BEFORE THE COMMISSION
APPOINTED BY THE OTAGO REGIONAL COUNCIL

UNDER	the Resource Management Act 1991 (RMA)
IN THE MATTER	Of an application by Dunedin City Council for resource consent being processed with reference RM20.280
BY	**ŌTOKIA CREEK AND MARSH HABITAT TRUST, BIG STONE FORESTS LIMITED AND SOUTH COAST NEIGHBOURHOOD SOCIETY INC** **Submitter**

STATEMENT OF EVIDENCE OF KELVIN LLOYD

DATED 6 MAY 2022

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STATEMENT OF EVIDENCE OF KELVIN LLOYD

Introduction

1. My name is Kelvin Michael Lloyd I have been employed as an ecologist by Wildland Consultants Ltd from 2004 to the present, based in Dunedin, and my current position is Principal Ecologist. I specialise in terrestrial and wetland ecology.

Qualifications and Experience

2. I hold the degrees of Bachelor of Science with First Class Honours, and Doctorate of Philosophy, both obtained from the University of Otago, where my studies were undertaken at the Department of Botany. Subsequent to University study I was awarded a three year Post-Doctoral Fellowship from the Foundation for Research, Science and Technology, during which I was employed by Landcare Research Ltd in Dunedin

3. I am an author of 22 scientific papers published in peer-reviewed national and international scientific journals, as well as several popular articles. I have also presented aspects of my research at national and international scientific conferences. I have lectured in plant ecology at 3rd year level at the University of Otago. I remain an honorary research associate of Landcare Research Ltd and continue to publish research papers in collaboration with other scientists as time permits. I am a member of the New Zealand Ecological Society, the Ornithological Society of New Zealand, the New Zealand Biosecurity Institute, the New Zealand Native Forest Restoration Trust, and the New Zealand Plant Conservation Network.

4. My work as an ecological consultant has covered a wide range of vegetation types, including wetlands, grasslands, shrublands, forests, and alpine vegetation. This work has included ecological investigations of areas of vegetation throughout New Zealand, including sites in Northland, Auckland, Hawkes Bay, Wairarapa,

Horowhenua, Wellington, Chatham Islands, Marlborough, Nelson, Canterbury, Buller, Westland, Otago, and Southland. I am an author of almost 300 contract reports covering these assessments and I have prepared expert evidence in 32 Environment Court or similar cases in relation to these projects.

5. My experience includes numerous assessments of large-scale developments affecting indigenous vegetation and habitats. These include assessments of roading and transportation developments, the proposed monorail through Snowdon Forest and Fiordland National Park, and the proposed tunnel between the Routeburn and Hollyford Valleys. I have also undertaken ecological assessments relating to several large wind farms, hydro-electric and water storage reservoirs, and open cast coal and gold mines affecting natural areas.

6. I have considerable experience in biodiversity offsetting, having led several Wildlands projects, contracted by the Department of Conservation, to assess the utility of biodiversity offsetting in New Zealand. I routinely provide technical advice to other Wildlands staff on the design of robust biodiversity offsetting approaches.

7. In 2019 I provided evidence on biodiversity offsetting and compensation on behalf of the Director-General of Conservation at the Notices of Requirement (NOR) hearing for the proposed Manawatu Gorge highway realignment. In 2020 I reviewed an offsetting approach for a wetland affecting by roading in Invercargill[1]. I recently provided technical advice to Otago Regional Council on biodiversity offsetting and compensation policy in the proposed Otago Regional Policy Statement.

8. Some of my work experience which is relevant to this application is as follows:

   (a) In 2021 I prepared a strategic biodiversity plan for the Otokia Creek catchment, for the Otokia Creek and Marsh Enhancement

[1] Wildland Consultants 2020: Review of Elles Road wetland biodiversity offsetting proposal. *Wildland Consultants Contract Report No. 5211a*. Prepared for Beale Consultants Ltd. 3 pp.

Trust (Attachment 1). For this project I visited several sites in the catchment, including the site of the proposed landfill.

(b) In 2021 I provided evidence for a resource consent hearing for a rural subdivision and existing effluent system and their effects on a natural wetland and permanent stream in Nelson.

(c) In 2020 I led a project to better delineate Otago's regionally significant wetlands, including marsh wetland near the mouth of Otokia Creek.

(d) In 2020 I led a project to map the potential natural ecosystems, current ecosystems, and significant habitats of indigenous fauna, across Otago, including across the Otokia Creek catchment. This included the mapping of over 8,000 wetlands across Otago.

(e) Also in 2020, I led a project that involved detailed mapping of indigenous and exotic vegetation cover across Dunedin City District, including across the Otokia Creek catchment.

(f) Wildland Consultants has assessed other coastal wetlands in the area, such as Akatore Creek swamp[2] and the Takitakitoa wetland.

Expert witness code of conduct

9. Although not necessary in respect of council hearings, I can confirm I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note dated 1 December 2014 and agree to comply with it. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

[2] Wildland Consultants 2012: Ecological assessment of Akatore Creek swamp. *Wildland Consultants Contract Report No. 2874*. Prepared for Otago Regional Council. 12 pp.

Scope and Structure of Evidence

10. My evidence will address the following matters within my areas of expertise:

    (a) Description of Ōtokia Creek and Environs

    (b) Fish and Macroinvertebrate Communities

    (c) Ecological Values

    (d) Effects of discharges and leachate on flora and fauna

    (e) Could adverse effects be remedied and mitigated?

    (f) The utility of the EIANZ framework used in the application.

    (g) The utility of the biodiversity offsetting framework used in the application

11. In this evidence, Appendix 11 of the application, the ecological impact assessment, is referred to as the 'ecology report'.

12. In preparing this evidence I have also reviewed the following evidence and documents:

    (a) The evidence of Andrew John Rumsby

    (b) The evidence of David Ife

    (c) Tonkin & Taylor technical review 2022: Smooth Hill landfill - Appendix 11 - Ecology assessment.

    (d) Smooth Hill landfill draft landfill management plan framework

    (e) Smooth Hill landfill Conditions (final)

13. I wish to note that at the time of writing this evidence I had not had an opportunity to review all the evidence filed by the Applicant of relevance to my area of expertise. I will have done so prior to the hearing and will advise if it alters any of my conclusions.

The Otokia Creek catchment

14. The proposed landfill is located in the western headwater catchment of Otokia Creek. The Otokia Creek catchment is large (2,704 hectares) and retains approximately a quarter of this area in indigenous forest. Small gully wetlands are common in the upper catchment, and a significant marsh wetland, recognised as a regionally significant wetland, is located just upstream from Brighton. This wetland supports areas of saltmarsh habitat and is the focus of an ecological restoration project run by the Trust.

15. The ecology report describes this wetland as "modified and partially drained", but while channels have been excavated in the wetland, these have not 'drained' it. The hydrology of the wetland is relatively intact and dominated by its connection to the brackish main stem of the lower part of Otokia Creek, but also has freshwater inputs from a northern tributary. The lower Otokia Creek is a low energy water body affected by tidal events, and which is occasionally blocked from reaching the sea. As such, it represents a receiving environment for any sediment or contaminants that enter the creek in upstream areas.

16. Spatial prioritisation has identified indigenous broadleaved forest associations in the catchment, and the main stem of Otokia Creek, as high priority sites within Otago[3]. Land Environments in the Otokia Creek catchment are largely covered with the less than 30% of their original indigenous cover. The greatest loss has been experienced at low elevation and on broad ridges. The proposed landfill site is covered by land environments that retain only 10-20% of their indigenous cover.

Fish and Macroinvertebrates

17. Fish and macroinvertebrate records from Otokia Creek, obtained by Trust members from 2011-2017, include records of giant kōkopu (*Galaxias argenteus*), inanga (*Galaxias maculatus*), common bully

[3] Leathwick J. 2020: Indigenous biodiversity rankings for the Otago Region. Report prepared for Otago Regional Council. 79 pp.

(*Gobiomorphus cotidianus*), giant bully/tīpokopoko (*Gobiomorphus gobioides*), and short-fin eel (*Anguilla australis*). Brown trout (*Salmo trutta*) are also present. Kōura (*Paranephrops zelandicus*) have been recorded in upper catchment, and kakahi (freshwater mussel; *Echydriella menziesii*) has also been recorded in the creek. Short-fin eel had been feeding on freshwater shrimps, bullies, and slugs.

18. More recently, a water sample obtained from the lower Otokia Creek was analysed for eDNA. This sample confirmed records of giant kokopu, common bully, and shortfin eel, and added new records for banded kokopu (*Galaxias fasciatus*), longfin eel (*Anguilla dieffenbachii*), and redfin bully (*Gobiomorphus huttoni*).

19. A range of freshwater invertebrates were also revealed by the eDNA analysis, including ciliates, oligochaete worms, sludgeworms, algae, cryptomonads, bivalves, and other invertebrates.

20. Of these species, giant kōkopu and longfin eel are classified as At Risk-Declining, while giant bully is classified as At Risk-Naturally Uncommon[4]. Kākahi and kōura are both classified as At Risk-Declining[5].

21. These records indicate that the lower Otokia Creek comprises an important freshwater habitat.

Avifauna

22. The ecology report notes that 51 bird species that may utilise habitats at the landfill site were identified in a desktop review, but that this was narrowed to 31 species after exclusion of species that had primary habitats elsewhere or are likely to be rare visitors. In addition to the other sites of significance the report notes, the Otokia Creek marsh

[4] Dunn N.R., Allibone R.M., Closs G.P., Crow S.K., David B.O., Goodman J.M., Griffiths M., Jack D.C., Ling N., Waters J.M. and Rolfe J.R. 2018: Conservation status of New Zealand freshwater fishes, 2017. *New Zealand Threat Classification Series 24*. Department of Conservation, Wellington. 11 pp

[5] Grainger N., Collier K., Hitchmough R., Harding J., Smith B., and Sutherland D. 2014: Conservation status of New Zealand freshwater invertebrates, 2013. *New Zealand Threat Classification Series 8*. Department of Conservation, Wellington. 28 pp

wetland is known to provide habitat for additional species, including white heron (*Ardea modesta*; Threatened-Nationally Critical), royal spoonbill (*Platalea regia*; At Risk-Naturally Uncommon) and black stilt (*Himantopus novaezelandiae*; Threatened-Nationally Critical)[6].

Vegetation and Habitats

23. The ecology report provides a comprehensive description of the vegetation and habitats of the designation area containing the landfill site. Kānuka (*Kunzea robusta*) is the only Threatened, At Risk, or locally uncommon plant species observed. However two of the species observed in kānuka forest, gully fern (*Pneumatopteris pennigera*) and leafless lawyer (*Rubus squarrosus*) are uncommon in the Dunedin area.

