Research Report
Urban Lizards

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restoring indigenous nature in urban environments

Understanding New Zealand's Urban Lizards

Raukawa gecko

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Background

New Zealand has an internationally renowned reptile fauna including tuatara and two highly diverse families of lizard: skinks and geckos (Chapple 2016). Due to the ecology of New Zealand (the absence of mammals, and its temperate climate), New Zealand lizards evolved unusual life history characteristics including high rates of nocturnal, slow breeding, and live-bearing species (Chapple 2016). While there are fewer records of reptile extinctions compared with birds, many species have suffered dramatic range contractions. Tuatara and some 37% of lizard species are currently restricted to offshore or mainland islands (Towns et al. 2001).

Key threats to New Zealand lizards are ongoing habitat loss and introduced predators, especially rats and mustelids. Some evidence also indicates that house mice, hedgehogs, and owned and unowned house cats may also pose a significant threat to populations (van Heezik et al. 2010; Jones et al. 2013; Norbury et al. 2014). Impacts of introduced predators, especially rats, have been well documented in studies of population recovery following rodent eradication on offshore islands. Less is known, however, about the impacts of predators in medium and low densities as might be maintained through control or suppression on the mainland. While some evidence suggests intensive pest control may be adequate in some cases (e.g., Reardon et al. 2012), in others, control has not been sufficient to prevent further decline of native populations (Hoare et al. 2007).

Little is known about urban lizard populations in New Zealand despite them being a key component of the native terrestrial fauna. Anecdotal and limited published research suggests that lizards are present in many cities, but how populations are faring is largely unknown. Given the relatively small home ranges of many species and the current interest in urban conservation and restoration, it is possible that urban environments, such as bush reserves and backyards, may provide opportunities for lizard conservation.

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Research Aims

The People, Cities and Nature lizard research programme aimed to build a greater understanding of lizards in cities to help inform urban restoration and wildlife management. Our research had three key questions:

Methods

Research aim 1

We reviewed knowledge about current and historical (pre-human) lizard faunas in six New Zealand cities: Auckland, Hamilton, Wellington, Nelson, Christchurch and Dunedin. Within a standardised urban area for each city, we searched for records of lizards in unpublished reports, published literature and records in the Department of Conservation Bioweb herpetofauna database.

To identify species that would have been present in the areas of cities prior to human colonisation we made inferences based on biogeographical classification of species and the proximity of historical species records (including fossil evidence) to the cities. The full methods for this review can be found in Woolley et al. 2019.

Research aim 2

We carried out pitfall trapping surveys in a range of urban habitats in four New Zealand cities: Hamilton, Wellington, Nelson and Dunedin. Habitats included reserves, amenity green spaces (such as cemeteries, parks, margins of transport infrastructure), and domestic gardens (Figure 1). We recorded species diversity and characteristics of skink populations, including density estimates and individual body measurements, and related them to habitat characteristics and pest mammal abundances (see urban mammals project) at study sites.

1

Distribution

- What is known about the current and historical distribution of lizards in New Zealand cities?
- What is the potential for conservation and restoration of urban lizard populations?

2

Habitat

- What urban environments are lizards inhabiting?
- How does lizard abundance relate to local mammalian predators and habitat complexity?

3

Management

- What can we do to best manage urban lizards?

Figure 1 Examples of three habitat types from Wellington City where skinks were found. a. bush reserve site (Scorching Bay Domain) that receives community planting and weeding and is adjacent to a native forest; b. amenity type site of scrub/grassland habitat next to the coast and a major road (Cobham Drive); c. unmanaged residential garden (Miramar) with a mixture of exotic and native vegetation; d. more highly managed residential garden (Karori) with mainly native species. Photos: C. Woolley.

Additionally, in Wellington we used a public sightings website to gather landscape-scale information about lizards. The distribution of these records was mapped and their occurrence analysed with respect to a range of environmental and socio-economic factors.

Findings

Research aim 1

Little research had been published about lizards in the six cities and the majority of records within the defined urban area came from theses, unpublished reports of salvage or biosecurity operations, as well as regional and national databases.

Comparing the current and historical faunas, we found that, although each of the cities has at least one currently urban-dwelling species, the diversity of lizards in all of the cities has declined dramatically since human colonisation (Figure 2). Patterns of species loss in cities reflect those observed across New Zealand more generally; that is, the loss of large-bodied skinks and geckos, likely resulting from predation by introduced mammals, as well as the loss of regionally endemic species.

