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Restoration Strategies for Three *Dacrycarpus dacrydioides* (A.Rich.) de Laub., Kahikatea Remnants in Hamilton City, New Zealand

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Abstract: Identifying appropriate restoration strategies is vital for successful urban remnant restoration, but projects often lack consistent methods that distinguish them. In New Zealand, there are unique opportunities to restore depleted *Dacrycarpus dacrydioides* (A.Rich.) de Laub. (kahikatea, white pine) semi-swamp forest remnants in numerous urban centres. To assess potential restoration strategies for three kahikatea remnants in Hamilton City, we compared their physical features, native vascular species composition, age structures, life forms and epiphytes with a notional reference site (Te Papanui). Numerous native vascular species gaps are revealed among Te Papanui (66 species), Totara Park (40 species), Hillcrest Park (15 species) and Grove Park (nine species). Age structure analyses suggest that Hillcrest Park comprises the oldest kahikatea population, with an average age of 82 years, followed by Grove Park (70 years), Te Papanui (60 years) and Totara Park (32 years). A native floristic analysis of thirteen life forms found that Te Papanui contains the most (11), followed by Totara Park (eight), Grove Park (six) and Hillcrest Park (five). Despite the abundance of invasive plants at Totara Park, its high-water table and favourable humid, sheltered conditions support more epiphytes (nine) than Te Papanui (six), Hillcrest Park (one; *Pyrrosia eleagnifolia*), and Grove Park (none). Epiphytes absent from Te Papanui found at Totara Park may be due to the loss of the once abundant tree fern and host, *Dicksonia squarrosa* (whekī). Totara Park requires careful manipulation of troublesome weeds, whereas Hillcrest Park and Grove Park necessitate buffer extensions and native understory plantings. This study provides a simple framework that uses biophysical differences among urban remnants and a reference site to reveal suitable restoration strategies that could guide other urban restoration projects regionally and nationally.

Keywords: urban restoration; kahikatea; white pine; urban remnants; ecological restoration; regeneration; swamp forest; secondary forest; microclimate; vascular species; life forms

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1. Introduction

1.1. Urban Ecological Restoration

Urban ecological restoration is increasingly recognised as a pragmatic solution for reversing some of the degradation caused by urbanisation [1–3]. Ecological restoration provides numerous ecosystem services such as water purification, improved air quality, food and fresh water, and mitigation of the heat island effect, extreme weather events and soil erosion. In cities, restoration provides an additional body of social services due to their larger populations, including educational and recreational opportunities, social cohesion and the chance to reconnect with the environment.

In a global review, approximately 40% of urban policy plans were found to promote native biodiversity and 20% mentioned quantitative targets for specific native plant and animal taxa [4]. Urban ecological restoration generally focuses on reinstating ecosystems that resemble historic sites [5] and reintroducing and conserving diversity at the species or population level [6]. These projects vary by the type of sites selected (often due to site availability) and the adopted approaches. For example, urban restoration may focus on open parks [7], remnant restoration [8], riparian plantings [9] or rewilding gardens and infrastructure [10]. Urban ecological restoration objectives also differ with scale [2] but generally include biodiversity conservation, improving nature connectedness and wellbeing [11], and mitigating extreme weather events such as flooding [12]. In China and the United States, habitat restoration is also frequently employed to compensate for urban development [13,14]. In parts of Australia, studies have prioritised urban forest remnant restoration because they are havens for local biodiversity and are easy to monitor and access [15,16].

Ecological restoration in New Zealand has primarily focused on large national parks, offshore islands and reserves [17]. However, recognition that most of New Zealand's threatened environments exist in urban centres [18] has shifted the focus to include urban restoration. Besides common goals like controlling invasive species, planting native flora, riparian planting, reconstructing pre-European vegetation patches and enhancing connectivity, many urban restoration projects have attempted to restore native remnants to their condition before the city's establishment [17].

In New Zealand, *Dacrycarpus dacrydioides* (A.Rich.) de Laub.(kahikatea) semi-swamp forest was once widespread across most of the North Island and west and southern areas of the South Island [19]. Despite its wide natural disruption, it is predicted that more than 98 per cent of New Zealand's pre-European kahikatea forest has been lost [20,21]. The primary cause of this clearance includes agricultural and forestry pressures resulting in artificial drainage and often the invasion of grey willow (*Salix cinerea*) [22]. Such lowland environments contain some of the richest species assemblages in the country despite their extensive clearance [23]. Given the lack of indigenous vegetation in New Zealand's urban centres and the extensive clearance of kahikatea forest, it is crucial that appropriate restoration strategies are identified for these remnants. Species composition [24] or traits [25,26] are often used to guide species selection and enhance community assembly in restoration sites. Here, we investigate kahikatea age structures and indigenous plant composition, focusing on life forms to characterise each site. Life form analyses enable the rapid identification of missing functional groups to ensure restoration strategies reinstate the complete range of ecological functions. Hence, the purpose of this study is to provide a framework to identify appropriate restoration strategies that improve the ecological integrity and functioning of urban forest remnants.

