



Original article

Biodiverse residential development: A review of New Zealand policies and strategies for urban biodiversity

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ABSTRACT

Urban residential development is expanding globally to accommodate increasing housing demand, greatly impacting biodiversity and human wellbeing. Enhanced sustainability of these developments requires an integrated approach to conserving, supporting, and restoring biodiversity through the built environment and understanding the implications of residential development policies, regulations, and guidelines. This paper details a review of current New Zealand policies, strategies, planning documents, and design guidelines that inform urban design and planning at national, regional, and local levels. Three major gaps in biodiversity considerations and opportunities for improvement in residential developments were identified. Firstly, current policies and strategies tend to protect significant indigenous habitats, but the interventions required to improve or retain biodiversity in residential developments are not explicitly considered. Secondly, there is a need for design guidelines with explicit biodiversity outcomes. Thirdly, existing planning documents and guidelines do not account for biodiversity monitoring and management and could be amended to include biodiversity-related outcomes. We conclude that current New Zealand policies and strategies related to residential developments are inadequate and fail to recognise or encourage the enhancement of urban biodiversity in any meaningful way. Holistic and strategic ecosystem-based approaches are required to protect and enhance urban biodiversity and human wellbeing through the built environment to ensure that biodiversity continues to thrive in New Zealand cities and enrich the lives of urban residents.

1. Introduction

More than 50% of the world's population lives in urban areas, but in higher-income regions (such as North America and Western Europe), this proportion is closer to 80% (Ritchie and Roser, 2019). Urbanisation often occurs in areas where biodiversity is high and can directly cause the degradation and fragmentation of habitats (Ives et al., 2016; Nilon et al., 2017). Promoting biodiversity in cities can help to address many

of the challenges that face human populations in urban environments (Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019). For example, vegetation can moderate city heat-island effects and other climate change impacts (NASA, 2015; Pedersen Zari et al., 2022), and access to green space can provide numerous health benefits such as improved cognitive function and physical health (e.g., blood pressure) and enhanced social cohesion (Shanahan et al., 2016). Indeed, the Global Assessment Report on

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Biodiversity and Ecosystem Services by [IPBES \(2019\)](#) highlights the important role that nature-based solutions (which often include vegetation) have in helping cities achieve Sustainable Development Goals (SDGs) ([United Nations, 2015](#)). This raises the question: how can cities grow and densify while protecting and enhancing the health and resilience of both people and biodiversity?

Despite commonly-recorded negative relationships between human population density and indicators of biodiversity (such as tree cover; ([Tratalos et al., 2007](#))), many interventions and strategies can support urban densification while maintaining or enhancing biodiversity ([McDonald et al., 2023](#)); e.g., the addition of vegetated features such as green walls on buildings, vegetated roadsides, the use of bioswales and rain gardens for stormwater management, planting for ecological outcomes, and constructed wetlands. When applied at a landscape scale in a cohesive way, such 'green interventions' can support considerable biodiversity ([Filazzola et al., 2019](#)) and compensate to an extent for habitat fragmentation, degradation and loss ([Norton et al., 2016](#)).

In many cities, green interventions are applied in a piecemeal way, and rely on the interests and commitment of developers ([Hansen et al., 2023](#)). They can have a high initial installation cost, which is a potential barrier to their implementation if whole life cycle costs are not considered ([Hostetler et al., 2011](#)). This is where supportive policy, planning and regulations (building codes, by-laws, etc.) can make a difference. For example, [Irga et al. \(2017\)](#) assessed 100 city councils across Australia and found a positive correlation between the number of green walls and green roofs and the presence of local government green envelope policies. An international review of green roofs and green wall incentives by [Liberalesso et al. \(2020\)](#) found that the incentives for green roofs were primarily implemented as financial subsidies or mandated by law. The Cities and Biodiversity Outlook Report ([Secretariat of the Convention on Biological Diversity, 2012](#)) outlines actions and policies to increase urban biodiversity and ecosystem services for the numerous health and climate change mitigation benefits they provide. The report argues for the importance of Local Biodiversity Strategy and Action Plans to guide and incentivise the design and practice of urban greening ([Secretariat of the Convention on Biological Diversity, 2012](#)). While there are some notable exceptions, few cities globally have developed policies that incentivise or mandate nature-based infrastructure, particularly at system change levels ([Guerry et al., 2021](#); [Liberalesso et al., 2020](#)). In the UK, the government has been working on integrating biodiversity net gain into planning policies to address the loss of biodiversity due to urbanisation and development which require developers to assess the biodiversity value of a site before development, and then to implement measures that result in a net gain in biodiversity once the project is completed ([UK Department for Environment, 2023](#)).

New Zealand (NZ), like other countries, is facing many challenges as the population grows. Currently, 86% of NZ's population is urban and this is projected to increase over the next 30 years through natural population growth and net migration gain ([Stats, 2018](#); [Stats, 2021](#)). To address housing shortages, the supply of new dwellings will need to increase by 45,000 dwellings just in Auckland alone ([Ministry of Business Innovation and Employment, 2017](#)). The landscape of NZ's cities provides a unique context, with harbours and hills often constraining development to central neighbourhoods, driving urban densification. A new National Policy Statement on Urban Development (NPSUD) was introduced by the NZ Government in 2020 with policies encouraging higher-density development through increased medium-density housing (MDH) ([Ministry for the Environment, 2020, 2022b](#)). Different definitions for MDH are used across NZ with varying criteria such as the height of the building, number of people per hectare, number of dwelling units per hectare and overall size (BRANZ: Building Research Association of NZ, Study Report SR376, ([Bryson and Allen, 2017](#))). Some define MDH as four or more dwelling units with an average density of less than 350 m² while others are based on the number of dwelling units per hectare (30–60 du/ha) ([Bryson and Allen, 2017](#); [Marriage, 2023](#)). BRANZ SR376 further defined MDH as "multi-unit housing up to six storeys high",

divided into three categories. Category 1: 1–2 storey attached houses (such as duplexes or semi-attached terraced houses), Category 2: 2–4 storey attached houses (2, 3 or 4 storey terraced houses) and Category 3: apartments (3–6 storey apartments).

