THECATALYSTGROUP
strategy and environment

p 06 358 6300
e enquiries@thecatalystgroup.co.nz
w www.thecatalystgroup.co.nz
a Top Level, 31 George Street,
PO Box 362, Palmerston North 4440

A Biodiversity Offsets Accounting Model for New Zealand

User Manual

Fleur Maseyk, Martine Maron,
Richard Seaton, and Guy Dutson

A Biodiversity Offsets Accounting Model for New Zealand

A simple model for calculating no net loss for disaggregated biodiversity attributes, incorporating like for like trades, time preference discounting, confidence in offset actions and net present biodiversity value but not other types of risk or dynamic baselines.

PROJECT TEAM:
Fleur Maseyk[1], Dr Martine Maron[2], Dr Guy Dutson[3], Professor Hugh Possingham[2] Dr Richard Seaton[1], Greg Carlyon[1], Alistair Beveridge[1]

[1]The Catalyst Group
PO BOX 362
Palmerston North 4440
New Zealand

[2]Univeristy of Queensland
St Lucia Campus
Brisbane
Queensland 4972
Australia

[3]The Biodiversity Conservancy
28 Golf Links Road
Barwon Heads
Melbourne
Australia

Contract Report No: 2014-008

PREPARED FOR:
Department of Conservation
Hamilton Service Centre
Private Bag 3072
Hamilton
New Zealand

VERSION DATE: March 2015

Acknowledgements: We would like to acknowledge the previous work of Dr Theo Stephens that helped inform the development of this model, Dr Laurence Barea for contributions to the structure and content of the model and manual, and the valuable feedback provided by five anonymous external reviewers.

Table of Contents

1. Introduction

Biodiversity offsetting is a last-resort option to address residual adverse biodiversity impacts due to economic development after all feasible avoidance, minimisation, and remediation actions have been taken. Biodiversity offsetting refers to a process that seeks to counter-balance the unavoidable impacts of development activities on biodiversity by enhancing the state of biodiversity elsewhere. It requires the quantification of biodiversity losses and gains, and their expression in a common currency. The equivalence of the exchange is then evaluated in an accounting model to assess whether no net loss has been demonstrated.

There is currently no over-arching legislation or national policy within New Zealand requiring residual biodiversity losses to be offset, or prescribing how a biodiversity offset is to be developed. However, a regional policy statement or district or regional management plan developed under the Resource Management Act (RMA, 1991) may require biodiversity offsetting. Biodiversity offsets are also a matter that can be considered under the RMA when making decisions about sustainable resource management. Under certain scenarios, offsetting can be relevant under the Crown Minerals Act and the Conservation Act. Offsetting is increasingly proposed as a voluntary means of managing the impacts of development proposals.

The increasing engagement in offsetting led to a three year project implemented by The Department of Conservation (the Department, DOC) and funded by the Cross Departmental Research Pool (CDRP) to investigate biodiversity offsetting within the New Zealand context. A key output of the CDRP project was the production of the New Zealand Government's non-statutory guidance document 'Guidance on Good Practice Biodiversity Offsetting in New Zealand' (Good Practice Guidance), and supporting resources[1] targeted at policy makers, planners, developers, and decision makers.

Engagement in biodiversity offsetting is made easier and more consistent by the availability of ecologically robust and user-friendly decision support tools. Such tools can assist with the development and consideration of biodiversity offsetting proposals.

To this end, the Department contracted The Catalyst Group to develop a biodiversity offset accounting model consistent with the Good Practice Guidance. The Catalyst Group compiled a mixed discipline project team including personal from other organisations to combine academic, theoretical, planning, application, and in-field implementation expertise in biodiversity offsetting. Use of this Model and User Manual is intended to be done in conjunction with the Guidance on Good Practice Biodiversity Offsetting in New Zealand.

1.1 Project scope

The Biodiversity Offset Accounting Model (the Accounting Model) was developed to help find a balance between capturing the inherent complexity of trading biodiversity, and being transparent and simple enough to use.

[1] http://www.doc.govt.nz/biodiversity-offsetting

In summary, the Accounting Model:

- Accounts only for 'like for like' biodiversity trades aimed at demonstrating no net loss (the model does not address 'like for unlike' exchanges)
- Relies on three hierarchical levels to categorise biodiversity (1: biodiversity types; 2: biodiversity components; 3: biodiversity attributes)
- Uses a disaggregated area x condition currency
- Calculates net present biodiversity value (NPBV[2]) for individual biodiversity attributes and average NPBV across the range of attributes representing a biodiversity component
- Uses NPBV to estimate whether no net loss is achieved in the exchange with project level no net loss being demonstrated when all components demonstrate no net loss
- Incorporates the use of a discount rate
- Increases transparency of input values
- Adjusts for uncertainty of success regarding the proposed offset actions
- Includes in-model explanations to assist the user

These elements of the model are discussed in further detail in later sections of this User Manual.

The Accounting Model is a non-prescriptive, flexible 'empty shell' that the user populates by entering biodiversity measures, estimates, and discount rates. Before using the model, an offset developer should be familiar with the concepts relating to the construction of biodiversity currencies and accounting, concealed loss and data adequacy. Useful information in this context is provided in the Good Practice Guidance and its supporting resources.[3]

1.2 Purpose and scope of the User Manual

This document has been prepared to provide context and user support for the Accounting Model. In particular, it includes two development proposal scenarios to illustrate how a user might go about using the Accounting Model and communicating the outputs.

This Manual does not reiterate biodiversity offsetting definitions, principles, key concepts, application in the New Zealand legislative and planning framework, or other background aspects of biodiversity offsetting adequately addressed elsewhere.

It is assumed the reader:

- has a working understanding of biodiversity offsetting principles, concepts, and terminology,
- has read the Good Practice Guidance, and
- is familiar with Microsoft Excel.

[2] Overton JMC, Stephens RTT, Ferrier S 2013. Net present biodiversity value and the design of biodiversity offsets. AMBIO 42(1):100–110.
[3] http://www.doc.govt.nz/biodiversity-offsetting

Part A: The Biodiversity Offsets Accounting Model

Biodiversity offsetting is complex and challenging because 'biodiversity' itself cannot be reduced to simple measures. These inherent complexities cannot be removed entirely in the interests of simplicity and user-friendliness. The Accounting Model may appear complex at first, but has been developed on a foundation of a relatively simple internal structure. Users will find that the Model can be easily worked through in a considered, step-wise process.

2. Terminology

Key words and phrases used within the Accounting Model are defined below. Further explanation for each can be found in relevant sections of this User Manual.

Benchmark The benchmark value is specific to each biodiversity attribute to be accounted for and represents the 'best defensible' measure available for that attribute. The benchmark is either directly measured (from a high quality reference site) or defensibly estimated (by consensus of suitably qualified experts).

Biodiversity hierarchy

Biodiversity types are the key biodiversity features of concern found at the **impact site**, and as necessary for a like for like exchange at the **offset site**. Biodiversity types can be either ecosystems, habitats, or species. Biodiversity types are the highest level of the hierarchy used to categorise biodiversity in the design of the offset.

Biodiversity components help describe what makes up the **biodiversity type.** Biodiversity components are the second level of the hierarchy used to categorise biodiversity in the design of the offset. Biodiversity components can respond differently to both the impacts of development proposals and offset actions. As many components as thought necessary to fully describe the biodiversity type, and to account for loss can be entered into the Accounting Model.

Biodiversity attributes are elements that collectively make up the **biodiversity component**. Biodiversity attributes are the lowest level of the hierarchy used to categorise biodiversity in the design of the offset. Attributes are the measured values balanced within the Accounting Model to demonstrate no net loss. Usually several attributes are required to adequately describe a component, but one may be sufficient. As the Accounting Model uses a disaggregated like for like currency, attributes are equally weighted.

Discount rate accounts for the time preference of a certain loss now (due to the proposed development) in exchange for a uncertain gain in the future (due to the **offset action**) by recognising the risk inherent within the temporal lag between loss and gain. This model does not separately account for other discount types (such as default risk or inflation/deflation), although they can be incorporated into time preference if desired.

Impact site is the location in geographical space where residual adverse effects of a proposed development occur. There may be more than one impact site associated with a proposed development. Within the Accounting Model the impact site is defined in terms of area of impact (measured in hectares).

Offset actions are the management interventions proposed to effect a gain in biodiversity in response to a loss in value at the **impact site**. Offset actions are implemented at the **offset site(s)**. It is typical to have several offset actions proposed as part of an offset proposal.

Offset site is the location in geographical space where **offset actions** are to be implemented. There may be more than one offset site associated with a proposed offset. Within the Accounting Model the offset site is defined in terms of area of **offset action** (measured in hectares).

3. Conceptual approach

The Accounting Model has been designed to support the design of a biodiversity offset in accordance with the structure of Good Practice Biodiversity Offsetting in New Zealand (Fig 1).

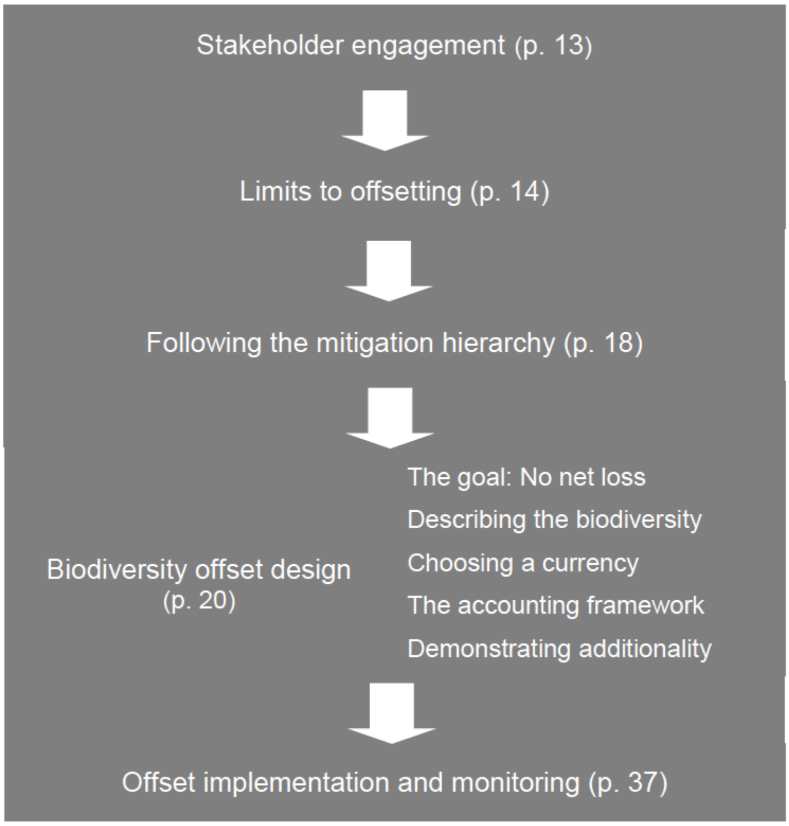

Figure 1: Structure of Guidance on Good Practice Biodiversity Offsetting in New Zealand. Taken from the Good Practice Guidance (page 12, Fig. 1). The Accounting Model provides support the 'Biodiversity offset design'. Page numbers in brackets reference relevant sections of the Good Practice Guidance document.

The Accounting Model uses a disaggregated condition x area currency to demonstrate no net loss for biodiversity types by comparing losses and gains in biodiversity components and attributes. Each condition measure is represented as a proportion of a stated benchmark value. Condition does not refer primarily to ecosystem health, but to the quantity, structure, and function of biodiversity.

The structure of the Accounting Model allows for use of either indirect measures (proxies or surrogates based on structural features or functional indicators correlated with the state of biodiversity) or direct measures (counts or measures of individuals). The Good Practice Guidance discusses the strengths and limitations of both approaches to constructing a currency.

Condition x area currencies can be appropriate to account for complex biodiversity offset situations when the following constraints and standards are adhered to:

- Selected biodiversity attributes are inclusive of a meaningful range of biodiversity components that represent biodiversity types.
- Biodiversity attributes are selected to capture important biological states (e.g. different stages and/or ages of species).
- Parameters and values are empirically informed wherever possible and the use of unverifiable parameters or values is avoided.
- The currency is disaggregated, thereby avoiding trade-offs between dissimilar biodiversity.
- Currency limitations are understood and rules that addresses concealed loss are set outside of the model.

More detail on selecting attributes and creating currencies is available in the Good Practice Guidance.

The first three bullet points are addressed by the user but are presented explicitly in the Accounting Model, enabling peer review and regulatory consideration. The fourth bullet point is explicitly provided for within the Accounting Model. To minimise concealed loss, calculations for biodiversity components within biodiversity types are explicit and disaggregated. If a user chooses to aggregate calculations for biodiversity attributes into a single metric for each biodiversity component, exchange restrictions should be considered to avoid unacceptable concealed loss. Using a disaggregated currency increases transparency and allows ‘winners and losers’ to be easily identified.

The Accounting Model assumes that the state of biodiversity, in the absence of either the impact or the offset, will remain stable (i.e. a fixed baseline). The amount of offset gain generated at the offset site is the difference between the value of the attribute if the offset action occurs, and the value of the attribute if it does not occur. The scenario in which the offset action does not occur is referred to as the baseline scenario, and it is against this scenario that offset benefits are calculated. In this manner, the value of the attribute before the offset action occurs is used as the baseline throughout the time frame considered. The Accounting Model does not incorporate uncertainty about the baseline scenario.

The Accounting Model demonstrates whether a no net loss like-for-like exchange is supported based on the proposed offset design at a biodiversity attribute and component level. No net loss for a biodiversity type is demonstrated when all associated components demonstrate no net loss. Thus, no net loss at the project-level is supported for all biodiversity types when all associated components demonstrate no net loss. No net loss is not actually *achieved* until the offset actions have been fully implemented and targets have been demonstrably reached and secured for the long term.

4. Model format

The Accounting Model sits within an Excel workbook and consists of three interconnected spreadsheets. The Accounting Model operates in two parts: 1) the Impact Model and 2) the Offset Model. Within the Offset Model, the user has the option to either calculate net present biodiversity value[4] at a user-defined finite end point (within the Offset Model), or as it accrues at five yearly time-steps across a 35 year period. Each of these options operate within a separate spreadsheet. The Accounting Model is presented as an 'empty-shell' template that can be applied to any project.

Information can be entered into the Accounting Model by users with a range of experience and expertise, although foundation knowledge of Excel and biodiversity offsetting principles is required. As for any model, the quality of the result is dependent on the quality of the data input.

5. Mathematical approach

There are several calculations within the Accounting Model that occur in sequential order. These are:

Impact Model

1. Change in measure of biodiversity attribute per unit area due to the impact, in proportion to the benchmark measure.

$$\Delta A_i = \left(\frac{M_{after}\,A_i}{B_i}\right) - \left(\frac{M_{before}\,A_i}{B_i}\right) \qquad (1)$$

   Where ΔA_i is the loss in a given biodiversity attribute measure, $M_{before}\,A_i$ is the value of that biodiversity attribute prior to the impact, $M_{after} A_i$ is the value of the same biodiversity attribute after the impact, and B_i is the benchmark value for that attribute.

   The measured biodiversity attribute value is entered into the model, which is then automatically expressed as a proportion of the benchmark, with a value between 0 and 1. In cases where the value of the biodiversity attribute measure is greater than the benchmark value, the value is truncated to 1 within the calculation to ensure all values fall between 0 and 1.

2. Biodiversity value of attributes at the impact site

$$BVA_i = \Delta A_i \; x \; a \qquad (2)$$

   Where BVA_i is the biodiversity value of an attribute, ΔA_i is the loss in biodiversity attribute value (equation 1) due to the impact, and a is the area over which the impact occurs.

[4] In the Good Practice Guidance, 'biodiversity value' is defined as referring to "the importance of a particular biodiversity component or assemblage" and expressed in as 'Low, Medium, High, Very High or Extremely High' (pg. 15). Within the Accounting Model, 'Biodiversity Value (BV) is a numerical value, that represents the measured change in value of an biodiversity attribute.

Offset Model

Option 1: Calculating NPBV to a finite end-point:

3. Change in measure of biodiversity attribute per unit area in response to the offset management actions, in proportion to the benchmark measure.

   This is calculated in the same manner as equation 1, but now $M_{before}\ A_i$ is the value of the biodiversity attribute prior to the Offset and $M_{after}\ A_i$ is the value of the biodiversity attribute after the offset.

   As for the Impact Model, biodiversity measures are truncated to 1 if they exceed the benchmark value.

