Conservation strategy for New Zealand braided rivers: biodiversity values, issues and priority actions

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1 Summary

Braided rivers in New Zealand support unique communities of plants and animals and many threatened species. However, these communities are threatened by predation, weed invasion, water abstraction, dams and human activities on rivers. In recent years, public awareness of the natural values of braided rivers and threats to these values has increased. The number of initiatives to undertake conservation work within braided rivers has likewise increased. At the same time, greater demands are being placed on braided rivers, particularly as sources of water for irrigation and hydro development, but also for gravel extraction and recreational purposes such as jet-boating, four-wheel driving, and fishing.

Our vision is that New Zealanders will value and enjoy braided river ecosystems as a unique and integral part of their natural heritage. Stakeholders will support ongoing, sustainable local conservation programmes, and these will be demonstrably successful in maintaining native biodiversity of braided rivers. We emphasise ecosystem and multi-species approaches with emphasis on conserving indigenous species that specifically depend on braided rivers (including a range of threatened species).

There is a clear need to improve conservation outcomes for braided river ecosystems and species through the development of more effective management tools. This strategy aims to assist this process by providing guidance on current 'good practice' for managing biodiversity on braided rivers, priorities for management and future research, and by promoting co-operation among a range of stakeholders (including all levels of government, institutions, iwi, community groups, and local people and businesses) to conserve braided river ecosystems and species.

This strategy:

1. Describes our vision for the conservation of biodiversity on braided rivers.

2. Provides an overview of braided rivers ecosystems and the factors that influence them, in the context of conservation of indigenous biodiversity, and particularly threatened species.

3. Summarises current 'good practice' for managing biodiversity on braided rivers and uses a range of case studies as examples.

4. Identifies and prioritises specific management and future research actions in relation to the main factors that directly impact braided river ecosystems.

Vision

Our vision is that New Zealanders will value and enjoy braided river ecosystems as a unique and integral part of their natural heritage. Stakeholders will support ongoing, sustainable local conservation programmes, and these will be demonstrably successful in maintaining native biodiversity of braided rivers.

Threats

Natural braided river habitats have been reduced significantly. As well as being shaped by natural processes such as floods, braided river ecosystems have been, and continue to be, influenced by a number of human-mediated threats, in particular:

1. Predation of birds, lizards and invertebrates by introduced mammalian predators and native avian predators (whose numbers appear to have increased as a result of human induced land use changes);
2. Weed invasion by exotic plants;
3. Altered flow regimes and creation of impoundments (e.g. water abstraction for irrigation, hydroelectric power development);
4. Surrounding land use changes;
5. River control works (stop banks, channelisation);
6. Recreational activities (e.g. 4WD use, fishing, dogs).

Current 'good practice' for managing biodiversity on braided rivers

Management practices for maintaining and restoring biodiversity on braided rivers are still developing. However, current management practices focus on:

1. Maintaining and restoring populations of threatened species by controlling pest animals (using trapping and poisoning);
2. Restoring and enhancing terrestrial breeding habitats using weed control (using a combination of mechanical methods and chemical application);
3. Advocating for the protection of braided river habitat, biodiversity and threatened species through statutory processes (e.g. for maintaining flow regimes);
4. Minimising human disturbance;

5. Monitoring the responses of species to management and using this information to adapt and improve management.
6. Integrating management through good planning, community involvement and education.

Future research and management priorities

This strategy identifies the following research and management priorities that are needed to improve our understanding of threats to braided rivers and how to manage them more effectively:

1. **Predation**
   - Develop cost effective method of killing predators to levels sufficient to benefit indigenous fauna, and measure those benefits.
   - Test whether indirect methods such as habitat or land-use management can reduce predation risk.
   - Understand predator ecology to better inform predator management.
2. **Weeds**
   - Monitor and prevent invasion of terrestrial weeds into new area.
   - Clear and control introduced woody trees and shrubs, grasses, herbs and ground cover to zero density or low levels using a combination of mechanical methods using mechanical methods and chemical application at priority sites. For example, willows, broom, gorse, lupins, false tamarisk.
   - Improve understanding of optimal environmental weed control strategies in braided rivers, weed spread processes and seed dispersal pathways.
   - Protect sites without the aquatic weed Didymo using education of public and signs or by closing access through negotiation with landowners and stakeholders.
   - Minimise likelihood of vehicles spreading weeds through education.
3. **Altered flow regimes**
   - Improve understanding of how flow regimes influence indigenous plant and animal communities on braided rivers.
   - Reduce the impacts of water loss on threatened species through statutory and non-statutory means.
4. **Human disturbance**
   - Identify important nesting areas and discourage driving and other recreational activities in those areas.
   - Undertake research to better understand the impacts of recreational and commercial use on braided river communities.
5. **Surveys and monitoring**
   - Undertake baseline surveys of flora and fauna of braided rivers to improve knowledge of the significance of braided rivers.
   - Monitor the abundance and distribution of key species in order to describe population trends and to assess effects of management and human-induced changes to rivers.
   - Monitor the fate of breeding colonies identified during surveys.
6. **Fundamental research**

- Improve understanding of how braided river ecosystems function through fundamental research.

7. **Advocacy and education**
    - Develop relationships and general agreements among stakeholders to reduce impacts, and, where possible, to achieve conservation gains.
    - Provide advice, engage in consultation, and make submissions within the RMA context in relation to planning documents (policies, plans, and standards) and development proposals where these may affect braided river communities.
    - Identify communication and education opportunities and enhance public awareness of the values of braided river ecosystems and their key communities.
    - Provide a source of ongoing strategic guidance to those who affect or seek to manage braided river ecosystems.
    - Promote the development of tools and build the capacity of natural resource managers, decision makers and local stakeholders to manage braided river ecosystems for biodiversity.
8. **Prioritise sites**
    - Develop a robust system for prioritising sites for research and management actions.

2 Introduction

Braided rivers in New Zealand have long been recognised among ecologists as internationally rare river forms that support specialised assemblages of plant and animal communities (O'Donnell & Moore 1983; Gray & Harding 2007; Plate 1). In New Zealand, the high level of endemism in our plants and animals means the unique character of our braided river ecosystems is exceptional. These systems are under threat from multiple sources, including: introduced predators, weed invasion, water abstraction, dams, river protection works, and human disturbance. In recent years, public awareness of the natural value of braided rivers and associated threats they face has increased dramatically, particularly on the east coast of the South Island. At the same time, human demands on braided rivers have been increasing, particularly as sources of water for irrigation and hydro development, but also for development of arable land, gravel extraction, and recreational purposes such as jet-boating, four-wheel driving, and fishing.

In response, a number of conservation programmes have been initiated by community groups (e.g., the Ashley, Upper Rangitata, and Orari River landcare groups). Several are jointly managed with regional councils (e.g. Canterbury Water Management Strategy 'Immediate Steps' Braided River flagship programme, see **BOX 1**). Conservation programmes have also arisen as a result of mitigation for resource management related activities, such as private gravel extraction companies working with Environment Canterbury and the Department of Conservation to develop codes of practice to minimise impacts on breeding birds.

Insert Plate 1: Image of DOC's braided river poster showing the range of species that use the habitat (artwork by Sandra Parkkali)

The increased awareness, desire and resources to undertake conservation work on braided rivers presents good opportunities to achieve conservation gains. However, extensive research and management since the late 1970s has revealed that understanding and managing the problems facing braided river communities is complex and challenging (Keedwell & Maloney 2002; Cameron et al. 2005; O'Donnell & Hoare 2011; Woolmore 2011). There are no easy solutions and there is much we don't know about the composition and relationships among all the component parts within these ecosystems.

In our view, ongoing research and management must be well-directed and informed by the work undertaken to date. Braided river management is more likely to be beneficial and cost-effective, and less likely to cause unintended harm if those commissioning or undertaking the work understand the current state of knowledge of braided river values and the key threats and management issues facing them.

Insert Box 1: **Environment Canterbury's Immediate Steps programme** see rear of document

2.1 Purpose and scope of this strategy

The overall purpose of this strategy is to improve conservation outcomes for braided river ecosystems and species. This will be achieved by providing guidance on management and research priorities, by promoting active management initiatives, and by fostering co-operation and collaboration among a range of stakeholders including all levels of government, institutions, iwi, community groups, and local people and businesses. This strategy:

1. Describes our vision for the conservation of biodiversity on braided rivers (Section 2).
2. Provides an overview of braided river ecosystems and the factors that influence them in the context of indigenous biodiversity conservation, particularly threatened species (Section 3). This includes an assessment of the state of knowledge about natural values, the factors that influence them, and our current ability to manage them.
3. Summarises current 'good practice' for managing biodiversity on braided rivers (Section 4) and uses a range of case studies as examples.
4. Identifies and sets priorities for specific management and research actions in relation to the main factors that directly influence braided river ecosystems (Section 5).

This strategy is not a recreation guide, integrated management plan, specific planning resource, bibliography or review of everything that is known about biodiversity of braided rivers or the threatened species that occur on them, although it does provide references to key braided river information sources. Nor does it include individual species action plans or a plan of what can be done on specific river reaches (site specific management plans).

The strategy is intended to provide assistance in the future development of specific site or species management plans. It is also intended to complement the growing number of other documents focussed on braided river biodiversity management, such as those developed by regional councils and other organisations mentioned above. We seek to encourage a holistic approach to conservation of braided river biodiversity because management actions are highly likely to affect the various biotic and abiotic components of these systems in complex, interacting ways. Hence, we emphasise ecosystem and multi-species approaches with emphasis on conserving indigenous species that specifically depend on braided rivers for their survival.

2.2 Stakeholder interests in braided rivers

Braided river land tenure, statutory management responsibilities and recreational and community interests are complex. The Department of Conservation is responsible for conserving New Zealand's natural heritage with special responsibilities for indigenous wildlife, but only administers relatively small areas of braided river habitat within National Parks and reserves. The active beds of most braided rivers are crown land administered by the Commissioner of Crown Lands, and are managed by Land Information New Zealand (LINZ) on behalf of the commissioner. Among other roles, LINZ undertakes weed and animal pest control on crown land including braided rivers. Regional and district councils manage local reserves on riverbed lands (river protection reserves, regional parks) as well as having regulatory responsibilities for the use of water from rivers. Councils also have river control responsibilities (e.g. stop banks, flood management, land use, water quality, ecosystem health) and manage most gravel extraction. Many landowners occupy the recent floodplains of braided rivers and various organizations, community groups and individuals are also interested in braided rivers for water abstraction, hydroelectric power development, gravel extraction, recreation and conservation purposes. Some landowners have special land titles which confer limited property rights to adjoining riverbeds (ad medium filium or AMF rights).

Central and local government, when carrying out their riverbed and waterway regulatory and consenting functions, are required to take into account a range of legislative responsibilities, consider natural and cultural values and to consult widely. In the context of the Resource Management Act 1991 [RMA] they are required to recognise and provide for the protection of areas of significant vegetation and significant habitats of indigenous fauna from inappropriate subdivision, use and development (s 6(c)), and the relationship of Maori and their culture with taonga (6(e)). There is also a duty to have a particular regard to the intrinsic values of ecosystems (7(d)). As the Government implements its national biodiversity strategy local authorities are playing an active interest in safeguarding indigenous biodiversity, including those of braided rivers.

