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EFFECT OF WILLOW REMOVAL ON HABITAT USE BY FIVE BIRDS OF BRAIDED RIVERS, MACKENZIE BASIN, NEW ZEALAND

Summary: We evaluated willow removal as a technique for enhancing habitat for birds of braided rivers by monitoring five bird species at three sites in the Mackenzie Basin, New Zealand, from 1991 to 1994. Four species - banded dotterel (*Charadrius bicinctus*), pied stilt (*Himantopus novaezelandiae*), black-fronted tern (*Sterna albostriata*) and South Island pied oystercatcher (*Haematopus ostralegus*) used the areas of riverbed cleared of willows for nesting and foraging, at the same or greater density than other areas of riverbed already free from willows. Wrybills (*Anarhynchus frontalis*) were occasionally seen in cleared areas of riverbed but were not nesting there during the study. Densities of banded dotterel and wrybill were lowest at sites with the greatest densities of willows, and only three out of 327 monitored nests were located in willow habitat. Nest predation rates did not differ significantly among sites with differing levels of willow infestation, nor did they differ between areas of cleared riverbed and riverbed already free from willow. In addition to weed control, predator control may be necessary to increase bird populations. This study indicates that willow removal increases foraging and nesting habitat for some river bird populations, but further surveys are necessary to assess whether willow removal has any long-term benefits.

Keywords: Habitat enhancement; willows; braided rivers; bird abundance.

Introduction

The wide, braided rivers of Canterbury, South Island, New Zealand, provide breeding and feeding habitat for over 20 species of native birds (O'Donnell and Moore, 1983). Three of these have special conservation status: wrybill plover (*Anarhynchus frontalis*)[1] , black-fronted tern (*Sterna albostriata*) are threatened, and black stilt (*Himantopus novaezelandiae*) is endangered (Collar, Crosby and Stattersfield, 1994). All three rely almost exclusively on the braided rivers and wetlands of Canterbury for breeding (O'Donnell and Moore, 1983; Robertson *et al*., 1984; Pierce, 1996; Maloney *et al*., 1997). Braided rivers also provide breeding grounds for other less specialised species such as banded dotterels (*Charadrius bicinctus*), South Island pied oystercatcher (*Haematopus ostralegus*) and pied stilts (*Himantopus h. leucocephalus*) (Maloney *et al*., 1997).

The main causes of decline of birds along braided rivers are habitat loss and degradation, and predation by introduced mammalian carnivores such as cats (*Felis catus*), ferrets (*Mustela furo*) and stoats (*M. erminea*) (Hay, 1984; Pierce, 1986; Pierce, 1987; Marchant and Higgins, 1993; Sanders, 1997). Construction of hydroelectric dams in the Waitaki River catchment has reduced the amount of riverbed habitat available to nesting and foraging birds and has substantially reduced mean water flows and flood levels. This reduction allowed invasive weed species such as crack willow (*Salix fragilis* L.) and broom (*Cytisus scoparius* L.) to establish in the riverbed. These introduced species stabilise shingle islands, increase channelisation of the riverbed and decrease the availability of shallow feeding areas. In addition, areas of established vegetation can provide cover for mammalian predators (Pascoe, 1995).

In 1990, Project River Recovery, a Department of Conservation project funded by the Electricity Corporation of New Zealand, was established to mitigate habitat degradation of braided rivers in the Mackenzie Basin. One aim of Project River Recovery was to remove willows from a section of riverbed to enhance river bird habitat. This study reports the changes in abundance, distribution and breeding success of five bird species in response to willow removal.

[1]Bird nomenclature follows Heather and Robertson (1996), mammal nomenclature follows King (1990)

Methods

Study sites

Breeding activity and bird density were monitored at two sites on the Tekapo River and at one site on the Ohau River, South Island, New Zealand (Fig. 1). All sites were 1.5-2.5 km in length and 1-1.5 km in width. The mean daily flows were <10 $m^3 s^{-1}$ on the Tekapo River and <5 $m^3 s^{-1}$ on the Ohau River. We selected two control sites with different willow cover. Site A (willows Absent), in the Ohau study area, had <5% willow cover and willows covered 58% of the upper Tekapo study site (site P, willows Present; Figure 1). Sites A and P provided non-treatment comparisons because willow density remained unchanged at both sites throughout the duration of the study (Table 1).

