicated to the Department's work at the wetland;
- Hosting planting days with local schools, in conjunction with educational visits;
- Distribution of promotional material including magnets, sticker books, fact sheets, colouring competitions and pens;
- Attending community events like the annual A&P show;
- Improving interpretive signage in the vicinity of the wetland (see Objective 7);
- Supporting graduate students in relevant wetland research; and
- Providing work experience for students completing the Waikato Institute of Technology (Wintec)/Waikato-Tainui wetland restoration course (Figure 19).



Figure 19. Rimutere Wharakura, Wintec student, enjoying a day in the field setting DOC250 traps targeting wetland predators. Photo: DOC 2013.

Despite the activities outlined above, community uptake has been limited. The Waikato Area subsequently commissioned research to determine the most effective ways for the Department to engage with the Whangamarino community. A strategic communications plan was developed based on the research findings, with target audiences identified including the rural community, Te Kauwhata and Meremere communities, local iwi, and local schools.

Outcome monitoring

Baseline information regarding community perceptions and involvement was established by conducting a postal survey in the Whangamarino district (Duggan 2011, Versus Research 2011a), followed by focus groups to identify how the Department can better engage with local residents (Versus Research 2011b). The postal survey was sent to a random selection of 500 homes and 149 were returned.

The focus groups were undertaken in Te Kauwhata and Meremere and were comprised of community groups and landowners, primary school teachers, and one in-depth interview with a secondary school geography teacher. The objectives were to better understand residents' awareness and usage of the wetland and how the Department could best engage with residents and schools.

Records of website hits were collated to determine the level of external interest in the Whangamarino Arawai Kākāriki webpage. The numbers of volunteers participating in projects at Whangamarino were also recorded.

Progress is measured using the following outcome indicators:

- Proportion of community, iwi and stakeholders with improved awareness of the Arawai Kākāriki programme [AK 8.i, AK 8.iii]
- Level of external interest (website hits) [AK 8.ii]
- Level of engagement of stakeholders with conservation at the site [AK 8.v]
- Number of partnerships that involve tangata whenua [AK 8.vi]
- Number of volunteers who participate in conservation projects [AK 8.vii]

Results

IMPROVED AWARENESS

The postal survey conducted in 2010 provides a baseline level of community awareness about the Whangamarino Wetland and the Arawai Kākāriki programme. Changes in perceptions and involvement can be evaluated by re-surveying residents in the future. Participants were asked about their perceptions of different wetland values (Table 12). The values that ranked most highly were: the wetland as a reserve of public conservation land, home to native species, and threatened plant and fish habitat.

Consistent with these values, 90% of respondents considered it highly important that the health and wellbeing of the Whangamarino Wetland is looked after. However, fewer (43%) considered that they had a personal responsibility to look after wetland health, and fewer again (32%) believed that any actions they did take could make a practical difference to wetland condition.

Awareness of the Arawai Kākāriki wetland restoration programme was very low, with 74% of respondents reporting that they had 'never heard of it'. Encouragingly, 74% of respondents indicated they would like to receive regular updates about the restoration work occurring at the site. Wetland biodiversity was the feature people most wanted to learn more about, but a number of other topics were considered of interest, including water quality, pest animals and plants, and the economic values of the wetland.

Table 12. Summary of community perceptions of the Whangamarino Wetland. Data from postal survey 2010.

Attribute	Perception level (numbers of responses)			Total
	Very important	Moderately important	Not Important	
Provision of flood protection	104	19	5	128
Ability to filter water	92	26	4	122
Place to hunt game birds	40	51	47	138
Place to fish	22	58	55	135
Cultural uses	16	48	57	121
Scenic beauty	106	29	6	141
Reserve of PCL	115	19	7	141
Home to native species	128	14	0	142
Threatened plant habitat	117	18	2	137
Threatened bird habitat	130	9	1	140
Game bird habitat	94	30	19	143
Native fish habitat	121	18	3	142
Supply of freshwater	88	32	12	132
Carbon storage	94	27	14	135

LEVEL OF EXTERNAL INTEREST

The level of external interest has been measured by recording the number of 'hits' on the primary DOC Whangamarino Wetland webpage (Figure 20). This ranged between 130-193 hits during the six quarters from January 2010 to June 2011. A further four web pages relating to the wetland were developed between July 2011 and April 2012, but these fall out of the scope of this report.

