REPORT

A Biodiversity Compensation Model for New Zealand

A User Guide (Version 1)

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1 Introduction

1.1 Overview

A key challenge for ecologists and decision-makers is determining the adequacy of offsets and compensation for residual adverse effects on terrestrial and wetland biodiversity values. That is, those adverse effects remaining after all appropriate measures to avoid, remedy, or mitigate effects have been sequentially applied.

The Biodiversity Compensation Model (BCM) is a decision support tool developed to provide guidance on the type and amount of compensation required for a project to achieve predicted[1] net gain outcomes for biodiversity in a New Zealand context (Baber *et al.* 2021*a*). The BCM should be applied for a given project only once adherence to 'limits to offsetting' principles and the effects management hierarchy have been demonstrated. That is:

- The recognition that some adverse effects are so significant that adverse effects cannot be offset (limits to offsetting principle); and that
- Measures to avoid, remedy, mitigate or offset adverse effects must be exhausted before compensation can be considered.

The BCM builds on the foundations of the Biodiversity Offset Accounting Model (BOAM) developed by Maseyk and others (Maseyk *et al.* 2015; 2018). However, it is intended for use when the information required for the BOAM or other offset accounting models cannot be reliably quantified and effects cannot be demonstrably offset with adequate precision[2]. This is the case for most projects during project optioneering or the plan change/ consent application stages (Baber *et al.* 2021*a*).

It is important to emphasise that:

- The BCM is intended only for use under the foundations of biodiversity offsetting or compensation principles[3]. In particular, only once adherence to the effects management hierarchy and limits to offsetting principles have been demonstrably achieved.
- As with any method or tool, it is up to the practitioner to justify its use for their assessment based on their relevant experience, professional judgement, and the applicability of the tool to the project site and scale of assessment (Roper-Lindsay *et al.* 2018).
- The BCM is not intended to be a formulaic tool applied in the absence of a robust ecological assessment, and the appropriateness and validity of its use stands or falls on the practitioner(s) who apply it.

1.2 Document purpose and scope

This User Guide accompanies the Excel Calculator Tool (Baber *et al.* 2021*b*) and sets out the approach for applying the Excel Calculator Tool for residual adverse effects on terrestrial and wetland biodiversity values. Worked examples of hypothetical projects are provided.

The Excel Calculator Tool consists of a data input Excel spreadsheet and an output table that details data inputs and outputs. The Excel Calculator Tool is used to inform a BCM report that would

[1] By the model.
[2] This applies to BOAMs that rely on future quantitative data predictions at offset sites, such as a tui BOAM that predicts the expected relative abundance of tui 20 years after commencement of revegetation at a proposed offset site.
[3] We prefer the biodiversity offsetting and compensation principles as set out in the Draft National Policy Statement for Indigenous Biodiversity (NPSIB) (see Appendix A of this report)).

typically serve as an appendix to an ecological assessment accompanying a resource consent or plan change application.

We intend this User Guide and the Excel Calculator Tool to be live documents that can be updated and refined in response to user feedback, which can be sent to *BCMfeedback@tonkintaylor.co.nz*.

Those applying the tool should be qualified and experienced ecologist(s) with a working understanding of biodiversity offset accounting models (Maseyk *et al.* 2015); biodiversity offsetting and compensation principles (e.g., the Draft NPSIB), and the Ecological Impact Assessment Guidelines (EcIAG; Roper Lindsay *et al.* 2018).

1.3 Applicability

This User Guide and the Excel Calculator Tool have been developed by Tonkin & Taylor Limited (T+T) for the purposes set out above, by reference to applicable standards, guidelines, procedures and practices at the date of issue of this User Guide. While we intend to update and refine the User Guide and the Excel Calculator Tool from time to time, T+T is under no obligation to do so. T+T accepts no liability to any person in relation to this User Guide or the Excel Calculator Tool (Baber et al. 2021b) other than to its clients in the context of a specific engagement. The application and interpretation of this User Guide and the Excel Calculator Tool by others is outside the control of T+T and is at the sole risk of the user.

2 The BCM approach

2.1 Overview

The BCM includes the use of qualitative data where quantitative data is not available or lacks adequate precision to determine if adverse effects can be demonstrably offset. The model centres on the determination of a qualitative biodiversity value score (herein "value score") for a habitat or species, both before and after impacts ("losses") and before and after implementation of compensation action(s) ("gains"). These value scores are based on a combination of site-specific field assessments, scientific literature and experience of suitably qualified and experienced ecologist(s) that are involved in the project — ideally including appropriately qualified and experienced ecologists representing mana whenua, submitters or regulatory authorities.

For terrestrial and wetland habitat type BCMs, value scores are based on the four sub-criteria used to assess 'Ecological Value' under the EcIAG: representativeness; rarity/distinctiveness; diversity and pattern; and ecological context. We recommend that the ecological value assessment should also factor in the contribution that a habitat makes to ecological function or to the provision of ecological services. These aspects should be considered in relation to impacted habitats and the proposed compensation action(s).

For species or species assemblages, value scores are based on the importance of habitats for that species or species assemblage, both before and after impacts, and before and after compensation measures. The importance of a habitat for a species or species assemblage is based on habitat characteristics, and if available, information on the estimated relative abundance of individuals (species) or composition and relative abundance (community or ecosystem assemblage).

In summary, BCMs:

- Provide guidance on addressing all residual adverse effects associated with a project for which impacts or gains cannot feasibly be measured or quantified with adequate precision, and for which residual effects management is deemed appropriate when assessed against the 'limits to offsetting' principle.
- Provide additional transparency and rigour to the process of addressing residual adverse effects on biodiversity through compensation measures at proposed compensation site(s). Additional transparency and rigour can be achieved through sensitivity analyses that involves recalculating predicted Net Gain (NG) outcomes under alternative assumptions or data inputs. For example, this might include running BCMs for a given biodiversity value under best-case versus worst-case scenarios.
- Provide guidance on whether NG outcomes are predicted to be achieved for specified biodiversity values. Predicted NG outcomes are sought, rather than No Net Loss (NNL) outcomes, to provide more confidence that NNL will actually be achieved.
- Operate at the 'as close to offset as possible' end of the compensation continuum. This is termed 'biodiversity compensation' in the Draft National Policy Statement for Indigenous Biodiversity (NPSIB).
- Operate across the full spectrum and scale of project optioneering and plan change or consent applications.
- Allow for conversion of a BCM to a BOAM through the provision of field data at compensation site(s) after the commencement of compensation actions. This is to verify that predicted NNL/NG outcomes have been achieved and to identify additional effects management requirements, if necessary.

The BCMs meet the above intentions through:

- Use of Net Present Biodiversity Value (NPBV) to estimate whether NG outcomes are predicted to be achieved based on data inputs.
- Inclusion of an impact 'risk' contingency measure to account for increased likelihood that adverse effects will result in the permanent and irreplaceable loss of significant biodiversity values when impacting on high ecological values. In turn this addresses the increased risk of not achieving predicted Net Gain outcomes for higher ecological values.
- Inclusion of an 'uncertainty' contingency measure to account for increased uncertainty when impacting on more complex biodiversity values, e.g. mature forests or highly mobile species such as long-tailed bat.
- Accounting for time lags between impact associated with project activities and the gain at the proposed compensation site(s).
- Inclusion of a compensation confidence contingency for proposed compensation actions at compensation sites to account for the potential risk of failure or under-delivery of the proposed compensation actions.
- The ability to factor in the significance and importance of benefits to ecosystem function that are difficult to quantify but which are essential to biodiversity and ecological integrity. This includes, but is not limited to, carbon sequestration, pollination and seed dispersal, water quality, air quality, ecological connectivity and sequencing, and microclimate regulation.