Management of the biodiversity of braided rivers happens within the context of these multiple interacting stakeholder relationships. Balancing the many demands made on rivers for human use against sustaining biodiversity values and ecosystem processes in braided rivers is challenging. In order to manage this tension, this strategy is intended to inform and assist those making key strategic decisions relating to braided rivers and their future management, including:

1. Senior managers in the Department of Conservation;
2. Resource Management Act (RMA)decision makers;
3. Businesses that want to use water or other resources from braided rivers;
4. Regional and District Councils with responsibilities for land and water management;
5. Iwi;
6. Universities and other research agencies;
7. Adjoining and nearby land owners and riverbed administrators;
8. The community of river users (e.g., zone committees (Canterbury), river care groups and other community based organisations involved in restoration activities).

2.3 Vision

Our vision is that New Zealanders will value and enjoy braided river ecosystems as a unique and integral part of their natural heritage. Stakeholders will support ongoing, sustainable local conservation programmes, and these will be demonstrably successful in maintaining native biodiversity of braided rivers.

3 Overview of braided river ecosystems and species

3.1 Braided rivers as ecosystems

Braided rivers of the type found in New Zealand are nationally and internationally rare river types with only the North American continent and parts of Asia having similar systems (O'Donnell & Moore 1983; Gray and Harding 2007). Braided rivers are highly unstable, being characterised by high spring-summer flows, frequent flooding and rapid substrate deposition that control the establishment and survival of plants across extensive floodplains (sometimes many kilometres wide) (Plate 2). Floodplains develop mosaics of different aged vegetation, spring fed tributaries and marginal wetlands, which are progressively reworked by active channels, forming new networks of bare shingle bars, sparsely vegetated recent flood channels and flowing braids (Miall 1977; Gray & Harding 2007).They are characterised by numerous islands and multiple and constantly changing channels of different sizes that change their location and characteristics constantly because of the variable flows. Nor are river channels uniform, with their flows, depths and velocities changing constantly, leading to an increased diversity of aquatic habitat types and invertebrate species (Gray et al. 2006).

In New Zealand, braided rivers are recognised as naturally rare ecosystems (Williams et al. 2007) and there are at least 312 rivers with braided ecosystems on at least some of their sections. While these rivers can be found through much of the country, most are in the South Island (Department of Conservation Rare Ecosystems Database; D. Brown pers. comm.). Collectively, areas of braided river cover > 250 000 ha in New Zealand (Table 1). The majority of braided rivers are found in the South Island, particularly Canterbury (64%), as well as the West Coast (15%), Marlborough (8%), Southland (4%) and Otago (7%) (Table 1). The remainder are in the North Island, particularly small rivers in the Manawatu and Hawkes Bay regions (Table 1; Wilson 2001).

Insert Plate 2: Image of braided river habitat

3.2 Natural values of braided rivers

Braided rivers support a diverse range of indigenous wetland birds, freshwater fish, bats, lizards, invertebrates and plants that are either unique to braided rivers, depend on them for a critical part of their life history; Table 2) or form community assemblages which are best represented in braided rivers.

Braided rivers provide habitat for over 80 bird species, some of which are threatened (e.g., black stilt, black-fronted tern, black-billed gull, wrybill plover, banded dotterel) (Plate 3, Table

2). About 20 wetland bird species are characteristic of braided rivers and are found widely on them (O'Donnell & Moore 1983). These birds have specialised adaptations for living on rivers, including specialised morphological features, foraging behaviours, breeding behaviours and migration patterns (O'Donnell & Moore 1983; Robertson et al. 1983; Pierce 1979, Lalas 1977; Hughey 1985; O'Donnell 2000a, 2004). Many birds and some fish are migratory, not spending their whole lives on braided rivers.

The occurrence of indigenous freshwater fish on braided rivers is also relatively well known, including the distribution of 15 threatened species (Plate 3, Table 2; Allibone et al. 2010), although new species and genetic lineages continue to be described (e.g., Waters & Wallis 2001; Waters & Craw 2008).

Knowledge of indigenous plants, bats, reptiles and invertebrates that use braided rivers is less well known (Plate 3), largely because there have been few comprehensive studies (but see O'Donnell 2000b; Woolmore 2011). New studies of these animals and plants in braided rivers invariably identify previously undescribed species, new locations of threatened species, new nationally important populations as well as contributing to a better understanding of community assemblages and relationships (e.g., braided river springs; Gray 2006). For example, a recent survey of the Tasman River recorded 20 new taxa (1 beetle, 18 flies, 1 bee). This result is not surprising when so little invertebrate research has been carried out in braided river ecosystems (S. Anderson pers. comm.).

Insert Plate 3: Collage of threatened species on braided rivers 1. Robust grasshopper (Photo: Warren Chin) + plants, birds, fish……etc.

3.3 Conservation Status of braided river flora and fauna

Many of the endemic plants and animals present in braided river ecosystems are declining and more than 50 species are classified as threatened or at risk (Table 2; Townsend et al. 2008). This number will be an underestimate given our poor knowledge of the population status and distribution of invertebrates, lizards and plants on rivers. Of particular concern are those species which are obligate or primary species that depend on braided rivers for their continued survival (e.g., robust grasshopper, upland longjaw galaxias (Waitaki), black stilt, wrybill, black-fronted tern, black-billed gull and banded dotterel; Table 2; Pierce 1979; Rebergen et al. 1998; Maloney 1999; O'Donnell 2000a; Keedwell et al. 2002; Sanders & Maloney 2002; McClellan 2009).

Some recent freshwater bird colonists appear to be stable or expanding in abundance and distribution, notably black-fronted dotterels and spur-winged plovers. Pied stilts have been a highly successful colonist since the mid-1800s (Pierce 1986), although are now considered to be declining (Miskelly *et al*. 2008).

3.4 Significance and protection of braided river ecosystems

Braided rivers are all considered ecologically significant to varying degrees, being either locally, regionally or nationally significant (O'Donnell & Moore 1983; O'Donnell 2000a). While the values of braided rivers are being increasingly recognised in statutory planning and regulatory processes, overall, braided river ecosystems are very poorly represented in protected natural areas. Few braided rivers have been formally reserved except where high altitude reaches are included in national parks (e.g., Tasman, Godley and Waimakariri Rivers) or local amenity reserves. In both cases protection of the rivers is piecemeal and ad hoc. The waters of some nationally significant rivers are protected by National Water Conservation Orders (e.g., Rakaia, Rangitata and Ahuriri Rivers), which place controls on the damming and abstraction of water whereas others have similar restrictions on water use placed on them via Environment Court planning decisions (e.g., Hurunui River).

3.5 Human-induced threats to braided river communities

Braided river ecosystems have been, and continue to be influenced by a number of human-mediated factors. In many cases these factors are key drivers of decline in threatened species populations and ecosystem integrity. In particular:

- Predation and disturbance by introduced mammalian predators and by native avian predators (numbers of the latter appear to be high as a result of human induced land use changes);
- Invasive terrestrial and aquatic plants, which threaten habitat integrity and food webs and displace species;
- Altered flow regimes and creation of impoundments which change flow patterns, and in some cases, destroy preferred habitats and threaten food availability;
- Water abstraction (affecting in stream habitat as well as groundwater, floodplain springs and wetlands);
- Eutrophication and changes to in stream water quality;
- River control works (stop banks, channelisation), which channel, stabilise and modify habitats;
- Recreational activities (e.g. 4WD use, fishing, dogs), which disturb or kill wildlife and reduce habitat quality;

The flow regime of a river has a strong direct influence on its physical structure (Mosley 2002, 2004a) and vegetation (native and introduced), which provide habitat for river birds, lizards and invertebrates. Flowing water transports sediment, and shapes channels (and islands). Floods are important in clearing vegetation and maintaining areas of bare or sparsely-vegetated substrate that provide habitat for characteristic early-succession native plant communities, and are preferred nesting habitats of many river birds (Robertson *et al*. 1986; O'Donnell 2000a, Hughey and Warren 1997).

Reductions in the magnitude or frequency of floods can reduce the weed-clearing effects of floods, exacerbating invasion by weeds that can out-compete native plants and reduce the amount of sparsely-vegetated substrates available for river birds.

As well as altered flood regimes, changes in 'normal' flow regimes may affect both terrestrial and aquatic braided river biota, although these effects are still poorly understood. If flows are reduced so much that channels dry up there will be an almost complete loss of water dependent fauna (e.g., Pukaki River, Maloney 1999). However, the effects of reductions in flow are less clear. O'Donnell and Hoare (2011) showed that declines in black-fronted tern numbers have been greatest on smaller rivers (less than 30 m3/s mean flow), suggesting that reductions in flow may be detrimental to this species, at least. Overall, the predictions about the impacts of low flows are complex and involve numerous interactions (Table 3).

Raising the levels of natural lakes or creating new lakes results in a direct loss of terrestrial habitat through inundation (e.g. upper Waitaki Lakes; Wilson 2001). Impoundments can also alter downstream flow regimes and interrupt sediment transport, resulting a in a range of complex interacting effects. Controlling waterways with dams can result in flooding of bird nesting sites by untimely discharges and ameliorate natural floods thereby exacerbating weed invasions (e.g. Waitaki Dams). Conversely, ameliorating flood events during nesting may improve breeding success for some species.

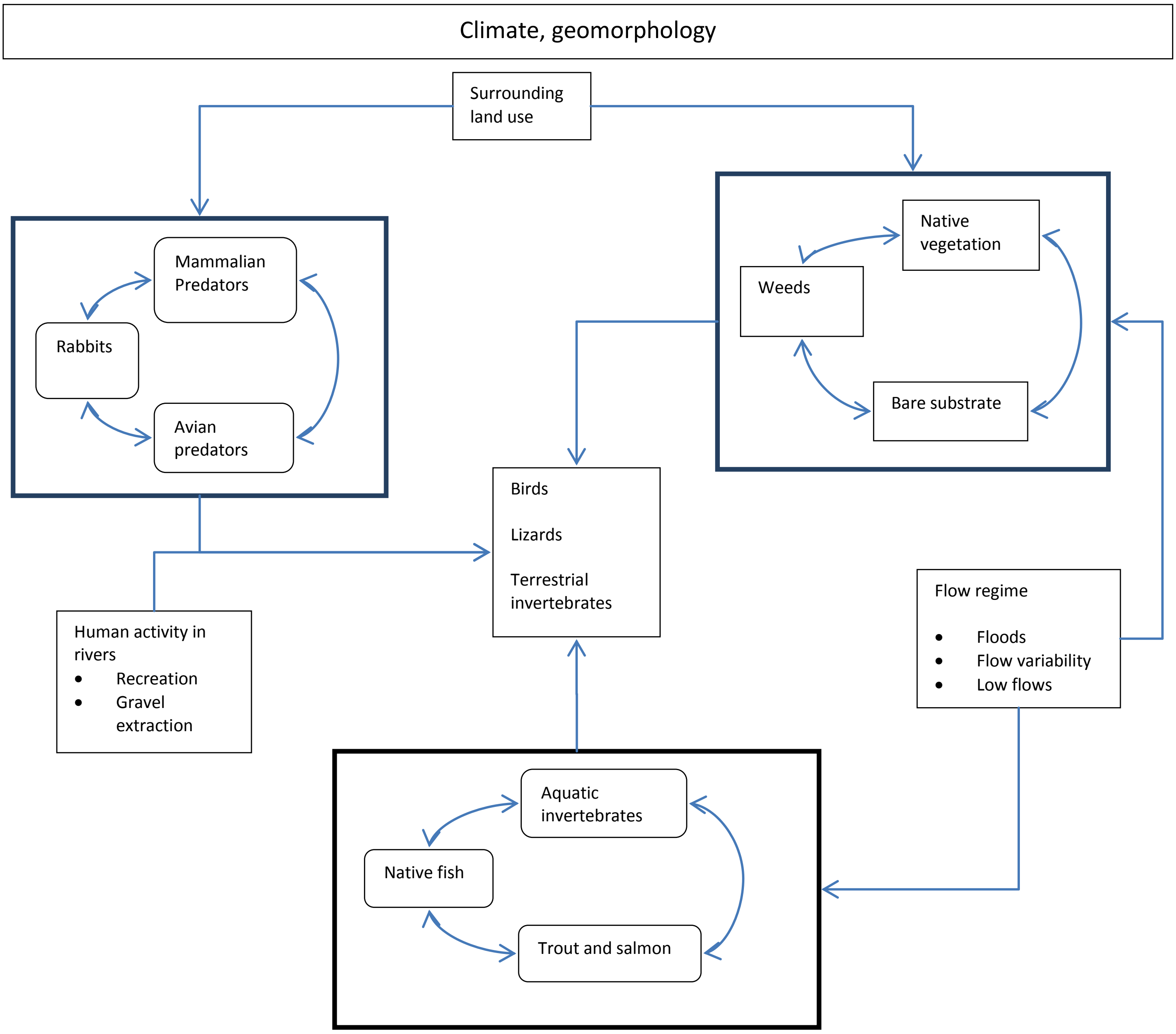
Structural modifications of riverbeds (e.g., stop banking, gravel extraction) can alter the quantity and biological diversity of braided river habitats. Construction of river protection works and encroachment by associated introduced vegetation can constrain a floodplain to its actively flowing channels, effectively displacing these other natural features and contributing to changes in river geomorphology such as channelisation or reduction in the number of river braids.   These types of structural works can have large scale and possibly irreversible impacts.

