IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	Applications for resource consents in relation to Te Ahu a Turanga; Manawatū Tararua Highway Project
BY	**NEW ZEALAND TRANSPORT AGENCY** Applicant

TE AHU A TURANGA: TECHNICAL ASSESSMENT G

TERRESTRIAL OFFSET AND COMPENSATION

TAT-0-EV-06001-CO-RP-0008

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INTRODUCTION

1. My name is Joshua Andrew Markham. I hold the position of Senior Ecologist at Tonkin & Taylor Limited ("**T+T**") Environmental and Engineering Consultants, and I am the author of this report.

2. I have been providing advice on terrestrial ecology matters related to the proposed Te Ahu a Turanga; Manawatū Tararua Highway Project (the "**Project**") to the Alliance, and ultimately Waka Kotahi NZ Transport Agency ("**Transport Agency**"), since January 2019.

3. My contributions include:

   (a) Technical support on ecological matters and stakeholder engagement during the Notices of Requirement ("**NoRs**") phase of the Project;

   (b) Input to refining the Project alignment to avoid sensitive ecological areas;

   (c) Designing and undertaking follow-up field surveys to fill gaps identified during the process of preparing and considering the NoRs and to inform the development of an offset / compensation package to address residual effects on terrestrial and wetland ecology; and

   (d) Preparation of terrestrial offset and compensation reporting including attendance and participation in numerous offset / compensation workshops with the Department of Conservation ("**DOC**"), Horizons Regional Council ("**Horizons**"), representatives of the Te Āpiti Governance Group, and iwi.

Qualifications and experience

4. I hold the qualifications of Bachelor of Science (Ecology) and Postgraduate Certificate in Science (Ecology) from Massey University, have recently completed the Ministry for the Environment's Making Good Decisions course and have been certified as an Independent Hearing Commissioner.

5. I hold the position of senior ecologist and Discipline Manager at T+T and have nine years' experience as a professional ecologist. My work experience includes preparing assessments of ecological effects; providing input into statutory and non-statutory policies, plans, and strategies; the design and implementation of biodiversity offset and compensation packages; ecological restoration initiatives, biodiversity monitoring programmes and appearance as

an expert witness for various council and environment court hearings. I have been involved in several large infrastructure projects that are similar in technical nature and scale to this Project, including:

(a) Hamilton and Longswamp Sections of the Waikato Expressway – Provided technical review of terrestrial matters on behalf of Waikato Regional Council (2016 – 2017);

(b) Puhoi to Warkworth Road of National Significance – Led terrestrial fieldwork and offset and compensation components (2017);

(c) Mt Messenger Bypass SH3 – Led terrestrial fieldwork and implementation of the offset and compensation components (2018 – ongoing); and

(d) Biodiversity Management Framework for the Peacocke Structure Plan Area – Provided technical review and oversight of the offset and compensation framework (2019).

Code of conduct

6. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. Unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Purpose and scope of assessment

7. The purpose of this report is to explain the offset and compensation measures that I consider appropriate for addressing the residual adverse effects relating to terrestrial and wetland ecology (hereafter referred to as 'terrestrial ecology') resulting from the Project.

8. This report addresses the following

(a) The methodology and approach for developing the offset and compensation package;

(b) The proposed biodiversity offset and compensation actions that are required to be undertaken in order to achieve a net gain in biodiversity values; and

(c) Recommendations and standards to be incorporated within the Ecology Management Plan ("**EMP**") in order to assess progress and compliance.

9. My assessment should be read in conjunction with the following subject matter expert reports that have been developed to support the Assessment of Effects on the Environment ("AEE"):

    (a) **Dr Baber's** Technical Assessment F addressing terrestrial and wetland ecology, and the appended supporting assessments:

        (i) **Ms Cummings'** assessment (F.1) addressing the ecological effects on bats; and

        (ii) **Dr Curry's** assessment (F.2) addressing ecological effects on terrestrial invertebrates.

    (b) I acknowledge the cultural values that underpin this Project, particularly those with relevance to the importance of indigenous flora and fauna to tangata whenua. Cultural impact assessments have been prepared in respect of the Project and these address indigenous flora and fauna and terrestrial ecology impacts from a mana whenua perspective.

Assumptions and exclusions in this assessment

10. My assessment addresses the offset and compensation package anticipated to be required based on the level of effects identified in **Dr Baber's** Technical Assessment F. That assessment is based on the 'Main Works' of the Project as described in the Design and Construction Report ("**DCR**"), summarised in section 3 of the AEE Report, and shown on the Drawing Set in Volume III of the Application.

11. Enabling works activities are currently underway and include geotechnical investigations and creation of access tracks to the Project area from the public road network. Some enabling works require Resource Management Act 1991 ("**RMA**") consents and these have been applied for and obtained independently of the Main Works consents. The overall works, including those that have been consented, are described in section 3 of the AEE Report.

12. Enabling works draft consent applications and issued consents include ecological offset or compensation measures to address residual adverse effects. Enabling works conditions of consent that require delivery of ecological offset and compensation provide for this to be delivered as part of

the overall terrestrial ecological offset and compensation package for the Main Works consent, allowing for better ecological outcomes. Accordingly, as appropriate the offset and compensation package that I present in this assessment includes all the residual adverse effects associated with terrestrial ecology for both enabling work and main work consents.

13. The offset and compensation package outlined in this assessment should be viewed in conjunction with the Project's freshwater offset package reported in **Ms Quinn's** Technical Assessment H (freshwater ecology), albeit the reports address separate residual effects, with the actions proposed being additional to each other.

EXECUTIVE SUMMARY

14. The Project comprises the construction, operation, use, maintenance and improvement of approximately 11.5 km of state highway connecting Ashurst and Woodville, via a route over the Ruahine Range.

15. Construction and operational activities will result in residual adverse effects on terrestrial biodiversity values that cannot be avoided or minimised. These residual effects include the loss of 11.82 ha of native terrestrial habitats and the loss of 4.97 ha of wetland habitats as well as associated actual or potential effects on a number of nationally 'Threatened' or 'At Risk' flora and fauna.

16. These residual effects that cannot be avoided or minimised will be addressed through a range of offsetting and compensation measures, including:

    (a) Revegetation (with weed and mammalian pest control for a ten year period, stock exclusion fencing and forest resource reuse (log and tree crown seeding) of:

        (i) 45.6 ha of native terrestrial revegetation; and

        (ii) 6.55 ha of native wetland revegetation

    (b) Stock exclusion (with weed and mammalian pest control for a ten year period) within:

        (i) 48.3 ha of existing bush retirement; and

        (ii) 0.4 ha of existing wetland habitat.

(c) Mammalian pest control for 10 years within approximately 300 ha of Old Growth Forest (Hill Country) in the Northern Manawatū Gorge Scenic Reserve ("**NMGSR**").

17. The type and quantum of habitat restoration and enhancement actions considered necessary to adequately address residual effects and achieve an overall Net Gain ("**NG**") outcome for the 12 affected habitat types was determined with the assistance of:

(a) Biodiversity Offset Accounting Model ("**BOAM**") to offset or compensate for habitat loss where quantifiable data was available; and

(b) Biodiversity Compensation Model ("**BCM**") in instances where quantitative data is not available and qualitative information (supported by literature) was included in the data inputs.

18. Taken together these models provide a transparent and systematic method for assessing the residual adverse effects on biodiversity values at impacts site(s) and the equivalent biodiversity benefits associated with offsetting or compensatory actions at the proposed offset or compensation sites.

19. Based on the type and quantum of revegetation (and associated habitat enhancement measures) proposed, the BOAM models indicated that:

(a) Seven habitat types could be offset to a 'verifiable' Net Gain standard within 35 years; and

(b) Five habitat types could be compensated to an 'expected' Net Gain standard within 35 years.

20. For the five habitats where the 'verifiable' Net Gain standard is not achieved through the revegetation (and enhancement measures within the revegetated areas), that is a consequence of the following factors:

(a) Biodiversity values in these habitat types take too long time to reinstate and to demonstrably offset (i.e., the 3 mature forest habitat types); or

(b) Some values cannot be replaced (i.e., while wetland habitat types can be compensated for by improving wetland habitat quality within compensation wetlands, this does not constitute an offset because all three wetland habitats affected by the Project would incur a Net Loss in Wetland area per se).

21. While the BOAMs indicate that the revegetation and associated habitat enhancement measures would achieve a 'verifiable' or 'expected' NG within 35 years, taking a conservative approach I consider that further compensation measures are necessary to address short to medium term 'Net Loss' and the risk of 'false positives', which relate to:

    (a) The fact that not all biodiversity values are measured (and those that are not measured may incur a 'Net Loss' outcome, which may result in a 'Net Loss' outcome overall); and

    (b) Inaccurate data inputs or assumptions that may understate the effects at the impact site(s) or overstate the benefits at the offset or compensation site(s).

22. To this end, additional compensation was proposed in the form of stock exclusion fencing (and associate habitat enhancement measures) and mammalian pest control as described in [16].

23. In the absence of quantitative field data, a BCM for forest species diversity was developed based on qualitative information. The BCM outputs indicates that Net Benefit outcomes are expected after 10 years when the full suite of proposed restoration and enhancement measures was included, i.e. revegetation, stock exclusion fencing and mammalian pest control.

24. Importantly, for a number of biodiversity values, the expected Net Gain outcome from the BCM can be verified as an offset once the offset monitoring programme has been developed and implemented, which will include monitoring of vegetation and avifauna at the offset or compensation site(s) once the availability of these sites has been confirmed.

25. In summary, I consider that residual effects have been addressed through offsetting and compensation actions and in accordance with the key biodiversity offsetting principles, which include No Net Loss and Net Gain ("**NNLNG**") outcomes, increased landscape ecological connectivity, additionality, permanent protection of restored areas, and ecological equivalence.

PROJECT DESCRIPTION

26. The Project comprises the construction, operation, use, maintenance and improvement of approximately 11.5 km of state highway connecting Ashurst and Woodville via a route over the Ruahine Range. The purpose of the

Project is to replace the indefinitely closed existing State Highway 3 ("**SH3**") through the Manawatū Gorge.

27. The Project comprises a median separated carriageway that includes two lanes in each direction over the majority of the route and will connect with State Highway 57 ("**SH57"**) east of Ashhurst and SH3 west of Woodville (via proposed roundabouts). A shared use path for cyclists and pedestrian users is proposed as well as a number of new bridge structures including a bridge crossing over the Manawatū River.

28. The design and detail of each of the elements of the Project are described in:

(a) Section 3 of the AEE (Volume I);

(b) the DCR (Volume II); and

(c) the Drawing Set (Volume III).

29. The elements of the Project that are particularly relevant to this assessment are construction and operational activities associated with the Project that result in residual adverse effects on terrestrial biodiversity values.

EXISTING ENVIRONMENT

30. I have reviewed the descriptions of the existing environment as set out in the Transport Agency's NoR Terrestrial Technical Assessment ("**Technical Assessment 6**[1]"). The description in Technical Assessment 6 remains applicable to the resource consent application with the addition of minor amendments that have resulted from additional field surveys, all of which are addressed in **Dr Baber's** Technical Assessment F, with which I agree.

BACKGROUND

Relationship to the NoR process

31. I have familiarised myself with the technical assessments previously prepared by the Transport Agency in support of the NoRs in relation to terrestrial ecology, including NoR Technical Assessment 6 and its primary appendices:

(a) Assessment of Terrestrial Vegetation and Habitats (Forbes Ecology, 2018) ("**Technical Assessment 6A**"); and

[1] Terrestrial ecology technical report: https://www.nzta.govt.nz/assets/projects/sh3-manawatū/NZTA-NOR-Volume-3.6-Terrestrial-ecology.pdf

(b) Assessment of Terrestrial Fauna and Ecological Effects (Boffa Miskell 2018) ("**Technical Assessment 6B**").

32. I am also familiar with evidence presented at the council-level hearing relating to the NoRs, including:

    (a) Statement of Evidence of Dr Forbes on Behalf of the New Zealand Transport Agency dated 8 March 2019, and the addendum dated 25 March 2019;

    (b) Statement of Evidence of Mr Blayney on Behalf of the New Zealand Transport Agency dated 8 March 2019, and the addendum dated 25 March 2019;

    (c) Section 42A Technical Evidence of Mr Lambie dated 1 March 2019, and the addendum dated 5 April 2019;

    (d) Statement of Evidence of Dr Martin on Behalf of the Director-General of Conservation dated 15 March 2019, and the addendum dated 4 April 2019;

    (e) Statement of Evidence of Dr Lloyd on Behalf of the Director-General of Conservation dated 15 March 2019, and the addendum dated 4 April 2019; and

    (f) The Joint Witness Statements prepared by Dr Forbes and Dr Martin on the 22 February 2019 and by Dr Forbes, Mr Blayney and Mr Lambie on the18 March 2019.

33. I have read the recommendation of the hearing panel to the Transport Agency in respect of the NoRs, as well as the Transport Agency's subsequent decision to confirm the NoRs subject to conditions.

34. In parallel with the NoR process and as part of the tender phase, the Project's design and alignment was developed through a series of multi-disciplinary technical and interactive workshops with the following Project Partners and Key Stakeholders:

    (a) Rangitāne o Manawatū, Rangitāne o Tamaki nui-ā-Rua, Ngāti Kahungunu ki Tāmaki nui-a-Rua and Ngāti Raukawa (now the Transport Agency's Project Partners);

    (b) Department of Conservation ("**DOC**");

(c) Horizons Regional Council ("**Horizons**");

(d) Palmerston North City Council ("**PNCC**");

(e) Manawatū District Council ("**MDC**");

(f) Tararua District Council ("**TDC**");

(g) Forest and Bird ("**F&B**");

(h) Elizabeth II National Trust ("**QEII Trust**"); and

(i) Key landowners and community groups.

35. Key outcomes in terms of Project design that respond to the above workshops consist of the inclusion of the Northern Alignment and extension of Bridge 3 (BRO3), with further avoidance and minimisation of effects on significant ecological areas (ecosystem types) through iterations of the design.

36. Additional to the above multi-disciplinary technical and interactive workshops, workshops with DOC, Horizons and Project Partners were held to discuss the Project's design and alignment. Separate meetings with QEII Trust were also held with a focus on avoidance and minimisation measures on the QEII Trust West and East covenants in catchment 6 and 7.

37. I have also been part of the Environment Court mediation processes relating to appeals against the NoRs brought by the Department of Conservation ("**DOC**") and Queen Elizabeth II National Trust ("**QEII Trust**"), which focused on ecological matters. My involvement in that process related to:

(a) The 'Northern Alignment', being the updated alignment (and proposed change to the confirmed designation boundaries) proposed by the Transport Agency, largely to reduce effects on the QEII covenant areas;

(b) Other design updates resulting in either avoiding or minimisation of ecological effects; and

(c) Technical input into discussions around the conditions referring to offset and compensation measures to address residual effects on ecological values.

38. Based on the evolution of the Project design and alignment, the Transport Agency has asked the Court to modify the NoRs to reflect the now proposed 'Northern Alignment'. Dr Forbes and Mr Blayney produced an addendum to Technical Assessment 6 (dated 21 August 2019) addressing the ecological

effects of the Northern Alignment, as compared to the originally confirmed NoRs.

39. The Transport Agency has also agreed to amendments to the decision-version of the designation conditions with DOC, QEII Trust, the territorial authorities and other parties. References in this assessment to the "Designation Conditions" are to the version agreed with those parties dated 15 October 2019.

40. While not yet approved by the Environment Court, these agreed conditions have provided guidance to the Project's designers and the input of ecologists. In particular, I have responded to the outcome of the NoR mediation process and used the offset and compensation framework referenced in agreed Designation Condition 24 as a transparent and robust method for addressing residual adverse terrestrial effects associated with the implementation of the Project.

EVOLUTION OF THE TERRESTRIAL ECOLOGICAL OFFSET AND COMPENSATION PACKAGE

41. Within this section I provide background and context of the evolution of the terrestrial ecological offset and compensation package from the NoRs stage of the Project through to this regional resource consenting stage.

42. Like the engagement processes (including the recent ones referenced above) employed by the Transport Agency to inform the Project's design, it was recognised that a collaborative and iterative process was needed for the design and development of the terrestrial ecological offset and compensation package. Collaboration is also important in evaluating, implementing, and monitoring the success of such a package.

43. Five ecological design workshops with the Project Partners, DOC, Horizons and representatives of the Te Āpiti Governance Group were undertaken between October and November 2019 in order to collaborate on inputs into the ecological offset and compensation package. In summary, the following matters were discussed within these workshops:

    (a) Measures undertaken within the evolving Project design and alignment to avoid and minimise ecological effects;

(b) Horizons One Plan Chapter 13 context relating to *avoidance – remedying – mitigating – offsetting* of more than minor significant adverse effects on *rare, threatened or at-risk habitats*;

(c) Biodiversity offsetting guidance which extends the ecological effects management hierarchy to *avoid – remedy – mitigate – offset – compensate*;

(d) Historic and current ecological knowledge of the Project area and surrounding environment;

(e) A modelling approach to determine a measurable and transparent offset and compensation package;

(f) Further ecological survey that was required to fill any information gaps between the NoRs and regional consenting phases;

(g) Measurable, quantifiable and meaningful ecological components and attributes to be further surveyed onsite for incorporation into the models; and

(h) Cultural and ecological aspirations for the legacy of the Project in terms of restoration of the surrounding environment and the potential for the Project's ecological offset and compensation package to achieve this. This has helped inform the strategy and philosophy for selection of offsetting and compensation sites and methods.

44. The above workshops resulted in effective engagement and agreement with DOC of the use of biodiversity offsetting guidance (discussed below), application of a modelling approach with the selection of appropriate biodiversity components and attributes to use in the models and the methodology for the use of either site-specific data or the literature for benchmarking justifications.

45. A further meeting was held with DOC in late February 2020 to discuss the approach to offset and compensation as taken in this assessment.

STATUTORY CONTEXT AND OFFSET AND COMPENSATION GUIDANCE

46. This section provides an outline of the statutory context and relevant guidance relating to the management of significant residual adverse terrestrial ecological effects which are relevant to this report.

Resource Management Act 1991

47. The purpose of the RMA is to promote the sustainable management of natural and physical resources, while avoiding, remedying, or mitigating adverse effects on the environment.

48. The RMA also specifically requires decision makers on applications for resource consent to have regard to:[2]

> "*any measure proposed or agreed to by the applicant for the purpose of ensuring positive effects on the environment to offset or compensate for any adverse effects on the environment that will or may result from allowing the activity*"

49. The RMA itself does not set out a 'hierarchy' in terms of actions to avoid, remedy or mitigate adverse effects (or offsetting and compensation measures); as discussed in this assessment the 'mitigation hierarchy' is applied as a matter of ecological best practice.

One Plan Chapter 6 - Indigenous biological diversity, landscape and historic heritage

50. The approach of the One Plan's objectives and policies relating to the management of indigenous biodiversity is focused on *rare*, *at risk* and *threatened habitats* which are classified within Schedule F. The aim is to "halt further decline" in indigenous biodiversity.

51. Objective 6-1 requires the protection of the above Schedule F habitats as "significant indigenous vegetation and significant habitats of indigenous fauna" and to "maintain indigenous biological diversity including enhancement where appropriate".

One Plan Chapter 13.2 – Indigenous Biological Diversity

52. Policy 13-4 (a), (b), (c), (d) addresses activities in *rare habitats*, *at risk habitat* and *threatened habitats*. This policy focusses on avoiding, remedying or mitigating "more than minor" adverse effects. If these steps cannot be "reasonably achieved" then an offset resulting in a net indigenous biological diversity gain is expected with general guidance of what this entails provided in (d).