The Resource Management Amendment Act ([Ministry for the Environment, 2020](#)) strengthen the NPSUD to increase the housing supply in urban areas by requiring tier 1 councils in the greater urban areas of Auckland, Hamilton, Tauranga, Wellington, Christchurch and Rotorua Lakes district to apply the Medium Density Residential Standards (MDRS) to most of the existing residential areas as part of their plans from August 2022. Tier 2 and 3 councils may also be required to include MDRS in their plans if they are experiencing acute housing needs ([Ministry for the Environment, 2020](#)). These MDRS allow landowners to develop up to three-storey dwellings on most sites in cities without needing to apply for resource consent, provided they comply with all other rules and standards in relevant plans ([Ministry for the Environment, 2020](#)). These changes may have the effect of reducing the area of private gardens, which in Dunedin, for example, comprise 36% of the total urban area and 46% of residential areas ([Mathieu et al., 2007](#)). Paved areas for car access and parking for multi-storey apartments have the potential to further reduce permeable areas for vegetation. In most instances, densification will reduce the biodiversity that people can experience day-to-day in their neighbourhoods ([Tratalos et al., 2007](#)). The question arises: how can NZ increase the number and density of residential developments while maintaining and enhancing biodiversity?

In this paper, we seek to examine the extent to which the current framework for the development of the urban built environment promotes biodiversity in medium-density residential developments. We investigate the current state of urban biodiversity policies, strategies, planning documents, and design guidelines in NZ that inform urban design and planning at the national, regional, and local levels.

2. Materials and methods

2.1. Data collection

NZ's local government consists of 11 regional councils and 67 territorial authorities, which include 12 city councils, 54 district councils and 6 unitary councils according to the Local Government Act 2002 ([Department of Internal Affairs, 2017](#)) ([Table S6 in Supplementary Information](#)). Regional councils have responsibilities to manage freshwater, land, air and coastal waters within their regions ([Department of Internal Affairs, 2017](#)). Territorial authorities (TA) have responsibilities to manage the sustainable wellbeing of districts including the provision of local infrastructure and controlling the effects of land use (including indigenous biodiversity) ([Department of Internal Affairs, 2017](#)). Unitary councils are territorial authorities with regional council responsibilities ([Department of Internal Affairs, 2017](#)), and therefore, they were included and reviewed with the regional councils.

We first extracted documents that were relevant to either district and local level urban residential development processes (e.g., NZ building code (NZBC), district plans (DPs) and medium-density residential guidelines), or environmental protection. These were drawn in the first instances from NZ's national and district government official websites. The NZ Biodiversity Strategy (NZBS) also provided a list of documents relating to biodiversity (key legislation, strategies, and policies) in their Appendices 2 and 3 ([Department of Conservation, 2020](#)) which were then sourced. The documents that focused on urban built environment development, particularly those related to the Resource Management Act (RMA) 1991 ([Ministry for the Environment, 2022c](#)), were extracted from the full list for use in the analysis. A full list of document types reviewed at different levels is presented in [Fig. 1](#).

Legislation, strategies, and frameworks that affect the management of specific species or habitats, such as the Conservation Act 1987 ([Department of Conservation, 2022a](#)), Biosecurity Act 1993, and

National	• Resource Management Act (RMA) • National Policy Statement for Indigenous Biodiversity (NPSIB) • National Policy Statement on Urban Development (NPSUD) • Te Mana o Te Taiao Aotearoa New Zealand Biodiversity Strategy (NZBS) 2020 (includes an action plan) • Medium density residential guidelines • New Zealand Building Code (NZBC)
Regional	• Regional Policy Statement (RPS) • Regional Biodiversity Strategy (RBS)
District	• District Plan (DP) • Local Biodiversity Strategy (LBS) • Medium Density Residential Guidelines (by Territorial Authorities (TA))

Fig. 1. Types of documents reviewed at the national-, regional- and district-levels.

Wildlife Act 1953 (Department of Conservation, 2022b), were not included in this review as they are primarily applied to inform *in-situ* development decisions rather than high-level urban planning processes.

Some national-level documents were applicable in this context, such as the Resource Management Act, National Policy Statement for Indigenous Biodiversity (NPSIB) and National Policy Statement on Urban Development (NPSUD) (Tables S1 in Supplementary Information). These were retrieved from the official Ministry for the Environment website. (Local Government New Zealand, n.d) was investigated to source website links for local government agencies. Each regional and district council website was explored for regional policy statements (RPSs), regional biodiversity strategies (RBSs) and action plans, district plans (DPs) and local biodiversity strategies (LBSs) for their biodiversity-related policies/strategies/guidelines, residential planning and design guidelines that inform the medium-density residential development (Tables S2 – S5 in Supplementary Information).

2.2. Data analysis

We synthesised and evaluated all documents to identify gaps related to medium-density residential development in New Zealand. Firstly, the national and regional level policies were reviewed to identify the current approaches for conserving and enhancing biodiversity through the urban built environment. Then the national, regional, and district-level biodiversity strategies were reviewed to identify the themes, strategies and actions outlined for conserving and enhancing urban biodiversity through urban developments. Relevant parts of the district plans were reviewed with regard to objectives, policies, and rules relating to biodiversity in residential zones (especially medium-density).

After reviewing the documents individually, combined, and comparative analyses were conducted to assess the implementation of national-level policies. To do this, all the regional-level policies were compared to the national-level policies to identify the relationships between them and highlight any gaps that need to be addressed. Similarly, all the regional-level biodiversity strategies were compared to the national biodiversity strategy. Further, common objectives and approaches were identified across the national and regional policies and strategies. Lastly, medium-density residential design guidelines, planning documents and biodiversity strategies and action plans at the district level were reviewed for their urban biodiversity enhancement considerations in cities through building and urban design. Common biodiversity regulations and recommendations between regions were identified in the planning documents and design guidelines.