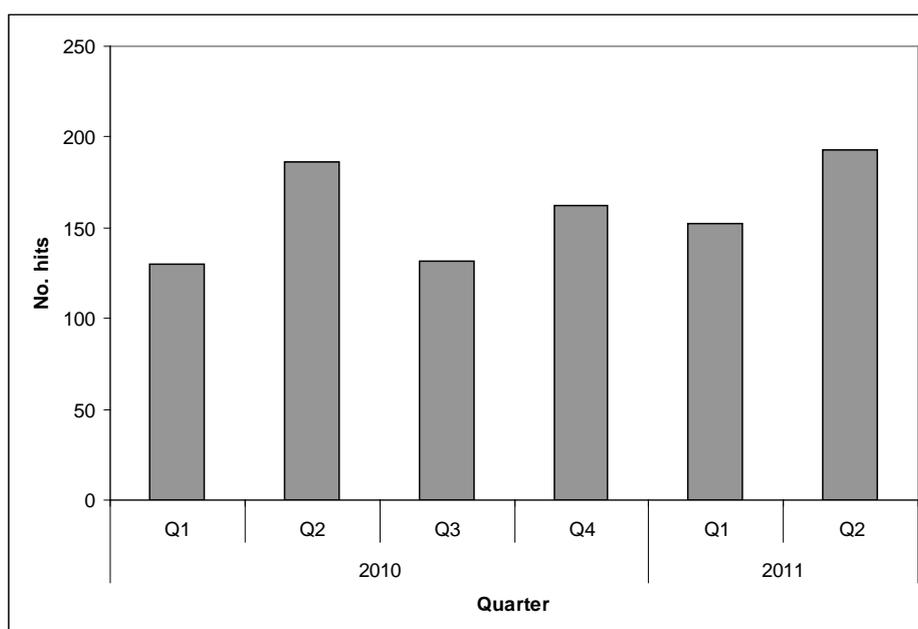


Figure 20. Variation in the number of website hits on the main Whangamarino webpage (www.doc.govt.nz/conservation/land-and-freshwater/wetlands/wetlands-by-region/waikato/whangamarino) from January 2010 and June 2011.

ENGAGEMENT OF STAKEHOLDERS

A number of stakeholders are invested in the Whangamarino Wetland, particularly WRC and Fish and Game, as well as research organisations, NGOs and iwi. The most significant partnership for the project is with Waikato Regional Council, as the management of the Flood Control Scheme has major implications for the wetland. The Department's engagement with WRC has been improved through the formation of a working group, which has jointly commissioned research to improve understanding of wetland processes and has committed to ongoing liaison. Engagement has also taken place with the Lower Waikato Catchment Sub-Committee; the importance of these relationships deserves increased investment by the Department.

Auckland/Waikato Fish and Game Council is also a noteworthy stakeholder, with most of the 737 ha of wetland under their ownership directly adjoining public conservation land. The Department is in regular contact with Fish and Game and often takes a joint approach to management, particularly in addressing weed incursions.

Research stakeholders include NIWA, Landcare Research and the University of Waikato. Significant collaboration occurs between these organisations, though there is scope to improve information sharing. The National Wetland Trust, Landcare Trust and Weedbusters are non-governmental organisations with an interest in wetlands and are also engaged with on a regular basis. Articles featuring the Arawai Kākāriki programme are regularly submitted to the National Wetland Trust's quarterly magazine. Iwi partnerships are discussed below.

PARTNERSHIPS WITH TANGATA WHENUA

The Department has a formal partnership with tangata whenua at the iwi level, and informal partnerships at the hapū level. The partnership with Waikato-Tainui has been formalised through the Waikato River Deed of Settlement, through which the Conservation Accord was signed in 2008 detailing a number of priorities for the relationship.

The Conservation Accord recognises that Waikato-Tainui have a special relationship with the Waikato River and associated wetlands, lakes, streams, and taonga species. The overarching purpose of the Accord is to restore and protect the health and well being of the Waikato River (and catchment) for generations to come. The Conservation Accord commits the Department and Waikato-Tainui to enter into a new era of co-management and a collaborative approach with iwi and mana whenua. The Department's Whangamarino Restoration Programme has close links with the Waikato River Restoration Programme with a shared Programme Manager, and matters relating to Whangamarino are regularly discussed at the bi-monthly meetings.

Ngā Muka Development Trust is a collection of local hapū and marae that are kaitiaki of the Whangamarino area. The Department does not have a formal partnership with Ngā Muka, but the Trust has been engaged numerous times in work relating to matters of interest to mana whenua (see Objective 5).

Waahi Whanui Trust is another collection of hapū and marae with an interest in the Whangamarino area, primarily Lake Waikare. The northern boundary of their rohe extends to the southern section of Lake Waikare.

Effective management of the cultural values of the Whangamarino Wetland will progress as the relationship with iwi has been strengthened at iwi and hapū level. Progressing this relationship and collaborative approach is a high priority for the Waikato Area Office and the Whangamarino Wetland team.

VOLUNTEER PARTICIPATION

Volunteer numbers at the wetland have been relatively low (Table 13), with the highest numbers being local primary school children undertaking organised restoration planting (Figure 21). Conservation Volunteers initial involvement with the site was through their partnership with Fonterra Catchment Care. Kanae Kākāriki Trust was a practical training programme for working-aged Māori in both Huntly and Ngaruawahia. It focused on the basic skills required for fishing and conservation programmes. Since the death of its founder in 2011, the Trust has changed slightly to be more focused on environmental restoration. Both of these groups focused primarily on restoration planting.

Table 13. Summary of volunteers who participated in conservation projects at Whangamarino between 2008-2011.

Volunteer group	Year				Total
	2008	2009	2010	2011	
Conservation Volunteers	0	0	7	0	7
School students	0	100	100	100	300
Huntly Youth Assist	0	0	10	7	17
Kanae Kākāriki Trust	0	0	0	15	15



Figure 21. Students from Te Kauwhata Primary, Conservation Volunteers (in high visibility yellow) and DOC staff working hard at a planting day in 2010. Photo: DOC 2010.

Management implications

The Department has obtained baseline information on the level of community awareness and values relating to the Whangamarino Wetland, as well as awareness of the Arawai Kākāriki programme. Repeat surveys in future will show changes in awareness and perceptions that can be attributed to the ongoing implementation of Arawai Kākāriki.

The level of external interest will continue to be tracked by monitoring website hits. Opportunities to update and improve the Whangamarino website will be considered when resourcing allows.