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[2] Section 104(aa).

53. Policy 13-5 sets out the criteria for assessing the significance of habitats in terms of representativeness, rarity and distinctiveness, ecological context. The policy also states, "the potential adverse effect of an activity on the *rare habitats*, *at risk habitat* and *threatened habitats* must be determined by the degree to which the proposed activity will diminish representativeness, rarity and distinctiveness, ecological context for each habitat".

54. Schedule F sets out the classification of habitat type through a regional lens (Table F.1 of the One Plan) and then criteria to apply to habitat types to determine if they qualify as *rare habitats*, *at risk habitat* and *threatened habitats,* that then relate to Policy 13-4.

55. An assessment of Schedule F is found within Dr Baber's Technical Assessment F and ecosystem types that meet the above criteria are presented in the terrestrial ecosystems and survey locations in the Drawing Set (drawings TAT-3-DG-E-4131 to 4137).

Offset and Compensation Guidance

56. The relevant One Plan objectives and policies direct the use of offsetting to balance residual adverse ecological effects but do not provide guidance as to how. As such, I have referred to terminology and the principles of biodiversity offsetting used in national technical guidance (as described below) in order to develop a transparent and robust offsetting and compensation package.

57. Biodiversity Offsetting Under the Resource Management Act 2018[3] (hereafter "**BOURMA**") is the most recent national guideline that draws from and builds on the New Zealand Government's Guidance on Good Practice Biodiversity Offsetting.[4] Both these documents rely on an offset evaluation tool in order to achieve a robust and transparent transaction in biodiversity value.

58. A Biodiversity Offset Accounting Model and User Manual[5] was commissioned by DOC in 2015 which was intended to be used in conjunction with the Guidance on Good Practice Biodiversity Offsetting document referenced above. Since then, the BOURMA has become the most recent guidance which also provides reference to the Biodiversity Offset Accounting Model as an

[3] Biodiversity Offsetting Under the Resource Management Act – A Guidance Document, 2018. Prepared by Fleur Maseyk, Graham Ussher, Gerry Kessels, Mark Christensen and Marie Brown.
[4] Guidance on Good Practice Biodiversity Offsetting in New Zealand, 2017. Prepared by the Department of Conservation and the Ministry for the Environment.
[5] A Biodiversity Offsets Accounting Model for New Zealand – User Manual, 2015. Prepared for the Department of Conservation by Fleur Maseyk, Martine Maron, Richard Seaton and Guy Dutson.

option for evaluating the likelihood of No Net Loss (NNL) / Net Gain (NG) outcomes.

59. In terms of defining biodiversity offsetting and compensation BOURMA states:

(a) **Offsetting** - "*a measurable conservation outcome resulting from actions designed to compensate for residual, adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied. The goal of a biodiversity offset is to achieve no-net-loss, and preferably a net-gain, of indigenous biodiversity values*", and

(b) **Compensation** - "*designed to compensate for losses but is not designed to demonstrate a no-net-loss outcome, and therefore does not have to fully account for and balance losses and gains".*

60. Further to the above definition of compensation, the Designation Conditions[6] define compensation as meaning "*positive actions (excluding biodiversity offsets) to compensate for residual adverse biodiversity effects arising from activities after all appropriate avoidance, remediation, mitigation and biodiversity offset measures have been applied*".

61. Hereafter, I use the term offset as defined in the BOURMA and compensation as defined in the designation conditions. Furthermore, I used both the BOURMA and the Biodiversity Offset Accounting Model and User Manual for guidance throughout this assessment.

Application of offsetting and compensation

62. BOURMA sets out the following eleven principles of biodiversity offsetting:

(a) Limits to offsetting – biodiversity offsetting is considered unsuitable when residual ecological effects cannot be accounted for based on the irreplaceability and or vulnerability of biodiversity exchange, and or biodiversity gains are not achieved within acceptable timeframes;[7]

(b) No-net-loss and preferably a net gain – in type, amount or condition of the biodiversity component and attributes measured. With consideration of benchmarking and applicable timeframes in which no-net-loss will result[8];

[6] Designation Conditions dated 15 October 2019, Definitions and Abbreviations, Page 2.
[7] Pilgrim, J. D., Brownlie, S., Ekstrom, J. M., Gardner, T. A., von Hase, A., Kate, K. T.,...& Ussher, G. T. (2013). A process for assessing the offsetability of biodiversity impacts. *Conservation Letters, 6 (5), 376 – 384*
[8] Noting that the One Plan Policy 13-4 expects a net gain in biodiversity to be "reasonably demonstrated".

(c) Landscape context – the biodiversity offset should be designed with landscape context to include and benefit from temporal and spatial interactions between species, habitats and whole ecosystems;

(d) Additionality – the proposed offset needs to be additional to what would be achieved without the offset being applied;

(e) Permanence - the outcomes of the proposed offset needs to be secured for the length of time the effect exists for and preferably in perpetuity for permanent effects;

(f) Ecological equivalence – the measurement and balance of biodiversity losses and gains between the impact and offset sites resulting in a no-net-loss for the proposed biodiversity exchange;

(g) Adherence to the mitigation hierarchy – refers to residual adverse effects with offset only being provided after avoiding – remedy – mitigation options have been exhausted;

(h) Stakeholder participation – engagement and collaboration with key stakeholders to determine, evaluate, select, design, implement and monitor offsets;

(i) Transparency – of biodiversity exchange, offset methodology and evaluation;

(j) Science and traditional knowledge – offsets should be informed by science and traditional knowledge; and

(k) Equity – sharing the rights, responsibilities, risks and rewards of an offset respecting legal and customary arrangements.

63. After options to *avoid - remedy - mitigate* have been exhausted, any significant residual adverse effects need to be offset or compensated, providing a verified or expected net gain in biodiversity values (measurable and non-measurable). Offsetting is preferable and in accordance with the effects management hierarchy (one of the principles of offsetting), compensation should only be considered after the potential for offsetting biodiversity values has been assessed and ruled out as a viable option.

64. It is important to note that a hierarchy also exists within compensation in that compensation measures should also adhere to the principles of offsetting to the extent possible and should aim to achieve no net loss and net gain outcomes, ecological equivalence and should factor in landscape context.

Compensation measures that fail all or some of the offsetting principles should only be offered as a last resort.

OFFSET AND COMPENSATION METHODOLOGY

Determination of residual effects that require offsetting or compensation

65. A summary of measures undertaken to avoid or minimise ecological effects is described in the AEE, the DCR and Technical Assessment F in respect of matters related to terrestrial and wetland ecology. As explained in Technical Assessment F, details of management measures are provided in the EMP provided in Volume VII.

66. Furthermore, Technical Assessment F provides an assessment of ecological values and effects and provides a summary of residual adverse effects that cannot be practicably avoided or minimised. Table G.1 replicates Table 10 from Technical Assessment F, providing a summary of these residual effects. It is these biodiversity values for which offsetting and compensation is required to balance losses and gains of biodiversity values across the Project. In broad terms these residual adverse effects that cannot be entirely avoided or minimised relate to:

(a) Clearance or alteration (including fragmentation and edge effects) of indigenous vegetation 'ecosystem types';

(b) Loss or alteration of potential habitat for At Risk or Threatened indigenous fauna (lizards,[9] birds[10] and invertebrates[11]); and

(c) Mortality, injury and disturbance of indigenous fauna.

Table G.1: Residual effects summary for which offsetting and compensation is required

Biodiversity value	Habitat loss (ha)	Level of residual effect (EcIAG)
Habitat types		

[9] Hitchmough, R., Barr, B., Lettink, M., Monks, J., Reardon, J., Tocher, M., van Winkel, D. & Rolfe, J. (2015). Conservation status of New Zealand reptiles. New Zealand Threat Classification Series 17. 14 p.
[10] Robertson, H. A., Baird, K., Dowding, J. E., Elliott, G. P., Hitchmough, R. A., Miskelly, C. M., McArthur, N., O' Donnell, C. F. J., Sagar, P. M., Scofield, R. P. & Taylor, G. A. (2016). Conservation status of New Zealand birds. New Zealand Threat Classification Series 19. 27 p.
[11] Grainger, N., Collier, K., Hitchmough, R., Harding, J., Smith, B. & Sutherland, D. (2014). Conservation status of New Zealand freshwater invertebrates, 2013. New Zealand Threat Classification Series 8. Wellington: Department of Conservation.

Biodiversity value	Habitat loss (ha)	Level of residual effect (EcIAG)
Old-growth forest (alluvial)	0.10	'High'
Old-growth forest (hill country)	0.85	'High'
Secondary broadleaved forests with old-growth signatures	0.25	'High'
Old-growth treelands (+ ramarama)	0.13	'Moderate'
Kānuka Forests	1.30	'Moderate'
Advanced Secondary Broadleaved Forest	0.04	'Moderate'
Secondary Broadleaved Forests and Scrublands	6.72	'Moderate'
Divaricating Shrublands	0.33	'Moderate'
Indigenous Dominated Seepage Wetland (raupō wetland)	0.11	'High'
Indigenous Dominated Seepage Wetland (*Carex* dominated wetlands)	0.44	'Moderate'
Pasture Wetlands	4.42	'Moderate'
Plant species		
Giant maidenhair		'Moderate'
Birds		
Australasian bittern	0.55	'Moderate'
Spotless crake		'Moderate'
Marsh crake		'Moderate'
Whitehead	11.79***	'Moderate'
Rifleman		'Moderate'
North Island robin		'Moderate'
Bush falcon		'Moderate'
Long-tailed cuckoo		'Moderate'
Kereru		'Moderate'
Bellbird		'Moderate'

Biodiversity value	Habitat loss (ha)	Level of residual effect (EcIAG)
Tui		'Moderate'
Lizards		
Barking gecko	11.79***	Potentially 'Moderate'
Ngahere gecko		Potentially 'Moderate'
Pacific gecko		Potentially 'Moderate'
Glossy brown skink		Potentially 'Moderate'
Ornate skink		Potentially 'Moderate'
Invertebrates		
Powelliphanta traversi traversi	11.79***	Potentially 'High'
Powelliphanta traversi tararuaensis		Potentially 'High'
Powelliphanta marchanti		Potentially 'High'
Megadromus turgidceps		Potentially 'Moderate'
Meterana grandiosa		Potentially 'Moderate'
Meterana exquisita		Potentially 'Moderate'
Wainuia urnula		Potentially 'Moderate'

***11.79 ha loss equates to the loss of indigenous terrestrial habitats which affects all forest birds, lizards and invertebrates, i.e. the loss is not cumulative across taxonomic groups.

The Modelling Approach

67. The proposed models are used as decision support tools to determine the type and quantum of measures required to offset or compensate for the residual effects summarised in Table G.1 is provided below.

68. In brief, the proposed modelling approach has used:

(a) The Biodiversity Offset Accounting Model ("**BOAM**"), to guide the type and magnitude of revegetation (and associated habitat enhancement) where impacts and gains can be demonstrably measured using quantitative data; and

(b) The Biodiversity Compensation Model ("**BCM**"), which is used to guide the type and magnitude of compensation activities where impacts and gains have not or cannot (at this stage) be demonstrably measured as explained below.

69. As discussed below, the BOAM has been the primary model relied on; with the BCM relied on in respect of what I assessed to be additional compensation measures not directly addressed through applying the BOAM.

BOAM approach

70. The BOAM was commissioned by DOC in 2015 as an evaluation tool, providing a transparent way of trading biodiversity values while capturing inherent complexities. The BOAM is now the most applied ecological biodiversity offsetting model in New Zealand with the user guide and model being publicly available on the DOC website.

71. The BOAM provides an accessible, transparent, flexible and structured means of assessing an offset proposal. Based on data inputs, the model calculates whether a no-net-loss ("**NNL**") and net-gain ("**NG**") outcome will be achieved, accounting for uncertainty and time lag between losses occurring at impact sites and gains being generated at offset sites. In summary, the BOAM:

(a) Accounts only for 'like for like' biodiversity trades aimed at demonstrating NNL/NG outcomes (the model does not address 'like for unlike' exchanges);

(b) Calculates net present biodiversity value ("**NPBV**") (biodiversity value in the present compared to some future value) to estimate whether NNL/NG is achieved;

(c) Incorporates the use of a time discount rate (which factors in the time lag between when biodiversity is lost at the impact sites and when gains occur at the offset site(s)); and

(d) Adjusts for uncertainty of success (the degree of confidence) regarding the proposed offset actions.

72. The BOAM is used to determine the type and magnitude of offsetting required to achieve demonstrable biodiversity offsets in instances where data inputs yield quantifiable and demonstrable measures of effects associated with impacts and measures of projected gains at the proposed offset sites. For example, plant species richness based on vegetation plots or the relative abundance of select native bird species based on 5 minute bird counts.

73. Beyond the fact that some biodiversity values simply cannot be offset (under the 'limits to offsetting principle)', many values are technically difficult to measure or project impacts and/or benefits associated with proposed offsetting are simply unclear. Correspondingly, it is not always possible to demonstrably offset effects. This is especially true for:

(a) Highly diverse and complex mature habitat types, for which the amount and complexity of information required to adequately demonstrate an offset is considerable;

(b) Rare or secretive species that are difficult to detect and therefore difficult to obtain detailed information on (e.g., nationally 'Threatened' or "At Risk' lizards);

(c) Highly mobile species with complex life-cycles for which cause and effect is difficult to determine because population dynamics are influenced by landscape level factors (that extent well beyond the project footprint or offset site(s)); and

(d) Species for which there is uncertainty on the benefits of commonly applied conservation management actions (e.g., the benefits of intensive introduced predator control on invertebrates).

BCM approach

74. The BCM has recently been developed by T+T in an effort to address issues with the ad hoc and highly variable nature of determining the type and magnitude of proposed compensation measures for addressing residual adverse effects that cannot be demonstrably offset.

75. Where offsetting is considered unachievable, efforts to address residual effects associated with many projects often default to compensation measures

that are based on professional opinion (which may or may not be supported by literature). This approach lacks transparency and generates high variability in the type and management of compensation across projects relative to the type and level of residual effects.

76. In some instances, compensation can amount to the 'horse trading' of significant residual adverse ecological effects for minor and/or un-related gains elsewhere. Typically, the quantum of compensation is determined through the application multipliers or Environmental Compensation Ratio's (ECRs) that are used to indicate the magnitude of habitat restoration or enhancement measures relative to the magnitude of impact. The use of multipliers to determine the magnitude of compensation has increasingly been challenged due to the lack of transparency and often ad hoc nature of their application.

77. At present and despite the need, there is no agreed or consistently applied approach for determining the type and quantum of compensation requirements for addressing adverse effects to a likely NNL/NG standard. To this end, T+T have recently developed a Biodiversity Compensation Model based on the Biodiversity Offset Accounting System (BOAS)[12] to assist with determining expected NG in biodiversity value. Early versions of the BCM have been used to:

(a) Determine the type and quantum of compensation that was likely to achieve NNL/NG outcomes for the long-tailed bat and other biodiversity values within the Peacocke Structure Plan Area in Hamilton, New Zealand; and

(b) Determine the type and quantum of compensation that was likely to achieve NNL/NG outcomes for residual effects that could not feasibility be offset in relation to the Auckland Regional Landfill Project for Waste Management in Auckland, New Zealand.

78. For this Project, the BCM is used to determine the type and magnitude of effort that is likely or expected to achieve NNL/NG outcome for values affected by the Project that cannot (at this stage) be demonstrably be offset and for which data inputs include the use of qualitative information derived from expert assessment and literature (where available).

[12] Maseyk. F., Barea. L., Stephens. RTT., Possingham. HP., Dutson. G., Maron. M. 2016. A disaggregated biodiversity offset accounting model to improve estimation of ecological equivalency and no-net-loss. Biological Conservation 204:322-332.

79. The BCM follows the BOAM approach in all aspects except some of the data inputs used to determine the likelihood of achieving NNL/NG for each biodiversity value are based on qualitative assessments rather than quantitative assessments (where this is not available). Specifically, the BCM determines the likelihood of achieving an NNL/NG outcome for each biodiversity value based on:

(a) Available information on the areal extent of impact and the areal extent of the proposed compensation site(s);

(b) Expert assessment supported by a review of relevant literature or data (where quantitative data is not available) on:

(i) The reduction in habitat value or population/assemblage at the impact site(s) as a result of the project activities; and

(ii) The increase in habitat value or population/assemblage that can be directly attributed to compensation actions at the compensation site(s) within a fixed time period.

Limitations and constraints with biodiversity offset and compensation models

80. It is important to acknowledge the limitations, constraints and uncertainties associated with the BOAM and BCM. Most notably and particularly with respect to the BCMs, these limitations, constraints and uncertainties have the potential to generate false positives, i.e. instances where the models generate NNL/NG outcomes when the converse is true. This occurs anytime:

(a) A biodiversity value that is not explicitly accounted for is lost in the trade, e.g., a tree-dwelling beetle that is not known to occur or not measured at the impact site and that does not self-colonise the offset or compensation site or does not benefit from proposed restoration or enhancement measures at the offset or compensate site; and

(b) Data or assumptions are incorrect and indicate that the level of effects at the impact site(s) are lower than they are and/or the benefits associated with the proposed habitat restoration or enhancement at the offset or compensation site(s) are greater than they actually are.

81. The likelihood or risk of a false positive is higher when:

(a) Affected habitat types have high biodiversity or are more complex (often a feature of more mature habitat types);

(b) When models quantify or capture only a subset of biodiversity values (e.g. only quantify plant biodiversity values within an ecosystem type and do not account for fauna values);

(c) When models lump (aggregate) biodiversity values (e.g. lump all the biodiversity values associated with an ecosystem type into a single measure such as 'biodiversity condition' or ecological integrity); and

(d) When models rely heavily or exclusively on expert opinion, inaccurate data or incorrect assumptions.

82. Despite limitations and constraints with BOAMs and BCMs, the risk of a 'false positive' can be reduced in part by:

(a) Including a representative diversity of biodiversity value measures in the models (e.g. vegetation and fauna biodiversity values). Ecologically meaningful and measurable biodiversity attributes have been selected as referred to in [68];

(b) Conservatism with respect to the likelihood of achieving the expected benefits at the offset or compensation sites. Conservatism has been incorporated by using a 3% discount rate within the BOAM and BCM as referred to in [72];

(c) Provision of an adequate 'Net Benefit' buffer through the type and quantum of habitat restoration or enhancement measures proposed. A net benefit buffer has been applied in terms of an additional 10 buffer planting area proposed around compensation wetlands and provision for log seeding within restoration and enhancement areas; and

(d) The development and implementation of a biodiversity outcome monitoring programme that enables the conversion of compensation models into offset models through substitution of qualitative information for quantified data. This has been provided for within the Ecology Management Plan.

83. Equally, it is important to recognise that:

(a) While there are a number of potential limitations and constraints with the development and application of the BCM (and BOAMs), the BCM constitutes a considerable improvement, with respect to transparency and process, over the status quo application of multipliers or 'horse trading'; and

(b) As is the case for this Project, the BCMs (and BOAMs) should be used as a decision support tool to assist with understanding the rationale and justification for determining compensation measures that are expected to result in tangible NNL/NG outcomes for affected biodiversity values.

Parameter Selection with the BOAMs

84. For this Project I have supervised the construction of the BOAM and BCM models. BOAMs have been built to assist with determining the quantum of revegetation (and associated habitat enhancement measures) that is likely to offset or compensate for residual effects on each of the 12 habitat types referred to in Table G.1 above.

