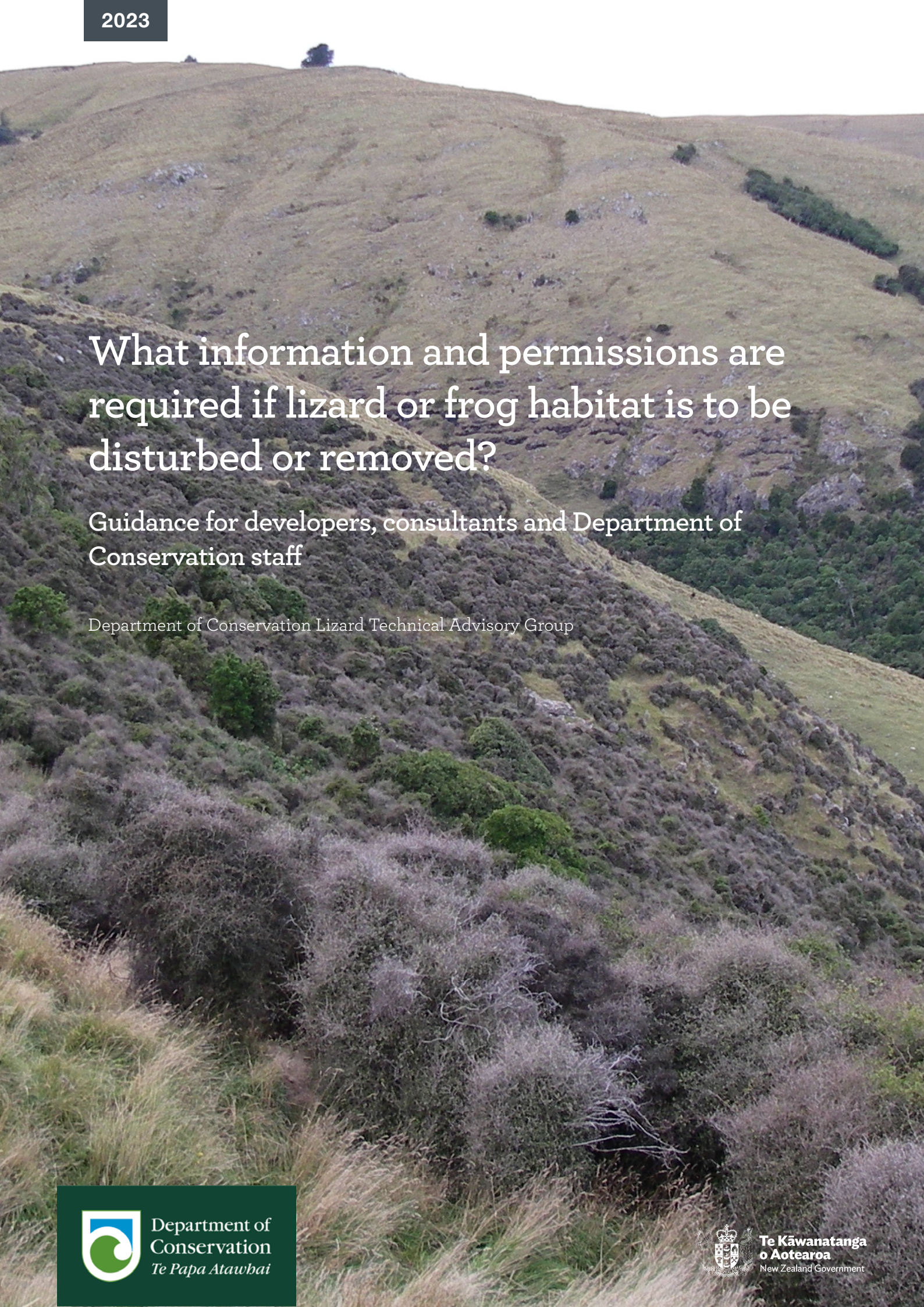
2023



What information and permissions are required if lizard or frog habitat is to be disturbed or removed?

Guidance for developers, consultants and Department of Conservation staff

Department of Conservation Lizard Technical Advisory Group

Department of Conservation
Te Papa Atawhai

Te Kāwanatanga o Aotearoa
New Zealand Government

This document provides guidance and easy access to information for project developers, lizard and frog experts and environmental/ecological consultants, Department of Conservation (DOC) staff, local authority staff and any others involved in preparing development proposals, concession applications, Wildlife Act applications or submissions, and DOC staff providing advice to others and assessing applications under (primarily) the Wildlife Act 1953. It may also be useful for the Resource Management Act 1991, Crown Minerals Act 1991 and Conservation Act 1987. This is a live document and will be reviewed and updated when required.

Key author: DOC Lizard Technical Advisory Group
Person responsible for updating: Lynn Adams

Cover: Small-leaved shrubs and forest remnants, Banks Peninsula. *Photo: Marieke Lettink*

ISBN 978-1-99-118367-5

This report was prepared for publication by the Creative Services Team; editing and layout by Lynette Clelland. Publication was approved by the Manager, Terrestrial Ecosystems Unit, Department of Conservation, Wellington, New Zealand.

Published by the Department of Conservation, PO Box 10420, The Terrace, Wellington 6143, New Zealand.

In the interest of forest conservation, we support paperless electronic publishing.

CONTENTS

What information and permissions are required if lizard or frog habitat is to be disturbed or removed?

Guidance for developers, consultants and Department of Conservation staff

1. Introduction

This document has been prepared to assist those people and organisations involved with changes in land-use in areas where lizards or frogs are known or suspected to occur. Killing, disturbing, capturing and/or moving lizards or frogs requires an authority under the Wildlife Act 1953 (a wildlife permit). Destroying their habitats should only be considered as a last resort, and only when this forms part of a wider **mitigation**[1] scheme that ensures a benefit to wildlife, i.e. the future conservation of the population is protected. This is also the expectation of a wildlife permit.

This document outlines a range of mitigation options that could be considered if the development might result in the loss of lizards or frogs or their habitat. Normally, **compensation**[2] for the loss of habitat is also required, and this often takes the form of habitat creation, restoration or enhancement. Such a programme of mitigation and compensation should allow the population of impacted species of lizard(s) or frogs to be maintained or enhanced following completion of the development.

There are 127 species of endemic lizards in New Zealand and 3 species of endemic frogs. They occupy a range of habitats across New Zealand, including highly modified habitats.

The outcomes of mitigation actions are generally poorly documented. Despite many projects aimed at mitigating impacts of development having been carried out throughout the world, little attention has been paid to measuring the success of these actions, or whether they have resulted in species surviving and establishing populations or augmenting existing population(s). This is particularly the case in New Zealand where mitigation methods must be tested on a range of different species over a range of climatic conditions to understand their utility for each species or species population. For example, a particular habitat created successfully in Auckland for copper skinks may not be successful in the cooler climate of Wellington, and almost certainly won't be successful for southern grass skinks in Canterbury who have an entirely different life history and habitat requirement. Monitoring the outcomes of mitigation actions provides opportunities to test hypotheses and, over time, devise optimal protocols based on clear empirical evidence. A greater focus on achieving this is needed.

A successful mitigation package that aims to test and improve techniques may involve changes in timing of operations, capturing and excluding lizards, setting aside land for lizards, purchase of additional land, habitat creation and post-development commitments to ensure the population is monitored and safeguarded.

---

[1] Mitigation means actions to reduce potential adverse effects resulting from a proposed development or activity.

[2] Compensation means balancing the negative effects of a development or activity with other actions or activities that improve the state of the environment, not necessarily at the development or activity site. Compensation is generally regarded as the last line of defense in avoiding environmental impacts.

Developers are frequently unaware that when investigating proposals and moving through the permitting process for them, they also need to consider requirements under the Wildlife Act 1953. Discovering, at a late stage in the process, that the site of a proposed development has wildlife values that need to be addressed can cause significant delays or, in worst case scenarios, bring developments to a complete halt. It is recommended that developers start the process to identify what wildlife may be present on or around the site of their proposed development as early as possible.

In summary:

- The number of projects aimed at mitigating impacts of development on lizard and frogs – whether they be habitat enhancement or species salvage – is increasing in New Zealand and internationally. In many cases these projects far exceed the number of conservation-driven recovery actions for those same species.
- Mitigation methods and tools are presently poorly developed and tested and there is very little data demonstrating the success of even commonly used approaches. This is a particular problem in New Zealand where many lizard species are affected by development, and there are wide climate and habitat variations.
- The international literature tells us that mitigation methods and tools commonly fail because they do not follow accepted scientific best practice and are usually poorly documented. There is a need to test and measure the efficacy of mitigation techniques as an integral part of mitigation packages in order to improve them and, ultimately, outcomes for lizards and frogs.

This guidance document seeks to clarify what information needs to be provided by developers and their consultants to the Department of Conservation (the Department or DOC) in applications under the Wildlife Act (1953) for an authority (or permit) for development works that may involve the capture, handling, release, killing, disturbance or molestation of indigenous lizards and frogs. It also provides technical guidance for applications where disturbance (including complete or partial removal and modification) of lizard and frog habitat is proposed. The requirements of the Wildlife Act are explained in Box 1.

Aotearoa New Zealand's indigenous lizards and frogs occur in a very wide range of habitats (Box 2), in both indigenous and exotic vegetation and in many settings, including rocks, bluffs, talus, logs, litter, dunes, pakihi swamplands and countless combinations of these within a range of landforms and vegetation types. Potential lizard and frog habitats include areas not always identified as significant under the Resource Management Act (1991) (RMA). Lizard habitat can also include human-made habitat such as rock piles/stacks in urban and agricultural settings or in discarded rubbish on 'waste' land. It is important to note that it is frequently difficult to know if lizards and frogs are present and determining this often requires time-consuming, weather- and season-dependent surveys involving lizard experts and other specialist consultants.

Habitat loss remains a significant cause of lizard and frog declines and so DOC seeks to actively promote avoidance (including consideration of alternatives) of damage to known and potential habitat of lizard and frog species, and to ensure that adequate mitigation is provided for any adverse impacts on their habitats (See Appendix 1 for technical detail on potential habitats).