24. A natural wetland is present downstream of the proposed landfill, which is described in the ecology report as a 'Harakeke-gorse/(purei-rautahi) flaxland. Other species found in this wetland include trees such as makomako (*Aristotelia serrata*), tarata (*Pittosporum eugenioides*), and radiata pine (*Pinus radiata*).

Potential Effects on Wetland Integrity

25. The Tonkin & Taylor review of the application concludes that it is uncertain if the reduction in surface runoff will affect the wetland because insufficient information has been provided by the Applicant. The Applicant claims that changes in hydrology would not affect wetland extent because similar wetlands are present in smaller catchments in the local landscape, and because the wetland contains indigenous plant species that are adapted to varying runoff and prolonged dry periods.

26. This conclusion by the Applicant does not take account of dryland species increasing in cover within the wetland if water supply to it decreases. Gorse, for example, already a prominent plant in the

[6] Attachment 1: Wildland Consultants 2021: Strategic biodiversity plan for the Otokia Creek and Marsh Habitat Trust, Brighton, Otago. *Wildland Consultants Contract Report No. 5770*. Prepared for the Otokia Creek and Marsh Habitat Trust. 26 pp.

wetland, could increase in abundance at the expense of lower-stature indigenous plant species such as sedges and rushes. Similarly, trees such as makomako, tarata, and radiata pine could invade further and have similar shading effects. This could reduce the extent of indigenous dominance in the wetland.

27. Even though it is proposed to control weeds in the wetland and plant indigenous wetland obligates, if persistent adverse hydrological changes occurred the wetland would remain vulnerable to invasion of dryland species after project closure.

Potential Downstream Effects

28. The ecology report identifies potential downstream effects including discharge of contaminants, discharge of sediment, and reduced water supply, and acknowledges that any hydrological changes would persist following landfill decommissioning. The ecology report suggests a pond located 300 metres downstream of the designation area would act as a water supply buffer to freshwater habitats downstream, but it is not clear how this would happen, as in dry periods, surface water is restricted to the pond. The pond therefore appears to be a sink for water rather than a source.

29. The issue of contaminants from the proposed landfill reaching the significant habitat in the lower Otokia Creek is understandably of great concern to the Trust. The evidence of Matthew York shows that extreme flood events can affect the landfill area. I am aware that consented works can fail to protect water ways. For example, Bullock Creek in Wanaka is regularly exposed to sedimentation from subdivision earthworks despite upstream controls being in place. Similarly, I recently provided evidence on a proposed subdivision in Nelson, where a consented existing effluent system was shown to be discharging unacceptable levels of contaminants to an adjacent stream, and was declared non-compliant. Although ‘best practice’ methods may be used to reduce the risk of landfill leachate entering soil, ground water, or surface water, there remains a risk of

contaminants reaching Otokia Creek, as these controls may fail or have relatively service life, as detailed in the evidence of Mr Rumsby[7].

30. The evidence of Mr Rumsby notes a risk of biological accumulation of highly mobile PFAS (Per and Polyfluoroalkyl substances) in aquatic organisms such as eels, gastropods, and crustaceans[8]. As described above, these biota are present in Otokia Creek. Mr Rumsby also refers to food chain bio-magnification of toxins as a pathway, which can be more significant than direct toxicity from exposure to water or sediment[9]. Mr Ife concludes that seepage of persistent organic pollutants through the landfill liner will be significant[10].

Proposed Pest Control

31. The ecology report states that an 'appropriate' predator control programme is to be designed for the designation site, and recommends that ongoing trapping is undertaken in selected habitats to benefit lizards. No detail is provided on this proposed predator control programme, and as such its effectiveness is uncertain.

32. The Landfill Management Plan contains only draft content on pest animal monitoring, and does not specify the control methods nor the spatial arrangement of control devices. As such, it is impossible to assess whether the pest control programme would be effective. In this context, the increased densities of rodents and mustelids that are expected result from landfill operation[11] would exert a stronger predation effect on indigenous fauna than is currently the case.

33. Fencing is proposed to exclude pigs and goats from 'high value biodiversity sites' within the designation boundary. The use of deer netting for this fencing would be most effective to prevent access by goats and feral deer, and this alone would have a positive effect on

[7] Paragraphs 46-66 of the evidence of Mr Rumsby.
[8] Paragraph 30 of the evidence of Mr Rumsby.
[9] Paragraph 33 of the evidence of Mr Rumsby.
[10] Paragraph of the evidence of Mr Iles
[11] Section 5.3.4 of the ecology report

forest biodiversity. Pigs often find weaknesses in fences, such as small gullies crossed by fences where pigs can pass beneath the fence.

Proposed Planting

34. It is proposed to plant kahikatea in wetlands as a wetland enhancement action. While kahikatea can grow in wetlands, it doesn't require wetland habitat and is likely to grow relatively slowly in such habitat. The ecology report claims that kahikatea would rapidly become the tallest trees in the wetland area, and thus improve habitat complexity and provide nesting habitat for birds. In my opinion this vastly overstates the speed at which significant benefits of planted kahikatea would accrue. Based on kahikatea growth rates in the Dunedin area, it would take many decades before planted kahikatea grow sufficiently large to provide significant habitat complexity and nesting habitat.

Proposed monitoring

35. The Landfill Management Plan (LMP) contains only draft content on pest animal monitoring, and does not specify the control methods nor the spatial arrangement of particular control devices. Only in the lizard release area is a bait station/trapping grid defined, but even here the distribution of bait stations and traps on this grid is not specified, and the protocol to check and refill quarterly relates only to bait stations, and not to traps. As such, it is impossible to assess whether the pest control programme would be effective.

36. The monitoring section of the LMP is incomplete, and does not provide any detail on monitoring sites, methods, or frequency. This is a major deficiency of the application, particular given the ecological benefits claimed and the risks of downstream effects.

37. Surface water quality monitoring is proposed to be undertaken "at least every few months" in one part of the proposed conditions[12], but weekly

[12] Proposed Condition 17.

(when flow occur) in a different part[13]. Three monthly monitoring would be a very low frequency of monitoring that would almost certainly miss sediment and contaminant pulses after high rainfall events. Sampling and analysis of deposited sediment in downstream reaches of Otokia Creek should also be undertaken, as sediment provides a time-integrated sample of contaminants that capture intermittent contributions from flood flows[14]. It is important that baseline information is collected for 1-2 years prior to project works.

38. I support monitoring of freshwater biota for bioaccumulative contaminants, as discussed by Mr Rumbsy[15].

EIANZ framework

39. The EIANZ framework (set out in Section 2.9 of the ecology report) is not helpful to the application. A key issue is that it relies on subjective assessment of ecological values, and the effects of this flow through to the outcomes of the framework. The framework makes indigenous biodiversity abstract, by classifying it into high, moderate or low values or levels of effect. Furthermore, the final table used to generate an overall level of effect has arbitrary values that represent inconsistent mathematical operations.

40. As an example of the subjective input, the review of the application by Tonkin and Taylor often disagrees with the levels of effects outlined in the ecology report.

41. The lack of utility of the framework can be seen in its outcomes. For example, loss of 'significant wetland habitat adjacent to roadsides' is assessed as a very low level of ecological effect, which according to Section 2.9 of the ecology report 'should not normally be of concern' and is 'generally classed as a not more than minor effect'. None the less, when statutory policy is considered (The Otago RPS, Dunedin

[13] The table in Proposed Condition 19.
[14] Wildland Consultants 2020: Land use effects on the health of urban streams in Wanaka. *Wildland Consultants Contract Report No 4922*. Prepared for the Upper Clutha Lakes Trust and Otago Fish and Game Council. 77 pp.
[15] Paragraph 42 of the evidence of Mr Rumsby.

City District Plan, National Policy Statement for Freshwater Management, National Environmental Standards for Freshwater Management), these effects are definitely of concern, and 'no net loss, or net gain', is the required level of offset. Thus the EIANZ criteria reach different, and much less conservative outcomes compared to statutory policy.

42. In my opinion, the EIANZ framework is a smoke-screen and is not helpful in assessing the potential effects of the proposed landfill.

Biodiversity offsetting accounting model

43. The biodiversity offsetting currency (Appendix 7 of the ecology report) has very limited value.

    (a) It includes only two attributes, indigenous wetland cover, and indigenous wetland tiers. This conceals the identity of species, and could result in just one or two species making up the indigenous cover.

    (b) The after-offset number of wetland tiers could be achieved instantly once planting had been undertaken in the wetland, by planting species representing those tiers (e.g. trees, shrubs, sedges, herbs).

    (c) There is no currency for indigenous fauna such as lizards or birds.

44. As such, the offsetting outcome provides no certainty that a substantial net gain would be achieved. Rather, there will be net loss of wetland extent (albeit small) if no additional wetland area is created.

Conclusions

45. The Otokia Creek catchment supports important ecological values that have been recognised as high priorities in regional prioritisation. The Otokia Creek marsh wetland and adjacent riverine habitat is vulnerable as a receiving environment, and particularly important as habitat for indigenous fauna, including for birds, fish, and macroinvertebrates.

46. Key ecological issues are adverse effects on a downstream wetland and the potential for contaminants and sediment to reach Otokia Creek and be carried down to the lower river and its important habitats.

47. There is scant detail on proposed pest control to benefit terrestrial ecological values, and as such it is impossible to assess whether this will be effective.

48. Fencing of indigenous forest within the designation site is supported, and should comprise deer fencing to prevent access by feral goats and deer.

49. Proposed planting of kahikatea overstates the benefits of this action, and especially the timeframe for achieving benefits.

50. The EIANZ framework is subjective and its outcomes differ from those of statutory policy. As such, the framework provides little utility for the application.

51. The proposed offsetting approach has limited value, and does not provide any certainty that a net gain may be achieved.

52. Monitoring proposals are couched only in broad terms and have no detailed methodology on monitoring design, methods, or frequency. This is a major deficiency of the project. Monitoring in downstream reaches of Otokia Creek should include regular sampling and analysis of both freshwater biota and sediment in order to detect potential contamination. Water sampling may easily miss first flush events which typically carry the most contaminants.

Kelvin Lloyd

5 May 2022

STRATEGIC BIODIVERSITY PLAN FOR THE OTOKIA CREEK AND MARSH HABITAT TRUST, BRIGHTON, OTAGO

providing outstanding ecological services to sustain and improve our environments

Wildlands

R5770

STRATEGIC BIODIVERSITY PLAN FOR THE OTOKIA CREEK AND MARSH HABITAT TRUST, BRIGHTON, OTAGO

Slopes planted by the Trust, with lower Otokia Creek and marshland below.