85. Ecologically meaningful and measurable biodiversity 'attributes' have been used as inputs into the BOAMs, with the following being discussed with DOC and Horizons prior to being used:

(a) Canopy (height, basal area, diameter at breast height ("**DBH**") 'basal area', % cover);

(b) Understorey (% indigenous cover);

(c) Indigenous diversity (indigenous species richness);

(d) Emergent indigenous species (basal area, DBH, number of individual indigenous species, height); and

(e) Fauna habitat and food provision (canopy epiphytes, cavities, fruiting, course woody debris, flaky bark).

86. The above attributes were then measured within each habitat type (as appropriate) using the RECCE plot methodology.

87. Benchmark data is required to determine the deviation of the current state from a reference condition. Benchmark data was derived from field surveys or scientific literature. Benchmark justification used within each habitat type Model is provided in Appendix G.1: Benchmark Data and Justification.

88. Fauna measurements or responses for each ecosystem type have not been used in the models due to complexities of how fauna relate spatially and temporally to restoration planting 'creation of habitat'. Therefore, biodiversity

components and attributes for each ecosystem type have been recognised and selected for inherent fauna ecological values.

89. A 'discount rate' is applied to the BOAM to account for uncertainties in offsetting and the time lag between the loss and subsequent gains. Discount rates are typically between 0 and 4%. Within each ecosystem type BOAM, I have used 3% as a conservative and best practice approach based on the inherent complexities within each biodiversity component and attribute being modelled.

90. The BOAM operates on a like-for-like basis. It is important that offset actions proposed are the same as that being impacted. I have used the "like-for-like" exchange of both biodiversity component and attribute modelled.

91. A level of confidence (low confidence – confident – very confident) has been assigned to offset actions in the BOAM based on the likelihood of success that the offset action will be achieved in the selected timeframe. I have used "confident 75 – 90%" based on best practice methodologies being applied and restoration planting undertaken in natural non engineered soils that are currently covered in pasture and with a viable seedbank.

92. The time horizon 'time to endpoint' is the number of years that it will take to reach the modelled outcome. I have used various time to endpoints dependent on the rate of recovery to the same, similar or above the impacted value depending on the ecosystem type and offset proposed. The maximum time to endpoint that I have used is 35 years (which is generally an appropriate time scale for offsetting activities under the RMA); it is reasonable to expect NNL to be demonstrated within this timeframe as specified by BOURMA.

Parameter Selection with the BCMs

93. BCMs were used to assist with determining pest control necessary to address short term NL and the risk of 'false positive' outcomes from the BOAMs described above.

94. While there are identified target sites for these measures (discussed below), the areal extent of each habitat type within these compensation site(s) has yet to be quantified.

2. As a result the BCMs are based on a single qualitative metric of forest species diversity.

DETERMINING OFFSET AND COMPENSATION REQUIREMENTS

95. This section explains what offset and compensation measures are proposed to address residual effects, and is structured as follows:

    (a) Summary of restoration and habitat enhancement measures;

    (b) Residual effects offsetting measures; and

    (c) Residual effects compensation measures.

Summary of restoration and enhancement measures

96. The habitat restoration and enhancement package that serves to offset or compensate for residual adverse effects (11.82 ha of forest habitat and 4.97 ha of wetland habitat) that cannot be avoided or minimised is as follows:

    (a) 45.6 ha of native terrestrial revegetation, and 6.55 ha of wetland revegetation with additional 10 m buffer plantings, including:

        (i) provision for seeding of forest resources and artificial cavities for fauna (if necessary);

        (ii) plant establishment pest control;

        (iii) 10 years of mammalian pest and weed control;

        (iv) stock exclusion; and

        (v) legal protection;

    (b) 48.3 ha of bush retirement and 0.4 ha of existing wetland including:

        (i) stock exclusion;

        (ii) 10 years of mammalian pest and weed control; and

        (iii) legal protection; and

    (c) approximately 300 ha of mammalian pest control within old growth (hill country) forest in the NMGSR over a 10 year period.

97. The above habitat restoration and enhancement package requires confirmation that DOC and KiwiRail will agree to these activities occurring as they own or administer the land, although it is understood that this activity aligns with the objectives of the Te Āpiti Governance Group who are tasked with managing the Manawatū Gorge Scenic Reserve.

98. Table G.2 below provides further detail on the restoration and habitat enhancement activities to be undertaken as part of the revegetation, retirement and pest control measures.

Table G.2: Summary of habitat loss and offset and compensation measures

<table>
<tr><th>Biodiversity type</th><th>Habitat loss (ha) and associated indirect effects</th><th>Revegetation areas (ha) to offset adverse residual effects in the long term (plus pest control and other actions)</th><th>Revegetation areas (ha) to compensate for adverse residual effects in the long term (plus pest control and other actions)</th><th>Pest control for 10 years across across retirement areas (ha) to compensate for adverse residual effects</th><th>Pest control for 10 years in old growth forest to compensate for short-term Net Loss of biodiversity values</th></tr>
<tr><td colspan="6">Forest and shrubland habitat and species</td></tr>
<tr><td>Old growth treelands</td><td>0.13 ha</td><td>0.6 ha</td><td rowspan="6"></td><td>0 ha</td><td rowspan="10">Approx 300 ha annual pest control for 10 years within the Northern Manawatu Gorge Scenic reserve. Pest control would be pulsed every two years during peak bird and fruiting breeding season (July – December inclusive)</td></tr>
<tr><td>Kānuka forest</td><td>1.3 ha</td><td>2.3 ha</td><td>6.4 ha</td></tr>
<tr><td>Advanced secondary broadleaved forest</td><td>0.04 ha</td><td>0.17 ha</td><td>0 ha</td></tr>
<tr><td>Secondary broadleaved forest and scrublands</td><td>6.71 ha</td><td>24 ha</td><td>12.6 ha</td></tr>
<tr><td>Mānuka and kānuka shrublands</td><td>2.11 ha</td><td>5.7 ha</td><td>12.8 ha</td></tr>
<tr><td>Divaricating shrublands</td><td>0.33 ha</td><td>0.65 ha</td><td>0 ha</td></tr>
<tr><td>Secondary broadleaved forest with old growth signatures</td><td>0.25 ha</td><td rowspan="4">Can't offset</td><td>1.3 ha</td><td>0 ha</td></tr>
<tr><td>Old growth forest (alluvial)</td><td>0.10 ha</td><td>0.9 ha</td><td>8.9 ha</td></tr>
<tr><td>Old growth forest (hill country)</td><td>0.85 ha</td><td>10 ha</td><td>0 ha</td></tr>
<tr><td>Exotic scrublands</td><td>0 ha</td><td>0 ha</td><td>7.6 ha</td></tr>
</table>

Biodiversity type	Habitat loss (ha) and associated indirect effects	Revegetation areas (ha) to offset adverse residual effects in the long term (plus pest control and other actions)	Revegetation areas (ha) to compensate for adverse residual effects in the long term (plus pest control and other actions)	Pest control for 10 years across across retirement areas (ha) to compensate for adverse residual effects	Pest control for 10 years in old growth forest to compensate for short-term Net Loss of biodiversity values
Forest and shrubland species (plants, birds, lizards, invertebrates)	11.82 ha		45.6 ha	48.3 ha	
Wetland habitats and species					
Raupō dominated seepage wetlands	0.11	Can't offset	0.35 ha + 10 m wetland margin	0.4	Mammalian pest control not proposed
Indigenous dominated seepage wetlands	0.44		1.2 ha + 10 m wetland margin	0	
Pasture wetlands	4.42		5 ha + 10 m wetland margin	0	
Wetland birds	4.97 ha		6.55 ha + 10 m wetland margin	0.4	

Revegetation to address residual effects on habitat types that can be demonstrably offset

99. The BOAM achieves NNL and NG (within 35 years), via revegetation and associated actions within revegetation areas, for all biodiversity attributes measured within each of the following ecosystem types:

    (a) Old growth treelands;

    (b) Secondary broadleaved forest with old growth signatures;

    (c) Kānuka forest;

    (d) Advanced secondary broadleaved forest;

    (e) Secondary broadleaved forest and scrublands;

    (f) Mānuka and kānuka shrublands; and

    (g) Divaricating shrublands.

100. A summary of the BOAM inputs and results is provided in Table G.3 with a description of offset actions proposed. Each habitat type achieves a positive (indicated by green font) NPBV based on the proposed offset actions demonstrating NNL and NG in biodiversity components and attributes measured verifying the offset.

101. NPBV of zero indicates a no-net-loss in the attribute measured. As the NPBV approaches zero the biodiversity benefit increases linearly. Any NPBV over zero indicates a net gain in the average biodiversity component measured. There is currently no guidance on the evaluation or target thresholds of positive NPBV, therefore within this assessment I consider that any NPBV over zero results in a no-net-loss and net gain in the biodiversity attribute measured.

102. Proposed offset actions used within the BOAM include restoration and enhancement planting, as well as the following additional actions in respect those planted areas:

    (a) Fencing to exclude livestock from both the restoration and enhancement planting areas and adjacent forest fragments;

    (b) Provision for artificial cavities for fauna;

    (c) Reuse 'seeding' of forest resources (eg. course woody debris and tree crowns) salvaged from vegetation clearance areas;

(d) Plant establishment pest control (mainly hares and pukeko) and weed control for a duration of 10 years; and

(e) Legal protection to secure the offset sites in order to protect the proposed biodiversity gain long-term.

103. The seven ecosystem types listed above are well within the limits to offsetting when referring to the appropriateness of risks and achievability of the offset. It is predicted that the ecosystem succession trajectory will result in a similar community assemblage to what is being impacted within a 35-year period due to:

(a) Restoration and enhancement plantings being undertaken within natural non-engineered soils; and

(b) Indirect ecological benefits which are predicted to accelerate the NG through time from:

(i) natural regeneration from the viable seedbank and seed rain from the surrounding landscape; and

(ii) The revegetation areas mainly being in and around existing forest fragments which provide wind protection for young plants within these existing forest areas/fragments.

104. The proximity and degree of connectivity between the offset site, existing adjacent forest fragments,[13] landscape planting areas and freshwater offset planting areas provides landscape context and will result in a higher level of ecosystem functionality over time compared to if the offset was proposed in an isolated location.

105. In summary the habitat types, and proposed measures to address residual effects on those habitat types listed above, are well within the limits to offsetting and meet all the relevant offset principles. I consider the offset is a like-for-like exchange 'balance between the impact and offset' providing a high level of proof that ecological equivalence has been achieved.

[13] Proposed ecological mitigation offset overview plan set – Drawing Set: TAT-3-DG-E-4150-A.

Table G.3: Summary of the BOAM inputs and results for habitat types that can be verifiably offset.

Habitat type	Impact to be offset (ha)	Required offset (ha)	Biodiversity components (and attributes)	Component Net Present Biodiversity Value	Net Gain Outcome
Old growth treelands	0.13 of vegetation loss	0.6 ha of restoration planting	Canopy (cover, height, basal area)	0.19	Verified Net Gain in 20 years
			Diversity	0.18	Verified Net Gain in 20 years
			Understorey	0.20	Verified Net Gain in 20 years
			Fauna resources (cavities, fruiting trees, canopy epiphytes, flaky bark, CWD)	0.11	Verified Net Gain in 35 years
			Fauna resources (leaf litter)	0.21	Verified Net Gain in 20 years
Kānuka forest	1.3 of vegetation loss	2.3 ha of restoration planting	Canopy (cover, average height, basal area)	0.27	Verified Net Gain in 20 years
			Diversity	0.19	Verified Net Gain in 20 years
			Understorey	0.31	Verified Net Gain in 20 years

Habitat type	Impact to be offset (ha)	Required offset (ha)	Biodiversity components (and attributes)	Component Net Present Biodiversity Value	Net Gain Outcome
			Fauna habitat and food provision (flaky bark, cavities, CWD, leaf litter, canopy epiphytes)	0.36	Verified Net Gain in 35 years
Advanced secondary broadleaved forest	0.04 of vegetation loss	0.17 ha of restoration planting	Canopy (cover, height, basal area)	0.04	Verified Net Gain in 35 years
			Diversity	0.04	Verified Net Gain in 20 years
			Understorey	0.01	Verified Net Gain in 35 years
			Fauna resources (canopy epiphytes, cavities, tawa fruit, leaf litter, flaky bark)	0.06	Verified Net Gain in 35 years
			Fauna resources (CWD)	0.08	Verified Net Gain in 20 years
Secondary broadleaved forest and scrublands	6.71 of vegetation loss	24 ha of restoration planting	Canopy (cover, height, basal area)	5.41	Verified Net Gain in 20 years
			Diversity	0.07	Verified Net Gain in 20 years
			Understorey	1.62	Verified Net Gain in 20 years

Habitat type	Impact to be offset (ha)	Required offset (ha)	Biodiversity components (and attributes)	Component Net Present Biodiversity Value	Net Gain Outcome
			Emergent trees (number of individuals/ha, average height)	8.22	Verified Net Gain in 20 years
			Fauna habitat and food provision (canopy epiphytes, cavities, fruiting trees, CWD, flaky bark)	5.73	Verified Net Gain in 20 years
			Fauna habitat and food provision (average leaf litter)	7.54	Verified Net Gain in 20 years
Mānuka and kānuka shrublands	2.11 of vegetation loss	5.7 ha of restoration planting	Canopy (cover, average height, basal area)	1.16	Verified Net Gain in 20 years
			Diversity	0.14	Verified Net Gain in 20 years
			Understorey	0.28	Verified Net Gain in 20 years
			Emergent trees (number of individuals/ha, average height)	0.86	Verified Net Gain in 15 years

Habitat type	Impact to be offset (ha)	Required offset (ha)	Biodiversity components (and attributes)	Component Net Present Biodiversity Value	Net Gain Outcome
			Fauna habitat and food provision (flaky bark, cavities, CWD, canopy epiphytes, leaf litter)	1.18	Verified Net Gain in 20 years
Divaricating shrublands	0.33 vegetation loss	0.65 ha of restoration planting	Canopy (cover, height, basal area)	0.16	Verified Net Gain in 10 years
			Diversity	0.05	Verified Net Gain in 15 years
			Understorey	0.01	Verified Net Gain in 15 years
			Fauna resources (canopy epiphytes, cavities, fruiting trees, leaf litter, flaky bark)	0.01	Verified Net Gain in 15 years
Secondary broadleaved forest with old growth signatures	0.25 of vegetation loss	1.3 ha of restoration planting	Canopy (cover, height, basal area)	0.39	Verified Net Gain in 20 years
			Diversity	0.28	Verified Net Gain in 20 years
			Understorey	0.17	Verified Net Gain in 20 years

Habitat type	Impact to be offset (ha)	Required offset (ha)	Biodiversity components (and attributes)	Component Net Present Biodiversity Value	Net Gain Outcome
			Fauna habitat and food provision (canopy epiphytes, cavities, fruiting trees, CWD, flaky bark)	0.32	Verified Net Gain in 35 years
			Fauna habitat and food provision (average litter depth)	0.35	Verified Net Gain in 20 years

Revegetation to address residual effects on habitat types that cannot be verifiably offset using the BOAM

106. For five of the 12 habitat types, BOAMs have been applied to generate a necessary quantum of revegetation to reach 'expected net gain'. The distinction between 'expected net gain' and 'verified net gain' reflects that for those five habitats, the proposed revegetation is not technically an 'offset' due to one or more offsetting principles not being met.

107. As such, for those five habitat types (Old growth forest (alluvial and hill country); and the three wetland habitat types), the proposed revegetation is considered compensation rather than offset. That is explained in more detail below.

108. A summary of the BOAM inputs and results is provided in Table G.4 with a description of offset actions proposed. Each habitat type achieves a positive (indicated by green font) NPBV based on the proposed compensation actions demonstrating an expected NNL and NG in biodiversity components and attributes measured.

Old growth forest (alluvial and hill country)

109. The rationale for applying the term 'compensation' to revegetation to address effects on old growth (alluvial) and old growth forests (hill country) habitat types is that a like for like exchange of old growth tree species and forest

components is not feasible within a 35-year timeframe. Old growth species take between 150 and 300 years to re-establish[14][15] (including associated epiphyte communities). It is considered that old growth forests would always default to compensation due to the limits to offsetting.

110. The BOAM has been applied resulting in a mid-successional secondary broadleaf species composition that is able to be achieved within a 35-year timeframe. The old growth (alluvial and hill country) restoration is proposed to be undertaken within gaps of an existing old growth forest which is expected to provide further indirect ecological benefits. In broad terms these indirect ecological benefits are associated with increased seed rain from bird species contributing to species diversity and increase in growth rates of new plantings resulting from wind protection provided by existing vegetation. It is considered that indirect ecological benefits such as the above are too complex to be modelled and as such haven't been included in the BOAM so further contributes to the overall conservatism and Net buffer in biodiversity value achieved.

111. Due to the BOAM not completely allowing for the loss of old growth tree species, an additional compensation method of using trunk cross sectional area (Diameter at Breast Height – DBH) is proposed below. It is considered that this will account for the lag period associated with the slow growth rates of pukatea, miro, matai and kahikatea and provide the correct percentage of the above species in the planting specification that is needed to replace the trunk cross sectional area lost. The above species are considered the main canopy species within the old growth (alluvial and hill country) habitat type.

112. The above trunk cross sectional area compensation method is considered robust and transparent, using a prescribed methodology and average growth predictions for each of the above species from Tane's Tree Trust Planting and Managing Native Trees Technical Publication.[16] In summary the methodology includes:

    (a) The total DBH loss for each individual nominated species above 15 cm DBH;

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[14] Smale, M. C., Richardson, S. J., & Hurst, J. M. (2014). Diameter growth rates of tawa (Beilschmiedia tawa) across the middle North Island, New Zealand–implications for sustainable forest management. *New Zealand Journal of Forestry Science*, *44*(1), 20.

[15] Ogden, J. W. C. J., & West, C. J. (1981). Annual rings in Beilschmiedia tawa (Lauraceae). *New Zealand journal of botany*, *19*(4), 397-400.

[16] Tane's Tree Trust (2011). Planting and Managing Native Trees. Technical Handbook. Revised in 2014. *Tane's Tree Trust. Native Trees for the Future.*

(b) Results of each individual tree is grouped into species;

(c) The total DBH lost for each species is then calculated;

(d) The replacement size of each species used as compensation is identified;

(e) The expected DBH of each replacement species after 35-years is then predicted from the above publication;

(f) The number of replacement trees is then calculated that would balance the total DBH lost within the 35-year period;

(g) These replacement trees are then provided as additional to the Modelled compensation extending the total overall old growth restoration area to accommodate the replacement trees at a 5 m spacing; and

(h) The above replacement trees are then interspersed with the same species composition which is proposed for the old growth habitat type which is proposed to be planted between chainage 4000 and 5600.

113. The trunk cross sectional area of pukatea, miro, matai and kahikatea within the old growth (alluvial and hill country) impact areas needs to be verified. Once verified the percentage of these species within the old growth (alluvial and hill country) plant specification will be increased in order to achieve the desired replacement DBH of each species at year 35. The compensation area provided by the BOAM will remain the same, with the only change being a modification of the percentage of these species within the plant specification.

114. I consider that the above compensation combined with the trunk cross sectional area compensation method appropriately accounts for the lag between losses occurring at the impact site and gains generated at the compensation site and includes a level of conservatism for both old growth (alluvial and hill country) forest types.