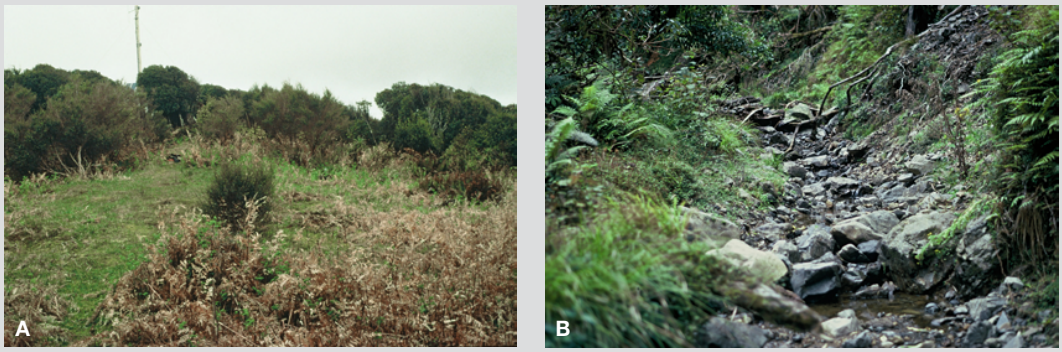
While there are many ways in which lizard and frog habitat may be disturbed; the most common include:

- land development, including subdivision and recreation/tourism activities,
- construction, installation or maintenance of infrastructure including roads, wind turbine projects, masts and aerials etc.,
- mining and quarrying,
- farming practices, including draining, flooding and pasture improvements,
- plantation forestry and associated activities,
- logging and clearance of indigenous vegetation.

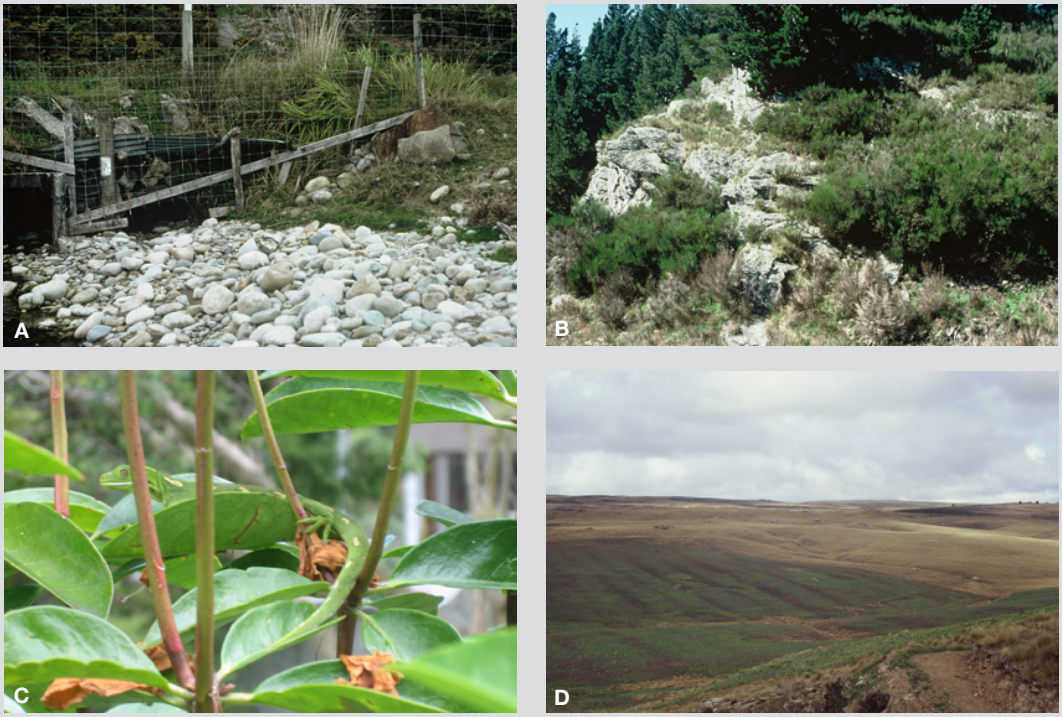
Box 1. Requirements of the Wildlife Act 1953

A Wildlife Act authority (wildlife permit) is required to catch (by any means), handle and release as well as hunt, kill, disturb, molest or hold for rehabilitation or in captivity any animal protected under the Wildlife Act 1953 within or outside of public conservation land. The Department of Conservation has a mandate under the Wildlife Act 1953 to permit or decline, and impose conditions on, any activity that involves protected wildlife, which includes all species of indigenous lizards and indigenous frogs.

Box 2. Examples of frog and lizard habitats



Frog habitats are sometimes quite nondescript, as shown in these two examples. A. Archey frog (*Leiopelma archeyi*) habitat, Maungamangero. *Photo: Ian Flux*. B. Hochstetter's frog (*L. hochstetteri*) habitat, Toatoa District, Whakatane. *Photo: D. Parker*.



Lizards can be present in many areas likely to be subject to development. A. Chesterfield skinks (*Oligosoma salmo*) were present in the stones around this farm culvert near Hokitika, which have since been removed. *Photo: G.B. Patterson*. B. Skink (*Oligosoma* sp.) habitat at Garston Quarry, Southland. *Photo: G.B. Patterson*. C. Auckland green gecko (*Naultinus elegans*) in a Birkenhead garden, Auckland. *Photo: Rebecca Stanley.* D. Pasture development and grand skink (*Oligosoma grande*) habitat, Redbank Scenic Reserve, Macraes Flat, Otago. *Photo: Bruce McKinlay*.

2. What outcomes does DOC seek for lizards and frogs affected by development?

When development is likely to affect lizard or frog habitat and values at a site, DOC requires applications under the Wildlife Act to demonstrate a benefit to wildlife through protection of the:

- diversity of species at the site,
- species' population sizes (taking into account natural fluctuations) and long-term viability,
- area occupied by the species and its natural range,
- range and ecological health and functioning of assemblages of species, community types and ecosystems.

Post development, the number of lizards or frogs – for each of the species affected – should be the same or better at the development site or at an appropriate alternate site, or a combination of both.

Avoiding disturbance and retaining the status quo for lizards and frogs at development sites is the most desirable outcome. Due consideration must be given to the viability of any lizard or frog population(s) remaining post-development. For example, lizards and their habitat present at the development site but not directly affected, are not necessarily viable in the long term if, post development, they represent only a remnant population of one that was formerly numerically and/or geographically stronger or previously connected to other populations via a habitat corridor.

Post-development, lizard or frog populations must remain in the same or an improved condition at the development site or an appropriate alternate site. Be aware that best practice for lizard or frog habitat enhancement is still being developed and refined and most proposed methods (including those described in this report) have not been tested (see Appendix 3). Many previously implemented mitigation initiatives have yielded ambiguous results for lizards and frogs. The onus is on the applicant to appropriately measure the effects of habitat disturbance and removal on the lizard or frog population and to propose mitigation methods that work. Uncertainty needs to be addressed in any application and uncertainty needs to be balanced by methods that are known to work. There is much that is still unknown about most mitigation methods and tools. Use of an untested mitigation method will require considerable research and lead-in time or need to incorporate an adaptive management approach.

In occasional cases, if habitat enhancement is carried out in an area adjacent to a development site (for more detail see Appendix 3), lizards within the development footprint may be left to perish and, in return, the developer will be required to compensate fully, by other means, for the losses of individual lizards and lizard habitat. This scenario is generally not considered to be best practice but may sometimes be adopted for a non-threatened cryptic (hard to find and inherently difficult to salvage (see Appendices 2 & 4) species known to occur at very low densities in a development area which is known to be surrounded by other populations of the same species.

Grass skink (*Oligosoma* aff. *polychroma* Clade 5) living in a stone row, Canterbury. *Photo: Marieke Lettink.*

3. Applications for Wildlife Act authorities (wildlife permits)

A Wildlife Act authority (wildlife permit, Box 3) is required if indigenous lizard or frog species are to be disturbed or killed during a development project. The Department has a mandate under the Wildlife Act 1953 to permit or decline, and impose conditions on, any activity that involves absolutely protected wildlife, which includes all species of indigenous lizards and frogs. Additional requirements may be needed in relation to applications under the Conservation Act 1987 (e.g. concession applications), the Crown Minerals Act 1991 (access agreements), the Reserves Act 1977, or all three simultaneously for some large-scale developments on land administered by DOC. The Department can also impose conditions on concession agreements and access agreements. Lastly, DOC has an obligation under Section 4 of the Conservation Act 1987, and therefore under the Wildlife Act 1953 (an enactment of the Conservation Act 1987), to consult fully with relevant iwi, a process that runs in parallel with any consultation undertaken by a developer. Permitting instructions are on the DOC website: https://www.doc.govt.nz/get-involved/apply-for-permits/.

Early engagement with DOC ensures that developers, their consultants and the Department are clear on what might be required to:

- achieve the best outcomes for lizards or frogs,
- ensure all groups meet their required timeframes and legal responsibilities,
- and, ideally, reach agreement on the best way forward for future applications.

Poorer outcomes and slower permitting timeframes are common if there is no early engagement.

A range of documentation may need to be produced for resource consent purposes (under the Resource Management Act (RMA) 1991). These documents also provide useful information

Box 3. Applying for Wildlife Act authorities (permits)

Wildlife Act Authority form from DOC website.

Any operation that will disturb or kill lizards or frogs must submit a Wildlife Act application form [https://www.doc.govt.nz/get-involved/apply-for-permits/interacting-with-wildlife/]. It is beneficial to supplement the application with documents such as a Lizard or Frog Management Plan (LMP), Assessment of Environmental Effects (AEE) and/or an Environmental Impact Assessment (EIA). The application (or supplemental documents) should outline, as a minimum, the information previously described in this section and clearly outline the benefit to Wildlife.

for Wildlife Act applications (e.g. Assessment of Environmental Effects (AEE), Environmental Impact Assessment (EIA), lizard management plan (LMP)). Information required for Wildlife Act Authority applications includes:

- goals and objectives for managing lizards or frogs,
- lizard or frog habitats and populations at the site(s) and significance of the habitats,
- actual and potential effects of the proposed activity,
- identification of all potential effects and evidence that these have been adequately addressed (measures to avoid impacts and mitigation measures),
- proposed mitigation contingency and incidental discovery actions,
- methods to be used for monitoring andresearch, reporting requirements.

It is the applicant's responsibility to provide the required information. The Department may help facilitate the collection of information, but this is NOT DOC's responsibility. Note that even if an RMA Section 95D is approved (proposed development will have an effect that is less than minor on the values of interest to DOC), Wildlife Act authorities (wildlife permits) are still needed.

3.1 Other issues that need to be considered by developers when assessing lizard or frog species and site significance

Disturbing indigenous lizards or frogs requires a wildlife permit, irrespective of the land status. However, you will still need to ascertain who manages or owns the land, i.e. DOC, a district council (e.g. on unformed/paper road or esplanade reserve), regional council, unitary authority or private landowner, as this may also have implications. If land is managed by DOC, a concession and/or access agreement will be required. For proposed developments on Crown pastoral leasehold land, DOC must be consulted on the protection of **inherent values of the land concerned (other than attributes and characteristics of a recreational value only), and in particular the inherent values of indigenous plants and animals, and natural ecosystems and landscapes** (Crown Pastoral Land Act 1998; Section 18).