Wetlands, springs and advanced successional surfaces are important repositories of biological diversity in braided river floodplains and these features often lie outside the active channels in a riverbed. They are also vulnerable to activities which affect groundwater flows (eg water abstraction, drainage), surface hydrology (e.g., compaction) and water quality (elevated nutrient or pollutant concentrations).

In addition, a range of anthropogenic factors away from braided rivers, either in the surrounding catchment (land use changes and encroachment in to river floodplains) or at wintering sites (for migratory species) can impact on braided river species. In addition, rivers and human settlements are often in close proximity, creating a plethora of disturbance-related threats.

These factors interact in complex ways (Figure 1). Although their effects are generally adverse, some of these factors can also have positive effects on some components of braided river ecosystems. For example, hydroelectric impoundments can reduce the frequency and magnitude of floods, resulting in lower losses of nests to floods, but greater invasion by exotic weeds and loss of ecosystem components through inundation. Such complexities need to be taken into account in managing braided rivers.

Figure 1. Simplified conceptual model of major ecological components and processes of braided river ecosystems.



4 Current 'good practice' for managing threats to braided river biodiversity

4.1 Managing predation

Strong evidence indicates that predation by introduced mammals and native avian predators is one of the most important threats to the viability of bird populations that live on braided rivers (e.g., Hay 1984; Pierce 1986, 1987; Rebergen et al. 1998; Sanders & Maloney 1999; Keedwell & Maloney 2002; Steffens et a. 2012; Plate 4). Studies to date demonstrate that the most important predators are cats, stoats, ferrets, hedgehogs, harriers and southern black-backed gulls, although the relative impacts of these and other predator species are not well-understood. However, it is clear that the relative impacts vary from river to river, and probably change over time. Lizards and terrestrial invertebrates are also likely to be adversely affected by predation (Reardon et al. 2012), although this is less well understood.

Insert Plate 4: Examples of predation of threatened bird species including A. predation of adult wrybill by feral cats and banded dotterel eggs by hedgehog (Photos: Peter Langlands) and black-fronted terns preyed on by a feral cat (Photo: Colin O'Donnell).

Many trapping and poisoning operations have been undertaken over the past 30 years with the aim of protecting river birds but only three of these have yielded clear benefits for river birds (O'Donnell & Hoare 2011; Cruz et al. 2013; Monks et al. 2013). Most predator control programmes for braided river birds have had equivocal results or have failed to demonstrate benefits, largely because they were not implemented at a landscape scale at sufficient intensity and failed to target the full range of potential predators responsible for wildlife deaths.

In the absence of more detailed knowledge, predator management needs to:

1. Target the entire predator guild mentioned above, including native avian predators.
2. Be implemented at an extensive landscape scale (thousands of hectares and preferably catchments with barriers to reinvasion, see **Box 2**)
3. Use all available predator control methods (different trap types for cats, mustelids, possums; shooting, appropriate toxins), following the model provided by the Tasman River predator control programme (see **Box 2**);
4. Apply traps devices at high densities to maximise the chances of lowering predator densities (i.e, start more intensively and potentially reduce intensity over time if justified);
5. Use very high densities of capture devices if small high value sites need protection, (e.g., Ohau River black-fronted tern protection, see **Box 3**).
6. Monitor predator capture rates regularly and monitor outcomes for species so that management can be adapted and improved;
7. Consider indirect ways of controlling predators by:

a. reducing other prey (e.g., associated rabbit populations, which are known to enhance predator numbers; although sporadic control can result in increased predation through 'prey-switching'; Norbury & McGlinchy 1996; Norbury & Hayward 2007)

b. Maintaining safe islands with high flows around them to limit predator access. We now have good evidence that islands are safer, on average, from mammalian predators than mainland sites, almost certainly because flow limits the ability of some predators to reach islands (i.e. the 'moat effect'; Hay 1984; Rebergen et al*.* 1998; Boffa Miskell 2007; McClellan 2009; Sanders 2009).

8. Note that predator control is expensive, and any benefits will cease soon after control stops because predators rapidly reinvade and/or increase in numbers.

However, actions that aim to benefit native fauna by killing predators should be viewed as management experiments and should be carefully monitored to evaluate their effectiveness. Small-scale, short-term control has not worked in the past, and resources should not be directed to this.

Although the size of the 'moat effect' is weak and highly variable (mammalian predation is still very common on river islands; G. Pickerell pers. comm.), maintaining or creating suitable island habitat (e.g., Jobin & Picman 1997; Nordstrom & Korpimaki 2004; Zoellick et al. 2004) may help improve breeding success of fauna, especially if combined with other predator management. It may also benefit other fauna.

Insert Box 2: **Predator control at a landscape scale in the Tasman River Valley** see rear of document

Insert Box 3: **Intensive predator control around black-fronted tern colonies** see rear of document

4.2 Managing weeds

Introduced weeds (particularly willows *Salix fragilis, S. cinerea*, broom *Cytisus scoparius*, yellow tree lupin *Lupinus arboreus*, Russell lupin *L. polyphyllus* and gorse *Ulex europaeus*) can be highly invasive in river systems with long lasting, possibly irreversible impacts on river braid geomorphology, ecosystem process and competitive displacement of many indigenous plants and animals. In particular, weed invasions are a serious threat to habitats of braided river birds (e.g., Stead 1932; O'Donnell & Moore 1983; O'Donnell 1992; Maloney 1993a; Brown 1999a, 1999b).

Exotic weeds cover areas of riverbed that were formerly bare shingle or covered in low-stature indigenous plants (e.g., *Raoulia* spp. *Muehlenbeckia axillaris*, *Epilobium* spp.) (Plate 5).

Areas clear of emergent plants are key breeding and foraging habitats for many birds. By mapping the extent of weeds from aerial photographs it is possible to gain an idea of the large amount of habitat lost to specialist river species. Encroachment reaches up to 75% in some rivers (Wilson 2001) and as such reflects the extent of habitat loss.

Insert Plate 5: The effects of weed encroachment can be dramatic A. healthy natural herb field on the Godley River (Photo: Chris Woolmore) compared to B. Complete loss of open bird nesting habitat through weed encroachment on the Ashburton River (Photo: Colin O'Donnell)

Apart from these direct impacts, exotic weeds are thought to stabilise shingle islands, deepen river channels, decrease the availability of shallow water foraging areas, and increase risk of predation (by providing predator habitat), although further work is needed to test these ideas (e.g., O'Donnell & Moore 1983; Robertson *et al.* 1983; Balneaves & Hughey 1990; O'Donnell 1992; Pascoe 1995; Hughey & Warren 1997; Rebergen et al. 1998).

In braided rivers, weed diversity and abundance is generally lower in river headwaters and highest in lower reaches closer to the sea (Williams & Wiser 2004; Woolmore 2011). These distributions are generally correlated with the amount of human occupation and related activities at sites ((Sullivan et al. 2004, 2009). There is also evidence of correlations between riverbed weed distributions and climatic gradients eg water balance ratio, water deficits, winter solar radiation, minimum annual temperature (Williams &Wiser 2004; Woolmore 2011).

Not all invasive weeds are terrestrial. The invasive algae *Didymosphenia* ('didymo') has become widely spread throughout braided rivers (Plate 6). Research on didymo has focussed on in-stream effects and has shown shifts in invertebrate community composition and a reduction in drift of certain invertebrate species, both of which potentially affect food supplies for fish and birds (Arscott et al. 2009; Whitton et al. 2009).

Insert Plate 6: The invasive weed Didymo encroaching in stream habitat on the Mararoa River (Photo: Colin O'Donnell)

Specific best management practice for weed control operations includes:

- Giving priority to preventing or removing new incursions of weed species known to have large impacts in braided river systems.
- Targeting weed species with highly invasive characteristics (eg high numbers of seed produced, seed bank persistence, very effective seed dispersal mechanisms, ability to reproduce from fragments) and which have serious impacts on braided

river ecosystem function eg disruption of successional pathways, changes to geomorphic process, or pertubators of key ecosystem components.

- Making weed control decisions based on informed assessments of the range of natural values being protected, appropriate target weeds, the impact of target weeds on values to be protected, the impacts of proposed control methods on these values, achievability of controlling target weeds and resources required to achieve desired outcomes.

- Long term commitment of resources where necessary. Many riverbed weeds (e.g., gorse, broom, tree lupin, Russell lupin) produce large quantities of seed each year which can last decades in soil seed banks. A one year lapse in control can negate many previous years of investment.

- Timing control of weeds with persistent soil seed banks to prevent them reaching seeding maturity. With these types of plants failure to achieve zero density of seeding plants will result in little long term reduction in infestations over time.

- Making use of control buffers and removal of seed sources where possible to prevent or minimise reinvasion of areas under management.

- If using herbicides, selection of products and formulations that are least persistent and have lowest impacts in aquatic environments. For example, Glyphosate products are widely recognised as suitable for use near waterways but there is a large variation in risk to aquatic systems between brands due to different additives in each formulation.

The tools available for weed control include:

- Hand weeding (hand pulling, hand tools, scrub bars) – effective for many weeds but most efficient on small scale control operations. Hand tools are required for deeply rooted plants but can be combined with chemical methods (e.g., cut and paint stump. See Eglinton Valley black-fronted tern colonies – **Box 4**).

- Mechanical methods (heavy earthmoving machinery) – can be effective for large scale control operations, especially dense infestations. Need to be aware of seed bank disturbance, dispersal of vegetative propagules (e.g., crack willow) and impacts to other site values. Can be combined with chemical control such as removal of standing dead plant material following herbicide application. See experimental clearing of islands with bulldozers on the Waitaki River – **Box 5**.

- Hand held herbicide use (knapsack, low pressure basal stem treatment) – Effective for low density infestations, low volume delivery allows precise delivery of herbicide to individual plants, ability to minimise non target impacts in desirable vegetation.

- Mechanised use of herbicides (vehicle mounted handgun, mist blowers, vehicle mounted boom) – Effective on high density or dense patches of target weeds, high volume delivery, less targeted than hand held methods, requires adequate access for vehicle mounted methods.