Wetlands

115. The rationale for applying the term 'compensation' to planting proposed to address residual effects on wetland habitat types is that an exchange in wetland extent for wetland condition has been applied. The offset principle of no-net-loss is achieved based on the biodiversity components and attributes

input into the BOAM but based on the above exchange (extent vs condition) a full no-net-loss outcome is unable to be achieved resulting in compensation rather than an offset.

116. A no-net-loss outcome discussed above is measured by type, amount and condition currencies ('exchanges in biodiversity values'). It is considered that wetland area is considered a typical currency of 'amount' which has not been provided, as hydrological function in constructed or extended seepage wetlands within gullies at an appropriate scale for this Project is difficult. Therefore, an exchange in wetland extent for wetland condition is considered justified in this instance based on a better conservation outcome. Apart from the exchange of wetland area for extent the BOAM output should be viewed as close as possible to true offsetting.

117. Indigenous dominated seepage wetland (moderate value) and pasture wetland (low value) restoration will be undertaken on existing wetland seepages. Raupō dominated wetland (high value) restoration will be undertaken on an existing online farm pond. After restoration the compensation wetlands will be restored to kahikatea dominant seepage wetlands and a raupō dominated wetland including a 10 m buffer planting providing further positive indirect biological NG. Approximately 17.3 ha 10 m buffer planting is considered an additional compensation measure to provide habitat for fauna and a set-back for stock limiting nutrient and sediment inputs. This additional measure adds conservatism and provides further support that the wetland compensation should be viewed as close as possible to a true offset. Both proposed restored wetland types have a much higher biodiversity value than the wetlands impacted. In this instance the proposed wetland compensation is considered a trade-up in wetland condition, resulting in a better conservation outcome.

Table G.4: Summary of the BOAM inputs and results for habitat types that cannot be verifiably offset but for which an expected Net Gain outcome will be achieved due to revegetation (and associated habitat enhancement measures) at proposed compensation sites.

Habitat type	Impact to be compensated (ha)	Required compensation (ha)	Biodiversity components (and attributes)	Component Net Present Biodiversity Value	Net Gain outcome
Old growth forest (alluvial)	0.10 of vegetation loss	0.9 ha of restoration planting	Canopy	0.22	Expected Net Gain in 35 years
			Diversity	0.22	
			Understorey	0.20	
			Fauna habitat and food provision	0.04	
			Fauna habitat and food provision	0.13	
Old growth forest (hill country)	0.85 of vegetation loss	10 ha of restoration planting	Canopy	2.66	Expected Net Gain in 35 years
			Diversity	2.66	
			Understorey	2.51	
			Fauna habitat and food provision	0.70	
			Fauna habitat and food provision	1.74	
Raupō dominated seepage wetlands	0.11 of vegetation loss	0.35 ha of restoration planting including 10 m buffer planting	Canopy	0.12	Expected Net Gain in 15 years
			Diversity	0.13	
			Understorey	0.12	
			Fauna habitat and food provision	0.12	
			Emergent	0.8	
			Canopy	0.06	

Habitat type	Impact to be compensated (ha)	Required compensation (ha)	Biodiversity components (and attributes)	Component Net Present Biodiversity Value	Net Gain outcome
Indigenous dominated seepage wetlands	0.44 of vegetation loss	1.2 ha of restoration planting including 10 m buffer planting	Diversity	0.22	Expected Net Gain in 35 years
			Understorey	0.24	
			Fauna habitat and food provision	0.01	
Exotic wetlands	4.42 of vegetation loss	5 ha of restoration planting including 10 buffer planting	Canopy	0.70	Expected Net Gain in 35 years
			Diversity	0.01	
			Understorey	2.48	
			Fauna habitat and food provision	1.65	

Additional compensation measures developed with the aid of the BCM

118. Despite the BOAMs indicating that the revegetation and associated habitat enhancement measures would achieve a 'verifiable' or 'expected' NG between 10 and 35 years across all habitat, taking a conservative approach I consider further compensation necessary to address:

(a) the short to medium term NL that is expected until the revegetation becomes established; and

(b) the risk of 'false positives' which relate to:

(i) The fact that not all biodiversity values are measured (and the those that are not measured may incur a NL outcome; and

(ii) Data inputs or assumptions with respect to quantitative or qualitative data or information may be incorrect.

119. To this end, additional compensation is proposed in the form of:

(a) Ten years of mammalian pest control within approximately 300 ha of old growth forest (hill country) in the NMGSR;

(b) 48.3 ha of bush retirement and 0.4 ha of existing wetland including stock exclusion, 10 years of mammalian pest and weed control and legal protection; and

(c) Ten years of mammalian pest control over 45.6 ha and 6.55 ha of wetland area of the revegetation areas.

120. The BCM has been applied as a decision support tool in respect of these additional proposed compensation measures, as described below.

121. These measures will address the temporal lag in achieving NNL NG outcomes for biodiversity values in the short to medium term within the above areas.

122. These additional compensation measures will also address the risk of 'false positive' NNL/NG outcomes (i.e. where NL outcomes are not picked up by the BOAM because biodiversity values that are subject to NL outcomes are not measured or because data inputs are incorrect). Pest control addresses potential 'false positive' outcomes by facilitating the recovery of a number of flora and fauna within old-growth hill country forests that are vulnerable to/ at risk from mammalian pests. This will benefit a number of species that are impacted by the Project as well as some species that may not be impacted by the Project. Stock exclusion also addresses potential 'false positive' outcomes by removing browsing pressure allowing the rejuvenation of the understory. Pest control and stock exclusion are expected to have direct benefits for flora and fauna by reducing predation or browsing pressure, and are likely to have indirect benefits on ecological integrity of the compensation sites and surrounding habitats. Most notably, the recovery of keystone species such as tui, bellbird and kereru will increase pollination and seed-dispersal processes in the landscape.

Application of the BCM

123. BCMs have been constructed and used to indicate the likelihood of expected net benefit in biodiversity outcomes based on assumed benefits ('expected net gain') of pest control across the 300 ha NMGSR, 48.3 ha bush retirement and 0.4 ha of existing wetland and 45.6 ha forest and 6.55 ha of wetland restoration area. These BCMs are deemed coarse models as they use forest species diversity (species richness and abundance as a surrogate for ecosystem health and aggregate (lump) all biodiversity values into a single forest biodiversity metric. As previously stated, this metric can be

desegregated and the BCM models converted to a series of BOAM once the pest control and retirement compensation site(s) have been confirmed and assessed and verified in due course through the development and implementation of specific biodiversity monitoring programmes.

124. The BCM model for forest species diversity results in an impact of -4.73. After applying the positive biodiversity values for each of the compensation actions (NMGSR mammalian pest control, bush retirement and revegetation) a NPBV of 1.31 is achieved resulting in an overall NNL/NG compensating for temporal lags in biodiversity values and false positives associated with 11.82 ha of forest impact. A summary of the BCM inputs and results is provided in Appendix G.3.

125. The above BCM relies on information of selected species assemblages (communities) that are either found onsite or assumed to be onsite and that are known to have response (i.e. non-bias to positive outcomes and well supported in the literature) to pest control. These species assemblages are forest birds, terrestrial invertebrates and lizards.

The approach to pest control

126. Pest animal control in New Zealand is relatively prescribed with known conservation outcomes,[17][18][19] therefore the focus on the control of pest animals to low densities, which will be set targets / performance standards at the levels discussed below and as assumed in the BCM, is considered an achievable outcome with a high degree of confidence (75% - 90%) that an expected NG will result.

127. To achieve the required BCM outcome, pest animal control is likely to consist of:

(a) A 1 ha ground-based grid-network across (where practicable due the steepness of the landscape) the 300 ha NMGSR area of poison and trap stations with a 11 km perimeter control of 1 poison and trap station every 100 m;

[17] O'Donnell, C.F.J. and Hoare, J. M. (2012). Quantifying the benefits of long-term integrated pest control for forest bird populations in a New Zealand temperate rainforest. *New Zealand Journal of Ecology 36* (2): 131-140.
[18] Byrom, A. E., Innes, J., & Binny, R. N. (2016). A review of biodiversity outcomes from possum-focused pest control in New Zealand. *Wildlife Research*, *43*(3), 228-253.
[19] Fea, N., Linklater, W., & Hartley, S. (2020). Responses of New Zealand forest birds to management of introduced mammals. *Conservation Biology*.

(b) A 1 ha ground-based grid-network of poison and trap stations across 48.7 ha with the bush retirement area;

(c) A 1 ha ground-based grid-network of poison and trap stations across 45.6 ha of forest habitat types restoration areas;

(d) All of the above poison stations are to be pulsed every two years for a 6-month period over winter months when bait take is at the highest level due to the shortage of alternative food sources and prior to bird breeding season (July – December inclusive) for a 10-year period.

128. The current level of pest control in the NMGSR consists of a day a month provided by a community group to maintain a network of 70 traps (30 single set DOC 200's, 30 double set DOC 200's and 10 Goodnature self-setting traps). This level of pest control over a 300 ha area is unlikely to be effective. Pest control in the bush retirement and habitat type restoration areas is also considered minimal consisting of mainly possum control.

129. The proposed pest control approach involves a far greater magnitude of effort and will result in a better biodiversity outcome. Therefore, I consider that the proposed pest control approach meets the principle of additionality and can be considered as part of the Project's offset and compensation package.

130. The above pest control approach will need to be undertaken for 10-years in order to achieve up to a 5% improvement in biodiversity values as predicted by the BCM. The proposed pest control approach should be undertaken for 10 years unless superseded by a better pest management solution, approach or management framework in the future that results in the same or higher biodiversity outcome predicted by the BCM.

Performance Standards for BOAM and BCM Outputs and Outcome Monitoring

131. It is important to use performance standards to validate the BOAM and BCM outputs.

132. Performance standards for planting include:

(a) 75 % canopy formed by starting crop species;

(b) Grass and weeds suppressed to low densities;

(c) Establishment of enrichment species measured by 90% survival in the understory and subcanopy at year 10; and

(d) The required DBH of pukatea, miro, matai and kahikatea within the old growth (alluvial and hill country) habitat types the in 20 years;

133. Standard performance standards for pest control have been adopted which include:

(a) 5 % increase from a pre pest control baseline in forest bird (tui, bellbird, kererū, whitehead and riffleman) relative abundance using 5-minute bird count methodology after each pulsed pest control effort; and

(b) 5 % to 10 % Chew Card Index ("**CCI**") or Residual Trap Catch ("**RTC**") for possums and 5 % to 10 % Tracking Tunnel Index ("**TTI**") for rats after each pulsed pest control effort.

Proposed Offset and Compensation Locations

134. A strategy for offset and compensation site selection is necessary in order to contribute to existing biodiversity values within the surrounding landscape.

135. A strategy of using the proposed offset and compensation planting and pest control to extend, infill, connect and enhance existing habitats has been adopted resulting in additional indirect biodiversity benefits.

136. Further to the above strategic approach, the proposed offset and compensation package also contributes towards, but is additional to, long-term strategies and aspirations of the Te Āpiti Governance Group[20] and PNCC[21] in relation to species translocation for the NMGSR and the ongoing management of biodiversity and amenity values of the Ashhurst Domain.

137. In summary, the proposed offset and compensation planting and pest control contributes to:

(a) The extension and connection of a mosaic of existing habitats including:

(i) The NMGSR;

[20] Te Āpiti Manawatū Translocation Plan 2019. Prepared by Kevin A Parker.
[21] Ashurst Domain Development & Management Plan, August 2019. Prepared by Palmerston North City Council.

(ii) The existing old growth forest (alluvial) which includes the high value raupō wetland area,[22]

(iii) The existing old growth forest (hill country) in the western QEII area,[23] and

(iv) The existing regenerating forest in catchment 9.

(b) The addition and extension of native vegetation on Parahaki Island and at Ashhurst Domain which has the potential to be used as steppingstone habitats;

(c) Connection of wetland compensation with riparian margin restoration proposed as freshwater offset in order to achieve greater conservation outcomes; and

(d) Pest control in an area that will contribute towards future species translocation that may occur.

138. A summary of the potential offset and compensation sites is provided in Table G.5 below. These sites are also visually presented in the Drawing Set (drawings TAT-3-DG-E-4150 to 4157 and TAT-3-DG-E-4161 to 4162).

Table G.5: Summary of potential offset and compensation sites.

Habitat type	1461 Napier Road, SECS 1654 1684 1686 Town of Palmerston North (ha)	Parahaki Island (ha)	985 Saddle Road, Lot 2 DP 84523 (ha)	PT SEC 1 SUB X DP 239 (ha)	1630 Napier Road, Sec 406 Town of Fitzherbert Lot 50 DP 185(ha)	Section 7 Block XVI Woodville Survey District (ha)	Total available (ha)	Amount required by BOAM or BCM Output (ha)
Secondary Broadleaved Forest with Old Growth Signatures			1.3				1.3	1.3
Old Growth Treelands			0.6				0.6	0.6
Kānuka Forest			2.23	0.07	2.1		4.4	2.3
Advanced Secondary Broadleaved Forest			0.17				0.17	0.17

[22] Chainage 3900 to 4300 on drawing TAT-3-DG-E-1431.
[23] Chainage 5400 to 5700 on drawing TAT-3-DG-E-1432.

Secondary Broadleaved Forest and Shrublands		2.79	2.64	0.21	2.1	at least 17 ha with additional areas between the 20 m riparian margin and proposed fencelines	24	24
Mānuka and Kānuka Shrublands			5.02	0.68	2.1		7.8	5.7
Divaricating shrublands			0.65				0.65	0.65
Old Growth Forest (Alluvial)	5.98		0.1	0.8			6.88	0.9
Old Growth Forest (Hill Country)			10				10	10
Raupō Dominated Seepage Wetland (High Value)			0.29			0.06	0.35	0.35
Indigenous Dominated Seepage Wetland (Moderate Value)			1.2				1.2	1.2
Exotic Wetland			0.18	0.01		4.81	5	5

CONCLUSION

139. In summary the offset and compensation response address residual ecological effects which results in:

(a) 45.62 ha of forest revegetation, and 6.55 ha of wetland revegetation (with an additional 10 m buffer planting area), as offset and compensation for various habitat types as specified by the BOAM and BCM models;

(b) Restoration and habitat enhancement measures within those planted areas including the exclusion of livestock and the direct transfer of forest resources;

(c) Intensive pest management over the approximately 300 ha NMGSR, 48.3 ha of bush retirement and 0.4 ha of existing wetland and 45.6 ha of forest habitat type restoration areas for a 10-year period resulting in a biodiversity gain both short and long term; and

(d) Performance standards and targeted outcome monitoring of specific restoration and habitat enhancement measures and pest control.

140. I consider that:

(a) The mitigation hierarchy has been fully adhered to with avoidance (including mitigation measures) and minimisation measures being fully incorporated into the Project design and EMP;

(b) The offset and compensation measures used within this assessment have been applied in a transparent manner using BOAM or BCM with benchmarking provided from either onsite data collection or sourced from New Zealand based literature;

(c) In summary, the offset and compensation response specifically achieves:

(i) No-net-loss of biodiversity – the BOAM achieves a net gain offset for 7 out of 12 habitat types. After compensation is applied, I considered that a gain in biodiversity value will result over the short and long term across all habitat types;

(ii) Landscape context – the offset and compensation response has been designed to enhance and connect surrounding forest fragments achieving spatial connections between a variety of habitats for a range of indigenous species;

(iii) Additionality – is provided based on the offset and compensation response being a magnitude beyond conservation efforts currently being undertaken in the surrounding landscape;

(iv) Permanence – protection in perpetuity (or until a time that a better management framework is established which supersedes what is proposed) of all offset and compensation areas and measures is proposed which provides assurance that the net gain in biodiversity value is achieved long term;

(v) Ecological equivalence – is provided for within the offset for 7 out of 12 habitat types. Where ecological equivalence is not achieved based on habitat type in the short term, it is considered that with the proposed management outlined within the EMP that ecological equivalence or greater will be achieved long term; and

(vi) Stakeholder participation – during the Project's evolution various stakeholders have had and continue to have input into aspects of this offset and compensation response and measures outlined within the EMP.

141. The offset and compensation package outline in this assessment should viewed in conjunction with the Project's freshwater offset package reported in **Ms Quinn's** Technical Assessment H (Freshwater Ecology), albeit they both address separate residual effects and are considered additional to each other. In my opinion, when viewed together both packages deliver a long-term gain in biodiversity value across the landscape that is a magnitude above and additional to anything that wouldn't be achieved otherwise.

142. I expect that if the offset and compensation package outlined within this assessment is undertaken in accordance with the EMP, then residual ecological effects will be appropriately managed resulting in an overall biodiversity gain over short-term and long-term timeframes.

Josh Markham

APPENDIX G.1: BENCHMARK DATA AND JUSTIFICATION

[tables on following pages]

Table 6: Biodiversity attribute, benchmark, and expected biodiversity value of old-growth forests (hill country, alluvial, and old-growth treelands). No plots were undertaken in old-growth forest (alluvial), therefore all offset estimates are based on old growth forest (hill country).

Table 7: Biodiversity attribute, benchmark, and expected biodiversity value of secondary broadleaved forests and scrublands, advanced secondary broadleaved forest and secondary broadleaved forests with old-growth signatures.

Table 8: Biodiversity attribute, benchmark, and expected biodiversity value of kānuka forests and mānuka, kānuka shrublands.

Table 9: Biodiversity attribute, benchmark, and expected biodiversity value of expected biodiversity value of divaricating shrublands.

Table 10: Biodiversity attribute, benchmark, and expected biodiversity value of indigenous dominated seepage wetlands (high value).

Table 11: Biodiversity attribute, benchmark, and expected biodiversity value of exotic dominated wetlands (EW) and indigenous dominated seepage wetlands (moderate value; IW)

Table 6: Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of Old-Growth Forests (Hill country, Alluvial, and Old-Growth Treelands). No plots were undertaken in old-growth forest (alluvial), therefore all offset values for Old Growth Forest (Alluvial) are based on Old Growth Forest (Hill Country). The discount rate for all values was set at 0.03 in the offset model.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Canopy	Percentage (%) cover indigenous	90	The benchmark 90% canopy cover considers best scenario conditions for remnant old-growth podocarp-broadleaf forests. 90% is cover is considered appropriate as natural gaps occur in forest canopy due to die back or fallen trees.	90 (10 years)	Plots in old growth forest (hill country) has a canopy cover of 85%, with reduced cover often due to large fallen trees causing canopy gaps. Plantings after 10 years are not expected to have large canopy gaps formed by fallen trees therefore 90% is expected to be a realistic target. Plantings will be established at typical spacings to ensure fast canopy closure. Plants which do not survive will be replaced after each planting season. Canopy closure typically occurs within 5 -10 years depending on species composition and spacing (Tane's Tree Trust, 2011).	Overall the average canopy coverage was 85% across old growth forest (hill country) plots. Canopy gaps were formed from occasional fallen or senescing trees, and possible possum browse. Old growth treelands had a canopy cover of 25%, as vegetation in this ecosystem consists of sparely distributed, moderately-sized remnant trees.	Restoration planting and fencing to exclude livestock.	Hill Country: 0.94/10 Alluvial: 0.06/0.9 Treeland: 0.15/0.6	Estimate based on plots undertaken on site and information from Tane's Tree Trust, (2011).