Wildlife permit applicants must consider whether their development site adjoins land managed by DOC (including a Coastal Marine Area under the Marine and Coastal Areas Act 2011) and, therefore, whether a concession will be required for the activity to be undertaken at this location. DOC's concession process should ideally proceed at the same time as or before the RMA process. DO NOT wait until the resource consent has been granted to seek Wildlife Act permits from DOC.

When disturbing or removing wildlife from privately-owned land, be aware that a range of requirements set by district councils or unitary authorities will need to be met. Developments near waterbodies may also be managed under regional council consent processes. It is not the intent of this document to provide guidance on council requirements (the Wildlife Act requirements are separate from these), but it is time-efficient to consider the effects of the activity as a whole when planning Wildlife Act matters.

Maud Island frog (*Leiopelma pakeka*). *Photo: © Sabine Bernert.*

3.2 Assessing actual and potential effects of a development and their significance

Various matters need to be considered when assessing how disturbance and habitat modification will impact lizards or frogs. This section provides an outline of the process that needs to be worked through to determine the potential effects of a development on lizards or frogs.

Keep in mind that habitat loss includes the loss of all or some habitat elements, e.g. schist/rock removal, log removal and/or the removal of human-made habitat occupied by indigenous lizards and frogs. Note also: **human-made habitat (such as rock stacks or piles in farmland) that have been present in the environment for over 100 years come under the jurisdiction of the Heritage New Zealand Pouhere Taonga Act 2014 and removal or disturbance requires an authority/permit under this Act.**

Where it is suspected that the information from databases such as Bioweb Herpetofauna is inadequate or (more likely) requires interpretation from a herpetologist (see Appendix 5), and the potential effects (in terms of local lizard or frog population persistence) of the development activity are likely to be large, it is likely that a herpetological survey will need to be carried out (see appendix 5 for frog hygiene requirements when surveying). Remember that locations infested with pest plant species can provide important habitat and habitat linkages for lizards and frogs.

Applications under the Wildlife Act should address measures to avoid loss of habitat used or potentially used by lizards or frogs. It is preferable that, post-development, the area involved in a development is returned as soon as possible to the same, or better, condition than was present prior to the work.

To help determine the key potential effects of the proposed activity, use Table 1 (p. 11) as a prompt (it outlines potential values of interest to DOC and associated potential effects). Departmental staff familiar with the area may also need to be able to identify key values and/or provide advice on potential effects of the activity at that site.

The values considered in Table 1 need to be applied to each individual species of lizard or frog. Each species has specific ecological requirements and thus the potential effects of a development and any mitigation need to be appropriate for each species, i.e. each species will require specific mitigation actions related to their particular habitat requirements. Each species needs to be considered when preparing (developers and consultants) and assessing (DOC staff) applications for wildlife permits. These will need to be assessed on a case-by-case basis and are likely to require local knowledge and/or discussion with appropriate DOC staff.

Once all relevant values have been defined (using Table 1 as a guide), use Table 2 (p. 13) to evaluate potential effects of the proposed development on lizard or frog habitats; for example, if lizards or frogs have been identified at a site, then Effects 5, 7 and 9 in Table 2 will need to be considered. Note that these tables are only a guide and there may be other effects that aren't listed in Table 2 that will also need to be considered. Broader effects may also result from the activity, and these also need to be considered. Broad effects may include the:

- Potential to **affect important natural processes**. For lizards and frogs, 'stepping-stone habitats' (this refers to smaller habitat patches that may provide adequate cover for an animal to disperse between sites, but is not of sufficient quality and/or quantity to allow longer term persistence at the site) and linkages over a wider area can be very important, e.g. weed-infested terraces along rivers.
- Potential for **cumulative effects** to arise from the activity, associated works or other activities already undertaken at or near the site (i.e. a consideration wider than just the direct impacts of the proposed development or activity). For example, the development may result in the loss of a stretch of lizard/frog habitat that on its own may not result in

a more than a minor effect listed in Section 3, but may contribute to wider cumulative changes if other activities or developments that affect lizards are also being undertaken, perhaps by different people, within the same general area.

Note that **all potential effects that involve the killing and/or disturbance of indigenous lizards are considered to be significant**, as they require a wildlife permit.

As part of the wildlife permit process, DOC will assess whether the applicant's proposed mitigation measures will appropriately address the effects of the activity. Various factors will inform the type and scale of mitigation that is appropriate, including:

- Scale of the development and its effects. What is the size of the area that will be disturbed/removed? How much vegetation will be removed? How much of the local habitat will be affected?
- Duration of the development or activity. Are the effects short-term or one-off, or are they ongoing or cyclic, sporadic, or occur on an as-required basis?
- Significance of the habitat values and the time of year the development activity will be undertaken. For example, work carried out during winter may lead to more significant effects as lizards or frogs are less active and/or brumate (hibernating).
- Risk of significant damage or loss of values and whether losses will be permanent or temporary.
- How well and easily the existing lizard and/or frog habitat and associated values can be restored after completion of the development work, if at all. For example, fast-growing versus slow-growing or reproducing lizard species, or vegetation dominated by one species versus complex plant communities.

Once all site and/or species values and likely development effects have been considered, an informed judgement can then be made about whether the mitigation proposed is appropriate for addressing the concerns identified. If there are concerns that the development or activity will have unacceptable adverse effects, or effects on important values have not been considered by the applicant, further information and discussion with the applicant will be required. The wildlife permit may be declined or put on hold until the applicant can adequately address concerns.

An application relating to a site which contains no particular special or significant values and where the effects of the work are relatively small and short term should be able to be processed using some of the general conditions provided in Table 2, e.g. conditions relating to minimising site disturbance and restoration of site values when development activity is finished.

There may also be cases where values of interest to DOC are high, and potential effects will result in a high risk of permanent loss of these values. Generally, in these situations the activity and resulting loss of lizard or frog habitat should be avoided. However, there may be some instances where it is essential that the proposed development and/or activity procedes and no alternative options exist. In these cases, more substantial mitigation (or compensation) measures may be required, such as relocation of protected species, creation and long-term protection of new habitat, off-site compensation, or various combinations of these. These will be reflected in conditions in the wildlife permit granted.

3.3 Consideration of alternatives

Consideration should be given to alternatives such as:

- Are there alternative sites with lower impacts? Where impacts of a proposed development or activity are likely to be high, are there alternative options and/or can sites with lower impacts be found? This may include micro-adjustments where some movements of the footprint could avoid damage to important habitat. This may be especially important in situations where effects on lizard or frog population(s) are likely to be significant.

- Is the development or activity necessary? Examination of the necessity of the development or activity will help determine whether it is appropriate. For example, does the development or activity need to occur at the scale proposed and would reducing the scale affect project viability?

Applications should address measures to avoid the habitat and potential habitat (see Appendix 1) of lizard or frog species. If avoidance is not possible then it is preferable that, post-development, the area is returned as soon as possible to the same, or better, condition than that present prior to the work (i.e. aim for at least no loss of the population(s) post-development). There will be situations, however, where this may not be achieved, and ecological compensation will be necessary.

3.4 Threatened species require more careful consideration

Any development or activities involving habitats and/or species of high conservation concern, (i.e. ranked as Threatened or At Risk under the New Zealand Threat Classification Scheme (NZTCS); Fig. 1) require more rigorous consideration. Justification for the loss of species of high conservation concern and/or their habitat must be thorough and persuasive. There needs to be greater certainty that any techniques or proposed approaches will have been previously tested and be reliably successful. Threatened species are likely to require more comprehensive (more intensive, frequent and longer duration) predator control.

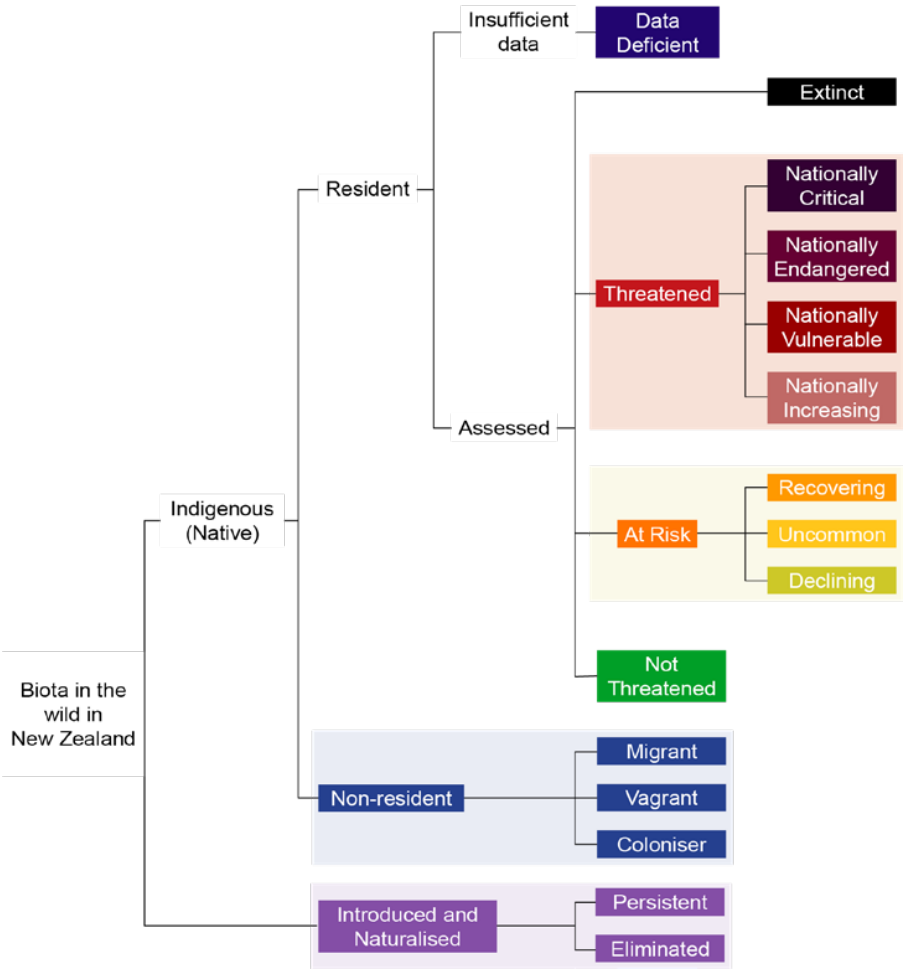


Figure 1. Structure of the New Zealand Threat Classification System (revised 2020).