4. Incorporating confidence in offset management action

$$\Delta A_{i\ adjusted} = \Delta A_i\ x\ c_i \qquad (3)$$

   Where $\Delta A_{i\ adjusted}$ is gain in biodiversity attribute measure due to the offset adjusted for confidence in the offset action, ΔA_i is the gain in attribute measure, c_i is the mid-value of the percentage range associated with the chosen confidence level. [5]

5. Biodiversity value of attributes at the offset site

$$BVA_i = \left(\frac{\Delta A_{i\ adjusted}}{(1+d)^t}\right) x\ a \qquad (4)$$

   Where BVA_i is the biodiversity value of an attribute, $\Delta A_{i\ adjusted}$ is the adjusted gain in biodiversity attribute value (equation 3) due to the offset, *d* is the time discount rate, *t* is time at which the offset is expected to demonstrate no net loss and *a* is the area over which the offset occurs.

6. Net present biodiversity value of biodiversity attributes

$$NPBV\ A_i = Offset\ BVA_i - Impact\ BVA_i \qquad (5)$$

   Where $NPBV\ A_i$ is the net present biodiversity value of a given biodiversity attribute across impact and offset sites, $Offset\ BVA_i$ is the biodiversity value of the attribute at the offset site (equation 4) and $Impact\ BVA_i$ is the biodiversity value of the attribute at the impact site (equation 2).

7. Average net present biodiversity value of biodiversity components

$$\bar{x}\ NPBV\ C_i = \frac{\sum NPBV\ A}{n} \qquad (6)$$

[5] **Low confidence**: likelihood of success is >50% but < 75%, c_i = 0.62; **Confident**: likelihood of success is greater than 75% but less than 90%, c_i =0.825; **Very confident** = likelihood of success is >90%, c_i = 0.955.

Where $\bar{x}$ *NPBV* C_i is the average net present biodiversity value of a given biodiversity component, $\sum$*NPBVA* is the sum of the net present biodiversity value of each of the biodiversity attributes associated with the biodiversity component and *n* is the number of biodiversity attributes associated with the biodiversity component.

Option 2: Calculating accrued NPBV at five-yearly time intervals:

Accrued NPBV is calculated in the same manner as Option 1, with the following differences:

1. The change in biodiversity attribute measure at each time-step

$$\Delta A_i = \left(\frac{M_{TimeStep}\ A_i}{B_i}\right) - \left(\frac{M_{TimeStepPrior}\ A_i}{B_i}\right) \qquad (7)$$

   Where ΔA_i is the change in a given biodiversity attribute measure, $M_{TimeStep}\ A_i$ is the value of that biodiversity attribute at the time-step being calculated (e.g. Year 5), $M_{TimeStepPrior}\ A_i$ is the value of the same biodiversity attribute at the time-step prior to that being calculated (e.g. Year 1), and B_i is the benchmark value for that attribute.

   The change in biodiversity attribute measure is adjusted for confidence in offset management action, and BV calculated in the same way as for Option 1 (equation 3 and equation 4). **NB:** the time period (*t*) in equation 4 is adjusted to correspond to the relevant time-step (e.g. Year 5, $t = 5$, Year 10, $t = 10$).

2. Accrued biodiversity value at the offset site is calculated by adding the biodiversity value for the prior time-step to the biodiversity value calculated at each time-step

$$BV_{accrued}\ A_i = BV_{TimeStep}\ A_i + BV_{TimeStepPrior}\ A_i \qquad (8)$$

   Where $BV_{accrued}\ A_i$ is the accrued BV of a given biodiversity attribute at an offset site, $BV_{TimeStep}\ A_i$ is the time-step being calculated (e.g. Year 5) and $BV_{TimeStepPrior}\ A_i$ is the time-step prior to that being calculated (e.g. Year 1).

3. Net Present Biodiversity Value of biodiversity attributes calculated across five-yearly time intervals

$$*\ NPBV\ A_i = BV_{accrued}\ A_i - Impact\ BVA_i \qquad (9)$$

   Where **NPBV* A_i is the net present biodiversity value of a given biodiversity attribute across impact and offset sites at each time-step, $BV_{accrued}\ A_i$ is the accrued biodiversity value of the attribute at the offset site (equation 8) and *Impact BV* A_i is the biodiversity value of the attribute at the impact site (equation 2).

The above equations are presented here as separate calculations for simplicity. Within the Accounting Model, the calculations are combined and embedded within scripts that drive the operation of the model. The full formulae are presented in Appendix 1.

6. Strengths and Limitations of the Accounting Model

6.1 Strengths of the Accounting Model

The Accounting Model has a number of features that contribute to the robustness of the output:

Disaggregated biodiversity components and attributes: The Accounting Model allows for no net loss to be calculated for individual components and attributes for the biodiversity type of concern. This disaggregated currency provides for the avoidance of concealed trades and explicitly identifies 'winners and losers' within an exchange where no net loss is demonstrated for some elements but not others.

The use of benchmarks: Use of a benchmark provides a reference measure of condition from which to compare biodiversity condition at an impact and offset site. The benchmark value is specific to each biodiversity attribute and represents the 'best defensible' available measure (field measured or modelled) for that attribute, or a defensible state that describes conservation goals.

Ideally, the benchmark value would be determined using direct measurements from a real site of the same community type and which has not been subject to modification or has been under sustained conservation management for some decades, or is representative of accepted conservation goals. As such sites are limited in the New Zealand landscape, it may not be possible to directly determine a benchmark value relevant to specific attributes or specific local scales. In such cases, a defensible estimated value agreed to by suitably qualified experts may be substituted.

The use of benchmarks helps clarify the capacity of the offset site for biodiversity gain at the attribute level, and can illustrate the potential of poor quality sites to contribute to improved state and trend of biodiversity at a local, regional, and national level under an offset proposal. The reverse is also true, and the use of benchmarks is useful to illustrate where a proposed offset site offers little additional improvement to biodiversity.

The Accounting Model has been developed to incorporate benchmark values. Information on developing benchmarks is provided in the supporting document to the Good Practice Guidance titled 'Currencies and accounting systems' (http://www.doc.govt.nz/Documents/our-work/biodiversity-offsets/currency-and-accounting-systems.pdf)

Adjusts for uncertainty about reliability of proposed offset actions: When predicting the outcomes of offset actions there is always some uncertainty, even with accepted management methods. The Accounting Model accounts for uncertainty about outcomes from methods and techniques used for the proposed offset action by incorporating a simplified scale of uncertainty that the stated offset action will be successful. When selecting the level of uncertainty, the user considers whether the technique to be used has been successful in the past, its rate of success, and other relevant issues.

User defined discount rate: The Accounting Model allows the user to set the value of discount rate that best addresses equity over time. Discounting is addressed in the Good Practice Guidance.[6] The

[6] See section 4.5.5 of the Good Practice Guidance.

Accounting Model does not incorporate default risk or inflation/deflation, although in principle, these could be incorporated into the discount rate used.

User defined time horizon for delivery of offset: The Accounting Model allows for the user to choose how to define the time horizon, by use of a user defined finite endpoint or calculation of accrued NPBV at five yearly intervals across a period of 35 years.

Simple internal structure: Working through the Accounting Model is a step-wise process that moves in a linear fashion across columns and across worksheets. The Model itself has built-in explanations for each cell, and utilises a clear, colour-coded lay-out to assist with navigation and use. The Model template is accompanied by worksheets containing detailed explanatory notes relating to each entry within the Model. These features enhance usability of the Model and have maximised the trade-off between simplicity of use and the inherent (and necessary) complexity of biodiversity offsetting.

6.2 Limitations of the Accounting Model

Every model has limitations, but provided these are clearly stated and taken into account within a decision making process, they do not need to prevent the application of the model or undermine the outputs.

Biodiversity baselines: The model assumes a static rather than temporally dynamic biodiversity baseline. Robustly estimating biodiversity trends over time in the absence of the development or offset action is challenging. Accounting for no net loss against a dynamic baseline requires high confidence in the baseline, otherwise no net loss in an averted loss context might be falsely demonstrated. The opposite is also true. As robust dynamic baselines at the scale that offsets are likely to be implemented in New Zealand are unavailable, this model assumes a static baseline (i.e. one of no change, see discussion in section 3). This is not unreasonable for much of New Zealand's biodiversity where it is already protected by legislation or council policies and plans, although there are exceptions. Biodiversity also declines under the pressure of introduced pests and where pressures can be reduced through management, biodiversity gain can accrue. Similarly, retired, early successional sites may be improving in condition even without any further intervention. In effect, the use of a stable baseline means that an outcome of no net loss based on this Accounting Model in fact means no net loss compared to before the impact, rather than no net loss compared to what is likely to have occurred in the absence of the impact and offset.

Uncertainty of offset being successful: The uncertainty built into the Accounting Model relates to the level of confidence in the likely success of the methods and techniques associated with the proposed offset action (see above). This reflects that even well established management methods sometimes fail to achieve targets, sometimes due to uncertainty or unanticipated variation in the ecological system. Confidence in the applicant or the implementer of the proposed offset action, likelihood of abandonment of the project post impact but prior to offset being achieved, or the offset action simply not being implemented (default risk) are not considered in the Model.

7. Using the Accounting Model: key considerations

Deriving or estimating meaningful measures to enter into the Accounting Model requires the involvement of experts, most likely a team of experts, including those experienced in implementing, monitoring and reporting on management actions (e.g. pest control and restoration actions). Evaluating the outputs of the Accounting Model will equally benefit from multi-disciplinary interpretation.

7.1 Data requirements

The robustness of the outputs of the Accounting Model depend on the quality of the inputs, and it would be good practice to invest effort and resources at the front-end of this process to ensure a high level of confidence in the input data.

It would be good practice to compile all input data prior to using the Model. The user may wish to consider using a separate spreadsheet to house this data outside of the Model. The use of additional spreadsheets could be particularly useful if the user is interested in running various offset scenarios through the Accounting Model and/or keep track of an iterative accounting process.

A checklist of the information required to run the Accounting Model

- ❑ A list of all biodiversity types[7]
- ❑ A list of all biodiversity components
- ❑ A list of all biodiversity attributes[8]
- ❑ Discount rate (%) for use in the Offset Model
- ❑ For each biodiversity attribute (across all biodiversity components) to be accounted for:
  - ❑ Measurement unit (x)
  - ❑ The area of impact (ha) for each attribute
  - ❑ Benchmark measure (x) for each attribute
  - ❑ Value of each attribute at the impact site prior to impact (x)
  - ❑ Predicted/estimated value of each attribute at the impact site post impact (x)
  - ❑ Proposed offset actions
  - ❑ Area over which the offset action is be implemented (ha) for each attribute
  - ❑ Confidence level in the offset action for each attribute (%)
  - ❑ Value of each attribute at the offset site prior to the offset action (x)
  - ❑ Predicted/estimated value of each attribute at the offset site post the offset action (x)
  - ❑ Time over which offset management actions will occur (years)

[7] A separate Model (Excel workbook) is used for each biodiversity type (see next section).

[8] The same biodiversity types, components, and attributes are to be used in both the Impact and the Offset Model and all attributes must have a value above zero. That is, attributes that are present at the offset site but not the impact site cannot be included in the model by entering these attributes into the Impact Model with a zero value.

7.2 Documenting choices and sources of information

It would be good practice to support the use of the Accounting Model with documentation to assist in its evaluation by others. Suggested areas where additional documentation would be useful are listed in Table 1.

Table 1: Suggested supporting documentation to enhance transparency of offset development process.

Supporting documentation	Explanation
Choice of biodiversity type, components and attributes	Justification for the choices made including reasons for excluding particular elements of biodiversity (especially if they have been raised by stakeholders). This documentation could include discussion on how chosen attributes provide adequate and appropriate values of the chosen components.
Discount rate	Justification for choice of discount rate.
Source of input data	Providing documentation of the source of input data will increase the transparency of the offset proposal and help to evaluate certainty regarding outcomes. An example of what this might look like in its most simple form is provided in Appendix 3. In addition, the user may wish to include methods for arriving at estimates (e.g. detailed expert elicitation methods such as Delphi Method and explain any model derived parameters and assumptions made) and describe methods used for any additional monitoring undertaken for the purposes of developing the offset proposal.
Offset site	Justification for the choice of offset site(s) including discussion of any alternative options. It would be useful to place this discussion within the landscape context relevant to the impact.
Offset actions	The Accounting Model allows for a brief description of the proposed offset actions. It would be good practice to describe in detail the methods, frequency, and timing proposed to implement the offset actions, as well as clearly defined roles and responsibilities for the implementation, monitoring, and evaluation of the offset. It would also be useful to the evaluation of an offset design if the rationale for choosing offset actions is provided and discussion of how they relate to an improvement in condition of attributes and components in question. This information can be fed into the Biodiversity Offset Management Plan (BOMP) as discussed by the Good Practice Guidance.
Confidence in offset action	Justification for the stated level of confidence in the proposed offset action, including examples of where these offset actions have been successful and/or discussion of known limitations or risks associated with the proposed offset actions. This could be drawn from the assessment of limits of offsetability discussed by the Good Practice Guidance.
Summary of outcome	Presentation of the outputs from the Accounting Model form the offset application. The outcome summary could include discussion on elements of biodiversity impacted by the proposal that were not accounted for in the offset (e.g. due to absence of knowledge or

Supporting documentation	Explanation
	management techniques). This information can be fed into the Biodiversity Offset Management Plan (BOMP) discussed by the Good Practice Guidance.

7.3 Choosing biodiversity types, components and attributes

The Accounting Model relies on three hierarchical levels to categorise biodiversity and allows for disaggregated accounting across these levels:

Level 1: biodiversity types

Level 2: biodiversity components

Level 3: biodiversity attributes

Biodiversity types are the elements of biodiversity of concern that will be subject to residual adverse effects of the proposed development activity. Biodiversity components are used to describe the biodiversity types, and biodiversity attributes are used to measure the quantity or condition of the biodiversity component. It is the biodiversity attributes that are accounted for within the Model to demonstrate no net loss.

Choosing biodiversity types, components, and attributes is largely a subjective process but a critical one as no net loss can be evaluated for only those elements of biodiversity entered into the Accounting Model. All other elements of biodiversity will either be offset by default or lost in the exchange, but in either case the trade will be concealed. It is therefore good practice to invest considerable effort, including inclusive stakeholder consultation, into the choice of biodiversity attributes to account for.

7.3.1 Choosing biodiversity attributes

When choosing biodiversity attributes the following might be useful to consider:

- That only attributes that occur at both the impact and offset sites can be chosen (attributes present at the offset site cannot be entered into the Impact Model and assigned a zero-value)
- Including sufficient attributes to account effectively for the complexity and ecological value of the biodiversity to be traded
- The ability to measure the attribute quantitatively
- The ability to translate the attribute measure to quantifiable management targets
- The effect of landscape context on the target biodiversity
- Biodiversity values or management priorities identified in local resource management plans or at the national level
- Rarity (natural or induced) of the impact ecosystem or species
- Threat classification status of ecosystems and species
- Distinctive species or assemblages of species
- Dominant or keystone species
- Aspects of ecosystem functionality

- Values of stakeholders, locally and nationally

For further discussion on selecting biodiversity attributes to include when designing an offset, see the Good Practice Guidance.

Exchange rules

The Accounting Model does not prescribe any exchange rules, but the user may choose to self-impose restrictions that define plausible exchanges and recognise limits to offsetting and irreplaceability. The Good Practice Guidance provides useful discussion on these issues.

The user may consider it useful to summarise the demonstrated outcomes for each biodiversity attribute through the use of a 'winners and losers' table. Such a table would provide the foundation for stakeholder debates regarding the acceptability of the offset proposal and clearly identify tradeoffs.

Suggestions for presenting outcomes of the Accounting Model are also presented in later sections of this Manual.

7.4 Evaluating outputs

No net loss is demonstrated by a zero or positive NPBV value. The Accounting Model indicates when a no net loss offset is not demonstrated by highlighting a negative NPBV in red font. Beyond this, the Model does not provide any interpretation or evaluation of outputs.

The Accounting Model assumes that as the value of a biodiversity attribute approaches its benchmark value, biodiversity benefit increases linearly. There are likely to be exceptions to this simplified assumption which should be taken into consideration when evaluating outcomes from the Model.

It would be good practice to summarise the outputs from the Model in a format easily digested by stakeholders and decision makers, and to provide interpretation of the offset proposal in the context of the both the attributes accounted for and those that are not, and other critical considerations (e.g. landscape context, regional and national priorities etc.). Such summaries are also useful to compare alternative offset designs.

The worked examples (Part B) demonstrate how this might be presented.

