Urban ecology: a case study in how to improve urban biodiversity.

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Introduction

The world is urbanising rapidly, with most of the Earth's population already living in urban areas, and this amount is expected to keep increasing for the foreseeable future. A tension between environmental impacts and urbanisation has existed ever since the Industrial Revolution observed in Great Britain. Biodiversity is the variability of species, and since 1970, biodiversity has decreased by 69%, a significant portion of which has come about due to urbanisation. Urban planning practices such as green fingers and wedges have been pioneered and trialled over the years to find a middle-ground where urbanisation can happen, and biodiversity loss can be minimised. This report will assess and measure the biodiversity value of a 1km squared urbanised area and utilise the case study to discuss how biodiversity in an urban area can be increased.

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Background

Auckland Tamaki Makaurau is Aotearoa New Zealand's largest city. Aotearoa, New Zealand, was one of the last habitable spaces on Earth to be found. Polynesians settled in the area between 1200-1300 AD, and though no urbanisation took place, hunting led to the extinction of species such as the Moa, reducing biodiversity.

In the late 1700s, Europeans landed on the shores of Aotearoa, and the colonisation process started. As immigration increased and European governments and planning practices were imported into Aotearoa, urbanisation increased. Since colonisation, human impacts have led to massive loss of forests and biodiversity.

Tamaki Makaurau Auckland has seen the most extensive urbanisation and suburban sprawl. The area of the case study, Wakaaranga Creek Reserve in Farm Cove, had already lost most of its biodiversity in the 1940s, as the area was majorly used for monoculture farming (as seen in Figure 1); however, since then, the area has rapidly urbanised, and now most of the area is made up of built-up areas.

Figure 1: *Historical aerial of Farm Cove from 1940*

Source: Auckland Geomaps

The Wakaaranga Creek Reserve consists of a recreational shared path that runs alongside the Tamaki River. The Tamaki Estuary is 17km long, and its mouth at Tamaki Strait opens to the Hauraki Gulf. The Tamaki Estuary is home to a mangrove forest, observable within the area boundary. This reserve penetrates the observed area like the green finger's plans, which have seen urban biodiversity improve; furthermore, the estuary is connected to a palustrine wetland, forming an ecological corridor. This wetland captures runoff from the nearby suburban areas and Pigeon Mountain.

Literature Review

Urban Ecology

Urban Ecology is a distinct field of study, separate from natural ecology, though it borrows many of its central ideas from natural ecology and applies them to an urban context (Forman, 2016; Wu, 2014). Urban sustainability, biodiversity, urbanisation patterns, ecosystem services and ecological restoration are all areas of study within urban ecology (Wu, 2014).

The world population has urbanised rapidly and is likely to continue doing so. It is essential to understand how urbanisation affects the natural environment, how ecosystems can be restored, and how well-functioning ecosystems can provide services to humans (Wu, 2014). Urban ecology, at its simplest, is the study of the interaction of people with their environments.

Contemporary urban ecology considers cities as socio-physical hierarchies, with the neighbourhood being the smallest, encapsulated by the city and broader region (Wu, 2014). Furthermore, a thinking has emerged that thinks not only of cities as containing ecosystems but of the city as an ecosystem itself.

Urban ecosystem thinking considers the city as containing both natural and socioeconomic ecosystems. Urban sustainability can be considered an oxymoron as it is urbanisation, which has often come at the cost of environmental protection. However, it can seem a challenging but worthwhile and attainable goal when considering sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs (International Institute for Sustainable Development, n.d.)."

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Urban Biodiversity

The impact of urbanisation on biodiversity has been widely researched. Urbanisation destroys and fragments species' habitats, often leading to reduced biodiversity. An example of how urban ecology examines the city's natural and socioeconomic aspects is that the biodiversity of plants tends to be higher in more affluent neighbourhoods (Wu, 2014).

Other disruptions to ecosystems, such as increased runoff and contamination, as well as habitat fragmentation, can lead to the devastation of species and a reduction in biodiversity.

Urban biodiversity restoration efforts have been increasing in scope and frequency; this often involves restoring an ecosystem to its former glory, improving its function, biodiversity, and resilience.

A study of New Zealand restoration projects found that most projects focused on freshwater streams, wetlands and or lakes, and all focused-on planting native species. Some restoration projects, such as Zealandia in Wellington, have been highly successful. Zealandia is a sanctuary, which, through pest elimination and predator fences, amongst other things, has immensely improved the natural function of the ecosystem and the services it provides to the residents of Wellington (Clarkson & Kirby, 2016).