- Aerial use of herbicides (boom, handheld wand) – Effective over large treatment areas, boom spraying of dense infestations, spot spraying of large target plants over wide areas, higher risk of non target impacts.

- Regional pest management strategies can play an important role in coordinating and giving effect to control programmes, especially when seeking to restrict the further spread of problem weeds.

- Advocacy and development of "codes of practice" can play an important role in reducing the spread of invasive weeds (e.g., requiring machinery to be cleaned, and certified as clean, before commencing work at new sites, or minimising likelihood of recreational vehicles spreading weeds by educating river users).

Clearance of weeds to benefit riverbed fauna can also be integrated into other management activities. If managed carefully, gravel extraction operations can be used to clear infested riverbeds and create suitable habitat for wading birds (islands and shallow, sheltered edges for foraging). However, if done in the breeding season at breeding sites or if substrate removal adversely affects downstream river geomorphology this could be catastrophic. But if done appropriately, once breeding has finished, using wetland enhancement techniques, and with a long enough lead in time for invertebrate communities to re-establish (before the following breeding season), there could be mutual benefits. Various mechanical weed clearance operations have demonstrated that birds (and their aquatic prey) colonise newly-cleared sites immediately (Maloney *et al.* 1999; Sanders and Maloney 2000; Boffa Miskell 2009).

Insert Box 4: **Hand pulling of weeds on islands in the Eglinton River for black-fronted terns** see rear of document

Insert Box 5: **Mechanical clearing of large islands of weeds on the Waitaki River** see rear of document

4.3 Advocating for the protection of braided river ecosystems and biodiversity through statutory means

Changes to a range of habitat-related factors sometimes threaten braided river species. These can arise from changes to natural flows, raising or altering the variation in levels of natural lakes, damming rivers to create new impoundments, altering the physical structure of ecosystems (e.g., gravel extraction), invasion by introduced weeds, and disturbance as a result of human activities. Advocacy using legal statutory and other indirect can be useful tools for maintaining, enhancing or protecting river biodiversity and habitats (e.g. **Box 6**).

Insert Box 6: **Setting flow regimes** see rear of document

The following discussion focuses on consultation and resource hearings under the RMA because the main developments that affect rivers are heard in this context, in the form of resource consent hearings (at Council, Environment Court, or Board of Inquiry), District or Regional Plan hearings, or Water Conservation Order Tribunals. Other contexts include submissions on National Policy Statements or National Environmental Standards (see Brake and Peart 2013 for a detailed discussion of relevant legislation and planning processes).

Generally, opportunities to influence proposals occur in two phases: first, during consultation and second at hearings (but also thirdly during implementation). In our experience, actual or potential concerns are more likely to be given due consideration during consultation and hearings when the following good advocacy practices are applied:

- Engage early. Proponents of significant projects typically want to resolve as many issues as possible as early as possible, and actively seek to engage with stakeholders. The earlier that advocates are involved the better chance that require issues can be identified and addressed or resolved. For example, if specific surveys may require lead in time, or high value contentious sites may be able to be avoided at the design stage.
- Build and maintain positive relationship with key individuals (applicants, council staff). Positive respectful engagement is more likely to achieve good outcomes than an adversarial approach.
- Consider asking for assistance. Addressing major consent applications can be very time consuming and expensive. Assistance with costs/resources/expertise may be available from Councils, the applicant, or conservation organisations such as Forest and Bird or the Environmental Defence Society.
- Request early on-site meetings with proponents and their advisors (and potentially key council and/or DOC staff). These can by highly useful; understanding of the proposals and the individuals involved is most effectively gained on site, and written material will make more sense if the site has been visited. This also helps build relationships with key players.

- Read and understand the relevant material – ask for assistance /clarification if necessary. As with on-site meetings, presentations by technical experts followed by questions and answer sessions can be very helpful in identifying and resolving issues early in the process. Consider asking proponents to organise such presentations.

- Understand that project development is an iterative process – engaging early creates scope for positive influence, but requires a recognition that, at the early stage of proposals, investigations and design may be incomplete, and will likely change (potentially for the better as a result of stakeholder input).

- Identify the key issues and desired *outcomes* as specifically as possible (and avoid sweeping generalisations). It is helpful to suggest solutions or alternatives to achieve those outcomes. The focus should be on outcomes rather than means. For example, if weed invasion of bird habitat is a concern, rather than a general request for weed control, it may be more useful to advocate for a flow regime and/or weed control that will achieve the outcome of maintaining a specified quantity and quality of habitat, in specific reaches of the river.

- Play by the rules. Obtain guidance on how to make submissions from council websites or directly from council staff, and ensure that your submission complies.

- Acknowledge uncertainty. Our understanding of braided river ecosystems is limited and it is important that uncertainties are acknowledged. For example, optimal flows for various terrestrial flora and fauna of rivers are not well-understood.

- Ensure that submissions are, as far as possible, evidence-based, rather than mere assertions. Where resources are limited, and strong evidence based submission cannot be made, is can be reasonable and helpful to ask specific key questions, as addressed in the following point.

- Make use of technical experts. Technical experts have an over-riding duty in law to provide impartial advice to decision-makers (hearing committees or Environment Court). Ideally, issues are resolved during consultation, but if not, it is helpful during the hearing process if specific questions are put to applicants (in submission or at hearings). This places the onus on applicants to address these issues, typically through their technical advisors.

4.4 Minimising human disturbance

Most riverbed birds have well-camouflaged nests that are difficult to see and are therefore highly vulnerable to being trampled or run over by vehicles. Physical disturbance from vehicles driving on riverbeds and on the shores of coastal lagoons is a major concern (O'Donnell & Moore 1983; Robertson et al. 1983). Four-wheel drivers often use braided rivers for recreation. When this coincides with the breeding season of indigenous birds there can be direct impacts from vehicles crushing nests. Gravel extraction is a common commercial activity on riverbeds. If extraction occurs during the breeding season of terrestrial birds, nests can be disturbed or crushed and in-stream biodiversity may be affected by machinery crossing channels or diverting their flows.

Vehicles can also damage fragile plant communities, such as cushion plants, and, in particular, wetland turf communities that are often found within and adjacent to braided river beds (PLATE 7). Impacts on lizards and terrestrial invertebrates are unknown, but it seems likely that adverse effects on plant communities will also adversely affect associated fauna.

Insert Plate 7: Vehicle damage to wetland habitats (Photo:)

In addition to these direct impacts, increasing levels of disturbance on rivers from humans and their pets, on vehicles or foot, and jet boats is a concern if they cause birds to vacate feeding areas or abandon nests. Wave action from boats can cause low-lying nests to be flooded. Direct disturbance by humans or their pets is also a concern. This can be in the form of recreationalists walking through nesting colonies and causing birds to abandon nests, collection of eggs, vandalism, and inadvertent deaths caused from fishing and shooting near to nesting birds. Even where birds do not abandon nests, nesting success can be significantly lower because they leave nests for longer than normal. As a result predation rates and egg mortality from cooling or overheating increase. Similarly, chicks are probably more susceptible to predation and weather (heat, cold, rain) when separated from their parents.

Current management methods include:

- Fencing or other physical barriers (e.g. rocks) to exclude vehicles.
- Providing specific, clearly identified parking areas with signs to educate river users about flora and fauna – in particular, educate users to recognise and move away from disturbed breeding birds (many outdoor enthusiasts are receptive to understanding the animals around them).
- Identifying (and/or creating) alternative areas where recreational activities will have minimal impact.
- Marking a clear track and fording locations to limit impacts where river crossings by vehicles are necessary.
- Education through articles (e.g. in fishing and 4WD magazines and newspaper columns), and non-threatening direct contact with river users in the field.

- Development of the “Braided River Care Code” and widespread circulation to known riverbed users.
- Working with commercial operators on rivers such as jet boat operators and gravel extraction companies. Setting conditions on gravel extraction consents such pre-extraction biodiversity surveys, minimum distances between nests and extraction activities, rules about timing of extraction and zones of activity is now relatively common.

4.5 Monitoring the responses of species to management and using this information to adapt and improve management.

Distribution and relative abundance of freshwater fish, aquatic invertebrates and birds on most braided rivers is fairly well-described. In contrast, the distribution of lizards and plants on braided rivers is poorly-known (although these groups are well-described in general). Even less is known of the terrestrial invertebrate fauna of braided rivers, and it is likely that many new species remain to be discovered. Thus, there is a clear need for surveys to describe the flora and fauna of braided rivers.

There is also a need for ongoing monitoring in order to understand long term population trends and responses to both modifications and active conservation management. It is unrealistic to monitor all river species (although most birds can be monitored relatively easily) so efforts will need to focus on key species. Identifying which species to monitor is an important question.

With regard to birds, measuring the response to conservation management is essential for both helping to improve management in the future and to report on outcomes. Considerable information is available on the relative importance of braided rivers for different bird species from bird counts, although the data are piecemeal in time and space. Formal monitoring programmes need to be set up. Ongoing monitoring need not include all water bird sites, but should include a range of representative habitats of significance. Specific guilds, which are most vulnerable to habitat modification, could be monitored.

Strict standardisation of survey methods will be necessary for the development of monitoring techniques so that results can be compared over time. At least one census of all indigenous species should be undertaken along the lengths of all rivers (see O’Donnell & Moore 1983 for techniques for birds). The importance and value of sites vary seasonally: sites may only be used at a particular time of year (e.g., breeding, over-wintering, or a staging site for migration. Therefore, surveys should include bird counts in different seasons (e.g., spring, summer, autumn, winter). For sites that currently have no data, baseline surveys should be undertaken *before* evaluating potential impacts of future developments or control works.

Braided river birds, particularly colonial species appear to be highly mobile. Annual variability in counts of some species on single rivers suggests that they may use a network of rivers during their life cycles; perhaps moving among rivers as conditions vary over time. Thus, management or protection of single rivers may not secure a population long term. National population counts (e.g., black-billed gull) and compilation and analysis of existing datasets would assist in understanding trends. A recent analysis of all known survey data on black-fronted terns has provided the most comprehensive picture of the status of this species, and shed light on how river flow may affect population trends (O'Donnell & Hoare 2011).

The current best practice for monitoring include:

1. Walking index counts for braided river birds (**Box 7**).
2. Standardised sampling for aquatic invertebrates (River Macro-invertebrate sampling. At http://www.doc.govt.nz/publications/science-and-technical/doc-procedures-and-sops/biodiversity-inventory-and-monitoring/freshwater-ecology/; Start with "Introduction to macro invertebrate monitoring in freshwater ecosystems").
3. Standardised electric fishing sampling is available for single channel rivers (Joy et al. 2013), but these techniques have not been adapted fully for use on braided rivers.

Insert Box 7: **Monitoring braided river birds** see rear of document

4.6 Integrating management through good planning, partnerships, community involvement and education.

Effective management involves not only implementing the techniques described above, but doing so in a co-ordinated manner that involves as much of the community as possible. As mentioned above, braided rivers are used and managed by many different stakeholders, some of which have direct statutory responsibilities for management, others of which have direct interests as users. These various parties have the potential not only to adversely affect rivers but also to bring about beneficial results.

Communication, education and participation are all critical processes to increase awareness and can be used at all levels to achieve the objectives of this strategy. There is a need to continue to develop and provide the communication and education tools (skills, templates, materials etc.) to raise awareness of the importance of braided river ecosystems and their biodiversity so that people will participate in activities that contribute towards the conservation of braided river ecosystems that will benefit the community and contribute to sustainable development.