2.2 Model limitations

In applying any model, it is important to acknowledge limitations, constraints and uncertainties. Notably, BCMs have the potential to generate false positives, i.e. instances where model outputs suggest NNL/NG outcomes when the converse is true. This occurs when:

- A biodiversity value that is not explicitly accounted for ('hidden currency') is lost in the trade. e.g., a tree-dwelling beetle species that is not known to occur or not measured at the impact site, does not self-colonise the compensation site or does not benefit from proposed compensation actions at those sites. This is a key limitation that is difficult to address and in relatively rare instances where reliable, disaggregated and quantifiable data can be obtained at impact and offset or compensation sites, Biodiversity Offset Accounting Models (BOAMs) should be used instead of BCMs.
- Data inputs or assumptions are incorrect and indicate that the level of effects at the impact site(s) are lower than they are estimated to be and/or the benefits associated with the proposed compensation actions are greater than they actually are.

The likelihood of a false positive is higher when:

- Models aggregate biodiversity values (e.g. lump biodiversity values associated with an ecosystem type into a single measure such as 'biodiversity condition' or 'ecological integrity') and do not include independent assessments of all key biodiversity values that warrant the application of independent BCMs.
- Affected habitat types have high values or are more complex (often a feature of more mature habitat types).
- Models quantify or capture only a subset of values (e.g. only quantify plant biodiversity values within an ecosystem type and do not account for fauna values or ecosystem functions).
- Models rely heavily or exclusively on unsubstantiated expert opinion, inaccurate data or incorrect assumptions.

The risk of a 'false positive' when applying BCMs can be substantially reduced by:

- Aiming for a NG rather than an NNL target, so outcomes are more likely to at least achieve NNL.
- Including and considering a representative diversity of biodiversity value measures in the models for a given ecosystem type (e.g. vegetation and fauna biodiversity values) and applying standalone BCMs for each of the habitats and species that are of high conservation value, and for which efforts to demonstrate predicted NG outcomes are warranted.
- Applying conservatism with respect to the likelihood of achieving the predicted benefits at the compensation sites over a realistic and meaningful timeframe.
- Providing an adequate 'Net Gain' buffer through the type and quantum of compensation proposed.
- Developing and implementing a biodiversity outcome monitoring programme that enables the conversion of BCMs into BOAMs through replacement of qualitative information for quantified data once available at both the impact sites and the compensation sites[4].
- Consent conditions that lock in:
  - Biodiversity monitoring to verify NNL/NG outcomes (where feasible); and
  - Adaptive management to adjust compensation efforts in the event that NNL/NG outcomes seem unlikely to eventuate within stated timeframes (or, equally, if benefits far exceed expectations within stated timeframes).

Overall, it is key to recognise that BCMs have limitations and should therefore be used simply as decision support tools. As such, their role is to help practitioners understand the rationale and justification for determining compensation measures that are predicted to result in tangible NNL/NG outcomes for affected biodiversity values. In other words, they do not provide certainty that NNL/NG outcomes will be achieved. As is also the case for BOAM, this will not eventuate until *after* compensation activities have commenced, providing that a robust biodiversity monitoring programme has been implemented and the biodiversity impacts and gains can indeed be quantified with a high degree of accuracy.

[4] Through a biodiversity monitoring programme implemented via an approved management plan, perhaps as a condition of consent.

3 BCM applications

3.1 Application overview

In broad terms, the BCM prompts the user to fill in a series of data inputs relating to project impacts (impact model) to generate an impact score, and a series of data inputs relating to proposed compensation actions (compensation model) to generate a compensation gain score.

The BCM then produces output tables that indicate whether targeted NNL/NG outcomes are likely, based on the information provided.

3.2 Determining which affected values require BCMs

The suite of BCMs required for a given project should be determined by a suitability qualified and experienced ecologist(s) involved in the project. BCMs should focus on residual adverse effects that cannot be demonstrably avoided, remedied, mitigated or offset and for which a higher standard of transparency and rigour is required to demonstrate predicted NG outcomes. Ultimately, the number and type of BCMs applied for a given project will be influenced by:

- The number and type of values affected by project activities.
- The ecological objectives of the project with respect to NNL/NG expectations for compensation. For example, is the intent to achieve NNL/NG outcomes for all values affected by the project, or for just those values for which residual effects are deemed to be moderate or higher?
- The feasibility of applying BCMs. For some species there may not be enough information to warrant a species-specific BCM. This is particularly true for cryptic or poorly studied species such as flighted arboreal invertebrates for which impacts or compensation gains are unclear and the number of species-specific BCMs would be prohibitive. In such instances, it may be best to combine these into a species assemblage BCM.
- The likelihood that ecologists and decision makers will accept that predicted NNL/NG outcomes will be achieved without the need for a BCM. For example, a BCM for tūī values may be considered unnecessary for a project that is proposing a sizeable compensation package (for example, including 100 ha of native revegetation and 1,000 ha of pest control for 35 years in existing mature forest) to address effects associated with the removal of 10 ha of early regenerating kānuka forest. In this instance, a BCM may not be considered necessary due to the quantum of compensation proposed coupled with the high degree of certainty that the compensation will result in tangible net benefits for tūī in both the short and long-term.

3.3 Determining how to run the BCMs

Once the suite of BCMs has been selected, the approach taken for each BCM needs to be addressed on a case-by-case basis. Considerations include:

- The use of a single BCM to assist with determining compensation requirements for an affected biodiversity value, or the need to run more than one BCM for an affected biodiversity value. For a project it may be useful to present:
  - the lower or upper bounds of compensation requirements based on a conservative versus optimistic model, i.e., a sensitivity analysis; or
  - the outcome of multiple models based on different scenarios to help select the most effective compensation action(s).
- The use of a single BCM to assist with decisions on proposed compensation for an affected biodiversity value at a given finite point, or the need to run more than one BCM at different

finite points. For example, a project that relies on native revegetation and a 10-year mammalian pest control programme in existing forest would warrant:

– a BCM at 10 years that includes both of these compensation actions, and
– a BCM beyond 10 years that excludes pest control because the benefits from the mammalian pest control would be lost (or at least on a decline trajectory). This does not mean the pest control was of little value as it may be essential to improving the likelihood of NNL/NG outcomes in the short term until native revegetation is mature enough to provide suitable habitat for fauna.

3.4 BCM inputs

The inputs for the 'losses' and 'gains' associated with each biodiversity value are provided in Table 3.1 with an instruction of what to do, alongside an explanation of what the input relates to and why it is required.

Table 3.1: Data input descriptions for the Biodiversity Compensation Model (BCM)

Model inputs	Description
Project reference/ name	**Instruction** Manually type project reference as applicable.
Biodiversity type	**Instruction** Manually type in the biodiversity type to which the BCM relates, e.g., terrestrial vegetation, kahikatea swamp forest, raupō wetland, indigenous fauna assemblage, lizard assemblage, kānuka or Australasian bittern. **Explanation** Models can be applied to broad habitat types (e.g. forest habitat or wetland habitat) for which impact scores for several specific forest or wetland habitat types can be independently determined (e.g. exotic wetland versus a raupō wetland). This approach is often taken when the same compensation action or actions are proposed for different impacts on different habitat types. For example, for a long-tailed bat BCM, native revegetation may be proposed as a common compensation measure to address effects associated with the loss of three habitat types (exotic plantation forest, exotic scrub and pasture).
Technical expert input(s)	**Instruction** Manually type in the names of all technical experts involved in contributing to and agreeing data inputs. **Explanation** Determining data inputs with maximum accuracy requires the involvement of experts, likely a team, including those experienced in implementing, monitoring and reporting on management actions. Evaluating the outputs of the BCM will equally benefit from interpretation by a representative team of suitability qualified and experienced experts.
Benchmark	**Instruction** Manually type in **5** (the benchmark is always 5). **Explanation** The benchmark of 5 is a reference measure score which constitutes a hypothetical but realistic potential state. Typically, this would include a large, contiguous, native-dominated terrestrial or wetland ecosystem type that has been subject to intensive