Forty-nine percent of the Tekapo Delta site (site R, willows Removed) was covered in willows in 1991. By late 1993, this decreased to zero as willows were mechanically dug out and burned in the winters of 1992 and 1993 (Table 1). Bulldozers were also used to clear areas of shingle covered in exotic grasses.

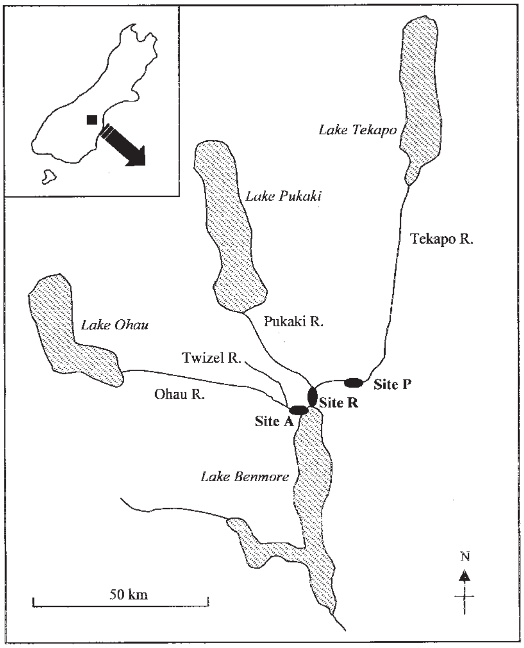

Figure 1: *Location of study sites on the Tekapo and Ohau Rivers, Mackenzie Basin, South Island. New Zealand. Site A had 5% of habitat covered in willows, at site P 58% of the habitat was covered with willows, and at site R willows (49% of area) were removed in 1992 and 1993.*

Table 1: *Area (ha) of willow and willow-free habitat at two non-treatment sites (sites A and P) and one willow removal site (site R).*

Site	Year	Willow	Willow-free	Total habitat
Site A	All years	5	103	108
Site P	All years	73	52	125
Site R	1991	80	83	163
	1992	44	119	163
	1993	4	159	163
	1994	0	163	163

Monitoring river bird populations

Density and nesting success of five species of birds (banded dotterels, South Island pied oystercatchers, pied stilts, wrybills and black-fronted terns) were monitored during each breeding season at the three sites from 1991 to 1994. Monitoring in 1991 commenced in October and finished in January 1992 and focussed on nesting success only. In the remaining three breeding seasons (1992-1994), bird abundance and nest success were monitored from September to early January of each year. Bird distribution within site R was also recorded during the last three seasons.

Bird populations at each site were monitored 1-2 times per week by 2-5 trained observers, with each observer working separately. During each visit, equal effort was spent searching in willow and non-willow habitat. On each walk the observer recorded the location, identity and behaviour (to establish whether the bird was nesting) of every target bird species seen. Observers also checked for incubation activity or signs of predation at nests; and mapped any new nests found. Adult birds were caught using a drop trap over the nest and were colour-banded with an individual colour combination.

All observations were recorded onto a photocopy of a 1:6000 scale aerial photograph of the study site, which had been divided into 50 m grid squares. To aid the mapping of bird and nest locations, labeled pegs were placed at every 100 m gridpoint in all three study sites. Nests were marked by placing a small stone cairn approximately 5 m from the nest in a random direction.

Estimates of bird density

The density of birds was calculated and compared among sites, years and species. Because it was not possible to accurately census the entire bird population, a measure of relative density was based on the number of birds seen at the peak of the breeding season in October of each year, in each site. The relative density of birds was calculated as the number of nesting birds recorded in October (i.e., the number of nests multiplied by two), plus the number of non-nesting colour-banded individuals seen in October, plus the maximum number of unbanded individuals seen in one day in October. Unbanded birds displaying nest or chick-protecting behaviour were excluded from the count because one bird in a nesting pair often remained unbanded.