8. Using the Accounting Model: data input

Using the Accounting Model is highly likely to be an iterative process, with the adjustment of offset proposals in response to outputs from the Model. However, certain steps must be completed before other steps and the Model is best described as a linear process.

These steps are described below (Fig. 2) and illustrated using worked examples (see Part B). Explanatory notes are also embedded in the Model and provided in Appendix 2.

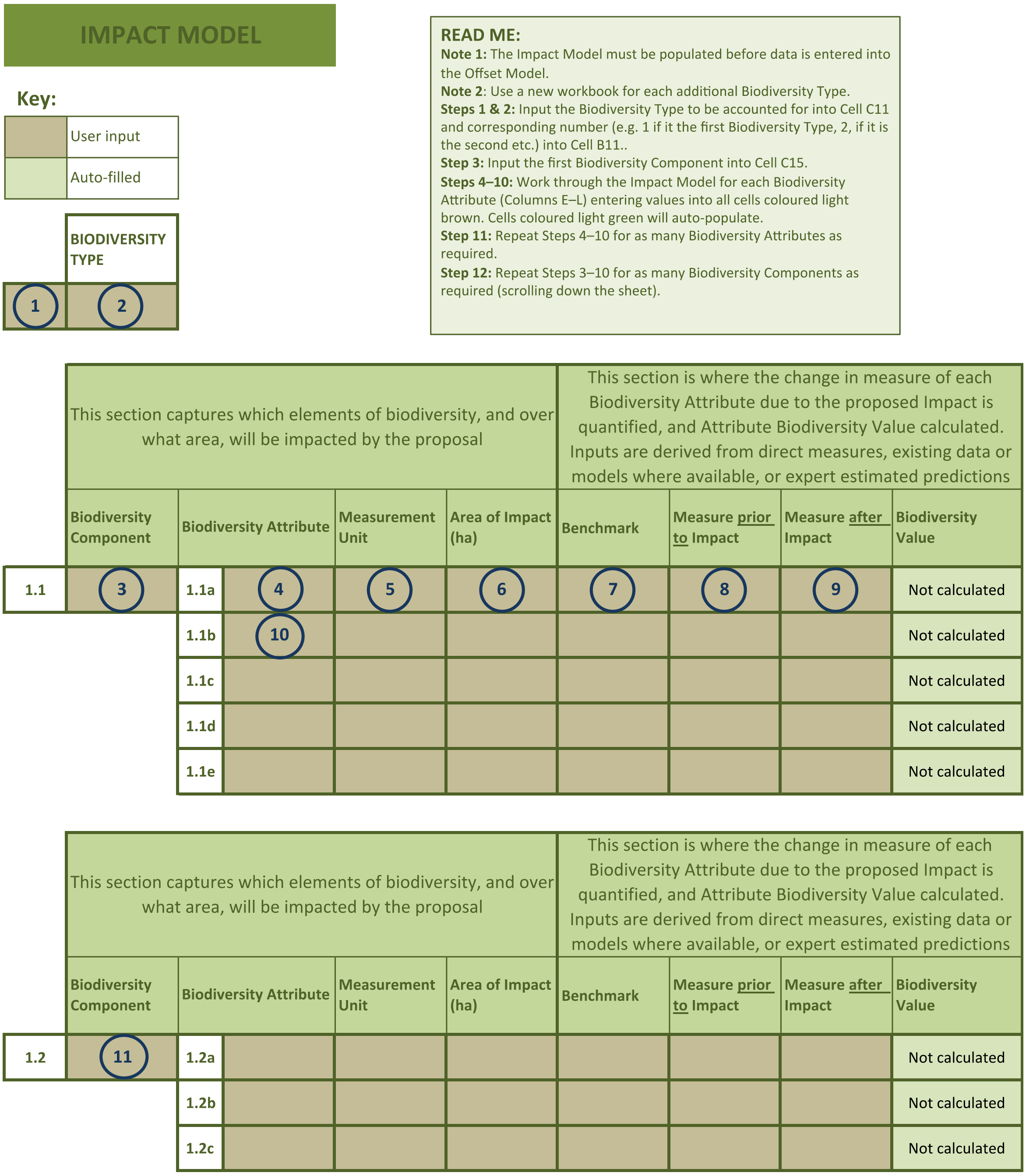

Figure 2: Screen shot of the Impact Model of the Biodiversity Offset Accounting Model. The numbers in circles indicate the entry point in the model for each step of data input.

Open the Biodiversity Offset Accounting Model template and click on the Impact Model (coloured green) tab to open the worksheet.

Steps 1 & 2: From the list of biodiversity types subject to offsetting, enter the first as shown in Fig. 2 and number it accordingly (e.g. 1) using numbers not words. The numbering throughout the rest of the model will auto-update to correspond with the number entered in this first step. That is, where the screen shot (Fig. 2) shows biodiversity component 0.1, and biodiversity attributes 0.1a, 0.1b etc., this will update to 1.1, 1,1a, 1.1b etc. once Step 1 is completed.

Step 3: Each biodiversity type may have several associated biodiversity components. Enter the first of these here.

Step 4: Each biodiversity component may have several associated biodiversity attributes. Enter the first of these here.

Biodiversity types, components, and attributes are defined in section 2 (Terminology) and discussed in section 7.3 (Choosing biodiversity types, components and attributes)

Step 5: Enter the unit used to measure the biodiversity attribute. For example, if the attribute was 'number of adults', the measurement unit would be 'count'. The same units for each attribute must be used for the Impact and Offset Model. Different units between different attributes are permissible.

Step 6: Enter the area (measured in hectares) over which impacts to the attribute will occur. In other words, the extent of habitat or area supporting the biodiversity type within which the attribute is represented. For example, if the attribute is emergent trees, the area of impact is the total area of the vegetation community supporting the emergent trees that will be impacted by the proposal, and not just the summed area occupied by individual emergent trees.

Step 7: Enter the benchmark value for the attribute. Benchmarks are an important component of a condition x area currency and it would be good practice to take care to ensure the value entered here is meaningful in the context of the attribute being measured. The same benchmark is entered into both the Impact and Offset Models.

Step 8: Enter the measure of the attribute at the impact site prior to the impact occurring. This is the *measured* value of the attribute, expressed in the stated unit (Step 5). This value must be above zero. That is, attributes that only occur at the offset site cannot be chosen.

Step 9: Enter the expected value of the attribute at the impact site post-impact. This is the *predicted* value of the attribute, expressed in the stated unit (Step 5). The magnitude of impact may be derived from the Assessment of Environmental Effects (AEE), predictive models, or expert estimates.

It would be good practice to document the source of data used to define attribute measures pre- and post-impact (see section 7.2).

The input requirements are now complete and the biodiversity value for this attribute will auto-calculate.

The user may wish to enter all biodiversity components and attributes for a biodiversity type into the Impact Model before moving to the Offset Model, or complete both the Impact and Offset Model component by component. Either approach can be taken, as long as the biodiversity type (and number) has been entered first, and data is entered into the Impact Model prior to the Offset Model for any given component or attribute.

Step 10: Repeat Steps 4–9 for as many attributes needed to describe the biodiversity component.

Step 11: Repeat Steps 3–9 for as many biodiversity components needed to describe the biodiversity type.

Step 12: Click on the Offset Model tab (coloured blue) to open the worksheet (Fig. 3)

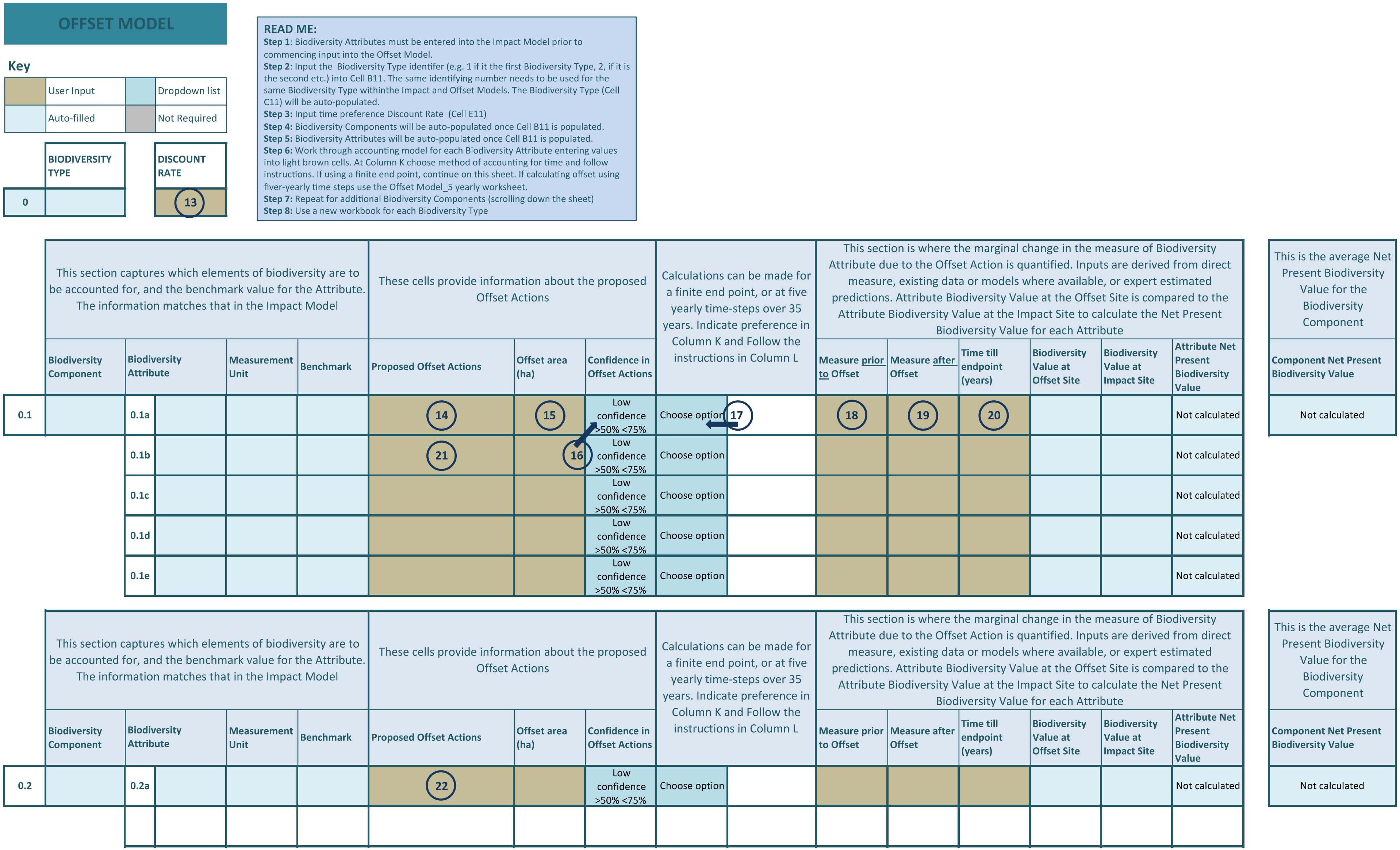

Figure 3: Screen shot of the Offset Model worksheet of the Biodiversity Offset Accounting Model. The numbers in circles indicate the entry point in the model for each step of data input.

The number and description of biodiversity type will auto-populate based on the information entered into the Impact Model.

Step 13: Enter the time preference discount rate to be used (enter 0.03 for 3%). If no discount rate is applied, enter '0'.

The description of the biodiversity component, attributes, measurement unit, and the benchmark will auto-populate based on the information entered into the Impact Model.

Step 14: Enter an abbreviated description of the proposed offset action(s). The same offset action(s) may apply to more than one attribute, but actions for different attributes must be accounted for separately.

It would be good practice to provide a detailed description of the proposed works in a supporting document (see section 7.2).

Step 15: Enter the area (in hectares) over which the offset action will be implemented. The same offset action(s), over the same area may address more than one attribute (e.g. stoat control for both kaka and kiwi management even though the attribute responses are independent of each other). Where this is the case, this information needs to re-entered for every attribute it relates to. This value feeds into the biodiversity value calculation and cannot be left blank.

Step 16: Use the dropdown box to choose a level of confidence that the estimated result of the offset action will occur within the specified time estimate (Step 21).

Low confidence: The proposed Offset Action uses methods that have either been successfully implemented in New Zealand or in the situation and context relevant to the Offset Site but infrequently, or the outcomes of the proposed Offset Action are not well proven or documented, or success rates elsewhere have been shown to be variable. Likelihood of success is > 50% but < 75%.[9] *Calculated biodiversity gain is multiplied by 0.62.*

Confident: The proposed Offset Action uses well known and often implemented methods which have been proven to succeed greater than 75% of the time although enough complicating factors and/or expert opinion exists to not have greater confidence in this Offset Action. Likelihood of success is greater than 75% but less than 90%. *Calculated biodiversity gain is multiplied by 0.825.*

Very confident: The proposed Offset Action uses methods that are well tested and repeatedly proven to be very reliable for the situation and context relevant to the Offset Site; evidence-based expert opinion is that success is very likely. Likelihood of success is > 90%. *Calculated biodiversity gain is multiplied by 0.925.*

More information is provided in the 'Guide for Offset Model' (brown tab within the Model), and in Appendix 2.

[9] It would be good practice to not propose an Offset Action in which confidence of success was less than 50%.

Step 17: Use the dropdown box to choose whether to calculate biodiversity value (BV) at a finite end point, or at five yearly time-steps across a 35 year period. Follow the instructions in the adjacent column. **NB:** when calculating at five yearly time-steps, the calculation returns net present biodiversity value (NPBV) at each time step, whereas the calculation of NPBV occurs after PBV has been calculated when using a finite end point calculation.

If 'five yearly time-step' is chosen, move to the Offset Model_5 yearly spreadsheet, (see 'B. Calculating NPBV at five yearly time-steps across a 35 year time period' below), otherwise continue working within the Offset Model spreadsheet. Within the same biodiversity component, it is possible to have some attributes measured to a finite end point and some attributes calculated at time-steps. The two spreadsheets align, and feed results generated in the Model_5 yearly spreadsheet back into the Offset Model spreadsheet.

A. Calculating PBV to a finite end point:

Step 18: Enter the measure of the attribute at the offset site prior to the offset occurring. This is the *measured* value of the attribute, expressed in the same unit entered within the Impact Model (Step 5).

Step 19: Enter the measure of the attribute at the offset site after the offset has occurred. This is the *predicted* value of the attribute, expressed in the same unit entered within the Impact Model (Step 5). Predictive models or expert input may be required to inform this value.

If the value of the attribute increases as the condition of the attribute decreases, the value for that attribute needs to be entered as a negative number.

It would be good practice to document the source of data used to estimate attribute values pre- and post-offset (see section 7.2).

Step 20: Enter the time from present (in years) that the offset actions are expected to have achieved their targets. This information is used to apply the discount rate and cannot be left blank. If no discount rate is used, enter 0.

The input requirements are now complete and the biodiversity value for this attribute at the offset site will auto-calculate. The biodiversity value at the impact site for this attribute will auto-populate from the Impact Model, and the net present biodiversity value will then auto-calculate. Finally, the average net present biodiversity value for the biodiversity component is auto-calculated. This value is updated as additional attributes are added to the Model.

Step 21: Repeat Steps 13–21 for as many attributes as required to describe the biodiversity component.

Step 22: Repeat Steps 13–22 for as many biodiversity components as required to describe the biodiversity type.

New component tables and attribute rows will stay blank until data are entered into the Impact Model, at which point they will become 'live'.

Step 23: Open a new copy of the template (new Excel workbook) to enter additional biodiversity types. Only one biodiversity type can be entered into each workbook. When entering subsequent biodiversity types, ensure they are numbered correctly (e.g. 2 for the second, 3 for the third etc.). Repeat the above process for each biodiversity type.

Step 24: Manually compile a summary of the Model outputs, evaluation of offsets, and comparison with alternative offset designs.

B. Calculating NPBV at five yearly time-steps across a 35 year time period:

Click on the Offset Model_5 yearly tab (coloured blue) to open the worksheet (Fig. 4).

