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Biodiversity Offsets: Two New Zealand Case Studies and an Assessment Framework

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Abstract Biodiversity offsets are increasingly being used for securing biodiversity conservation outcomes as part of sustainable economic development to compensate for the residual unavoidable impacts of projects. Two recent New Zealand examples of biodiversity offsets are reviewed—while both are positive for biodiversity conservation, the process by which they were developed and approved was based more on the precautionary principal than on any formal framework. Based on this review and the broader offset literature, an environmental framework for developing and approving biodiversity offsets, comprising six principles, is outlined: (1) biodiversity offsets should only be used as part of an hierarchy of actions that first seeks to avoid impacts and then minimizes the impacts that do occur; (2) a guarantee is provided that the offset proposed will occur; (3) biodiversity offsets are inappropriate for certain ecosystem (or habitat) types because of their rarity or the presence of threatened species within them; (4) offsets most often involve the creation of new habitat, but can include protection of existing habitat where there is currently no protection; (5) a clear currency is required that allows transparent quantification of values to be lost and gained in order to ensure ecological equivalency between cleared and offset areas; (6) offsets must take into account both the uncertainty involved in obtaining the desired outcome for the offset area and the time-lag that is involved in reaching that point.

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Introduction

Biodiversity offsets are rapidly emerging as an internationally important policy instrument for securing biodiversity conservation outcomes (ten Kate and others 2004). Typically they involve the protection of habitat that either holds existing significant conservation value or where restoration will be undertaken to compensate for the loss of similar values elsewhere. Biodiversity offsets are being used widely by government organizations and the private sector to permit development activities which involve clearance of natural ecosystems and habitats within a framework of no-net-loss or net-gain (ten Kate and others 2004). Although relatively new as a concept, the offset approach has a number of antecedents most notably in North American wetland mitigation projects (Zedler 1996).

Biodiversity offsets have been defined by ten Kate and others (2004) as: “Conservation actions intended to compensate for the residual, unavoidable harm to biodiversity caused by development projects, so as to ensure no net loss of biodiversity.”

In North America, biodiversity offsetting is usually referred to as “mitigation.” For example, under the no-net-loss policy for wetlands in the United States, unavoidable impacts that damage wetlands (e.g., infilling or draining) must be mitigated by replacement or enhancement elsewhere (Zedler 1996). In Europe, offsetting is more often referred to as compensation, and usually involves habitat creation to offset development impacts (Morris and others 2006).

One of the major criticisms of biodiversity offsets, especially in North America, is that most approved offsets fail to meet their objectives or never actually occur. For example, one study of wetland offsets in Florida found that no mitigation work had even been attempted for 34% of the 63 permits reviewed (Race and Fonseca 1996), while a more recent study of 76 wetland mitigation projects found that 67% failed to create or restore their minimum required area (Matthews and Endress 2008). In Canada, Harper and Quigley (2005) found that offset conditions were not followed in 86% of 124 fish habitat developments.

Notwithstanding these concerns, biodiversity offsetting is now being widely used (ten Kate and others 2004), but the assessment of the ecological costs and benefits of this policy tool have been slower to occur. However, several recent papers (Hilderbrand and others 2005; Harper and Quigley 2005; Morris and others 2006; Gibbons and Lindenmayer 2007; Moilanen and others 2008; Matthews and Endress 2008) provide the basis for the development of a framework for assessing the applicability of biodiversity offsets.

In this article, I initially review two New Zealand development proposals where offsets have been proposed and accepted by the New Zealand environmental planning process, and then outline an environmental framework within which to consider the use of biodiversity offsets. Given that biodiversity offsets sit at the nexus between environmental science and policy, this framework will assist both those developing offset proposals, and the regulatory authorities consenting such proposals, to ensure that offsets do meet the no-net-loss of biodiversity definition (ten Kate and others 2004).