3.5 Monitoring is required to ascertain whether mitigation and other authority (permit) conditions are successful

Monitoring is an essential part of any management action and is particularly pertinent given that most of the lizard and frog management and mitigation methods outlined in this guidance are presently under-developed and untested. Monitoring requires clear objectives to be set prior to initiation of development activities and rigorous monitoring is essential to determine when contingencies (see section 3.7 below) in permits are triggered. The Department of Conservation Herpetofauna toolbox at http://www.doc.govt.nz/ can assist in planning post-release monitoring of lizard or frog populations, or those translocated as part of mitigation measures associated with authorities or permits.

3.6 Reporting is required to improve and communicate outcomes

As a condition of a wildlife permit (and most Resource Consents), a detailed report on the outcomes of any mitigation must be sent to DOC and iwi. For large-scale projects involving multiple species and/or significant habitat, interim reports and/or liaison are required to ensure that agreed milestones and performance standards set out in the wildlife permit are met. For these larger projects, reporting should also include progress against any lizard mitigation and/or management plan objectives (relating to the development), including monitoring objectives.

All lizard location data must be forwarded to DOC (herpetofauna@doc.govt.nz) for inclusion in the Bioweb Herpetofauna database.

3.7 Contingency measures for when mitigation methods fail are required in wildlife permits

As previously mentioned, there are presently very few quantified options for mitigating lizard or frog population or habitat loss in New Zealand. Options that are commonly used are largely untested and their effectiveness is uncertain. This uncertainty needs to be taken into account when deciding whether a mitigation package is adequate for a development that results in habitat disturbance or loss. When unproven techniques are used, there is also a need to develop contingency measures that are triggered if failures occur. **Contingencies are back-up activities designed with careful thought and a genuine commitment to their being implemented if needed**. They help to ensure that there is no loss in lizard populations and habitat after development projects are completed, should planned lizard mitigation methods fail or be only partly successful due to unforeseen issues

Contingency measures are commonly omitted from lizard management plans relating to developments, and therefore are also commonly absent from Wildlife Act applications regarding lizards. Even the best-laid plans can go wrong and, given that many of the methodologies involved in mitigation are untested, they carry an inherent risk of failure. As such, it is an essential requirement that contingency activities are identified in applications for wildlife permits for lizards or frogs.

Contingency activities, if required, must undergo the same scrutiny as the original proposal that they replace; conditions imposed in the wildlife permit should signal a requirement that contingency actions represent a fresh proposal and a sub-project, with its own unique wildlife permit and appraisal process.

Compliance with wildlife permit conditions is monitored through the reporting functions in the permit.

Table 1. Identification of lizard and frog population and habitat values at development sites and potential development-related effects on them.

VALUES PRESENT WITHIN ACTIVITY AREA, ADJACENT TO ACTIVITY AREA AND ALONG ACCESS ROUTES TO THE ACTIVITY AREA		WHERE/HOW TO FIND INFORMATION ON VALUES*	PRESENT AT SITE ✓/×	POTENTIAL EFFECTS**
Lizard and frog population values	Significant values include all native lizards and frogs but particularly Nationally Threatened, At Risk or Data Deficient indigenous lizard or frog species present or potentially present (see Appendix 1).	Site-specific herpetofauna survey of activity area; Hitchmough et al. 2013; Newman et al. 2013; DOC website; Bioweb Herpetofauna Database; Threatened Species Strategy; DOC Species Prioritisation System; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); Protected Natural Areas Programme (PNAP) survey reports; DOC herpetofauna Technical Advisory Group (TAG); relevant Conservation Management Strategies (CMSs); DOC GIS; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); DOC Species Recovery Plans, and recovery group leaders; scientific papers.		1–4, 9
	Locally (within the ecological district) uncommon indigenous lizard or frog species present.	Site-specific herpetofauna survey of activity area; Bioweb Herpetofauna Database; Threatened Species Strategy; DOC Species Prioritisation System; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); PNAP survey reports; DOC herpetofauna TAG; relevant CMSs; DOC GIS; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans and recovery group leaders; scientific papers.		1–4, 9
	A lizard or frog species present that requires a unique or unusual habitat; e.g. Hochstetter's frog, Leiopelma hochstetteri (first and second order streams, cloud forest); chevron skink, Oligosoma homalonotum (gullies and streams near water); green skink, O. chloronoton (high humidity/ damp sites).	Site-specific herpetofauna survey of activity area; Bioweb Herpetofauna Database; Threatened Species Strategy; DOC Species Prioritisation System; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); PNAP survey reports; DOC herpetofauna TAG; relevant CMSs; ecological and herpetological survey reports (e.g. consultancy reports); Recovery Plans and recovery group leaders; scientific papers.		1–4, 9
	Activity site is at the edge of a species' range within the ecological district and/or nationally or is a known stronghold for the species nationally.	Site-specific herpetofauna survey of activity area; Bioweb Herpetofauna Database; Threatened Species Strategy; DOC Species Prioritisation System; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); PNAP survey reports; DOC herpetofauna TAG; relevant CMSs; DOC GIS; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans and recovery group leaders; scientific papers.		1–4, 9
	Unusual species assemblage or, alternatively, an intact species assemblage for the habitat type on this landform.	Site-specific herpetofauna survey of activity area; DOC herpetofauna TAG; Bioweb Herpetofauna Database; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); relevant CMSs; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans, and recovery group leaders; scientific papers.		1–4, 9
	Community or scientific interest, e.g. rare, unusual or unique colour morphs are present, taonga species or a recovering population (e.g. following disease/predator management).	Site-specific herpetofauna survey of activity area; local knowledge (e.g. Universities), discussion with iwi/hapu; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); DOC herpetofauna TAG; relevant CMSs; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans, and recovery group leaders; scientific papers.		1–4, 9

Table 1 *continued*.

VALUES PRESENT WITHIN ACTIVITY AREA, ADJACENT TO ACTIVITY AREA AND ALONG ACCESS ROUTES TO THE ACTIVITY AREA		WHERE/HOW TO FIND INFORMATION ON VALUES*	PRESENT AT SITE ✓/×	POTENTIAL EFFECTS**
Lizard and frog population values	Presence of high lizard and/or frog species richness either nationally, or locally (within Ecological District), or over a habitat on a particular landform.	Site-specific herpetofauna survey of activity area; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); DOC herpetofauna TAG; relevant CMSs; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans and recovery group leaders; scientific papers.		1–4, 9
	Evidence of a viable indigenous lizard or frog population present.	Site-specific herpetofauna survey of activity area, including adjacent areas that show wide range of sizes and ages within the lizards and/or frogs present; DOC herpetofauna TAG; DOC Species Prioritisation System; scientific papers.		1–4, 9
	A large area (for the ecological district) of intact lizard and/or frog habitat present.	Site visit, expert opinion, DOC GIS, Google Earth satellite maps and/or aerial photos of the site with vegetation classes mapped and ground-truthed; DOC herpetofauna TAG; PNAP survey reports; DOC Ecosystem Prioritisation System.		5–9
	The site is important for maintaining linkages between lizard and/or frog populations or metapopulations and/or contains a potential hybrid zone, including being continuous or maintaining linkages with protected areas.	Regional, District, or Unitary Plans; CMSs; Optimised Ecosystems ('Biodiversity Management Units'); 'Significant Natural Area (SNA) or equivalent'; a 'Recommended Area for Protection (RAP), listed in PNAP survey reports; the 'Protected Natural Area Programme (PNAP)'; meets local policy, plan or DOC significance criteria; LENZ threatened environments; site-specific herpetofauna survey of activity area; Bioweb Herpetofauna Database; lizard action plans (Southland, West Coast, Canterbury, Nelson/ Marlborough, Wellington); DOC herpetofauna TAG; relevant CMS; DOC GIS; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans and recovery group leaders; scientific papers; DOC Ecosystem Prioritisation System.		5–9
	Habitat at the activity site has high restoration potential for a nationally threatened lizard or frog species.	Site-specific herpetofauna survey of activity area; Hitchmough et al. 2013; Newman et al. 2013; local DOC Ranger, Bioweb Herpetofauna Database; DOC herpetofauna TAG; relevant CMSs; DOC GIS; local NGOs; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans and recovery group leaders; scientific papers.		5–9
	The site has a high diversity (>2) species of lizards and frogs present or likely to be present.	Site visit, expert opinion, DOC GIS, Google Earth satellite maps and/or aerial photos of the site with vegetation classes mapped and ground-truthed; DOC herpetofauna TAG; scientific papers.		5–9
	The site has either a naturally low incidence of lizard and frog predators, has a habitat structure that allows persistence of lizards in the presence of predators (e.g. rock talus, divaricating shrubs), or has been subject to long-term, and will be subject to ongoing, predator control.	Expert opinion; Local knowledge; local DOC ranger; DOC herpetofauna TAG; site-specific herpetofauna survey of activity area; lizard action plans (Southland, West Coast, Canterbury, Nelson/Marlborough, Wellington); relevant CMSs; ecological and herpetological survey reports (e.g. consultancy reports, tenure review reports; DOC or Council survey reports); Recovery Plans, and recovery group leaders; scientific papers.		5–9

Table 2. Significance and potential effects of development-related activities on lizard and frog populations and habitats and possible mitigation.