Ecosystem services

Ecosystem services are related, however, separate to ecosystem function. Ecosystem function is, in turn, related to biodiversity. An increase in biodiversity leads to increased ecosystem function, such as nutrient retention and resilience. In turn, an increase in ecosystem function results in increased goods and services that nature provides humans. The concept of ecosystem services is a way of assessing what a well-functioning natural ecosystem can give to humans, whether through recreation, water retention or oxygen production; humans directly benefit from these ecosystem services when natural ecosystems thrive (Wu, 2014).

Ecological Restoration

An understanding of urban ecology, the impact of urbanisation on biodiversity, and the importance of ecosystem services and urban sustainability leads to a natural conclusion: How can the ecosystems threatened and destroyed by urbanisation be restored? Ecological restoration focuses on speeding up the recovery of ecosystems; this can involve improving ecosystem functions such as biodiversity or remediating previously damaged ecological systems through reducing pollution. Restoration can involve reducing the negative impacts of urbanisation and actively improving ecosystem services by increasing patch connectivity (Klaus & Kiehl, 2021).

Low-impact urban design and development is a concept proposed to help achieve urban sustainability whilst improving urban biodiversity (*Low Impact Urban Design and Development*, 2009). LIUDD involves steps as simple as respecting the land's existing topography and identifying green corridors to protect and enhance. Other steps are done at a much smaller scale, such as on-site stormwater retention through rain gardens, which deal with contaminants before they reach larger catchments, or how to increase biodiversity in home gardens or city-wide landscaping (*Low Impact Urban Design and Development*, 2009; Ignatieva et al., 2008).

Urbanisation has significantly reduced biodiversity and ecosystem function through habitat fragmentation, contamination, and more. However, increased urban ecological restoration efforts have improved urban biodiversity in select areas. Through the examination of Wakaaranga Creek Reserve, our case study, we will examine the biodiversity of an urban area, how it has retained or lost its biodiversity, how it can be improved and why it is essential to do so through examining the services it can provide.

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Methodology

Urban biodiversity must first be quantified to assess how to improve it. A one-kilometre-squared urban area was chosen. In this case, the area chosen contains Wakaaranga Creek Reserve, Pigeon Mountain, Pigeon Mountain Wetland, Wakaaranga Intermediate and its sports field, a commercial village, and suburban residential neighbourhoods.

The percentage cover of various categories within the site was quantified to assign a numerical value to the area's biodiversity. This was done utilising satellite imagery from 2017. These categories include hardstand areas with impervious surfaces, such as roads and buildings, which receive a biodiversity multiplier of zero—Pastureland, which receives a 0.2x multiplier for biodiversity value. Trees with no understory receive a 0.3x multiplier. Urban forests receive a 0.6x multiplier for biodiversity, and ecologically significant areas, such as the mangrove forest and scrub with the case study site, receive a multiplier of 1x.

The immediate surroundings of the waterways are also categorised, and immediate hard stand surrounding waterways received a multiplier of 0x, pasture or trees with no understory a multiplier of 0.3x, and forest and ecological sites surrounding waterways a multiplier of 0.6x.

After categorisation and measuring using satellite imagery, the final biodiversity values were calculated, and ground-truthing was conducted to verify that conditions on site were similar to those seen on satellite imagery, which at this stage is six years out of date.

Using this method, an urban area's biodiversity can be measured out of a maximum of one hundred and sixty. However, an area with a biodiversity of one hundred and sixty would, inherently, not be urban. This value can be utilised to understand better how biodiverse the area is, how it can be improved, and how it compares to other areas.

Findings

After measuring the percentage cover of all categories (as seen in Figure 2) using satellite imagery, the multiplier values were used to reach a final biodiversity value of 65.38 out of 160, as seen in Figure 3.