Contract Report No. 5770

April 2021

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Reviewed and approved for release by:

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1. INTRODUCTION

The Otokia Creek and Marsh Habitat Trust (the Trust) is keen to enhance the ecological functioning of the Otokia Creek catchment in coastal Otago. The Otokia Creek catchment is a large 2,704 hectare catchment on the Otago Coast, with the mouth of the river reaching the sea at Brighton (Figure 1).

The Trust engaged Wildland Consultants to provide advice on ecological enhancement opportunities for the Otokia Creek catchment, and to develop and evaluate priorities for the Trust.

2. METHODS

A visit to the Otokia Creek catchment was undertaken on 19 March 2021 to assess the activities of the Trust and to inspect potential enhancement sites in the catchment.

Existing information on the catchment was reviewed, including potential ecosystem mapping (Wildland Consultants 2020a), significant habitats of indigenous fauna mapping (Wildland Consultants 2020b), and detailed vegetation mapping (Wildland Consultants 2020c). Information on water quality, birds, and freshwater fish was provided by the Trust and was also reviewed.

Aerial imagery and information on more intact estuaries further south on the coast was reviewed to determine the likely historic estuarine vegetation pattern at the mouth of Otokia Creek.

Potential for future work was evaluated and relative priorities were developed.

3. ECOLOGICAL CONTEXT

3.1 Topography and sub-catchments

The Otokia Creek catchment is a large catchment oriented parallel to the coastal Otago hills, distinguishing it from the many smaller catchments to the north and south, which run more directly to the sea (Figure 1). The catchment ranges from sea level at its mouth to high points just over 300 metres above sea level north of Maclaren Gully Road, and to 355 metres above sea level at Scroggs Hill at the northern end of the catchment (Figure 1). McColl Creek and Scrub Creek are major sub-catchments in the northern part of the wider catchment, while smaller un-named tributaries run into Otokia Creek in the southern part of the catchment (Figure 1). The catchment largely comprises moderately steep hill country landforms with numerous gullies and intervening ridges, but also contains gently sloping land near the coast.

3.2 Protected areas

Several large protected areas are present in the centre of the Otokia Creek catchment (Figure 1), comprising Conservation Area - Hope Hill, and contain important remnants

of podocarp/broadleaved forest as well as kānuka-dominant forest and regenerating forest.

Forest in gullies under Gledknowe at the southern end of the catchment are protected by conservation covenants, and there is a QEII covenant protecting marshland just above Brighton (Figure 1).

The Lower Otokia Creek Marsh, which extends beyond the QEII covenant, is identified as a regionally significant wetland in the Otago Regional Plan: Water for Otago, and is also recognised as an area of significant biodiversity value (ASBV) in Chapter 10, Appendix A.1.2 of the operative Dunedin City District Plan.

3.3 Threatened Environments

The Threatened Environment Classification is a combination of three national databases: Land Environments New Zealand (LENZ), classes of the 4th Land Cover Database (LCDB4, based on 2012 satellite imagery) and the protected areas network (version 2012, reflecting areas legally protected for the purpose of natural heritage protection). The classification provides national scale context on how much indigenous cover remains within LENZ environments, and how past vegetation loss and legal protection are distributed across New Zealand (Cieraad *et al.* 2015).

The Threatened Environment Classification for the Otokia Creek catchment is shown in Figure 2. Two patterns of loss are evident, with land environments on gentle topography at low elevation and on elevated ridges having been the most susceptible to vegetation loss. The catchment is mostly (1,471 hectares) within At Risk land environments that have lost 20-30% of their indigenous cover, followed by Acutely Threatened (613 hectares) and Chronically Threatened (604 hectares) land environments that have less than 10% and 10-20% if their former indigenous cover respectively. Only a very small area (16.5 hectares) of the catchment is covered by land environments that are Less Reduced and Better Protected, with >30% indigenous vegetation cover remaining, and >20% of it protected.

3.4 Potential natural vegetation

Five potential natural ecosystem types have been mapped within the Otokia Creek catchment (Wildland Consultants 2020; Figure 3), based on a national classification of New Zealand's indigenous ecosystems (Singers and Rogers 2014). At the coastal end of the catchment, non-vegetated beach, foredune sedgeland (DN3 pingao sedgeland), and rear dune forest (CLF2 Halls tōtara forest [dune forest]) would have been present on sandy landforms. A belt of relatively warm forest corresponding to MF3 matai, tōtara, kahikatea, broadleaved forest would have been present on the coastal plains and gently rolling foothills behind the dune forest. Further upslope, cooler forest corresponding to CLF4 kahikatea, tōtara, matai forest would have been widespread across the catchment, with a rimu-dominant variant in the vicinity of Scroggs Hill (Figure 3). Wetlands dominated by *Carex* sedges, corresponding to WL22 *Carex*, *Schoenus pauciflorus* sedgeland would have been present in gullies. Marsh wetland ecosystems near the mouth of the creek are missing from potential ecosystem mapping, but would have historically comprised WL18 flaxland, dominated by

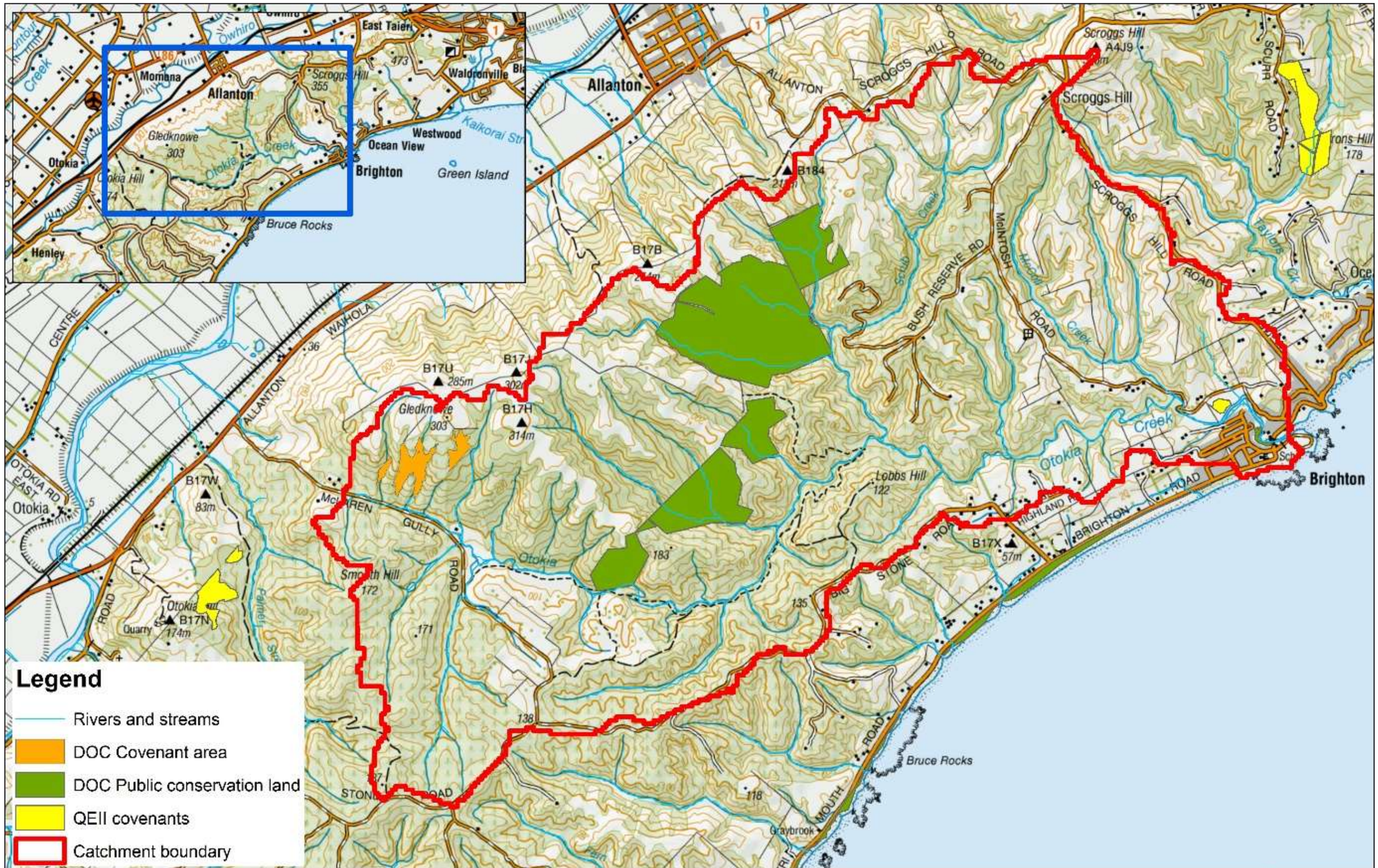

Figure 1. Location of Otokia Creek.