	mammalian pest control over the long-term with the full suite of indigenous flora and fauna present at or near carrying capacity. This habitat would generally be of such high quality that compensation actions would provide negligible additional ecological gain. The benchmark is always 5 so that it aligns with the Ecological Impact Assessment Guidelines (EcIAG, Roper-Lindsay *et al.* 2018). In broad terms the following numerical scores for ecological value align with the following ecological value categories: • < 1 = Negligible • 1 - <2 = Low • 2 - <3 = Moderate • 3 - <4 = High • 4 - <5 = Very High • 5 = Benchmark
How many habitat types OR sites are impacted	**Instruction** Select from the drop-down menu the number of different habitat type or sites/locations impacted. Up to 5 different habitat types or sites can be selected. **Explanation** When the affected biodiversity value constitutes a broad habitat type (e.g. native forest) there may be different habitat types that are impacted. For example, the biodiversity type 'native forest' may include pūriri forest, kānuka forest, and kauri forest. Each of these specific habitat types will likely require different impact contingencies and have different ecological value scores and should therefore be considered separately. When an affected biodiversity value includes a specific habitat type that is impacted at different sites or locations, considering these as separate may be warranted if the ecological value or the type of impacts differ across sites or locations. For example, a project may have different types and magnitude of impacts on a single 0.4 ha of kauri forest, (including 0.1 ha of total habitat loss through vegetation clearance and 0.3 ha of habitat degradation through edge effects and general disturbance associated with land use change). In this situation, the impacts on this kauri forest fragment could be separated out because the type and magnitude of effects differs. Equally though, the areas could be assessed as one, provided the impacts are appropriately captured in the assessment. If there are more than 5 habitat types or sites/locations impacted, a new BCM can be created, and the overall impact scores added.
Number of proposed compensation actions	**Instruction** Select from the drop-down menu the number of different compensation actions proposed. Up to 5 different compensation actions can be selected. **Explanation** Where compensation actions differ AND are undertaken in different locations or sites, or the spatial extent of the compensation action is different, then each action must be assessed independently. In some instances, different compensation actions in the same location can be lumped into a single compensation action (e.g. native revegetation and weed control), provided appropriate justification is given. Similarly, it may be appropriate to combine the same compensation action at different locations into a single compensation action, with appropriate explanation.
Net Gain target	**Instruction** Manually type in the desired Net Gain target as a percentage, e.g., if the number 20 is typed, this will be converted to 20%.

	Explanation In general terms, the greater the assigned Net Gain outcome target, the greater the likelihood that No Net Loss or preferably Net Gain outcomes will be achieved. For compensation a Net Gain outcome target of 10% is considered by the authors to be generally appropriate. This equates to a 10% exceedance of No Net Loss, i.e. the Compensation Score is 10% higher than the Impact Score. However, the selected Net Gain outcome target will need to be justified and should be assigned on a case-by-case basis.
Habitat/site impacts	**Instruction** Manually type the name of the habitat(s) or site(s) impacted. The number of named habitat(s) or site(s) will need to match the number of proposed compensation actions specified above.
Impact risk contingency	**Instruction** Select from the drop-down menu: 1 = Negligible or low risk/ Negligible or low value (calculated impact score is multiplied by 1.0 (+0%)) 2 = Moderate risk/Moderate value (calculated impact score is multiplied by 1.05 (+5%)) 3 = High risk/High value (calculated impact score is multiplied by 1.1 (+10%)) 4 = Very high risk/Very high value (calculated impact score is multiplied by 1.2 (+20%)) **Explanation** The impact risk contingency addresses the increased likelihood that adverse effects will result in the permanent and irreplaceable loss of significant biodiversity values when impacting on habitats or species that are of higher ecological value. The assigned ecological value is based on the EcIAG ecological value assessment. The risk contingency percentage multiplier is commensurate with the EcIAG assigned ecological value with the multiplier assigned to each ecological value category based on testing under a range of scenarios[5]. For avoidance of doubt, the impact risk contingency relates to the biodiversity type. For example: • If the model biodiversity type is 'long-tailed bat' then the impact risk contingency relates to the assigned ecological value for long-tailed bat and would therefore be the same across the different long-tailed bat habitat types that are impacted and included in the model (e.g. pasture versus shelterbelts, versus mature forest). • If the model biodiversity type is a broad habitat type, e.g. 'native forest', and the impacts relate to more specific habitat types that differ in their ecological value, then the impact risk contingency for each habitat type will be different (e.g. kauri forest versus young regenerating kānuka forest).
Impact uncertainty contingency	**Instruction** Select from the drop-down menu: 1 = Low uncertainty (calculated impact score is multiplied by 1.05 (+5%)) 2 = Moderate uncertainty (calculated impact score is multiplied by 1.1 (+10%)) 3 = High uncertainty (calculated impact score is multiplied by 1.2 (+20%)) 4 = Very high uncertainty (the model will not work if this option is selected) **Explanation** By providing for a greater margin of error, the impact uncertainty contingency addresses the increased risk of permanent or irreplaceable biodiversity loss when impacting on more complex habitats, or on species for which there is less information regarding species-

[5] In general terms, the application of higher percentage multipliers was difficult to justify and generated predicted Net Loss outcomes when the converse would be expected. Similarly, the use of lower multipliers undermined confidence that predicted Net Gain model outputs would be achieved.

	specific impacts associated with an effect. The rationale for category selection will need to be justified on ecological grounds. Where very high uncertainty exists in relation to adverse effects, this constitutes a limit to the use of the BCM model; project redesign or avoidance of effects should instead be considered. The percentage multipliers used for the impact uncertainty contingency levels have been assigned based on testing different multipliers under a range of scenarios.[6]
Areal extent of impact (ha)	**Instruction** Manually type in the areal extent of impact in hectares with respect to the value being considered (incorporating both direct and indirect effects). **Explanation** If there is more than one habitat type or more than one site of the same habitat type, then impact (ha) will relate to that specific habitat or site. However, the total habitat loss (ha) will be automatically summed and factored into the impact score calculations.
Value <u>prior to</u> impact	**Instruction** Manually type in a numerical score between 0 and 5 that relates to the value score <u>prior to</u> impact relative to the benchmark value score of 5. **Explanation** The assigned value score in all instances must relate explicitly to the biodiversity type that the model relates to. Adequate detail must be provided to justify the assigned ecological value score based on desktop and field investigations. This enables an understanding of the adequacy and certainty surrounding the assessment and should include an explanation of why the value score was neither higher nor lower. **Habitat value scores:** For habitats, the ecological value prior to impact relates to the representativeness, rarity and distinctiveness, diversity and pattern, and ecological context associated with the habitats/vegetation types within a project footprint as assessed against the benchmark. Refer to Section 5.2 and Table 4 of the Ecological Impact Assessment Guidelines (EcIAG, Roper-Lindsay *et al.* 2018), the detail of which would be provided in the Assessment of Ecological Effects report for the Project. In broad terms: • < 1 = Negligible • 1 - <2 = Low • 2 - <3 = Moderate • 3 - <4 = High • 4 - <5 = Very High • 5 = Benchmark NB: • In some instances, consideration of loss of 'potential value' may be required for impact values (e.g. for natural inland wetlands under the National Policy Statement for Freshwater Management 2020 (NPS FM)). This should be considered in the context of the value affected and the potential value if it were restored (using best practice,

[6] In general terms, the application of higher percentage multipliers for each level of uncertainty category was difficult to justify and generated predicted Net Loss outcomes when the converse would be expected. Similarly, the use of lower percentage multipliers for each level of uncertainty category undermined confidence that predicted Net Gain model outputs would be achieved.