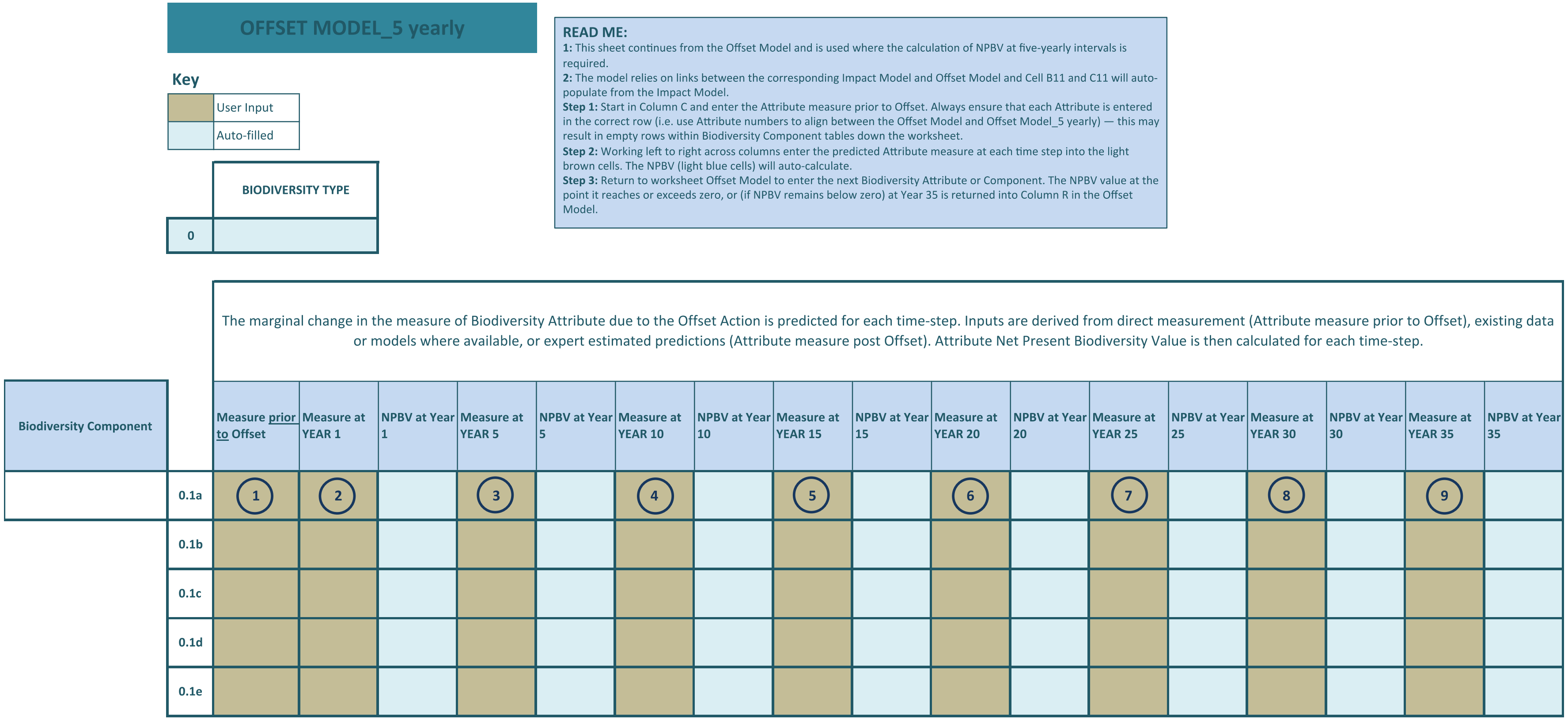

Figure 4: Screen shot of the Offset Model_5 yearly worksheet of the Biodiversity Offset Accounting Model. The numbers in circles indicate the entry point in the model for each step of data input.

The number and description of biodiversity type will auto-populate based on the information entered into the Impact Model.

The time-step spreadsheet is linked to the finite end point spreadsheet (Offset Model). Within the same biodiversity component it is possible for some attributes to be modelled to a finite end point, and some attributes modelled at time-steps. Therefore, it is important to ensure data are entered into the correct row (i.e. the attribute numbers need to correspond between spreadsheets) when entering data for attributes associated with the first component within a workbook (model template). For subsequent components, alignment is aided by rows becoming 'live' when the 'five yearly time-step' option is selected and remaining inactive when it is not.

Step 1: Enter the value of the attribute at the offset site prior to the offset occurring. This is the *measured* value of the attribute, expressed in the same unit entered within the Impact Model (Step 5).

Step 2: Enter the value of the attribute at the offset site at Year 1 after the offset commences. This is the *predicted* value of the attribute, expressed in the same unit entered within the Impact Model (Step 5 above). Predictive models or expert input may be required to inform this value.

Steps 3-9: Repeat Step 2, for each five year time-step (e.g. Year 5, Year 10, Year 15 etc.).

The accrued NPBV will be auto-calculated at each time interval as the estimated measures are entered. These calculations call on information entered into the first half of the Offset Model (Steps 13–16) as well as the estimated biodiversity attribute measure and the calculated NPBV for the previous time-step.

Step 10: Return to the Offset Model spreadsheet and continue from Step 22.

Results generated in the Offset Model_5 yearly spreadsheet will be auto-populated into the Offset Model spreadsheet. The Model scans across the time-step calculations and returns the first value when NPBV is equal to or greater than zero. If none of the accrued NPBV calculations at each time-step reach this threshold (i.e. no net loss is not demonstrated), the NPBV at Year 35 is automatically fed into the Offset Model spreadsheet. This value is the NPBV for that attribute and feeds into the calculation for the average NPBV for the biodiversity component.

Part B: The Accounting Model in practice

The following two scenarios have been developed for the purpose of demonstrating the use of the Accounting Model. They are theoretical case studies designed to be representative of 'real-world' offsetting scenarios. They are not intended to be fully accurate and some creative licence has been applied to the identification of biodiversity types, components, and attributes and to the engineered measures that have been used to populate the Accounting Model. The scenario narratives are highly simplified and provide only enough context to follow the modelled examples. Values and measures prior to and after offset actions are for illustrative purposes only and do not necessarily reflect the outcomes of real offsetting scenarios. When considering the scenario narratives and modelled examples the following should be kept in mind:

- The descriptions of site values and proposed impacts are not intended to serve as an example of an Assessment of Environmental Effects (AEE).
- The description of the 'proposed offset package' is likewise not reflective of the level of detail and specificity that would reflect good practice (for example, it does not outline methodologies, timing of implementation, level of intervention, management targets, or monitoring and evaluation).
- When deriving model input values, the scenario examples have assumed the application of good practice in that:
  - best practice/industry standards for management interventions (offset actions) will be applied,
  - objectives and targets have been agreed to and are clearly documented, and
  - all actions will be monitored and reported at a level commensurate to the intervention to allow for adaptive management to successfully achieve the demonstrated no net loss offset.

Further, in compiling these scenarios it has been assumed that:

- the mitigation hierarchy has been adhered to and only residual adverse effects remain to be addressed,
- offset sites have been secured,
- a full AEE has been conducted at the impact site(s), as well as additional monitoring or measurements needed to obtain data required for input into the Accounting Model,
- a full assessment of the biodiversity values at the offset site(s) has been done, and
- the biodiversity attributes to be accounted for have been agreed.

The following scenarios do not include any discussion or example paperwork of the above.

9. A simple scenario — intensification of agriculture on sand country

9.1. Proposal overview

Highcroft Farm is a 1,600 ha property located on the sand country on the west coast of the lower North Island. Almost half (750 ha) of the property is currently in intensive dairy farming with the remainder in unimproved pasture supporting extensive beef cattle grazing (835 ha) and exotic forestry (15 ha). The property includes wetland habitat (7.25 ha) but no other indigenous vegetation or non-productive areas.

The dairy farm is currently an $8 million operation, milking 2000 cows, and the owners wish to increase production by converting a further portion of the farm to intensive dairy. This will involve the conversion of forestry to pasture, the levelling and realignment of 140 ha of dunes, and the introduction of irrigation, fertiliser, and new grass species to improve pastoral growth. This will be supported by the installation of a 685 m long centre pivot irrigator.

This proposal will result in the permanent loss of two areas of wetland habitat. The current condition of these sites is highly degraded although both sites are still representative of wetland habitat. Wetland habitat has been drastically reduced regionally, is nationally recognised as a priority for protection, and is recognised by the regional plan as being of significance under the Resource Management Act.

9.2. Ecological context

The property comprises exotic pasture grasses, *Pinus radiata* plantation, scattered exotic scrub (lucerne and gorse), wetland habitat (7.25 ha) and 8 km of unfenced waterways that traverse the farm to the sea (weirs are present but do not impede fish passage). There is no woody riparian vegetation along the banks of the waterways and pasture extends to the stream edge.

The 7.25 ha of wetland habitat is spread across five areas:

a. **Wetland A** (Impact site) 0.5 ha dune slack wetland comprising a small dune lake (0.35 ha), wetland turf on the lake margins, and flaxland (0.1 ha). The wetland is heavily modified, grazed, and was recently subjected to unconsented drainage. Exotic plant species are common. New Zealand dabchicks (Nationally Vulnerable) and pukeko are known to regularly feed here, and other waterfowl also use the wetland, although it is not known as a breeding site. The proposal will result in the permanent loss of this wetland.

b. **Wetland B** (Impact site) 2 ha of modified raupo-flax-carex swamp between two arms of a parabolic dune. This wetland has recently been sprayed and a historic drain that circles the wetland was reopened and deepened 24 months ago to drain the wetland in preparation for land conversion. The wetland is currently subject to heavy grazing and has been substantially degraded by these recent events. Over 50% of the wetland vegetation is now dead. The proposal will result in the permanent loss of this wetland.

c. **Wetland C** (Offset site) 1 ha of raupo-flax-carex swamp, that has recently had a drain dug along one boundary. This wetland will not be impacted by the proposal.

d. **Wetland D** (Offset site) 3 ha of willow swamp, subject to grazing and drainage. This wetland will not be impacted by the proposal.

e. **Wetland E** (Avoided) 0.75 ha of high quality, fenced dune slack wetland subject to ongoing pest control. This wetland was initially going to be lost as a result of the proposal, but is now completely avoided due to a re-design of the proposal.

The wetland habitat on Highcroft Farm has a long history of human induced modification. A large reduction in wetland extent occurred when the area was first converted to farmland (>100 years ago). The creation and maintenance of drainage systems surrounding the wetlands has had considerable impact by significantly lowering the water table. In the last 2 years these drains have been substantially deepened and the impacts on wetland health are now very much evident. Wetlands A—D are also subject to summer grazing, especially during exceptionally dry periods such as the last two summers. Possum control within the area is undertaken by the Animal Health Board and the Regional Council. However, other pest animals (rabbit, hare, cat, mustelid, and deer) are present in the area and weed species (gorse, blackberry, and willow) have become established.

Wetland habitat in the Region has been drastically reduced to less than 3% of former extent and any further loss of extent further threatens the long-term persistence of wetland habitat and obligate wetland species in the landscape. The loss of two areas of wetland habitat has ecological consequences disproportionate to their small size and degraded state, and will directly contribute to the permanent loss of wetland habitat from the Region.

Swamp wetland habitat and flaxland are recognised in the regional plan as *Threatened* habitat types and dune slack wetlands as a *Rare* habitat type*.* All five areas of wetland on the Highcroft Farm meet the regional plan definitions and thresholds for wetland habitat.

9.3 The proposed offset package

The proposal includes an offset package to demonstrate no net loss of wetland habitat.

- **Wetlands A & B** will be developed as pasture (Impact sites)
- **Wetland C & D** are proposed for restoration (Offset sites)
- **Wetland E** will be avoided by the proposal (Impact avoided)

The offset package includes the following actions and outcomes:

1. The rehabilitation of Wetland C (1 ha) and Wetland D (3 ha) in accordance with a restoration management plan which includes the following:
   a. permanent stock exclusion
   b. infilling of drains
   c. re-establishment of hydrological regimes and connectivity between the two wetlands
   d. contouring of dunes
   e. ongoing pest control (hare, rabbit, cat, mustelid, and deer)
   f. weed control (gorse, blackberry, and willow)
2. Planting to create an additional 1 ha of raupo-flax-carex wetland habitat to extend Wetland C.

3. Creation of 1 ha of open water associated with Wetland D (an estimated 0.1 ha of wetland turf habitat is expected to self-establish over time on the margins of the open water and flaxland).
4. Planting within Wetland D in conjunction with willow control to initiate the creation of 2 ha of raupo-flax-carex wetland and 1 ha of flaxland.
5. Stock exclusion (8 km of fencing) from Koitiata Stream and its unnamed tributaries.
6. The establishment of 15 m wide flax plantings along a 2 km stretch of the Koitiata Stream (both banks).
7. Placement of a legal covenant over Wetlands C, D, and E.

9.4 Identification of biodiversity elements

Biodiversity types, components, and attributes of concern, and which could potentially be addressed by offset actions were identified (Table 2).

Within this scenario, stakeholder concern was focussed on habitat types and the key species of these habitat types.

Table 2: Biodiversity type, components, and attributes impacted by the proposed intensification and the proposed offset goals to account for residual impacts on these elements of biodiversity.

Biodiversity type	Biodiversity component	Biodiversity attribute	Measure (Unit)	Proposed offset goal
1. Dune slack wetland	1.1 Open water	1.1a Depth	Depth (cm)	Creation of habitat
	1.2 Wetland turf	1.2a Cover	Percentage cover (%)	
	1.3 Flaxland	1.3a Cover	Percentage cover (%)	
2. Raupo-flax-carex wetland	2.1 Diversity	2.1a Species composition of native wetland plant species	Diversity Index (#)	Creation of habitat and restoration of condition of wetland habitat
	2.2 Raupo-flax-carex	2.2a Cover	Percentage cover (%)	
	2.3 Twiggy tree daisy	2.5a Number of individuals	Count (#)	
	2.4 Cabbage tree	2.6a Number of individuals	Count (#)	
3. Wetland avifauna	3.1 Species diversity	3.1a Number of native resident species	Count (#)	Restoration of existing habitat and creation of new habitat

9.5 Using the Accounting Model: data input

It would be good practice to compile all input data before using the Accounting Model, and documenting the source of this information (see section 7.2). An example of this documentation is provided in Appendix 3.

Data was entered into the Impact Model (see section 8) starting with the first biodiversity type and first biodiversity component (Fig. 5) and moving onto the second biodiversity component and associated biodiversity attributes (Fig. 6).

IMPACT MODEL

Key:

	User input
	Auto-filled

	BIODIVERSITY TYPE
1	Dune slack wetland

READ ME:
Note 1: The Impact Model must be populated before data is entered into the Offset Model.
Note 2: Use a new workbook for each additional Biodiversity Type.
Steps 1 & 2: Input the Biodiversity Type to be accounted for into Cell C11 and corresponding number (e.g. 1 if it the first Biodiversity Type, 2, if it is the second etc.) into Cell B11..
Step 3: Input the first Biodiversity Component into Cell C15.
Steps 4–10: Work through the Impact Model for each Biodiversity Attribute (Columns E–L) entering values into all cells coloured light brown. Cells coloured light green will auto-populate.
Step 11: Repeat Steps 4–10 for as many Biodiversity Attributes as required.
Step 12: Repeat Steps 3–10 for as many Biodiversity Components as required (scrolling down the sheet).

	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	Open water	1.1a	Depth of water	Depth (cm)	0.35	30	30	0	-0.35
		1.1b							Not calculated
		1.1c							Not calculated
		1.1d							Not calculated
		1.1e							Not calculated

Figure 5: Screen shot from the Impact Model spreadsheet showing input data for the first biodiversity type (dune slack wetland), and first biodiversity component (open water) associated with this biodiversity type, and the biodiversity attribute used to measure this component (of water).

	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**
1.2	Wetland turf	**1.2a**	Cover	Percentage (%)	0.05	90	70	0	-0.04
		1.2b							Not calculated
		1.2c							Not calculated
		1.2d							Not calculated
		1.2e							Not calculated

	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**
1.3	Flaxland	**1.3a**	Cover	Percentage (%)	0.1	90	60	0	-0.07
		1.3b							Not calculated
		1.3c							Not calculated
		1.3d							Not calculated
		1.3e							Not calculated

Figure 6: Screen shot from the Impact Model spreadsheet showing input data for the second (wetland turf) and third (flaxland) biodiversity components associated with this biodiversity type.

For this scenario, biodiversity value was calculated using only the 'finite end point' time horizon, and therefore only the Offset Model spreadsheet was required (Fig.7).