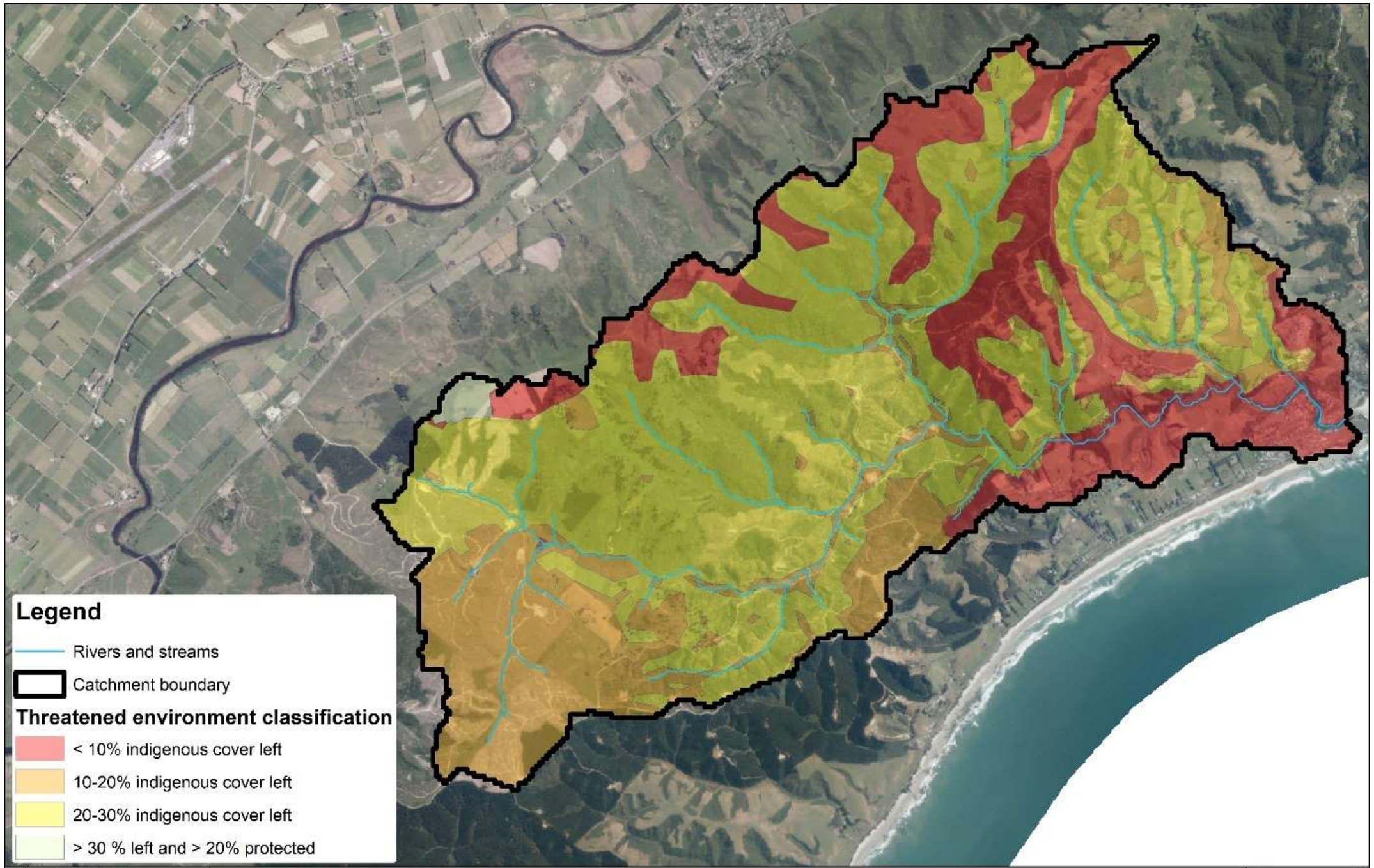

Figure 2. Threatened Environment Classification of the Otokia Creek catchment.

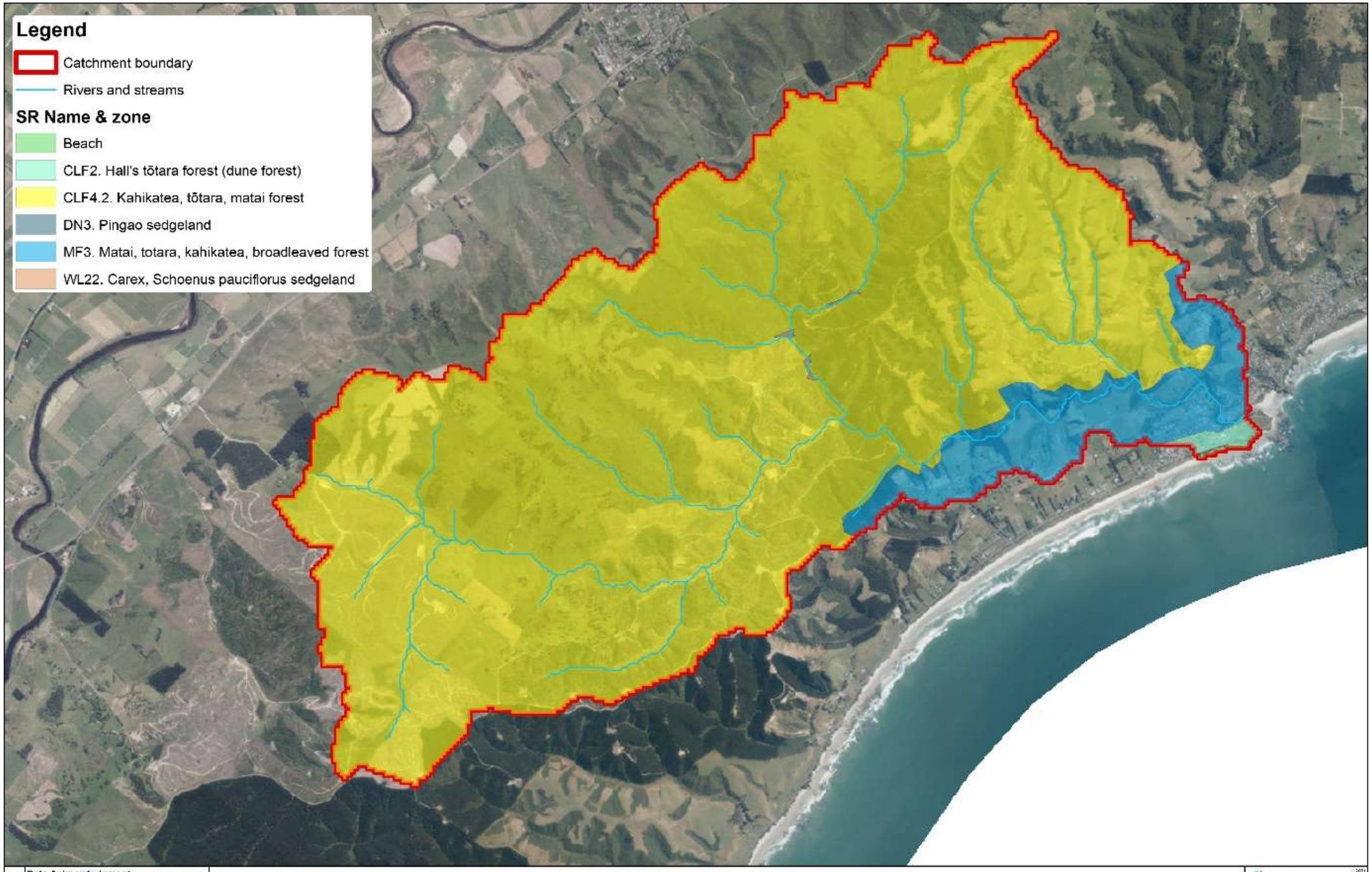

Figure 3. Potential Natural Ecosystems of the Otokia Creek catchment.

harakeke (*Phormium tenax*) in freshwater marshes, and WL10 oioi restiad rushland/ reedland, dominated by oioi (*Apodasmia similis*) in brackish marshes.

3.5 Recent spatial prioritisation

Spatial prioritisation of indigenous biodiversity remaining in Otago was undertaken by Leathwick (2020). Much of the kānuka-broadleaved, broadleaved, and podocarp/broadleaved indigenous forest in the Otokia Creek catchment is ranked in the top 20% of sites in Otago.

The ranking of rivers and streams has ranks allocated to individual stream reaches. The main stem of Otokia Creek above the marshland is ranked in the top 10% of sites in Otago (Leathwick 2020).

3.6 Trust activities to date

The Trust has initiated planting of ecologically-appropriate indigenous tree species on slopes above the Lower Otokia Creek marsh, and has cleared a track around the margin of the marsh on the southern side of Otokia Creek.

Trust members have also monitored water quality in the catchment, and engaged with landholders and forestry companies in relation to access to riparian planting.

4. CURRENT VEGETATION

Current vegetation in the Otokia Creek catchment is predominantly exotic, comprising plantation forest dominated by radiata pine (*Pinus radiata*), which covers 38% of the catchment, and high producing exotic grassland, which covers 28% (Wildland Consultants 2020b; Figure 4). The most common indigenous vegetation types are kānuka-dominant forest and scrub (18%), which is present in most gullies (Figure 4), broadleaved forest (4%), and podocarp/broadleaved forest (3%). A mixed forest type, regenerating forest, largely comprising areas of gorse with scattered kānuka or broadleaved trees, covers 4% of the catchment.

Riparian vegetation in the catchment includes the following:

- Crack willow (*Salix fragilis*) is commonly present along the lower part of the creek, and dense gorse scrub is commonly present on the hill slopes above the creek in these areas, especially on sunny slopes (Figure 4).
- Shady slopes above the creek support remnants of indigenous forest.
- Northeastern tributary streams drain farmland and the steep-sided gullies along these tributaries typically support stands of kānuka-dominant forest and treeland (Plate 1; Figure 4).
- Central and northwestern gullies within the catchment contain more diverse areas of kānuka-broadleaved forest.

- Southern and southwestern parts of the catchment comprise exotic plantation forest and have relatively little indigenous riparian vegetation cover (Figure 4).

Plate 1: Part of the McColls Creek catchment in the northeastern part of the wider catchment, with stands of kānuka lining gullies.

Plate 2: Riparian land beside lower Otokia Creek, suitable for planting of indigenous forest species.