Figure 2: *Categorisation Map*

Source: Author

Figure 3: *Percentage cover and ecological value*

Data		% cover or % length	Multiplier	Final score
Ecosystems	1. Hardstand	75	X 0	0
	2. Pasture	14	X 0.2	2.8
	3. Trees over open	5.5	X 0.3	1.65
	4. Forest	1.5	X 0.6	0.9
	5. Ecological site	5	X 1.0	5
Water ways	6. Hard stand	6.42	X 0	0
	7. Pasture or trees over pasture	3.72	X 0.3	1.116
	8. Forest or ecological site	89.86	X 0.6	53.916
Total (maximum 160)		65.382		

Source: Author

After the final biodiversity value was calculated, ground-truthing took place. Whilst on-site, most conditions were similar to the satellite imagery. The playground, which separates the Palustrine wetland, which is being regenerated, and the Wakaaranga Creek Reserve, were well used by the community and contained plenty of pastureland as seen in Figure 4.

Figure 4: *Photo of a playground*

Source: Author

Some signs warned residents not to feed birds and put dogs on leashes at the gate that controlled entry into the wetland area as seen in Figures 5 and 6.

Figures 5 & 6: *Photo of signs*

Source: Author

The area was overrun with native plants, and an elevated walkway transported residents to surrounding neighbourhoods. A sign about Pigeon Mountain Wetland provided insight into the area's history and how freshwater wetlands existed here in pre-European times as seen in Figure 7.

Figure 7: *Photo of sign describing wetlands*

Source: Author

Wetlands such as this provide a habitat for native plant species such as Toetoe, Harakeke, and Ti Kouka and native bird species such as Kotare, Pukeko and Mataku-moana. The elevated walkway transforms into a well-trodden muddy path, which climbs the hill towards Pigeon Mountain Hill as seen in Figures 8 and 9. Trash, such as road cones, were observed in and around the wetland.

Figures 8 & 9: *Photos showing the wetlands and tracks of Pigeon Mountain*

Source: Author

The reserve had signs that were a testament to the cultural ecosystem services that the ecosystem has been providing since the early 21st century as seen in Figure 10.

Figure 10: *Photo of a sign describing local legend Dick Quax*

Source: Author

There was a large amount of mangrove scrub that kept going on and on along the coastline as seen in Figure 11.

Figure 11: *Photo of mangrove scrubs*

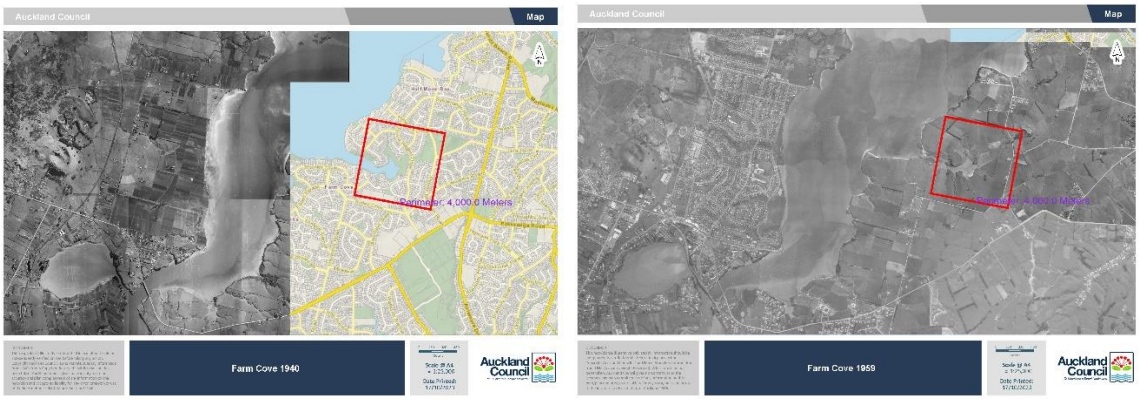
Source: Author

Birds could be heard chirping, and a Pukeko walked by. An area of the footpath was flooded, and though drains were present, it remained muddy, and the path's colour had browned, suggesting that this area has a high-water table and that this pedestrian path disrupts groundwater movements.

Discussion

The Farm Cove area's ecosystems, consisting of Pigeon Mountain and Wakaaranga Creek, have changed immensely over the years. Pre-European times would have seen the Pigeon Mountain wetland and the Tamaki Rivers mangrove forests thriving.

Figures 12 & 13: *Historical aerials of Farm Cove from 1940 and 1959*



Source: Author

Human settlement of the area led to the destruction of terrestrial habitats, with most of the land being used for low biodiversity value pasturelands used for agricultural purposes as seen in Figures 12 and 13. By 1996, the suburban sprawl of Tamaki Makaurau was in full swing, and most of the area had been paved over to make way for suburban buildings as seen in Figure 14.