3. Results

3.1. Biodiversity-related documents within New Zealand

A total of one hundred and fourteen relevant documents related to

biodiversity in New Zealand's urban environments were located through the search and were reviewed (Table 1 and also see Supplementary Information). Although there are sixty-seven territorial authorities in New Zealand, only sixty-five district plan documents were found because the Chatham Islands does not have one and the Masterton, Carterton, and South Wairarapa councils use the Combined Wairarapa District Plan, and the Waikato District Council has two separate plans for Waikato and Franklin.

3.1.1. Resource Management Act, policies and strategies at the national level

Under the Resource Management Act 1991 (Ministry for the Environment, 2022c) section s30(1)(ga), the policies, objectives and methods for maintaining indigenous biodiversity must be established, implemented, and reviewed. The National Policy Statement for Indigenous Biodiversity (NPSIB) proposes protecting, maintaining, and increasing indigenous vegetation cover and enhancing habitat connectivity (Ministry for the Environment, 2023). It sets out objectives, policies and implementation requirements to maintain indigenous biodiversity in New Zealand. The National Policy Statement on Urban Development (NPSUD) for growth and intensification recognises public open space as one of the features of a high-quality urban environment (Ministry for the Environment, 2022b). The NPSIB aims to provide direction to councils according to the RMA for protecting and maintaining indigenous biodiversity and minimising and controlling the adverse effects of land use change or subdivision. Moreover, it suggests regional councils prepare monitoring plans by establishing methods and timeframes to maintain indigenous biodiversity and monitor the percentage of indigenous vegetation cover in urban and non-urban built environments (Ministry for the Environment, 2023).

Te Mana o Te Taiao Aotearoa New Zealand Biodiversity Strategy (Department of Conservation, 2020) is the only national-level strategy for protecting and restoring species and ensuring ecosystem connectivity. The strategy targets thirteen main objectives grouped under three pillars: getting the system right, empowering action, and protecting and restoring (Department of Conservation, 2020). The strategy includes increasing green spaces and restoring ecological corridors through infrastructure and urban planning; collaborating with different communities, stakeholders and industry partners; improving skills and knowledge; and effective management for long-term benefits (Department of Conservation, 2020). As a party to the International Convention on Biological Diversity (CBD), New Zealand is required to have a national biodiversity action plan, which is included in Te Mana o Te Taiao Aotearoa New Zealand Biodiversity Strategy (CBD, 1992).

3.1.2. Policies at the regional level

Regional Policy Statements (RPS) are a statutory requirement under the RMA 1991 and are prepared and implemented to help guide and manage land use and resource management at the regional level. Biodiversity conservation is an integral part of sustainable resource

Table 1

A summary of documents retrieved from official government websites for this review.

Document type		Number reviewed
National	Act (Resource Management Act)	1
	Indigenous biodiversity policy	1
	Urban development	1
	Biodiversity strategy	1
	Medium-density residential guideline	1
	New Zealand Building Code	1
Regional	Policies	15
	Biodiversity strategies	8
District	Biodiversity strategies and action plans	17
	Medium-density residential guidelines	3
	District plans	65
Total		114

management and RPSs have objectives related to biodiversity conservation that reflect the unique diversity in each region. However, none of these documents discussed objectives explicitly related to promoting biodiversity in urban built environments or medium-density residential developments. Most of the RPSs are categorised into five areas: issues, objectives, policies, method of implementation, and anticipated results. They include objectives to conserve indigenous biodiversity in line with the NPSIB (Fig. 2). A total of fifteen regional-level policies out of seventeen that outline the implementation of biodiversity-related strategies were found (Table S2 in Supplementary Information).

Eight out of the nine documents for North Island regions were studied to identify policies related to indigenous biodiversity. The Te Kaupapa Tauāki ā-Rohe - Gisborne RPS (Gisborne District Council, n.d) was unavailable because it is currently being updated. The RPSs by Northland Regional Council (2016) and Auckland Council (2016) and the Regional Resource Management Plan by Hawke's Bay Regional Council (2021) (includes RPS) identified policies focusing on preserving indigenous habitats and coastal environments. Most of the policy statements include identifying significant natural areas (SNAs) as indigenous habitats and protecting them (Ministry for the Environment, 2022c).

Seven out of the eight documents for South Island regions were studied to identify policies related to indigenous biodiversity. The Chatham Islands' RPS was not found. RPSs typically set broad goals and objectives related to indigenous biodiversity conservation and resource management. While they may not always include detailed metrics or explicit design/planning guidelines for the urban built environment, they often provide a strategic framework that guides regional and local planning. District plans translate the broader regional policies into actionable strategies for specific areas and communities. Local authorities are typically responsible for ensuring that the objectives set out in RPS are implemented effectively in their district plans.

3.1.3. Biodiversity strategies at the regional level

According to the NPSIB (Ministry for the Environment, 2023), every regional council must prepare a regional biodiversity strategy (RBS) and monitoring plan with methods and timeframes. The timeline for preparing or updating the RBSs by regional councils according to the NPSIB policy is within the next 10 years, i.e., by 2033 (Ministry for the Environment, 2023). Our search identified regional biodiversity strategies

for eight out of seventeen regional councils (Fig. 3). The biodiversity strategy by the Tasman District Council (2022) is the latest (published in July 2022) and corresponds to Te Mana o Te Taiao Aotearoa New Zealand Biodiversity Strategy (NZBS). All other regional biodiversity strategies were published before 2020 and have not been updated to align with the NZBS.

Out of the nine North Island regions, biodiversity strategies were found for only four: Auckland, Hawke's Bay, Taranaki, and Wellington. Out of the eight South Island regions, biodiversity strategies and action plans were found for only four: Tasman, Nelson, Canterbury, and Otago. The goals mentioned in most of the regional biodiversity strategies included protecting and restoring high biodiversity habitats, maintaining ecosystem functioning, partnership and collaboration, integrating mātauranga Māori (indigenous knowledge) in biodiversity research and management, pest management, and increasing funding and government support for such projects. In some areas, other forms of biodiversity initiatives or programmes are underway. For example, the Biodiversity Programme by the Bay of Plenty Regional Council (2022) is a voluntary programme to empower landowners and community groups to protect valuable sites of native biodiversity across the region. Sites of high biodiversity value are identified on private land across the region, and councils and landowners work in partnership to protect these sites (Bay of Plenty Regional Council, 2022).