Improving engagement with iwi as partners in conservation will be a major focus of the programme going forward. We are entering into a new era of co-management under the Conservation Accord, supported by the objectives of the Arawai Kākāriki programme as well as the commitment made by the Department to its new direction. This will have significant implications on how we manage Whangamarino and Lake Waikare, as well as how we engage and work with iwi, and requires the appointment of a staff member with appropriate partnership skills to support this.

Effective ongoing communication and collaboration with WRC and adjacent landowners is also critical to the success of this project. Strengthening our relationship with WRC through the Whangamarino working group lends itself to achieving great gains, including jointly funded projects and possibly jointly funded staff. Improving these relationships will facilitate increased volunteer and community participation.

3.3. Learning

Objective 9: Undertake research to inform wetland management

Understanding how wetlands function, testing approaches to protect their values, and sharing this information with other wetland managers is an important part of the Arawai Kākāriki Programme. A number of research projects have been implemented under the Whangamarino project since 2007 and are being used to guide conservation. Some of these were led by the Department and others in partnership with agencies and universities.

A synopsis of each research project is provided below.

Ecohydrological characterisation of Whangamarino Wetland. J. Blyth (MSc project), University of Waikato. *Complete*

The hydrology of Whangamarino Wetland has been altered by lowered riverbed levels, the Lower Waikato Waipa Flood Control Scheme (Flood Control Scheme) (operational since 1982) and altered minimum water levels.

Research objectives were to: characterise seasonal and annual hydrological regimes, identify hydrological processes associated with flow regimes of the Whangamarino River and Flood Control Scheme, describe water quality of a flood event that caused wetland inundation, and explore relationships between vegetation, soil chemistry, nutrient inputs, and hydrological processes.

Key findings indicate:

- Increased sediment and nutrient deposition may be encouraging mānuka invasion towards the restiad bog.
- Flood waters deliver high loads of suspended solid and high nutrient concentrations into the wetland.
- Sites up to 500 m from the river are likely to be inundated annually and a 100 yr flood is estimated to inundate 1.75 km from the river, but not cover the entire wetland.
- Inundation with nutrient and sediment rich waters is a major risk to the integrity of the wetlands.

Findings of this research have been published in two journal papers, Blyth 2011 and Blyth *et al* 2012.

Wetland ecosystem response to broad-scale glyphosate application for control of invasive willow. MBIE⁸ Restoring Wetlands programme. B. Clarkson, C. Watts (LCR), K. Bodmin, J. Wech (NIWA). *On going*

Arawai Kākāriki has developed a partnership with the MBIE Restoring Wetland programme to address key issues relating to the conservation of wetland ecosystems. A multi-year programme was established at Whangamarino involving researchers from Landcare Research and NIWA.

The research project examines the impact of broad-scale glyphosate application on both native wetland fauna and flora, and is also tracking the recovery and restoration of wetland vegetation, aquatic invertebrates and terrestrial invertebrates post spraying.

Approximately 12 ha of Whangamarino has been treated with glyphosate to replicate a typical management activity, and numerous response variables are being measured.

⁸ Ministry for Business Innovation and Employment

Trialling different approaches to the control of grey willow (*Salix cinerea*) in New Zealand's non-forest wetlands. J. Griffiths (DOC). *On going*

The introduced shrub willow *S. cinerea* poses a significant threat to New Zealand's non-forest wetland ecosystems, as it can rapidly displace low stature (<2m) rush, sedge and low shrub habitats over large areas. However, there remains uncertainty about which control methods to apply in different wetland environments.

Key objectives of this research are to: determine how willow stand density, cover and size influences the efficacy and target specificity of the aerially applied glyphosate and tryclopr for large scale willow control, and to determine how plant community structure and composition influences native plant community recovery and weed invasion post willow control.

In contrast to the MBIE project, this research applied two different herbicides across a willow density gradient.

Ecological impacts of the Lower Waikato Waipa flood control scheme on Whangamarino Wetland, and potential mitigation options. Wildland Consultants, in conjunction with DOC and WRC. *Final draft*

A number of investigations have indicated that the Flood Control Scheme has had negative effects on Lake Waikare and the Whangamarino Wetland. The Department of Conservation and Waikato Regional Council commissioned this report to review the ecological impacts of the Scheme and compile recommendations for mitigation options.

The key findings of the review were:

- There have been significant changes to the hydrological regimes of Lake Waikare, the Whangamarino Wetland and the Waikato River, including an increase in the frequency and extent of flooding in the wetland.
- Increased sedimentation and nutrient levels in the Whangamarino Wetland, and loss of wetland habitat.
- A greater risk of weed invasion.
- None of the mitigation options provide a single solution to reducing sediment inputs in Lake Waikare and Whangamarino. Any solution will need to include a combination of options.

Knowledge gaps identified included:

- Better quantification of sediment inputs and outputs.
- Quantification of the extent of surface flooding within the Whangamarino Wetland at different water levels.
- Better understanding of the impacts of introduced fish make on suspended sediment concentrations.

Sediment sources and accumulation rates in Whangamarino Wetland: initial investigation. G. Reeve, M. Gibbs, A. (NIWA). *Complete.*

Increased sediment deposition has been identified as one of the key threats to the ecological integrity of Whangamarino wetland. The research aimed to: quantify sediment accumulation rates, identify if accumulation rates have changed since the construction of the Pungarehu Canal, and assess changes in sediment source over the last 50-100 years.