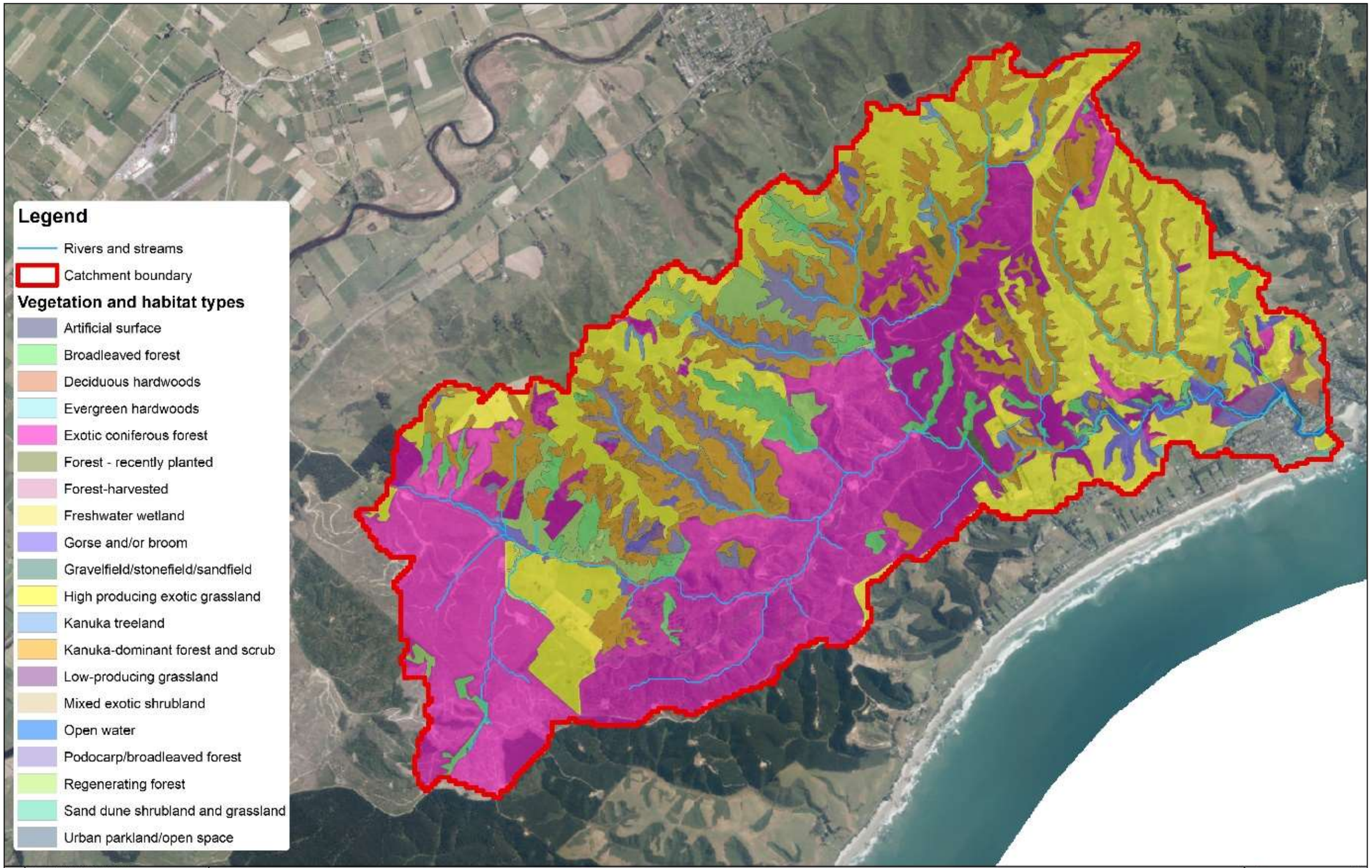

Figure 4. Current vegetation cover of the Otokia Creek catchment.

5. FAUNA

5.1 Avifauna

Larger examples of indigenous podocarp/broadleaved forest, broadleaved forest, and kānuka-dominant forest within the Otokia Creek catchment have been identified as significant habitats of indigenous forest birds (Wildland Consultants 2020b).

The eBird database contains records of 40 bird species (excluding coastal birds and seabirds) within the Otokia Creek catchment, or close to it (Table 1). Four additional bird species - domestic goose (*Anser anser*), kotuku (white heron; *Ardea modesta)*, Canada goose (*Branta canadensis*), and kaki (black stilt; *Himantopus novaezelandiae*) - have also been recorded from the Lower Otokia Creek Marsh (Matthew York, Otokia Creek and Marsh Habitat Trust, pers comm.).

Of these species, kotuku and kaki are classified as Threatened-Nationally Critical, torea and red-billed gull are classified as At Risk-Declining, New Zealand falcon and torea pango (variable oystercatcher; *Haematopus unicolor*) are classified as At Risk-Recovering, and royal spoonbill (*Platalea regia*) is classified as At Risk-Naturally Uncommon (Hitchmough *et al.* 2016). New Zealand falcon is likely to have breeding habitat in the catchment, as exotic plantation forest provides good breeding and feeding habitat for karearea/New Zealand falcon. Torea may also breed on farmland within the catchment. The other species are all likely to visit the Otokia Creek marsh habitats for feeding and resting, but are not likely to breed in the catchment.

Table 1: Terrestrial and wetland bird species observed within or adjacent to the Otokia Creek catchment, based on eBird records and personal observations of Matthew York. Threat classification is from Hitchmough *et al.* 2016.

Species	Common Name	Threat Classification
Alauda arvensis	Skylark	Introduced and Naturalised
Anas gracilis	Grey teal	Not Threatened
Anas platyrhynchos	Mallard	Introduced and Naturalised
Anas rhynchotis	Australasian shoveler	Not Threatened
Anser anser	Domestic goose	Introduced and Naturalised
Anthornis melanura	Kōparapara; bellbird	Not Threatened
Ardea modesta	Kotuku; white heron	Threatened-Nationally Critical
Branta canadensisi	Canada goose	Introduced and Naturalised
Carduelis carduelis	Goldfinch	Introduced and Naturalised
Carduelis chloris	Greenfinch	Introduced and Naturalised
Carduelis flammea	Redpoll	Introduced and Naturalised
Chrysococcyx lucidus	Pipiwharauroa; shining cuckoo	Not Threatened
Circus approximans	Kahu; Australasian harrier	Not Threatened
Columba livia	Rock pigeon	Introduced and Naturalised
Cygnus atratus	Black swan	Not Threatened
Egretta novaehollandiae	White-faced heron	Not Threatened
Emberiza citrinella	Yellowhammer	Introduced and Naturalised
Falco novaeseelandiae	New Zealand falcon	At Risk-Recovering
Fringilla coelebs	Chaffinch	Introduced and Naturalised
Gerygone igata	Riroriro; grey warbler	Not Threatened
Gymnorhina tibicen	Australasian magpie	Introduced and Naturalised
Haematopus finschi	Torea; New Zealand oystercatcher	At Risk-Declining
Haematopus unicolor	Torea pango; variable oystercatcher	At Risk-Recovering
Hemiphaga novaeseelandiae	Kererū; New Zealand pigeon	Not Threatened
Himantopus leucocephalus	Pied stilt	Not Threatened

Species	Common Name	Threat Classification
Himantopus novaezelandiae	Black stilt	Threatened-Nationally Critical
Hirundo neoxena	Welcome swallow	Not Threatened
Larus dominicanus	Black-backed gull	Not Threatened
Larus novaehollandiae	Red-billed gull	At Risk-Declining
Passer domesticus	House sparrow	Introduced and Naturalised
Petroica macrocephala	Miromiro; tomtit	Not Threatened
Phalacrocorax melanoleucos	Little shag	Not Threatened
Platalea regia	Royal spoonbill	At Risk-Naturally Uncommon
Platycercus eximius	Eastern rosella	Introduced and Naturalised
Porphyrio melanotus	Pukeko	Not Threatened
Prosthemadera novaeseelandiae	Kōkō; tui	Not Threatened
Prunella modularis	Dunnock	Introduced and Naturalised
Rhipidura fuliginosa	Piwakawaka; fantail	Not Threatened
Sturnus vulgaris	Starling	Introduced and Naturalised
Tadorna variegata	Putangitangi; paradise shelduck	Not Threatened
Todiramphus sancta	Kotare; kingfisher	Not Threatened
Turdus merula	Blackbird	Introduced and Naturalised
Turdus philomelos	Song thrush	Introduced and Naturalised
Vanellus miles	Spur-winged plover	Not Threatened
Zosterops lateralis	Pipihi; silvereye	Not Threatened

5.2 Bats

Bats have not been detected recently in the Otokia Creek catchment, but the catchment is located within an area identified as a high priority for bat surveys (Wildland Consultants 2020b).

5.3 Lizards

There are no lizard records in the Department of Conservation BioWeb Herpetofauna Database or in the public iNaturalist database for the Otokia Creek catchment, although the database does show records for lizards within a 10-kilometre radius. Lizards known from elsewhere within the Tokomairiro and Dunedin Ecological Districts include the jewelled gecko (*Naultinus gemmeus*, At Risk-Declining), korero gecko (*Woodworthia* "Otago/Southland large", At Risk-Declining[1]), Otago green skink (*O.* aff. *chloronoton* “Eastern Otago”, At Risk-Declining), cryptic skink (*O. inconspicuum*, At Risk-Declining) and southern grass skink (*O.* aff. *polychroma* Clade 5, At Risk-Declining) (Bell and Wiles 2015). Some of these species are likely to be present locally, especially southern grass skink. All indigenous lizards are protected by the Wildlife Act (1953).

The absence of lizard records is not necessarily due to absence of lizards, but a lack of survey effort to date. Lizard populations are often (but not always) in low densities in mainland New Zealand due to predation pressure and habitat modification. Indigenous lizards are highly cryptic and can be particularly difficult to find, especially when in low numbers.

Within the Otokia Creek catchment, lizard populations may be found in marsh and riparian habitat (Otago green skink, cryptic skink, southern grass skink). Jewelled gecko may be found in kānuka-dominant forest and scrubland habitat and there are also

[1] Threat classifications are from Hitchmough *et al.* (2016).

some records of this species in exotic plantation forest. Southern grass skink is likely to be widespread in areas of rank exotic grassland. Korero geckos may not be present locally, unless there are rocky sites.

5.4 Freshwater fish and invertebrates

Information on freshwater fish observations and surveys undertaken in Otokia Creek from 2011-2017 was provided by Matthew York (Otokia Creek and Marsh Habitat Trust) and are summarised below:

- Giant kōkopu (*Galaxias argenteus*), inanga (*Galaxias maculatus*) unidentified kōkopu (*Galaxias* sp.), common bullies (*Gobiomorphus cotidianus*), giant bully (tīpokopoko; *Gobiomorphus gobioides*) and shortfin eel (*Anguilla australis*) have been recorded from the Otokia Creek catchment.
- Dissected shortfin eels have been found to have been feeding on freshwater shrimps, bullies, and slugs.
- Flounder (*Rhombosolea plebeia*) have been observed near the mouth of Otokia Creek.
- Brown trout (*Salmo trutta*) have also been observed within the creek, actively chasing bullies.
- Kōura (*Paranephrops zelandicus*) have been observed in upper catchments of Otokia Creek, and kākahi (freshwater mussel; *Echydriella menziesii*) have also been recorded in the creek.

Subsequently (April 2021), a water sample obtained from the lower Otokia Creek by Matthew York was analysed for eDNA. This sample confirmed records of giant kokopu, common bully, and shortfin eel, and added new records for banded kokopu (*Galaxias fasciatus*), longfin eel (*Anguilla dieffenbachii*), and redfin bully (*Gobiomorphus huttoni*). These records indicate that the lower Otokia Creek is an important habitat for indigenous fish.

Of these species, giant kōkopu and longfin eel are classified as At Risk-Declining, while giant bully is classified as At Risk-Naturally Uncommon (Dunn *et al.* 2018). Kākahi and kōura are both classified as At Risk-Declining (Grainger *et al.* 2014).

Additional invertebrates and algae identified from the eDNA sample are recorded in Table 2.