OFFSET MODEL

Key

(light brown)	User Input	(blue)	Dropdown list
(light blue)	Auto-filled	(grey)	Not Required

	BIODIVERSITY TYPE	DISCOUNT RATE
1	Dune slack wetland	0.03

READ ME:
Step 1: Biodiversity Attributes must be entered into the Impact Model prior to commencing input into the Offset Model.
Step 2: Input the Biodiversity Type identifer (e.g. 1 if it the first Biodiversity Type, 2, if it is the second etc.) into Cell B11. The same identifying number needs to be used for the same Biodiversity Type withinthe Impact and Offset Models. The Biodiversity Type (Cell C11) will be auto-populated.
Step 3: Input time preference Discount Rate (Cell E11)
Step 4: Biodiversity Components will be auto-populated once Cell B11 is populated.
Step 5: Biodiversity Attributes will be auto-populated once Cell B11 is populated.
Step 6: Work through accounting model for each Biodiversity Attribute entering values into light brown cells. At Column K choose method of accounting for time and follow instructions. If using a finite end point, continue on this sheet. If calculating offset using fiver-yearly time steps use the Offset Model_5 yearly worksheet.
Step 7: Repeat for additional Biodiversity Components (scrolling down the sheet)
Step 8: Use a new workbook for each Biodiversity Type

	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	Open water	1.1a	Depth of water	Depth (cm)	30	Creation of open water	1	Confident 75-90%	Finite end point	Continue to Column M	0	30	1	0.80	-0.35	0.45	0.45
		1.1b						Low confidence >50% <75%	Choose option							Not calculated	
		1.1c						Low confidence >50% <75%	Choose option							Not calculated	
		1.1d						Low confidence >50% <75%	Choose option							Not calculated	
		1.1e						Low confidence >50% <75%	Choose option							Not calculated	

Figure 7: The first entry in the Offset Model spreadsheet for Scenario One. The entry of biodiversity types, components, and attributes needs to be in the same order as used in the Impact Model spreadsheet. This is facilitated by auto-population of the relevant cells within the Offset Model spreadsheet from data entered into the Impact Model spreadsheet (see explanatory notes within the Model and in Appendix 2 for more detail). For this scenario a time preference discount rate of 3% (entered as 0.03) has been used.

9.6 Summary and evaluation of Model outputs

Summary results are manually compiled into a separate document for all biodiversity types impacted by the proposal. An example summary table of calculated offset benefits from Scenario One is presented in Table 3.

In this scenario, a no net loss of all attributes could be demonstrated, except for the species diversity of native wetland plant species. The area of offset (creation of new habitat and restoration of existing habitat) would need to increase from 4 to 22 ha, or produce a greater increase in species composition across the original offset site, in order for a no net loss trade to be demonstrated (over a period of ten years, with a discount rate of 3%).

Table 3: Summary of outputs from the Accounting Model for Scenario One.

Biodiversity type	Biodiversity component	Biodiversity attribute	Area of offset (ha)	Confidence in offset action	Demonstrated at Year	NPBV	Winners and losers
1. Dune slack wetland	1.1 Open water	1.1a Depth	1	Confident	1	0.45	✓
	1.2 Wetland turf	1.2a Cover	0.1	Low	10	0.00	✓
	1.3 Flaxland	1.3a Cover	1	Very confident	5	0.76	✓
2. Raupo-flax-carex wetland	2.1 Diversity	2.1a Species diversity	4	Low confidence	7	-1.16	✗
	2.2 Raupo-flax-carex wetland	2.2a Cover	4	Very confident	3	2.08	✓
	2.3 Twiggy tree daisy	2.5a Number of mature individuals	4	Confident	10	0.46	✓
	2.4 Cabbage tree	2.6a Number of individuals	4	Very confident	10	0.51	✓
3. Wetland avifauna	3.1 Species diversity	3.1a Number of resident native species	6	Low confidence	10	0.37	✓

10. A complex scenario — water storage dam to allow for irrigation of intensive agriculture

10.1 Proposal overview

The Waipaki Catchment is on the east coast of the North Island and is subject to prolonged dry periods, the frequency of which is forecast to increase over the next 25 years.

The Waipaki Water Storage Scheme is proposed to create a 4 km long, 100 million m^3 storage reservoir through the construction of a 90 m high dam on the Waipaki River 50 km upstream from the river mouth to store water during winter and wet periods. Stored water will be released into the Waipaki River to supplement flow during summer and dry periods. The released flow will be available for abstraction downstream. The dam will have sufficient capacity to reliably support the irrigation of 35,000 ha of farmland within the Waipaki Catchment, much of which is earmarked for conversion to intensive diary production.

The proposal will flood 500 ha of land upstream of the dam, including a mixture of farmland (sheep and beef), indigenous forest (Podocarp/tawa forest and black beech forest), braided river habitat, regenerating manuka-kanuka scrub, and exotic plantation forestry (comprising mostly *Pinus radiata*).

The proposal will create a public recreational area suitable for secondary contact water sports such as the use of jet boats and water skiing. The dam will provide for fish passage via a fish ladder over the dam, and the reservoir will be kept stocked with rainbow trout for the purposes of recreational fishing.

The proposal will result in the permanent loss of:

Indigenous habitat	**Exotic habitat supporting native species**	**Production land**
150 ha podocarp/tawa forest 100 ha manuka-kanuka scrub 40 ha podocarp-broadleaved forest 10 ha black beech forest 5 ha wetland habitat 95 ha of braided river	75 ha *Pinus radiata* forest	25 ha sheep/beef
Total: 400 ha	**75 ha**	**25 ha**

Further, the proposal is predicted to:

- Permanently degrade 50 km of aquatic habitat due to the loss of natural variation in flow below the dam wall downstream to the river mouth.
- Temporarily (at least for a period of two years) degrade a 8 km stretch of aquatic habitat due to the discharge of 1000 tonnes of sediment to the Waipaki River during construction of the dam.
- Impact (permanent loss or degradation) the habitat of 21 threatened native species (11 bird, eight freshwater fish, one plant, and one bat species) and numerous common flora and fauna species.

- Equate to a significant loss of natural capital, and cause interruption of and reduction in currently occurring ecosystem processes. The proposal will substantially enhance the availability of water and will enable more intensive production of food for human consumption. The increase in these provisioning ecosystem services come at the cost of all other regulatory and cultural ecosystem services currently provided by natural capital stocks within Waipaki Catchment.

10.2 Ecological context

The Waipaki Catchment upstream of the proposed dam is largely comprised of steeply incised hill country leading down to a wide bottomed valley supporting alluvial terraces and a highly braided river system. Historically (approximately 150 years ago) the entire catchment was burnt to clear the land for farming. However, the steepest slopes were never brought into production and indigenous forest has regenerated. Grazing of the steep, low fertility land at the top of the catchment has been attempted over the years but this practice has ceased in recent times due to the marginal production value of these areas and frequent erosion events. Exotic plantation has been planted in places to stabilise soils and provide an alternative income. Areas unsuited to exotic plantation have been retired and indigenous vegetation has been allowed to regenerate.

Currently, cattle are grazed primarily on the river terraces and have unimpeded access to the Waipaki River and are frequently mob-stocked in the riverbed during winter. Sheep grazing is mostly restricted to the hill country.

Downstream of the proposed dam site, land use intensifies from extensive sheep and beef, through areas of horticulture/viticulture, to lifestyle blocks and townships nearer the coast. The Waipaki River supports an important trout fishery throughout its length despite issues with over-allocation of water and degraded water quality.

Near its mouth, the river enters a tidal estuary before discharging into the sea across a gravel bar. The estuary is an important recreational area (fishing, whitebaiting, duck shooting), and is culturally significant to local iwi.

Six habitats of concern and a number of threatened species will be impacted by this proposal as outlined below. In addition to their specific ecological value, all of these habitats contribute to the natural capital of the impact area and play an important role in sustaining ecosystem processes and thus the provision and flow of ecosystem services.

1. Forest and scrub habitats

The 300 ha of indigenous vegetation that will be permanently covered by the proposed reservoir comprises:

a. **150 ha podocarp/tawa forest.** Tawa dominated lowland hill country forest with scattered emergent podocarp species (mostly totara but also matai, kahikatea, miro, and rimu). Mahoe, titoki, and kohekohe are common in the canopy with hinau, tree fuchsia, rewarewa, and pukatea also present. Black beech are occasionally found on ridges. The subcanopy comprises typical indigenous broadleaved species, but shrub layer and ground cover vegetation are sparse. A number of threatened fauna species are present and are likely breeding within this habitat including: North Island kaka, New Zealand falcon, North Island brown kiwi, rifleman, and long-tailed bat.

b. **100 ha manuka-kanuka scrub.** Regenerating manuka-kanuka dominated scrub. Small-leaved divaricating shrubs and tauhinu are common, and there is frequent occurrence of regenerating broadleaved species (e.g. mahoe, lacebark, kowhai, and rewarewa). The threatened North Island fernbird is found within this habitat.

c. **40 ha podocarp-broadleaved forest.** Mixed species forest on lowland alluvial terraces comprising mostly tawa and titoki with mahoe, kohekohe, pukatea, kowhai, and rewarewa also common. Totara and matai are present with the occasional kahikatea and miro. The subcanopy comprises typical indigenous broadleaved species, but shrub layer and ground cover vegetation are sparse. A population comprising 27 individuals of the threatened tree heart-leaved kohuhu is found within this habitat type.

d. **10 ha lowland black beech forest.** Black beech dominated forest found on spurs and ridges. Other species are uncommon although a few totara and hinau trees are present within the canopy. This forest is very open and the understorey is sparse, comprising mostly small-leaved *Coprosma* species, prickly mingimingi, rangiora and the occasional whauwhaupaku. This habitat supports the threatened rifleman and a pair of breeding New Zealand falcon.

All the areas of indigenous vegetation above are currently unfenced. The manuka-kanuka scrub is subject to regular grazing by livestock. Livestock also has access to other forest types and grazing is evident on the edges. Possums are present in high numbers throughout, and goats are common within the podocarp/broadleaved forest and also present in the other forest/scrub types. Deer are also occasionally found within all forest/scrub types. It is assumed that introduced mammalian predators including rats, cats and mustelids are common throughout and are negatively impacting breeding success and survival of most fauna.

Lowland indigenous vegetation has been drastically reduced regionally (only 23% of former cover remaining in the lowland areas of the region) and is nationally recognised as threatened habitat, lacking adequate protection, and highly vulnerable to further loss. Scrub habitat, while not threatened in itself is ecologically important for providing the environmental conditions for future (currently depleted) lowland forests to become established, as the dominant vegetation type on lowland environments within the region, and as habitat for threatened species.

2. Wetland habitat

Three areas (a total of 5 ha) of unnamed wetland habitat (Wetland A = 2.5 ha, Wetland B = 0.5 ha, and Wetland C = 2 ha) will be flooded by the proposal. All three wetlands comprise open water with margins of flaxland. Grey willow is present in low numbers at all three sites. Wetland B also supports a small area of raupo. *Carex* species and slender spike sedge are also occasionally found within the flaxland at all three wetland sites. Several emergent cabbage trees are present at Wetland A. The native floating aquatic *Azolla* fern is common at Wetland A and also present at both Wetland B and Wetland C. Blackberry, gorse, and rank pasture grasses are also present on the margins of all three wetlands. Stock can access all three wetlands and regularly do so during dry periods.

These three wetlands, although small, provide important open water habitat and shelter for wetland species. Although no species are known to breed at any of the three sites, wetland species are commonly seen using the wetlands (including pukeko, mallard duck, Australasian coot, and the threatened pied stilt).

Wetland habitat has been reduced to less than 3% of former cover within the region and is nationally recognised as a threatened habitat type and a priority for protection.

3. Braided river habitat

In total 95 ha of braided gravel riverbed along a 4 km reach will be flooded by the proposed scheme. This reach of the Waipaki River is highly braided and typically features numerous isolated gravel islands even during low flows.

Braided riverbeds provide habitat for a number of indigenous stress-tolerant, and ephemeral flora species including shrubs (e.g. tutu, koromiko, and wineberry), creepers (e.g. pohuehue) and perennial mat forming herbaceous species. This habitat is highly vulnerable to disturbance and invasion and a number of invasive plant species including broom, blackberry, gorse, lupin, buddleia, and Californian poppy are abundant throughout, with grey willow dominating the riparian margin habitat. Common indigenous shrubs and ground ferns are present beneath the willow canopy. Rank pasture grass is also common within the riparian margin and extending onto the gravel beds.

The wide gravel beaches, associated riparian habitat, and gravel islands also provide habitat to over forty avifauna species including the threatened banded dotterel, black-billed gull, New Zealand pipit, Caspian tern, pied stilt, and the red-billed gull. The gravel islands are of particular note as they provide important refugia from predators for threatened species.
Eleven native fish species are recorded as present within this habitat including black flounder, banded kokopu, Cran's bully and threatened species koaro, redfin bully, dwarf galaxiid, shortjaw kokopu, bluebill bully, lamprey, longfin eel, and torrentfish. The introduced rainbow trout is also present.

In addition to the direct impact on the braided river habitat, the downstream effects on in-stream flows are expected to impact on the full 50 km of the channel down to the river mouth.

Nationally, the Waipaki River can be considered significant due to the rarity of braided rivers in the North Island. It is also important to note that the relative importance of the Waipaki River continues to increase nationally as braided river habitats continue to degrade in the South Island.

4. Notable species

The proposed permanent loss of forest, scrub, wetland, and braided river habitats will result in the loss of habitat availability for a number of threatened species. The mixed aged *Pinus radiata* plantation (creating a mosaic of habitat ranging from recently cleared compartments to 24 year old trees) also provides important habitat for threatened species that utilise clearings (e.g. New Zealand falcon and New Zealand pipit), tree fall gaps (e.g. New Zealand falcon), and edge habitat between different aged compartments adjacent to each other (e.g. long-tailed bat).

The change in natural in-stream flows will also reduce and compromise remaining aquatic and riverbed habitat for the stretch of the Waipaki River from the dam downstream to the river mouth.

10.3 The proposed offset package

For this scenario, offset actions were tested using the Accounting Model to gauge their potential to deliver a no net loss offset. In this way, the Accounting Model can be used to show where a proposal fails to demonstrate a no net loss exchange, and where additional modelling may be required to better define the size and nature of the offset action required, and to more accurately estimate the biodiversity gain achieved under those offset actions.

The Accounting Model can then be re-run using the adjusted offset actions and estimated biodiversity gains. From this process, a quantified proposed offset package can be developed. It would be good practice to draw measureable management targets, linked to specific management (offset actions) and specified by the amount of biodiversity gain required to demonstrate no net loss, from the Model outputs.

The outputs of initial testing of the potential offset actions are presented here. This scenario description does not extend beyond the initial modelling of potential offset actions nor does it present a detailed offset plan or offset management plan.

10.3.1 Potential offset actions

An offset package is required to address the key areas of biodiversity impact that are anticipated due to the proposed development, specifically:

- Loss of 220 ha of indigenous forest and scrub cover[10]
- Loss of wetland habitat (5 ha).
- Loss of 27 mature individuals of the threatened tree species heart-leaved kohuhu.
- Loss of terrestrial indigenous vegetation habitat for eight threatened bird species and one threatened species of bat.
- Loss of braided river habitat (95 ha along a 4 km reach of the Waipaki River) for six threatened bird species and eight threatened fish species.
- Permanently compromised and reduced habitat (50 km reach) of instream aquatic habitat and braided river habitat.
- Temporary loss of instream aquatic habitat and increased sediment loading during construction.

[10] In this scenario, the loss of 40 ha of lowland Podocarp/broadleaf forest on alluvial terraces was not included in the modelling as offset sites could not be secured, and potential offset actions did not meet the additionality test (see the Good Practice Guidance for guidance on additionality), as remaining habitat of this type is restricted to private land and is subject to a existing publically funded enhancement programme.

The following actions have been modelled to test whether a no net loss can be demonstrated:

1. **Offset Site 1:** Undertake possum and goat control[11] across 600 ha of podocarp/tawa forest and 75 ha of black beech forest on Public Conservation Land[12] adjacent to, but unaffected by, the proposal (known as Block 2YW) on a sustained basis for a period of 35 years.

2. **Offset Site 1:** Locate nests of the North Island kaka, New Zealand falcon, and roosts of long-tailed bat within Offset Site 1 and undertake intensive annual predator control (mustelid, rodents, feral cat) around nests and roost sites for the duration of the breeding season of these species for a period of 35 years.

3. **Offset Site 1:** Undertake:
    a. seed collection of heart-leaved kohuhu from the impact site 18 months prior to impact,
    b. propagation of heart-leaved kohuhu, and
    c. planting of 100[13] established saplings of heart-leaved kohuhu in suitable micro-sites within Offset Site 1.

4. **Offset Site 1:** Locate and transfer all North Island brown kiwi individuals from the impact site (estimated at 6 breeding pairs and 15 individuals), prior to the impact occurring and then translocate these individuals to Offset Site 1.

5. **Offset Site 1:** Undertake:
    a. the removal of all kiwi eggs from the impact site prior to Impact occurring,
    b. the captive breeding of 60[14] kiwi (including those removed as eggs from the impact site), and
    c. sixty kiwi (including those removed from the impact site) to be progressively released into Offset Site 1 over the next ten years.