POTENTIAL EFFECTS OF HABITAT REMOVAL AND/OR DISTURBANCE	EXPLANATION	GENERAL ADVICE (INCLUDING SIGNIFICANCE)	POTENTIAL CONDITIONS (❖) AND MITIGATION (★)
1. Lizards or frogs subjected to light and glare, noise, dust or vibration, temporarily or permanently.	• Some industries operate day and night, so need to use lighting and potentially generate constant noise and disruption. • Some indigenous lizards are diurnal and others are nocturnal; all indigenous frogs are nocturnal. • Depending on the activity, these effects may only occur during the set-up and construction phase of a development. Alternatively, some effects may be permanent (over the life of the activity). • Light can alter insect activity which may affect the biology of specialist feeders. • Dust can coat plants (foliage and fruit) used for food and activity/basking sites (e.g. frogs climb onto vegetation at night to forage); dust may contain chemicals and particulate matter dangerous to lizards and frogs (depending on its origin). • Indigenous frogs, which use their skin for water regulation, are likely to be highly susceptible to dust; juveniles and eggs are particularly susceptible to desiccation and have little (juveniles) or no (eggs) ability to regulate water balance (e.g. see Cree 1985, 1989). • Dust particles can fill important interstitial spaces (e.g. rock crevices) into which lizards and frogs and their invertebrate food sources would otherwise retreat. • Vibration can dislodge rocks and crush lizards and frogs • Effects of noise and vibration on New Zealand skinks and geckos have not been investigated. • There is evidence in the scientific literature that lizards exposed to noise can become quite quickly desensitised to it, which affects the way they orient themselves and move and interact on a day-to-day basis. • Research indicates that stress (i.e. elevated stress hormones) alters basking behaviour in some lizards, which can lead to heightened vulnerability to predation (Cree et al. 2003.	• Permanent effects on protected species and/or their habitats are likely to be highly significant. • Temporary effects on protected species and/or their habitats, subject to type and scale, may not be highly significant. • Habitat removal and disturbance actions at the activity site can have permanent, temporary or intermittent (but permanent) effects on adjoining areas that contain lizard or frog values of interest to DOC; i.e. the activity area includes lizard and frog habitat and populations of these animals that can feel, see or hear these effects. • For many developments these effects cannot be entirely avoided, only minimised. • Actual (as opposed to potential) effects of light, noise and vibration are difficult to quantify but these effects need to be included in the accounting of development compensation as they may be highly significant in some instances (precautionary principle).	❖ Situate access roads and infrastructure to avoid actual and potential habitat of protected indigenous frogs and lizards, including adjacent buffering areas. ❖ For operations that require 24:7 activities, including lights at night, ensure that no light spill occurs beyond the boundary of the activity area Activities that cause noise, dust and vibration should be situated as far as possible from areas where lizard and frog habitat values occur or could potentially occur. ❖ Watering of dusty roads can help minimise dust; avoid using roads at night if nocturnal protected species are present or potentially present. ★ Minimisation of effects through sensible site management and compensation – on site or off site. Mitigation needs to account for effects beyond the activity footprint. ★ On mainland sites, potential mitigation to address habitat and/or population loss could include installation of refuges (artificial or natural) and/or the creation of new habitat of at least the same quality and quantity as what is lost, within areas protected from further development in perpetuity – see Appendix 2. ★ At some sites, removal and control of woody weeds can be part of a mitigation package. When there are residual effects that need to be addressed following the successful implementation of a mitigation package, compensation may be required to make up for habitat and/or population loss to achieve no net loss overall in lizard/frog habitat values.

Continued on next page

Table 2 continued

POTENTIAL EFFECTS OF HABITAT REMOVAL AND/OR DISTURBANCE	EXPLANATION	GENERAL ADVICE (INCLUDING SIGNIFICANCE)	POTENTIAL CONDITIONS (❖) AND MITIGATION (★)
2. Lizards and/or frogs subjected to displacement, death and injury (e.g. trampling/crushing).	• Removal of debris and shelter structures (e.g. logs, rock and wood piles), via dragging or rolling and/or burying them under soil, may cause injury or mortality to resident herpetofauna communities at those sites. • Many New Zealand lizards and frogs spend a large part of the year in a low-temperature induced torpor (sleep) or brumation, especially at higher latitudes/altitudes. Such behaviour can alter the success of mitigation and – little is known about the relative success of carrying out mitigation actions in either warmer or cooler months, but it's likely to be less successful in cool months given lizards are harder to detect Effects can include loss of breeding opportunity or other factors that affect individual or population fitness, e.g. tail loss in lizards, stress leading to re absorption of developing embryos. • Lizards and frogs can have a high degree of site fidelity and can remain in the same location for decades. Many will not move even after the habitat becomes unsuitable. Even displaced individuals of some species may attempt to return to their home site. • Habitat disturbance can alter microclimates important to all or some life-stages, e.g. indigenous froglets and some *Oligosoma* spp. (skinks formerly known as *Cyclodina*). • Displacement may cause an increase in vulnerability of displaced lizards and frogs to predation and/or extremes in climate (both summer and winter extremes). • Displacement may also adversely affect individuals by forcing them to face novel inter- and intraspecific competition, at least in the short-term. • Stock can cause trampling and crushing.	• Effects such as the displacement, death and/or injury of protected species will be highly significant. • Wildlife Act (1953) authority (wildlife permit) is required to hunt, kill, take, trap, capture by any means, pursue, disturb, or molest indigenous lizards and frogs, regardless of threat status. • On a case-by-case basis (seek advice) avoid earthworks in winter, except where there is evidence that lizards are active (e.g. sunny north-facing site) and are active enough to find safe shelter. On a case-by-case basis (seek advice) avoid earthworks in winter, except where there is evidence that lizards are active (e.g. sunny north-facing site) and are active enough to find safe shelter. • Assume a high loss of lizard and frog individuals, even if salvage is attempted (see Appendix 2); there will always be individuals left behind after a salvage operation; particularly with cryptic and rare species. Wildlife Act permits are required to both salvage and kill indigenous lizards and frogs. • Captivity can be used to temporarily house lizards or frogs, but disease issues need to be considered when they are re-released into the wild i.e. could captive stock spread disease to wild animals? There is very little information (baseline data) on what is considered to comprise a normal pathogen load for wild New Zealand lizards and frogs, meaning that disease screening can lead to inconclusive results and indecision. • Salvaged animals may be used for translocation to safe locations or to supplement existing wild (or captive) populations (see Appendix 3).	❖ Avoid, if possible, habitat or potential habitat for lizards and frogs Have herpetologist(s) and trained assistants ready to safely capture fleeing lizards. ★ At mainland sites, mitigation to address habitat loss and/or population loss could include installation of artificial refuges and/or the creation of new habitat of at least the same quality and quantity as what is to be lost, in areas protected in perpetuity from further development – see Appendix 2. ★ At some sites, removal of woody weeds (which can provide unwanted shade) can form part of a mitigation package. ★ When there are residual effects that need to be addressed following the successful implementation of the mitigation package, compensation maybe required to make up for habitat and/or population loss to achieve no net loss overall in lizard or frog habitat values.

Continued on next page

Table 2 continued

POTENTIAL EFFECTS OF HABITAT REMOVAL AND/OR DISTURBANCE	EXPLANATION	GENERAL ADVICE (INCLUDING SIGNIFICANCE)	POTENTIAL CONDITIONS (❖) AND MITIGATION (★)
3. Introduction of a biosecurity threat.	• Some development proposals have the potential to introduce threats to the activity area and surrounds, through lack of awareness of the risks e.g. the unwanted organism plague (rainbow) skink (and its eggs) can be moved to a site inside plants sourced from nurseries infested with the species. • Other biosecurity issues that can affect lizards and frogs in and around a development area include exotic ants, woody weeds (these can shade lizard habitat) and, at some frog sites, chytrid fungus; see Appendix 6.	• Introduction of one (or more) biosecurity threats to habitat, potential habitat and/or populations of protected species is a highly significant effect. This includes areas adjacent to habitat (and potential habitat) of threatened species. • Be aware of and ensure that biosecurity issues are appropriately covered in the application as a potential effect of the development, including any mitigation and/or compensation activities (such as restoration plantings). • Chytrid fungus management documents are available from DOC (DOCCM-214757). Appendix 6. • Rainbow (plague) skink management advice is available in a DOC fact-sheet http://www.doc.govt.nz/conservation/threats-and-impacts/animal-pests/animal-pests-a-z/rainbow-skinks/	❖ Ensure that restoration plants are sourced from a 'clean' nursery (i.e. one that recognises and manages biosecurity risks). ❖ Ensure that machinery, boots, clothing and other gear are free from loose soil and seeds. ❖ Use chytrid fungus protocols when moving to and from indigenous frog sites. (DOCCM-214757). See Appendix 6. ★ In some cases, a Biosecurity Management Plan (BMP) may be required, especially if lizard or frog species are present or potentially present over the activity area. The BMP should include, but not be limited to, methods for avoiding and minimising biosecurity threats and provide detailed contingency plans in case, despite best efforts, planned actions fail.
4. Changes in predation pressure through predator and prey guild changes.	• Some habitat removal and disturbance can alter the dynamics of predators in a way that disadvantages lizards and frogs. As an example, removal of indigenous vegetation cover in an agricultural setting may improve conditions for rabbits that then support higher predator numbers. Removing rabbits or making habitat less suitable for them may cause their hungry predators to prey more on lizards or frogs, i.e. 'prey-switching'. Predator-prey dynamics are complex and generally impossible to quantify in terms of potential and actual effects on indigenous lizards and frogs. • Changing grazing regimes can affect the complement of predators at a site, e.g. removing grazing may increase rodent numbers, while increased grazing pressure may remove rank grass previously supporting lizards. • Lizard and frog populations on the mainland are often limited by lack of the sort of habitat that can keep them safe from predators and/or extremes of climate. • Quality of over-wintering habitat is very important for lizards in cold climates, as individuals cannot 'move' to a new spot if they get it wrong. Over-wintering herpetofauna are vulnerable to introduced mammalian predators (e.g. mice, rats, cats). • Opening up of habitat can create new pathways for predators (e.g. feral cats in dense tussock and mustelids moving along new roads).	• Context is important: seek ecological advice from experts on the importance and likely significance of changes in predator numbers and species composition that could arise from the proposed activity. • Predator effects tend to flow on from habitat removal but may not manifest immediately, or even within the life of the project. • Seek advice on the potential for this effect (potential effects are relevant for RMA applications), and the level of stringency that needs to be applied to mitigation. • The scale of the project and herpetofauna taxa involved will ultimately determine the level (e.g. single or multi-specific) and scale of pest control operations required. Seek expert advice.	❖ For sites where lizards and/or frogs occur, predator control may be required, with predator and/or lizard or frog monitoring, to help determine the extent and likelihood of predator changes impacting on the species. ❖ Monitor both pests and lizard or frogs concurrently to elucidate and understand trends. ❖ Consider leaving light sheep grazing in place at some sites, to minimise impact of grass seeding or mast seeding of *Chionochloa* species. ★ When there are residual effects that need to be addressed following the successful implementation of a mitigation package, compensation maybe required to make up for habitat and/or population loss to achieve no net loss overall in lizard or frog habitat values.