This need extends beyond the immediate bounds of braided rivers. Many native birds migrate from riverbed breeding grounds to local coastal sites, northern wintering grounds at harbours such as the Firth of Thames, Manukau Harbour, and even to sites in eastern Australia. There is a need to use a range of tools (e.g. RMA processes) for protection of estuarine habitats, and for input into developments (e.g. wind farms) that might intrude on migration routes or wintering grounds.

Practices that enhance outcomes of management include:

1. Identifying communication and education opportunities and enhance public awareness of the values of braided river ecosystems and their key species.
2. Involving all stakeholders in management planning and decisions, promoting coordination.
3. Setting up networks to enhance communication and information flow (e.g., Braid – Braided River Aid Network - **Box 8**).
4. Organise local community groups interested in restoring braided river ecosystems (e.g., Ashley-Rakahuri Rivercare Group – **Box 9**).
5. Developing specific partnerships (e.g., Project River Recovery, **Box 10**).
6. Providing sources of ongoing strategic guidance to those who affect or seek to manage braided river ecosystems. For example, the National Braided River Technical Advisory Group (TAG) currently provides support and strategic advice for management of braided river biodiversity. The TAG comprises a small group of experts (science, technical and operational capabilities and key stakeholders) with a national focus, and the ability to ask for additional expertise when considering traits and threats of individual species.
7. Fostering connection among site managers.
8. Undertaking specific management planning such as species recovery plans or strategies, to focus restoration efforts and objectives (e.g., kaki/black stilt recovery plan**– Box 11**).
9. Developing education opportunities wherever possible to help improve understanding of the significance and plight of biodiversity on braided rivers. Education can focus at multiple levels from posters and pamphlets (http://www.doc.govt.nz/publications/conservation/native-animals/birds/life-on-a-braided-river/) to teacher classroom resources (http://www.doc.govt.nz/getting-

involved/for-teachers/conservation-education-resources/river-life-braided-rivers-in-the-mackenzie-basin/).

10. Identifying opportunities to integrate management initiatives in braided rivers with research opportunities and coordinating these at a regional or national scale

Insert Boxes 8 – 11 **Advocacy etc examples** see rear of document

5 Priorities for future research

Despite there being a range of good practices available for conservation of braided river habitats and species, much knowledge is still required so that management practices can be improved, or in some cases developed. This section identifies and prioritises these over-arching 'high-level' management and research actions required that will contribute to significant improvements in understanding factors that influence braided river biodiversity and their effective management. The highest priority topics are summarised in **Box 12**.

Insert Box 12 Highest priority research needs see rear of document

5.1 Predator control

Given the profound effect of predation on native fauna, a very high priority for braided river conservation is to develop cost-effective and efficient strategies to maintain and restore populations of threatened species by reducing the impacts of predators on river birds, lizards and (probably) terrestrial invertebrates. Although we know how to kill the predators in question there have been few broad scale successes and these have benefited few species (Keedwell & Maloney 2002; O'Donnell & Hoare 2011; Cruz et al, in press). Required improvements revolve around increasing effectiveness of control to ensure enough predators are removed to provide sustained biodiversity benefits and that these benefits can be clearly demonstrated.

Problems with our current understanding include long timeframes needed to see results across a range of species, the large number of predator species, the large scale of the control required to protect species at the population level, and the reality that predator control methods employed only reduce predator numbers, and may not be impacting on rogue-type predators at sufficient levels.

Specific priorities are:

A. Develop cost effective methods of killing predators to levels sufficient to benefit native fauna, and measure those benefits

A range of methods need to be tested and new, more efficient and cost effective techniques need to be developed, For example:

1. Mustelid, cat, hedgehog, harrier and rat control methods using kill traps and a range of baits and lures.
2. Black-backed gull control to low levels using ground application of toxins (alphachloralose).
3. Utilising new technology such as self-resetting traps, new toxins and delivery methods (such as PAPP and the "spitfire" delivery system).

B. Test whether indirect methods such as habitat or land-use management can reduce predation risk

Alternative approaches to direct control of predators need to be investigated, particularly the idea that controlling populations of primary prey (primarily rabbits) could lead to greater suppression in predator numbers. Options include:

4. Sustained rabbit and hare control to low levels by ground hunting and ground application of toxic baits to reduce food supplies for predators.
5. Physical manipulation of islands and channels in rivers to maintain a protective moat around bird breeding sites (and potentially reduce flood-vulnerability)

C. Understand predator ecology to better inform predator management

Our ability of develop effective predator management strategies is limited by a limited understanding of predator ecology. There is a strong need to address fundamental ecological questions relating to predator behavioural ecology in landscape including how their numbers and their impacts vary in time and space. Understanding their ecology will give clues to help improve control techniques and efficiencies.

There is also a need to better quantify the relationship between various 'flow' parameters and risk of predation (e.g., width, depth, velocity, number of channels, turbulence, etc.) and how predation risk might vary through the breeding season. Key research questions are:

6. What is the relative importance of different predator species and predator guilds?
7. Which ecological factors drive variation in predator numbers and risk?
8. How does predation risk vary in space and time and what is the influence of predator dynamics in the adjacent catchments?

9. How are predation impacts affected by variation in flow regimes, weed encroachment and their interactions?

10. How do various predators use the environment, and how is their behaviour influenced by flow and weeds?

11. What is driving stoat irruptions in river headwaters (e.g., tussock seeding or beech masting)?

12. How important are the effects of interactions between causes of mortality (e.g., predation and flow or vegetation encroachment and nest flooding interactions).

13. What are the longer term impacts of predation on population viability both for individual populations and species as a whole? Good population models are needed so we know when we achieve predator control targets (i.e. threatened species recover).

5.2 Weeds

Whilst there is a need to improve understanding of how weeds affect river communities, this should not impede weed management; it is clear that weeds are detrimental, and well-established principles and methods of weed control can be employed to control weeds at many sites. However, sustaining resources to apply such techniques cost-effectively at a landscape scale and over decades is still challenging).

The potential effects of most herbicides have not been field tested, but many modern glyphosate based herbicides are considered to be of low toxicity provided they are used in accordance with label instructions. Priorities for weeds are:

A. Continue developing tools to improve monitoring and identification of harmful new weed invasions.

It is critically important to identify new incursions of weeds and prevent their spread before they become a major problem. This requires robust systems of monitoring and reporting by field staff, good spatial weed database, ongoing follow up by control agencies and legislative support of regulatory authorities.

B. Improve understanding of optimal environmental weed control strategies in braided rivers

Key research questions include:

1. How much weed control do we need to do before natural geomorphic processes sustain enough habitat? (see also flow related question in Section 5.3)

2. What is the optimal mix of human weed control and natural processes? (E.g. is it better in some cases to wait for a flood then maintain the cleared substrate until the next flood comes).
3. Are weeds in some rivers so bad that they can't be controlled cost-effectively? How to prioritise weed control?
4. How much weed control do we need to do (spatial and temporal scales) to increase breeding success of threatened species?
5. Are there more effective weed control methods available?
6. To what extent is habitat a limiting factor for threatened species?
7. How important are grasses and herbs as weeds?
8. How does weed invasion alter the community composition of terrestrial invertebrates and lizards?
9. How do weeds influence predation risk, e.g. by providing habitat or supporting prey such as rabbits?
10. What is the impact of didymo on food supplies of threatened species and can we manage it?
11. To what extent can we manipulate or create weed free habitat (e.g., island, clear shingle areas) and will threatened species use and continue to us those sites?

5.3 Altered flow regimes

Currently our understanding of the relationship between flow regimes and terrestrial biota is not sufficient to accurately assess the effects of altered flow regimes nor to prescribe optimal flow regimes. We can hypothesise about potential effects and their consequences on flora and fauna (e.g., Table 3), but data need to be collected to verify these hypotheses. This is a major limitation in a resource management context where questions, are being asked about setting minimum flows in regional plans, or assessments of projects that propose to abstract water from rivers. Thus the main recommendations here relate to improving understanding of these questions.

Flows influence the abundance and composition of aquatic invertebrate communities, which in turn influence food availability for freshwater fish, birds and other wildlife. It is common for the breeding densities of birds to be limited by resources such as food (Newton 2004), including the braided river species (Lalas 1977), although the extent to which New Zealand river fauna are limited by food is unknown.

While there is a reasonable knowledge of general foraging behaviours and diet of some braided river birds and fish, detailed knowledge of feeding habitat use patterns is essential to be able to make predictions about the potential impacts of modifying river flows. It is important to establish the importance of specific aquatic microhabitats for feeding and how flow modification influences food abundance and availability. The priority is to:

A. Improve understanding of how flow regimes influence indigenous plant and animal communities on braided rivers

Key research questions:

1. How important is variation in flows to sustaining habitat (substrates and vegetation) and what are optimal flow regimes for different species and rivers?
2. What flow regimes (size, spatial and temporal variation etc.) would sustain the habitats of the threatened plant and animal species?
3. What are the effects of altered flow regimes on weed encroachment?
4. What are the interactions and dependencies with weed control (Section 5.2 Weeds, above).

B. Develop accurate models and predictions about consequences of altering flow regimes on indigenous plant and animal communities on braided rivers

5.4 Human disturbance

The impacts of human disturbance in all its guises on river flora and fauna are difficult to measure and not well-understood. Specific research is needed to assess the impact of these factors on the ecology of braided river flora and fauna, and particularly on the long term viability of populations. Specific priorities are listed below, although these issues also need to be dealt with through education and advocacy as set out in Section 4.6. Priorities are to:

A. Identify important nesting areas and discourage driving and other recreational activities in those areas.

B. Undertake research to better understand the impacts of recreational use on braided river communities

Key questions are:

1. What are the combined impacts of recreation disturbance on the viability of populations of threatened species?

2. How do changes in flow regimes – particularly reduction in flow – affect recreational use of rivers, and how does this affect river birds? (E.g. do lower flows make river islands more accessible?)

3. Does education and advocacy result in changes in behaviour?

4. Buffer distances between gravel extraction and bird nesting sites are often specified in consents. Are these distances suitable?

5. Can the presence of humans confer benefits such as deterring predators?

6. How much do structures on rivers (e.g. ?) impact on food supplies (e.g., fish)?

5.5 Surveys and monitoring

Work needed to improve survey and monitoring includes the following priorities:

A. Undertake baseline surveys of flora and fauna of braided rivers to improve knowledge of the significance of braided rivers
Skills available to undertake surveys are limited, so development of training programmes for surveyors is essential.

B. Identify key species that should be monitored

C. Monitor the abundance and distribution of key species in order to describe population trends and to assess effects of management and human-induced changes to rivers

D. Develop standard methods for monitoring and surveying key components of braided river ecosystems. Particular gaps are:

1. Freshwater fish

2. Terrestrial invertebrates

5.6 Prioritise sites

There are over 300 rivers in New Zealand that are braided or contain braided sections (Appendix 1). These are distributed throughout much of New Zealand. Each braided river, while superficially similar to the other rivers in the region, is sufficiently distinctive in its habitat characteristics to provide for a distinctive assemblage of birds (O'Donnell & Moore 1983), and, probably, distinctive assemblages of other fauna and flora.

The habitat provided by braided rivers is used at different scales by different groups. With birds and migratory freshwater fish for example, individual river systems complement each other to provide a network of habitats spanning many hundreds of kilometres. In addition it appears (for some species at least) that patterns of usage change from one river to another, and from year to year as conditions change. In contrast, terrestrial invertebrates, lizards, and non-migratory fish are less mobile, and population and sub-populations are likely to be restricted to smaller sites (e.g. apparently isolated populations of robust grasshopper in Tekapo, Ohau and Pukaki Rivers). Similarly, indigenous plant distributions can be restricted to particular rivers or sites within rivers (Woolmore 2011).