3.1.4. Biodiversity strategies and action plans at the district level

At the district scale, biodiversity strategies and their action plans are used to support the needs of local biodiversity and ecosystems while remaining aligned to the regional and national level policies and strategies. A total of ten district-level biodiversity strategies were found, and out of these eight were reviewed. Auckland Council and Nelson City Council are unitary authorities performing both city and regional council duties, and therefore, their biodiversity strategies were reviewed in Section 3.1.3.

Supplementary Table S1-S5 in the Supplementary Information summarise the acts, policies, and strategies related to urban biodiversity at the national, regional, and district levels. Common themes were seen across the different documents and are summarised in Fig. 4. The most common visions described in the documents were ones of flourishing native biodiversity that is enjoyed and valued by the community. The most common objectives of these documents were the protection of

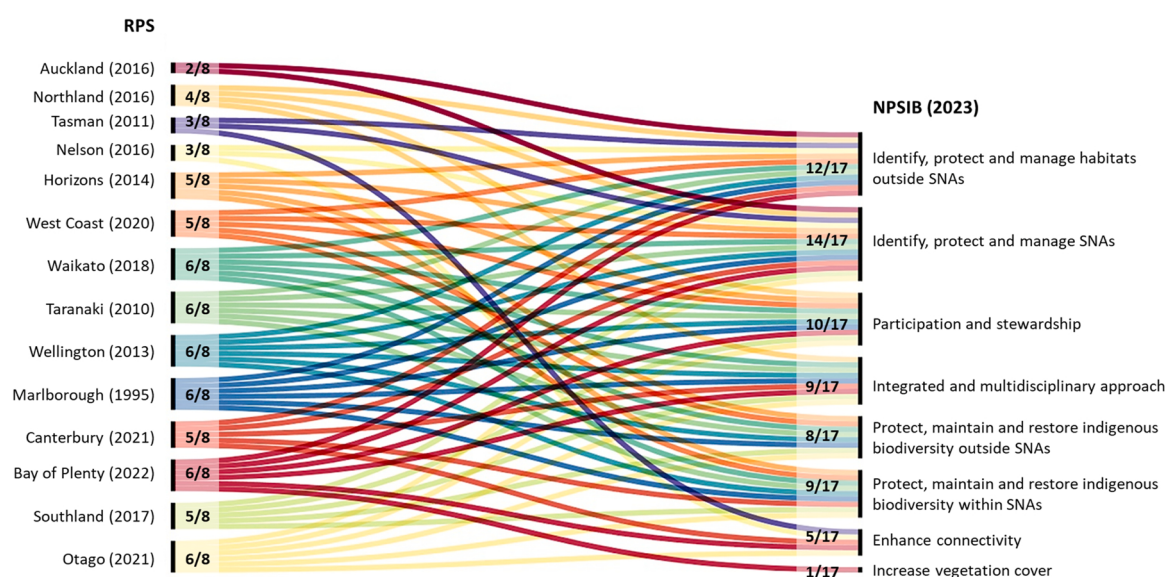


Fig. 2. Common objectives found in the Regional Policy Statements (RPSs) that connect with the objectives in the National Policy Statement for Indigenous Biodiversity (NPSIB). The left-hand side numbers indicate the proportion of NPSIB policies each region is meeting, and the right-hand side numbers indicate the proportion of regions that include the related NPSIB policy in their RPSs. SNA = Significant Natural Area.

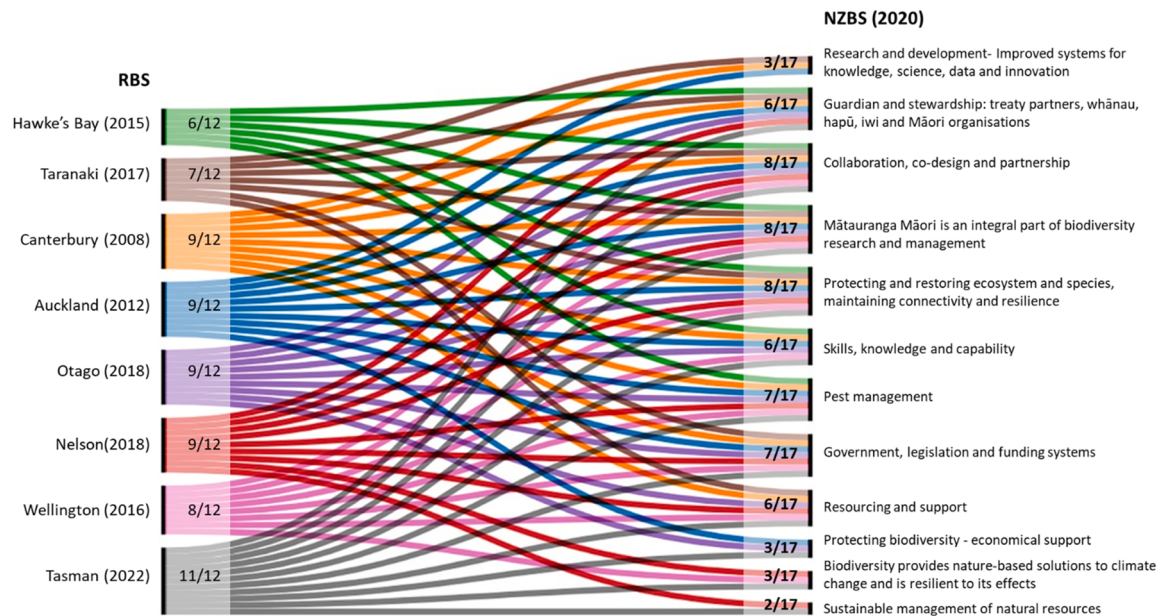


Fig. 3. Common approaches found in the regional biodiversity strategies (RBSs) that connect to approaches in the New Zealand Biodiversity Strategy (NZBS). The left-hand side numbers indicate the proportion of NZBS policies each region is meeting, and the right-hand side numbers indicate the proportion of regions that include the related NZBS strategy in their RBSs.