Continued on next page

Table 2 continued

POTENTIAL EFFECTS OF HABITAT REMOVAL AND/OR DISTURBANCE	EXPLANATION	GENERAL ADVICE (INCLUDING SIGNIFICANCE)	POTENTIAL CONDITIONS (❖) AND MITIGATION (★)
5. Population fragmentation and loss of viability of remaining fragments (including potential and future effects).	• There are many activities that can result in the fragmentation of lizard or frog habitat and introduce barriers to natural dispersal and contact with other populations, e.g. new roads, canals and rail tracks, agricultural development, and factors that render linkages hostile to the lizard or frog species wishing to disperse through them, e.g. mowing, irrigation, roads, canals, predators. • Development may not only affect the area subject to the proposal, but after the development is completed, remaining habitat remnants and the wildlife populations within them may no longer be viable.	• The effect of habitat fragmentation on indigenous lizards and frogs is difficult to quantify, and therefore it can be difficult to attribute an appropriate level of mitigation to this particular effect. There is, however, a large volume of robust literature indicating the deleterious implications of habitat fragmentation and therefore this effect should not be overlooked. • Depending on context, habitat fragmentation can be a highly significant effect. • Habitat fragmentation and its consequences to the long-term viability of populations, is a valid 'potential effect' under the RMA.	❖ DOC will expect higher levels of avoidance for Threatened, At Risk or Data Deficient species and their habitats. ❖ Development activity should be positioned to avoid population and habitat fragmentation. Work with the general principle that one large remnant is better than many small ones. ❖ Linkages that are safe for dispersing animals should be retained in perpetuity from further development. ★ Frog underpasses, predator control to assist linkages, artificial corridors and 'stepping-stone' areas; drift fences to orientate dispersing lizards and frogs to safe passageways and plantings and/or habitat creation to re-connect habitats all need to be considered. ★ When there are residual effects that need to be addressed following the successful implementation of a mitigation package, compensation maybe required to make up for habitat and/or population loss to achieve no net loss overall in lizard or frog habitat values.
6. Contribution to a cumulative loss of habitat (vegetation and/or retreat sites) and/or populations over a particular landform or Ecological District.	• Effects from this activity may not be highly significant in isolation, but when considered in combination with other activities and their effects (both like and unlike effects) over the ecological district or another relevant geographic extent, the cumulative effects maybe significant enough for DOC to require more stringent conditions and mitigation than if the effects from this activity were considered alone.	• Cumulative effects may seem unfair to the developer who may have the view they are being 'penalised' for developments that have gone before. However, the inclusion of cumulative effects is valid (Section 3 of the RMA 1991) and paying attention to the existing or receiving environment is part the development approval process under the RMA. As such, when reviewing an application, it is wise to ensure the effects arising from the activity documented in the application are considered in the context of other effects that have impacted on the same value within an appropriate geographic extent. • Significance of cumulative effects depends on the context of the proposal; should the proposal contribute to the cumulative degradation of habitat and potential habitat of a lizard or frog species, the effect is likely to be highly significant.	❖ A robust assessment of the 'necessity of the proposed development works' on this landform and/or within this ED should be carried out for proposals affecting habitats and potential habitats of protected species. ❖ For individual effects, see Effects 1–5 and 7–9 in this table for suggestions.

Continued on next page

Table 2 continued

POTENTIAL EFFECTS OF HABITAT REMOVAL AND/OR DISTURBANCE	EXPLANATION	GENERAL ADVICE (INCLUDING SIGNIFICANCE)	POTENTIAL CONDITIONS (❖) AND MITIGATION (★)
7. Effects on habitat quality within or nearby the activity area.	• Forestry management operations can cause siltation of streams within which indigenous frogs live and breed; these operations can cause downstream effects that can be temporary, intermittent or permanent. • Dams flood habitat, causing displacement and death of lizards and/or frogs. The fate of displaced lizards needs consideration. Displacement may negatively impact individuals by forcing them to face novel inter- and intraspecific competition, at least in the short-term. Displacement may lead to death. • Exotic afforestation can cause shading, death of lizard food plants and clogging of rock crevices. • Effects of irrigation on lizard or frog populations are poorly understood. • Introduction of grazing at a site can affect habitat quality and reduce cover; in some instances, grazing can assist herpetofauna by lessening rodent numbers (see Effect 4). • Urbanisation of areas adjacent to sites known to support protected lizards or frogs may degrade habitat quality long term (e.g. by exposure to light and glare and noise, or influx of predators such as cats), and may result in habitat fragmentation.	• Significance of effects depends on the context of the proposal. Effects can occur both within and beyond the activity area. • Effects are generally permanent and therefore significant for lizard and frog species.	❖ Avoid, if possible, habitat or potential habitat for Threatened, At Risk or Data Deficient species. ★ At mainland sites, a possible mitigation to address habitat and/or population loss is installation of refuges (artificial or natural) and or the creation of new habitat of at least the same quality and quantity as what is lost, in areas protected from further development in perpetuity – see Appendix 2. ★ At some sites, control and removal of woody weeds can form part of a mitigation package. ★ When there are residual effects that need to be addressed following the successful implementation of the mitigation package, compensation maybe required to make up for habitat and/or population loss to achieve no net loss overall in lizard or frog habitat values.
8. Irreversible alteration of habitat, soils or ecosystem.	• This effect can apply to areas where the development or activity site is altered to the point that remediation, post-development, cannot restore the indigenous lizard or frog habitat to the same quality as was present pre-development, e.g. open cast coal-mine or quarry areas.	• Complete removal of lizard or frog habitat at a development or activity site that supports protected species, particularly Threatened, At Risk, and Data Deficient species, is highly significant. • Soils and vegetation provide for shelter and food for lizards and frogs; changes to these components at a site affect these animals in ways that cannot be easily quantified. • Assume pre-development habitat is optimal unless research can demonstrate otherwise (use precautionary principle). • This effect is highly significant if the activity site contains, or has the potential to contain, threatened species.	❖ Avoid, if possible, all activity in habitat or potential habitat of threatened species and minimise all activities in habitat or potential habitat of all protected species. ★ At mainland sites, a possible mitigation to address habitat and/or population loss is installation of refuges (artificial or natural) and or the creation of new habitat of at least the same quality and quantity as what is lost, in areas protected from further development in perpetuity – see Appendix 2. ★ At some sites where woody weeds have invaded and shaded otherwise suitable habitat, control and removal of woody weeds can make available additional habitat as part of a mitigation package.

Continued on next page

Table 2 continued

POTENTIAL EFFECTS OF HABITAT REMOVAL AND/OR DISTURBANCE	EXPLANATION	GENERAL ADVICE (INCLUDING SIGNIFICANCE)	POTENTIAL CONDITIONS (❖) AND MITIGATION (★)
			★ When there are residual effects that need to be addressed following the successful implementation of the mitigation package, compensation maybe required to make up for habitat and/or population loss to achieve no net loss overall in lizard or frog habitat values. Offsite compensation will form a major component of the mitigation package.
9. Accidental poisoning (pesticide/herbicide use)	• Herbicides can be used to clear a site and/or as part of site maintenance and/or maintaining mitigation plantings post-development. • More work is needed to understand which pesticides and herbicides are of concern and in what circumstances and concentrations. • Many toxins are used in New Zealand on private land. Lethal and sub-lethal effects (e.g. reduced activity and fertility in lizards and frogs) may result. Sub-lethal effects are hard to measure but could be potentially critical for long-lived New Zealand species (see Appendix 7).	• Higher level of caution for threatened lizard or frog species. • Do not use baits attractive to lizards, e.g. apple, fish-based baits. • Avoid the use of herbicides in frog habitats.	❖ For habitat of protected species use targeted (spot-spraying) rather than blanket herbicide application methods. ❖ For habitat of threatened species use hand tools, if possible, to clear vegetation around plantings post-development. ❖ For toxins likely to be used repeatedly, a higher level of caution is required in selection of chemicals to be used. ❖ Avoid chemicals with known toxic effects, including additives (e.g. surfactants).

4. References

Bishop, P.J.; Daglish, L.A.; Haigh, A.J.M.; Marshall, L.J.; Tocher, M.D.; McKenzie, K.L. 2013: Native frog (*Leiopelma* spp.) recovery plan, 2013–2018. *Threatened Species Recovery Plan 63*. Department of Conservation, Wellington. 39 p.

Carpenter, J.K.; Monks, J.M.; Nelson, N. 2016: The effect of two glyphosate formulations on a small, diurnal lizard (*Oligosoma polychroma*). *Ecotoxicology 25(3)*: 548–554.

Chapple, D.G.; Ritchie, P.A.; Daugherty, C.H. 2009: Origin, diversification, and systematics of the New Zealand skink fauna (Reptilia: Scincidae). *Molecular phylogenetics and evolution 52(2)*: 470–487.

Cree, A. 1985: Water balance of New Zealand's native frogs. Pp. 361–371 in Grigg, G.; Shine, R.; Ehmann, H. (Eds): Biology of Australasian frogs and reptiles. Surrey Beatty in association with The Royal Zoological Society of New South Wales. Chipping Norton, NSW.

Cree, A. 1989: Relationship between environmental conditions and nocturnal activity of the terrestrial frog *Leiopelma archeyi*. *Journal of Herpetology 23*: 61–68.

Cree, A.; Tyrrell, C.L.; Preest, M.R.; Thorburn, D.; Guillette, L.J. 2003: Protecting embryos from stress: corticosterone effects and the corticosterone response to capture and confinement during pregnancy in a live-bearing lizard (*Hoplodactylus maculatus*). *General and Comparative Endocrinology 134(3)*: 316–329.

Crossland, M. 2006: Review of evidence for negative impacts of poison-based mammalian pest control operations on native frog populations. Waikato Conservancy, Department of Conservation, Hamilton (unpublished). 12 p.

DOC (Department of Conservation) 2013: Native frog hygiene and handling protocols. Department of Conservation, Wellington (unpublished). 2 p. (Docdm-1236812)

DOC (Department of Conservation) 2020: Reducing the impacts of development on New Zealand lizards: guidance for developers, consenting authorities and ecologists/herpetologists. Department of Conservation Lizard Advisory Group, Wellington. 18 p.

DOC (Department of Conservation) 2019 (a): Key principles for lizard salvage and transfer in New Zealand. Department of Conservation Lizard Technical Advisory Group, Wellington. https://www.doc.govt.nz/get-involved/apply-for-permits/interacting-with-wildlife/applying-to-develop-land-with-native-lizards-and-frog-species/

DOC (Department of Conservation) 2019 (b): Template for producing a lizard management plan. Herpetofauna Technical Advisory Group. Department of Conservation Lizard Advisory Group, Wellington. https://www.doc.govt.nz/get-involved/apply-for-permits/interacting-with-wildlife/applying-to-develop-land-with-native-lizards-and-frog-species/

Hitchmough, R.; Anderson, P.; Barr, B.; Monks, J.; Lettink, M.; Reardon, J.; Tocher, M.; Whitaker, T. 2013: Conservation status of New Zealand reptiles, 2012. *New Zealand Threat Classification Series 2*. Department of Conservation, Wellington. 16 p.

MfE (Ministry for the Environment) 2007. Protecting our Places: Information about the Statement of National Priorities for Protecting Rare and Threatened Biodiversity on Private Land. http://www.doc.govt.nz/Documents/getting-involved/volunteer-or-start-project/funding/biodiversity-funds/protecting-our-places-priorities-detail.pdf

Newman, D.G.; Bell, B.D.; Bishop, P.J.; Burns, R.J.; Haigh, A.; Hitchmough, R.A. 2013: Conservation status of New Zealand frogs, 2013. *New Zealand Threat Classification Series 5*. Department of Conservation, Wellington. 10 p.