Thus habitat degradation of rivers has the cumulative effect of reducing habitat availability across a range of scales, increasing risk for species dependent on these ecosystems. For example, when large mountain-fed rivers such as the Rakaia are in flood, the small hill-fed rivers of the plains such as the Selwyn now offer poor alternative habitat for birds because of lack of flow and weed invasion.

Considerable information is available about the relative importance of braided rivers for different bird species from bird counts (albeit, the data are piecemeal in time and space). However, little information is available regarding lizards, terrestrial invertebrates, and fish. If baseline surveys for all these groups are incomplete or greater than five years old, it may be difficult to assess sites for their ecological significance. Thus, caution should be exercised when prioritising sites for management, or assessing their significance in terms of the RMA; the quality of available information needs to be taken into account, and information gaps recognised.

Prioritisation of sites for conservation management is widely undertaken in New Zealand and elsewhere, and presents a number of challenges – at least partly because different people value ecological components differently, but also because of the need to work with 'patchy' information, as described above. Thus there is a need to develop methods of prioritising rivers that cope with these challenges and at the same time to improve knowledge of rivers in order to improve such evaluations.

O'Donnell's (2000) evaluation of rivers in Canterbury as habitat for birds provides an example of how to use a comprehensive range of detailed data about 'microhabitat' and bird communities present. O'Donnell ranked sites for habitat values and for threatened species presence. Such approaches, which incorporate information on plant, invertebrate, fish and lizard communities are needed, and should be applied nationally.

Use of FENZ?

Work needed to prioritise sites includes:

A. Develop a robust system for prioritising sites for research and management actions
This needs to take account of previous and current work mentioned above.

B. Identify and prioritise rivers, or sections of rivers, for conservation management
This needs to be done on the basis of existing information, and updated as new information is collected.

5.7 Decision support tools

Effective management of threats will be aided by having effective techniques for investigating and mitigating threats. A range of decision support tools and analytical methods require further development. Recent examples include the use of DNA analysis to identify potential predators (Steffens et al. 2012) and infrared digital video to aid understanding of breeding success (Maloney & Sanders 2002).

In order to develop effective tools there is an urgent need to gather accurate data on populations and input these parameters into population viability models so that we can generalise predictions about impacts of threats and outcomes of management. This need includes getting more precise population parameters across a range of representative sites. The priority is to:

A. **Promote the development of tools and build the capacity of natural resource managers, decision makers and local stakeholders to manage braided river ecosystems for biodiversity.** For example:
    1. Support tools to aid decisions on when and where to manage threats.
    2. Methods for identifying and ranking priority rivers for management.
    3. Modelling methods to predict benefits of management on population viability and predict flow regimes for management.
    4. More robust monitoring methods to record outcomes (e.g., fledgling success and rapid methods).

5.8 Braided river ecology

In addition to the various research priorities identified above, the following research needs apply across braided rivers as a whole.

Land use in catchments of braided rivers potentially impacts on habitats of threatened species, especially as intensification of farming and other uses increases. Clearance of vegetation in surrounding catchments can increase or change runoff patterns and cause erosion and increased siltation down-stream. Severe erosion can clog waterways and destroy habitat, or impacts may be more subtle, impacting for example on invertebrate food supplies. Drainage of backwaters and associated wetlands on the margins of braided rivers, causes direct loss of seasonal feeding and breeding habitat to birds.

Changes in water quality occur as a result of runoff from agricultural chemicals used in surrounding catchments (e.g., McColl et al. 1975). Inorganic fertilisers and pesticide residues enter waterways via runoff. Changes in water quality may influence aquatic food supplies available to wetland birds and organochlorides have been recorded accumulating in tissues of wetland birds (e.g., O'Donnell & Fjeldsa 1997). However, there has been no research conducted in New Zealand to determine what the precise impacts of such changes would be on the viability of threatened species populations.

Similarly, discharges of pollutants and sewage into waterways come from a wide variety of sources and cause loss of invertebrates and eutrophication (Hughes et al. 1974). Discharges of irrigation water following abstraction elsewhere within a catchment, or from elsewhere, may change the flow characteristics of a particular river. Such changes could be detrimental if such waters carry additional nutrient loads from farmland. Thresholds at which such discharges impact on indigenous birds have not been studied in New Zealand. Key questions to improve understanding of how braided river ecosystems function through fundamental research include:

A. Water quality

1. Does run off (nutrients) effect quality of braided river habitat?
2. What are the consequences of continued intensification in land use (e.g., dairy farms) adjacent to significant rivers?

B. Species habitat requirements

3. What is the importance of riparian areas for river species (moving on and off river)?
4. What threats face braided river species on their non-breeding grounds and how do we manage them?
5. What constitute a manageable "population" of threatened species?
6. How do threatened species use habitat at a macro scale? That is, are rivers 'networks' for populations of some species? Are birds nesting on one river in one year the same as those on another the next?
7. What are the relative impacts of various causes of mortality (i.e. various predator species (mammals and birds), floods, stock, disturbance etc.).
8. What is the relative importance of aquatic microhabitats within the river for different threatened species?
9. Where are the key populations of threatened species?

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TEXT BOXES

BOX 1

Environment Canterbury's Immediate Steps programme

Environment Canterbury's (ECan) Immediate Steps funding programme, which is part of the Canterbury Water Management Strategy, aims to protect and restore freshwater biodiversity in Canterbury.

Through this program the Regional Committee (Canterbury Water Management Strategy - CWMS) has allocated $540,000 over five years for the upper Rakaia and Rangitata Rivers. These catchments were chosen in part because of their importance for breeding wrybill and other braided river bird species.

The key outcomes sought are to maintain and enhance the open braided river landscape, enhance bird nesting opportunities, and protect and enhance wetlands and tributaries.

ECan worked with local community and stakeholders to develop priorities for the program. One of the key priority actions agreed to was weed control. Immediate Steps is contributing approximately $70,000 per year towards weed control across the two catchments over the next 5 to 10 years.

This weed control work is funded jointly by DOC, LINZ, local runholders via the Landcare Groups, and the Immediate Steps funding (Braided River Regional Flagship).

For further information: http://ecan.govt.nz/advice/biodiversity/funding/pages/immediate-steps.aspx

IMAGE

Community members discussing their options and priorities for biodiversity conservation in their area at an Ecan workshop

IMAGE

Management area decided on for weed control in the upper Rangitata catchment 2011-12

BOX 2

Predator control at a landscape scale in the Tasman River Valley

The Tasman Valley predator control project aims to test methods of large-scale predator control for the benefit of braided river birds. Specifically, the project is testing whether management of predators can be achieved over a large area (~230000 ha) to a level that benefits river breeding birds within a core area of ~9000 ha.

Predator control targets all small mammal predators found at the site (feral cats, ferrets, stoats, possums, weasels, Norway rats and hedgehogs), and catches harriers. The control programme mainly uses four types of kill traps (fenn, DOC150, DOC250, modified coni-bear), and two types of catch and kill traps (victors 1.5 leg-hold, and havahart cage traps). Kill traps are set year round and are checked monthly, while leg-hold traps and cage traps are set for 10 day periods several times per year and are checked daily. Kill traps are set 250 m apart in lines along the valley sides, valley floor, riverbed edge and mid-riverbed, and are alternated between types. Leg –hold traps are set in blocks of approximately 100 traps, set at 100 m spacings along the valley floor and on the edge of the river bed. Blocks of leg-hold traps are set and checked over a 10 day period several times per year. Cage traps are set in locations within 1 km of one land-owners residence to prevent injury to domestic cats.

The project has been undertaking predator control for 8 years. Over that time, there has been a total of 1932145 trap nights, capturing 12108 target species. Those captures were of 1553 feral cats, 656 ferrets, 772 harriers, 5884 hedgehogs, 28 rats (identified rats were Norway rats), 514 possums, 2616 stoats and 82 weasels. Capture rates for most show seasonal trends (higher in autumn, lowest in late winter and spring), and spatial differences (higher capture rates in buffer areas than in core zone). However, for some species, such as hedgehogs, capture distributions are generally even through out the trapping grid.

Four braided river bird species have been monitored over the length of the project; banded dotterels, wrybills, black-fronted terns and kaki. Factors monitored for these species included hatching success, fledging success, population trends, and adult survival. Responses of these species have been variable among years, and are related to predator control and differential responses to river flows. In general, hatching success of dotterels and wrybills was high. For dotterels, hatching was adversely affected by low minimum river flow and by a combination of high maximum flow and high predator abundance, and dotterels may be subject to a trade-off between predation and flooding risk. Wrybill chick survival was reduced by predation, and by high minimum and low maximum river flows. Tern chick survival was mostly low, and localised predation on terns may be due to specialisation by individual predators. Survival of adult kakī increased with predator control and with lower kakī abundance, and predator control is important for kakī persistence at this site.

Image

Map of predator control trap placement in the Tasman River catchment,

Image

Map of all predator captures im the Tasman Valley, 202005-2013, scaled by number of captures per trap

BOX 3

Intensive predator control around black-fronted tern colonies

Project River Recovery's upper Ohau black-fronted tern predator-control project aims to protect a colony of black-fronted terns that forms each year on an island in the Mackenzie Basin's upper Ohau River. This small-scale intensive control operation is being trialled to develop effective predator protection for birds that nest in colonies. It involves both direct predator control (using kill traps and, where necessary, toxins) and indirect predator control (by controlling rabbits, the primary prey of several of the introduced mammalian predator species).

The predator-trapping zone encompasses a 1 km radius area around the island on which the black-fronted terns nest. Several different types of kill traps and trap baits are used to target the full suite of mammalian species that have been identified as predators of black-fronted terns in the Mackenzie Basin—stoats, ferrets, rats, hedgehogs, cats and possums. Two types of possum trap are placed in areas of known possum activity and along the river margins. The remaining predator traps are positioned on a grid layout, with three types of cat trap placed at 200 m intervals along the grid lines and two trap types targeting the other smaller predator species placed at 100 m intervals along the grid lines (Figure x). The trap types alternate along their respective lines; the bait types alternate along the lines and between trap check sessions. The traps are run continuously all year round. They are checked, re-set and re-baited fortnightly during the winter months and weekly for the remainder of the year.

Toxins are used to assist with controlling Norway rats and possums because traps alone have proven insufficient for these two species. Bait stations are run continuously from two months before nesting commences through until the last chicks have fledged. The rat bait stations are placed at 50 m intervals along the waterway margins, with a double line of bait stations near the island; the possum bait stations are placed at 50 m intervals in areas of known possum activity and at 100 m intervals in other areas of suitable possum habitat and along the river margins near the island (Figure y).

The rabbit-control zone extends for a further 200 m radius beyond the trapping zone, to provide a buffer area with reducing rabbit densities. Rabbit numbers were sufficiently high at the start of the predator-control project that a toxin operation was carried out to reduce rabbit numbers to a level that could subsequently be maintained by a regular regime of night shooting.

IMAGE

Upper Ohau predator-control project boundaries and predator trap layout. Solid black line represents the boundary of the predator-trapping zone; dashed black line represents the boundary of the rabbit-control zone (the southern boundary is formed by a rabbit-barrier fence so the rabbit-control zone does not overlap the trapping zone entirely). White circles indicate positions of traps targeting mustelids, rats and hedgehogs; white squares indicate positions of traps targeting cats; white triangles indicate positions of traps targeting possums. Additional traps (not shown) are set on the island in the centre of the trapping area. Scale 1:12,000.