New Zealand Examples of Biodiversity Offsets

In New Zealand, the management of natural resources, including the clearance of indigenous vegetation, is governed by objectives, policies, and methods, including rules that are developed by local authorities (city/district and regional councils) and outlined in city/district and regional plans. These rules set the bounds for a wide range of different land and water uses and activities and are developed within the context of the New Zealand Resource Management Act 1991 (RMA; Memon and Gleeson 1995). The purpose of the RMA is to ensure the sustainable management of natural and physical resources (Section 5[1]), where sustainable management is defined as (Section 5[2]):

> "managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while:
>
> (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
> (b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
> (c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment."

Anyone who wishes to undertake activities that are not permitted in relevant city/district or regional plans must apply for resource consent(s) for the activity. These applications are considered by the relevant council in terms of both the provisions of their plan and the RMA itself. The decisions reached from these deliberations can then be appealed to the Environment Court which then re-hears the whole case before reaching a decision. Expert witnesses play a key role in placing technical and scientific material before the consent hearing or Court. While Environment Court decisions can be appealed to higher courts, such appeals are only on points of law and are uncommon. It is the Environment Court that clarifies the intent of the RMA and thus sets the case law which guides consideration of other applications. Where development results in what are considered as "more than minor" effects on the environment, then the applicant needs to show how they will "avoid, remedy or mitigate" effects.

The application of biodiversity offsets in New Zealand is relatively new (Borrie and others 2004; Christensen 2007). The idea of biodiversity offsets, usually called environmental compensation, has been considered in several recent decisions of the New Zealand Environment Court. In the Court's decision on the J F Investments Limited case (C48/2006) the Court defined environmental compensation as: "Any action (work, services or restrictive covenants) to avoid, remedy or mitigate adverse effects of activities on a relevant area, landscape or environment as compensation for the unavoided and unmitigated adverse effects of the activity for which consent is being sought."

The following examples illustrate the way in which the biodiversity offset concept has been applied in New Zealand and are typical of recent development projects that have included offset or compensation proposals.

Kate Valley Landfill

Kate Valley is located in coastal hill country in New Zealand's eastern South Island (Motunau Ecological District, 43° 06′ S, 172° 51′ E, 0-346 m a.s.l.; Norton 2005). The underlying geology comprises Tertiary seabed strata dominated by fine-grained compacted sedimentary deposits including limestone and mudstone. Annual rainfall is 921 mm but with considerable variation within and between years. The area typically experiences warm dry summers

Table 1 Kate Valley vegetation types at the time the biodiversity offset proposal was developed (Norton 2005)

Vegetation type	% land area
Exotic pasture	60
Kunzea ericoides shrubland and low forest	15
Indigenous shrubland	10
Exotic shrubland	7
Exotic conifer plantations	3
Wetland	4
Old growth *Nothofagus solandri* forest	1

and cool wet winters. Snow is rare, although frost can occur in winter, especially in valley bottoms away from the coast. The property has had a mixed farming history, but because of erosion and weed problems has been typically farmed as an extensive sheep and cattle property.

Pasture is the dominant vegetation type (Table 1). While some very small (<1 ha) remnants of old growth indigenous forest remain, the predominant indigenous vegetation is seral *Kunzea ericoides* (kanuka) shrubland and low forest with varying mixtures of other regenerating indigenous tree species, and mixed indigenous shrubland, although this accounts for 25% of the land area. All forest and shrubland areas have been strongly modified by domestic stock and are typically devoid of regeneration except in inaccessible sites.

After a long period of investigation, Transwaste Canterbury Ltd. (TCL) identified Kate Valley as the preferred site for a new regional landfill and applied in 2002 to Hurunui District Council for resource consent. TCL is a 50/50 public/private joint venture between local government and two waste management companies The consent was granted in 2003 subject to a number of conditions, some of which TCL felt were too restrictive while parties in opposition to the landfill felt that consent should have been declined in its entirety. One matter that was the subject of debate was a condition of the consent that required a <1 ha remnant of *Nothofagus solandri* (black beech) forest (referred to as 'Remnant A') be retained. TCL wished to see this removed to enable the landfill to be of a viable size while opposing parties wanted it to stay. TCL and three opposing parties filed appeals to the Environment Court which heard the case in September–November 2003. As part of their appeal TCL revisited a number of elements of the project including the environmental compensation (biodiversity offset) being offered and put a new and substantially bigger offset package before the Court. The Court accepted the biodiversity offset proposed and granted consent for the revised proposal including allowing removal of "Remnant A." (Environment Court decision C29/2004, 22 March 2004).