Table 2: Freshwater invertebrates and algae from an Otokia Creek water sample identified to species level based on eDNA analysis.

Species	Common Name/Group
Acrispumella msimbaziensis	Alga
Carchesium polypinum	Ciliate
Chaetogaster diastrophus	Oligochaete worm
Chomulinospumella sphaerica	Golden alga
Chydorus sphaericus	Crustacean
Cryptomonas paramecium	Cryptomonad
Cryptomonas pyrenoidifera	Cryptomonad

Species	Common Name/Group
Cyclidium marinum	Ciliate
Halteria grandinella	Ciliate
Hydra vulgaris	Freshwater polyp
Mallomonas akrokomus	Chrysomonad
Nais communis	Sludgeworm
Paranais litoralis	Oligochaete worm
Protocyclidium citrullus	Ciliate
Psidium hodgkini	Freshwater bivalve
Schmidtea mediterranea	Flatworm
Simocephalus vetulus	Water flea
Stentor roesellii	Ciliate
Stylodrilus heringianus	Oligochaete worm
Tubifex tubifex	Sludge worm

6. OPTIONS FOR BIODIVERSITY ENHANCEMENT

6.1 Overview

There are various opportunities for ecological restoration:

- Riparian planting.
- Weed control.
- Stock exclusion.
- Pest animal control.
- Lizard survey.
- Pond excavation.
- Monitoring.
- Restoration of marsh habitat.

6.2 Riparian planting

There are several opportunities for riparian planting in the Otokia Creek catchment (e.g. Plate 2). These include the better-drained margins of marshland vegetation, that currently support gorse and/or Scotch broom, and two small riparian areas further upstream that lack indigenous forest cover, one of which currently supports tall gorse shrubland. Further upstream, an extensive riparian corridor within plantation forest lacks indigenous vegetation cover and warrants riparian planting. In McLaren Gully, wet flats at the convergence of several streams (Plate 3) could potentially be planted. Riparian planting is important to provide forest cover for stream reaches, which helps to cool the stream water through shading, and provides inputs of organic matter. Riparian planting is only proposed in those areas that lack riparian forest cover, or which are in plantation forests where cover is harvested periodically. Willow cover, while not indigenous, currently provides riparian cover along many reaches of the lower Otokia Creek, and should not be removed unless it is replaced by indigenous cover. A list of species suitable for riparian sites and wet flats is provided in Appendix 1.

Plate 3: Wet flats in the upper part of Otokia Creek in McLaren Gully.

6.3 Weed control

Sycamore (*Acer pseudoplatanus*) is present at one site in the lower catchment and warrants control, as it is a significant invasive tree species that is capable of dominating riparian corridors. Sycamore has winged seeds that provide efficient dispersal to adjacent habitats. At this site, mature sycamore are present on the northern side of Otokia Creek, and regeneration of younger sycamore is present in gorse scrub on the southern side of the creek (Plate 4).

Plate 4: Sycamore trees emergent above gorse scrub on the margin of Otokia Creek.

Taupata (*Coprosma repens*) is a coastal indigenous tree that has invaded coastal sites in Otago, but is not naturally found in the region. It is present in a patch of forest on dry slopes on the point immediately upstream of Brighton. At this site, taupata could be controlled to favour locally indigenous tree species such as māpou (*Myrsine australis*) and ngaio (*Myoporum laetum*). A list of tree and shrub species suitable for planting on dry slopes is provided in Appendix 1.

6.4 Stock exclusion

Stock exclusion from riparian forest is a key issue in the northeastern tributaries of Otokia Creek, where indigenous kānuka-dominant forest occurs in most gullies, but is open to stock browse. In these circumstances, palatable indigenous broadleaved trees will struggle to regenerate, resulting in a maintenance of kānuka dominance. Kānuka does have value, particularly as habitat for indigenous forest birds, but also by shading the tributary streams and contributing leaf litter and coarse woody debris to the stream ecosystem. However, a more diverse canopy and understorey of broadleaved tree species would provide additional habitat for indigenous fauna and stronger shading of the tributary streams.

6.5 Pest animal control

Pest animal control is not currently warranted in the lower part of Otokia Creek due to the lack of indigenous habitats. This could change if dense wetland vegetation was to be restored to the Otokia Creek marshland and vulnerable wetland bird species colonised it.

Pest animal control would likely be worthwhile in the upper catchments that retain significant areas of indigenous broadleavead and podocarp/broadleaved forest, as these

habitats will support a greater range and diversity of indigenous fauna, especially indigenous forest birds, lizards, and terrestrial invertebrates.

6.6 Lizard survey

Since all lizards in the local area have a moderate threat ranking (At Risk-Declining), and no lizard surveys appear to have been undertaken in the catchment, a lizard survey would add to knowledge of lizard values in the Otokia Creek catchment, and determine which species/populations in particular would benefit from ecological restoration and/or pest management. Lizards are a key element of Otago biodiversity, and lizard values should be ideally be addressed in biodiversity plan for the catchment.

Any lizard survey would need to be undertaken at an appropriate time of the year (October-May) and utilise appropriate survey methodology for the target species, habitat type and time of year. An expert herpetologist will be able to provide advice on optimum survey effort and techniques.

6.7 Pond excavation

The Trust is considering whether to excavate a pond in the marshland on the south side of Otokia Creek, and has requested advice on the merits of this. Pond excavation would increase the extent of open water habitat but there is already extensive open water habitat in the river and in previously-excavated areas in the northern marshland (Plate 6). As noted below, these excavations have reduced the extent of marsh habitat, and excavation of a new pond would further reduce this habitat. It would therefore be more beneficial to enhance marsh vegetation structure and composition, through the planting of species such as oioi, pukio, and harakeke, rather than by excavating areas of marshland to form more ponds.

6.8 Monitoring

6.8.1 Water quality

The Trust currently monitors water quality using a probe, at three sites in the lower, middle, and upper reaches of Otokia Creek. Variables monitored include dissolved oxygen, pH, total dissolved solids, water clarity, electrical conductivity, and salinity. This monitoring should be continued, and ideally summarised and evaluated with respect to environmental changes such as weather, plantation forestry cycles, and management of the Otokia Creek opening to the sea.

The Trust could consider undertaking additional monitoring of nutrients such as nitrates and phosphates, and sampling these below and above sub-catchments associated with different land uses. For example, the McColl Creek catchment is dominated by pastoral farming land use, while Scrub Creek in the centre of the catchment is dominated by a mixture of pastoral farmland, indigenous forest, and plantation forest, and the southwestern part of the catchment is predominantly plantation forest. Results of this monitoring should be evaluated against fresh water quality standards, and may provide information that is helpful for the Trust's advocacy to landholders within the catchment.

6.8.2 Biodiversity and social outcomes

Ecological Restoration Inputs

Time volunteered toward the Trusts projects should be documented and summarised.

The number of trees successfully propagated and/or planted by the Trust, and areas planted, or riparian lengths planted, should also be documented.

The area of protected habitat within the catchment could be monitored, for example to show new protected areas such as QEII covenants.

Areas fenced to exclude stock should also be documented.

Marshland Bird Counts

It would be useful to establish more quantitative baseline information on the use of the Otokia Creek marsh by wetland birds. This could be achieved by observing and documenting all birds utilising the marsh, including counts of individuals within each species, from an elevated viewpoint that provides a good overview of the marsh habitat. These observations should be timed, for example completed as 5-minute bird counts or within larger timed intervals (e.g. one hour). They could be undertaken in spring and in autumn, thus capturing breeding and non-breeding activity. Counts should be replicated so that 10-20 counts are undertaken within each sampling period. Count methodology should be documented to allow future repeat counts using the same methodology.

These counts could be either undertaken annually, for example if a suitably experienced Trust supporter was able to undertake them, or be commissioned at 5-10 year intervals and evaluated for trends. If sufficient dense wetland habitat is restored, then call-back techniques could be used to detect more cryptic wetland bird species, such as mātātā (South Island fernbird; *Bowdleria punctata*; At Risk-Declining) and koitareke (marsh crake; *Porzana pusilla*; At Risk-Declining).

6.9 Restoration of marsh habitat

Marsh habitat in the lower part of Otokia Creek is significantly degraded, largely comprising swards of creeping bent (*Agrostis stolonifera*) with sparse three square (*Schoenoplectus pungens*), scattered harakeke, patches of sedgeland most likely dominated by rautahi (*Carex geminata*), and occasional groves of saltmarsh ribbonwood (*Plagianthus divaricatus*) on the river margin (Plate 5).

Plate 5: Lower Otokia Creek marsh (northern side), showing the dominance of exotic grassland.

The marsh on the north side of Otokia Creek has been affected by excavation of channels (Plate 6), which has reduced the extent of marsh habitat and created elevated mounds of excavated material, which have been colonised by gorse. The lack of dense wetland vegetation cover means that while the marsh provides habitat for dabbling and wading bird species, it does not provide habitat for wetland birds such as matuku hurepo (Australasian bittern; *Botaurus poiciloptilus*; Threatened-Nationally Critical), mātātā, and koitareke, that require dense vegetation.

A key plant species missing from the Otokia Creek marsh is oioi (*Apodasmia similis*), which forms extensive reedland in nearby estuaries such as the Kaikorai estuary, Coutts Gully estuary, and Akatore estuary (Wildland Consultants 2012). These wetlands have been mapped as significant habitat for matuku hurepo and mātātā (Wildland Consultants 2012; 2020b), because of the extensive reedland, sedgeland, and flaxland habitats in these wetland complexes.

The typical pattern in these estuaries is for oioi and saltmarsh ribbonwood to inhabit the more saline and tidally affected parts of these estuarine marshes, with pūkio (*Carex secta*), rautahi, and harakeke (*Phormium tenax*) in fresher water marsh habitats upstream from the areas of dense oioi.

While Otokia Creek has a smaller area of marshland habitat, a similar gradient will still be present. It is likely that oioi historically dominated the marshland closest to the river, with pūkio and harakeke in fresher water areas behind these areas, particularly in the large area of marshland on the north side of the river.

Plate 6: Excavated open water channels on the northern side of Lower Otokia Creek marsh.

7. PRIORITIES FOR FUTURE MANAGEMENT

7.1 Higher priority actions

Sycamore control is a high priority, as the sycamore infestation is currently not large (Figure 6), but if no action is taken it will continue to expand rapidly. Successful control will become more and more difficult to achieve if no action is taken now. Control of sycamore can be achieved by cutting down trees and pasting stumps with an appropriate herbicide, or by drilling and injecting herbicide into standing trees.