	reasonable efforts). Ensure that the reporting outputs are clear as to whether the 'existing' or 'potential' values were used to quantify the compensation measures. • The EcIAG (Roper-Lindsay *et al.* 2018) assessment of ecological value does not assess the contribution that a particular habitat type may make to ecological functioning or the provision of ecosystem services. We recommend that these factors are also considered when assessing the value of impacted habitats. **Species or species assemblage value scores:** The EcIAG (Roper-Lindsay *et al.* 2018) does not include criteria for determining habitat suitability for a given species. Since habitat suitability is a key component of a magnitude of effects assessment, this will ideally be addressed in subsequent versions of the EcIAG. In the interim we set out proposed criteria below: • 0 = Habitat not suitable. • < 1 = Marginal habitat that may be used but is not important for any part of the species or species assemblage life-cycle(s). • 1 - <2 = Relatively low value habitat that provides some but not all of a species or species assemblages life-history requirements and/or the habitat is of low quality and the relative abundance within the habitat is low compared to other habitat types. • 2 - <3 = Relatively moderate value habitat that provides for most, if not all, of a species or species assemblage's life-history requirements and/or the habitat quality is of moderate quality and the relative abundance within the habitat is moderate compared to other habitat types. • 3 - <4 = Relatively high value habitat that would typically provide for all species or species assemblage life-history requirements and/or provides a critical resource or resource(s) for life-history requirements. The habitat quality is high and the relative abundance within the habitat is, or is likely to be, high compared to other habitat types. • 4 - <5 = Relatively very high value habitat that provides for all species or species assemblage life-history requirements and/or provides a critical resource or resource(s) needed for life-history requirements. The habitat quality is very high and the relative abundance within the habitat is or is likely to be very high compared to other habitat types. Likely to be a local hotspot for that species. • 5 = Highest quality habitat and/or relative abundance for a given species or species assemblage, likely to be a regional hotspot or benchmark with the species or species assemblage at carrying capacity. As with habitat scores, adequate detail must be included from desktop and field investigations to provide transparent justification for each value score. The reader needs to understand the adequacy and certainty surrounding the assessment and requires an explanation of why the score was neither higher nor lower. The model assumes a static rather than temporally dynamic biodiversity baseline at the impact site. The predicted NNL/NG outcome is therefore relative to pre-impact values. In instances where population densities or relative abundance appear higher in seemingly less suitable habitats than in more suitable habitats, this will need to be addressed and reflected in the relative value scores.
Value <u>after</u> impact	**Instruction** Manually type in a numerical score between 0 and 5 that relates to the value score <u>after</u> the impact relative to the benchmark value score of 5. **Explanation** The explanation for determining the habitat or species scores after impact is the same as the method for determining these scores prior to impact except that the assessment value score relates to the impact site after the impact has occurred.

	NB: • The drop in ecological value relates to the magnitude of impact based on the EcIAG, which is a function of the extent, intensity, frequency and permanence of the impact. It is important to factor in all types of impacts associated with the project which may range from earthworks, vegetation and sedimentation to increased exposure to artificial lighting or noise, or domestic mammalian predators. • The model does not accept a value score of 0 as the formula will not work, but it does allow for a score of 0.001 (virtually zero).
Compensation action(s)	**Instruction** Manually enter the compensation action proposed. The number of different compensation measures (habitat(s) or site(s)) will need to match the number of proposed compensation actions specified above. **Explanation** The compensation action relates to each type of habitat creation, restoration, or enhancement activity that is proposed, e.g., native revegetation into existing pasture and/or weed and mammalian pest control in existing forest. As long as it is explained, it is appropriate to lump different compensation types where they are applied as a total package within a particular habitat or site (e.g. bush retirement coupled with weed control and mammalian pest control).
Discount rate	**Instruction** Manually enter a discount rate. **Explanation** The discount rate addresses the temporal time lag between the impact occurring and the biodiversity gains being generated by the conservation action(s). A discount rate of 3% is recommended. This is the same as the discount rate recommended in the BOAM user guide (Maseyk *et al.* 2015), which is informed by research in Gibbons *et al.* 2015. That said, we note that a discount rate of 3% rewards benefits that deliver faster than those that take longer but provide greater ecological outcomes in the longer term, i.e. it punishes the tortoise and rewards the hare). For example, revegetation may deliver greater biodiversity gains in the long term for habitats than mammalian pest control, but all else being equal, a discount rate of 3% will favour mammalian pest control over revegetation because gains would be predicted to occur almost immediately after commencement of pest control operations.
Finite end-point	**Instruction** Manually enter the number of years between impact and assessment of biodiversity gain at the compensation site(s) resulting from compensation actions. **Explanation** The finite end-point is the time period (years) over which to calculate NPBV. This equates to the time between the commencement of proposed compensation action(s) and an assessment of the associated benefits for the affected biodiversity value (e.g. native revegetation at 20 years). For pest control this time period would be short because biodiversity gains occur almost immediately after commencement of pest control operations. However, these biodiversity gains will diminish once the pest control is terminated, and this needs to be addressed when applying the model. The finite end-point should generally be tied to the duration of the biodiversity management and monitoring programmes that are used to verify that the benefits at

	compensation sites have been achieved. For instance, if the finite end point is set at 10 years from commencement of compensation, then the biodiversity management and monitoring programme should be undertaken for 10 years (but possibly longer if predicted biodiversity gains are not achieved and adaptive management or contingency measures are required).
Compensation confidence contingency	**Instruction** Select from the drop-down menu: 1 = Very high confidence (>90%) 2 = High confidence (75%-90%) 3 = Moderate confidence (50-75%) 4 = Low confidence (< 50%) (The model will not work if this option is selected). **Explanation** The approach used to assign compensation confidence contingency is aligned with the approached used in Maseyk *et al.* (2015) except that the term 'offset' has been changed to 'compensation'. The compensation confidence contingency relates to the level of confidence in the likely success of the proposed compensation measures and methodology (see above). This reflects that even well-established management methods sometimes fail to achieve targets for a multitude of reasons. The model does not consider confidence in the implementer of the proposed compensation. Nor does it consider likelihood of abandonment of the project post-impact but prior to the implementation of compensation actions. • Very high confidence: The proposed compensation measure uses methods that are well tested and repeatedly proven to achieve intended biodiversity gains; evidence-based expert opinion is that success is very likely. Likelihood of success is > 90%. Calculated biodiversity gain is multiplied by 0.925. • High confidence: The proposed compensation measure uses methods that are well known, often implemented, and which have been proven to succeed greater than 75% of the time. However, complicating factors and/or expert opinion precludes greater confidence in this compensation measure. Likelihood of success is greater than 75% but less than 90%. Calculated biodiversity gain is multiplied by 0.825. • Moderate confidence: The proposed compensation measure uses methods that have either been successfully implemented in New Zealand or in the situation and context relevant to the compensation site but infrequently, or the outcomes of the proposed compensation measures are not well proven or documented, or success rates elsewhere have been shown to be variable. Likelihood of success is > 50% but < 75%. Calculated biodiversity gain is multiplied by 0.625. • Low confidence: Should not use the compensation measure and the model will not work if this option is selected on the basis that uncertainty is too high.
Areal extent (ha) of compensation action	**Instruction** Manually enter the areal extent (ha) of the proposed compensation action.
Value score prior to compensation action	**Instruction** Manually type in a numerical value score between 0 and 5 that relates to the value score at the compensation site(s) prior to implementation of compensation action(s). **Explanation** Adequate detail must be provided to justify the assigned ecological value score based on desktop and field investigations and assessed using EcIAG (Roper-Lindsay *et al.* 2018 or an updated version). This enables an understanding of the adequacy and certainty

	surrounding the assessment and should include an explanation of why the value score prior to the implementation of the compensation action(s) was neither higher nor lower. The EcIAG (Roper-Lindsay *et al.* 2018) assessment of ecological value does not include an assessment of value in relation to ecological functioning or the provision of ecosystem services. We recommend that these factors are also considered when assessing the habitat value associated with a compensation action(s). Note that the model does not accept a value score of 0 as the formula will not work, but it does allow for a score of 0.001 (virtually 0).
Value score after compensation measure	**Instruction** Manually type in a numerical value score between 0 and 5 that relates to the value score at the compensation site(s) after implementation of compensation action(s) as assessed at the finite end point (years). **Explanation** Adequate detail must be provided to justify the assigned ecological value score after implementation of compensation actions based on desktop and field investigations and assessed using EcIAG (Roper-Lindsay *et al.* 2018 or an updated version). This enables an understanding of the adequacy and certainty surrounding the assessment and should include an explanation of why the compensation value score after implementation of the compensation action(s) was neither higher nor lower. The EcIAG (Roper-Lindsay *et al.* 2018) assessment of ecological value does not include an assessment of value in relation to ecological functioning or the provision of ecosystem services. We recommend that these factors are also considered when assessing the habitat value associated with a compensation action(s).