Soil cores were collected along a transect in the Whangamarino wetland, starting in the Pungarehu Canal and ending in a drier area of manuka scrub within the wetland. A number of analytical methods were used to assess the sediment composition and sources.

Analysis showed:

- Sediment accumulation rates have increased since construction of the Pungarehu Canal. Rates are estimated at approximately 2.2 mm/yr before construction and 7.9 mm/yr post construction.
- Sediment sources have changed over time and since construction of the Pungarehu Canal. Prior to construction of the canal the main sediment sources were manuka scrub and the Waerenga River and reflected peat soil types. Post canal construction, the sediment sources have become muddier reflecting over flows of silt laden water from Lake Waikare, the source of the Pungarehu Canal.
- Sediment deposition in the wetland varied with increasing distance from the canal, reflecting differences in sediment sources during flood events.

The findings confirm altered sediment dynamics are a concern for the future integrity of the wetland and innovative approaches to management may be required.

Whangamarino Wetland hydrological model and sediment/nutrient source modelling. SKM Ltd. *On going*

A hydrological model has been developed to help form a better understanding of the dynamics of the system and interpret the wider implications of the various investigations and assess the impacts of potential management and mitigation options.

The purpose of the model is to provide: better resolution of variations in sediment and nutrient loads, information on the frequency, extent and duration of flooding, and provide the basis for assessing different water regime management scenarios.

This technical investigation is partway through. A hydrological model has been constructed and validated. Further work will incorporate source catchment modelling to quantify the sediment and nutrient loads entering Whangamarino wetland under different rainfall and flood scenarios.

Future research

Future research priorities at Whangamarino Wetland include:

- Ongoing investigation of the effects of the Flood Control Scheme on Whangamarino, including nutrient and sediment fluxes, and develop practical mitigation options.
- Characterise the ecohydrology of greater areas of the wetland to complement the hydrological model.
- Assessment of methods for the management of *Corybas carsei*, in particular translocation and propagation methods and use of managed fire to prevent competition with other vegetation.
- Studying the impacts of other (excl. willow) invasive weeds (e.g. royal fern) on native species and habitat, and development of new management techniques.
- Expanding knowledge of the fish populations in the wetland by addressing the recommendations identified by Lake *et al.* (2011).
- Investigating how koi carp utilise Whangamarino Wetland to inform control programmes.
- Investigating the implications of aerial willow control on native fish species.

- Conducting research into visitor numbers and satisfaction (applying the visitor survey proposal, see Objective 7).
- Quantifying the ecosystem services provided by Whangamarino.

Objective 10: Develop best-practice wetland restoration tools

Whangamarino Wetland has undertaken or contributed to a number of projects to develop national tools, protocols and methodologies for wetland management. These are outlined below.

Developing monitoring methods for cryptic wetland bird species. C. O'Donnell (DOC) and E. Williams (Massey University). *On going*

Wetlands support a wide range of threatened birds, but some such as the Australasian bittern (*Botaurus poiciloptilus*), are cryptic and difficult to monitor.

The research aimed to trial the use of acoustic recorders for bittern surveys to: determine their suitability for local and national monitoring, update distribution maps, identify critical habitat types and measure the response of bittern populations to management.

The surveys rely on recording bittern booming (mating calls from males) using either human listeners or automatic recorders distributed throughout a wetland.

The trials have found that:

- Recorders are excellent at capturing bittern calls
- Recorders generally perform as well as human listeners
- There is a strong relationship between the number of calls and individuals counted

Research undertaken at Whangamarino Wetland contributed to the development and trialling of national protocols for monitoring Australasian bittern. Further work will explore the optimal distance between listening stations and if there is a disturbance threshold.

Monitoring introduced mammalian predators in the Whangamarino Wetland. C. Gillies and M. Brady (DOC). *On going*

Managing predators which threaten the recovery of wetland birds is a key objective of the Arawai Kākāriki Programme. Little is known about introduced mammalian predators in New Zealand's wetlands and existing monitoring methods for assessing predator abundance may not be appropriate in these ecosystems.

This study aims to: describe the mammalian predator guilds, and test, develop and validate existing and novel small mammal monitoring techniques. Seasonal live trapping has been used to estimate predator abundance and was compared with surveys from camera-traps (for carnivores), and WaxTag® (for rodents).

The results indicate that:

- Ferrets are the most numerous carnivores present followed by feral cats and weasels.
- Other pests present or seasonally abundant include possums, two rat species, house mice, stoats and hedgehogs.
- Camera-traps and WaxTag® correlated well with live trapping results for carnivores and rodents.
- The WaxTag® has potential for use in wetlands; technical issues with the camera-traps need to be resolved before adopting for routine use.

These methods will help inform the success of predator removal and management at the site. The work carried out in Whangamarino is leading the way towards improving predator control in NZ wetlands by helping to identify the best way to assess predator populations and monitor the success of control programmes.



DOC Scientist Craig Gillies processing a weasel. Photo: DOC 2013.

Wetland mapping and classification guidelines. H. Robertson et al. (DOC). *On going*

Geospatial mapping provides the foundation for the Arawai Kākāriki Wetland Restoration Programme to: set wetland conservation objectives, prioritise restoration actions, and establish robust monitoring. Detailed vegetation mapping delivers baseline information on the extent and distribution of different wetland types.

Guidelines have been developed to provide a standardised method for wetland mapping that can be applied to other wetland management projects in New Zealand.