Estimates of density could not be calculated for black-fronted terns because they were not colour-banded due to the difficulty in observing colour bands on this species.

Bird distribution within the willow removal site

Change in the distribution of bird species in response to removal of willows at site R was measured by recording the number of nests and bird sightings in these areas before willow removal, in old riverbed areas (i.e., already free from willows) and in cleared riverbed areas (i.e., where willows had been removed). Bird sightings consisted of the total number of individual sightings of colour-banded birds made over the entire season, but excluded the regular sightings of parent birds at the nest site. Densities of each species in each type of habitat were compared among years.

Because of limited replication and low population sizes in site P, it was not possible to statistically test the observed differences in bird density among sites, or within areas of the willow removal site.

Nest success

The precocial nature of the chicks meant it was only possible to measure hatching success (the number of nests that hatched chicks) and not fledging success (the number of chicks that fledged). We tested whether the proportion of nests that hatched was related to site and year using contingency table analyses. We also used contingency table analyses to test whether the proportion of nests that hatched within site R was related to habitat type (i.e., cleared or old riverbed). The outcome (hatched or failed) of banded dotterel, wrybill, pied stilt and pied oystercatcher nests combined were used in these analyses because sample sizes were too small to examine each species individually by year and site. The outcome of 8% of nests was unknown and these nests were excluded from analysis. No monitored nests were deserted or flooded during the study, therefore we assumed that nest failures were caused by predation. This assumption is supported by video research on banded dotterel nests (Sanders, 1997).

The distance from nests to potential predator cover (vegetation, logs or other cover large enough to screen a predator from view) or potential predator den sites (piles of debris, dense vegetation, rabbit burrows) was measured to determine whether proximity to cover influenced nest outcomes at Sites A and R. Partitions were chosen to divide the number of nests into about three equal groups prior to calculation of loss rates. Distances to potential predator cover were classified as: near 0-15 m; mid 16-30 m; far >30 m; and potential den sites as: near 0-25 m; mid 26-59 m, far 60+ m. Chi-square tests were used to compare predation rates and proximity of nests to predator cover or den sites.

Results

Bird density

The density of banded dotterels was lower in site P (0 - 0.064 birds ha^{-1}) than in either of the other two sites (site A: 0.4 - 0.58 birds ha^{-1}; site R: 0.33 - 0.39 birds ha^{-1}) and wrybills were not recorded at site P (Fig. 2). Pied stilts and pied oystercatchers remained at similarly low densities at all three sites. Densities of all species at site R showed no evidence of decline, indicating that willow removal had no detrimental effect on the populations. Only three out of 327 monitored nests were found in willow habitat.

Distribution of birds within site R

In the willow areas of site R, only three banded dotterels and one pied oystercatcher were seen in 1992, prior to removal of all willows. The only nests found in the willow area of site R were two banded dotterel nests in 1992.

Banded dotterels nested and foraged in cleared riverbed areas within Site R in the seasons immediately following willow clearance, and were present at similar densities in the cleared and old riverbed areas (Fig. 3). Pied stilts and pied oystercatchers also immediately used cleared riverbed habitat at a similar density to that in old riverbed areas, but were not observed nesting in the cleared habitat until the second season after clearance (Fig. 3). Birds seen in cleared riverbed areas included colour-banded individuals that had nesting territories in areas of old riverbed in preceding seasons, indicating that they had shifted into the newly available habitat.