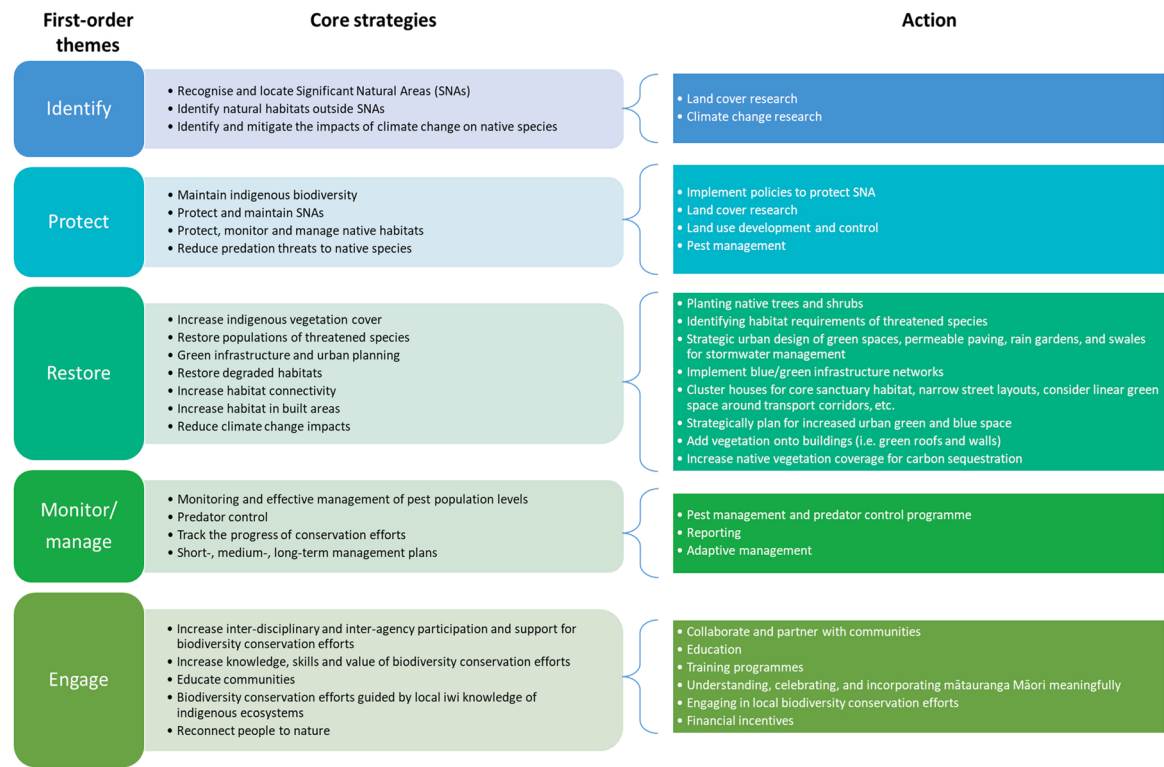


Fig. 4. Common themes and core strategies identified from the biodiversity-related New Zealand policies and strategies review.

existing significant native habitats, the restoration of degraded native habitats, and the careful maintenance of these habitats for long-term ecological health. A key part of achieving these objectives in most documents was increasing community education and involvement in native biodiversity conservation.

3.2. Medium-density residential design guidelines and district planning for biodiversity

This section analyses existing NZ district plans and residential design guidelines related to urban biodiversity (Fig. 5), which are summarised in Table S5 of the Supplementary Information. Sixty of the sixty-five district plans had sections that addressed native ecosystems, with restrictions on native vegetation removal or the destruction of character

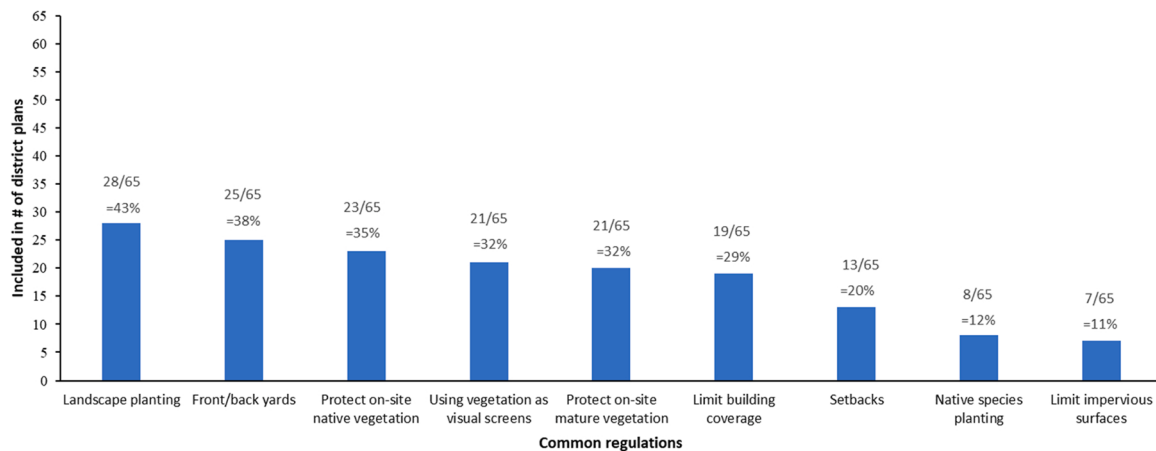


Fig. 5. Common biodiversity-related regulations applicable to residential properties from the review of 65 New Zealand District Plans. The bars represent the proportion of district plans that included a common regulation.

landscapes. Many of the rules were focused on the whole district or major new subdivision (neighbourhood/suburb) scales, which is important for protecting significant natural habitats (this was stated explicitly in forty-nine of the sixty-five district plans) and maintaining habitat connectivity across the district. However, only twenty-five included rules/guidelines related to native species conservation at the individual property or building scale. The district plans ensure that the location, density, and design of subdivisions/buildings align with the safety and performance standards established by the NZ Building Code; however, the building code is the primary source that dictates specific acceptable details and regulations for building and landscaping at the individual property scale. The NZ Building Code (Ministry of Business Innovation and Employment, 2014) was reviewed to see if there was anything related to urban biodiversity that was more specific to the individual property or building scale. There was no mention of native planting, species conservation, urban greening, or biodiversity.