The technical process applied to map wetland habitat at Whangamarino (Reeves & Haskew 2003) was used to develop the guidelines.

Standardised approaches to vegetation monitoring in wetlands. H. Robertson (DOC). *On going*

Reporting on progress towards restoring wetland condition is a critical part of Arawai Kākāriki and requires well developed monitoring systems.

All Arawai Kākāriki sites have implemented broad-scale wetland vegetation monitoring to examine plant composition and soil status. The monitoring methods have been standardised to provide data suitable for DOC reporting on biodiversity outcomes, and also to link in with monitoring applied by other agencies.

Testing of the vegetation monitoring methods was undertaken at Whangamarino.

Monitoring framework

All Arawai Kākāriki sites utilise a national outcome monitoring framework developed specifically for reporting on changes in wetland condition and for community involvement. The indicators used in this report represent one of the first comprehensive application of the NHMS-based monitoring system, and provides the foundation for monitoring the effectiveness of wetland conservation projects implemented by the Department.

Future development

Future priorities for the development of monitoring and management tools include:

- Development of cryptic bird call recognition software
- Guidelines for monitoring wetland hydrology
- Guidelines for determining water requirements of wetland ecosystems
- Improved methods for the control of pest fish in wetlands



Developing future restoration plans with others. Photo: DOC 2009

4. Summary of Conservation Outcomes

Conservation investment at Whangamarino Wetland has focused on protecting the high value peat bog areas and key threatened species (primarily *Corybas carsei* and Australasian bittern), while improving understanding of (and attempting to slow) the processes contributing to the degradation of areas of swamp and peat bog. Habitat condition has been assessed using vegetation maps derived from aerial photographs, in conjunction with information obtained through monitoring permanent vegetation plots, water quality and sediment accumulation rates, and weed surveillance. Inventories have been undertaken on threatened plant, weed, bird, fish and terrestrial invertebrate species.

Community outcomes include working with adjoining landowners to improve grazing techniques and retire grazing concessions, improving visitor facilities, and developing our relationship with key stakeholders, particularly Waikato Regional Council, Waikato-Tainui, Ngā Muka Development Trust and game bird hunters. Monitoring has taken place to establish a baseline of community involvement and interest in the Whangamarino Wetland. Local primary school children have been engaged in school talks and wetland restoration planting days.

Key highlights of the Whangamarino programme between 2007 and 2011 include the following:

- The extent of wetland habitat has increased by 80 ha due to the retirement and restoration of grazing concessions, exclusion of cattle through boundary fencing and by encouraging adjacent landowners to employ more wetland-friendly grazing techniques. More than 3,000 wetland plants have been planted by local primary school children alone.
- An extensive wetland weed control and surveillance programme continues to be implemented and refined.
- Detailed scientific understanding of the ecohydrology of Whangamarino has developed through: hydrological monitoring, soil analysis, study of sediment accumulation rates, vegetation monitoring and from supporting student research. This enabled the Department to understand the processes contributing to wetland degradation and the effect of activities taking place in the wider catchment, including operation of the Flood Control Scheme.
- Review of the ecological effects of the Flood Control Scheme (and other changes within the lower Waikato River, Whangamarino and Lake Waikare catchments) has been completed in conjunction with WRC. As part of this, options to mitigate the effects of the Flood Control Scheme on the wetland were identified (Reeves & Hancock 2012).
- Whangamarino Wetland is an important habitat for at least 17 threatened species. Numbers of the critically endangered *Corybas carsei* have increased following the implementation of management by fire, and we can now look into possibilities for further research on the plant, including the potential for translocation.
- Extensive research has been undertaken into monitoring methods for cryptic birds and mammalian predators in wetlands. This will feed into a high profile adaptive management control programme in 2013 to increase the population of threatened wetland birds and inform wetland management nationwide.
- Community and visitor awareness has been improved through the installation of an interpretation panel in Te Kauwhata township, distribution of factsheets and a community newsletter, regular media releases and DOC presence at community events. A successful guided kayak tour was run, providing a potential template for the future. The Department continues to maintain an ongoing relationship with game bird hunters.
- A significant upgrade of the Whangamarino weir was completed, helping maintain minimum summer water levels.

- Improvements have been made to the Whangamarino Redoubt access track, and three boat ramps providing key public access points to the wetland.
- Research carried out with local residents provided a baseline to measure changes in community awareness and engagement in the Whangamarino programme, informing our approaches to connect with key stakeholders, rural landowners and schools.
- Our approach to collaborative management has improved, particularly with Waikato Regional Council and Waikato-Tainui.



Recreated wetland on a retired concession block. Photo: DOC 2010.

5. Future Directions

The Department has achieved notable results at Whangamarino in programmes relating to wetland hydrology, weed control and surveillance, protection and enhancement of threatened species populations, and improvements to visitor facilities. Now future work is needed to build on these results.

Between 2007 and 2011 the Department invested significant resources into research and monitoring at Whangamarino Wetland and we are starting to assemble a detailed understanding of the processes driving ecological change, the ecological values and the key threats impacting the wetland, as well as levels of community awareness and interest in the site.

It will be important to continue an adaptive management approach by applying the findings of research into operational work carried out at the wetland and to inform wetland restoration projects nationwide. Addressing key knowledge gaps is also a priority, for example, to better manage the cultural values of Whangamarino.

Whangamarino Wetland was identified in the DOC ecosystem prioritisation process as a priority wetland site (and has been assigned an ecosystems prescription). The on-ground work programme identified in this prescription corresponds strongly with the biodiversity work already being carried out at Whangamarino through Arawai Kākāriki.