Nielsen, S.V.; Bauer, A.M.; Jackman, T.R.; Hitchmough, R.A.; Daugherty, C.H. 2011: New Zealand geckos (Diplodactylidae): cryptic diversity in a post-Gondwanan lineage with trans-Tasman affinities. *Molecular Phylogenetics and Evolution 59(1)*: 1–22.

Perfect, A.J.; Bell, B.D. 2005: Assessment of the impact of 1080 on the native frogs *Leiopelma archeyi* and *L. hochstetteri*. *DOC Research & Development Series 209*. Department of Conservation, Wellington. 58 p.

Weir, S.M.; Yu, S.; Knox, A.; Talent, L.G.; Monks, J.M.; Salice, C.J. 2016: Acute toxicity and risk to lizards of rodenticides and herbicides commonly used in New Zealand. *New Zealand Journal of Ecology 40(3)*: 342–350.

Weiser, E.L.; Grueber, C.E.; Jamieson, I.G. 2013: Simulating retention of rare alleles in small populations to assess management options for species with different life histories. *Conservation Biology 27(2)*: 335–344.

Appendix 1

Deciding whether the area of a proposed development has potential lizards habitats

As mentioned in section 3, for development proposals affecting public conservation land generated under the Conservation Act (1987), Wildlife Act (1953), Resource Management Act (1991), Crown Minerals Act (1991), Land Act 1948 and provisions of the Crown Pastoral Land Act 1998, DOC seeks to protect habitat for all indigenous lizard and frog species, in line with National Priority 4 of **the Statement of National Priorities for Protecting Rare and Threatened Biodiversity on Private Land** ('To protect habitats of acutely and chronically threatened indigenous species'; MFE 2007). Given that the presence of lizards and frogs can be difficult to ascertain without time-consuming, weather-dependent surveys, where the habitat is continuous with the development area or has likely linkages with other known habitat, a precautionary approach should be taken by assuming the development area also will contain the same species as nearby.

Protection of potential habitat for indigenous species will not always be an appropriate mitigation approach, as it is not always possible to ascertain exactly how much potential there is for a particular area of habitat to be occupied by various species. The likelihood of a patch of habitat having the potential to contain a particular species increases if:

- that species was known to occur at the site historically; and/or
- the species is known to be present, or was present over the last 20 years in an adjacent habitat patch where likely linkages still exist i.e. the species in question is capable of moving between the habitat patch in question and adjacent areas; and/or
- the species is known to be currently present in a habitat patch continuous with the habitat patch in question; and/or
- the species uses the same or similar habitat for shelter and/or food and/or basking and/or as stepping-stone habitat nearby (e.g. within 5 km).

Appendix 2

Creation of artificial habitat, enhancement of existing habitat and pest control

New Zealand herpetofauna are characterised by relatively slow rates of population increase due to their slow development to maturity and low reproductive output. As a result, predator pressure suppresses native lizard and frog populations in most places where predator control is not carried out (which is most of New Zealand). Predator control can allow lizard and frog populations to expand and reach carrying capacity, but only where control is permanent, on-going and targets all pests (including mice). However, proponents of development projects are often reluctant to undertake predator control in perpetuity. Given that the loss of frog or lizard values over a development footprint is permanent, relying on short-duration predator control as a mitigation tool will usually 'short-change' the lizard or frog habitat values of a development site and its surrounding area. Also, there is much uncertainty around the fate of lizard populations that have been allowed to reach higher densities through predator control, when the predator control is reduced or ceases at the end of the agreed timeframe of a development project. Cumulatively, on-going developments that 'short-change' lizard or frog populations will contribute to a net loss of New Zealand lizard and frog habitats and numbers.

Creation of new, safe habitat is a recently attempted approach that aims to enhance mainland sites and to increase long-term carrying capacity for lizard and frog species, but it has not been tested nor is there any certainty that the objectives are being achieved. Predator control is sometimes used in combination with habitat creation over a short period of time (typically 3–5 years), as it is assumed that short-term pest control will support the establishment of lizards/frogs translocated into the newly-created habitat and/or inflow of individuals from nearby sites. The assumption that this approach works has not been demonstrated.

Creating 'new' habitat involves augmenting areas of existing habitat in one or more of the following ways:

- provision of suitable and permanent cover that provides physical protection from predators (e.g. deep rock piles (Fig. A2.1), logs or layered spiny scrublands and vines),
- plantings of eco-sourced plants; translocation of trees, laying out slash and debris (including boulders) from the development site that provide microclimates and food sources suitable for target lizard species or, more likely,
- a combination of these methods.

For any particular development and/or mitigation site, there would need to be assurance that proposed augmentation method(s) will be successful in supporting all species of salvaged lizards or frogs in the long-term. Effectiveness of augmentation has not been tested for New Zealand

Figure A2.1. A. Rock stack constructed for skink species at Orokonui Ecosanctuary, Dunedin. *Photo: Elton Smith, Orokonui Ecosanctuary*. B. Otago skink (*Oligosoma otagense)* on rock pile, Orokonui Ecosanctuary. *Photo: Shellie Evans*.

herpetofauna and is therefore risky. Trialling proposed augmentation approaches or detailed investigation is recommended prior to a development commencing. At some sites where, depending on the lizard or frog species present, salvage and transfer actions may not be justified and especially if the species have the capacity for unassisted migration and have unaffected source populations nearby, it may be possible to establish new or enhanced habitat adjacent to the development footprint so the lizards can migrate naturally into it.

Human-made lizard habitat on the Taranaki coast used stacks of broken concrete which were colonised almost immediately by Tamatea/Kupe skinks (*Oligosoma* aff. *infrapunctatum* "southern North Island" (D. Caskey, Taranaki Regional Council, pers. comm., March 2014; Fig. A2.2). Within 1 year, healthy lizard populations consisting of a range of size-classes were present at the site, although it was not clear whether resident animals moved away from less-attractive areas and into the stacks, or whether the new habitat provided an opportunity for expansion and an overall increase in the area's population. It was subsequently decided that the size of each concrete stack was too small to prevent their eventual complete covering by rank grasses and weeds, and the long-term effects of this occurring have not been determined (D. Caskey, Taranaki Regional Council, pers. comm., March 2014).

Figure A2.2. A. Freshly stacked human-made (brocken concrete) skink habitat in rough pasture, south Taranaki Coast. Tamatea/Kupe skinks (*Oligosoma* aff. *infrapunctatum* "southern North Island") self-introduced into these new sites within a few months. B. The stacks were fenced from grazing stock, which resulted in them becoming completely covered in rank grass. What effect, if any, this has had on the lizards has not been determined. *Photos: Dean Caskey, Taranaki Regional Council.*

The type of habitat created needs to be designed for both the targeted species and the local environment. For example, southern grass skinks (noting that there are five different species in this group) may benefit from the creation of deep (≥ 1 m) habitat/rock piles and rank grass. Deep habitat, with minimal soil incorporated throughout it, will help to maximise resilience of the habitat to weed invasion (which could ultimately make the habitat unsuitable). In contrast, rock piles created for 'lizard habitat' in the Auckland Region quickly become colonised by the unwanted plague skink (*Lampropholis delicata*), whereas large piles of woody debris (e.g. logs, log discs; Fig. A2.3) form habitat that is readily colonised by native skinks. These varied results indicate how much is still unknown about the issue of creating new or improved habitat for lizards and frogs, and that proposals to use such measures for mitigation require considerable research and lead-in time.

The use of mulch, bark and woodchip in re-vegetation areas designed to create or enhance lizard habitat should be avoided. These types of ground covers maintain open spaces between plants, inhibit the growth of vegetation mats often relied upon by lizards for cover, reduce and often inhibit the re-establishment of invertebrate communities that provide important food resources for lizards and, ultimately, exclude the establishment of lizard communities from these areas for months or even years (i.e. until the woodchips decompose). Small amounts of woodchip may only be used around the bases of new plantings if required for weed suppression.

Figure A2.3. A. Fresh log stack for lizard mitigation. *Photo: Elton Smith, Orokonui Ecosanctuary*. B. Log stack and log rounds for lizard mitigation after 6 months. *Photo: Elton Smith, Orokonui Ecosanctuary*.

Herbaceous plants or weeds should generally be allowed to grow up between plantings or created habitat, as these provide temporary refuge for the lizards during native plant establishment. Small herbaceous weeds will quickly become shaded out by the growing plants. Invasive pest plants and those that directly inhibit the establishment of plantings should be regularly managed via spot spraying or hand-removal.

Appendix 3

Best practice principles for lizard and frog salvage and transfer

The document 'Key principles for lizard salvage and transfer in New Zealand' (DOC 2019 https://www.doc.govt.nz/get-involved/apply-for-permits/interacting-with-wildlife/applying-to-develop-land-with-native-lizards-and-frog-species/) provides detailed guidance on lizard salvage. The following key principles are summarised from this document. While these principles apply to lizards, the concepts could also be applied to frogs.

Principle 1: Assessment of lizard species and site significance is required.

Principle 2: Assessment of actual and potential effects and their significance is required.

Principle 3: Consideration of alternatives is imperative.

Principle 4: Threatened species require more careful consideration.

Principle 5: Salvage and transfer must use the best available methodology.

Principle 6: Receiving site and its carrying capacity must be suitable.

Principle 7: Monitoring is required to ascertain success.

Principle 8: Reporting is required to allow improvements and to communicate outcomes.

Principle 9: Compliance and contingency are required when methods fail.

Appendix 4

Genetic structuring within lizard species

Many lizard species in New Zealand display strong geographic genetic structuring; i.e. there are clusters of genetically distinct populations in different geographic areas within the range of many individual species. Genetic structure should be preserved as far as practicable because the current geographic distribution of a species, and the phenotypes observed, mask underlying genetics that result from important evolutionary processes. There are demonstrated benefits in protecting genetically distinct populations (Weiser et al. 2013) even if they are small and difficult to detect – they add to the robustness and diversity of the wider population – and they may be more suited or adapted to local environmental conditions. They may also have unique features not found over the rest of the species' range (e.g. the dimorphic population of the forest gecko, *Mokopirirakau granulatus*, on the Denniston Plateau).

Various terms are in common usage in the literature to describe populations of a genetically structured species: terms include 'management unit' (MU), which are units of larger 'Evolutionary Significant Units' (ESUs), genetic stocks, populations, subpopulations and metapopulations (a 'population of populations', each of which interact at some level). Mixing of ESUs and of populations should be avoided to maintain the genetic integrity of all populations. To avoid mixing ESUs when developing proposals that involve moving lizards from one place to another, the following principles should be applied:

Wellington green gecko (*Naultinus punctatus*). Photo: Leon Berard.