4 BCM examples

4.1 Hypothetical kahikatea-pukatea forest BCM

A BCM for a hypothetical Kahikatea-pukatea forest is provided below, including data inputs (Table 4.1) and the BCM output reporting table (Table 4.2).

In summary the model relates to effects of a proposed landfill development on kahikatea/pukatea forest (classified as WF8 in Singers *et al*. 2017) fragments at two separate locations totalling 1.4 ha. Despite being the same ecosystem type, the two forest fragments were assigned different ecological value scores based on field investigations and an assessment against ecological value criteria as described in the EcIAG. These values were predicted to decline to virtually zero as a result of the proposal. To achieve a predicted 10% Net Gain outcome within 10 years of impacts, and in accordance with biodiversity compensation principles, it was deemed necessary to:

- Undertake 6.5 ha of native revegetation into hydric soils immediately adjacent to existing kahikatea/pukatea forest; and
- Retire 14.9 ha of existing kahikatea/pukatea forest fragments from stock browse and trampling through the establishment of stock exclusion fencing (together with a weed management programme).

To justify each of the respective biodiversity value and contingency scores, significantly more detail will be required than that provided in this summary.

Table 4.1: Kahikatea-pukatea forest BCM data inputs

General model descriptor inputs	
Model inputs	**Explanation**
Project/reference name	Lumsden Landfill (hypothetical)
Biodiversity type	Kahikatea/pukatea forest (WF8)
Technical expert input(s)	XXXX, (Applicant's ecologist)
Benchmark	A benchmark of 5 equates to a large contiguous kahikatea forest ecosystem type that has been subject to intensive mammalian pest control over the long-term, with the full suite of indigenous flora and fauna present at or near carrying capacity.
How many habitat types OR sites are impacted	2
Number of proposed compensation measures	2
Net Gain target	10% (i.e. the compensation score needs to be at least 10% higher than the impact score)
Impact model inputs and descriptions	

Habitat/site impacted	WF8 – Site 1
Impact risk contingency	**Data input**: High risk (calculated biodiversity impact score is multiplied by 1.1 (+10%)) **Explanation**: The impact risk was assessed as 'High' because the forest was assessed as being of 'High' value based on the EcIAG as described in the Lumsden Landfill Ecology Report.
Impact uncertainty contingency	**Data input**: Moderate uncertainty (calculated biodiversity impact score is multiplied by 1.1 (+10%)) **Explanation**: This forest is mature with moderate complexity and there is a moderate level of uncertainty that impacts are clearly understood, as described in the Lumsden Landfill Ecology Report.
Areal extent of impact (ha)	**Data input**: 1 ha **Explanation:** This includes 0.05 ha (10 m width of vegetation) outside the project footprint to account for potential edge effects.
Value score <u>prior to</u> impact	**Data input**: 3.5 **Explanation**: A value of 3.5 relative to the benchmark of 5 for forest biodiversity as per the characterisation and assessment in the Lumsden Landfill Ecology Report.
Value score <u>after</u> impact	**Data input**: 0.001 **Explanation**: A value of 0.001 as there will be a permanent and complete loss of habitat (noting that the formula cannot work with 0).
Habitat/site impacted	**WF8 – Site 2**
Impact risk contingency	**Data input**: High risk (Calculated biodiversity impact score is multiplied by 1.1 (+10%)) **Explanation**: As above
Impact uncertainty contingency	**Data input**: Moderate uncertainty (calculated biodiversity impact score is multiplied by 1.1 (+10%)) **Explanation**: As above
Areal extent of impact (ha)	**Data input** 0.4 ha **Explanation**: This fragment will be lost in its entirety (so there has been no extra allowance to address edge effects).
Value score <u>prior to</u> impact	**Data input** 3 **Explanation**: A value of 3 relative to the benchmark of 5 (or 60% relative to the benchmark) as per the characterisation and assessment undertaken in the Lumsden Landfill Ecology Report. As described in the report the

	assigned value was lower than for WF8 – Site 1. While both were unfenced and subject to livestock browsing and tramping, WF8 – Site 2 was a smaller fragment that had lower diversity, and the hydrology of the fragment had been compromised such that it was no longer functioning as a wetland ecosystem.
Value score after impact	**Data input**: 0.001 **Explanation**: A value of 0.001 as there will be a permanent and complete loss of habitat (noting that the formula cannot work with 0).
Compensation model inputs	
Compensation action	**Data input**: Native revegetation into hydric soils adjacent to an existing WF8 fragment, including 10-year maintenance programme and stock exclusion fencing.
Discount rate	**Data input**: 3% **Explanation**: Default
Finite end-point	**Data input**: 10 years **Explanation**: At 10 years the revegetation should be well established and tracking towards a WF8 ecosystem type.
Compensation confidence contingency	**Data input**: High confidence **Explanation**: Native revegetation is a commonly applied effects management tool used to create or restore indigenous habitat. Revegetation will be undertaken on suitable hydric soils and immediately adjacent to an existing WF8 fragment.
Areal extent (ha) of compensation type	**Data input**: 6.5 ha **Explanation**: This is a large proportion of the available area of suitable habitat outside the Lumsden Landfill footprint.
Value score prior to compensation measure	**Data input**: 0.001 **Explanation**: The area is currently degraded wetland pasture (low-stature exotic wetland vegetation subject to livestock browsing) or improved pasture sown into hydric soils. It does not support any species that would ordinarily be in WF8.
Value score after compensation measure	**Data input:** 1 **Explanation:** A value score of 1 after 10 years equates to an ecological value of 20% relative to the benchmark. This is expected since the proposed planting will include key species present within early stage WF8 but will not include anywhere near the species or structural diversity of mature WF8 habitats based on literature and expert knowledge.
Compensation action	**Data input**: WF8 retirement from livestock browsing including stock exclusion fencing and a 10-year weed control programme.
Discount rate	**Data input**: 3%

	Explanation: Default
Finite end-point	**Data input**: 10 years **Explanation:** 10 years provides sufficient time for early gains to materialise, i.e. understory regeneration.
Compensation confidence contingency	**Data input**: Moderate confidence **Explanation**: Retirement from livestock browsing coupled with weed control is a common approach and for this forest type is likely to work so long as the hydrology and soil seedbank has not been significantly compromised.
Areal extent (ha) of compensation type	**Data input**: 14.9 ha **Explanation**: This is the areal extent of the largest WF8 fragment on the site that lacks stock-exclusion fencing.
Value score prior to compensation measure (relative to benchmark)	**Data input** 3.5 **Explanation**: A value of 3.5 relative to the benchmark of 5 (or 70% relative to the benchmark) as per the characterisation and assessment of potential compensation sites in the Lumsden Landfill Ecology Report. These habitats are generally small and unfenced, and subject to livestock browsing and tramping. However, they retain hydric soils and include large mature trees and other key biodiversity features that would be expected in high value WF8 forest fragments.
Value score after compensation measure (relative to benchmark)	**Data input** 3.75 (i.e., an increase of 5% relative to the benchmark) **Explanation**: The exclusion of stock coupled with weed control is expected to reinstate native regeneration and a dense forest understory. The increase in score is not higher because the establishment of lower mid-story to subcanopy layers (and associated biodiversity values) will take considerably longer than 10 years based on literature and expert knowledge.

Table 4.2: Kahikatea-pukatea forest BCM output table

Impact model outputs	**Totals**	**WF8-1 (1 ha loss)**	**WF8-2 (0.4 ha loss)**
Impact score	**-1.13706**	-0.84676	-0.29030
Compensation model outputs	**Totals**	**Retirement (14.9 ha gain)**	**Revegetation (6.5 gain)**
Compensation score	**1.25458**	0.79724	0.45734
Predicted Net Gain outcome	**10.3%**		

4.2 Hypothetical BCM for long-tailed bats

The hypothetical long-tailed bat BCM sets out data input tables and output reporting tables for both:

- a 10-year finite input (Table 4.3 and Table 4.4), and

- a 20-year finite input (Table 4.5 and Table 4.6).