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
	Average height (m)	20	Literature suggests a New Zealand tawa forest is 18-21 m in height (Dawson & Sneddon, 1969). Vegetation surveys in old-growth forests (hill country) on site returned an average canopy height of 18 m with one plot with a canopy height of 20m. The plots on site are in good condition, therefore under the local environmental conditions, a 20 m benchmark value is considered justified.	10 (20 years)	Vegetation plots at the reference site determined the average height of restoration plantings after 20 years to be 10 m.	18 m for Old-Growth Forests (Hill Country). Canopy trees in Alluvial Forests on site are likely to be of a similar age and height as Old Growth Forest (Hill Country). Average tree height was 6 m for old-growth treelands.	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site. Reference site height.
	Basal area (m^2/ha)	69	The Old-Growth Forest (Hill Country and Alluvial) being impacted is dominated by tawa. Literature suggests a mean basal area for tawa forest of 69 (SD ± 23.5) (Richardson *et al.*, 2014). On site basal area for the in-tact tawa forests is 66.5 m^2 ha, and therefore it is assumed that without pest animals, a benchmark for the	46 (35 years)	35 years is considered the time limit for which offsetting targets can reasonably be estimated. Tawa and other late-successional old-growth forest species are often slow-growing, and it is not expected that the benchmark can be reached in 35 years. Therefore, a basal area value below that of a typical mature tawa forest mean has been	66.5 for old growth forest (hill country) 18 for old-growth treelands.	Restoration planting and fencing to exclude livestock. To increase basal area growth rates, enhancement planting and gap generation will be undertaken. This will ensure late-successional species such as tawa will be able to establish more		Richardson *et al.*, (2014)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			forests on site would be slightly higher than this, and consistent with an average tawa forest in New Zealand. Old-Growth Treelands consist of remnant trees which would have likely formed part of a tawa forest and therefore the benchmark value is also deemed appropriate for this ecosystem type.		used, but which is within the Standard Deviation (SD) of tawa forest across New Zealand.		quickly than through natural processes, and light gaps will facilitate basal area growth.		
Diversity	Diversity of native vascular plants (species richness)	52	Old-growth forest (hill country) impacted is dominated by tawa. Literature suggests a mean species richness for tawa forest of 51 (SD ± 10.8) (Richardson *et al.*, 2014). Native species richness across old-growth plots resulted in the identification of 52 native species, therefore this higher number has been used. Old-Growth Treelands consist of remnant trees which would have likely formed part of a tawa forest and therefore the benchmark value is also	40 (20 years)	Given the measure after offset timeframe is set at 20 years, a species richness value below that of a typical mature tawa forest mean has been used, but which is within the Standard Deviation (SD) of tawa forest across New Zealand. 28-37 species are to be planted as part of offsetting of Old-Growth Forests, and it is expected that a few additional species will establish within 20 years through natural processes. Therefore 40 species is considered achievable.	Total native species richness across all plots in Old-Growth Forest (Hill Country) is 52. 52 has also been used in the offset model for the Old-Growth Alluvial Forest as a conservative estimate, however it is likely to be lower than this, given the Old—Growth Forest Alluvial area is unfenced resulting in	Restoration planting and fencing to exclude livestock. Enhancement planting of successional species.		Richardson *et al.*, (2014)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			deemed appropriate for this ecosystem type.			degradation from stock. 13 native species were identified in Old-Growth Treelands. Old-Growth Treelands are severely degraded by stock.			
Understorey	Indigenous species cover below 1.35 m (%)	55	Average understorey cover observed in New Zealand hill country forest fragments is 40% (Smale *et al.*, 2008). Understorey cover across plots Old Growth Forest (Hill Country) is 52.5%. Possum damage has likely degraded this value. With pest mammal control and less possum browse, this value is expected to be improve, therefore a slightly higher value than the value found during surveys has been used. Understorey cover is expected to be less than canopy cover as woody	40 (20 years)	Measure after offset value is the average understorey cover observed in New Zealand hill country forest fragments (Smale *et al.*, 2008). Restoration plantings typically have relatively high understorey cover values, as fast-growing ferns, native grasses, shrubs and plantings contribute to this tier. Therefore 20 years is considered sufficient time to achieve a 40% understorey canopy cover.	Understorey cover across all plots in old growth (hill country) is 52.5%. Old growth treelands has 1% understorey cover due to stock access.	Restoration planting and fencing to exclude livestock.		Smale *et al.*, (2008) Brockerhoff *et al.*, (2003)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			trunks, branches , shrubs and understorey gaps are frequent.						
Emergent trees*	Average height (m)	0	No emergent trees were recorded during surveys.						
	Number of trees (count/ha)	0	No emergent trees were recorded during surveys.						
Fauna habitat and food provision	**Epiphytes** Number of trees per plot supporting at least one epiphyte cluster (epiphytes/ha)	212.5	There is a paucity of literature on this value. The average epiphyte trees/ha found in plots in Old-Growth Forest (Hill Country) on site has been used as the benchmarch value. This is considered appropriate given old-growth forests surveyed are in reasonable ecological health.	50 (35 years)	Kānuka forest and secondary broadleaved forest and scrub had approximately 50 canopy epiphytes/ha according to plots across the site. Many of these forests are likely to be approximately 35 years old. It is therefore considered appropriate that some epiphytes may establish after 35 years. Furthermore, studies support fast epiphyte establishment. For instance, Taylor and Burns, (2015) found the mean DBH after which epiphytes begin to establish on māhoe is 5.58 cm, and for tawa, 11.70 cm. After 35 years,	212.5 epiphytes per ha for old growth forest (hill country). No epiphytes were observed within old growth treeland plots.	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken in relatively healthy Old Growth Forest (Hill Country) plots on site. Taylor and Burns (2015)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
					planted māhoe, tawa and other species are predicted to be larger than these initial epiphyte establishment tree sizes.				
	Cavities Number of trees per plot containing at least one cavity (cavities/ha)	562.5	Value derived from the average number of cavities per ha observed in Old-Growth Forest (Hill Country) plots on site. It is expected that the benchmark for an Alluvial Forest will be similar to that of Hill Country Forest, given both ecosystems have a similar community of large trees, with tawa being the dominant canopy species.	400 (35 years)	Given that over 1000 cavities per ha have been observed in 20 year-old kānuka forest at the reference site, it is considered 35 years is sufficient to achieve at least 400 cavities. Where offset targets are not being achieved, artificial cavities may be deployed such as weta houses, which can provide a similar ecological function.	562.5 for old growth forest (hill country). 50 for old growth treeland.	Restoration planting and fencing to exclude livestock. Enhancement plantings. Artificial cavity provision where offset targets not being met.		Reference site.
	Fruiting trees Fruiting tree abundance (no./ha) of tawa, matai, miro and or kahikatea	587.5	The average number of fruiting trees per ha found within Old Growth Forest (Hill Country) plots on site. This value is higher than has been found in other studies (e.g. Bockett, (1998) who found 200 tawa per ha in a study at Urewera National Park).	0 (35 years)	Tawa, matai, miro or kahikatea are not expected to be capable of fruiting after 35 years.	587.5 for old growth forest (hill country) 0 for old growth treelands.	Restoration planting and fencing to exclude livestock. Enhancement plantings.		Bockett, (1998) Estimate based on plots undertaken in relatively healthy Old Growth Forest (Hill Country) plots on site.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			The benchmark is considered appropriate for Old Growth Forest (Alluvial) too, as the Alluvial Forest on site is dominated by a similar species mix to the Old Growth Forest (Hill Country) (e.g. tawa canopy dominant).						
	Coarse woody debris (CWD) Volume of CWD (m^3 per ha). Does not include dead standing trees.	100	Estimate derived from Richardson *et al.,* (2009) 'fallen deadwood volume'. This study analysed deadwood volume from a sample of 894 permanent plots in New Zealand old growth forest, and the mean of this value has been taken. On site values are much lower than this mean, possibly due to the impacts of stock on deadwood retention.	30 (35 years)	Plots from the 20 year old restoration reference site returned a value of 22.13 CWD. Therefore it is predicted another 10 years of growth would provide an additional 10 m^3 of CWD per ha. Where the measure after offset is not being met, sites may be augmented with additional CWD from felled forests as part of the Project.	9.98 for old growth forest (hill country). 0.48 for old growth treeland.	Restoration planting and fencing to exclude stock. Enhancement plantings. CWD provision.		Richardson *et al.*, (2009) Reference site.
	Flaky bark Number of trees per plot with flaky bark (trees/ha)	37.5	Benchmark is the same as measured values on site.	600 (35 years)	After 35 years of restoration, the number of flaky bark trees is likely to be similar to that of the value determined from secondary broadleaf forests on site.	37.5 for old growth forest (hill country). 0 for old growth treelands.	Restoration planting and fencing to exclude stock. Enhancement plantings.		

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
					The number of flaky bark trees is expected to decline as the forest transitions into old growth (e.g. the number of kānuka and mānuka decreases).				
	Leaf litter (average litter depth per plot in mm, with five samples taken in each plot)	40	Average litter depth in Old Growth Forest (Hill Country) plots on site was 39.3. These were fenced with little stock access, and therefore this value is considered an appropriate benchmark for Old Growth Forests.	30 (20 years)	Litter fall from a 20 year old forest (reference site) was found to be 30 mm. After 20 years, and with stock exclusion, it is reasonable to expect litter fall to be of a similar depth to the reference site.	39.3 for old growth forest (hill country). 0 for old growth treelands.	Restoration planting and fencing to exclude stock. Enhancement plantings.		Estimate based on plots undertaken in Old Growht Forest (Hill Country) on site. Reference site.

Table 7: Biodiversity attribute, benchmark, and expected biodiversity value of Secondary Broadleaved Forests and Scrublands, Advanced Secondary Broadleaved Forest and Secondary Broadleaved Forests with Old-Growth Signatures. The discount rate for all values was set at 0.03 in the offset model.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Canopy	Percentage (%) cover indigenous	90	The benchmark 90% canopy cover considers best scenario conditions for secondary broadleaved forests. Vegetation surveys in secondary forests on site returned variable canopy covers. The most intact forest received scores of between 90 and 100% canopy cover. Other areas had been impacted by livestock and pests resulting in lower scores. 90% is considered an appropriate benchmark, as often, even in	90 (10 years)	Canopy closure typically occurs within 5 -10 years depending on species composition and spacing (Tane's Tree Trust, 2011). 10 years is therefore considered an appropriate timeframe in which to achieve the target.	Secondary Broadleaved Forests and Scrublands: 79% Advanced Secondary Broadleaved Forest: 90% Secondary Broadleaved Forest with Old-Growth Signatures: 40% (low due to a canopy of exotic conifers).	Restoration planting and fencing to exclude livestock.	Secondary broadleaved forest and scrublands: 6.72/24 Advanced secondary broadleaved forest: 0.09/0.5 Secondary broadleaved forest with old-growth signatures: 0.36/1.3	Estimate based on healthy advanced secondary broadleaved plots undertaken on site, and evidence from Tane's Tree Trust (2011).

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			healthy forests, treefall and natural gaps result in some canopy gaps.						
	Average height (m)	10 (secondary broadleaf forest) 12 (advanced secondary broadleaf and secondary broadleaf with old growth signatures)	Literature suggests a New Zealand secondary forest is on average 9-12 m in height (Dawson & Sneddon, 1969). Advanced secondary and secondary with old-growth signature forests have been given a slightly higher benchmark to reflect the older states of the forests.	Secondary broadleaf forest: 10 (20 years) Advanced secondary broadleaf forest and secondary broadleaf forest with old-growth signatures: 12 (25 years)	Measurement of trees in a 20 year planting at the reference site determined an average height of 10 m. Native trees grow at various rates, but 20 years is sufficient time to reach 10 m tall for early successional plants (e.g. kānuka can grow up to 1 m per annum (Tane's Tree Trust (2020)), so after 20 years should be at least 10 m in height).	Secondary Broadleaved Forests and Scrublands: 4.9 m Advanced Secondary Broadleaved Forest: 5 m Secondary Broadleaved Forest with Old-Growth Signatures: 4.5 m	Restoration planting and fencing to exclude livestock. Enhancement planting and gap creation will be undertaken in the advanced secondary broadleaf and secondary broadleaf forest with old-growth signatures to advance the growth of late-successional plantings.		Dawson & Sneddon, (1969). Reference site Tane's Tree Trust (2020b)
	Basal area (m^2/ha)	50	Literature suggests New Zealand 'tall shrubland' has a	30 (35 years)	Literature suggests New Zealand 'tall shrubland' has a	Secondary Broadleaved	Restoration planting and fencing to		Allen *et al.*, (2013) Reference site

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			mean basal area of 28, and a māhoe forest (18 m in height) mean basal area of 65 (Allen *et al.,* 2013). It is considered that the basal area of a pristine secondary forest would likely be a value between a tall shrubland and māhoe forest, as a secondary broadleaf forest is considered to be more mature than a tall shrubland, but not as mature as an 18 m tall māhoe forest. For instance, secondary broadleaved forests on site averaged approximately 5 m in height.		mean basal area of 28 (Allen *et al.,* 2013). After 35 years, each of the secondary broadleaf forest types is expected to be a tall shrubland – kānuka is at least 10 m tall after 20 years (according to reference site and Tane's Tree Trust (2020b)). Therefore a basal area of 30 is deemed to be an appropriate target value for each ecosystem type.	Forests and Scrublands: 22.9 Advanced Secondary Broadleaved Forest: 16.4 Secondary Broadleaved Forest with Old-Growth Signatures: 11.5	exclude livestock. Enhancement planting and gap creation will be undertaken in the Advanced Secondary Broadleaf and Secondary Broadleaf Forest with Old-Growth Signatures to advance the successional trajectory in these forest types.		Tane's Tree Trust (2020b)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Diversity	Diversity of native vascular plants (species richness)	55	Literature suggests an average of 50 native species in undisturbed mature māhoe forest Allen *et al.*, (2013). 55 species were identified in secondary broadleaved forests on-site, therefore this higher number has been used as the benchmark.	34 (20 years)	A 20 year restored kānuka forest at the reference site resulted in the identification of 34 species. Considering the diverse range of plantings (e.g. 24 species) and good seed source availability in surrounding landscapes, 34 species is considered an achievable target after 20 years.	Secondary Broadleaved Forests and Scrublands: 55 Advanced Secondary Broadleaved Forest: 14 Secondary Broadleaved Forest with Old-Growth Signatures: 20	Restoration planting and fencing to exclude livestock.		Allen *et al.*, (2013) Reference site
Understorey	Indigenous species cover below 1.35 m (%)	50 (Secondary broadleaf and advanced secondary broadleaf) 70 (Secondary broadleaf with old growth signatures)	Average understorey cover observed in New Zealand hill country forest fragments is 40% (Smale *et al.*, 2008). Understorey canopy cover from plots in secondary broadleaved	50 (20 years)	Restoration plantings typically have relatively high understorey cover values, as fast-growing ferns, native grasses, shrubs and plantings contribute to this tier. Therefore 20 years is	Secondary Broadleaved Forests and Scrublands: 49.3 Advanced Secondary Broadleaved Forest: 50 Secondary Broadleaved Forest with Old-	Restoration planting and fencing to exclude livestock.		Smale *et al.*, (2008)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			forests on site were higher than literature values. These values are considered closer to a pristine state, and therefore appropriate for benchmarking. Understorey canopy cover is typically lower than canopy cover above 1.35 m in secondary broadleaved forests.		considered sufficient time to achieve a 50% understorey canopy cover.	Growth Signatures: 70			
Emergent trees*	Average height (m)	0	No emergent trees were recorded during surveys.						
	Number of trees (count/ha)	0	No emergent trees were recorded during surveys.						
Fauna habitat and food provision	Epiphytes Number of trees per plot supporting at	Secondary broadleaved forests and scrublands and advanced	There is a paucity of literature on this value.	50 (35 years)	Kānuka forest and secondary broadleaved forest and scrub had	Secondary Broadleaved Forests and	Restoration planting and fencing to		Estimate based on early successional

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
	least one epiphyte cluster (epiphytes/ha)	secondary broadleaf: 60 Secondary broadleaved forest with old-growth signatures: 300	Value taken from secondary broadleaf plot results of 57.1 epiphytes/ha. Secondary broadleaved forest with old-growth signatures has a higher benchmark – this value was derived from plots undertaken on site in secondary broadleaved forest with old-growth signatures. It also reflects the presence of larger and older trees in this ecosystem type, and therefore more likely to host epiphytes.		approximately 50 canopy epiphytes on site. It is therefore considered appropriate that some epiphytes may establish after 35 years. Furthermore, studies support fast epiphyte establishment. For instance, Taylor and Burns, (2015) found the mean DBH after which epiphytes begin to establish on māhoe is 5.58 cm, and for tawa, 11.70 cm. After 35 years, planted māhoe, tawa and other species are predicted to be larger than these initial epiphyte establishment tree sizes.	Scrublands: 30 epiphytes per ha. Advanced Secondary Broadleaved Forest: 0 epiphytes per ha. Secondary Broadleaved Forest with Old-Growth Signatures: 300 epiphytes per ha.	exclude livestock.		plots undertaken on site. Taylor and Burns (2015)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Fauna habitat and food provision	**Cavities** Number of trees per plot containing at least one cavity (cavities / ha)	1300	20 year old reference site returned a value of 1150 cavities/ha. Results from plots in Secondary Broadleaved Forest with Old-Growth Signatures had a value of 1300 cavities/ha. This higher number has been used as benchmark. There is otherwise a paucity of literature on the number of cavities in secondary broadleaved forests.	1150 (20 years)	Given that 1150 cavities per ha have been observed in 20 year-old kānuka forest at plots undertaken at the reference site, it is reasonable to expect that a similar number of cavities will be present in 20 years at offset sites. Where measures after offset values are not being achieved, artificial cavities may be deployed such as weta houses, which provide similar ecological functions.	Secondary Broadleaved Forests and Scrublands: 1128.6 Advanced Secondary Broadleaved Forest: 100 Secondary Broadleaved Forest with Old-Growth Signatures: 1300	Restoration planting and fencing to exclude livestock. Artificial cavity provision.		Reference site
	Fruiting trees Fruiting tree abundance (no./ha) of tawa,	0	No fruiting trees were recorded during surveys.	0 (35 years)	Tawa, matai, miro or kahikatea are not expected to be capable of	Secondary Broadleaved Forests and Scrublands: 0			

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
	matai, miro and or kahikatea				fruiting after 35 years.	Advanced Secondary Broadleaved Forest: 0 Secondary Broadleaved Forest with Old-Growth Signatures: 0			
	Coarse woody debris (CWD) Volume of CWD (m^3 per ha). Does not include dead standing trees.	22	Benchmark derived from 20 year old reference site, which had CWD at 22 m^3/ha. Reference site is dominated by kānuka, and only partially reflects the community composition of a secondary broadleaf forest. There is a paucity of literature on CWD values of secondary broadleaved forest.	22 (20 years)	Plots from 20 year old kānuka forest reference site returned a value of 22.13 CWD. Where the measure after offset is not being met, sites may be augmented with additional CWD from felled forests as part of the Project. CWD values in these forests on site have likely been reduced by stock access.	Secondary Broadleaved Forests and Scrublands: 1.67 Advanced Secondary Broadleaved Forest: 0 Secondary Broadleaved Forest with Old-Growth Signatures: 0	Restoration planting and fencing to exclude stock. CWD provision.		Reference site