This review also highlighted opportunities for lizard conservation in cities including reintroductions into predator-free sanctuaries, community restoration of urban reserves, and backyard conservation initiatives such as lizard-friendly gardening and pest trapping. Full results of this review can be found in Woolley et al. 2019.

Research aim 2

Four species of endemic skink were captured during surveys in urban habitats, copper skinks in Hamilton; northern grass skinks, copper skinks and ornate skinks in Wellington; northern grass skinks in Nelson; and southern grass skinks in Dunedin. Site occupancy and numbers of captures were highly variable among species and cities, with a very high proportion of sites occupied by skinks in Nelson and Wellington compared with Hamilton and Dunedin (Figure 3).

Modelling showed that more northern grass skinks were caught at sites with lower tracking rates for rats, but only when the proportion of grass cover was high. Higher proportions of urban land cover within 500 m was associated with poorer body

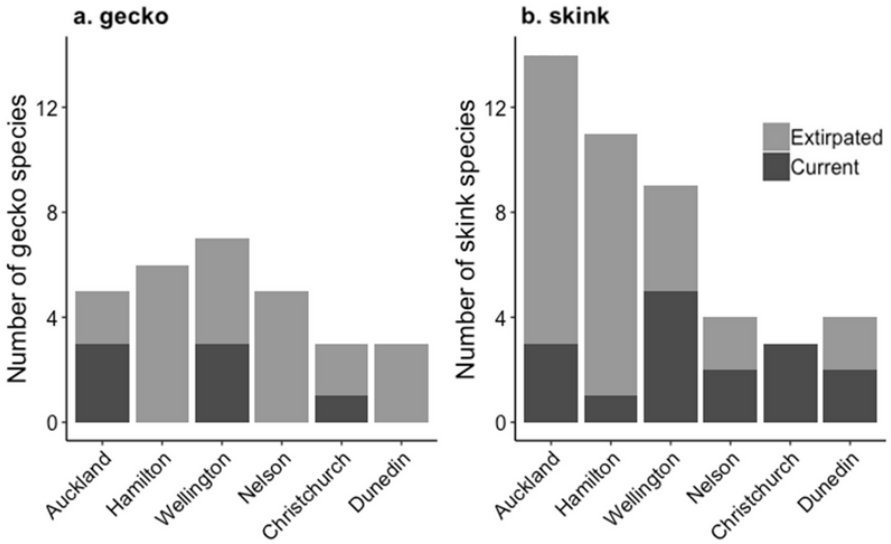


Figure 2 Variation in the number of species historically and currently present among the six urban centres for a. geckos and b. skinks. Total height of bar shows estimated number of historical species, dark grey the number currently present (within last 20 years) and light grey the number extirpated (lost from a city).

condition in northern grass skinks.

The public sightings website gathered more than 100 records from around the Wellington region over one summer, suggesting this may be a cost-effective solution to building knowledge about lizards in residential gardens that are otherwise difficult to survey. While skink sightings were reported from all over the city, gecko sightings appeared in clusters. Compared with the random sample of street addresses, both skink and gecko sightings were more common closer to forest land cover, and skink sightings were more common in backyards that were north facing.

Research aim 3

Our research has brought to light a number of knowledge gaps that require addressing to ensure that lizards, an integral part of New Zealand's fauna, remain present in cities. In the next section, we discuss how managers can build knowledge about urban lizards and what can be done to support existing lizard populations in cities, as well as opportunities for future research.