The biodiversity offset proposal accepted by the Court involved the long-term protection, restoration, and management of a 410 ha "Conservation Management Area" adjacent to the Kate Valley landfill (now known as Tiromoana Bush; www.tiromoanabush.co.nz). The Court further specified that the consent holder (TCL) must at its own cost undertake a number of actions including:

- Register a covenant against the title which provides legal protection in perpetuity of Tiromoana Bush prior to the acceptance of first waste.
- Permanently fence Tiromoana Bush and remove all domestic grazing animals within two years of the issuing of the consent and prior to the acceptance of first waste.
- Within two years of the issuing of the consent, and prior to the acceptance of first waste, commission and submit a detailed restoration plan for Tiromoana Bush.
- Commence and continue implementation of the Restoration Plan in accordance with the priorities and timeframes outlined in the Restoration Plan including:
    - producing an annual report on progress on the Restoration Plan.
    - sourcing all plant species used for planting either from Tiromoana Bush itself or from the southern part of the Motunau Ecological District.
    - initiating and continuing animal and plant pest control programmes within Tiromoana Bush during the operating life of the landfill.
    - carrying out propagation and transplanting of *Nothofagus solandri* seedlings from Remnant A into Tiromoana Bush.
    - providing controlled public access for recreational, educational and scientific use to Tiromoana Bush by a walking track.
- The costs of the obligations arising under this condition are to be funded directly by TCL, with such funding being independent of and not reliant upon cashflow from the landfill.

The Tiromoana Bush Restoration Management Plan (Norton 2005) identified three components to the restoration work; natural regeneration of the remnant indigenous forest areas as a result of removal of domestic grazing animals, natural regeneration in pasture areas as a result of removal of domestic grazing animals, and establishment of restoration plantings to enhance connectivity between remnant patches and to reintroduce key plant species for indigenous fauna.

Waikatea Station Farm Development

Waikatea Station (3570 ha) is typical of sheep and cattle farms that occur through the hill country of New Zealand's eastern North Island (Tiniroto Ecological District, 38° 46′

Table 2 Waikatea Station vegetation types at the time the biodiversity offset proposal was developed (Norton 2007)

Vegetation type	% land area
Exotic pasture	57
Kunzea ericoides shrubland and low forest	23
Poor quality exotic pasture	14
Regenerating Podocarpaceae forest	4
Old growth Podocarpaceae forest	1
Indigenous shrubland	1

S, 177° 29′ E, 80-537 m a.s.l.; Norton 2007). The underlying geology comprises young sedimentary rocks mainly of late Tertiary age, especially sandstone, siltstone, and mudstone. The topography is generally steep, with sharp hill crests separated by incised river systems. Waikatea Station is estimated to receive an annual average rainfall of 1400–1600 mm, with most rain falling in winter, while summers can be dry, although drought is usually not a problem. From a farming perspective, Waikatea Station is considered a well balanced property. In 2004, the property wintered 19,000 stock units (43% sheep and 57% cattle).

The most widespread vegetation type on Waikatea Station is pasture (Table 2), dominated by exotic grass and herb species (Norton 2007). However, 29% of the property supports indigenous forest and shrubland (mainly dominated by *Kunzea ericoides*) much of it of recent origin having established on areas that were previously under pasture. Indigenous forest and shrubland is heavily undergrazed by farmed cattle and sheep, and feral goats. The dominant understorey plants are species of low palatability, while palatable understorey species, including seedlings and saplings of most of the canopy dominants, are rare or absent. Undergrazing is used as part of farm management, especially during winter when feed is in short supply. Under this regime, forest regeneration is unlikely and canopy collapse is possible once the current seral canopy *Kunzea ericoides* start to senesce.