IMAGE

Upper Ohau predator-control project bait station layout. Solid black line represents the boundary of the predator-trapping area. White circles indicate positions of rat bait stations; white triangles indicate positions of possum bait stations. Scale 1:12,000.

BOX 4

Hand pulling of weeds on islands in the Eglinton River for black-fronted terns

Controlling local infestations of weeds around breeding colonies using hand pulling or mechanical means can make a difference. In the Eglinton Valley, four traditional black-fronted tern colony islands were cleared by hand-pulling and grubbing of Russell lupins over two days in 2009. Within a week a colony of c.50 black-fronted terns and several pairs of banded dotterels had established on one of the islands. The work involved hand pulling and grubbing by five energetic people. By visiting the area for several hours each spring, weeds have been kept down for the last four years and birds continue to nest on the islands

IMAGES

Island in the middle of the Eglinton River before and after weed clearance (Photos: Colin O'Donnell)

BOX 5

Weed control using machinery to provide island habitat

At sites with very dense weed infestation, especially by woody shrubs and trees, physical removal of weeds using earthmoving machinery may be the only viable option to re-create suitable bird habitat.

In 2007, Meridian Energy and ECan conducted a habitat enhancement trial on an 8-ha densely weed-infested island on the Waitaki River, employing mechanical removal of weeds followed by weed control using herbicides. The trial site was transformed, in a few days, from a silty, weed-infested island to a 'clean' site dominated by relatively coarse substrates (Figures xx and xx). The island was surrounded by wide, deep channels (total mean flow of 350 cumecs).

Monitoring during the breeding season following weed clearance showed that the cleared island provided highly suitable river bird habitat. River birds were essentially absent from the site prior to weed control, whereas after weed clearance the island was used as nesting and/or roosting habitat by a range of river birds including black-fronted tern (37 minimum), wrybill (3), banded dotterel (21), pied stilt (18), black-billed gull (6), and pied oystercatcher (1). An adjacent non-treatment site continued to see little use by birds. Higher parts of the island also provided refuge for chicks during a fairly large (920-cumec) flood in January 2008.

However, although the site provided suitable bird habitat, breeding success appeared to be low, almost certainly because eggs and/or chicks on the island were preyed upon (by unknown predator species). This reinforces the need for a reduction in predation pressure, in addition to the provision of suitable habitat, if threatened river bird populations are to persist or recover.

Two large-scale mechanical weed-clearance operations in the Waitaki catchment have also successfully restored bare substrates which birds have used for nesting and roosting (Maloney *et al. 1999;* Sanders & Maloney 2000). Whilst successful in restoring suitable habitat for birds, mechanical clearance is expensive, and requires ongoing weed control to prevent re-invasion. At flood–prone sites the new habitat may eventually be lost through natural channel erosion and deposition (in 2013 the Waitaki island is no longer discernible in aerial photographs). Thus, this technique may only be justified where there is a real lack of suitable bird habitat. Potential threats of this technique to indigenous plants, lizards and invertebrates should also be considered.

IMAGE

Typical dense weed growth on the island prior to weed-removal.

IMAGE

A low-lying part of the cleared island, after mechanical weed removal and after a 900-cumec flood that has removed machinery tracks and debris that remained flowing removal.

BOX 6

Setting flow regimes beyond minimum flows within statutory planning

Flow-setting in New Zealand has often focussed on setting minimum flows, even though it has long been understood that other aspects of flow such as flow variability and the frequency and duration of mid-range and large floods strongly-influence river ecosystems (Biggs *et al.* 2008). Increasingly, however, science is informing flow allocation decisions (e.g. in writing Regional Plans and in major resource consent allocations), and moving toward designing *flow regimes* that should achieve better environmental outcomes than achieved by simply setting minimum flows.

Consultation and resource consent hearings for Meridian's North Bank Tunnel Project provide a good example of how science (freshwater and terrestrial ecology, hydrology, hydraulic modelling, river geomorphology) contributed to setting a flow regime designed to balance the wishes of numerous stakeholders, including river conservation interests, irrigators, Meridian Energy, anglers and jet boaters, local communities and iwi. In designing the flow regime, detailed consideration was given to how flow affects river geomorphology (e.g. sediment transport and braiding patterns), instream biological processes (periphyton, aquatic invertebrates, native and salmonid fish), and terrestrial processes (weed invasion/removal).

The key elements of the designed flow regime of particular relevance to river birds are:

- **Channel maintenance flows.** When large floods (>900 m3/s) occur, abstraction for hydro generation will cease in order to allow the entire flood to pass unimpeded down the Waitaki River. The objective is to restore channel forming and weed clearing processes of these floods, which among other things and along with weed control, will help restore bird nesting and foraging habitat.
- **Flushing flows.** Each year, at least seven 'flushing flows' (at least 450 cumecs over 24 hours) must be provided. These are designed to clear nuisance periphyton and fine sediment. They are timed to avoid the bird nesting native fish spawning seasons.
- **Reduce artificially high flow variability.** Cessation of the current highly variable flow regime, which results in a barren 'varial zone' along channel edges, to allow development of productive aquatic invertebrate habitat in shallow channel edges, which should improve bird foraging habitat.
- **Adaptive management.** Monitoring is required, with specific, quantitative triggers and outcome-based performance measures to test whether these measures are effective. If not, the consents require that they are adjusted to achieve the specified ecological outcomes.

If or when the North Bank Tunnel is constructed, the extensive monitoring required in the resource consents will allow a thorough evaluation of the success or otherwise of the designed flow regime.

BOX 7

Using standard index counts of birds of braided rivers to monitor response to management

Standard bird counts on a large number of braided rivers since the 1960s provide valuable data on the significance of rivers and trends in numbers (O'Donnell & Moore 1983; O'Donnell & Hoare 2011).

Introduced mammalian predators, particularly rats, cats and mustelids, appear to be a serious threat to breeding black-fronted terns (Keedwell 2002). On the Eglinton River, Fiordland National Park, the number of terns present in the middle of the breeding season has been counted once annually since 1992. Numbers were very low until a valley-wide stoat trapping programme commenced in late 1997. Numbers appeared to increase each summer until an irruption of ship rats occurred in 2000. Numbers of terns dropped to their former levels, before recovering four years later, following continued valley-wide predator focused on both rats and stoats. Increases continue today, however, this area represents a relatively simple predator system, where several major black-fronted tern predators are rare (hedgehogs, ferrets and feral cats) (O'Donnell & Hoare 2011).

Other examples of monitoring include surveys of the Waitaki River in 2001, 2005, and 2010 involving 5 replicated surveys each year, and recent surveys of Canterbury Rivers. Helicopter surveys of black-fronted terns, black-billed gulls and other prominent species, using experienced observers and high resolution photography offering of key species, has yielded promising results on a number of rivers (Waitaki, Wairau, Waiau), and may offer a safe, rapid, and cost-effective alternative to on-river surveys (K. Steffens, pers. comm.).

IMAGE – people surveying/Eglinton tern monitoring graph + tabulated counts from Eglinton

BOX 8

BRaid – The Braided River Aid Network

BRaid, a group which promotes protection of all braided river ecosystems in Canterbury, was the brainchild of the Ashley-Rakahuri rivercare group and came into existence in 2007 (See BOX--). BRaid was formed to bring together the various parties involved in braided river management and conservation (including agencies, organisations, community groups, and individuals). A major aim is to assist in the formation of other community-driven rivercare groups. To this end, BRaid has regularly organises training courses for the management of birds in braided rivers. At the time of writing the network included

The goal of BRaid is 'to protect, enhance and restore braided river ecosystems' though providing leadership and advocacy; encouraging cooperation between interested parties; and facilitating information and data sharing. The group's website provides a repository for data from river counts, monitoring protocols, advice on management of rivers, news releases and other topical issues.

For more information see the BRaid website:

https://sites.google.com/site/braidedriveraid/

IMAGE

Community volunteers at a BRaid predator control workshop (Photo: Nick Legard)

BOX 9

Activities of the Ashley-Rakahuri Rivercare Group

The Ashley-Rakahuri Rivercare Group is a community group formed in 1999 to assist with the management of shorebirds and their habitat in the lower reaches of the Ashley River. This river has the northern-most stable population of wrybill, and provides good breeding habitat for all the other indigenous braided river birds. In 2005, the Group became an incorporated society. Meetings are held 4-5 times annually and there are sixty-four people on a membership email list. Major activities involve bird monitoring (one annual survey, plus a number of riverbed visits every week between September-January), predator control (4-5000 trap-nights annually), habitat enhancement (weed control) and advocacy (increasing awareness and minimising human disturbance), all of which are covered in annual reports - which also contain recommendations for future management. A professional ornithologist is employed part-time to assist with monitoring (particularly wrybill banding) and report writing. After 8 years of regular riverbed activity, the indications are that resident bird numbers are relatively stable and being maintained. Major funding has come from the Pacific Development and Conservation Trust, the New Zealand National Parks and Development Foundation, the Habitat and Protection Fund of World Wildlife Fund (New Zealand), and the Lotteries Environment and Heritage Fund, plus local sponsorship.

For further information see: http://www.naturespace.org.nz/groups/ashley-rakahuri-rivercare-group-inc

BOX 10

Project River Recovery

Project River Recovery was established in 1990 to deliver programmes of braided river and wetland ecosystem restoration and enhancement which are jointly agreed between Meridian Energy Ltd, Genesis Energy Ltd and the Department of Conservation. The programme is funded by the power generation companies through an agreement explicitly recognising the impacts of hydro-electric power generation on braided rivers and wetlands in the upper Waitaki River and is tied to the term of the power scheme resource consents which expire in 2025. PRR currently uses these funds to:

1. **Maintain indigenous vegetation and enhance habitat by removing weeds**
    - Targeted removal of problem weeds in priority locations before they become widespread.
    - Preventing problem riverbed weeds which aren't established in Upper Waitaki rivers from becoming naturalised (eg buddleia, yellow tree lupin, false tamarisk).
    - Undertaking research and field trials to improve effectiveness and reduce possible adverse impacts of PRR weed control programmes.
2. **Continue to build knowledge of natural heritage in braided river ecosystems**.
    - Ongoing riverbed surveys to assess long term bird population trends throughout upper Waitaki Rivers.
    - Demonstrating the creation and successful management of wetland habitat for specialised wading birds.
    - Large scale survey and description of threatened plants and wider plant communities in upper Waitaki braided rivers.
3. **Test and develop more effective methods of predator control in braided rivers.**
    - Catchment scale trapping of predators in the Tasman River in conjunction with the Kaki Recovery programme to improve breeding success of a wide range of river-birds and other fauna.
    - Intensive trapping of predators as a technique to benefit colonial nesting birds.
4. **Increase public awareness of braided rivers and wetlands**
    - Preparing and distributing a wide range of attractive braided river resource materials including braided river posters, field guide, information pamphlets and a river-care code.
    - Development of a student/teacher resource which examines values, human impacts and management of braided river ecosystems and fits into the senior high school curricula.

For further information: http://www.doc.govt.nz/documents/science-and-technical/casn298.pdf

BOX 11

The black stilt recovery programme

Kaki or the black stilt is a wading bird that was once widespread in rivers and wetlands throughout the North and South Islands. However due to the impact of introduced predators and changes to their habitat, they are one of New Zealand's most critically threatened birds, and are one of the world's most endangered wading species.