Figure 14: *Aerial of Farm Cove from 1996*

Source: Author

At present, the majority of the area's biodiversity comes from the minuscule area that has been left untouched, the ecological corridor that connected the wetland, which is being regenerated, to the Tamaki Rivers estuary. The services that these ecosystems provide have changed throughout the times as well.

During pre-European times, supporting services such as nutrient and soil retention are likely to have been the most crucial services of the ecosystems. As times progressed and the area has been increasingly developed, impervious surfaces have taken up a larger and larger

area. This means that one of the most crucial services that the ecosystems provide has become water retention.

Another ecosystem service that has become increasingly important as the area has become more urbanised is the cultural services it provides. The paths along the wetland and estuary allow residents to unwind, exercise, and meet with their community. The ecosystem and its associated recreational paths have become an essential community amenity.

An ecosystem service that these ecosystems have been providing throughout their existence is their regulatory benefits on the air and climate of the area. Overall, the area's ecosystems currently have a relatively low value, and only a tiny portion of the area provides a significant amount of the existing value. The ecosystems' cultural, regulation, and support services have been essential to the area.

A significant benefit of the area is creating an ecological corridor connecting various ecosystems. The facilitation of these eco-tones and the way the ecosystems penetrate deep into the developed area in the form of green fingers is essential to the function of these ecosystems and ensures the immense cultural ecosystem services these ecosystems provide through recreational paths that spread out and connect multiple neighbourhoods.

The ecosystems are providing the majority of the services that they can, as provisioning things such as food and freshwater are not necessarily applicable in this area, which is highly urbanised. The water from the Tamaki River is high in saline. The ecosystem values of the area could, however, be immensely improved. A major downfall of the area is the large amount taken up by suburban developments providing no ecological value.

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A report by Singers et al. (2017) into the significant indigenous ecosystem of the Auckland region provides further insight into what the coastal mangrove forest could have looked like in the pre-human era, stating that the ecosystem was likely to be used not only by the native birds we currently see such as shags, herons, pukeko and more but that it likely would have also been home to now extinct birds such as the Moa, adzebill and more.

Furthermore, the importance of these ecosystems, as the transition between the terrestrial and marine ecosystems, is emphasised. These ecosystems are essential for stabilising sediment, preventing wave damage, and nutrient cycling. The report also emphasises that these ecosystems are at grave risk of eutrophication as the areas nearby urbanise, and runoff and contaminants run into the areas (Singers et al., 2017).

Ignatieva et al. (2008) created an urban greening manual, in line with Low Impact Urban Design and Development guidelines for New Zealand, which can be utilised to understand better how to increase biodiversity in urban areas. These approaches range from incorporating rain gardens and green roofs into development proposals to strategic planning goals such as minimum canopy cover. A campaign aimed at residents which promotes the planting of native species, and a more diverse group of plants is also likely to increase biodiversity (Ignatieva et al., 2008). However, this would need to be done with a community reach and systematic programme to eliminate the invasive species that outcompete many native species (Ignatieva et al., 2008). Another approach to increase biodiversity would be introducing native lawns and grasses into homes rather than traditional lawns, which provide almost zero biodiversity (Ignatieva et al., 2008).

Conclusion

In conclusion, the area chosen as a case study was Farm Cove. It contained Pigeon Mountain, associated wetland, Wakaaranga Creek, and the Tamaki Estuary, all along an ecological corridor deep into a suburban neighbourhood. The area's history and the importance of ecosystem services throughout time were examined. In pre-historic times, the mangrove forests of the Tamaki Estuary played an essential role in soil retention, nutrient cycling, and provisioning food for native bird species. The regulatory, provisioning, and supporting services did not operate alone, and as the area has urbanised, the cultural services provided by the ecosystems have risen in importance. The recreational paths alongside the ecological sites allow residents to connect with nature and their community. From a biodiversity and ecological value point of view, the area's ecological value is relatively low, and this is due to the majority of the site being taken up by the suburban development. The small area that houses the mangrove forests and wetlands provides immense ecological value to the site. In the future, it should be ensured that these ecosystems are protected from eutrophication as runoff from surrounding urban expansion increases, from exotic predators introduced by humans, and from urban expansion itself. Whilst this is being done, an effort should be made to increase the biodiversity value of the built-up areas by using more varied, native species in home gardens.

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