In addition to the district plans and building code, several other residential design guides were found. Building codes are regulations that must be strictly adhered to, as they are mandatory requirements aimed at ensuring the safety and compliance of structures. Design guides, however, while providing recommendations and best practices, are not mandatory and following them is at the discretion of the developer or designer. At the national scale, there are two relevant guidelines. The National Medium Density Design Guide (Ministry for the Environment, 2022a) encourages the conservation of existing larger trees and vegetation areas on site for environmental benefits such as biodiversity and stormwater management. The guidelines and principles of the National Medium Density Design Guide will need to be included in district plans (allowing for adaptation to local contexts and priorities) of greater urban areas, such as Auckland, Wellington, and Christchurch, from August 2023, with other regions to follow as there is an acute housing need. At the regional and district level, there is much more variation in the focus and approach for site planning and designing landscapes and buildings related to biodiversity, but only twenty-one of the district plans have specific requirements for medium-density residential developments.

4. Discussion

We reviewed one hundred and fourteen relevant documents related to biodiversity in New Zealand's urban environments including policies, strategies, district plans and design guidelines from national levels through to individual districts, focusing on biodiversity restoration and enhancement through residential development. New Zealand's policies and regulations related to biodiversity protection and promotion in medium-density residential design are hierarchical in nature, with national-level legislation and policy informing the emergence and

content of regional, district, and development-level approaches (Fig. 6).

There are significant inconsistencies across NZ that will likely lead to unequal outcomes for biodiversity. Further, some high-level gaps in policy, strategy, and planning and design guidelines exist that will limit the possibilities for protecting biodiversity in urban landscapes. These gaps and the opportunities that arise from these are discussed in the following sections. We also highlight international examples that could provide a template for addressing these inconsistencies in NZ.

4.1. Acknowledging the possibility of restoring nature in built environments through linked policies and strategies

The primary gap identified in NZ's biodiversity strategies and policies is the lack of consideration given to the role of the built environment, specifically urban infrastructures and buildings, when planning for biodiversity conservation and regeneration approaches. The NPSUD and the NPSIB have complementary aspects, such as the NPSUD acknowledging the importance of open space in urban areas and the NPSIB promoting policies that encourage a specific level of indigenous vegetation coverage in urban environments (Ministry for the Environment, 2023).

At the regional level, regional policies aim to protect, maintain, and enhance indigenous ecosystems through statutory plans and strategies, such as pest control and allocating responsibilities for land use controls. A common theme that emerged from the assessment of the regional biodiversity-focused policies and strategies is that these documents require that monitoring and information gathering occurs through collaboration with other regional and district councils and partnerships with mana whenua, other landowners, and other relevant organisations. RPSs encourage advocacy and education by promoting voluntary efforts and working with mana whenua and educating landowners and the community for better implementation of the policy statements. However, not all regions provide funding and assistance for biodiversity management approaches (Fig. 3). This is observed as a common problem because RPSs mainly focus on setting strategic objectives without delving into the financial aspects of implementation. The biodiversity strategy by Tasman District Council (2022) is, however, an example of integrating funding in their governance for biodiversity protection and embracing partnership opportunities with relevant organisations by including them in their objectives in line with the NZBS.

Only five of the North Island's 42 districts (12%) and five of the South Island's 24 districts (21%) have local biodiversity strategies (LBS). Combined with strategy and policy gaps at the regional level, this leaves a total of 56 districts (37 in the North Island and 19 in the South Island; 84%) with only regional and national biodiversity strategies as a guide for biodiversity conservation in their areas. It is recommended that these