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
	Flaky bark Number of trees per plot with flaky bark (trees/ha)	2000	Benchmark derived from 20 year-old reference site. Reference site is dominated by kānuka, and only partially reflects the community composition of a secondary broadleaf forest. There is a paucity of literature on flaky bark values of secondary broadleaved forest.	2000 (20 years)	Estimate derived from 20 year-old reference site. Kānuka and mānuka are within the proposed species to be planted in secondary broadleaved forests. These two species are particularly flaky, and are expected to form the majority of flaky bark trees.	Secondary Broadleaved Forests and Scrublands: 685.7 Advanced Secondary Broadleaved Forest: 0 Secondary Broadleaved Forest with Old-Growth Signatures: 200	Restoration planting and fencing to exclude stock. Enhancement plantings.		Reference site
	Leaf litter (average litter depth per plot in mm, with five samples taken in each plot)	30	Litter depth estimate derived from plots undertaken in secondary broadleaved forest with old-growth signatures, which had the highest litter depth values.	30 (20 years)	Litter fall from a 20 year old reference site was 30 mm.	Secondary Broadleaved Forests and Scrublands: 15.3 Advanced Secondary Broadleaved Forest: 10 Secondary Broadleaved Forest with Old-	Restoration planting and fencing to exclude stock. Enhancement plantings.		Estimate based on plots undertaken on site.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
						growth Signatures: 29.4			

Table 8: Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of kānuka forests and mānuka, kānuka shrublands. The discount rate for all values was set at 0.03.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset	Overall Impact Area/Offset Area (ha)	Reference
Canopy	Percentage (%) cover indigenous	90	The benchmark 90% canopy cover considers best scenario conditions for kānuka forests and mānuka, kānuka scrublands.	90 (10 years)	10 years is considered an appropriate time to establish a closed canopy. Canopy closure typically occurs within 5 -10 years depending on species composition and spacing (Tane's Tree Trust, 2011).	Kānuka Forest: 52.5 Mānuka, Kānuka Shrublands: 45	Restoration planting and fencing to exclude livestock.	Kānuka forest: 1.02/2.3 Mānuka, kānuka forest: 2.24/5.7	Estimate based on plots undertaken on site. Tane's Tree Trust, 2011
	Average height (m)	12 (kānuka forest) 5 (mānuka, kānuka shrubland)	Literature suggests a New Zealand secondary forest is 9-12 m in height (Dawson & Sneddon, 1969). Furthermore reference site results at a kānuka forest returned values of 8-12 m. Mānuka, kānuka shrubland is characterised by a shorter stature than kānuka forest (Esler & Astridge, 1974).	10 (20 years) 4 (15 years)	Measurement of kānuka trees at 20 year old reference site determined an average height of 10 m. Literature suggests mānuka, kānuka shrubland can reach 4 m in 15 years (Esler & Astridge, 1974). Given kānuka can grow up to 1 m per annum, (Tane's Tree Trust (2020b), a 4 m target is a conservative estimate.	Kānuka Forest: 52.5 Mānuka, Kānuka Shrublands: 45	Restoration planting and fencing to exclude livestock.		Dawson & Sneddon, (1969) Esler & Astridge (1974) Reference site Tane's Tree Trust (2020b)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset	Overall Impact Area/Offset Area (ha)	Reference
	Basal area (m^2/ha)	28	Literature suggests New Zealand 'kānuka forest and tall shrubland' has a mean basal area of 28 (Allen *et al.,* 2013).	22 (20 years)	Reference site returned a value of 22 m^2/ha after 20 years.	Kānuka Forest: 22.9 Mānuka, Kānuka Shrublands: 15.3	Restoration planting and fencing to exclude livestock.		Allen *et al.*, (2013) Reference site
Diversity	Diversity of native vascular plants (species richness)	44	Literature suggests a mean species richness in kānuka forest mānuka shrub as of 44 and 20 respectively. (Allen *et al.*, 2013). The higher species richness value has been used as proxy for a more pristine ecosystem, and also reflects the diversity of species found in kānuka forest and mānuka and kānuka shrubland plots on site.	34 (20 years)	The 20 year old reference site resulted in the identification of 34 species during a short site walkover. 14 species are proposed as an initial starting crop for this ecosystem type. Furthermore, Manawatū Gorge Scenic Reserve is considered to likely provide a sufficient seed source for a variety of species to establish. Average species richness was 31 at young kānuka plots in the Wellington region (Sullivan *et al.* 2007). These plots had kānuka 2-4 m tall. This study is evidence that a high number of	Kānuka Forest: 21 Mānuka, Kānuka Shrublands: 39	Restoration planting and fencing to exclude livestock.		Allen *et al.*, (2013) Sullivan *et al.*¸(2007) Reference site

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset	Overall Impact Area/Offset Area (ha)	Reference
					species can establish in young kānuka plots.				
Understorey	Indigenous plant cover below 1.35 m (%)	40	Average understorey cover observed in New Zealand hill country forest fragments is 40% (Smale *et al.*, 2008).	15 (20 years)	Reference sites had a relatively low rate of understorey growth with the highest plot having a value of 15%. With a relatively diverse starting crop which includes broadleaved species, 15% is considered appropriate for this site.	Kānuka Forest: 2.5 Mānuka, Kānuka Shrublands: 13.2	Restoration planting and fencing to exclude livestock.		Smale *et al.*, (2008) Reference site
Emergent trees* (Mānuka, Kānuka Shrublands only) Kānuka Forest plots were not found to have any emergent trees.	Number of trees (count/ha)	30	30 trees per ha is considered a conservative estimate.	20 (15 years)	20 trees at 4 m height in 15 years is considered a conservative estimate. There is a paucity of literature on emergent trees of mānuka, kānuka shrublands. Data determined from plots on site.	20	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site
	Average height (m)	8	Height of typical woody shrubs observed in plots (such as lacebark) which may become emergent trees.	4 (15 years)	15 years is an appropriate length of time for trees to reach 4 m in a mānuka kānuka shrubland (Esler & Astridge, 1974).	1.5 m	Restoration planting and fencing to exclude livestock.		Esler & Astridge (1974)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset	Overall Impact Area/Offset Area (ha)	Reference
Fauna habitat and food provision	**Epiphytes** Number of trees per plot supporting at least one epiphyte cluster (epiphytes/ha)	50	There is a paucity of literature on this value. Value taken from kānuka forest plots of 50 epiphytes/ha.	50 (35 years)	Kānuka forest on site was recorded as having 50 canopy epiphytes on site. It is therefore considered appropriate that some epiphytes may establish after 35 years.	Kānuka Forest: 50 Mānuka, Kānuka Shrublands: 0	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site.
	Cavities Number of trees per plot containing at least one cavity (cavities / ha)	1150	20 year-old reference site returned a value of 1150 cavities/ha.	1150 (20 years)	Given that 1150 cavities per ha have been observed in 20 year-old kānuka forest plots undertaken at the reference site, it is reasonable to expect that a similar number of cavities will be present in 20 years. Where measures after offset values are not being achieved, artificial cavities may be deployed such as weta houses, which provide similar ecological functions.	Kānuka Forest: 400 Mānuka, Kānuka Shrublands: 1120	Restoration planting and fencing to exclude livestock. Artificial cavity provision.		Reference site
	Fruiting trees Fruiting tree abundance (no./ha) of tawa,	0	No fruiting trees were recorded during surveys.	0 (35 years)	Tawa, matai, miro or kahikatea are not expected to be present in these ecosystem types.	Kānuka Forest: 0			

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset	Overall Impact Area/Offset Area (ha)	Reference
	matai, miro and or kahikatea					Mānuka, Kānuka Shrublands: 0			
	Coarse woody debris (CWD) Volume of CWD (m^3 per ha). Does not include dead standing trees.	22	Benchmark derived from 20 year-old reference site which returned a value of 22 m^3/ha.	22 (20 years)	Estimate derived from reference site. Where the measure after offset is not being met, sites may be augmented with additional CWD from felled forests as part of the Project.	Kānuka forest: 9.55 Mānuka, Kānuka Shrublands: 1.67	Restoration planting and fencing to exclude stock. CWD provision.		Richardson *et al.*, (2009) Reference site
	Flaky bark Number of trees per plot with flaky bark (trees/ha)	2000	Benchmark derived from 20 year old reference site.	2000 (20 years)	Measure after offset derived from 20 year old reference site.	Kānuka Forest: 1150 Mānuka, Kānuka Shrublands: 920	Restoration planting and fencing to exclude stock. Enhancement plantings.		Reference site

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset	Overall Impact Area/Offset Area (ha)	Reference
	Leaf litter (average litter depth per plot in mm, with five samples taken in each plot)	30	Approximate benchmark value determined from reference site.	30 (20 years)	Litter fall from the 20 year old reference site was 30 mm.	Kānuka Forest: 0.7 Mānuka, Kānuka Shrublands: 8.28	Restoration planting and fencing to exclude stock. Enhancement plantings.		Estimate based on plots undertaken on site.

Table 9: Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of Divaricating Shrublands. The discount rate for all values was set at 0.03 in the offset model.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Canopy	Percentage (%) cover indigenous	80	Estimate based on plots undertaken on site.	80 (10 years)	10 years is considered an appropriate time to establish a closed canopy. Canopy closure typically occurs within 5 -10 years depending on species composition and spacing (Tane's Tree Trust, 2011).	25	Restoration planting and fencing to exclude livestock.	0.15/0.4	Estimate based on plots undertaken on site in Divaricating Shrublands. Tane's Tree Trust (2011).
	Average height (m)	1	Estimate based on plots undertaken on site.	1 (10 years)	Literature suggests mānuka, kānuka shrubland can reach 4 m in 15 years (Esler & Astridge, 1974). Although the Divaricating Shrubland consists of small divaricating species such as *Coprosma rhamnoides*, as opposed to mānuka and kānuka, 1 m in 10 years is considered achievable and a conservative estimate for vegetative growth.	0.8	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site in Divaricating Shrublands. Esler and Astridge, (1974) Southern Woods (2020)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
					Grey literature suggests Coprosma rhamnoides can grow to 1.5 m height in 5 years (Southern Woods, 2020).				
	Basal area (m^2/ha)	0.5	Estimate based on plots undertaken on site.	0.32 (10 years)	Estimate based on plots undertaken on site. 10 years is considered sufficient time for sparsely distributed woody shrubs above 1.35 m to form.	0.32	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site in Divaricating Shrublands.
Diversity	Diversity of native vascular plants (species richness)	27	Estimate based on plots undertaken on site.	27 (15 years)	A total of 27 species are to be planted.	24	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site in Divaricating Shrublands.
Understorey	Indigenous plant cover below 1.35 m (%)	25	Estimate based on plots undertaken on site. Divaricating shrublands have a naturally sparse understorey.	25 (15 years)	After 15 years it is assumed that planted divaricating shrublands will be in a similar condition to the impacted shrublands.	25	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site in Divaricating Shrublands.
Emergent trees*	Number of trees (count/ha)	0	No emergent trees identified during surveys.						

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
	Average height (m)	0	No emergent trees identified during surveys.						
Fauna habitat and food provision	**Epiphytes** Number of trees per plot supporting at least one epiphyte cluster (epiphytes/ha)	0	Canopy epiphytes were not recorded in divaricating shrublands on site. They are considered unlikely to form on small divaricating shrubs with stock access.						
	Cavities Number of trees per plot containing at least one cavity (cavities / ha)	100	Estimate based on plots undertaken on site in divaricating shrublands.	100 (15 years)	Some woody shrubs are likely to establish within the divaricating shrublands which contain cavities as was observed in divaricating shrublands on site. 15 years is considered enough time for a woody shrub to develop cavities (as observed at reference site where some plants were seen to have cavities after 7 years). Where measures after offset values are not being achieved, artificial cavities may be deployed such as weta houses, which provide	100	Restoration planting and fencing to exclude livestock. Artificial cavity provision.		Estimate based on plots undertaken on site in Divaricating Shrublands. Reference site

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
					similar ecological functions.				
	Fruiting trees Fruiting tree abundance (no./ha) of tawa, matai, miro and or kahikatea	0	Fruiting trees were not present in divaricating shrublands on site	0 (35 years)	Tawa, matai, miro or kahikatea are not expected to be present in this ecosystem type.				Estimate based on plots undertaken on site in Divaricating Shrublands.
	Coarse woody debris (CWD) Volume of CWD (m^3 per ha). Does not include dead standing trees.	0	CWD was not present in divaricating shrublands on site.	0 (35 years)					Estimate based on plots undertaken on site in Divaricating Shrublands.
	Flaky bark Number of trees per plot with flaky bark (trees/ha)	0	Flaky bark was not present in divaricating shrublands on site.	0 (35 years)					Estimate based on plots undertaken on site in Divaricating Shrublands.
	Leaf litter (average litter depth per plot in mm, with five samples taken in each plot)	0	The small leaves of divaricating shrublands do not provide available leaf litter.	0 (35 years)					Estimate based on plots undertaken on site in Divaricating Shrublands.

Table 10: Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of Indigenous Dominated Seepage Wetlands (High Value), henceforth named 'Raupō Wetland'. The discount rate for all values was set at 0.03 in the offset model.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Canopy	Percentage (%) cover indigenous	100	Estimate based on plots undertaken on site. Raupō typically forms a dominant wetland canopy.	100 (7 years)	Seven years is considered an appropriate time to establish a closed canopy, as raupō is a fast-growing species (McK Pegman & Ogden, 2005).	100	Restoration planting and fencing to exclude livestock.	0.14/0.35	Estimate based on plots undertaken on site McK Pegman and Ogden (2005)
	Average height (m)	2.5	Estimate based on plots undertaken on site.	2.5 (7 years)	Raupō is a fast-growing species (McK Pegman & Ogden, 2005). Seven years is considered a conservative amount of time for raupō to reach 2.5 m in height.	2.5	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site
	Basal area (m^2/ha)	0	No vegetation of appropriate size or of woody biomass was present within the plot.	0		0			Estimate based on plots undertaken on site
Diversity	Diversity of native vascular plants (species richness)	19	Estimate higher than species richness of raupō wetland on site (17 species). The raupō wetland on site has been affected by stock browse, especially at the edges. Fencing the	19 (4 years)	A total of 19 species are proposed to be planted.	17	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			wetland would likely result in more wetland species establishing, hence the benchmark of 19 species. Raupō typically dominates as a monoculture, and a pristine raupō wetland is not expected to be highly diverse.						
Understorey	Indigenous plant cover below 1.35 m (%)	100	Understorey at plots on site is dominated by raupō reeds.	100 (7 years)	Seven years is considered an appropriate time to establish a full understorey, as raupō is a fast-growing species.	100	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site
Fauna resources	Complex habitat availability for nesting birds (%)	100	Raupō provides nesting habitat for wetland birds such as fernbirds, spotless crake, marsh crake and bittern. Pristine raupō habitats are generally dominated by a raupō monoculture. Estimate based on plot in raupō wetland undertaken on site.	100 (7 years)	Seven years is considered an appropriate time to establish a closed canopy, as raupō is a fast-growing species (McK Pegman and Ogden, 2005).	100	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site. McK Pegman and Ogden (2005)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Emergent trees* (mānuka and kānuka shrubland only)	Number of trees (count/ha)	100	Mānuka and kānuka occasionally present within raupō wetland. Estimate based on plots undertaken on site.	100 (15 years)	15 years is an achievable timeframe for mānuka to emerge at a higher tier than raupō (Esler and Astridge 1974). Mānuka to be planted at appropriate spacings to achieve 100 mānuka per ha.	100	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site Esler and Astridge (1974).
	Average height (m)	4	Estimate based on plot undertaken in raupō wetland on site. Emergent mānuka are typically 4 m tall.	4 (15 years)	15 years is an appropriate timeframe for mānuka to grow up to 4 m (Esler and Astridge, 1974).	4	Restoration planting and fencing to exclude livestock.		Esler and Astridge (1974). Estimate based on plots undertaken on site

Table 11: Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of Exotic Dominated Wetlands (EW) and Indigenous Dominated Seepage Wetlands (moderate value; IW). The discount rate for all values was set at 0.03 in the offset model.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
Canopy	Percentage (%) cover indigenous	90	It is expected that a fully planted wetland will consist of 90% canopy cover, which includes a mix of tall wetland species such as kahikatea, as well as lower strata wetland species such as Carex and harakeke. Altogether, these will provide 90% indigenous canopy cover, albeit at different height tiers.	90 (35 years)	It is considered that 35 years will be sufficient time for the proposed wetland restoration plants to establish and grow and cover 90% of the area. Wetland canopy cover has been shown to establish extremely quickly in some studies (e.g. 100% canopy cover in 2 years following fire in a New Zealand peat wetland; Johnson, 2001). Ground covers, and low stature wetland species are expected to create a dense canopy before wetland trees such as kahikatea. 19 wetland species are proposed for planting, which will create canopy cover at various height tiers.	EW: 7.13 IW: 90	Restoration planting and fencing to exclude livestock.	IW: 0.42/1.2 EW: 4.27/4.9	Johnson, (2001)
	Average height (m)	30	Kahikatea can grow up to 55 m in the optimal	10 (20 years)	Kahikatea grows between 10-70 cm	EW: 0.9	Restoration planting and		Tane's Tree Trust, (2020a)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			conditions. However typical pristine kahikatea forest canopies are at approximately 30 m (Harris & Burns, 2000).		annually (Tane's Tree Trust, 2020). Therefore 10 m of growth after 20 years is considered appropriate.	IW: 0.45	fencing to exclude livestock.		(Harris & Burns, 2000)
	Basal area (m^2/ha)	50	Basal area benchmark estimate based on a kahikatea forest remnant in Eastern Bay of Plenty (Smale, 1984).	20 (35 years)	It is considered that after 35 years	EW: 0.5 IW: 0	Restoration planting and fencing to exclude livestock.		Smale (1984)
Diversity	Diversity of native vascular plants (species richness)	60	High value kahikatea wetlands have been shown to sustain up to 98 species (Smale *et al.*, 2005). There is generally a positive species-area relationship found in the literature (e.g. as area sampled increases, so does the number of species; Palmer and White, 1994). As only a relatively small area of kahikatea restoration is being proposed, the benchmark has been set at a lower diversity than 98.	25 (10 years)	A total of 19 species are proposed for planting. It is considered reasonable to assume that an additional 6 species would self-propagate within a 10 year period, especially considering the close proximity of the offset sites to Manawatū Scenic Reserve.	EW: 16 IW: 4	Restoration planting and fencing to exclude livestock.		Smale *et al.*, (2005) Palmer and White (1994) Miller (2004)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
			Furthermore Miller (2004) found 37 to 44 species per 500 m^2 in floodplain forest plots in south Westland, New Zealand.						
Understorey	Indigenous plant cover below 1.35 m (%)	90	Benchmark kahikatea wetland mosaics are dominated by indigenous species.	90 (10 years)	All restoration plantings are indigenous species which are predicted to grow and establish canopies (at different strata levels) within 10 years (e.g. raupō, *Carex geminata*, *Cyperus ustulatus*, kānuka).	EW: 7.1 IW: 90	Restoration planting and fencing to exclude livestock.		Johnson, (2001)
Fauna resources	Complex habitat availability for nesting birds (%)	90	A natural and pristine wetland mosaic in New Zealand will typically provide sufficient habitat availability for wetland birds across its entire extent, due to a full canopy, sub canopy and undergrowth layers. Therefore a benchmark of 90% habitat has been assumed.	60 (10 years)	Approximately 60% of plantings are expected to be suitable for wetland bird nesting (e.g. raupō, *Carex geminata*). 10 years is considered sufficient time for these rush-like species to establish and grow sufficiently large. A 60% bird habitat availability target is considered achievable, especially as New Zealand wetland birds nest in a wide variety of wetland habitat types (e.g. O'Donnell, 2011;	EW: 4.75 IW: 90	Restoration planting and fencing to exclude livestock.		Anderson and Ogden, (2003); O'Donnell, (2011)

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Reference
					Anderson & Ogden, 2003).				
Emergent trees*	Number of trees (count/ha)	0				EW: 0 IW: 0	Restoration planting and fencing to exclude livestock.		
	Average height (m)	0				EW: 0 IW: 0	Restoration planting and fencing to exclude livestock.		