In summary the model relates to effects on long-tailed bats associated with impacts across three habitat types, including the loss of 21.06 ha of pasture and 0.4 ha of non-riparian exotic vegetation and general disturbance-related effects on 0.63 ha of exotic riparian vegetation. These habitat types were assigned different ecological value scores based on their importance for long-tailed bats as assessed through field investigations.

To achieve a predicted 10% Net Gain outcome within 10 years of impacts, and in accordance with biodiversity compensation principles, it was deemed necessary to undertake:

- 50 ha of mammalian pest control; and
- Native revegetation of 14 ha of riparian margin including stock-exclusion fencing and a 10-year weed management and infill planting programme.

It was also predicted that the 10% Net Gain outcomes would be achieved over the longer term (20 years). This was based on running the model at 20 years and working on the assumptions that:

- the gains associated with the native revegetation would be higher at 20 years (compared to 10 years) and
- the gains associated with the 10-year mammalian pest control programme would have declined to zero.

The input tables are a summary for illustrative purposes; in practice significantly more detail would be needed to justify each of the respective biodiversity value and contingency scores.

Table 4.3: Hypothetical BCM for long-tailed bats (10-year finite end point)

General model descriptor inputs	
Model inputs	**Explanation**
Project	Kissimmee Quarry
Biodiversity type	Long-tailed bats
Technical expert input(s)	XXXX, (Applicant's ecologist), XXXX (Department of Conservation), XXXX (Department of Conservation), XXXX (Waikato Regional Council)
Benchmark	A large contiguous indigenous forest that includes remnant trees, river and gully reaches, and has been subject to mammalian pest control for more than 20 years.
How many habitat types OR sites are impacted	3
Number of proposed compensation measures	2
Net Gain target	10% (i.e. the compensation score needs to be at least 10% higher than the impact score)
Impact model inputs	

Habitat/site impacted	Pasture habitat
Impact risk contingency	**Data input**: Very high risk (calculated biodiversity impact score is multiplied by 1.2 (+20%) **Explanation**: The risk was assessed as 'Very high' because Long-tailed bats are classified as Nationally Threatened (Nationally Critical) which equates to a 'Very high' ecological value under EcIAG (Roper Lindsay *et al*. 2018).
Impact uncertainty contingency	**Data input**: Moderate uncertainty (calculated biodiversity impact score is multiplied by 1.1 (+10%)) **Explanation**: Impacts on bats associated with habitat loss and disturbance relating to quarrying effects are generally understood but uncertainties remain.
Site OR habitat type size (ha)	**Data input**: 21.06 **Explanation**: This is the amount of pasture habitat loss associated with the quarrying activities. Residual edge effects on pasture habitat adjacent to the footprint are considered negligible because the quarry will be bordered by a 5m bund planted with low stature vegetation to minimise disturbance in the immediate surrounds.
Value score <u>prior to</u> impact	**Data input**: 0.25 **Explanation**: A value of 0.25 relative to the benchmark of 5 (or 5% value relative to the benchmark) has been assigned based on a desktop review and field investigations and an assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. In particular, the results of ABM field investigations, which suggest that pasture within the footprint is marginal habitat that is used infrequently by bats for commuting and foraging.
Value score <u>after</u> impact	**Data input**: 0.001 **Explanation**: A value of 0.001 (virtually zero) has been assigned as there will be a permanent and complete loss of habitat within the footprint due to quarrying activities (noting that the formula cannot work with 0).
Habitat/site impacted	**Exotic forest (riparian)**
Impact risk contingency	**Data input**: Very high risk (calculated biodiversity impact score is multiplied by 1.2 (+20%) **Explanation**: As above.
Impact contingency (uncertainty)	**Data input**: Moderate uncertainty (calculated biodiversity impact score is multiplied by 1.1 (+10%)) **Explanation**: As above.

Site or habitat type size (ha)	**Data input**: 0.63 ha **Explanation**: While no riparian margin will be lost within the project footprint, 0.63 ha of riparian margin adjacent to the project footprint is expected to be affected through general disturbance. This cannot be mitigated for as set out in the Kissimmee Quarry Ecology Report.
Value score prior to impact	**Data input**: 3.5 **Explanation**: A value of 3.5 relative to the benchmark of 5 (or 70% value relative to the benchmark) has been assigned based on a desktop review and field investigations and an assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. In particular, the results of ABM field investigations, which suggest that this riparian habitat is frequently used for foraging and commuting and while ABMs did not pick up signs of roosting within the project footprint, the presence of roosts cannot be ruled out.
Value score after impact	**Data input**: 3 **Explanation**: A value of 3 relative to the benchmark of 5 (or 60% value relative to the benchmark) after impact has been assigned based on a desktop review and field investigations and an assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. As described in that report, there will be no direct impact on the riparian margin and potential effects will be mitigated through the establishment of a 5 m high bund as well as 10 m of native buffer plantings between the bund and existing riparian vegetation. However, despite mitigation, effects are still expected to result in a decline in overall habitat suitability by approximately 10% relative to the benchmark.
Habitat/site impacted	**Exotic forest (non-riparian)**
Impact risk contingency	**Data input**: Very high value (calculated biodiversity impact score is multiplied by 1.2 (+20%)) **Explanation**: As above.
Impact uncertainty contingency	**Data input**: Moderate uncertainty (calculated biodiversity impact score is multiplied by 1.1 (+10%)) **Explanation**: As above.
Site or habitat type size (ha)	**Data input**: 0.4 ha **Explanation**: This is the area of non-riparian exotic forest habitat loss associated with the quarrying activities. Residual edge effects on non-riparian exotic forest habitat adjacent to the footprint are considered negligible because the quarry will be bordered by a 5 m bund with low stature vegetation on top to minimise disturbance in the immediate surrounds.

Value score prior to impact	**Data input**: 2 **Explanation**: A value of 2 relative to the benchmark of 5 (or 40% value relative to the benchmark) has been assigned based on a desktop review and field investigations and an assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecological Assessment of Effects Report. In particular, the results of ABM field investigations, which suggest that this non-riparian habitat is frequently used for foraging and commuting though much less than exotic forest riparian margin. Also, the vegetation is typically much younger than that found in the exotic forest margin and is considered less likely to be used for roosting, though this cannot be ruled out.
Value score after impact	**Data input**: 0.001 **Explanation**: A value of 0.001 (virtually zero) has been assigned as there will be a permanent and complete loss of habitat within the footprint due to quarrying activities (noting that the formula cannot work with 0).
Compensation model inputs	
Compensation action	**Data input:** 10 years of intensive mammalian pest control of key target species within existing exotic-dominated forest riparian margin.
Discount rate	**Data input**: +3% (default)
Finite end-point	**Data input**: 1 year **Explanation**: Pest control benefits will occur soon after commencement as the benefits for long-tailed bat are realised almost immediately. However, the proposed duration of pest control is 10 years to provide additional short-term benefits within existing riparian margin until revegetation is able to provide suitable habitat for foraging and commuting.
Compensation confidence contingency	**Data input**: Moderate confidence (50%-75%). The success of the pest control programme is largely dependent on ensuring that pest control is in the same location as high-value roosting trees. However, while it is considered highly likely that the proposed pest control area will include high value bat roosts, this is not certain, as baseline studies had not been undertaken at the time of applying this model. **Additional notes**: If baseline roost survey work within the proposed pest control area provides evidence that active roost sites are present, then the model could be re-run using a higher compensation confidence category, which may decrease the areal extent of mammalian pest control required to achieve the Net Gain target of 10%. Conversely if baseline surveys revealed that the proposed area for compensation did not include active roost sites, then the assigned compensation confidence category should drop to 'Low'. Accordingly, mammalian pest control should not be used as proposed compensation action, or