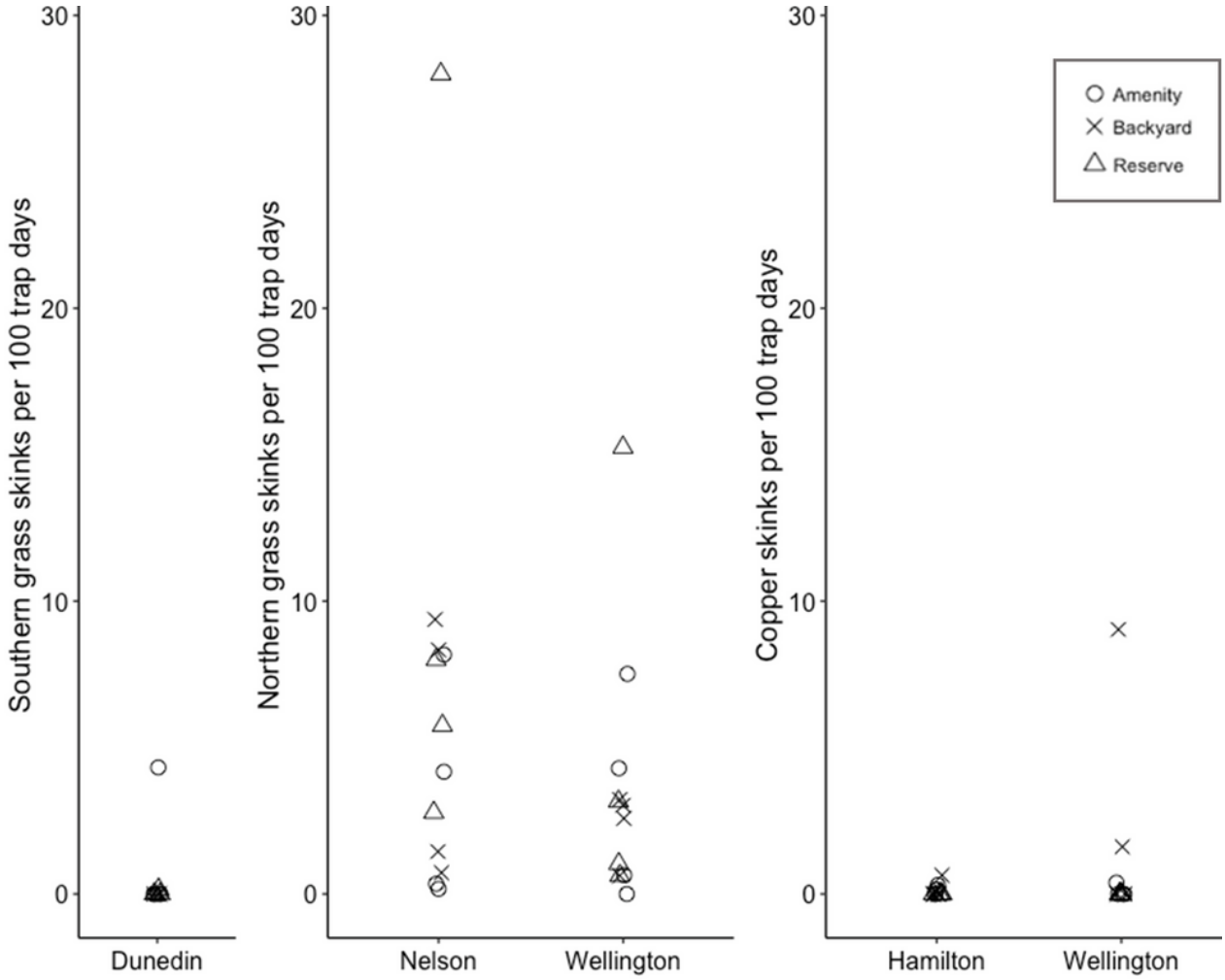


Figure 3 Number of a. southern grass skinks in Dunedin, b. northern grass skinks in Nelson and Wellington and c. copper skinks in Wellington and Hamilton caught per 100 trap days (e.g., rate of capture was greatest for northern grass skinks in a reserve site in Nelson). Ornate skinks were captured only twice at one backyard site in Wellington and so are not shown in figure.

KEY FINDINGS

1

Dramatic decline in lizard diversity across New Zealand cities since human colonisation

2

High urban land cover is associated with poor body condition in northern grass skinks

3

Public sightings can be a cost-effective solution to lizard monitoring in urban settings

Recommendations

How can we improve knowledge of urban lizard populations?

In light of the dearth of information about lizards in cities identified in the review, there is a **pressing need to build knowledge** about what species are occurring in cities, where they are present and which populations are vulnerable.

A good place for managers to **start building this knowledge is with broad-scale species occurrence** (Table 1: Question 1). While this type of information might seem trivial, it is lacking for many New Zealand cities, despite it being essential for protecting populations. In particular, it may help to protect lizards from habitat destruction and disturbance during urban development. Because all endemic lizards and their habitat are protected under the Wildlife Act (1953) and Resource Management Act (RMA, 1991), developers are required to mitigate the impacts of their activities on populations. However, due to the lack of knowledge about the locations of lizard populations, development in some jurisdictions takes place under the assumption that no populations are present. In addition to protecting populations that are at risk from development, **knowledge of where lizard populations occur could inform where more targeted, resource-intensive surveys and monitoring should take place in the future**.