The Trust is considering establishing a plant nursery and we endorse this, as planting of marshland and riparian areas in the Otokia Creek catchment will absorb significant numbers of plants and is likely to be undertaken over many years. The Tomahawk Smaills Beachcare Trust has a very efficient plant nursey which could be a useful model for Otokia Creek.

Initiating wetland enhancement in the marshland is important, as this will require a lot of planting to restore dense wetland vegetation over a large enough area (Figure 5) to make a difference for indigenous wetland fauna. Initiating planting now will help to guide future plantings and also identify suitable sources of plant material.

In addition, initiating riparian planting in the smaller riparian planting areas on the margins of the Otokia Creek marsh, and on either side of the sycamore control area (Figure 6) is important, to build experience and credibility for the Trust, and to provide better shading of stream reaches in this part of the catchment.

Ideally, a targeted lizard survey would be undertaken within the next five years.

7.2 Longer term actions

Planting projects that are already initiated should be continued until completion.

Planting should extend to the wet flats in the upper catchment in McLaren Gully (Figure 7). Establishment of kahikatea (*Dacrycarpus dacrydioides*)-dominant forest would be appropriate in this area.

The Trust should work with plantation forestry managers in the catchment to promote planting of permanent indigenous riparian forest along the larger streams that pass through plantation forest (Figure 7).

The Trust should also continue to engage with other rural landholders to gain access for riparian planting sites, weed control, and marsh enhancement, and to advocate for stock exclusion from all areas of indigenous forest and wetland vegetation within the catchment.

8. INDICATORS OF SUCCESS

8.1 Five year targets

Within the next five years:

- Sycamore should be eradicated from the site identified in Figure 6.
- Riparian planting should have commenced on the smaller riparian sites adjacent to the Otokia Creek marsh and either side of the sycamore control area, using plants generated from a plant propagation site/nursery maintained by the Trust.

8.2 Longer term indicators

Matuku hurepo, mātātā, and koitareke are all capable of self-colonising restored dense marshland habitat in the lower Otokia Creek marshland. None of these bird species have been observed recently in the Otokia Creek wetlands, so any future detection of these species would indicate marsh habitat restoration has been successful.

Increased abundances of any larger lizard species that are present, such as Otago green skink or cryptic skink, would comprise another potential indicator.

Permanent indigenous riparian forest has been established along the stream reaches identified in Figures 5-7 of this report.

At least some areas of kānuka-dominant forest in the northeast of the catchment have been fenced off to exclude stock.