6. **Offset Site 2**: Purchase 250 ha of contiguous manuka-kanuka scrub in the upper reaches of the Waipaki catchment (currently in private ownership) and;
    a. permanently exclude stock,
    b. undertake sustained annual possum and goat control (over a period of 35 years), and
    c. legally protect the site.

[11] All pest control to be undertaken accordingly to DOC best practice and to achieve and maintain agreed targets (e.g. RTC).
[12] During consultation with DOC it was identified that no pest management was occurring or was planned to occur, thus this action is additional.
[13] This is an example where the final quantification of the offset actions to be included within the proposed offset package can be informed by information and data external to the Accounting Model (e.g. population modelling) as well as outputs from the Accounting Model.
[14] In a real example, this figure would be informed by (for example) modelling and expert opinion outside of the Accounting Model.

7. **Offset Site 3**: Protect the 50 km reach of the Waipaki River below the dam to the river mouth, a further 50 km of tributary stream, and a 50 km reach of the neighbouring Waipakatu River by:
    a. permanently excluding stock within 5 years,
    b. undertaking staged willow control within 15 years following the impact,
    c. establishing riparian margin habitat[15] (20 m wide on both banks) within 15 years following the impact, and
    d. undertaking sustained predator control (hedgehog, mustelid, feral cat, possum) for a period of 35 years, targeted to improve breeding success of braided river bird species.

8. **Offset Site 3**: Undertake sustained predator control (hedgehog, mustelid, feral cat, possum) for a period of 35 years within the riverbed and riparian margins of the Waipaki River between the dam and river mouth targeted to improve breeding success of braided river bird species.

9. **Offset Site 3**: Undertake the identification, prioritisation, and removal/mitigation of artificial fish barriers across 75% of the Waipaki catchment to be completed by Year 10 following the impact.

10. **Offset Site 4:** The creation of 20 ha of indigenous wetland habitat on the margins of the reservoir.

10.4 Identification of biodiversity elements

Biodiversity types, components, and attributes of concern, and which could be addressed by offset actions (i.e. are responsive to management) were identified (Table 4).

[15] Riparian plantings to comprise appropriate native species and be undertaken in accordance with a detailed staged restoration plan prepared by an appropriately qualified restoration ecologist and agreed to by all parties.

Table 4 Biodiversity type, components, and attributes impacted by the water storage project and the proposed offset goals to account for residual impacts on these elements of biodiversity.

Biodiversity type	**Biodiversity component**	**Biodiversity attribute**	**Measure (Unit)**	**Proposed offset goal**
1. Podocarp/tawa forest	1.1 Diversity	1.1a Species diversity of native vascular plant species	Diversity index (#)	Restoration of habitat condition
	1.2 Emergent trees	1.2a Number of emergent individuals	Count (#)	
		1.2b Basal area of emergent trees	Basal area (m^2/ha)	
		1.2c Cover of crown foliage	Percentage cover (%)	
	1.3 Canopy	1.3a Cover of native vascular plant species in the canopy	Percentage cover (%)	
		1.3b Height of canopy	Height (m)	
	1.4 Sub-canopy	1.4a Cover of native vascular plant species in the sub-canopy	Percentage cover (%)	
		1.4b Height of sub-canopy	Height (m)	
	1.5 Understorey	1.5a Cover of native vascular plant species in the understorey	Percentage cover (%)	
	1.6 Ground layer	1.6a Number of native plant species in the ground layer	Count (#)	
		1.6b Cover of native vascular plant species in the ground layer	Percentage cover (%)	
2. Manuka-kanuka scrub	2.1 Diversity	2.1a Species diversity of native vascular plant species	Diversity index (#)	Restoration of habitat condition
	2.2 Canopy	2.2a Cover of native vascular plant species in the canopy	Percentage cover (%)	
		2.2b Height of canopy	Height (m)	
	2.3 Understorey	2.3a Cover of native vascular plant species in the understorey	Percentage cover (%)	

Biodiversity type	Biodiversity component	Biodiversity attribute	Measure (Unit)	Proposed offset goal
		2.3b Height of understorey	Height (m)	
	2.4 Ground layer	2.4a Cover of native vascular plant species	Percentage cover (%)	
3. Black beech forest	3.1 Diversity	3.1a Species diversity of native vascular plants	Diversity index (#)	Restoration of habitat condition
	3.2 Canopy	3.2a Cover of native vascular plant species in the canopy	Percentage cover (%)	
		3.2b Height of canopy	Height (m)	
	3.3 Understorey	3.3a Cover of native vascular plant species in the understorey	Percentage cover (%)	
		3.3b Height of understorey	Height (m)	
	3.4 Ground layer	3.4a Cover of native vascular plant species in the ground layer	Percentage cover (%)	
4. Wetland habitat	4.1 Open water	4.1a Depth of water	Depth (cm)	Creation of wetland habitat
	4.2 Flaxland	4.2a Cover	Percentage cover (%)	
		4.2b Species diversity of native wetland plant species	Diversity index	
5. Braided river avifauna	5.1 Banded dotterel	5.1a Number of breeding pairs	Count (#)	Active management of riparian margin and gravel beds
	5.2 Black-billed gull	5.2a Number of breeding pairs	Count (#)	
	5.3 New Zealand pipit	5.3a Number of breeding pairs	Count (#)	
	5.4 Pied stilt	5.4a Number of breeding pairs	Count (#)	
	5.5 Red-billed gull	5.5a Number of breeding pairs	Count (#)	
6. Aquatic habitat	6.1 Aquatic habitat	6.1a Macroinvertebrate	Community Index (MCI)	Enhancement of habitat
		6.1b Native fish species diversity	Diversity index (#)	
7. Forest avifauna	7.1 Forest avifauna	7.1a Number of resident native species	Count (#)	Restoration of habitat condition

Biodiversity type	Biodiversity component	Biodiversity attribute	Measure (Unit)	Proposed offset goal
8. North Island Kaka	8.1 Population size	8.1a Number of breeding pairs	Count (#)	Restoration of habitat condition and intensive predator control around nest sites
9. North Island brown kiwi	9.1 Population size	9.1a Number of breeding pairs	Count (#)	Translocations into Offset Site 1
10. Heart-leaved kohuhu	10.1 Population size	10.1a Number of adults	Count (#)	Propagation and introduction into Offset Site 1
		10.1b Number of saplings	Count (#)	
11. Long-tailed bat	11.1 Population size	11.1a Number of individuals	Count (#)	Restoration of habitat condition and intensive predator control around nest sites
	11.2 Potential habitat	11.2a Number of potential roost sites	Count (#)	
12. New Zealand falcon	12.1 Population size	12.1a Number of breeding pairs	Count (#)	Restoration of habitat condition and intensive predator control around nest sites

10.5 Using the Accounting Model: data input

Data is entered into the Impact Model as detailed in section 8, and illustrated in Scenario One. Within this scenario, net present biodiversity value for some attributes is calculated at five yearly time-steps.

Calculating NPBV at five yearly time-steps:

In this scenario a number of biodiversity components comprised attributes that were calculated at five yearly time-steps. This required the use of both the Offset Model and Offset Model_5 yearly spreadsheets. Fig 8 shows data input to the Offset Model spreadsheet which is required for all attributes, and Fig 9 shows data input to the Offset Model_5 yearly spreadsheet which is then required for all attributes where calculation across five yearly time-steps is selected.

	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**
1.5	Understorey	**1.5a**	Native cover	Percentage cover (%)	85	Possum and goat control	600	Very confident >90%	Five yearly time-step	Switch to Offset Model_5 yearly					-26.47	2.60	2.60

	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**
1.6	Ground layer	**1.6a**	No. of native species	Count (#)	15	Possum and goat control	600	Very confident >90%	Finite end point	Continue to Column M	5	10	50	43.57	-50.00	-6.43	8.26
		1.6b	Density	Percentage cover (%)	75	Possum and goat control	600	Very confident >90%	Five yearly time-step	Switch to Offset Model_5 yearly					-10.00	22.95	

Figure 8: Screen shot from the Offset Model spreadsheet (Biodiversity Type 'Podocarp/tawa forest') showing selection of 'five yearly time-step', instruction to shift to Offset Model_5 yearly, and greying out of cells in the offset Model that do not require data entry under this selection. Both Offset Model spreadsheets have been used to account for attributes within biodiversity component 1.6 (bottom table): attribute 1.6a is calculated at a finite end point, and 1.6b is calculated at five yearly time-steps.

The marginal change in the measure of Biodiversity Attribute due to the Offset Action is predicted for each time-step. Inputs are derived from direct measurement (Attribute measure prior to Offset), existing data or models where available, or expert estimated predictions (Attribute measure post Offset). Attribute Net Present Biodiversity Value is then calculated for each time-step.

Biodiversity Component		Measure prior to Offset	Measure at YEAR 1	NPBV at Year 1	Measure at YEAR 5	NPBV at Year 5	Measure at YEAR 10	NPBV at Year 10	Measure at YEAR 15	NPBV at Year 15	Measure at YEAR 20	NPBV at Year 20	Measure at YEAR 25	NPBV at Year 25	Measure at YEAR 30	NPBV at Year 30	Measure at YEAR 35	NPBV at Year 35
Understorey	1.5a	15.00	15.00	-26.47	20.00	2.60	25.00	27.68	30.00	49.32	40.00	86.64	50.00	118.84	55.00	132.73	60.00	144.70

The marginal change in the measure of Biodiversity Attribute due to the Offset Action is predicted for each time-step. Inputs are derived from direct measurement (Attribute measure prior to Offset), existing data or models where available, or expert estimated predictions (Attribute measure post Offset). Attribute Net Present Biodiversity Value is then calculated for each time-step.

Biodiversity Component		Measure prior to Offset	Measure at YEAR 1	NPBV at Year 1	Measure at YEAR 5	NPBV at Year 5	Measure at YEAR 10	NPBV at Year 10	Measure at YEAR 15	NPBV at Year 15	Measure at YEAR 20	NPBV at Year 20	Measure at YEAR 25	NPBV at Year 25	Measure at YEAR 30	NPBV at Year 30	Measure at YEAR 35	NPBV at Year 35
Ground layer																		
	1.6b	15.00	15.00	-10.00	20.00	22.95	25.00	51.38	35.00	100.41	45.00	142.72	50.00	160.96	55.00	176.70	60.00	190.27

Figure 9: Screen shot from the Offset Model_5 yearly spreadsheet (Biodiversity Type 'Podocarp/tawa forest') showing calculation of NPBV at five yearly time-steps. Data (value of attribute at the offset site following the offset at Year 1, 5, 10 etc.) is entered into brown cells, and the corresponding NPBV is returned in the blue cells. The Accounting Model scans across the time-step calculations and returns the value where NPBV first reaches zero or greater into the Offset Model spreadsheet If NPBV doesn't reach zero or greater, the model returns the value at Year 35. In this example, '2.60' is returned for attribute 1.5a, and '22.95' is returned for attribute 1.6b (see Fig 8). The time point at which NPBV is returned (in this example, Year 5) needs to be manually entered into the summary document of Model outputs.

10.6 Summary and evaluation of Model outputs

Summary results are manually compiled for all biodiversity types impacted by the proposal. The summary table of calculated offset benefits from proposed offset actions under Scenario Two is presented in Table 5.

Table 5: Summary of outputs from the Accounting Model for Scenario Two.

Biodiversity type	Biodiversity component	Biodiversity attribute	Area of offset (ha)	Confidence	Demonstrated at Year	NPBV	Winners and losers
1. Podocarp/tawa forest	1.1 Diversity	1.1a Species diversity of native vascular plant species	600	Very confident	35	-68.65	✗
	1.2 Emergent trees	1.2a Number of emergent individuals	600	Very confident	35	-78.00	✗
		1.2b Basal area of emergent trees	600	Very confident	35	-19.70	✗
		1.2c Cover of crown foliage	600	Very confident	35	-63.08	✗
	1.3 Canopy	1.3a Cover of native vascular plant species in canopy	600	Very confident	35	-83.01	✗
		1.3b Height of canopy	600	Very confident	35	-150.00	✗
	1.4 Sub-Canopy	1.4a Cover of native vascular plant species in sub-canopy	600	Very confident	35	-59.08	✗
		1.4b Height of sub-canopy	600	Very confident	35	-150.00	✗
	1.5 Understorey	1.5a Cover of native vascular plant species in understorey	600	Very confident	5	2.60	✓
	1.6 Ground layer	1.6a Number of native species in the ground layer	600	Very confident	50	-6.43	✗
		1.6b Cover of ground layer	600	Very confident	5	22.95	✓
2. Manuka-kanuka scrub	2.1 Diversity	2.1a Species diversity of native vascular plant species	250	Very confident	35	-56.07	✗
	2.2 Canopy	2.2a Cover of native vascular	250	Very	35	-76.52	✗

Biodiversity type	Biodiversity component	Biodiversity attribute	Area of offset (ha)	Confidence	Demonstrated at Year	NPBV	Winners and losers
		plant species in canopy		confident			
		2.2b Height of canopy	250	Very confident	35	-63.03	✗
	2.3 Understorey	2.3a Cover of native vascular plant species in understorey	250	Very confident	5	27.86	✓
		2.3b Height of understorey	250	Very confident	35	-80.00	✗
	2.4 Ground layer	2.4a Cover of native vascular plant species in ground layer	250	Very confident	5	20.79	✓
3. Black beech forest	3.1 Diversity	3.1a Species diversity of native vascular species	75	Very confident	35	-6.31	✗
	3.2 Canopy	3.2a Cover of native vascular plant species in canopy	75	Very confident	35	-3.98	✗
		3.2b Height of canopy	75	Very confident	35	-10.00	✗
	3.3 Understorey	3.3a Cover of native vascular plant species in understorey	75	Very confident	35	0.09	✓
		3.3b Height of understorey	75	Very confident	35	-10.00	✗
	3.4 Ground layer	3.4a Cover of native vascular plant species in ground layer	75	Very confident	35	10.81	✓
4. Wetland habitat	4.1 Open water	4.1a Depth of water	10	Low confidence	35	-1.02	✗
	4.2 Flaxland	4.2a Cover	500	Very confident	10	13.31	✓
		4.2b Species diversity of native wetland plant species	500	Confident	15	5.73	✓
5. Braided river avifauna	5.1 Banded dotterel	5.1a Number of breeding pairs	150	Confident	35	7.43	✓
	5.2 Black-billed gull	5.2a Number of breeding pairs	150	Confident	35	24.98	✓
	5.3 New Zealand pipit	5.3a Number of breeding pairs	150	Confident	35	-17.01	✗
	5.4 Pied stilt	5.4a Number of breeding pairs	150	Confident	35	12.49	✓
	5.5 Red-billed gull	5.5a Number of breeding pairs	150	Confident	35	-12.76	✗
6. Aquatic habitat	6.1 Aquatic habitat	6.1a Macroinvertebrate	150	Confident	20	-17.75	✗
		6.1b Native fish species	150	Confident	35	2.99	✓

Biodiversity type	Biodiversity component	Biodiversity attribute	Area of offset (ha)	Confidence	Demonstrated at Year	NPBV	Winners and losers
		diversity					
7. Forest avifauna	7.1 Forest avifauna	7.1a Number of resident native species	925	Very confident	35	-198.14	✗
8. North Island kaka	8.1 Population size	8.1a Number of breeding pairs	600	Confident	35	6.48	✓
9. North Island brown kiwi	9.1 Population size	9.1a Number of breeding pairs	675	Confident	35	23.95	✓
10. Heart-leaved kohukohu	10.1 Population size	10.1a Number of adults	50	Low confidence	35	-13.98	✗
		10.1b Number of saplings	50	Low confidence	35	4.77	✓
11. Long-tailed bat	11.1 Population size	11.1a Number of individuals	600	Confident	35	73.82	✓
	11.2 Potential habitat	11.2a Number of potential roost sites	600	Very confident	35	-78.00	✗
12. New Zealand falcon	12.1 Population size	12.1a Number of breeding pairs	600	Confident	35	12.96	✓

10.6.1 Evaluating outputs from the Accounting Model

Modelling of the potential offset set actions has shown that for a high proportion of biodiversity attributes (59%), a no net loss exchange cannot be demonstrated. At this point, offset actions can be adjusted (e.g. applied to a larger offset area, or additional actions modelled that may have a greater success of increasing biodiversity gain at the offset site).