* Emergent trees were only observed in wetland ecosystem types and mānuka, kānuka scrublands. Vegetation was generally too young to identify distinct emergent trees above the main existing canopies, therefore emergent trees were generally not used within offset models. Trees growing in and around wetlands could be distinctly identified as emergent.

Reference site

Two Recce plots were undertaken at Mutukaroa/Hamlin's Hill, an area of ecological restoration in urban Auckland. Vegetation consists of a typical suite of early successional restoration plantings in the Auckland region; the canopy is dominated by kānuka, while whau, hangehange, māhoe and other sub-canopy broadleaf species and ferns fill lower tiers. Recce plots were undertaken in two areas which have been planted and fenced, aged at approximately 20-25 years, and used to inform benchmark and measure after offset values. The reference plots are considered in good ecological condition, due to stock exclusion fencing and pest mammal control. However, Mutukaroa/Hamlin's Hill is isolated from other forests, is present in a highly urbanised environment, and likely suffers edge effects. The approach of using data from Mutukaroa/Hamlins bush was discussed with DOC as an appropriate approach in obtaining benchmark data from a stand of kanuka of a known age.

APPENDIX G.2: OFFSET MODEL OUTPUTS

[on next page]

Advanced secondary broadleaved forest:

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	0.04	90	90	0	-0.04
		1.1b	Height	metre	0.04	12	5	0	-0.02
		1.1c	Basal area	m2/ha	0.04	50	16.5	0	-0.01
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.04	55	14	0	-0.01
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	0.04	50	50	0	-0.04
1.4	Emergent trees	1.4a	Number of individuals/ha	Count	0.04	0	0	0	0.00
1.5	Fauna resources	1.5a	Canopy epiphytes	Epiphytes/ha	0.04	60	0	0	0.00
		1.5b	Cavities	Cavities/ha	0.04	1300	100	0	0.00
		1.5c	Tawa fruit	Number of fruiting trees/ha	0.04	0	0	0	0.00
		1.5d	Leaf litter	Average litter depth (mm)	0.04	30	10	0	-0.01
		1.5e	Flaky bark	Flaky bark trees/ha	0.04	2000	0	0	0.00
1.6	Fauna resources	1.6a	CWD	m3/ha	0.04	22	0	0	0.00

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	**Biodiversity Attribute**		**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodivers**	**Component Net Present Biodiversity Value**
1.1	Canopy	**1.1a**	Cover	percent	90	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	90	10	0.10	-0.04	0.06	0.04
		1.1b	Height	metre	12	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	0.06	-0.02	0.05	
		1.1c	Basal area	m2/ha	50	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	30	35	0.03	-0.01	0.02	
1.2	Diversity	**1.2 a**	Diversity of native vascular	Species richness	55	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	34	20	0.05	-0.01	0.04	0.04
1.3	Understorey	**1.3 a**	Percentage cover of indigenous	Percent	50	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	50	35	0.05	-0.04	0.01	0.01
1.4	Emergent trees	**1.4 a**	Number of individuals/ha	Count	0	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	0	35	0.00	0.00	0.00	#DIV/0!
1.5	Fauna resources	**1.5 a**	Canopy epiphytes	Epiphytes/ha	60	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	50	35	0.04	0.00	0.04	0.06
		1.5 b	Cavities	Cavities/ha	1300	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	1150	20	0.07	0.00	0.07	
		1.5 c	Tawa fruit	Number of fruiting trees/ha	0	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	0	35	0.00	0.00	0.00	
		1.5 d	Leaf litter	Average litter depth (mm)	30	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	0.08	-0.01	0.06	
		1.5 e	Flaky bark	Flaky bark trees/ha	2000	Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	2000	20	0.08	0.00	0.08	
1.6	Fauna resources	**1.6 a**	CWD	m3/ha		Planting, weed control and fencing	0.17	Confident 75-90%	Finite end point	Continue to Column M	0	22	20	0.08	0.00	0.08	0.08

Divaricating shrublands:

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	**Biodiversity Attribute**		**Measurement Unit**	**Area of Impact (ha)**	**Benchmark**	**Measure prior to Impact**	**Measure after Impact**	**Biodiversity Value**
1.1	Canopy	1.1a	Cover	percent	0.33	80	25	0	-0.10
		1.1b	Height	metres	0.33	1	0.8	0	-0.26
		1.1c	Basal area	m2/ha	0.33	0.5	0.32	0	-0.21
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.33	27	24	0	-0.29
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	0.33	25	25	0	-0.33
1.4	Emergent trees	1.4a	Number of individuals/ha	Count	0.33	0	0	0	0.00
		1.4b	Average height	Metres	0.33	0	0	0	0.00
1.5	Fauna resources	1.5a	Canopy epiphytes	Epiphytes/ha	0.33	0	0	0	0.00
		1.5b	Cavities	Cavities/ha	0.33	100	100	0	-0.33
		1.5c	Fruiting trees	Number of fruiting trees/ha	0.33	0	0	0	0.00
		1.5d	Leaf litter	Average litter depth (mm)	0.33	0	0	0	0.00
		1.5e	Flaky bark	Flaky bark trees/ha	0.33	0	0	0	0.00
1.6	Fauna resources	1.6a	CWD	m3/ha	0.33	0	0	0	0.00

Offset model:

1.1	Canopy	1.1a	Cover	percent	80	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	80	10	0.40	-0.10	0.30	0.16
		1.1b	Height	metres	1	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	1	10	0.40	-0.26	0.14	
		1.1c	Basal area	m2/ha	0.5	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	0.32	10	0.26	-0.21	0.04	
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	27	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	27	15	0.34	-0.29	0.05	0.05
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	25	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	25	15	0.34	-0.33	0.01	0.01
1.4	Emergent trees	1.4a	Number of individuals/ha	Count	0	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!
		1.4b	Average height	Metres	0	planting of shrubland, fencing, periodic grazing once established	0.65	Very confident >90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.5	Fauna resources	1.5a	Canopy epiphytes	Epiphytes/ha	0	planting of shrubland, fencing, periodic grazing once established	0.65	Low confidence >60%-<75%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	0.01
		1.5b	Cavities	Cavities/ha	100	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	100	15	0.34	-0.33	0.01	
		1.5c	Fruiting trees	Number of fruiting trees/ha	0	planting of shrubland, fencing, periodic grazing once established	0.65	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
		1.5d	Leaf litter	Average litter depth (mm)	0	planting of shrubland, fencing, periodic grazing once established	0.65	Low confidence >60%-<75%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
		1.5e	Flaky bark	Flaky bark trees/ha	0	planting of shrubland, fencing, periodic grazing once established	0.65	Low confidence >60%-<75%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.6	Fauna resources	1.6a	CWD	m3/ha	0	planting of shrubland, fencing, periodic grazing once established	0.4	Low confidence >60%-<75%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!

Exotic dominated wetlands (low value):

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	4.42	90	7.13	0	-0.35
		1.1b	Height	metre	4.42	30	0.9	0	-0.13
		1.1c	Basal area	m2/ha	4.42	50	0.5	0	-0.04
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	4.42	60	16	0	-1.18
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	4.42	90	7.1	0	-0.35
1.4	Emergent trees	1.4a	Number of individuals	Count/ha	4.42	0	0	0	0.00
		1.4b	Average height	Metres	4.42	0	0	0	0.00
1.5	Fauna habitat and food provision	1.5a	Percent complex habitat for nesting birds	Percent	4.42	90	4.75	0	-0.23

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	5	Confident 75-90%	Finite end point	Continue to Column M	7.13	90	35	1.35	-0.35	1.00	0.70
		1.1b	Height	metre	30	Planting, weed control and fencing	5	Confident 75-90%	Finite end point	Continue to Column M	0.9	10	20	0.69	-0.13	0.56	
		1.1c	Basal area	m2/ha	50	Planting, weed control and fencing	5	Confident 75-90%	Finite end point	Continue to Column M	0.5	20	35	0.57	-0.04	0.53	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	60	Planting, weed control and fencing	5	Very confident >90%	Finite end point	Continue to Column M	5	25	10	1.18	-1.18	0.01	0.01
1.3	Understorey	1.3a	Percentage cover of	Percent	90	Planting, weed control and fencing	5	Confident 75-90%	Finite end point	Continue to Column M	7.125	90	10	2.83	-0.35	2.48	2.48
1.4	Emergent trees	1.4a	Number of individuals	Count/ha	0	Planting, weed control and fencing	5	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!
		1.4b	Average height	Metres	0	Planting, weed control and fencing	5	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.5	Fauna habitat and food provision	1.5a	Percent complex habitat for	Percent	90	Planting, weed control and fencing	5	Confident 75-90%	Finite end point	Continue to Column M	4.75	60	10	1.88	-0.23	1.65	1.65

Indigenous dominated seepage wetlands (moderate value):

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	0.44	90	90	0	-0.44
		1.1b	Average height	metre	0.44	30	0.45	0	-0.01
		1.1c	Basal area	m2/ha	0.44	50	0	0	0.00
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.44	60	4	0	-0.03
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	0.44	90	90	0	-0.44
1.4	Emergent trees	1.4a	Number of individuals	Number of individuals/ha	0.44	0	0	0	0.00
		1.4b	Average height	Metres	0.44	0	0	0	0.00
1.5	Fauna habitat and food provision	1.5a	Percentage complex habitat for nesting birds	Percent	0.44	90	90	0	-0.44

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	1.2	Confident 75-90%	Finite end point	Continue to Column M	7.125	90	35	0.32	-0.44	-0.12	0.06
		1.1b	Average height	metre	30	Planting, weed control and fencing	1.2	Confident 75-90%	Finite end point	Continue to Column M	0.9	10	20	0.17	-0.01	0.16	
		1.1c	Basal area	m2/ha	50	Planting, weed control and fencing	1.2	Confident 75-	Finite end	Continue to	0	30	35	0.14	0.00	0.14	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	60	Planting, weed control and fencing	1.2	Confident 75-90%	Finite end point	Continue to Column M	5	25	10	0.25	-0.03	0.22	0.22
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	90	Planting, weed control and fencing	1.2	Confident 75-90%	Finite end point	Continue to Column M	7.125	90	10	0.68	-0.44	0.24	0.24
1.4	Emergent trees	1.4a	Number of individuals	Number of individuals/ha	0	Planting, weed control and fencing	1.2	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!
		1.4b	Average height	Metres	0	Planting, weed control and fencing	1.2	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.5	Fauna habitat and food provision	1.5a	Percentage complex habitat for	Percent	90	Planting, weed control and fencing	1.2	Confident 75-90%	Finite end point	Continue to Column M	4.75	60	10	0.45	-0.44	0.01	0.01

Kānuka forest:

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	1.3	90	52.5	0	-0.76
		1.1b	Average height	metre	1.3	12	4.5	0	-0.49
		1.1c	Basal area	m2/ha	1.3	28	22.9	0	-1.06
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	1.3	44	21	0	-0.62
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	1.3	40	2.5	0	-0.08
1.4	Emergent trees	1.4a	Number of individuals/ha	Count	1.3	0	0	0	0.00
		1.4b	Average height	Metres	1.3	0	0	0	0.00
1.5	Fauna habitat and food provision	1.5a	Flaky bark	Flaky bark trees/ha	1.3	2000	1150	0	-0.75
		1.5b	Cavities	Count	1.3	1150	400	0	-0.45
		1.5c	CWD	m3/ha	1.3	22	9.55	0	-0.56
		1.5d	Leaf litter	Average litter depth (mm)	1.3	30	0.7	0	-0.03
		1.5e	Canopy epiphytes	Epiphytes/ha	1.3	50	50	0	-1.30
1.6	Fauna habitat and food provision	1.6a	Tawa fruit	Furiting trees/ha	1.3	0	0	0	0.00

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	90	10	1.41	-0.76	0.65	0.27
		1.1b	Average height	metre	12	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	0.88	-0.49	0.39	
		1.1c	Basal area	m2/ha	28	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	22	20	0.83	-1.06	-0.24	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	44	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	34	20	0.81	-0.62	0.19	0.19
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	40	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	15	20	0.39	-0.08	0.31	0.31
1.4	Emergent trees	1.4a	Number of individuals/ha	Count	20	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!
		1.4b	Average height	Metres	0	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.5	Fauna habitat and food provision	1.5a	Flaky bark	Flaky bark trees/ha	2000	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	2000	20	1.05	-0.75	0.30	0.36
		1.5b	Cavities	Count	1150	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	1150	20	1.05	-0.45	0.60	
		1.5c	CWD	m3/ha	22	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	22	20	1.05	-0.56	0.49	
		1.5d	Leaf litter	Average litter depth (mm)	30	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	1.05	-0.03	1.02	
		1.5e	Canopy epiphytes	Epiphytes/ha	50	Planting, weed control and fencing	2.3	Confident 75-90%	Finite end point	Continue to Column M	0	50	35	0.67	-1.30	-0.63	
1.6	Fauna habitat and food provision	1.6a	Tawa fruit	Furiting trees/ha	0	Planting, weed control and fencing	2.3	Low confidence >50% <75%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!

Mānuka and kānuka shrublands:

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	2.11	90	45	0	-1.06
		1.1b	Average height	metre	2.11	5	4.22	0	-1.78
		1.1c	Basal area	m2/ha	2.11	28	15.3	0	-1.15
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	2.11	44	39	0	-1.87
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	2.11	40	13.2	0	-0.70
1.4	Emergent trees	1.4a	Number of individuals/ha	Count	2.11	30	20	0	-1.41
		1.4b	Average height	Metres	2.11	8	1.5	0	-0.40
1.5	Fauna habitat and food provision	1.5a	Flaky bark	Flaky bark trees/ha	2.11	2000	920	0	-0.97
		1.5b	Cavities	Cavities/ha	2.11	1150	1120	0	-2.05
		1.5c	CWD	m3/ha	2.11	22	1.67	0	-0.16
		1.5d	Canopy epiphytes	Epiphytes/ha	2.11	50	0	0	0.00
		1.5e	Leaf litter	Average litter depth (mm)	2.11	30	8.28	0	-0.58

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	5.7	Confident 75-90%	Finite end point	Continue to Column M	0	90	15	3.02	-1.06	1.96	1.16
		1.1b	Average height	metre	5	Planting, weed control and fencing	5.7	Confident 75-90%	Finite and point	Continue to Column M	0	4	15	2.41	-1.78	0.63	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	44	Planting, weed control and fencing	5.7	Confident 75-90%	Finite end point	Continue to Column M	0	34	20	2.01	-1.87	0.14	0.14
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	40	Planting, weed control and fencing	5.7	Confident 75-90%	Finite end point	Continue to Column M	0	15	20	0.98	-0.70	0.28	0.28
1.4	Emergent trees	1.4a	Number of individuals/ha	Count	30	Planting, weed control and fencing	5.7	Confident 75-90%	Finite end point	Continue to Column M	0	20	15	2.01	-1.41	0.61	0.86
		1.4b	Average height	Metres	8	Planting, weed control and fencing	5.7	Confident 75-90%	Finite and point	Continue to Column M	0	4	15	1.51	-0.40	1.11	
1.5	Fauna habitat and food provision	1.5a	Flaky bark	Flaky bark trees/ha	2000	Planting, weed control and fencing	5.7	Confident 75-90%	Finite end point	Continue to Column M	0	2000	20	2.60	-0.97	1.63	1.18
		1.5b	Cavities	Cavities/ha	1150	Planting, weed control and fencing	5.7	Confident 75-90%	Finite end point	Continue to Column M	0	1150	20	2.60	-2.05	0.55	
		1.5c	CWD	m3/ha	250	Planting, weed control and fencing	5.7	Confident 75-90%	Finite and point	Continue to Column M	0	30	20	0.21	-0.16	0.06	
		1.5d	Canopy epiphytes	Epiphytes/ha	50	Planting, weed control and fencing	5.7	Confident 75-90%	Finite and point	Continue to Column M	0	50	35	1.67	0.00	1.67	
		1.5e	Leaf litter	Average litter depth (mm)	30	Planting, weed control and fencing	5.7	Confident 75-90%	Finite end point	Continue to Column M	0	40	20	2.60	-0.58	2.02	

Old growth treelands:

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	0.13	90	25	0	-0.04
		1.1b	Height	metre	0.13	20	6	0	-0.04
		1.1c	Basal area	m2/ha	0.13	66.4	18.2	0	-0.04
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.13	52	13	0	-0.03
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	0.13	55	1	0	0.00
1.4	resources	1.4a	cavities	Number of cavities per ha	0.13	562.5	50	0	-0.01
		1.4b	Fruiting trees	Number of frutiing trees/ha	0.13	587.5	0	0	0.00
		1.4c	Canopy epiphytes	No of epiphytes per ha	0.13	212.5	0	0	0.00
		1.4d	flaky bark	Flaky bark trees per ha	0.13	37.5	0	0	0.00
		1.4e	CWD	volume (m3)/ha	0.13	100	0.48	0	0.00
1.5	Fauna resources	1.5a	Leaf litter	mm	0.13	40	0	0	0.00

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	90	10	0.37	-0.04	0.33	0.19
		1.1b	Height	metre	20	Planting, weed control and fencing	0.6	Confident 75-90%	Finite and point	Continue to Column M	0	10	20	0.14	-0.04	0.10	
		1.1c	Basal area	m2/ha	66.4	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	46	20	0.19	-0.04	0.15	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	52	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	40	20	0.21	-0.03	0.18	0.18
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	55	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	40	20	0.20	0.00	0.20	0.20
1.4	resources	1.4a	cavities	Number of cavities per ha	562.5	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	600	35	0.18	-0.01	0.16	0.11
		1.4b	Fruiting trees	Number of fruiting trees/ha	587.5	Planting, weed control and fencing	0.6	Confident 75-90%	Finite and point	Continue to Column M	0	0	35	0.00	0.00	0.00	
		1.4c	Canopy epiphytes	No of epiphytes per ha	212.5	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	50	35	0.04	0.00	0.04	
			flaky bark	Flaky bark trees per ha	37.5	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	600	35	0.18	0.00	0.18	
			CWD	volume (m3)/ha	100	Planting, weed control and fencing	0.6	Confident 75-90%	Finite and point	Continue to Column M	0	30	35	0.05	0.00	0.05	
1.5	Fauna resources	1.5a	Leaf litter	mm	40	Planting, weed control and fencing	0.6	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	0.21	0.00	0.21	0.21

Old growth forest (alluvial):

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	0.1	90	85	0	-0.09
		1.1b	Height	metre	0.1	20	18	0	-0.09
		1.1c	Basal area	m2/ha	0.1	69	66.5	0	-0.10
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.1	52	52	0	-0.10
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	0.1	55	52.5	0	-0.10
1.4	Emergent trees	1.4a	Basal area	Metres square per hectare	0.1	0	0	0	0.00
		1.4b	Number of individuals	Count	0.1	0	0	0	0.00
		1.4c	Height	Metres	0.1	0	0	0	0.00
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Count	0.1	212.5	212.5	0	-0.10
		1.5b	Cavities	Count	0.1	562.5	562.5	0	-0.10
		1.5c	Tawa fruit	Kilos per hectare	0.1	587.5	587.5	0	-0.10
		1.5d	CWD	Volume (m3)/ha	0.1	100	9.88	0	-0.01
		1.5e	flaky bark	Number of flaky bark trees/ha	0.1	37.5	37.5	0	-0.10
1.6	Fauna habitat and food provision	1.6a	Average litter depth	mm	0.1	40	39.3	0	-0.10