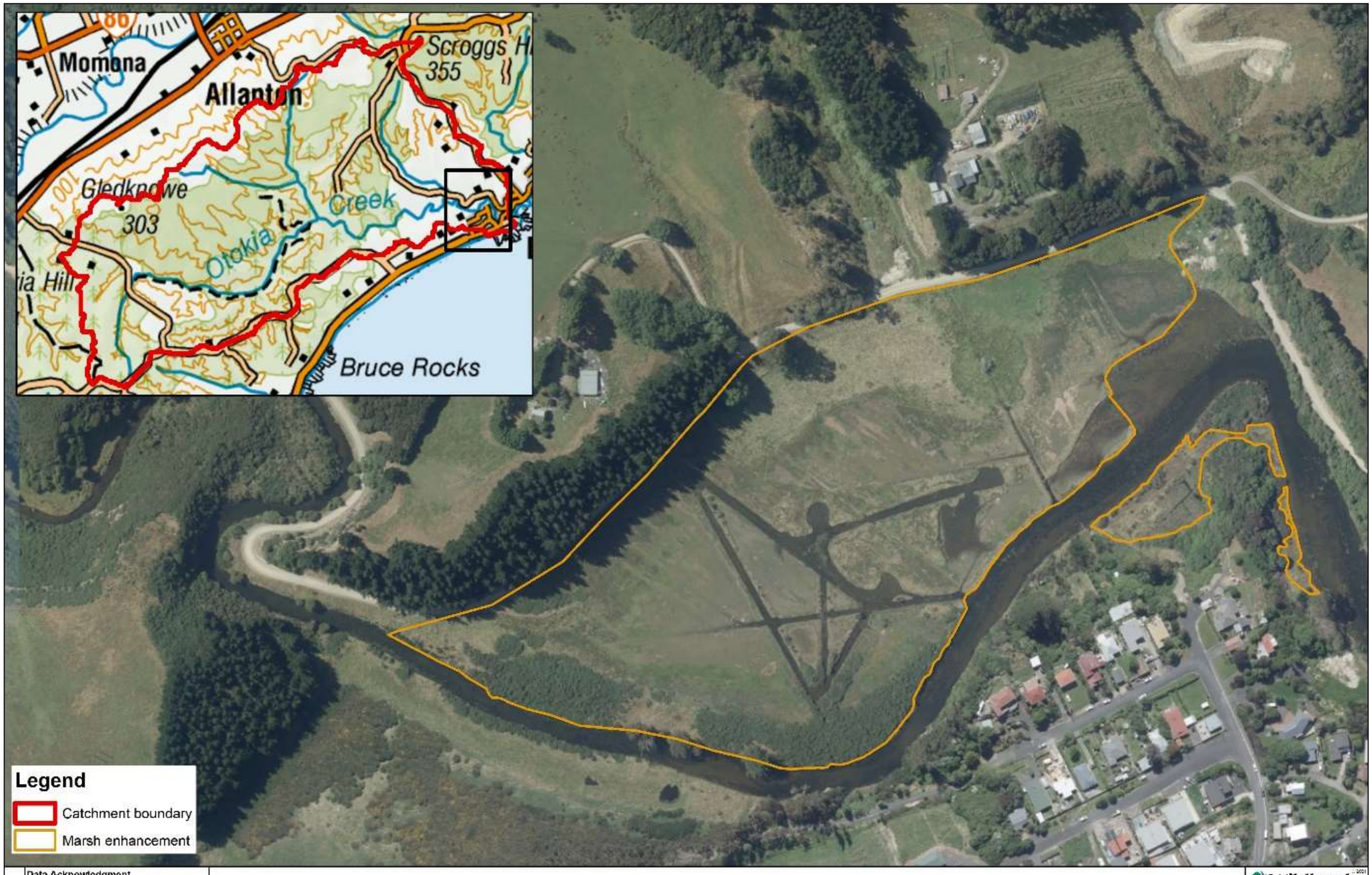

Figure 5: Marsh enhancement sites in the lower Otokokia Creek

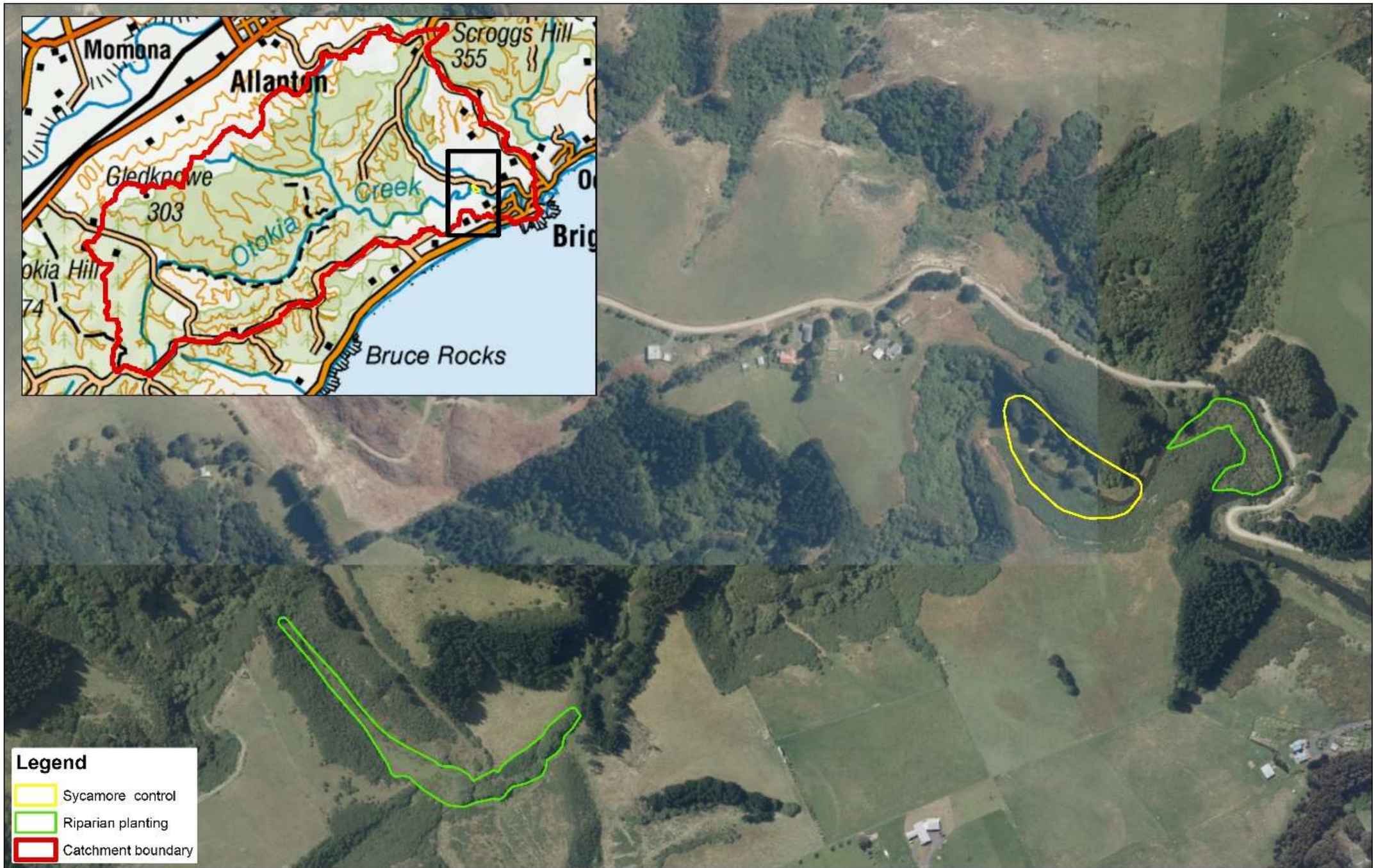

Figure 6: Sycamore control and riparian planting in the lower Otokia Creek

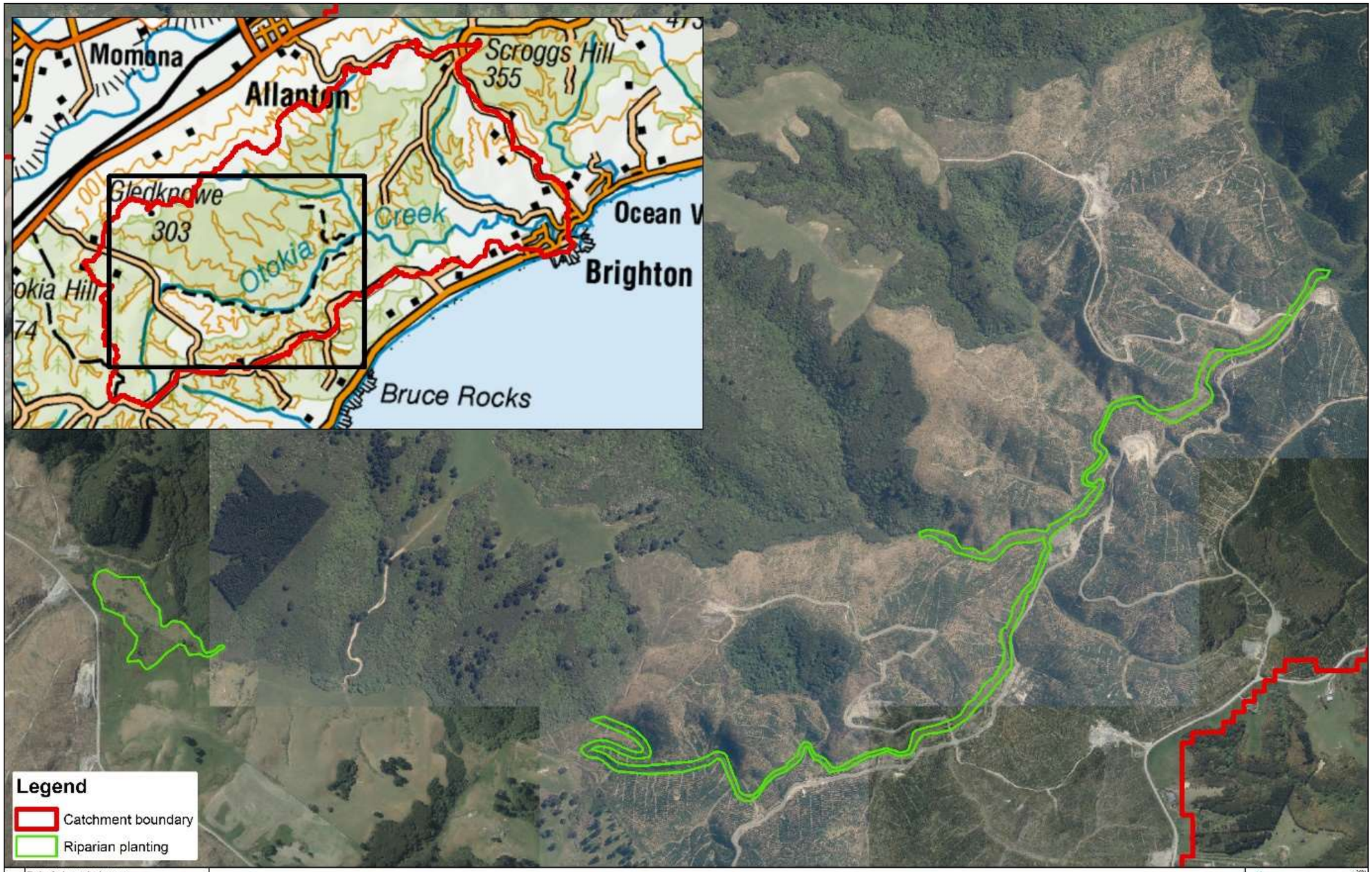

Figure 7: Riparian planting sites in the upper Otokia Creek catchment.

9. CONCLUSIONS

The Otokia Creek and Marsh Habitat Trust has undertaken many positive activities to date, in particular the relationships it is forging with landholders in the catchment, its commitment to enhance indigenous biodiversity in the Otokia Creek catchment, and its long term vision for the catchment.

The Otokia Creek catchment is 2,704 hectares, and approximately one quarter of the catchment is current covered by indigenous forest. Small gully wetlands occur in the upper catchment, and there is a sizeable area of riparian marshland in the lower catchment just above Brighton. Several large protected areas are present in the upper catchment. Like other parts of Aotearoa/New Zealand, indigenous vegetation has been cleared from gentle topography at lower elevation and from elevated ridges, leaving most of the indigenous vegetation in gullies. Spatial prioritisation has identified broadleaved forest associations in the catchment, and the main stem of Otokia Creek, as high priority sites within Otago.

At least 44 bird species have been recorded from the Otokia Creek catchment, 28 of which are indigenous, but indigenous wetland birds that require dense wetland habitat, such as matuku hurepo, mātātā, and koitareke, are absent. A number of indigenous freshwater fish and invertebrates also utilise Otokia Creek freshwater habitats.

A targeted lizard survey is suggested as populations of At Risk lizard species may be discovered, some of which could benefit from active management. Lizards are likely to benefit from habitat restoration activities, particularly those that establish dense terrestrial vegetation cover (such as through marsh and riparian revegetation programmes) and pest management.

Key options for biodiversity enhancement in the catchment include restoration of marshland habitats, control of sycamore, riparian planting, and advocacy to landholders in relation to riparian planting and stock exclusion from indigenous habitats.

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PLANTING SCHEDULE FOR THE OTOKIA CREEK CATCHMENT

Table A1: Indigenous plant species suitable for planting in the Otokia Creek catchment.

Species	Common Name	Plant Type	Planting Priority	Exposure Tolerance	Notes
Riparian Sites					
Aristotelia serrata	Makomako	Tree	Moderate	Moderate	Fast-growing tree with annual fruit crops.
Coprosma propinqua	Mingimingi	Shrub	Moderate	High	Hardy shrub with plentiful fruit crops.
Griselinia littoralis	Kāpuka	Tree	High	High	Spreading tree with good shading.
Pittosporum eugenioides	Tarata	Tree	Moderate	Moderate	Long-lived tree.
Kunzea robusta	Kānuka	Tree	High	High	Good pioneer tree and habitat for insectivores.
Plagianthus regius	Manatū, Lowland ribbonwood	Tree	High	High	Long-lived tall deciduous tree.
Hoheria angustifolia	Narrow-leaved lacebark	Tree			Long-lived canopy tree.
Fuchsia excorticata	Kōtukutuku	Tree	Low	Moderate	Spreading tree with good shading and nectar/ fruit.
Sophora microphylla	Kōwhai	Tree	Moderate	High	Long-lived deciduous tree providing important food sources for indigenous fauna.
Dacrycarpus dacrydioides	Kahikatea	Tree	Low	High	Damp microhabitats.
Podocarpus tōtara	Tōtara	Tree	High	High	Long-lived emergent tree.
Prumnopitys taxifolia	Matai	Tree		High	Long-lived emergent tree.
Hebe salicifolia	Koromiko	Shrub	Low	Moderate	Shrub of riparian habitats.
Wet Flats at Top of Catchment					
Aristotelia serrata	Makomako	Tree	High	Moderate	Fast-growing tree with annual fruit crops.
Coprosma propinqua	Mingimingi	Shrub	Moderate	High	Hardy shrub with plentiful fruit crops.
Cordyline australis	Tī kōuka	Tree	High	High	Good for initial planting in most sites.
Dacrycarpus dacrydioides	Kahikatea	Tree	Low	High	Damp microhabitats.
Coprosma rotundifolia		Tree	Moderate	High	Avoided by browsing animals.
Fuchsia excorticata	Kotukutuku	Tree	Low	Moderate	Spreading tree with good shading and nectar/ fruit.
Carex secta	Pūkio	Sedge	High	High	In very wet sites.
Phormium tenax	Harakeke	Monocot	High	High	
Pseudowintera colorata	Horopito	Tree	Moderate	High	Avoided by browsing animals.

Species	Common Name	Plant Type	Planting Priority	Exposure Tolerance	Notes
Dry Hill Slopes					
Coprosma crassifolia		Shrub	Moderate	High	Divaricating shrub/small tree.
Coprosma propinqua	Mingimingi	Shrub	Moderate	High	Hardy shrub with plentiful fruit crops.
Cordyline australis	Tī kōuka	Tree	High	High	Good for initial planting in most sites.
Coprosma propinqua	Mingimingi	Shrub	Moderate	High	Hardy shrub with plentiful fruit crops.
Griselinia littoralis	Kāpuka	Tree	High	High	Spreading tree with good shading.
Pittosporum eugenioides	Tarata	Tree	Moderate	Moderate	Long-lived tree.
Kunzea robusta	Kānuka	Tree	High	High	Good pioneer tree and habitat for insectivores.
Podocarpus tōtara	Tōtara	Tree	Moderate	High	Long-lived emergent tree.
Prumnopitys taxifolia	Matai	Tree	Moderate	High	Long-lived emergent tree.
Plagianthus regius	Manatū, Lowland ribbonwood	Tree	Moderate	High	Long-lived tall deciduous tree.
Hoheria angustifolia	Narrow-leaved lacebark	Tree	Moderate	Moderate	Long-lived canopy tree.
Myrsine australis	Māpou	Tree	Moderate	High	Slow-growing tree.
Melicytus ramiflorus	Mahoe	Tree	Moderate	Low	Plant only in sheltered sites.
Myoporum laetum	Ngaio	Tree	Moderate	High	Coastal locations only, frost-sensitive.
Sophora microphylla	Kōwhai	Tree	Moderate	High	Long-lived deciduous tree providing important food sources for indigenous fauna.
Marsh Habitats					
Apodasmia similis	Oioi	Rush	High	High	Tall reed forming dense clumps in more saline areas.
Carex secta	Pūkio	Sedge	High	High	Pedicelled sedge suitable for very wet freshwater sites.
Austroderia richardii	Toetoe	Grass	Moderate	High	Freshwater wetland margins.
Carex geminata	Rautahi	Sedge	Moderate	High	Sward-forming sedge for moderately wet sites.
Cordyline australis	Tī kōuka	Tree	Low	High	Tough tree suitable for better-drained or damp sites.
Carex virgata		Sedge	Moderate	High	Tussock-forming sedge for damp sites.
Leptospermum scoparium	Mānuka	Tree	Moderate	High	Freshwater wetland margins.
Phormium tenax	Harakeke	Monocot	High	High	Tall herb suitable for all freshwater habitats.
Plagianthus divaricatus	Saltmarsh ribbonwood	Shrub	Moderate	High	Saline-tolerant shrub of estuary margins.

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