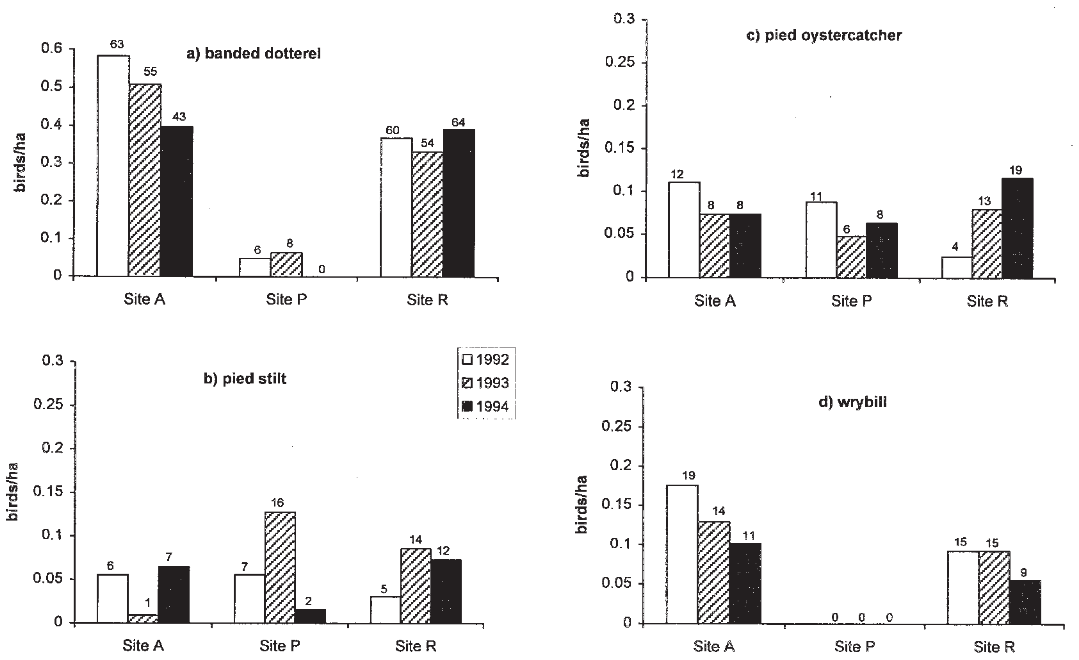

Figure 2: *Estimated density of four bird species in October at three sites, 1992-1994. Areas of sites were: site A (willows absent) 108 ha, site P (willows present) 125 ha, and site R (willows removed) 163 ha. Numbers above bars represents the total number of individuals seen.*

Black-fronted terns nested in cleared riverbed areas and individuals were also seen foraging there. Wrybills were not observed nesting in cleared riverbed areas and few individuals were seen foraging there (Fig. 3).

Nest success

The percentage of nests that successfully hatched eggs did not differ among sites (χ^2=0.03, d.f.=2, P=0.986, but hatching success varied among years because of high predation in 1992 and low predation in 1994 (χ^2=40.69, d.f.=3, P<0.001; Table 2).

The two nests in willow areas of site R failed, and nests in cleared riverbed had a slightly higher success rate (66%, n=47) than nests in old riverbed (56%, n=88). This difference was not significant (χ^2=1.34, d.f.=1, P=0.247; Table 2).

Mean distances from nests to potential predator cover and den sites at site R (cover 50 m, range 4 - 250 m; den site 72 m, range 4 - 280 m) were more than twice as far as at site A (cover 24 m, range 2 - 100 m; den site 43 m, range 4 - 220 m). Nests at site A closer to cover or den sites had higher failure rates than those further away (cover: χ^2=7.58, d.f.=2, P=0.023; den, χ^2=6.21, d.f.=2, P=0.045). Nest outcomes at site R were independent of proximity to cover (χ^2=0.84, d.f.=2, P=0.656) and den sites (χ^2=0.12, d.f.=2, P=0.941).

Discussion

Four of the five monitored bird species nested in and used areas of riverbed cleared of willows. Furthermore, the four species used these areas soon after clearance and in densities comparable to other available habitat within the site. Less than 1% of nests were found in willow habitat, and at least two species had the lowest densities in site P, where willow infestation was highest. Our results support the hypothesis that braided riverbeds dominated by willows decrease available habitat for nesting and feeding river birds, and that willow removal was beneficial for some bird species.