1.2. Kahikatea

Dacrycarpus dacrydioides (kahikatea, white pine) is an endemic podocarp found in the lowlands of the North, South and Stewart Islands of New Zealand, reaching up to 600 m elevation [27]. Kahikatea forest typically develops in open swamp or shrublands on poorly drained gley and organic soils with a high water table. Kahikatea display several distinct features throughout their lifespan. Juvenile trees have an abundance of short shoots from their leaf axils along the trunk and branches with subdistichous, small, dark green leaves and are shade-intolerant [28]. Kahikatea grow up to 60 m as the tallest tree in New Zealand and can have a trunk as large as two metres in diameter. They shed their lower branches with maturity while the smooth bark flakes off to form thick, black, round segments. Large buttress roots support kahikatea in its preferred swamp environment with a limited supply of oxygen. Male trees have narrow cones, while females produce cones with four to five-millimetre black seeds and fruit that ripen from green to red. Kahikatea relies on birds such as tūī and kererū for dispersal [27] and provide a range of services, including habitat for vulnerable native fauna (e.g., *Chalinolobus tuberculatus*, New Zealand's endemic and nationally critical long-tailed bat).

1.3. Regional and Local State of Kahikatea Forest

In the Waikato region, about one per cent of the original extent of kahikatea forest remains, and just 13 per cent are legally protected [20]. The kahikatea-dominated fragments only constitute 0.2 per cent of the dairy landscape in central Waikato [29]. These remnants demonstrate similar size and age structures, commonly having a core of 350 to 450 year-old trees surrounded by 80 to 120 year-old trees [30]. With a life span of about 450 years and relatively young fragments in the Waikato region, kahikatea are expected to dominate the canopy of these stands for at least another three centuries [29]. Kahikatea forest typically grows on flat, fertile land ideal for agriculture and face several threats, including clearance, grazing, the invasion of exotic plants, edge effects and drainage. Half of the remaining kahikatea forests in Waikato are not fenced off from stock [20]. Heavily grazed kahikatea fragments require at least 15 to 20 years of fencing for major functional groups to recover and 40 to 50 years for a site to resemble its natural state [29]. Persistent forest clearance exacerbates edge effects and the vulnerability of fragments to weed invasion and unfavourable microclimatic conditions, including prevailing winds. Kahikatea are also threatened by drainage, which encourages its replacement with other dry land species such as *Podocarpus totara*, *Prumnopitys taxifolia* and *Beilschmiedia tawa* [31,32].

Once a conspicuous vegetation type of Hamilton City, kahikatea forest has been reduced to just 15 ha [33]. This total area comprises 17 sites, with the largest remnants including Te Papanui (5.5 ha), Burbush Road Bush (1.8 ha), Hillcrest Park (1.5 ha) and Southwell Bush (1.2 ha). The residual area is spread across patches of less than one hectare [33]. In the city, kahikatea forest is commonly found on recent fertile alluvial soils, such as Te Kowhai silt loam [29]. They also suit waterlogged soils found on low rolling hills (footslopes), shallow depressions or swales and narrow gully floors [18]. Protecting these sites is crucial for local kahikatea forest conservation.

1.4. Characteristic Species of Kahikatea Forest

Most restoration projects strive to assist a site's recovery or return it to its original state [34]. Therefore, determining characteristic species of a specific forest provides essential information for successful restoration. Six characteristic species lists have been developed for semi-swamp kahikatea forest [18,30,35–38]. Canopy species mentioned in most sources include kahikatea and *Laurelia novae-zelandiae* and, less frequently, *Beilschmiedia tawa, Dacrydium cupressinum* and *Prumnopitys taxifolia*. Species in lower forest tiers (ground cover and understory) typically included *Asplenium bulbiferum*, *Freycinetia banksii*, *Streblus heterophyllus*, *Coprosma areolata, Ripogonum scandens*, *Cyathea dealbata*, *Dicksonia squarrosa*, *Melicytus micranthus*, *Microlaena avenacea* and *Myrsine australis*. The species found within kahikatea forest also reflect the age, seed sources and historical disturbances, including clearance, drainage, grazing, and edge effects [39]. The natural flooding regimes responsible for the development of kahikatea forest have been irreversibly altered in many places. Maintaining kahikatea forest in such modified environments requires active management (see [40]), including planting kahikatea itself.