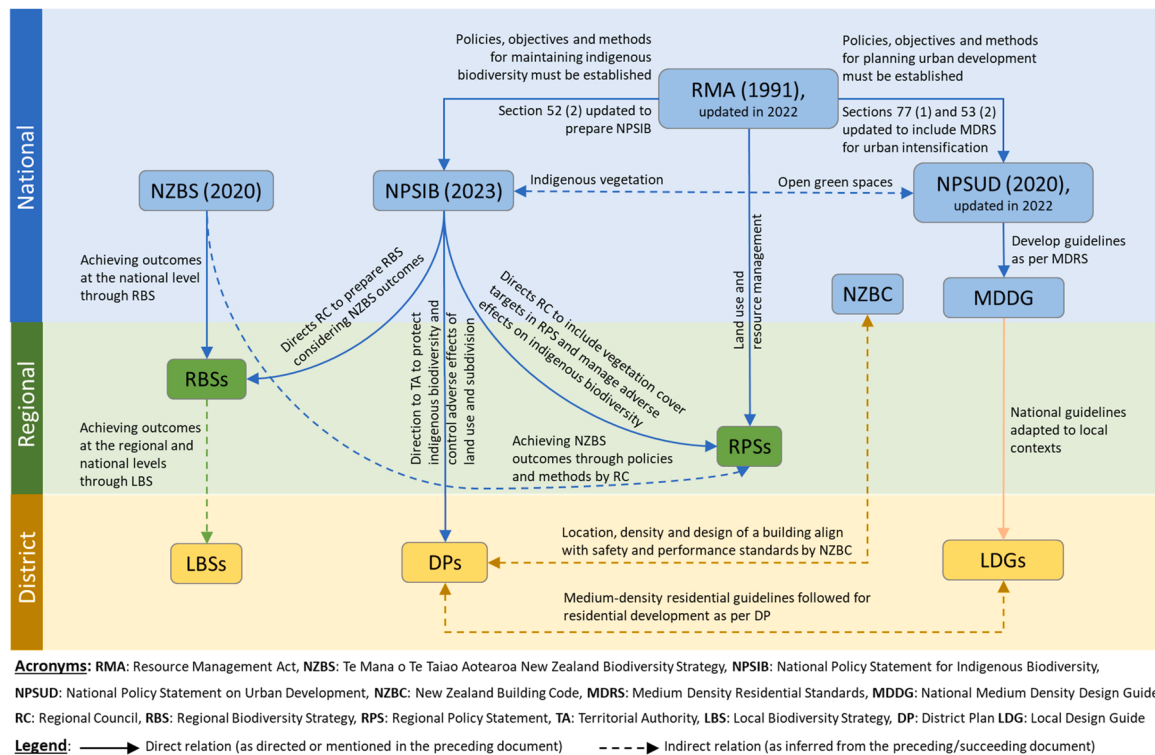


Fig. 6. Flow diagram showing the relationship between different documents reviewed at the national, regional and local levels.

district councils develop their LBSs in order to achieve the RBSs and NBS planned outcomes (Fig. 6). The role of territorial authorities in most of the RPSs includes setting out objectives and methods in district plans to identify and protect areas of significant indigenous vegetation and habitats of indigenous fauna. A common theme that emerged from the few district-level biodiversity strategies that do exist is that district councils tend to focus on protecting and/or restoring biodiversity, however, they do not include objectives explicitly related to restoring biodiversity by way of urban development through setting targets and metrics. Nearly all of the district-level strategies include increasing education and engagement with the community for biodiversity conservation. While this objective is not directly connected to biodiversity outcomes for residential developments, it could inspire developers, property owners, and built environment professionals to consider native planting and/or building-integrated vegetation in their residential projects. An example of a district-level strategy is Wellington's Our Natural Capital Strategy and Action Plan (Wellington City Council, 2015). It outlines the protection of significant natural areas on public and private land. Restoring native habitats in residential developments is not considered, although green roofs are discussed for their contribution to rainfall management (Wellington City Council, 2022).

Policies like those seen in Melbourne, Australia and Singapore could provide a template for how NZ city councils can better incorporate urban green infrastructures (green roofs, green walls, etc.) into their biodiversity strategies and therefore begin to transform urban built environments. Singapore is a prominent global leader in urban greening. Singapore's vision is to increase the city's greenery and biodiversity and become a 'City in a Garden' (Schröpfer and Menz, 2019). This effort has been guided by a number of policies, including their National Biodiversity Strategy and Action Plan, which outlines how the dense urban environment will be greened (National Parks Board, 2019). There are also specific policies that address greening buildings. The Landscape for Urban Spaces and High-rises (LUSH) programme, for example, was implemented in 2009, mandating and incentivising greenery on building envelopes (Goh, 2017). The National Parks Board can fund up to 50% of the installation costs for green roofs and green walls through the

Skyrise Greenery Incentive Scheme (National Parks Board, n.d.). Despite Singapore's ongoing population growth, the policies have resulted in an over 20% increase in green coverage in the city (Schröpfer and Menz, 2019). Another example is the City of Melbourne (CoM) in Australia, which adopted a Green Our City Action Plan with the goal of increasing the number of green walls and green roofs (City of Melbourne, 2017). The plan outlines four focus areas: lead by example, develop and maintain partnerships, targeted advocacy, and effective regulation. Engagement with the private sector for urban green infrastructure planning is integral to the plan because of the limitations of what can be accomplished with only council-owned land as well as the lack of room for new green spaces in densely built-up areas. Bush et al. (2023) examined the evolution of the CoM's urban nature policies and their implementation across the 2010–2020 decade. They explored 51 urban nature activities being implemented within the CoM and suggested that innovation and leadership of the CoM in policy and then mainstreaming this through a cross-organisational approach has been instrumental in biodiversity restoration and management (Bush et al., 2023). One of the tools being used extensively in CoM is the Green Factor Tool that gives a score to a site relative to the weight and volume of vegetative elements in the area (Bush et al., 2021). Tools like this, that are specific to a certain context, are useful examples to investigate and potentially emulate, but would require adaptation when applied to the different contexts of NZ.

4.2. Design guidelines with explicit biodiversity outcomes

A systematic review of the last two decades by Hernandez-Santin et al. (2023) indicated that biodiversity is mostly considered either as an inconsequential byproduct in urban development processes or is not considered at all. They also found that there are a few design approaches that address biodiversity more actively. Those design approaches are related to ecosystem services-based approaches for regenerative development. They proposed a design approach: "biodiversity inclusive design", where the needs of individual species and their habitats are considered while designing (Hernandez-Santin et al., 2023).

Our findings indicate a need for NZ specific strategic design guidelines to drive better development practices in relation to biodiversity. These should be accompanied by tools and techniques for quantifying the status of biodiversity (quality and quantity) and measuring the benefits it provides, along with a framework to monitor the progress of biodiversity enhancement at different stages of the residential development lifecycle. This is the next phase of our research where we will develop evaluation and design tools for enhancing biodiversity at individual building site and neighbourhood scales, prioritising native biodiversity.

4.3. Consistently addressing biodiversity in residential planning and design guidelines

The expansion of urban residential development to accommodate growing populations increases the urgency with which the consideration and quantification of biodiversity (status, trends and forecast) at local, regional, and national scales must be evaluated and designed for. Concerningly, the DPs and residential design guidelines in NZ (summarised in Table S5 of the Supplementary Information) lack key outcomes related to urban biodiversity. Moreover, none of the planning/design guidelines refer to or relate back to the national NZBS, RBSs, and/or LBSs if they exist. In their City Plan Part 2 (2022), the Brighton and Hove City Council in the UK have set a minimum target of 10% biodiversity net gain for developments as a way to begin to address habitat and species loss (Brighton and Hove City Council, 2022). Setting minimum targets for native planting and biodiversity in NZ district plans, as was done in Brighton and Hove, could potentially help urban planning and design guideline documents better align with the ambitions of the NZBS as well as other international biodiversity targets.