Species of interest encapsulated by the Whangamarino work programme include Australasian bittern (identified as an indicator species), black mudfish and longfin eel. *Corybas carsei* is the only species identified through the DOC species optimisation process to have Whangamarino Wetland as the lead location for management, although it is recognised that management of *C. carsei* will also benefit *Lycopodiella serpentina*, another highly prioritised species. *Physcomitrium pusillum*, a moss described as 'nationally critical' is also found in the wetland, although currently there are no plans to manage this species.

The adaptive management and research currently being implemented at the site (e.g. controlled burns of *Corybas carsei*, wetland predator management) will continue to inform and refine both the ecosystems and species prescriptions.

Future directions for Whangamarino Wetland are outlined below, divided into the five new Arawai Kakariki 'purposes' that were confirmed in 2013, these are: *Ecological Restoration*; *Mātauranga Māori*; *Working with Others*; *Promotion*; and *Learning*. These purposes will replace the previous three 'themes' identified in Box 1.

ECOLOGICAL RESTORATION

The objectives under Ecological Restoration will remain closely linked to the four Biodiversity objectives discussed in this report. Key future directions at Whangamarino wetland include:

- An updated assessment of changes in wetland extent will be completed in 2013/14 following receipt of aerial photography.
- Wetland habitat will be created and protected through appropriate management of grazing concessions on public conservation land, to ensure net conservation value is attained. Opportunities to purchase wetland habitat on neighbouring private land will be considered and there is also scope to increase the number of covenants in place at the site, particularly of the 274 ha of privately owned high value bog and fen habitat.
- Application of the dynamic hydrological model to evaluate different water regime management scenarios.
- Further review of options to mitigate the impacts of the Flood Control Scheme on high value wetland habitat, through the DOC-WRC working group.

- Developing and maintaining a good working relationship with WRC and iwi on issues relating to the wider catchment.
- Protection and restoration of wetland habitat will be achieved by continuing to implement the weed management plan and annual red deer operations. Weed surveillance will also continue at key sites.
- Boundary fencing also remains a priority, with the aim being to fence all areas of wetland vulnerable to stock incursion. Currently 58 km remains unfenced, with 27 km of this considered high priority. Collaboration with WRC and the implementation of the rural engagement strategy will be critical to achieving this.
- Management of threatened species will focus on Australasian bittern and *Corybas carsei*. Controlled burning of *Corybas carsei* will continue, along with monitoring and weed control. The possibility of translocating *Corybas carsei* to other wetland areas will be investigated.
- A significant adaptive management trapping programme will be implemented from 2013 to enhance the populations of native wetland birds (e.g. Australasian bittern) and game species, while at the same time refining methods of monitoring and controlling mammalian predators in wetlands. Control methods and results will be shared with other agencies and community groups, with a focus on coordinating trapping efforts with key stakeholders at Whangamarino such as Fish and Game.

MĀTAURANGA MĀORI

Mātauranga Māori is usually recognised as including modern, historic, traditional and local knowledge; the ways in which this knowledge is retained and passed on; and indigenous aspirations and issues. The Mātauranga Māori objective under Arawai Kākāriki focuses on working with iwi, hapū and whanau to incorporate and recognise the value of Māori knowledge.

The Conservation Accord, signed by Waikato-Tainui and the Crown in 2008, provides an important foundation for Mātauranga Māori in the Waikato. The Accord recognises the special relationship Waikato-Tainui have with the Waikato River and its catchment, of which Whangamarino Wetland and Lake Waikare are part. The Conservation Accord Implementation Strategy outlines a number of agreements and mechanisms that illustrate the commitment from both parties to work together to ensure the recognition of mana whakahaere (governance) and the respect of mana o te awa (the spiritual authority of the Waikato River).

Priorities are:

- Completion of the cultural values assessment remains a high priority for the Department. This will require strengthening the relationship between DOC, iwi and mana whenua.
- Continue to work with Waikato Raupatu River Trust (the iwi authority) and local hapū to establish what co-management of Whangamarino Wetland means to all parties, through consultation and the Waikato-Tainui Environmental Plan.
- Support Waikato-Tainui in the development of the Cultural Flora Harvest Plan and its application at Whangamarino through the Conservation Accord.
- Continue to work with Waikato-Tainui to identify opportunities to provide training and work experience for tangata whenua in wetland restoration and management (such as the Wintec/Waikato-Tainui wetland restoration course and Māori cadetship scheme).

WORKING WITH OTHERS

Working with Others embraces the new direction of the Department to grow people and conservation, aiming to develop and lead community, stakeholder and business partnerships and participation. It will involve input of staff from the Department's Partnerships Group. Future directions include:

- Developing the partnership between DOC and WRC to work jointly on catchment and wetland management. Developing a rural engagement strategy will be an important step in solidifying the partnership at an operational level.
- Improving communication and collaboration with key partners (iwi and WRC) and stakeholders is a major focus for Whangamarino over the next five years.
- Maintaining an ongoing presence in the media, e.g. Te Kauwhata Chatter, National Wetland Trust newsletter, leading to increased volunteer and community participation.