In November 2004 the Bayly Trust, who own Waikatea Station, applied to Wairoa District Council for resource consent to clear 536 ha of *Kunzea ericoides* shrubland and low forest for pasture reestablishment, while protecting a further 674 ha of forest remnants and riparian zones. Following the resource consent hearing at which the Department of Conservation (DOC, a central government agency which manages public conservation land and advocates for preservation on private land) opposed the application, the Council granted consent in March 2006 which, subject to conditions, authorized the clearance of 356 ha of *Kunzea ericoides*. DOC then appealed this decision to the Environment Court which heard the case in July/August 2007. A revised proposal involving the clearance of 354 ha of *Kunzea ericoides* shrubland and low forest for pasture development, and protection through covenanting and fencing of a further 799 ha of forest and shrubland as a biodiversity offset was put to the Environment Court at this hearing. Although DOC expert witnesses at the hearing claimed that the project, including the offset proposal, would result in a net loss of biodiversity on the property, the Court accepted expert evidence that there would in fact be a net-gain in biodiversity because of the removal of grazing animals from the 799 ha to be protected and granted consent for the revised proposal (Environment Court decision W081/2007, 19 September 2007).

The biodiversity offset proposal accepted by the Court involved:

- Permanent protection of 799 ha of indigenous forest and shrubland, together with some areas of pasture (primarily riparian areas), through a QEII National Trust Open Space Covenant (www.openspace.org.nz) on the property title.
- Removal of domestic grazing pressure from all protected areas through the establishment of new fencing and the repair of existing fencing, and then the removal of all domestic grazing animals.
- Active control of feral grazing and browsing animals especially goats and brushtail possums.
- Monitoring of biodiversity values.
- Natural regeneration of pasture areas included within the covenanted and fenced area once they have been retired from grazing.

The areas selected for protection and fencing were chosen to be (Norton 2007):

- Inclusive of all remaining areas of remnant old growth forest.
- Fully representative of the range of environments that occur on Waikatea Station (especially with respect to altitude, aspect and landform).
- Large enough to be well buffered and have good resilience (the ability to recover from natural disturbances).
- Provide connectivity between protected areas, and with other areas of indigenous forest outside the property, both for aquatic and terrestrial biota.
- Provide habitat for nationally uncommon species, especially fauna.

Framework for Assessing Biodiversity Offsets

While substantial biodiversity offsets were approved as part of the regulatory process in the case studies, the manner in which they were developed was based more around the precautionary principal than from the application of a formal assessment framework. Given the increasing uptake of biodiversity offsets internationally (ten Kate and others 2004) it is important that the merits of individual proposals are rigorously assessed against an appropriate framework. The recent literature on biodiversity offsets provides the basis for such a framework. Based on both the case studies and this literature, a preliminary framework of key environmental principles, which should be considered in developing and evaluating biodiversity offsets, is now proposed.

The six principles fall into two groups; the first two are primary socio-economic principles, in that they are concerned with the process by which offsets are considered and implemented while the remaining four are primarily ecological, as they are concerned with the selection and quantification of offsets. Notwithstanding this distinction, all six principals are relevant for both the design of offsets (a largely ecological process) and their approval and implementation within regulatory frameworks (a regulatory/policy process).

Principle One

Biodiversity offsets should only be used as part of an hierarchy of actions in which a development project must first seek to avoid impacts and then minimize the impacts that do occur (ten Kate and others 2004; Moilanen and others 2008). Offsets are an activity that compensates for the residual, unavoidable impacts (harm) after avoiding and minimizing as much as possible.

The use of such an hierarchical approach explicitly places biodiversity offsets within a broader context of responsible development. A development project must first seek to avoid any adverse impacts, or when these are unavoidable, it should seek to minimize such impacts. Only when these steps have been addressed and there is still residual impact (e.g., through vegetation clearance), can offsets be considered as a compensation mechanism. Biodiversity offsets should not be used to justify adverse impacts; rather they are the final step in a process that focuses first on avoidance and minimization. However, the way in which such an hierarchy is used will necessarily reflect the local policy/regulatory situation and there may be cases where a favorable offset might be accepted where the "avoid" option is less attractive on social or economic grounds.