The use of the newly cleared areas of riverbed for breeding and foraging varied among species. Banded dotterels and black-fronted terns nested in cleared riverbed as soon as it became available, whereas pied stilts and pied oystercatchers used the

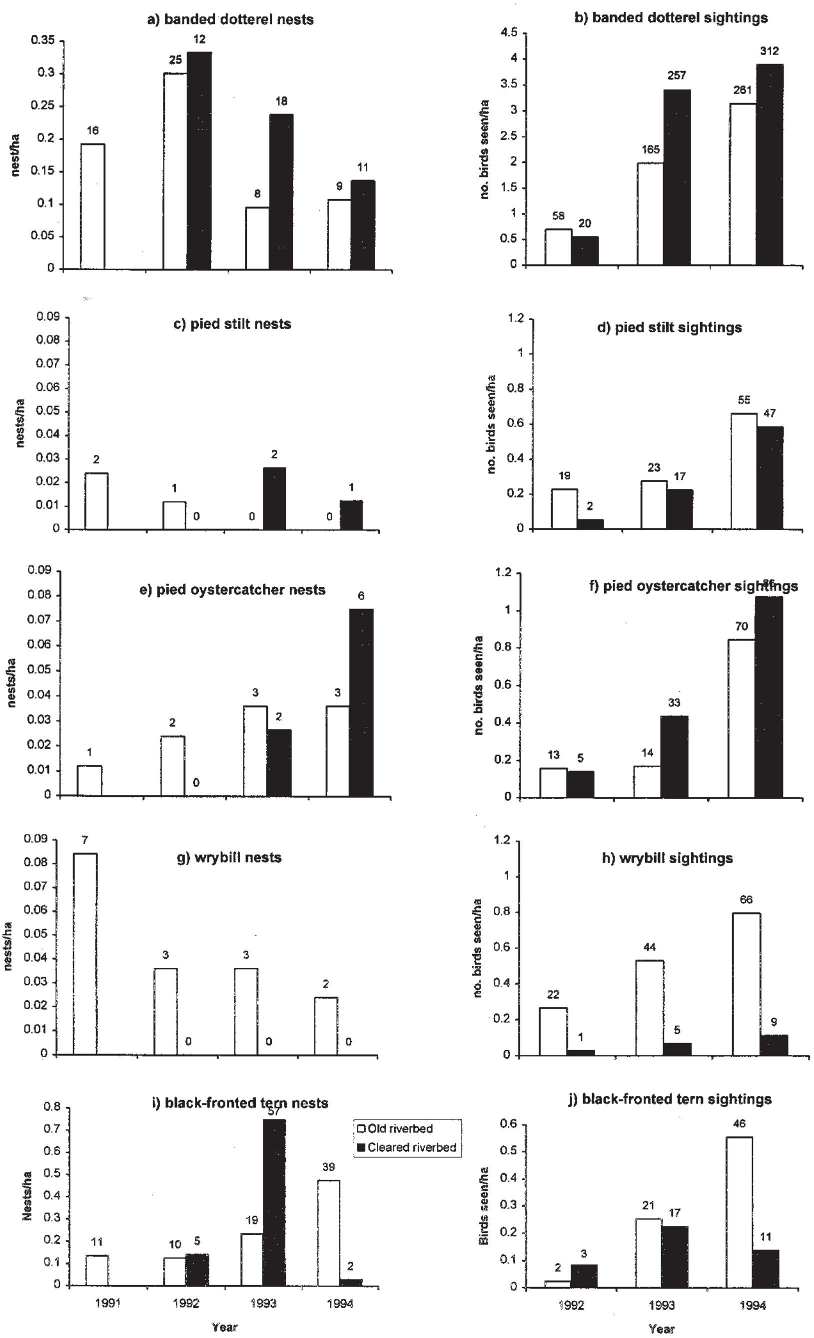

Figure 3: *Estimated density of nests and individuals of five river bird species in unvegetated areas (old riverbed) and areas recently cleared of willows (cleared riverbed) on the Lower Tekapo River, site R. Old riverbed comprised 83 ha of the study site and remained constant through time, areas of cleared riverbed were: 0 ha, 1991; 36 ha, 1992; 76 ha, 1993; 80 ha, 1994. Density of individuals was not recorded in 1991. Numbers above bars represent the number of nests or birds sighted.*