A common theme that emerged from the assessment of residential development design guidelines is that the preservation of some native vegetation is considered across all levels of governance. However, little attention is given to habitat restoration in these design guidelines and planning documents. Habitat restoration is not limited to conserving existing vegetation or planting more vegetation. It must extend beyond the immediate site boundary of a development or neighbourhood and consider the quantity, quality, and connectivity between different habitat patches and types (McDonnell et al., 2008). Integrating habitat restoration into planning practices has the potential to partially address some of the ecological impacts of urbanisation and would contribute to overall interconnected ecological and human well-being (Soanes et al., 2023).

The five main strategies described in New Zealand residential design guidelines are: protecting existing vegetation; using plants that define the characteristics of that area; using locally appropriate plants to support biodiversity; creating living roofs, rain gardens and planted swales for stormwater management; and using vegetation as visual screens. The goals of these strategies are primarily focused on positive stormwater management outcomes and privacy. While these approaches can benefit biodiversity, their value to species would be much greater if biodiversity outcomes were explicitly considered during the design process, not as an afterthought (Garrard et al., 2018; Parris et al., 2018). The lack of targeting of specific biodiversity outcomes also means that some important design considerations are missed, such as the prevention of invasive pest species.

Some residential rules around building coverage, setbacks, front/back yards, using vegetation for visual screening, and impervious surfaces are set for street character, privacy, and stormwater management purposes without considering the potential co-benefits they could have for native species if designed well. Aside from some restrictions on removing mature trees, there is little guidance on landscape design and appropriate planting. Even in the district plans that do include sections on landscape and/or native species planting (see Table S5 of the Supplementary Information), words such as “encourage” or “promote” are used to suggest these strategies might be employed by property owners;

however, they are not mandated or incentivised so may not be implemented often.

Native plant species are in decline in urban environments due to the dominance of exotic species for amenity and aesthetic values, and because of competition from invasive weeds. This has negative consequences for the native fauna that depend on native plants (Sullivan et al., 2009). Moreover, more effective guidance and partnership with mana whenua to integrate indigenous knowledge and values into district planning could help create regulations and outcomes for biodiversity on residential properties specific to their region, while working towards greater cultural well-being and potentially social justice (Rodgers et al., 2023). The National House Building Council (2021) in the UK published *Biodiversity in New Housing Developments: Creating Wildlife Friendly Communities* aimed at professionals in urban planning, residential construction and design, green/blue infrastructure, and urban ecology. It describes design strategies for residential developments that consider biodiversity at every stage and produce positive outcomes for nature and human wellbeing. The strategies for wildlife integration cover all aspects of development (buildings, landscape, infrastructure etc.) and could be an example of how biodiversity strategies suited to native species could be integrated into NZ specific design guidelines.

5. Conclusion

It is clear that biodiversity strategies should be integrated more explicitly into district plans and other residential design guidelines. Policies and strategies that do exist to support biodiversity in medium-density residential development in NZ are narrowly focused on significant natural areas and other green spaces, and do not adequately consider the potential role of the urban built environment, and in buildings themselves, in enhancing biodiversity outcomes. Here, we have identified several opportunities and pathways for the enhancement of relevant policies and strategies in relation to positive biodiversity outcomes. Outcomes in these areas could be further facilitated through incentives or mandates for urban green infrastructures, including vegetation-integrated buildings to increase their uptake by developers and homeowners. There is an urgent need to link biodiversity-related planning requirements and design guidelines to proposed urban built environment developments for low-, medium- and high-density housing.

NZ district plans and other residential design guidelines suggest maintaining or increasing on-site vegetation. However, the approaches for doing so do not have specific biodiversity outcomes, nor do they include plans to measure and monitor biodiversity during or after construction. Setting explicit urban biodiversity targets and quantifying positive urban biodiversity outcomes in biodiversity-related policies and strategies is a key and urgent area of improvement needed to achieve the municipal, regional, and national biodiversity-related goals in NZ and, beyond that, international biodiversity targets. This will help to ensure that biodiversity-related objectives are clear and therefore more attainable at different scales of residential development. The resourcing and pragmatism required to enforce biodiversity-related strategies and guidelines at all levels depend in large part on the revenue raising and enforcement ability of local governments, which is likely to be low. A key issue is likely that there are multiple priorities other than biodiversity for limited financial resources at both national and local government levels. This may in part explain why the rules and application of them tend to be patchy, and why some policy edicts at all levels of government appear to be tokenistic or hollow in their approach. Despite this, policy approaches should recognise that increased biodiversity health forms a crucial foundation for human physical, psychological, and social wellbeing, for essential supporting, regulating, provisioning, and cultural ecosystem services, and increasingly is a key part of urban climate change adaptation strategies. In the context of New Zealand where indigenous human-nature-biodiversity relationships are unique, meaningful, spiritual, and often political, reflecting a worldview aligned with a concept of interconnected relational living ecologies that bind

human and non-human life into an interdependent whole, there is additional reason to ensure that biodiversity is more adequately considered at urban development policy levels as part of partnership obligations under Te Tiriti (the treaty agreement between Māori, New Zealand's indigenous people, and the British crown). Biodiversity is the heartbeat of our planet and could be of our cities also; nurturing it ensures the health of us all.

CRedit authorship contribution statement

Kamiya Varshney: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Chris Woolley:** Writing – review & editing, Validation, Methodology, Conceptualization. **Danielle Shanahan:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Maibritt Pedersen Zari:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Maggie MacKinnon:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Yolanda van Heezik:** Writing – review & editing, Validation, Supervision, Software, Resources, Project administration, Methodology, Funding acquisition, Conceptualization. **Claire Freeman:** Writing – review & editing, Validation, Methodology, Conceptualization.

Declaration of Competing Interest

The authors declare no competing interests.

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Appendix A. Supporting information

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