In the Kate Valley case, a rigorous process was undertaken to identify the best site for the regional landfill that had to meet geotechnical, logistical, and environmental concerns (including avoiding damaging or destroying significant indigenous habitat). While no single site could totally avoid all impacts, the Kate Valley site was considered the best. The Waikatea situation was more complex as the land owner was restricted to the one location and wished to increase the area of pasture. This meant that "avoidance" was not possible in terms of clearance of indigenous vegetation. However, the direct impacts of clearance were minimized by ensuring that the areas that were not to be cleared (the offset) would offer the best outcome for the sustainable conservation of indigenous biodiversity on the property.

Principle Two

Some form of guarantee must be provided that the offset proposed will occur (Race and Fonseca 1996; Harper and Quigley 2005; Gibbons and Lindenmayer 2007; Matthews and Endress 2008).

One of the major criticisms of offsets, especially in North America, is that most approved offsets fail to meet their objectives or never actually occur (e.g., Race and Fonseca 1996; Matthews and Endress 2008; Harper and Quigley 2005). In approving biodiversity offsets as part of economic development projects, consenting authorities must ensure that adequate systems are put in place to ensure that compliance does occur. Furthermore these systems must be robust enough to take into account the time-lags that are likely to occur in achieving a desired offset outcome (see principle six).

In New Zealand, the Environment Court will usually include specific conditions relating to biodiversity offsets that must be met prior to a development project commencing and, in some cases, to enable its continuation. In both the Kate Valley and Waikatea Station cases this included requirements for covenanting, cessation of grazing and management plan development (Kate Valley only) prior to commencement of development work. However, the biggest weakness in ensuring that offset conditions are enforced is a lack of relevant expertise within consenting authorities to monitor offset projects. While a guarantee is important from the developer, there also needs to be the ability to enforce the offset requirements to ensure that the proposed outcomes are actually realized.

Principle Three

Biodiversity offsets are inappropriate for certain ecosystem (or habitat) types because their rarity or the presence of particular species within them makes the clearance of these ecosystems inappropriate under any circumstances (Gibbons and Lindenmayer 2007).

Notwithstanding the hierarchy in principle one, it seems clear that there are some ecosystems or habitat types for which offsets are never going to be possible. These may be ecosystems that have already been diminished to such an extent that any further loss is unacceptable, or habitats of species whose loss would most likely lead to the extinction of the species as well. In the United States, the Endangered Species Act 1973 imposes specific requirements on developers to avoid impacting on listed species (Stokstad 2005). There may also be situations where the impact of a development will have adverse off-site effects, for example, through alteration of ecological processes (e.g., hydrological regimes) which results in further habitat loss and/or species extinction at other sites. Specific thresholds to trigger this principle will vary depending on the local situation but may include the presence of species listed as nationally threatened or of habitats that have less than a particular percentage of their total area remaining (e.g., <10%).

In New Zealand, published lists of threatened species and habitats (de Lange and others 2004; Walker and others 2005) provide a framework for the Environment Court to consider if clearance is permissible, but there is no statutory basis for restricting development as is the case with the Endangered Species Act. In both the Kate Valley and Waikatea cases, the Environment Court determined, based on detailed ecological evidence, that while indigenous biodiversity would be lost, it was not of such value that clearance was inappropriate. In the Kate Valley case, the Court determined that the remnant old growth forest was not significant, while in the Waikatea case, the Court concluded that while the indigenous vegetation proposed for clearance was significant, the effects of the proposed clearance were not sufficient to justify refusal of the application given the nature of the offset proposed.

Principle Four

Biodiversity offsets can involve protection of existing habitat but most often involve the creation of new habitat, especially when existing habitat already enjoys a degree of protection (Gibbons and Lindenmayer 2007).

While a biodiversity offset might involve the protection of an area of intact indigenous vegetation, offsetting normally involves the restoration and protection of new areas/habitats. In North America, wetland mitigation has focused primarily on creating new wetlands to offset impacts on existing wetlands (Zedler 1996; Race and Fonseca 1996; Matthews and Endress 2008), and this is also the case in the United Kingdom (Morris and others 2006). While it might be possible to include the protection of an existing area of indigenous habitat from clearance, the concept of "duty of care" (Gibbons and Lindenmayer 2007) means that this approach may still result in a net-loss of habitat if there are already mechanisms in place to limit the loss of the offset area (e.g., through local or regional plans). However, the use of existing indigenous habitat for offsets might be appropriate where "protection" results in a significant improvement in "condition" over what is the current or likely future condition.