- Freely mix populations that are now artificially isolated, but which would previously have been part of the same contiguous and more widespread population (e.g. Wellington green geckos (*Naultinus punctatus*) from different native vegetation remnants in the Wellington area).
- Freely mix genetic stocks to restore modified or changing environments or for introductions into novel environments (e.g. Cook Strait and northern populations of tuatara (*Sphenodon punctatus*) could, hypothetically, be mixed for reintroduction to the central North Island).
- Occasionally mix subpopulations that would previously have been linked by intermittent gene flow in a metapopulation structure (e.g. western populations of Otago skink, *Oligosoma otagense*, from different locations in the Lindis Pass area). Excessive mixing may mean loss of local population structure including possible local adaptations. However, movement of small numbers of animals from time to time may be used to mimic the rare natural dispersal between populations that would have occurred when the habitat was more intact.
- Do not mix populations that have remained separate over an evolutionarily significant length of time[3] (tens of thousands or more years, e.g. eastern and western populations of Otago skinks). An exception to this rule would be if it was the only way to rescue a genetically compromised population (e.g. supplementation of a remnant population that was showing signs of inbreeding depression).

[3] Key references are Chapple et al. (2009) for skinks and Nielsen et al. (2011) for geckos.

Sometimes there will be doubt about the genetic status of a population and its appropriateness as a source for lizard translocations; in such instances genetic confirmation is needed. If there is an existing remnant population at a release site, its morphology and genetics need to be compared with those of the source population for a translocation. A close match is needed in these circumstances. More often there will be no existing remnant population, in which case this matching process is less critical. However, it is still beneficial to match the population that was previously present as closely as possible, as this population will have been adapted to the local conditions. Tail tips can be taken (following the DOC Standard Operating Procedure for lizard genetic sampling) to determine the population's relationship to other populations of the species and, ultimately, to inform decision-making. In the absence of robust genetic data, a source population should be the closest population to the release site. If there remains some uncertainty, then we advocate using the precautionary principle and not undertake the translocation unless there is a clear conservation priority for the species.

Appendix 5

Constraints of the BIOWEB Herpetofauna Database

The Bioweb Herpetofauna Database is a useful place to find information on lizards. External parties, however, have only limited access due to concerns about locational data being used by poachers. Request data using the following form: https://www.doc.govt.nz/our-work/monitoring-reporting/request-monitoring-data/.

Data extracted from the Bioweb Herpetofauna Database requires careful interpretation, as some species records are now known to represent multiple species – each with a different threat status – or species with subpopulations that are considered very important (in a conservation sense) for ensuring long-term persistence of species and genetic diversity. The Bioweb Herpetofauna Database does not always capture important subpopulation information and extracted data must always be reconciled against the most recent threat classifications, which are based on the most up-to-date information on these entities. To ensure that any assessment of lizards is robust, check the species threat status on https://nztcs.org.nz/ which is the most up-to-date authority with which to reconcile Bioweb Herpetofauna data. It is not considered best practice to rely only on Bioweb Herpetofauna Database records when assessing lizard values and site significance.

Appendix 6

Indigenous frog hygiene and handling protocols (from DOC 2013)

These guidelines outline the hygiene requirement needed for any person authorised (permitted) to handle native frogs under the Wildlife Act, 1953 (i.e. herpetologists and their supervised assistants). Following these protocols is essential for any person working in frog habitat as it minimises the risk of human-assisted disease transmission and these protocols are suitable for any activity requiring frog handling (including, but not limited to, activities associated with mitigation or vegetation clearance).

Background

Over the past 25 years, amphibian populations have declined throughout the world and disease, in particular the amphibian chytrid fungus, is considered to play a major role in this decline. Given the risk of the fungus and other diseases being transmitted to and between our native frog populations, strict hygiene and handling protocols are required to ensure their safety. This document provides information on how to:

- Minimise any possible spread of the amphibian chytrid fungus and other pathogens.
- Avoid artificially increasing contact between frogs.
- Achieve the highest level of hygiene protocol that is effective and practical in the field.
- Safely handle frogs for any purposes.
- Principles
- Transmission risk can be managed/reduced through good hygiene practices.
- New or disinfected equipment and footwear should be used at every new population.

What should I do before entering known frog habitat?

Before you enter known frog habitat, ensure all your footwear, gaiters and equipment are clean, e.g. free of dirt or mud and dry. Footwear, gaiters and equipment must also be disinfected. You can ensure that your clothing and equipment is safe to take into frog areas by following simple hygiene protocols.

- Any equipment in direct contact with frogs should be new or disinfected before being used on a different frog, where practicable.

Site hygiene

- Remove all dirt and mud from footwear, gaiters and field equipment. Pay particular attention to field gear likely to come in contact with amphibians, soil and ground, freshwater, and/or that is already dirty (e.g. boot soles).
- Disinfect all field gear. Mud and dirt etc. must be cleaned off **clothing and equipment first** before it is disinfected.
- Wash and **dry** everything. This is **particularly important**; chytrid fungus cannot survive drying out, so it is very important that cleaned items are dried.
- Store gear in a clean dry area away from soil to avoid recontamination.
- If you have been to an area infected with the amphibian chytrid fungus **you must clean and disinfect all your gear**. Note: the more common introduced Australian frog species found in New Zealand can also be infected with chytrid fungus, so any field site should be regarded as a potential source of infection, not just known habitats of native frogs. Gear must also be cleaned between each field trip into the **same** indigenous frog area.

Tips

- Clean everything well before planned actions to allow time for clothes and equipment to be cleaned and completely dried out. Consider having multiple sets of high-use items if little or no time is available to clean and dry them between field trips.
- Wear different footwear when driving between areas and change into clean footwear at the point of entry into frog habitat.
- These hygiene protocols are subject to change in the event of new amphibian diseases emerging in New Zealand. Always check with your local DOC office for the most up-to-date hygiene information.

What disinfectant should I use for cleaning and how much?

Disinfection strategies for frog field studies (minimum times and concentrations) are provided in table A6.1. Trigene, Sterigene and Virkon and can be purchased from your local vet clinic.

Table A6.1. Disinfection strategies for frog field studies (minimum times and concentrations).

PURPOSE	DISINFECTANT	CONCENTRATION	TIME	PATHOGEN KILLED	RINSE REQUIRED
Disinfecting cloth (e.g. clothing, cloth bags)	Trigene	50 mL per 4.5 kg laundry load (do not use detergent, do not overfill)	Normal wash time	Chytrid ranavirus	Yes
	Hot wash and complete drying	60°C or greater	15 minutes	chytrid	No
Disinfecting footwear	Sodium hypochlorite (bleach)	1%	1 minute	chytrid	Yes
		4%	15 minutes	ranavirus	Yes
	Trigene	1%	1 minute	chytrid ranavirus?	Yes
	F10	1%	1 minute	chytrid ranavirus?	Yes
	Virkon (corrosive)	1:100	10 minutes	chytrid	Yes
Disinfecting collection equipment, instruments and containers	Sodium hypochlorite (bleach)	1%	1 minute	chytrid	Yes
		4%	15 minutes	ranavirus	Yes
	Trigene	1%	1 minute	chytrid ranavirus?	Yes
	F10	1%	1 minute	chytrid ranavirus?	Yes
	Ethanol	70%	1 minute	chytrid and ranavirus	Air dry
	Complete drying		3+ hrs	chytrid only	No
	Heat	60°C or greater	5 minutes	chytrid	No
			15 minutes	ranavirus	No
	Heat	37°C	4 hours	chytrid	No
	Sterilising UV light		1 minute	ranavirus only	No

Frog handling hygiene

- A new plastic bag or new powder-free nitrile gloves must be used for each frog when they are caught or handled. Within a local area (deemed as a continuous population) the same gloves may be used when for searching for frogs, but they need to be changed if they come into contact with a frog. It is important to ensure that new gloves are used when moving between areas. Also, if a frog displays signs of ill health or looks compromised in some way, make sure a separate glove is used to handle these individuals.
- Each frog should be housed in a separate plastic bag.
- For researchers working in indigenous frog habitat – please ensure all frog handling/measuring equipment that comes into direct contact with a frog is disinfected prior to its next use, both between frogs and between sites.
- Each frog must be weighed and measured in the plastic bag to reduce unnecessary contact.

- Ensure that frogs are kept cool at all times; in particular, avoid holding frogs in your hands to ensure their proper thermoregulation continues.
- Minimise handling times to reduce stress and to avoid the side effects of stress.
- Sick or dead frogs should be collected and held separately from all other frogs until delivered to the appropriate recipient. All equipment should be cleaned and disinfected after use.
- Although hind-leg handling is a common technique used while measuring and weighing other species of frogs, this technique must **never** be used with any indigenous frog (*Leiopelma*) species as it can cause injury.

If capture/recapture work involving photographing individual frogs is required:

- All stage platform covers must be sterilised with ≥ 70% ethanol, or surgical antiseptic wipes and air dried between frogs, between successive nights at the same site and between areas.
- The mirror stage must be disinfected with either 70% ethanol and then air dried, or disinfected with TriGene/Sterigene, rinsed thoroughly and then air dried, between sites.

If you find a sick or dead frog, please take it to or contact your local DOC office.

Appendix 7

Use of pesticides and herbicides and how these affect lizards and frogs

Little is known on the impacts of pesticides or herbicides to New Zealand indigenous lizards and frogs and more research is required (Bishop et al. 2013). Recent research undertaken in the United States on the western fence lizard (*Sceloporus occidentalis*) as a surrogate for New Zealand lizard species has shown that even very high doses of poisons administered to individuals did not result in their mortality, at least for the compounds tested (Weir et al. 2016). Some lizards did succumb, however, to high doses of Pindone and Trichlopyr, but it was considered that New Zealand lizards would be extremely unlikely to consume enough of either toxin, in nature, for it to be lethal. However, sub-lethal effects on lizards are still mostly unknown (Weir et al. 2016).

Glyphosate-based herbicides contain additives, surfactants in particular, that are actually more toxic than the glyphosate active ingredient alone. The effect of glyphosate on reptiles remain largely unknown. Recent work has shown that dermal exposure to commercial glyphosate formulations (e.g. Agpro Glyphosate 360 and Yates Roundup Weedkiller) has some effect on thermoregulatory behaviour (i.e. increased heat-seeking), but no significant impact on mass, in the northern grass skink (*Oligosoma polychroma*). Further research is needed to measure potential genotoxic and reproductive impacts of glyphosate exposure on terrestrial reptiles and understand their long-term effects at the population, or even species, level (Carpenter et al. 2016).

No correlation has been found between 1080 use and decline in Archey's frog (Perfect & Bell 2005; Crossland 2006).