Table 2: *Percentage hatching success of banded dotterel, wrybill, pied stilt and pied oystercatcher nests combined at sites A, P and R, 1991-1994. n = number of nests monitored; 95% binomial confidence intervals from Mainland, Herrera and Sutcliffe (1956). Old riverbed and cleared riverbed sections are a breakdown of hatching success at site R. Two nests in willowed areas of site R in 1992 both failed, but are not included in the breakdown of nesting success at site R.*

Site		1991	1992	1993	1994	All years
Site A	% hatched	69	37	58	81	58
	n	51	59	26	31	167
	95% C.I.	54-81	25-50	37-77	61-92	50-66
Site P	% hatched		56	50	75	57
	n	0	9	10	4	23
	95% C.I.		21-86	19-81	12-88	35-77
Site R	% hatched	67	37	61	92	58
	n	24	54	33	26	137
	95% C.I.	45-84	24-51	42-78	75-99	49-66
Site R	% hatched	67	41	46	100	56
(old riverbed)	n	24	41	13	10	88
	95% C.I.	45-84	28-58	19-75	100	45-66
Site R	% hatched	No data	27	70	88	66
(cleared	n		11	20	16	47
riverbed)	95% C.I.		6-61	46-88	62-98	51-79
Total	% hatched	68	39	58	85	58
	n	75	122	69	61	327
	95% C.I.	56-78	30-48	46-70	73-93	52-64

cleared areas for foraging immediately, but only nested there later. Wrybills were seen in low numbers in cleared areas but only used old riverbed habitat for nesting. Wrybills are a highly specialised species and usually nest close to water (Robertson, O'Donnell and Overmars, 1983; Hay, 1984). Because the majority of willows that were removed were away from the main river channels, the habitat created was unlikely to be suitable for nesting wrybills. Also, areas of stable clear shingle were not present in cleared areas. Riverbed directly adjacent to the main river channels had been cleared of willows by the Canterbury Regional Council to provide clear flood channels in previous years. Thus, wrybills likely benefited from prior clearance of willows immediately adjacent to the rivers.

Wader nests closer to vegetation (Espie, Brigham and James, 1996) or den sites (Rebergen *et al*., 1998) are often at higher risk of predation. In this study we found that nests closer to cover or to den sites had higher predation rates at one site, but the relationship did not hold at the other site. Further work is needed to explain this result, as it may be that the effect of proximity of cover to nests is not universal.

Predation rates in areas of cleared riverbed in site R were similar to those in old riverbed, suggesting that providing new habitat by clearing vegetation does not provide a reduction in predation rates. In addition to weed control, identification of the key predators involved and subsequent predator control may be necessary to increase bird populations, particularly to counteract years of high predation such as that observed in 1992.

The willow removal reported in this study is the first such large scale enhancement of braided river habitat undertaken in New Zealand. Further surveys are necessary to determine the long-term effects of willow removal on bird populations. Introduced grasses and herbs have established on cleared riverbed since willows were removed, and their influence and subsequent changes in riverbed vegetation on river birds is unknown. The reduced water and flood flows may not be adequate to prevent the establishment of new vegetation, thus without ongoing maintenance the habitat may again become unsuitable for river birds.

Many of New Zealand's braided riverbeds are no longer suitable bird habitat because of invasion by exotic vegetation, and the rivers in the Mackenzie Basin may contain as much as half of the country's remaining suitable habitat (Maloney *et al*., 1997). Existing braided river habitat in the Mackenzie Basin is continually under threat from further encroachment by willows and other invasive introduced plant species such as lupins (*Lupinus polyphyllus* Lindley) (Hughey and Warren, 1997). Without weed control, the area of river bird habitat in the Mackenzie Basin will continue to decline.

This study indicates that removing willows may help to ensure the survival of river bird populations by providing suitable habitat. For willow removal to be an effective management tool in these systems, it needs to increase bird population numbers and not merely redistribute members of existing populations. If further surveys prove a long-term positive effect on river bird populations, willow removal should be instigated widely to enhance the remaining braided river habitat.

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