Using a wide variety of data sources, it may be possible to gather broad-scale distribution data with a relatively low investment of resources. For many cities, much of this information may be available through surveys required under the RMA. This information could be supplemented with public-contributed records from iNaturalist or a purpose-built lizard citizen science project. While we trialled our public sightings website in backyards, such projects could be tailored to other urban

contexts by targeting contract gardeners working in public green spaces or community groups in urban reserves. Despite some limitations, **citizen science can be an effective method for gathering large-scale data about species distributions in cities** (Dickinson et al. 2010). The public sightings website recorded the presence of lizards at nearly 100 sites in Wellington over the course of one summer. Conducting expert lizard surveys in 100 backyards would have provided more detailed and potentially higher quality information (e.g., improved chance of recording cryptic species, greater certainty of species identification) and avoided limitations resulting from a lack of absence data, however, the time and financial cost of undertaking such surveys would likely have been prohibitive.

However, while opportunistic data may be able to identify broad-scale patterns of occurrence in urban habitats, in order to have confidence that species have not been overlooked, more intensive surveys are required. **Due to the cryptic nature of many New Zealand lizard species, it is possible that without intensive surveys and sustained effort, those whose populations are sparse may not be detected** (Hitchmough et al. 2016). Observations of lizards recovering from undetectable to detectable levels following predator eradication suggest that some species are able to persist at very low densities for extended periods of time (Bellingham et al. 2010; Morgan-Richards et al. 2016). The recent discovery of *O. ornatum* at a reserve in Hamilton illustrates that undetected populations of lizards can occur in urban settings (Pers. Comm. M. Nelson-Tunley, Waikato Regional Council 2020).

We therefore recommend that managers take a city-wide approach to lizard surveys that uses broad-scale data to identify locations for more resource-intensive surveys. These surveys should, at

Northern grass skink (*O. polychroma*) were the most commonly encountered species in the surveyed cities. This species occurs in Wellington and Nelson.

Processing (weighing and measuring) a skink.

least in some habitats, be sustained for long periods and use a wide range of tools capable of detecting the full suite of potential lizards. Due to the cost of such surveys, potential sites for this work should be prioritised based on previous knowledge of species occurrence, the quality of the habitat they offer for lizards, or where efficiencies can be found with other biodiversity work occurring in a city.

Management of urban lizards relies not only upon knowledge of where populations exist however, but also their viability over time. While characteristics such as abundance and body condition may be able to provide an indication of population health (Hoare et al. 2007; Moore et al. 2007), in order to confidently prevent future loss of species from cities, an understanding of population trajectories is required. Predation by introduced mammals can cause slow declines in lizard populations (Hoare et al. 2007). It is possible that some populations in cities are declining and, as a result, some species may be at risk of being lost. We therefore recommend that, in addition to surveys, long-term monitoring programmes should be established for representative lizard populations in a range of urban habitats (Table 1: Question 2). Such monitoring programmes could target species whose capture rates are found to be low during surveys (e.g., *O. ornatum* in Wellington).

Table 1: Range of methodologies available for gathering different types of information at different scales about lizards in cities

Question	Type of information	Management use	Spatial scale/ ecological unit	Data sources	Level of investment required
Where do lizards occur in cities?	Presence of any lizard species	Understand distribution of widespread species	Landscape scale/ metapopulations of multiple species	One off observation Citizen science iNaturalist RMA survey report	Low: use of existing data or citizen science
	Presence of particular species	Identify vulnerable populations by limited range Understand value of reserve	Landscape scale/ metapopulations of multiple species	One off observation Citizen science iNaturalist RMA survey report	Low: use of existing data or citizen science (verified observations)
	Presence of sparse/low density populations	Identify vulnerable species that are rarely encountered	Reserve or patch scale/population	Lizard survey using methods capable of detecting	Medium: one-off survey by herpetologist
Which species or populations are vulnerable?	Abundance estimate	Identify vulnerable populations by small sizes	Reserve or patch scale/population	Indices from pitfall trap or artificial cover object surveys (e.g., CPUE)	Medium: one-off survey by herpetologist
	Population health and demography	Identify how individual characteristics relate to habitat	Reserve or patch scale/population or subpopulation groups	Recording morphometric data, marking animals to allow estimation of density or survivorship	Medium: one-off survey by herpetologist
	Population trends	Identify where population declines are occurring and in what species	Reserve or patch scale/population	Repeated surveys	High: repeated surveys by herpetologist