PROMOTION

The purpose of Promotion is to increase community and visitor awareness and appreciation of wetland values, and to share scientific and technical information. Future work will include:

- Working in conjunction with the NZHPT investment in the Waikato War driving trail and associated interpretation at the Whangamarino Redoubt. The Redoubt and Te Teoteo's Pā site provide an excellent platform to interpret the biodiversity of the Whangamarino Wetland and explain the Waikato River Conservation Accord
- Further build the relationship with the National Wetland Trust and support the promotion of wetlands through their proposed National Wetland Centre at the Serpentine Lakes/Rotopiko.
- Repeat surveys of community awareness and appreciation to determine changes in community perceptions as the Arawai Kākāriki programme continues.
- Implementing the visitor survey proposal to collate information on visitor numbers.
- Reviewing potential sites for public access and recreation activities at Whangamarino, and implementing recommendations over the next five years.
- The sharing of scientific and technical information using effective methods to enable improved wetland management, working with DOC Science & Capability staff.

LEARNING

The Department will continue to look for opportunities to carry out research in the priority research areas identified under Objectives 9 and 10 of this report. In particular, focus will be given to:

- Seeking opportunities for collaboration on research and monitoring with WRC, universities and other research agencies.
- Evaluating water regime, nutrient and sediment management scenarios for Whangamarino with a view to mitigating the effects of the Flood Control Scheme.
- New approaches to weed management in modified wetland systems.
- Targeted research to enhance populations of threatened species.



Whangamarino kayak tour with local community members and stakeholders lead by DOC staff. Photo: DOC 2011

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Appendix 1: Arawai Kākāriki Outcome Reporting Framework.

Version 1.2 (Jan. 2011)

OVERVIEW

The Arawai Kākāriki outcome reporting framework was systematically compiled during 2010-2011 in a process involving representatives from R&D, ex-SRO and the three Conservancy Offices involved in the Arawai Kākāriki programme. The reporting framework is based on the department's NHMS model. The resulting indicators and measures enable national and site-level reporting on achievements in wetland management under the themes *Biodiversity*, *Community* and *Learning*, which corresponds to the 10 objectives of the Arawai Kākāriki programme.

This reporting framework provides the basis for the Whangamarino Outcomes Report 2007-2011.

BIODIVERSITY

1. Maintain wetland extent

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
1. Maintain or enhance the extent of wetland habitat	Wetland extent & protection	[AK1.i] Extent of wetland habitats on PCL in management area	OM1 - Wetland mapping/ground-truthing	5 yr
	Wetland extent & protection	[AK1.ii] Extent of wetland habitats outside of PCL in management area		
	Wetland extent & protection	[AK1.iii] Extent of wetland habitats legally protected outside of PCL in management area		

2. Maintain water regime and water quality

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
2. Maintain and enhance water regime and water quality to support aquatic values	Hydrological regime	[AK2.i] Frequency, duration, extent and timing of inundation for different wetlands, lakes and lagoons	OM2 - Hydrological monitoring / modelling	Continual / Monthly
	Sedimentation	[AK2.ii] Sediment deposition rates at key sites	OM3 - Sediment accumulation	Annual
	Water chemistry	[AK2.iii] Sediment load of tributary drains/creeks	OM4 - Water quality monitoring	Continual / Event
	Water chemistry	[AK2.iv] Water properties at key sites - select from nutrients, light, DO, pH, salinity, pollutants		
	Soil status	[AK2.v] Soil N/P levels	OM6 - Permanent habitat monitoring plots	5 yr (general); Annual (restoration)
	Soil status	[AK2.vi] Soil pH		
	Biological water quality metrics	[AK2.vii] Biotic indices of water quality at key sites - select from TLI, MCI, Periphyton (rivers)	OM5 - Aquatic index (combined metrics)	Varies (min. 1 yr - 5yr max)

3. Protect and restore wetland habitat

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
3. Protect and restore habitat	Indigenous habitat extent	[AK3.i] Extent of indigenous habitats on PCL in management area	OM1 - Wetland mapping/ground-truthing	5 yr
	Indigenous habitat extent	[AK3.ii] Extent of indigenous habitats outside of PCL in management area		
	Ecosystem composition & occupancy	[AK3.iii] Biotic indices of water quality at key sites - select from LakeSPI, Fish IBI	OM5 - Aquatic index (combined metrics)	Varies (min. 1 yr - 5yr max)
	Ecosystem composition & occupancy	[AK3.iv] Abundance of indicator species/plant functional types across height classes	OM6 - Permanent habitat condition monitoring plots	5 yr (general); Annual (restoration)
	Ecosystem composition & occupancy	[AK3.v] Proportion of sites with expected plant functional types (PFTs)		
	Indigenous dominance	[AK3.vi] Ratio of indigenous to exotic plant species (richness) in each habitat type		
	Indigenous dominance	[AK3.vii] Ratio of indigenous to exotic plant species (abundance) in each habitat type		
	Soil decomposition	[AK3.viii] Peat formation		
	Fire impact	[AK3.ix] Number and extent of wild fires	OM7 - Calculate area burnt	Event
	Environmental weed /pest dominance	[AK3.x] Distribution and abundance of weed species considered a threat	OM8 - Distribution / abundance weeds	Varies (min. 1 yr - 5yr max)
	Environmental weed /pest dominance	[AK3.xi] Distribution and abundance of pest species considered a threat (grazers)	OM9 - Distribution / abundance pests (grazers)	Annual
	New weed incursions	[AK3.xii] Number of new incursions of environmental weeds	OM8 - Distribution / abundance weeds	Incidental