The Department of Conservation have put in place a Recovery Plan to secure kaki from extinction, and to increase their numbers throughout their range. The Recovery Plan is a planning document designed to summarise the priority actions needed to help ensure the species recovers and persists. The plan is in two phases and the first phase is designed to maximise the number of young kaki in the population. It involves finding pairs and collecting as many eggs as possible. Eggs are then hand raised in captivity until they are either 2 or 9 months of age, when they are released back to the wild. Captive-rearing and release techniques are used because they give a much better survival rate for young birds than does trying to raise the chicks with wild parents. Most eggs and chicks in the wild are either killed by predators or nests get washed out by floods, so this phase avoids these losses and gives the population a much needed boost.

This phase is working well and in a good season, 160+ eggs are collected from wild and captive pairs, and over 100 chicks are successfully raised by hand to be released.

The second phase is designed to discover the best method of keeping kaki alive in the wild in mainland New Zealand. This has involved some research using radio transmitters on released birds to try to ascertain where and why they die. Also a large scale (23,000 ha) predator control programme in the Tasman River Valley has been established for the last seven years. Analysis of the first five years of results indicates that this form of predator control enhances adult survival and population viability of kaki. The challenge is to ensure that this predator programme can be effective in improving fledging success if kaki populations are to survive in the long term.

Images of aviaries and winter release

BOX 12

Highest priority research objectives

1. To develop effective predator control prescriptions for threatened species on braided rivers that focus on (a) optimising predator control (which requires increased understanding of many aspects of predator-prey dynamics), developing new tools (e.g., toxins), and (c) determining the importance of predator-safe habitat refugia (islands and flows).
2. To develop flow prescriptions that maintain or restore threatened species and their habitats.
3. To develop effective weed control prescriptions that enhancer key ecosystem components (where to do it, how much, cost-effectiveness)
4. To determine the relative importance of aquatic microhabitats within the river for threatened species to build predictive flow models.
5. To increase understanding of drivers of productivity and survival of threatened species and particularly the interactions among threats, including:
    a. Determining interactions between predation risk, flow management and weed encroachment.
    b. Gathering accurate data on productivity and survival of threatened species populations at a range of sites to develop population viability models (to generalise predictions about impacts of threats and describe outcomes of management.
6. To develop more robust monitoring methods to record outcomes of management and population trends in threatened species (e.g. breeding success, survival, quantitative survey and monitoring methods for fish and rapid methods).
7. To determine the effectiveness of creating or enhancing habitat for braided river species (e.g., artificial islands).
8. To quantify impacts of different (increasing) recreational activities on behaviour and breeding success of threatened species.
9. To assess whether the indicator species concept is useful for monitoring responses of braided river species to management and for reporting on those trends.
10. To quantify the impacts of gravel extraction on breeding species and their habitat.
11. To learn more about factors influencing survival of braided river species on non-breeding (wintering grounds) and the threats species face.

Table 1. Extent of braided river habitats in New Zealand (From Department of Conservation Rare Ecosystems Database)

Region	Active riverbed (ha)	Recent floodplain (ha)	Total area (ha)	%
Canterbury	103103	61067	164170	63.9
Nelson-Marlborough	16614	4265	20879	8.1
North Island	5511	152	5663	2.2
Otago	13181	4327	17508	6.8
Southland	4926	5097	10023	3.9
West Coast	28127	10736	38863	15.1
Total	171462	85644	257106	100.0

Table 2. Examples of threatened species on braided rivers. This is not an exhaustive list, but demonstrates the range of threatened taxa and their dependence on braided river habitats.

Threat status[1]	Common name	Scientific name	Type	Dependence on braided rivers	Use	Main threats	Breeding Distribution on Braided Rivers
Critically Endangered	Black stilt/kaki	*Himantopus novaeseelandiae*	Bird	Primary	F,B,S	Predation Habitat loss	Mackenzie Basin
	Grey duck	*Anas superciliosa*	Bird	Facultative	F,B,S	Hybridisation	Throughout South Island
	Long-tailed bat	*Chalinolobus tuberculatus*	Bat	Facultative	F	Predation	South Canterbury, Otago, Southland
	Waitaki Lowland longjaw galaxias	*Galaxias* aff. *cobitinis* "Waitaki"	Fish	Primary	F,B,S	Habitat loss	Mackenzie Basin
	Olearia	*Olearia adenocarpa*	Plant	Obligate			Two rivers in Canterbury
Nationally Endangered	Black-billed gull	*Larus bulleri*	Bird	Obligate	F,B,S	Predation Habitat loss	Throughout South Island

	Black-fronted tern	*Chlidonias albostriata*	Bird	Obligate	F,B,S	Predation Habitat loss	Eastern South Island
	Australasian bittern	*Botaurus poiciloptilus*	Bird	Facultative	F	Predation Habitat loss	Throughout
	Robust grasshopper	*Brachaspis robustus*	Invertebrate	Primary	F,B,S	Predation Habitat loss	Mackenzie Basin
	Hector's tree daisy	*Olearia hectori*	Plant	Facultative			South Island
Nationally Vulnerable	Wrybill plover	*Anarhynchus frontalis*	Bird	Obligate	F,B,S	Predation Habitat loss	Eastern South Island
	Banded dotterel	*Charadrius bicinctus*	Bird	Primary	F,B,S	Predation Habitat loss	Eastern South Island
	Blue duck	*Hymenolaimus malachorhynchos*	Bird	Facultative	F,B,S	Predation	South Island
	Pied shag	*Phalacrocorax varius*	Bird	Facultative	F,S	Coastal habitat loss	South Island

	Red-billed gull	*Larus scopulinus*	Bird	Facultative	B,S	Coastal habitat loss	Eastern South Island
	Caspian tern	*Sterna caspia*	Bird	Facultative	F,B,S	Coastal habitat loss	Eastern South Island
	Upland longjaw galaxias (Waitaki)	*Galaxias* aff. *prognathus* (Waitaki)	Fish	Obligate	F,B,S	Habitat loss	Mackenzie Basin
	Bignose galaxias	*Galaxias macronasus*	Fish	Primary	F,B,S	Habitat loss	Mackenzie Basin
	Upland longjaw galaxias (Cantebury)	*Galaxias prognathus*	Fish	Obligate	F,B,S	Habitat loss	Rakaia, Rangitata, Hurunui, Maruia
	Waitaki Lowland longjaw galaxias	*Galaxias* aff. *cobitinis* "Waitaki"	Fish	Primary	F,B,S	Habitat loss	Ahuriri, Edward, Hakataramea, Fraser,Otamatapiao
	wire broom	*Carmichaelia juncea*	Plant	Primary		Habitat loss	South Westland, Canterbury, NW Nelson
Declining	NZ pied	*Haematopus finschi*	Bird	Primary	F,B,S	Predation	Eastern South Island

oystercatcher					Habitat loss	
Pied stilt	*Himantopus leucocephalus*	Bird	Facultative	F,B,S	Predation Habitat loss	Eastern South Island
White-fronted tern	*Sterna striata*	Bird	Facultative	F,B,S	Predation Habitat loss	Eastern South Island
Rifleman	*Acanthisitta chloris*	Bird	Facultative	F,B,S	?	Eastern South Island
NZ pipit	*Anthus novaezeelandiae*	Bird	Facultative	F,B,S	Predation Habitat loss	Throughout
Longfin eel	*Anguilla dieffenbachii*	Fish	Facultative	F,B,S	Habitat loss	Throughout
Torrentfish	*Cheimarrichthys fosteri*	Fish	Facultative	F,B,S	Habitat loss	Throughout
Dwarf galaxias	*Galaxias* aff. *divergens*	Fish	Primary	F,B,S	Habitat loss	East Coast + North Island
Giant kokopu	*Galaxias argenteus*	Fish	Facultative	F,B,S	Habitat loss	Throughout
Koaro	*Galaxias brevipinnis*	Fish	Facultative	F,B,S	Habitat loss	Throughout
Gollum galaxias	*Galaxias gollumoides*	Fish	Facultative	F,B,S	Habitat loss	Throughout South Island

Inanga	*Galaxias maculatus*	Fish	Facultative	F,B,S	Habitat loss	Throughout
Shortjaw kokopu	*Galaxias postvectis*	Fish	Facultative	F,B,S	Habitat loss	Throughout
Lamprey	*Geotria australis*	Fish	Facultative	F,B,S	Habitat loss	Throughout
Bluegill bully	*Gobiomorphus hubbsi*	Fish	Primary	F,B,S	Habitat loss	Throughout
Redfin bully	*Gobiomorphus huttoni*	Fish	Facultative	F,B,S	Habitat loss	Throughout
	Luzula celata	Plant	Facultative		Habitat loss	South Marlborough, Canterbury, Otago
Canterbury common gecko	*Woodworthia* 'Canterbury'	Lizard	Facultative	F,B,S	Predation Habitat loss	Canterbury
Jewelled gecko	*Naultinus gemmeus*	Lizard	Facultative	F,B,S	Predation Habitat loss	Canterbury
Southern long-toed skink	*Oligosoma* aff. *longipes* 'southern'	Lizard	Primary	F,B,S	Predation Habitat loss	Canterbury
Scree skink	*Oligosoma waimatensis*	Lizard	Primary	F,B,S	Predation Habitat loss	Canterbury

		Pimelea pulvinaris	Plant	Facultative		Habitat loss	South Canterbury Central Otago
		Raoulia monroi	Plant	Facultative		Habitat loss	South Marlborough, Canterbury, Otago
	Wolf spider	*Anoteropsis arescens*	Invertebrate	Primary		Habitat loss	eastern South Island
Naturally Uncommon/Range restricted		*Craspedia* " Havelock"	Plant	Obligate		Habitat loss	South Canterbury - Rangitata River
		Myosotis uniflora	Plant	Obligate		Habitat loss	South Canterbury
		Carex kaloides	Plant	Facultative		Habitat loss	eastern South Island
		Carex muelleri	Plant	Facultative		Habitat loss	eastern South Island
		Lepinella serrulata	Plant	Facultative		Habitat loss	eastern South Island
	Grasshopper	*Sigaus minutus*	Invertebrate	Primary	F,B,S	Habitat loss	Otago, Mackenzie Basin
	Wolf spider	*Anoteropsis arenivaga*	Invertebrate	Primary	F,B,S	Habitat loss	eastern South Island

1. Sources of threat classifications: Miskelly et al. 2008; O'Donnell et al. 2010; Allibone et al. 2010, W. Chinn pers. comm.

2. Type of species: Obligate = and specialist user of braided rivers for part of its life cycle and a key focal species of this recovery strategy because of

3. Use code: F = Feed, B = Breed, S = Shelter

Table 3. Potential effects and consequences of reduced flow on braided river birds during the breeding season

Prediction	Potential effects	Potential consequences	Affected bird species
1. Lower flows	• Lower food availability • Increased weed encroachment • Less food producing habitat • Increased access to islands by mammalian predators	• Greater competition for food • Less nesting and feeding habitat • Increased cover for mammalian predators and their prey • Lower productivity and survival of birds	• All aquatic feeding bird species to some degree • Black-fronted tern in particular
2. Fewer channels (braids)	• Reduced area of feeding habitat • Increased access to islands by mammalian predators	• Fewer habitat choices-greater competition for food • Less optimal nesting habitat • Lower productivity and survival of birds	• All aquatic feeding bird species to some degree • Black-fronted tern in particular
3. Fewer islands	• Fewer islands safe from predators	• Lower productivity and survival of birds	• All river breeding bird species to some degree, black-fronted tern in particular
4. Increased channel	• Reduced accessibility to preferred	• Less nesting and feeding habitat	• All aquatic feeding bird species to some degree,

stability	foods • Increased weed encroachment	• Increased cover for mammalian predators	black-fronted tern in particular