In both the Kate Valley and Waikatea cases the biodiversity offset involved both the protection of existing habitat and the creation of new habitat, although the relative importance of these differed. At Kate Valley, the 410 ha Tiromoana Bush restoration area is a mixture of pasture (57 %), and indigenous shrubland and low forest (43 %). In contrast at Waikatea Station, the 799 ha offset area is predominantly indigenous shrubland and forest (79 %), with a much smaller area of pasture (21 %). However, in both cases, the "health" of the existing habitat is severely degraded because of the pervasive impacts of domestic and feral grazing and browsing mammals, a major problem in many New Zealand forests (Wardle and others 2001; Coomes and others 2003; Smale and others 2008), and it is likely that these animals will continue to suppress any palatable plant species, including forest canopy regeneration, resulting in nonreversible forest degradation. Thus the offset proposal will result in a significant improvement in the condition of the existing habitat because of the exclusion and control of invasive mammals.

Principle Five

A clear currency is required that allows transparent quantification of values to be lost and values to be gained in order to ensure ecological equivalency between cleared and offset areas (Salzman and Ruhl 2000; McCarthy and others 2004; ten Kate and others 2004; Morris and others 2006; Gibbons and Lindenmayer 2007; Moilanen and others 2008).

Any biodiversity offset proposal must be founded on very good knowledge of the biodiversity values of both the site that is to be impacted and the offset site, including composition, structure and pattern, function, and dynamics and resilience of the system (Hobbs and Norton 1996). The development of a clear currency to quantify the values at different sites being considered as part of biodiversity offsets is essential to ensure that clearance of high quality habitat or a rare ecosystem is not offset using an area of low quality habitat or common ecosystem and thus that biodiversity offsets have credibility.

A range of approaches to optimising conservation outcomes at the landscape scale have been proposed (Pressy and others 2007; Wilson and others 2007; Kremen and others 2008) and provide the opportunity to ensure that the location of offset sites are optimized to ensure that there is no-net-loss or even a net-gain in biodiversity. However, to utilize these tools as part of offset development, good quantitative knowledge of the biodiversity values present both within the target sites and at other sites within the broader landscape is required.

A clear currency is also essential if there is to be any objective determination of appropriate offset ratios (Gibbons and Lindenmayer 2007). While a number of metrics have been proposed (e.g., Parkes and others 2003; McCarthy and others 2004; Bruggeman and others 2006), the size of offsets has usually been based on subjective judgments (Morris and others 2006). The development of appropriate ratios for compensation may be important if there is to be a fair exchange of areas, but any such assessment must take into account the uncertainties discussed below (Moilanen and others 2008).

In both the Kate Valley and Waikatea Station cases, the offset areas are located adjacent to the clearance areas and involved the same ecosystem types. Detailed ecological information (species lists, community comparisons, quantification of historical ecosystem change, and regional analyses of habitat types) was presented to the Environment Court which enabled the Court to reach conclusions on the relative merit of the biodiversity offset proposed, although no formal offset ratio was proposed or optimization approach used in determining the outcome.

Principle Six

Determination of what is an appropriate offset must take into account both the uncertainty involved in obtaining the desired outcome for the offset area and the time-lag that is often involved in reaching this point (Zedler 1996; Hilderbrand and others 2005; Morris and others 2006; Moilanen and others 2008).

Uncertainty relates primarily to the inability of ecologists to accurately predict what a system will be like at some point in the future as a result of management actions implemented as part of the offset (e.g., restoration). Uncertainty is particularly high where offsets involve restoration of significantly modified sites (e.g., abandoned farmland) or where there are strong abiotic drivers of ecosystem processes that need to be reversed (e.g., disturbance regimes or hydrological factors) and there is no guarantee that the desired outcome will be achieved (Hilderbrand and others 2005). Uncertainty will be less where the offset involves, for example, the removal of a degraded influence, such as an herbivore or predator, in an otherwise intact ecosystem. However, uncertainty is exacerbated by the extinction debt associated with past and current habitat loss (Tilman and others 1994; Schrott and others 2005) which makes it difficult to predict future condition in highly fragmented landscapes irrespective of the development and associated offset proposal.