For some biodiversity attributes it can be very difficult to demonstrate a no net loss exchange either because these attributes do not respond directly to offset actions, or respond over very long time-periods beyond those acceptable for an offset (e.g. attributes associated with emergent trees). These biodiversity attributes represent limits to offsets and are permanent losses as a result of the proposal, and would not be included in a proposed offset package. Guidance on assessing limits to offsets is provided in the Good Practice Guidance.

The final model output needs to be evaluated within the context of other elements of biodiversity that will be impacted by the proposal and not directly accounted for due to offsetting limits.

Appendix 1: Equations used in the Accounting Model

The formulae used within the Accounting Model combine instructions and mathematical equations. The script for these formulae is provided below, referencing the first row of each Model. These scripts are also provided within the Accounting Model template (within the brown coloured tabbed 'Guide' spreadsheets).

Target	Formula script
Impact Model	
Biodiversity value (Column K)	IFERROR(IF(ISBLANK(J15),"",(IF(J15<H15,J15/H15,1)- IF(I15<H15,I15/H15,1)))*(G15),"Not calculated") J15 = attribute measure after impact H15 = benchmark measure I15 = attribute measure prior to impact G15 = area of impact If J15 is blank, formula returns "Not calculated"
Offset Model	
The following scripts look up values within the Impact Model and return those values into the Offset Model.	
Biodiversity type number (Column B)	='Impact Model'!B11 B11= biodiversity type number
Biodiversity type (Column C)	=VLOOKUP(B11,'Impact Model'!$B$10:$N$340,2,FALSE) B11 = Biodiversity type number
Biodiversity component (Column C)	=VLOOKUP(B15,'Impact Model'!$B$14:$N$340,2,FALSE) B15 = biodiversity component number
Biodiversity attribute (Column D)	=VLOOKUP(D15,'Impact Model_1'!$D$15:$N$340,2,FALSE) D15 = biodiversity attribute number
Measurement unit (Column F)	{=INDEX('Impact Model'!$D$15:$F$340,MATCH(D15&E15,'Impact Model'!$D$15:$D$340&'Impact Model'!$E$15:$E$340,0),3)} D15 = measurement unit E15 = biodiversity attribute description NB: This is an array formula
Biodiversity value at impact site (Column Q)	{=INDEX('Impact Model'!$D$15:$N$340,MATCH(D15&E15,'Impact Model'!$D$15:$D$340&'Impact Model'!$E$15:$E$340,0),9)} D15 = measurement unit E15 = biodiversity attribute description NB: This is an array formula
The following scripts calculate values within the Offset Model	
Biodiversity	=IF(K15="Finite end point",IFERROR(IF(ISBLANK(O15),"",((IF($J15="Low confidence

Target	Formula script
value at offset site (Column P)	>50% <75%",(IF(N15<$G15,N15/$G15,1)-IF(M15<$G15,M15/$G15,1))*0.62,IF($J15="Confident 75-90%",(IF(N15<$G15,N15/$G15,1)-IF(M15<$G15,M15/$G15,1))*0.825,IF($J15="Very confident >90%",(IF(N15<$G15,N15/$G15,1)-IF(M15<$G15,M15/$G15,1))*0.955)))))/(1+$E$11)^O15)*(I15),"Not calculated"),"Not calculated") K15 = cell within which to choose time horizon for calculation O15 = time until endpoint J15 = confidence in offset actions N15 = biodiversity attribute measure after offset G15 = benchmark measure M15 = biodiversity attribute measure prior to offset E11 = time preference discount rate I15 =offset area If 'finite end point is selected within K15 this cell is 'turned on', if O15 is blank the formula returns "Not calculated"
Attribute net present biodiversity value (Column R)	'=IF(K15="Choose option", "Not calculated",IF(K15="Finite end point",SUM(P15:Q15),IF(COUNTIF('Offset Model_5 yearly'!V15:AC15,">=0")<1,INDEX('Offset Model_5 yearly'!V15:AC15,1,COUNT('Offset Model_5 yearly'!V15:AC15)),INDEX('Offset Model_5 yearly'!V15:AC15,1,MATCH(TRUE,INDEX('Offset Model_5 yearly'!V15:AC15>=0,1,0),))))) K15 = cell within which to choose time horizon for calculation P15 = attribute biodiversity value at offset site Q15 = attribute biodiversity value at impact site If 'finite end point is selected within K15 this cell is 'turned on', if Model_5 yearly is activated this script returns an NPBV value from Model_5 yearly (the first NPBV equal to or greater than zero, or if this is not fulfilled the NPBV at Year 35)
Component net present biodiversity value (Column T)	=IF(R15="Not calculated","Not calculated",SUM(R15:R19)/ROUND(COUNTIF(R15:R19,">0")+COUNTIF(R15:R19,"<0"),0)) R15 =attribute net present biodiversity value This script determines the number of biodiversity attributes used to account for the biodiversity component and returns an average NPBV for the component.
Offset Model_5 yearly	
The following scripts look up values within the Impact Model and return those values into the Offset Model.	
Biodiversity type number (Column B)	='Impact Model'!B11 B11= biodiversity type number
Biodiversity type (Column C)	=VLOOKUP(B11,'Impact Model'!$B$10:$N$332,2,FALSE) B11 = Biodiversity type number
The following script calculates values within the Offset Model	

Target	Formula script
Net present biodiversity value at Year 1 (Column E)	'=IF('Offset Model '!$K15="Five yearly time-step",IFERROR(IF(ISBLANK(D15),"",((IF('Offset Model '!$J15="Low confidence >50% <75%",(IF(D15<'Offset Model '!$G15,D15/'Offset Model '!$G15,1)-IF($C15<'Offset Model '!$G15,$C15/'Offset Model '!$G15,1))*0.62,IF('Offset Model '!$J15="Confident 75-90%",(IF(D15<'Offset Model '!$G15,D15/'Offset Model '!$G15,1)-IF($C15<'Offset Model '!$G15,$C15/'Offset Model '!$G15,1))*0.825,IF('Offset Model '!$J15="Very confident >90%",(IF(D15<'Offset Model '!$G15,D15/'Offset Model '!$G15,1)-IF($C15<'Offset Model '!$G15,$C15/'Offset Model '!$G15,1))*0.955)))))/(1+'Offset Model '!$E$11)^1*'Offset Model '!$I15)+('Offset Model '!$Q15),""),"") Offset Model K15 = cell within which to choose time horizon for D15 = biodiversity attribute measure at year 1 Offset Model J15 = confidence in offset actions Offset Model G15 = benchmark measure C15 = biodiversity attribute measure prior to offset Offset Model E11 = time preference discount rate Offset Model I15 = offset area Offset Model Q15 = attribute biodiversity value at impact site
Net present biodiversity value at Years 5–35 (Columns G, I, K, M, O, Q, S)	=(E15-'Offset Model '!Q15)+IF('Offset Model '!$K15="Five yearly time-step",IFERROR(IF(ISBLANK(F15),"",((IF('Offset Model '!$J15="Low confidence >50% <75%",(IF(F15<'Offset Model '!$G15,F15/'Offset Model '!$G15,1)-IF($D15<'Offset Model '!$G15,$D15/'Offset Model '!$G15,1))*0.62,IF('Offset Model '!$J15="Confident 75-90%",(IF(F15<'Offset Model '!$G15,F15/'Offset Model '!$G15,1)-IF($D15<'Offset Model '!$G15,$D15/'Offset Model '!$G15,1))*0.825,IF('Offset Model '!$J15="Very confident >90%",(IF(F15<'Offset Model '!$G15,F15/'Offset Model '!$G15,1)-IF($D15<'Offset Model '!$G15,$D15/'Offset Model '!$G15,1))*0.955)))))/((1+'Offset Model '!$E$11)^5)*('Offset Model '!$I15))+('Offset Model '!$Q15),""),"") E15 =NPBV at Year 1 *[the NPBV at the previous time interval]* Offset Model Q15 = attribute biodiversity value at impact site Offset Model K15 = cell within which to choose time horizon for F15 = biodiversity attribute measure at year 5 *[the attribute measure for the time interval being calculated]* D15 = biodiversity attribute measure at year 1 *[the attribute measure at the previous time interval]* Offset Model J15 = confidence in offset actions Offset Model G15 = benchmark measure Offset Model E11 = time preference discount rate Offset Model I15 = offset area This script is repeated across years 5, 10, 15, 20, 25, 30, 35 (Columns G, I, K, M, O, Q, S) and the script adjusted accordingly: • the biodiversity value calculation takes the difference between the biodiversity attribute measure at the time interval being calculated and the measure at the time interval prior. (e.g. Year 5-Year 1, Year 10-Year 5 etc.) • the biodiversity value (NPBV-biodiversity value at impact site) of the previous time interval is added to the biodiversity value at the time interval being calculated (e.g. Year 1 + Year 5, Year 5 + Year 10 etc.) • The time until endpoint value within the script to correspond with the year NPBV is being calculated for.

Target	Formula script
Net present biodiversity value at each time interval (Columns V–AC)	Column V=E15, Column W=G15, Column X=I15, Column Y=K15, Column Z=M15, Column AA=O15, Column AB=Q15, AC=S15 E15 = net present biodiversity value at year 1 G15 = net present biodiversity value at year 5 I15 = net present biodiversity value at year 10 K15 = net present biodiversity value at year 15 M15 = net present biodiversity value at year 20 O15 = net present biodiversity value at year 25 Q15 = net present biodiversity value at year 30 S15 = net present biodiversity value at year 35 These columns have been hidden within the Model, and are used to create a contiguous range of cells to enable the script in Offset Model Column R to function.

Appendix 2: Guides for Accounting Model

The following guides (one each for the Impact Model, Offset Model and Offset Model_5 yearly spreadsheets) are also in the Biodiversity Offsets Accounting Model Template.

A. Guide for Impact Model spreadsheet

Column	Column heading	Explanation
Column B		Cell B11. The User is required to input the number assigned to the Biodiversity Type (1 for the first Type, 2 for the second, three for the third etc.). The number assigned to each Biodiversity Type must be the same within the Impact Model and the Offset Models (this auto populates to the Offset Model from the Impact Model). Biodiversity Components and Biodiversity Attributes are automatically numbered accordingly once Cell B11 is populated.
Column C	Biodiversity Type	Cell C11. Biodiversity Type describes the key biodiversity features of concern found at the Impact Site and can include ecosystems, habitats, or species. Examples include: Lowland podocarp-hardwood forest, coal measures, or a river and riparian ecosystem. Threatened and iconic species and rare or special features may also be listed as Biodiversity Types. Each Biodiversity Type requires its own workbook (copy of the Model template).
Column C	Biodiversity Component	"Identify and input Biodiversity Components to help describe what makes up the Biodiversity Type. Include as many Biodiversity Components as required to adequately represent the Biodiversity Type of concern. Each Biodiversity Type may have several associated Biodiversity Components and each Biodiversity Component requires its own set of Attributes. Examples of components include: vegetation tiers (e.g. ground, understory, canopy, epiphyte, climber), habitat types (e.g. lizard habitat, inanga spawning areas, dune slack wetland), related groups of indigenous species (e.g. vertebrate, invertebrate, bird, bat, lizard), or functional roles (insectivore/predator, nectarivore/pollinator and frugivore/seed disperser). Biodiversity Components are automatically identified numerically in relation to the Biodiversity Type they contribute to (e.g. 1.1, 1.2, 1.3). Biodiversity components must match between the Impact and Offset Models."
Columns D & E	Biodiversity Attribute	"Identify and input Biodiversity Attributes as measures of the condition or the quantity of the Biodiversity Component. The Biodiversity Attributes are the measures balanced in this accounting system to demonstrate no net loss. Biodiversity Attributes have equal weighting reflecting the like for like exchange. Each Biodiversity Component requires at least one Biodiversity Attribute, and may need several, to fully capture 'what we care about'. The tables allow for five Attributes to be entered, but each must have their own row. Attributes are automatically identified alphabetically in relation to the Biodiversity Component they are a part of (e.g. 1.1a, 1.1b, 1.1c). The disaggregated nature of the currency allows for the duplication of a component requiring more than five attributes. Biodiversity attributes must match between the Impact and Offset Models."
Column F	Measurement Unit	"Enter measurement Units for each Biodiversity Attribute. For example, if the Attribute is 'number of adults' the Measurement Unit would be a count. If the Attribute is 'spatial extent of a vegetation tier', the Measurement Unit might be percent.

Column	Column heading	Explanation
		For each attribute, the same measurement units must be used in the Impact and Offset Models."
Column G	Area of Impact (ha)	Measure and input the extent of habitat or area (ha) supporting the Biodiversity Type and over which the Biodiversity Attribute will be impacted by the proposal. For example, if the Biodiversity Type is a threatened plant species, the area of Impact is the total area (ha) of the vegetation community supporting that species that will be affected by the proposed impact, not just the summed area occupied by individual plants.
Column H	Benchmark	Input Benchmark values specific to each Biodiversity Attribute. Measurements of ecological condition or quality require reference to a benchmark state that reflects a 'natural' or 'pristine' or other desirable condition. The benchmark provides an objective framework, and a common reference point, for evaluating biodiversity losses and gains across Impact and Offset Sites. It may be necessary to employ multiple benchmarks relevant to different Biodiversity Attributes. Benchmarks are ideally measured, using the same units as for attributes, from a real site of the same vegetation community type of the Impact and Offset Site, and be a site that has been under sustained conservation management or be of the highest possible condition (and not simply a site reflective of general condition of other sites within the area). Where such a site does not exist, ecologists with expertise relevant to the Biodiversity Attribute being measured may be able to describe an appropriate Benchmark value. Expert derived estimates will likely require input from a number of ecologists whose expertise spans the relevant Biodiversity Components and Attributes. The overall condition of the Benchmark site is required to be equal to or greater than the overall condition of the Impact and Offset Sites. The same Measurement Unit (Column F) must be used to describe the Biodiversity Attribute within the Benchmark, Impact and Offset sites.
Column I	Measure prior to Impact	Measure and input the measured value of the Biodiversity Attribute at the Impact Site prior to the proposed Impact occurring. This is the measure of biodiversity loss in the loss/gain calculation. The value is expressed in the stated Measurement Unit (Column F), using the same method of measurement as for the Benchmark. If the Impact to the Attribute is total loss, enter a value of zero.
Column J	Measure after Impact	Estimate and input the predicted value of the Attribute at the Impact Site following the proposed Impact. The value is expressed in the stated Measurement Unit (Column F), using the same method of measurement as for the Benchmark. The quantum of Impact may be derived from the Assessment of Environmental Effects, or predictive models may be needed to inform this value. Experts with expertise relevant to each Biodiversity Attribute may be able to confidently estimate post Impact values.
Column K	Biodiversity value	This is the calculated value of the Biodiversity Attribute at the Impact Site following the Impact. Attribute biodiversity value is the measure of the Attribute after the Impact, relative to the measure prior to the Impact, and adjusted in proportion to the Benchmark. Any Attribute value greater than the Benchmark value is truncated to 1 within the equation. This change in biodiversity value is then multiplied across the area of proposed Impact.

B. Guide for Offset Model spreadsheet

Column	Column heading	Explanation
Column B		Cell B11. The Offsets Model will auto populate with the same number as was entered in the Impact Model. Biodiversity Attributes (Column D) are automatically numbered accordingly once Cell B11 is auto-populated.
Column C	Biodiversity Type	Cell C11. The Offsets Model will auto populate this cell with the text entered in Cell C11 of the Impact Model. See the Guide for Impact Model for further explanation on Biodiversity Type.
Column E	Discount Rate	Cell E11. Enter a discrete discount rate before any other values are entered into the Offset Model. The same discount rate applies to all Biodiversity Types, Components, and Attributes in the Offset Model. For more discussion on discount rates see the Good Practice Guidance.
Column C	Biodiversity Component	For Columns C, D, F, and G, the Offsets Model will auto populate the corresponding value from the Impact Model. See the Guide for Impact Model for further explanation on Biodiversity Components, Biodiversity Attributes, and Measurement Units. Biodiversity Components and Attributes are automatically assigned a unique identifier (Columns B and D) once Cell B11 is auto populated from the Impact Model.
Columns D & E	Biodiversity Attribute	
Column F	Measurement Unit	
Column G	Benchmark	The Offsets Model will auto populate this cell with the same value as was entered into the Impact Model (Column H, Impact Model). See the Guide for Impact Model for further explanation on Benchmarks.
Column H	Proposed Offset Actions	Define and Input brief detail of the action(s) (management intervention) proposed to Offset Impact. Further detail can be provided in supporting documentation.
Column I	Offset area (ha)	Input the area (in hectares) over which the Offset activity related to this Biodiversity Attribute will be implemented. The same Offset activity, and therefore the same area over which the Offset activity is to be implemented, can apply to more than one Attribute.
Column J	Confidence in Offset Actions	Estimate and input the likelihood that the proposed Offset Action (Column H) will be successful within the specified time estimate (Column O). This reflects that even with proven management techniques some uncertainty around outcomes is always present e.g. restoration plantings may fail due to unanticipated drought or pest pressures, or possum control targets may not be met due to bait interference by an unexpectedly high rat population. This confidence level does not include risk of default or failing to implement the proposed Offset Actions. Choose a confidence rating from the dropdown list, as follows: **Low confidence:** The proposed Offset Action uses methods that have either been successfully implemented in New Zealand or in the situation and context relevant to the Offset Site but infrequently, or the outcomes of the proposed Offset Action are not well proven or documented, or success rates elsewhere have been shown to be variable. Likelihood of success is > 50% but < 75%. **Confident:** The proposed Offset Action uses well known and often implemented methods which have been proven to succeed greater than 75% of the time although enough complicating factors and/or expert opinion exists to not have greater confidence in this Offset Action. Likelihood of success is greater than 75% but less than 90%. **Very confident:** The proposed Offset Action uses methods that are well tested and repeatedly proven to be very reliable for the situation and context relevant to the Offset Site; evidence-based expert opinion is that success is very likely. Likelihood of success is > 90%.