	alternatively, the proposed location for pest control would need to change.
Areal extent (ha) of compensation type	**Data input**: 50 ha **Explanation**: This the amount of available riparian margin on the property that will be subject to pest control.
Value score prior to compensation	**Data input**: 3.5 **Explanation**: A value of 3.5 relative to the benchmark of 5 (or 70% value relative to the benchmark) has been assigned based on desktop and field investigations and an assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. In particular, the results of ABM field investigations, which suggest that the existing riparian margin is frequently used by bats for commuting and foraging, and that bats are using the margin for roosting. The assigned score was not higher because the number of bat passes in this area was considerably lower than recordings in older growth native forest in the region.
Value score after compensation	**Data input**: 3.75 **Explanation:** A value of 3.75 relative to the benchmark of 5 (or an increase of 5% relative to the benchmark). This assessment based on a desktop review of the effectiveness of mammalian pest control on bats, and accounts for the uncertainty around expectations. **Additional notes**: To ensure short term compensation gains it is considered necessary to undertake pest control because benefits associated with other forms of compensation, e.g. native revegetation may take longer to eventuate. However, the benefits of mammalian pest control will diminish once pest control is terminated. The BCM for long-tailed bats should therefore also be run with a longer finite end-point without pest control. For example for a finite end point of 20 years, assuming that: • compensation included only revegetation, and • the native revegetation at 20 years was assigned a compensation score of 2 (i.e. 40% value relative to the benchmark). In this case, the predicted Net Gain at 20 years would be 14.4% (See Table 4.5 and Table 4.6 below).
Compensation action	**Data input**: Native riparian revegetation **Explanation**: Riparian revegetation will include native revegetation of riparian margin habitat that will ultimately link up two existing riparian margin fragments. Riparian revegetation will also include stock exclusion fencing and a 10-year weed control, infill planting maintenance programme and control of mammalian browsers (e.g. rabbits) if required.
Discount rate	**Data input**: 3% **Explanation**: Default

Finite end-point	**Data input**: 10
Compensation confidence contingency	**Data input**: High confidence **Explanation**: Native revegetation is a commonly applied effects management tool used to create or restore indigenous habitat.
Areal extent (ha) of compensation type	**Data input**: 14 ha **Explanation**: This is the areal extent of riparian margin that will be revegetated (at 20 m width) to link up existing riparian margin fragments.
Value score prior to compensation measure	**Data input**: 0.5 **Explanation**: A value of 0.5 relative to the benchmark of 5 (or 10% value relative to the benchmark) has been assigned based on field investigations and an assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. In particular, the results of ABM field investigations, which suggest that riparian pasture within the proposed revegetation site is used periodically by bats for commuting and foraging (around twice as frequently as non-riparian pasture within the Kissimmee quarry footprint).
Value score after compensation measure	**Data input**: 1 **Explanation**: A value of 1 relative to the benchmark of 5 (or 20% value relative to the benchmark) has been assigned based on desktop and field investigations and an expected assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. In particular, the results of ABM field investigations within similarly aged native riparian habitat in the region, which suggest that at 10 years these areas will be used by bats for commuting and foraging (though not for roosting as the trees are generally too young to have formed suitable roosting cavities).

Table 4.4: Long-tailed bat BCM output table at 10 years

Impact model outputs	**Totals**	**Pasture**	**Riparian Forest**	**Non-Riparian Forest**
Impact score	**-1.6787**	-1.3844	-0.08316	-0.21109
Compensation model outputs	**Totals**	**Revegetation**	**Pest Control**	
Compensation score	**2.37642**	0.85943	1.51699	
Predicted Net Gain outcome	**36.1%**			

While the model indicates a predicted Net Gain outcome for long-tailed bats at 10 years (Table 4.3 and Table 4.4 above), the predicted gains associated with the proposed mammalian pest control programme will diminish over time.

To determine if NNL/NG would be predicted in the longer term, the model was also run assuming a finite period of 20 years and that the predicted NG associated with the 10-year mammalian pest control programme had diminished to zero.

The general model inputs and the impact model inputs are the same as for Table 4.3, therefore only the compensation model inputs are presented in Table 4.5 below.

Table 4.5: Hypothetical BCM for long-tailed bats (20-year finite end point). Compensation model inputs only

Compensation model inputs	
Compensation action	**Data input**: Native riparian revegetation **Explanation**: Riparian revegetation will include native revegetation of riparian margin habitat that will ultimately link up two existing riparian margin fragments. Riparian revegetation will also include stock exclusion fencing and a 10-year weed control, infill planting maintenance programme and control of mammalian browsers (e.g. rabbits) if required.
Discount rate	**Data input**: 3% **Explanation**: Default
Finite end-point	**Data input**: 20 years
Compensation confidence contingency	**Data input**: High confidence **Explanation**: Native revegetation is a commonly applied effects management tool used to create or restore indigenous habitat.
Areal extent (ha) of compensation type	**Data input**: 14 ha **Explanation**: This is the areal extent of riparian margin that will be revegetated (at 20 m width) to link up existing riparian margin fragments.
Value score prior to compensation measure	**Data input**: 0.5 **Explanation**: A value of 0.5 relative to the benchmark of 5 (or 10% value relative to the benchmark) has been assigned based on field investigations and an assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. In particular, the results of ABM field investigations, which suggest that riparian pasture within the proposed revegetation site is used periodically by bats for commuting and foraging (around twice as frequently as non-riparian pasture within the Kissimmee quarry footprint).
Value score after compensation measure	**Data input**: 2 **Explanation**: A value of 2 relative to the benchmark of 5 (or 40% value relative to the benchmark) has been assigned based on desktop and field investigations and an expected assessment against habitat suitability criteria as described in the Kissimmee Quarry Ecology Report. In particular, the results of ABM field investigations within similarly aged native riparian habitat in the region, which suggest that at 20 years these areas will be used by bats for commuting and foraging (though not

	for roosting as the trees are generally still too young to have formed suitable roosting cavities).

Table 4.6: Long-tailed bat BCM output table at 20 years

Impact model outputs	**Totals**	**Pasture**	**Riparian Forest**	**Non-Riparian Forest**
Impact Score	**-1.6787**	-1.3844	-0.08316	-0.21109
Compensation model outputs	**Totals**	**Revegetation**		
Compensation Score	**1.91849**	1.91849		
Predicted Net Gain outcome	**14.3%**			

5 BCM calculations and outputs

The BCM produces data input and output tables that are based on the data inputs and on model calculations used to determine whether predicted NNL/NG outcomes are likely based on the information provided.

These data input and output tables can be readily extracted for reporting outputs as required.

5.1 BCM calculations and outputs

The data inputs into the BCM are used to generate the following calculations and outputs.

5.1.1 Equation 1: Impact score per unit area

The impact score per unit area equates to the change in value per unit area due to the impact (in proportion to the benchmark measure) and based on the following calculation.

$$\Delta \boldsymbol{A_i} = \left(\frac{\boldsymbol{M_{after}\,A_i}}{\boldsymbol{B_i}}\right) - \left(\frac{\boldsymbol{M_{before}\,A_i}}{\boldsymbol{B_i}}\right)$$

Where $\boldsymbol{\Delta A_i}$ is the reduction in the value score, $\boldsymbol{M_{before}\,A_i}$ is the value score prior to the impact, $\boldsymbol{M_{after}A_i}$ is the value score after the impact, and $\boldsymbol{B_i}$ is the benchmark value score.

5.1.2 Equation 2: Impact contingency

The total value impact score is adjusted in relation to:

- The assigned impact risk contingency which is based on the ecological value score as determined by the EcIAG assessment (c_i); i.e. all else being equal, impacts on biodiversity values that have a higher ecological value, will receive a higher impact risk contingency than impacts on biodiversity values of lower ecological value (based on an assessment of ecological value in accordance with EcIAG criteria).
- The assigned impact uncertainty contingency as determined by the ecologist(s) (c_{ii}); i.e. all else being equal, impacts on biodiversity values for which the level of uncertainty is higher, will receive a higher impact uncertainty contingency than impacts on biodiversity for which the degree of uncertainty is deemed lower.