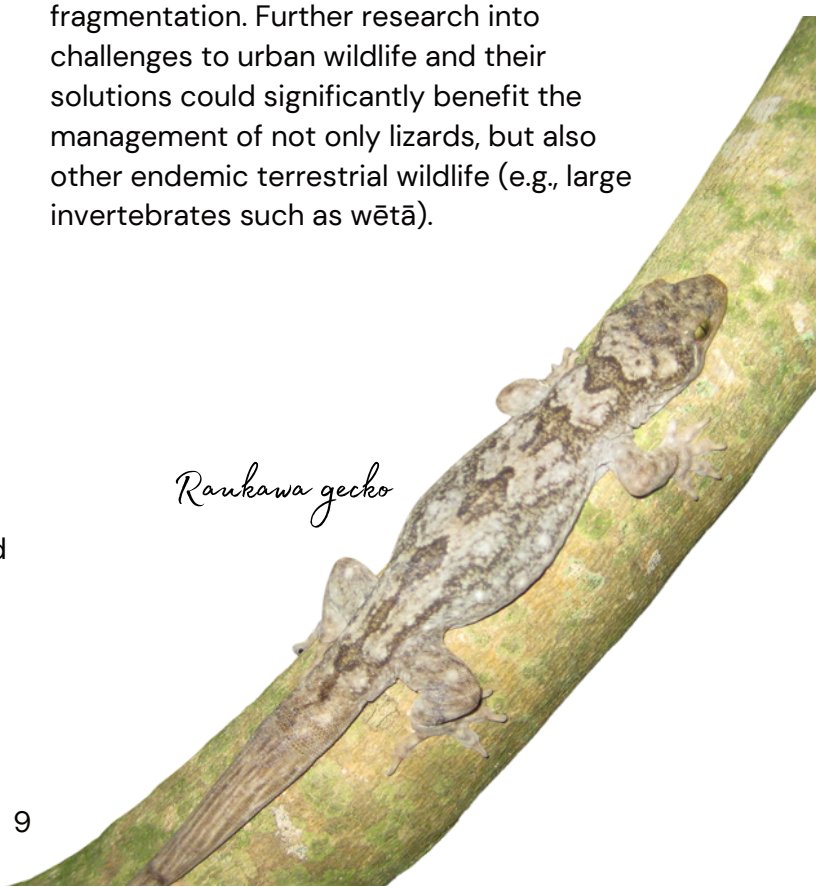
What can be done to support lizards in cities?

Due to the current lack of knowledge about lizards in cities, few strategies for managing urban lizard populations have been tested to date. However, if knowledge of urban lizard populations grows to allow the identification of population trends, population management may become necessary to ensure their persistence. **Potential tools that may be effective for management include predator control or elimination, and habitat enhancement.** These activities may be especially advantageous in cities due to the potentially large workforce available in engaged members of the public.

Managing the recovery of at-risk lizard species in non-urban habitats has relied heavily upon predator eradication, especially on offshore islands (Towns 1991; Newman 1994). In cities, a number of promising options for mammal control exist, including: **city-wide eradication** such as that proposed by 'Predator-free' initiatives (e.g., Predator-free New Zealand, Predator-free Wellington; Russell et al. 2015), **localised eradication such as in fenced ecosanctuaries** (Nelson et al. 2016), **and wide-scale suppression such as that commonly undertaken in urban reserves and, in some cities, backyards.** However, while eradication of predators on islands and in sanctuaries has been demonstrated to allow the recovery of lizard populations (Towns 1991; Nelson et al. 2016), evidence for the efficacy of mammal suppression or of eradication of only a subset of lizard predators (such as that proposed by Predator-free initiatives) is lacking (though see Reardon et al. 2012). Further research is needed to understand what impacts these may have on population recovery.

Another approach that has been proposed to support urban lizards is habitat enhancement. **Habitat enhancement involves the addition of natural or artificial components to the environment to provide conditions that increase individual survival and/or population viability** (Shoemaker 2007). For lizards, enhancements may provide an improved thermal environment, food resources, or refuge from predators. **Built rock piles** are a common enhancement used to provide habitat for lizards following mitigation translocation, with the idea that crevices between rocks may allow access to lizards but exclude larger predators (Towns 1996; Anderson et al. 2012; Lennon 2019). **Planting of some native species has also been suggested to provide food resources and cover from predation** (Auckland Council 2008; Department of Conservation 2018). However, the applied benefits of these strategies are yet to be demonstrated and further research is needed to test their efficacy (Lennon 2019).

In addition to the unknown efficacy of these management strategies, there is little known about other threats that may be more important in urban environments than non-urban areas of New Zealand. In particular, how disturbance by vehicles, green space maintenance or domestic animals may influence individual behaviour or survival, and what impact anthropogenic barriers to dispersal have for population fragmentation. Further research into challenges to urban wildlife and their solutions could significantly benefit the management of not only lizards, but also other endemic terrestrial wildlife (e.g., large invertebrates such as wētā).



Raukawa gecko

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