2. Materials and Methods

2.1. Site Selection and Descriptions

Hamilton City is located at the centre of the North Island, New Zealand. It is the country's fourth largest city at 11,000 hectares [41] and has a population of about 170,000 [42]. Once dominated by temperate lowland rainforest and wetlands, the city's indigenous vegetation cover has been reduced to approximately 1.8%. The city has a mild climate with an annual mean temperature of about 14.6 °C and an annual mean precipitation of about 1110 mm [43].

Three sites in Hamilton City were selected based on their existing features and restoration potential, that is, Hillcrest Park, Totara Park, and Grove Park (Figure 1). Some initial requirements of the sites were that they are publicly owned and include a kahikatea remnant because using existing vegetation as nuclei for restoration is sensible [44]. All three sites also comprise soils suitable for kahikatea semi-swamp forest [18], are significant natural areas (SNAs) [45] and adjoin areas not dominated by indigenous vegetation, thereby providing valuable restoration opportunities. Te Papanui, formally known as Jubilee Park and commonly known as Claudelands Bush (hereafter Te Papanui), was chosen as the notional reference site because it is the largest and most ecologically intact remnant of semi-swamp kahikatea forest in the city. This kahikatea remnant was previously surveyed using a plot-based methodology [36,45].

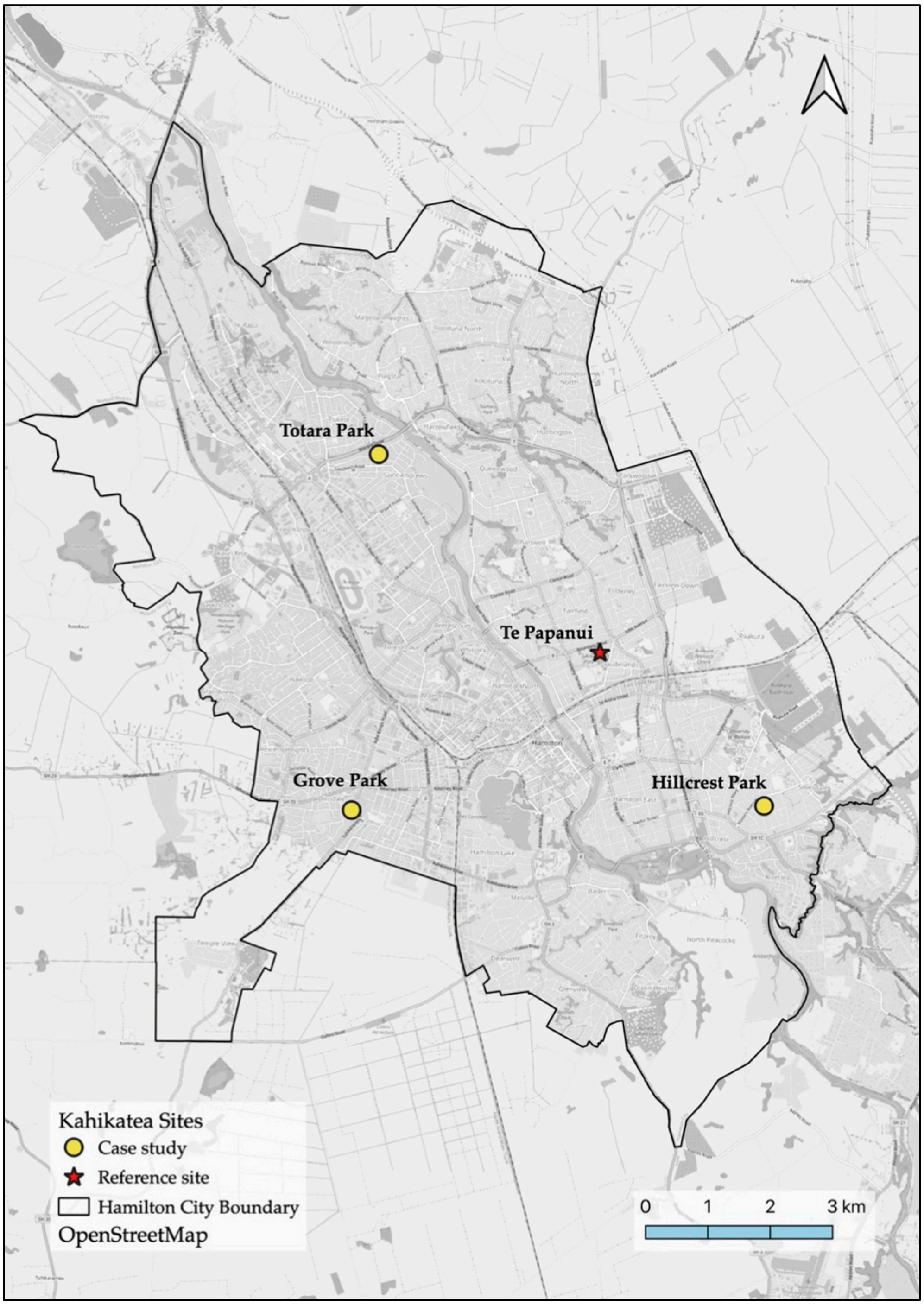

Figure 1. Location of the three kahikatea case studies and reference site. Totara Park is on the northwest, Grove Park is on the southwest, and Hillcrest Park is on the southeast of Hamilton City. Te Papanui is the reference site on the central-eastern side of the city.