Column	Column heading	Explanation
Columns K & L	Time period over which to calculate NPBV	Decide whether to run calculations across five yearly time-steps for 35 years, or at a finite, user defined end point. The time-step calculation is limited to 35 years to reflect the maximum life of a resource consent. The finite end point is not time restricted. It is important to consider that management required to maintain the Offset over the long-term may be necessary beyond the time taken to demonstrate no net loss. Indicate preference using the drop-down list in Column K and follow the instructions in Column L.
Column M	Measure prior to Offset	Measure and input the value of the Biodiversity Attribute at the Offset Site prior to the proposed Offset Action being implemented, expressed in the Measurement Unit (Column F). The methods/models used to measure the Attribute at the Offset Site need to be identical to those used to measure the same Attribute at the Impact Site.
Column N	Measure after the Offset	"Estimate and input the value of the Biodiversity Attribute at the Offset Site following the proposed Offset Action at the finite end point — the time at which the Offset Action is anticipated to have achieved the stated objective (Column O), expressed in the Measurement Unit (Column F). Predictive models may be needed to inform this measure. Experts with expertise relevant to each Biodiversity Attribute may be able to estimate future measures. For the Model output to be meaningful, it is important that the attribute is responsive to management and this value is plausible.
Column O	Time till end point (years)	Predict and input the anticipated number of years (from the time of implementing the Offset Action) until the Offset Action is expected to achieve the Offset goal.
Column P	Biodiversity Value at Offset Site	This is the difference between the future value of the Attribute after the Offset action (Column N) and the current value of the Attribute at the Offset Site prior to the Offset being implemented (Column M). This change in Attribute value is calculated as a proportion of the Benchmark (Column G). Any Attribute value greater than the Benchmark is truncated to 1. The proportional raw gain is adjusted to the level of confidence in the Offset Actions succeeding, by multiplying the raw gain by the midpoint of the confidence range (Column J). This calculation also incorporates the time preference discount rate (cell E11) and the time taken to reach the stated objective for the Offset Action (Column O). The gain in value is multiplied across the Offset Area (Column I) to give a final Attribute value.
Column Q	Biodiversity Value at Impact Site	This value is imported from the corresponding Impact Model and feeds into the Offset Model spreadsheet (Column R).
Column R	Attribute Net Present Biodiversity Value	"The Net Present Biodiversity Value (NPBV) is determined for each Attribute by calculating the difference between the Attribute biodiversity value at the Offset Site and at the Impact Site to give the net change in biodiversity value over time. A no net loss biodiversity exchange is demonstrated when this value is equal to or greater than zero. Negative values demonstrate a net loss, positive values demonstrate a net gain. Where the five yearly time-step option is chosen (Offset Model_5 yearly), this cell is populated with the Attribute NPBV value at the point that is equal or greater than zero or, when a equal or greater than zero NPBV is not reached, the NPBV at Year 35.
Column T	Component Net Present Biodiversity Value	The NPBV for each component is calculated by averaging the NPBV of all the Attributes used to account for the Biodiversity Component (whether they were calculated using a finite end point or a five yearly time-step). All Biodiversity Attributes are equally weighted.

C. Guide for Offset Model_5 yearly spreadsheet

Column	Column heading	Explanation
Column B		Cell B11. The Offset Model_5 yearly will auto populate the same number as was entered in the Impact Model (cell B11). Biodiversity Attributes (Column D) are automatically numbered accordingly once Cell B11 is auto-populated.
Column C	Biodiversity Type	Cell C11. The Offset Model_5 yearly will auto populate this cell with the text that was entered in the Impact Model (Cell). See the 'Guide for Impact Model' for further explanation on Biodiversity Type.
Column A	Biodiversity Component	The Offset Model_5 yearly will auto populate this cell with the text that was entered in the Impact Model (Cell). The Biodiversity Component is repeated here to assist in keeping track of calculations between the two Offset Models when calculating NPBV to both a finite end point and a five yearly time-step within the same Biodiversity Component.
Column C	Measure prior to Offset	Measure and input the Biodiversity Attribute measure at the Offset Site prior to the proposed Offset Action) being implemented, expressed in the Measurement Unit (Column F, Offset Model). The methods/models used to measure the Attribute at the Offset Site need to be identical to those used to measure the same Attribute at the Impact Site.
Columns D (F, H, J, L, N, P, R)	Measure at Year 1 (5, 15, 20, 25, 30, 35)	Predict and input the Biodiversity Attribute measure at the Offset Site following the proposed Offset Action expressed in the Measurement Unit (Column F, Offset Model spreadsheet), at Year X following the implementation of the Offset Action. Predictive models or informed expert opinion may be needed to inform these measures.
Columns E (G, I, K, M, O, Q, S)	NPBV at Year 1 (5, 15, 20, 25, 30, 35)	Net Present Biodiversity Value (NPBV) is determined for each Attribute by calculating the difference between the biodiversity value at the Offset Site and at the Impact Site (for each Attribute) to give the net change in biodiversity value as it accrues over time (at five yearly intervals). A no net loss biodiversity exchange is demonstrated when this value is equal to or greater than zero. The value when the NPBV value is equal or greater than zero, is exported to the Offset Model spreadsheet (Column R). If an equal or greater than zero NPBV is not reached, the NPBV at Year 35 is exported into the Offset Model spreadsheet (Column R).
Columns V-AC	NPBV at Year 1 (5, 15, 20, 25, 30, 35)	These columns are used to create a contiguous range of cells to enable the equation that imports these values into the Offset Model (Offset Model, Cell R15). The User should not make any alterations to these columns.

Appendix 3: Documenting source of information entered into the Accounting Model

Explicitly detailing the source of each measure or how it was derived is critical to ensuring robust and transparent biodiversity offset accounting. A supplementary document outlining how each measure in the Accounting Model was arrived at is a useful support to the offset calculations. Hypothetical supporting tables relating to Scenario One are provided here as an example of how this information might be presented (Tables A1 and A2).

While this example accompanies the hypothetical scenario of agricultural intensification on sand country (Scenario One) and does not represent a 'true' source of information, it does provide guidance on credible types of data and information sources.

In a real scenario, it would be useful to provide as much detail (e.g. cite published literature and/or reports, name experts involved) as needed to ensure a transparent process that can be followed by interested parties and stakeholders. To further ensure clarity, a description of the in-field methodology (e.g. size of plots, transects, number of replicates, random or non-random plot location, use of national or international standards etc.) would also be useful.

Table A1: A hypothetical example of documenting the source of information and data used in the Biodiversity Offset Accounting Model for Scenario One.

Biodiversity Type	Biodiversity Component	Biodiversity Attribute	Measure (units + description)	How input values were measured and/or derived					
				Benchmark	Source of information for benchmark	Current state	Source of information for current state	Future state	Source of information for future state
1. Dune slack wetland habitat	1.1 Open water	1.1a Depth	Depth (cm): The mean annual depth of the open water in the dune slack wetland habitat biodiversity type	Determined the mean annual depth of open water in all documented high quality sand country dune slack wetland areas	Regional council wetland database	In field measurement of Impact Site	Assessment of Environmental Effects report	Expert consultation on what the outcomes are likely to be given the proposed offset actions	Technical advice note summarising the results of an expert workshop[1], and a range of technical reports detailing the success of a similar project
	1.2 Wetland turf	1.2a Cover	Percentage cover (%): The density of vegetation cover within the area of wetland turf expressed as a percentage.	Measured the mean density (%) of wetland turf in all documented high quality dune slack wetland areas	Monitoring report to support proposed offset package	In field measurement of Impact Site	Monitoring report to support proposed offset package	Expert estimation until the results of field trials are available	TBC – experts agreed field trials are necessary to determine the likely outcome of the proposed offset action
	1.3 Flaxland	1.3a Cover	Percentage cover (%):The density of vegetation cover within the area of flaxland expressed as a percentage	Measured the mean density (%) of flaxland in all documented high quality dune slack wetland areas	Regional council wetland database	In field measurement of Impact Site	Assessment of Environmental Effects report	Expert consultation on what the outcomes are likely to be given the proposed offset actions	Obtained from a combination of: 1. Technical advice note summarising the results of an expert workshop[1] 2. A range of technical reports detailing the success of a similar project
2. Raupo-flax-carex wetland	2.1 Diversity	2.1a Native wetland plant species composition	Diversity Index (#): The Simpson's Diversity Index	Determined the Simpson's Diversity Index value from all documented high quality raupo-flax-carex wetland areas,	Scientific literature[2]	In field measurement of Impact Site	Assessment of Environmental Effects report	Expert consultation on what the outcomes are likely to be given the proposed offset actions	Obtained from a combination of: 1. Technical advice note summarising the results of an expert workshop[1]

Biodiversity Type	Biodiversity Component	Biodiversity Attribute	Measure (units + description)	How input values were measured and/or derived					
				Benchmark	Source of information for benchmark	Current state	Source of information for current state	Future state	Source of information for future state
				taking into account only native wetland species					2. A range of technical reports detailing the success of a similar project
	2.2 Raupo-flax-carex wetland	2.2a Cover	Percentage cover (%):The density of vegetation cover within the area of wetland expressed as a percentage	Determined the mean percentage cover of vegetation in all documented high quality dune slack wetlands	Regional council wetland database	In field measurement of Impact Site	Assessment of Environmental Effects report	Expert consultation on what the outcomes are likely to be given the proposed offset actions	Obtained from a combination of: 1. Technical advice note summarising the results of an expert workshop[1] 2. A range of technical reports detailing the success of a similar project
	2.3 Twiggy tree daisy	2.3a Number of mature individuals	Count (#): The number of individual twiggy tree daisy plants per hectare within raupo-flax-carex wetland habitat biodiversity type	Measured the mean number of individual twiggy tree daisy plants per hectare in all documented high quality raupo-flax-carex wetland areas	Monitoring report to support proposed offset package and DOC SSBI records	In field measurement of Impact Site	Monitoring report to support proposed offset package	Expert estimation until the results of field trials are available	TBC – experts agreed field trials are necessary to determine the likely outcome of the proposed offset action
	2.4 Cabbage tree	2.4a Number of individuals	Count (#): The number of individual cabbage trees per hectare within raupo-flax-carex wetland biodiversity type	Measured the mean number of individual cabbage trees per hectare within in all documented high quality raupo-flax-carex wetland areas	Monitoring report to support proposed offset package	In field measurement of Impact Site	Monitoring report to support proposed offset package	Expert estimation until the results of field trials are available	TBC – experts agreed field trials are necessary to determine the likely outcome of the proposed offset action
3. Wetland avifauna	3.1 Species diversity	3.1a Number of resident native species	Count (#): Number of resident native bird species recorded within	Determined the number of resident native bird species likely to be recorded	DOC monitoring report, OSNZ records (adjusted for	Desktop assessment and in field measurement	Assessment of Environmental Effects report	Expert consultation on what the outcomes are likely to be given the	Obtained from a combination of: 1. Technical advice note summarising

Biodiversity Type	Biodiversity Component	Biodiversity Attribute	Measure (units + description)	How input values were measured and/or derived					
				Benchmark	Source of information for benchmark	Current state	Source of information for current state	Future state	Source of information for future state
			dune slack / raupo-flax-carex wetland habitat biodiversity type	within high quality dune slack / raupo-flax-carex wetland habitat biodiversity type	sample effort)	of Impact Site		proposed offset actions	the results of an expert workshop[1], & 2. A range of technical reports detailing the success of a similar project

[1] A workshop of local and national wetland ecologists was held to determine future measures (in a real situation this table would be accompanied by a technical note that includes the names of these ecologists and details outcomes.

[2] In a real situation the actual literature referenced would be cited

Table A2: A hypothetical example of justifying the choice of confidence level used in the Biodiversity Offset Accounting Model for Scenario One.

Biodiversity attribute	Proposed offset action	Confidence in offset action being successful	Explanation
Biodiversity type: 1. Dune slack wetland			
Biodiversity component: 1.1 Open water			
1.1a Open water 1.1b Surface area of water	Creation of open water habitat	Confident 75–90%	Other wetland creation projects[1] within the catchment that involved creation of open water have been successful. However, there remains an element of uncertainty regards the outcome of re-contouring dunes to impound water and the behaviour of the water table that prevents confidence being greater than 90%.
Biodiversity component: 1.2 Wetland turf			
1.2a Area 1.2b Density	Creation of habitat	Low confidence > 50% < 75%	No active intervention aside from the creation of open water is planned to facilitate the establishment of wetland turf habitat. Natural processes (e.g. bird dispersal of turf plants) is being relied upon for self-establishment of wetland turf habitat. Self-establishment of turf populations have been observed in other wetland restoration projects[1] within the catchment, but results (extent and rate of establishment) have been variable.
Biodiversity component: 1.3 Flaxland			
1.3a Flaxland 1.3b Density	Creation of new habitat and enhancement of existing habitat	Very confident > 90%	The creation of flaxland via planting of flax has been repeatedly proven to be very

Biodiversity attribute	Proposed offset action	Confidence in offset action being successful	Explanation
			successful, with no known failures.
Biodiversity type: 2. Raupo-flax-carex wetland			
Biodiversity component: 2.1 Diversity			
2.1a Species diversity	Creation of new habitat and enhancement of existing habitat	Low confidence > 50% < 75%	It is assumed that planting dominant species of this habitat type and improving the condition of existing habitat will ultimately improve species diversity within the offset site due to natural establishment processes and the removal of grazing/browsing pressure. An increase of species diversity has been observed within other wetland restoration projects[1] within the catchment but results (magnitude of increase and time taken till increases observed) have been variable.
Biodiversity component: 2.2 Raupo-flax-carex wetland			
2.2a Density	Creation of new habitat and enhancement of existing habitat	Very confident > 90%	The planting and encouragement of key species (raupo, flax, carex) has been repeatedly proven to be very successful, with no known failures. The removal of grazing/browsing pressure has also been repeatedly proven to lead to increase in density.
Biodiversity component: 2.3 Twiggy tree daisy			
2.5a Number of mature individuals	Creation of new habitat and enhancement of existing habitat	Confident 75–90%	Twiggy tree daisy has been successfully propagated and restoration plantings in two other wetland restoration projects[1] in the catchment have shown that facilitated establishment of twiggy tree daisy via

Biodiversity attribute	Proposed offset action	Confidence in offset action being successful	Explanation
			direct planting is 85% successful. However, due to the infrequent testing of this method and 15% mortality rate of planted individuals, confidence in success is not greater than 90%.
Biodiversity component: 2.4 Cabbage tree			
2.6a Number of individuals	Creation of new habitat and enhancement of existing habitat	Very confident > 90%	The planting of cabbage tree has been repeatedly proven to be very successful, with no known failures. The removal of grazing/browsing pressure has also been repeatedly proven to lead to increase in density.
Biodiversity type: 3. Wetland avifauna			
Biodiversity component: 3.1 Species diversity			
3.1a Number of native species	Creation of new habitat and enhancement of existing habitat	Low confidence > 50% < 75%	It is assumed that increasing the area of available habitat (via wetland creation) and improving the condition of existing habitat will ultimately result in an increase in the number of native wetland avifauna species. An increase in species diversity has been observed within other wetland restoration projects[1] within the catchment but results (magnitude of increase and time taken till increases observed) have been variable.

[1] In a real-world example it would be good practice to reference the actual situation and/or any existing monitoring data/reports.