This is based on the following calculation:

$$\Delta \boldsymbol{A_{i\ adjusted}} = \Delta \boldsymbol{A_i\ x\ c_i\ x\ c_{ii}}$$

Where $\boldsymbol{\Delta A_{i\ adjusted}}$ is the percentage adjusted increase in the impact score per unit area due to both the assigned impact risk percentage multiplier ($\boldsymbol{c_i}$) and the assigned impact uncertainty percentage multiplier ($\boldsymbol{c_{ii}}$).

$\Delta \boldsymbol{A_{i\ adjusted}}$ can be based on a non-weighted score or weighted impact score per unit area.

5.1.3 Equation 3: Total impact score

The total impact score is based on the following calculation:

$$\boldsymbol{Impact\ BVA_i} = \Delta \boldsymbol{A_{i\,adjusted}\ x\ a}$$

Where $\boldsymbol{BVA_i}$ is the total value impact score, $\boldsymbol{\Delta A_i}$ is the impact score per unit area (equation 1), and $\boldsymbol{a}$ is the area over which the impact occurs.

$\boldsymbol{BVA_i}$ can be based on a non-weighted or weighted impact score per unit area.

5.1.4 Equation 4: Compensation gain score per unit area

The compensation gain score per unit area equates to the change in value score per unit area due to the compensation (in proportion to the benchmark measure) at a pre-determined fixed point in time and is based on the following calculation:

$$\Delta \boldsymbol{A_i} = \left(\frac{\boldsymbol{M_{after}\ A_i}}{\boldsymbol{B_i}}\right) - \left(\frac{\boldsymbol{M_{before}\ A_i}}{\boldsymbol{B_i}}\right)$$

Where $\boldsymbol{\Delta A_i}$ is the predicted compensation gain score per unit area, $\boldsymbol{M_{before}\ A_i}$ is the value score prior to compensation, $\boldsymbol{M_{after} A_i}$ is the value score after the compensation, and $\boldsymbol{B_i}$ is the benchmark value score.

5.1.5 Equation 5: Compensation contingency adjustment

The total compensation gain score is adjusted in relation to the assigned degree of confidence that the predicted compensation outcomes will be achieved ($\boldsymbol{c_i}$).

This is based on the following calculation:

$$\Delta \boldsymbol{A_{i\ adjusted}} = \Delta \boldsymbol{A_i\ x\ c_i}$$

$\boldsymbol{\Delta A_{i\ adjusted}}$ is the percentage adjustment for the compensation score per unit area based on the assigned degree of confidence. $\boldsymbol{\Delta A_i}$ is the predicted compensation gain score per unit area, and $\boldsymbol{c_i}$ is the percentage adjustment associated with the assigned level of confidence.

$\boldsymbol{\Delta A_{i\ adjusted}}$ can be based on a non-weighted or weighted compensation gain score.

5.1.6 Equation 6: Total compensation gain score

The total compensation gain score is based on the following calculation:

$$\boldsymbol{Compensation\ BVA_i} = \left(\frac{\Delta\ \boldsymbol{A_{i\ adjusted}}}{(\boldsymbol{1}+\boldsymbol{d})^{\boldsymbol{t}}}\right)\boldsymbol{x\ a}$$

Where $\boldsymbol{BVA_i}$ is the compensation gain score, $\boldsymbol{\Delta A_{i\ adjusted}}$ is the adjusted compensation gain score per unit area due to the compensation action, **d** is the time discount rate, $\boldsymbol{t}$ is time at which the compensation is predicted to achieve likely NNL/NG outcomes, and $\boldsymbol{a}$ is the area over which the compensation occurs.

$\boldsymbol{BVA_i}$ can be based on a non-weighted or weighted compensation gain score

5.1.7 Equation 7: NPBV across impact and compensation site(s)

Calculates the overall Net Present Biodiversity Value (NPBV) across the impact and compensation site(s) to determine if NNL/NG outcomes are predicted based on model inputs.

$$\boldsymbol{NPBV\ A_i} = \boldsymbol{Compensation\ BVA_i} + (-\boldsymbol{Impact\ BVA_i})$$

Where ***NPBV A**$_i$* is the NPBV across impact and compensation sites, ***Compensation BVA**$_i$* is the total compensation gain score (equation 6) and the ***Impact BVA**$_i$* is the total impact score at the impact site(s) (equation 3).

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[7] Excluding technical review of the model equations

Appendix A: Biodiversity Compensation Principles

Draft National Policy Statement for Indigenous Biodiversity (November 2019): Principles for biodiversity compensation (Appendix 4)

The following sets out a framework of principles for the use of biodiversity compensation. Principles 1–11 must be complied with for an action to qualify as biodiversity compensation. Principles 12– 3 should be met for an action to qualify as biodiversity compensation.

1. Adherence to mitigation hierarchy*: Biodiversity compensation is a commitment to redress [more than minor] residual adverse impacts. It must only be contemplated after steps to avoid, remedy, mitigate and offset adverse effects have been demonstrated to have been sequentially exhausted and thus applies only to residual biodiversity impacts.*

2. Limits to biodiversity compensation*: In deciding whether biodiversity compensation is appropriate, a decision-maker must consider the principle that many indigenous biodiversity values are not able to be compensated for because:*
a) the indigenous biodiversity affected is irreplaceable or vulnerable
b) there are no technically feasible or socially acceptable options by which to secure proposed gains within acceptable timeframes
c) effects on indigenous biodiversity are uncertain, unknown or little understood, but potential effects are significantly adverse.

3. Scale of biodiversity compensation*: The values to be lost through the activity to which the biodiversity compensation applies must be addressed by positive effects to indigenous biodiversity that are proportionate to the adverse effects on indigenous biodiversity.*

4. Additionality*: Biodiversity compensation must achieve gains in indigenous biodiversity above and beyond gains that would have occurred in the absence of the compensation, including that gains are additional to any remediation and mitigation undertaken in relation to the adverse effects of the activity. Compensation design and implementation must avoid displacing activities harmful to indigenous biodiversity to other locations.*

5. Landscape context*: Biodiversity compensation actions must be undertaken where this will result in the best ecological outcome, preferably close to the location of development or within the same ecological district. The actions must consider the landscape context of both the impact site and the compensation site, taking into account interactions between species, habitats and ecosystems, spatial connections and ecosystem function.*

6. Long-term outcomes*: The biodiversity compensation must be managed to secure outcomes of the activity that last as least as long as the impacts, and preferably in perpetuity.*

7. Time lags*: The delay between loss of indigenous biodiversity at the impact site and gain or maturity of indigenous biodiversity at the compensation site must be minimised.*

8. Trading up*: When trading up forms part of biodiversity compensation, the proposal must demonstrate the indigenous biodiversity values gained are demonstrably of higher indigenous biodiversity value than those lost. The proposal must also show the values lost* *are not indigenous taxa that are listed as Threatened, At-risk or Data deficient in the New Zealand Threat Classification System lists, or considered vulnerable or irreplaceable.*

9. ***Financial contributions****: Financial contributions must only be considered when there is no effective option available for delivering indigenous biodiversity gains on the ground. These contributions must be related to the indigenous biodiversity impact. When proposed, financial contributions must be directly linked to an intended indigenous biodiversity gain or benefit.*

10. ***Biodiversity compensation in advance****: Biodiversity compensation developed in advance of an application for resource consent must provide a clear link between the compensation and the future effect. That is, the compensation can be shown to have been created or commenced in anticipation of the specific effect and would not have occurred if that effect were not anticipated.*

11. ***Science and matauranga Māori****: The design and implementation of biodiversity compensation must be a documented process informed by science, including an appropriate consideration of matauranga Māori.*

12. ***Stakeholder participation****: Opportunity for the effective participation of stakeholders should be demonstrated when planning for biodiversity compensation, including evaluation, selection, design, implementation and monitoring. Stakeholders are best engaged early in the process.*

13. ***Transparency****: The design and implementation of biodiversity compensation and communication of its results to the public should be undertaken in a transparent and timely manner.*

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