4. Maintain and enhance species diversity

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
4. Maintain and enhance indigenous species diversity, including threatened species	Ecosystem composition & occupancy	[AK4.i] Species diversity in target local indicator guilds	OM10 - Species diversity and occupancy.	Annual
	Ecosystem composition & occupancy	[AK4.ii] Proportion of sites with expected indicator guilds		
	Indigenous dominance	[AK4.iii] Ratio of indigenous to exotic species within representative indicator guilds		
	Ecosystem composition & occupancy	[AK4.iv] Counts or indices of abundance of individuals of target indicator species	OM11 - Indicator species abundance.	Seasonal / Annual
	Threatened species status	[AK4.v] Number of nationally threatened species that rely on this site for long term recovery (>1% of population)		2 yr
	Threatened species status	[AK4.vi] Population dynamics of selected threatened species both under management and not under management	OM12 - Indicator species population dynamics.	Seasonal / Annual
	Environmental weed /pest dominance	[AK4.vii] Distribution / abundance of predators considered a threat	OM13 - Targeted predator monitoring (mammal/fish/birds)	Seasonal / Annual

COMMUNITY

5. Conserve cultural and historic sites

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
5. Conserve and interpret historic and cultural values	Historic / cultural site protection	[AK5.i] Level of protection of historic and cultural sites	OM14 - Inventory historic / cultural sites	5 yr
	Historic / cultural site status	[AK5.ii] Proportion of actively conserved sites with maintained / improved condition		Annual
	Historic / cultural site status	[AK5.iii] Proportion of not actively conserved sites with maintained condition		5 yr
	Historic / cultural site awareness	[AK5.iv] Visitor awareness of significant historic and cultural sites	OM19 - Survey visitor response to site visits and interpretation.	Site dependent
	Protection of iwi cultural values	[AK5.v] Identified iwi cultural values adequately protected, restored, or enhanced	OM16 - Qualitative assessment of cultural values and partnerships with iwi	Annual

6. Promote sustainable land use

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
6. Achieve sustainable land use	Concession impacts	[AK6.i] Concessions impact on conservation land	OM15 - Evaluate impact of concession activity on conservation land	Annual
	Catchment land use	[AK6.ii] Water quality on private land	OM4 - Water quality monitoring	Bimonthly
	Catchment land use	[AK6.iii] Indigenous habitat on private land	OM1 - Wetland mapping/ground-truthing	5 yr
	Catchment land use	[AK6.iv] Private land protected by covenants		
	Cultural harvest (iwi)	[AK6.v] Cultural harvest on conservation land	OM17 - Consultation with iwi	Annual

7. Improve recreation and visitor facilities

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
7. Provide facilities and opportunities for the public to visit the site and increase awareness	Recreational use	[AK7.i] Visitor numbers	OM18 - Visitor use monitoring	Site dependent
	Recreational use	[AK7.ii] Visitor satisfaction	OM19 - Survey visitor response to site visits and interpretation.	Site dependent
	Recreational use	[AK7.iii] Game bird hunting and fishing use	OM18 - Visitor use monitoring	5yr
	Recreational impacts	[AK7.iv] Impacts on habitat and native species from recreation activities	OM20 - Evaluate impact of recreation activity	Annual
	Visitor awareness & appreciation	[AK7.v] Visitor awareness and appreciation of wetland values	OM19 - Survey visitor response to site visits and interpretation.	Site dependent

8. Maximise community involvement and awareness

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
8. Maximise community awareness, appreciation and involvement in the project	Community and stakeholder awareness & appreciation	[AK8.i] Community and stakeholder awareness and appreciation of wetlands	OM21 - Survey of local community, iwi and stakeholder awareness and participation	Site dependent
	Community and stakeholder awareness & appreciation	[AK8.i] Community and stakeholder awareness and appreciation of the site		Site dependent
	Community and stakeholder awareness & appreciation	[AK8.ii] Level of external interest (website hits)	OM22 - Website hits database updated	Annual
	Iwi awareness & appreciation	[AK8.iii] Iwi awareness and appreciation of DOC programmes	OM17 - Consultation with iwi	2 yr
	Education group knowledge development	[AK8.iv] Education group knowledge of wetland valued and development of skills	OM23 - Survey of education clients skill retention	Site dependent
	Community and stakeholder involvement	[AK8.v] Level of engagement of partners and stakeholders with conservation at the site	OM24 - Summary of stakeholder engagement	Annual
	Iwi involvement	[AK8.vi] Level of participation of tangata whenua with conservation	OM17 - Consultation with iwi	Annual
	Community and stakeholder involvement	[AK8.vii] Volunteer contribution to project	OM25: Database of volunteer participation	Annual

LEARNING

9. Undertake research to inform wetland management

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
9. Undertake research to inform wetland management	Research and development uptake at AK sites	[AK9.i] Use of research findings to improve wetland management at Arawai Kākāriki sites	OM26 - Site managers to evaluate report usefulness	2 yr
	Research and development uptake at non-AK sites	[AK9.ii] Use of research findings to improve wetland management at other (non AK) sites	OM27 - Survey of wetland managers	5 yr

10. Develop best practice monitoring tools

AK NATIONAL OBJECTIVES	AK Indicator	AK Measure	How changes monitored	When
10. Develop best-practice wetland restoration methods	Best practice monitoring methods	[AK10.i] Number of new projects/ stakeholders using monitoring methods	OM27 - Survey of wetland managers	5 yr
	Best practice management methods	[AK10.ii] Number of new projects/ stakeholders using management methods/guidelines		