Offsets also need to allow for the delayed time that is involved in achieving the desired biodiversity outcome, especially when the economic development will be yielding economic benefits in a much shorter time frame than the ecological changes will be occurring over. Uncertainty and time-lags also present challenges for consenting authorities who need to factor these into the conditions that are imposed as part of a development consent—for example, the time period over which a bond might need to be held or the procedures that are established to monitor compliance.

One way to overcome uncertainty is through the use of biodiversity banks. These involve a third party owning an area that has been restored, established, enhanced, or (in certain circumstances) preserved for the purpose of trading with a developer who requires an offset as part of a development project. Wetland mitigation banks have been used extensively in the United States (Weems and Canter 1995) and enable a developer to purchase an offset prior to undertaking their development work, thus reducing some of the uncertainties associated with establishing a new offset. Bonnie (1999) suggests a similar approach for offsetting unavoidable adverse impacts on endangered species habitat, while habitat banks fulfill a similar function in Europe (Morris and others 2006).

In the Kate Valley and Waikatea Stations cases, two main areas of uncertainty were identified; (1) that the remnant indigenous forests will regenerate once the degrading influences had been removed, and (2) that natural regeneration and/or restoration plantings will be successful in re-establishing self-sustaining indigenous forest ecosystems in pasture areas. Both of these were addressed during the Environment Court process with ecological evidence presented to show that both were unlikely to be a major issue based on previous New Zealand research (Reay and Norton 1999; Dodd and Power 2007). The Court took this evidence into account in reaching its decision on the appropriate offset.

Conclusions

The environmental framework presented here provides a basis for assessing the potential usefulness of biodiversity offsets as a policy instrument in sustainable development and should assist both those developing offset proposals and consenting authorities evaluating such proposals. While there are instances where biodiversity offsets are going to be totally inappropriate (Gibbons and Lindenmayer 2007), offsets are likely to be increasingly used as people strive to meet environmental and social, as well as economic, standards in project development. The six principles outlined here provide a framework for both developing and assessing future biodiversity offset proposals, although they do not provide guidance on determining specific offset ratios (Moilanen and others 2008).

While it is possible to undertake detailed assessment of the values present at both the impact and offset site, the lack of any guarantee that an offset proposed will be realized is a significant problem with biodiversity offsets worldwide (Race and Fonseca 1996; Harper and Quigley 2005; Gibbons and Lindenmayer 2007; Matthews and Endress 2008). It is essential that when a condition requiring biodiversity offsetting is included when permitting a project development, that consenting or decision-making authorities should also ensure that the biodiversity offsetting work is substantially implemented prior to that development work commencing. In the Kate Valley case, this was done with a requirement for the completion of certain activities prior to any refuse being taken to the landfill. Ensuring that such enforceability is built into offset proposals is likely to be the biggest challenge for the future application of biodiversity offsets and it is beholden on the developer as well as regulatory authorities to ensure that workable methods for doing this are put in place. However, to be enforceable, consenting authorities need to have the relevant expertise to monitor offset projects.

The determination of appropriate offset ratios is likely to become an increasingly important part of biodiversity offsetting. However, the use of such ratios needs to be balanced by the need to ensure that solutions are appropriate to the local (country or region) situation, both in terms of biodiversity and social context. A degree of flexibility, but based on the precautionary principle, operating within a sound environmental framework (as outlined here) is likely to result in better biodiversity outcomes than adherence to a rigid offset ratio that might not be appropriate in every situation. However, it is likely that because of the uncertainties in future outcomes (e.g., Zedler 1996; Hilderbrand and others 2005; Morris and others 2006; Gibbons and Lindenmayer 2007) high offset ratios may be required in many instances to guarantee a robust fair exchange (Moilanen and others 2008).

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