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	90	10	0.55	-0.09	0.46	0.22
		1.1b	Height	metre	20	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	0.21	-0.09	0.12	
		1.1c	Basal area	m2/ha	69	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	46	35	0.18	-0.10	0.08	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	52	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	40	20	0.32	-0.10	0.22	0.22
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	55	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	40	20	0.30	-0.10	0.20	0.20
1.4	Emergent trees	1.4a	Basal area	Metres square per hectare	0	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!
		1.4b	Number of individuals	Count	0	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
		1.4c	Height	Metres	0	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Count	212.5	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	50	35	0.06	-0.10	-0.04	0.04
		1.5b	Cavities	Count	562.5	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	400	35	0.19	-0.10	0.09	
		1.5c	Tawa fruit	Kilos per hectare	587.5	Planting, weed control and fencing	0.9	Confident 75-90%	Finite end point	Continue to Column M	0	0	35	0.00	-0.10	-0.10	
		1.5d	CWD	Volume (m3)/ha	100	Planting, weed control and fencing	0.9	Low confidence >50% <75%	Finite end point	Continue to Column M	0	22	20	0.07	-0.01	0.06	
		1.5e	flaky bark	Number of flaky bark trees/ha	37.5	Planting, weed control and fencing	0.9	Low confidence >50% <75%	Finite end point	Continue to Column M	0	600	20	0.31	-0.10	0.21	

Old growth forest (hill country):

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	0.85	90	85	0	-0.80
		1.1b	Height	metre	0.85	20	18	0	-0.77
		1.1c	Basal area	m2/ha	0.85	69	66.5	0	-0.82
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.85	52	52	0	-0.85
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	0.85	55	52.5	0	-0.81
1.4	Emergent trees	1.4a	Number of individuals	Number of emergent trees/ha	0.85	0	0	0	0.00
		1.4b	Average height	metres	0.85	0	0	0	0.00
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Count	0.85	212.5	212.5	0	-0.85
		1.5b	Cavities	Number of cavities per ha	0.85	562.5	562.5	0	-0.85
		1.5c	Fruiting trees	Number of fruiting trees/ha	0.85	587.5	587.5	0	-0.85
		1.5d	CWD	Volume (m3)/ha	0.85	100	9.88	0	-0.08
		1.5e	flaky bark	Number of flaky bark trees/ha	0.85	37.5	37.5	0	-0.85
1.6	Fauna habitat and food provision	1.6a	Average litter depth	mm	0.85	40	39.3	0	-0.84

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	90	10	6.14	-0.80	5.34	2.66
		1.1b	Height	metre	20	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	2.28	-0.77	1.52	
		1.1c	Basal area	m2/ha	69	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	46	35	1.95	-0.82	1.14	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	52	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	40	20	3.51	-0.85	2.66	2.66
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	55	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	40	20	3.32	-0.81	2.51	2.51
1.4	Emergent trees	1.4a	Number of individuals	Number of emergent trees/ha	0	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!
		1.4b	Average height	metres	0	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Count	212.5	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	50	35	0.69	-0.85	-0.16	0.70
		1.5b	Cavities	Number of cavities per ha	562.5	Planting, weed control and fencing	10	Confident 75-90%	Finite end point	Continue to Column M	0	400	35	2.08	-0.85	1.23	
		1.5c	Fruiting trees	Number of fruiting trees/ha	587.5	pest control in perpetuity rats/possums	10	Confident 75-90%	Finite end point	Continue to Column M	0	0	35	0.00	-0.85	-0.85	
		1.5d	CWD	Volume (m3)/ha	100	Planting, weed control and fencing	10	Low confidence >50% <75%	Finite end point	Continue to Column M	0	22	20	0.76	-0.08	0.67	
		1.5e	flaky bark	Number of flaky bark trees/ha	37.5	Planting, weed control and fencing	10	Low confidence >50% <75%	Finite end point	Continue to Column M	0	600	20	3.43	-0.85	2.58	
1.6	Fauna habitat and food provision	1.6a	Average litter depth	mm	40	Planting, weed control and fencing	10	Low confidence >50% <75%	Finite end point	Continue to Column M	0	30	20	2.57	-0.84	1.74	1.74

Raupō dominated seepage wetlands (high value):

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	0.11	100	100	0	-0.11
		1.1b	Average height	metre	0.11	2.5	2.5	0	-0.11
		1.1c	Basal area	m2/ha	0.11	0	0	0	0.00
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.11	19	17	0	-0.10
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	0.11	100	100	0	-0.11
1.4	fauna resources	1.4a	Percentage complex habitat for nesting birds	Percent	0.11	100	100	0	-0.11
1.5	Emergent trees	1.5a	Average height	Metres	0.11	4	4	0	-0.11
		1.5b	Number of emergent trees per ha	Count/ha	0.11	100	100	0	-0.11

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	100	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	100	7	0.23	-0.11	0.12	0.12
		1.1b	Average height	metre	2.5	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	2.5	7	0.23	-0.11	0.12	
		1.1c	Basal area	m2/ha	0	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	19	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	17	4	0.23	-0.10	0.13	0.13
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	100	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	100	7	0.23	-0.11	0.12	0.12
1.4	fauna resources	1.4a	Percentage complex habitat for	Percent	100	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	100	7	0.23	-0.11	0.12	0.12
1.5	Emergent trees	1.5a	Average height	Metres	4	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	4	15	0.19	-0.11	0.08	0.08
		1.5b	Number of emergent trees per ha	Count/ha	100	Planting, weed control and fencing	0.35	Confident 75-90%	Finite end point	Continue to Column M	0	100	15	0.19	-0.11	0.08	

Secondary broadleaved forest and scrublands:

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	6.71	90	79.3	0	-5.91
		1.1b	Height	metre	6.71	10	4.9	0	-3.29
		1.1c	Basal area	m2/ha	6.71	50	22.9	0	-3.07
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	6.71	55	55	0	-6.71
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	6.71	50	49.3	0	-6.62
1.4	Emergent trees	1.4a	Number of individuals	Count	6.71	0	0	0	0.00
		1.4b	Average height	Metres	6.71	0	0	0	0.00
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Epiphytes/ha	6.71	40	30	0	-5.03
		1.5b	Cavities	Cavities/ha	6.71	1300	1128.6	0	-5.83
		1.5c	Fruiting trees	Fruiting trees/ha	6.71	0	0	0	0.00
		1.5d	CWD	volume(m3)/ha	6.71	32	1.67	0	-0.35
		1.5e	Flaky bark	Flaky bark trees/ha	6.71	2000	685.71	0	-2.30
1.6	Fauna habitat and food provision	1.6a	Average leaf litter	mm	6.71	30	15.3	0	-3.42

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	90	20	10.96	-5.91	5.05	5.41
		1.1b	Height	metre	10	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	10.96	-3.29	7.67	
		1.1c	Basal area	m2/ha	50	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	6.58	-3.07	3.50	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	55	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	34	20	6.78	-6.71	0.07	0.07
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	50	Planting, weed control and fencing	24	Low confidence >50% <75%	Finite end point	Continue to Column M	0	50	20	8.24	-6.62	1.62	1.62
1.4	Emergent trees	1.4a	Number of individuals	Count	20	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	15	20	8.22	0.00	8.22	8.22
		1.4b	Average height	Metres	0	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	0.00	0.00	0.00	
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Epiphytes/ha	40	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	8.22	-5.03	3.19	5.73
		1.5b	Cavities	Cavities/ha	1300	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	1150	20	9.70	-5.83	3.87	
		1.5c	Fruiting trees	Fruiting trees/ha	0	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
		1.5d	CWD	volume(m3)/ha	32	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	22	20	7.54	-0.35	7.19	
		1.5e	Flaky bark	Flaky bark trees/ha	2000	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	2000	20	10.96	-2.30	8.66	
1.6	Fauna habitat and food provision	1.6a	Average leaf litter	mm	30	Planting, weed control and fencing	24	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	10.96	-3.42	7.54	7.54

Secondary broadleaved forest with old growth signatures:

Impact model:

	This section captures which elements of biodiversity, and over what area, will be impacted by the proposal					This section is where the change in measure of each Biodiversity Attribute due to the proposed Impact is quantified, and Attribute Biodiversity Value calculated. Inputs are derived from direct measures, existing data or models where available, or expert estimated predictions			
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	0.25	90	40	0	-0.11
		1.1b	Height	metre	0.25	12	5	0	-0.10
		1.1c	Basal area	m2/ha	0.25	50	11.5	0	-0.06
1.2	Diversity	1.2a	Diversity of native vascular plants	Species richness	0.25	55	20	0	-0.09
1.3	Understorey	1.3a	Percentage cover of indigenous species	Percent	0.25	70	70	0	-0.25
1.4	Emergent trees	1.4a	Number of individuals	Number of individuals/ha	0.25	0	0	0	0.00
		1.4b	Average height	Metres	0.25	0	0	0	0.00
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Number of epiphytes/ha	0.25	300	300	0	-0.25
		1.5b	Cavities	Number of cavities/ha	0.25	1300	1300	0	-0.25
		1.5c	Fruiting trees	Number of fruiting trees/ha	0.25	0	0	0	0.00
		1.5d	CWD	volume(m3)/ha	0.25	32	0	0	0.00
		1.5e	flaky bark	number of flaky bark trees/ha	0.25	2000	200	0	-0.03
1.6	Fauna habitat and food provision	1.6a	Average litter depth	mm	0.25	30	29.4	0	-0.25

Offset model:

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
1.1	Canopy	1.1a	Cover	percent	90	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	90	20	0.59	-0.11	0.48	0.39
		1.1b	Height	metre	12	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	0.49	-0.10	0.39	
		1.1c	Basal area	m2/ha	50	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	0.36	-0.06	0.30	
1.2	Diversity	1.2a	Diversity of native vascular	Species richness	55	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	34	20	0.37	-0.09	0.28	0.28
1.3	Understorey	1.3a	Percentage cover of indigenous	Percent	70	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	50	20	0.42	-0.25	0.17	0.17
1.4	Emergent trees	1.4a	Number of individuals	Number of individuals/ha	0	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	#DIV/0!
		1.4b	Average height	Metres	0	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
1.5	Fauna habitat and food provision	1.5a	Canopy epiphytes	Number of epiphytes/ha	300	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	300	35	0.38	-0.25	0.13	0.32
		1.5b	Cavities	Number of cavities/ha	1300	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	1150	20	0.53	-0.25	0.28	
		1.5c	Fruiting trees	Number of fruiting trees/ha	0	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	0	0	0.00	0.00	0.00	
		1.5d	CWD	volume(m3)/ha	32	Planting, weed control and fencing	1.3	Low confidence >50% <75%	Finite end point	Continue to Column M	0	22	20	0.31	0.00	0.31	
		1.5e	flaky bark	number of flaky bark trees/ha	2000	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	2000	20	0.59	-0.03	0.57	
1.6	Fauna habitat and food provision	1.6a	Average litter depth	mm	30	Planting, weed control and fencing	1.3	Confident 75-90%	Finite end point	Continue to Column M	0	30	20	0.59	-0.25	0.35	0.35

APPENDIX G.3: FOREST BIODIVERSITY COMPENSATION MODEL

A negative NPBV = Net Loss, a NPBV of 0 = No Net Loss and a positive NPB = Net Gain.

Model inputs		
Model descriptor	Biodiversity type	Indigenous forest biodiversity
	Biodiversity component	biodiversity
	Biodiversity attribute	Condition/health
	Benchmark	5
Impact model	Impact area (ha)	11.82
	Pre-impact value relative to benchmark	2
	Post-impact value relative to benchmark	0
Pest control compensation model (10 years)	Compensation area (ha)	300
	Pre-compensation value	4
	Post-compensation value	4.08 (2 % improvement)
	Offset end point (years)	10
	Confidence in offset actions	Confidence (50%-75%)
Forest retirement compensation model (10 years)	Compensation area (ha)	48.7
	Pre-compensation value	1.5
	Post-compensation value	1.65 (10 % improvement)
	Offset end point (years)	10
	Confidence in offset actions	Confidence (75%-90%)
Forest revegetation compensation model (10 years)	Compensation area (ha)	45.6
	Pre-compensation value	0
	Post-compensation value	0.5
	Offset end point (years)	10
	Confidence in offset actions	Confidence (75%-90%)
Model outputs		
Impact model		-4.73
Compensation model (pest control)		+2.21

Compensation model (retirement)	+0.9
Compensation model (revegetation)	+2.80
Net Present Biodiversity Value (NPBV)	**+1.18**

Pest control forest compensation impact model

Biodiversity Component	Biodiversity Attribute		Measurement Unit	Area of Impact (ha)	Benchmark	Measure prior to Impact	Measure after Impact	Biodiversity Value
Indigenous Forest	0.1a	Biodiversity	Condition	11.82	5	2	0	-4.73

Pest control compensation model

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute					
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value
Indigenous Forest	0.1a	Biodiversity	Condition	5	Pest Control	300	Low confidence >60%-<75%	Finite end point	Continue to Column M	4	4.08	10	2.21	-4.73	-2.51

Forest and shrub retirement model

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute					
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value
Indigenous Forest	0.1a	Biodiversity	Condition	5	Forest and shrubland retirement	48.7	Confident 75-90%	Finite end point	Continue to Column M	1.5	1.65	10	0.90	-4.73	-3.83

Forest and shrub revegetation model

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute					
Biodiversity Component	**Biodiversity Attribute**		**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**
Indigenous Forest	0.1a	Biodiversity	Condition	5	Forest and shrubland revegetation	45.6	Confident 75-90%	Finite end point	Continue to Column M	0	0.5	10	2.80	-4.73	-1.93

Model inputs	Forest species diversity impact model
Biodiversity Type	*Forest biodiversity (genetic, species and ecosystem diversity)*
Biodiversity Component	*Forest species diversity*
Biodiversity Attribute	*Forest species richness and relative abundance*
Measurement Unit	*Value scale from 0 – 5 in ascending order of forest species richness and abundance in relation to the benchmark*
Area of Impact (ha)	*Area of impact based on calculations*
Based on Benchmark	*The benchmark state for forest species diversity is the forest diversity expected within a large contiguous Old Growth Forest habitats within the Manawatu Region that has been under long-term mammalian pest control.*
Measure prior to Impact	*I have assigned a numerical measure of 2 relative to the Benchmark of 5. This was determined based on* *1) an assessment of the forest species diversity within each of the habitat types based on detailed assessments undertaken to date to determine the ecological characteristics and values within each of these habitats. For example, the Old Growth Forest (Hill Country) received the highest score relative to the benchmark within a numerical value of 3.5, while the divaricating shrublands received a score of 0.5 relative to the benchmark of 5.* *2) Weighting of the forest species diversity values against the proportion of each forest type that will be impacted by the project*
Measure after Impact	*We assumed that forest species diversity at the impact site would be 0.*
Biodiversity value	*As per model calculation*

	Forest species diversity compensation model
Biodiversity Type	Same as impact model explanation
Biodiversity Component	
Biodiversity Attribute	
Measurement Unit	
Discount rate	I have used a discount rate of 3% to account for the inherent risk in the temporal-lag between the impact occurring (due to the development) and the biodiversity gains being generated (due to the offset actions). The worked examples provided in the model User Manual apply a discount rate of 3%, as informed by research conducted as part of the Department of Conservation's research project on biodiversity offsetting in New Zealand.
Pest control compensation	
Proposed compensation Actions (pest control)	Mammalian pest control in old growth forest (hill country) within the northern block of the Manawatu Gorge Scenic Reserve. Pest control would target possums and rats and be pulsed every 2 years during peak bird breeding and plant fruiting season from July – December inclusive. Pest control will target rats and possums and aim to achieve < 5% Residual Trap Catch Index during the pest control operations.
Pest control area (ha)	300 ha
Confidence in pest control compensation	I have conservatively assumed a Confidence of 50 - 75% that the pest control operation will achieve the predicted 3% increase in overall forest species diversity (richness and relative abundance during the 10 years of pest control activities.
Time period over which to calculate NPBV	The time period over which to calculate NPBV is 1 year for pest control offsets as the benefits will commence as soon as the target pest species are knocked down to target levels
Measure <u>prior to</u> Pest Control	I have assumed that the species diversity in the old growth forest in the Northern Manawatu block equates to a 4 relative to the Benchmark. While it is a large intact old growth forest it is not under continuous and intensive management of mammalian pests and therefore species diversity for vulnerable flora and fauna is likely to be compromised with many of those species below carry capacity.

	Forest species diversity compensation model
Measure after Pest Control	I have conservatively assumed a 2% increase in overall forest species diversity for the 10 year duration of the pest control operations. This is based on a comprehensive literature survey on the effects of pest control on forest biodiversity values in New Zealand. It is key to note that for some species or species assemblages, I expected a much higher increase but this is balanced by the fact that there is no evidence of a positive response to pest control for other species. Moreover, it is fully acknowledge that the benefits of pest control will diminish once the pest control operation is terminated (assuming it is not picked up by another organisation) although for some long-lived plants the benefits of pest control are likely to remain for hundreds of years.
Retirement compensation	
Proposed retirement compensation	Live stock exclusion fencing coupled with 10 years of mammalian pest control within existing forest and shrubland habitats
Retirement compensation area (ha)	48.7 ha
Confidence in Actions	I have assumed a Confidence of 75 - 90% that the proposed retirement compensation will achieve the predicted benefits to forest species diversity
Time period over which to calculate NPBV	10 years
Measure prior to Offset	I have assumed that the forest species diversity within the existing forest habitat types for which bush retirement is proposed equates to an average of 2 relative to the Benchmark. It is not higher because most of the habitat types have low forest biodiversity (i.e., of the 48.7 ha, 7.6 ha is exotic shrubland and 12.8 ha is kanuka and manuka shrubland and because while 8.9 ha is old growth is included this habitat includes a depauperate understory and mid-tiers due to the long-term impacts of livestock.
Measure after the Offset	I have conservatively assumed a 10% increase in overall forest species diversity after 10 years of stock exclusion (coupled with control of mammalian pests, the methods of which are identical to that proposed for the northern block of the Manawatu Gorge Scenic reserve). This is based on a comprehensive literature survey on the effects of pest control and livestock exclusion on forest biodiversity values in New Zealand. It is key to note that for some species or species assemblages, I expected a much higher increase but this is balanced by the fact that there is no evidence of a positive response to pest control for other species. Moreover, while stock will be excluded indefinitely, it is fully acknowledged that the benefits of pest control will diminish once the pest control operation is terminated (assuming it is not picked up by another organisation) although for some long-lived plants

	Forest species diversity compensation model
	the benefits of pest control are likely to remain for hundreds of years.

Revegetation compensation	
Proposed revegetation compensation	Revegetation of native terrestrial vegetation coupled with felled/fallen log deployment, stock exclusion fencing, salvaging of fallen or felled logs, weed and animal pest management and long term protection via covenants
Retirement compensation area (ha)	45.6 ha
Confidence in Actions	I have assumed a confidence of 75 - 90% that the proposed revegetation compensation will achieve the predicted benefits to forest species diversity
Time period over which to calculate NPBV	10 years
Measure prior to Offset	I have assumed that the forest species diversity will equal 0 relative to the benchmark as the revegetation will be undertaken within exotic pasture habitat.
Measure after the Offset	I have assumed that after 10 years of growth the forest species diversity will equate to 0.5 relative to the benchmark or 10% of the biodiversity value.