Hillcrest Park supports the third largest kahikatea remnant in Hamilton City, after Te Papanui and Burbush Road [32]. The 7.1-hectare (ha) site includes a 1.5 ha kahikatea patch surrounded by 5.6 ha of open grass on the east and west. The nearest indigenous vegetation includes the University of Waikato kahikatea stands and Mangaonua Esplanade, over a kilometre away [46]. The park comprises four soil types: Te Kowhai silt loam in the centre, Kainui silt loam and Rotokauri clay loam on the western side, and Horotiu sandy loam on the eastern side. It also contains three under-represented ecological units: shallow depressions, low mounds, and low rolling hills (footslopes). The remnant has been severely degraded, with the loss of most understory species by 1972 and drainage since 1977 [32]. Canopy species in the 1980s included *Cordyline australis*, *Laurelia novae-zelandiae*, *Nestegis lanceolata*, kahikatea, *Elaeocarpus hookerianus* and one *Elaeocarpus dentatus*. Since 1994, Hamilton City Council (HCC) and a local school have planted native species, fenced off the remnant and constructed a raised walkway for recreation and educational activities. A scout hall is sited on the south-western side of the forest, and a sports hall sits on the eastern edge. Although the ground cover is sparse, abundant native plants occupy the mid-tier, and the canopy is healthy with few gaps. The east and west boundaries of Hillcrest Park have the widest buffers with *Kunzea ericoides*, *Pittosporum tenuifolium*, *Myrsine australis* and *Podocarpus totara*. Kahikatea were also planted on these edges, occasionally close to the forest margin.

Grove Park was established as a reserve in 1975 [47]. It is the third-largest kahikatea forest remnant on the western side of the city in Dinsdale, supporting a rare secondary stand of about sixty trees. The site is relatively isolated, with the nearest indigenous vegetation patch about 500 m away. Additionally, the park's flat setting, encircled by residential properties, has resulted in its drainage and the unlikely return of a high-water table. The site is only 0.3 ha, with 0.1 ha of grass on its east and west that could be restored. Its Te Kowhai silt loam soil supports kahikatea forest [29], and the shallow depressions ecological unit of the alluvial plains is severely under-represented in Hamilton City. The ground cover primarily consists of leaf litter. Additionally, the understory is mostly bare amid some native plantings that began in 2003, such as *Podocarpus totara*, *Myrsine australis*, *Coprosma autumnalis*, *Carpodetus serratus*, *Blechnum parrisiae*, *Piper excelsum*, *Artistotelia serrata*, *Geniostoma ligustrifolium*, *Alectryon excelsus* and *Melicytus micranthus*.

Totara Park is in the northwest suburb of St Andrews in Hamilton City. Surrounded by residential properties and roads, the park is more than 500 m away from any indigenous forest [46]. It is a grey willow and kahikatea forest, hosting the best-regenerating kahikatea swamp forest in the city. In 1969 the site was mined for sand, and most of its vegetation was cleared [48]. Eventually, HCC altered the drainage system and enabled a functional flooding regime with small pipes that supported the development of the wetland. The canopy is dominated by grey willow with emergent kahikatea in the central gully floor or the park's wetter sections that retain a high water table for most of the year [49]. The 2.7 ha site comprises two distinct environments: a gully (terrace scarps) and a grassy park with peaty soils. The vegetated component of the park is dominated by Tamahana, Kaipaki peat and Kirikiriroa complex soils, whereas the open side of the park comprises Kaipaki peaty loam.

2.2. Data Collection

All 84 research-grade kahikatea observations within the Hamilton City boundaries were downloaded from iNaturalist NZ (hereafter iNaturalist) on 5 November 2021. The observations were carefully assessed to determine if the individuals established naturally or were planted. A conservative approach was taken in which observations were retained based on the descriptive notes and photographs provided for each plant. As a result, only 32 observations likely established prior to the city's main development phase and indicative of the relict natural range of kahikatea were employed to select the case studies. Using research-grade iNaturalist data also ensures species have been identified by a minimum of two contributors and have been subject to wider scrutiny.

The diameter at breast height (DBH, 1.35 m) of the kahikatea stems at each site were measured. The size and number of naturally regenerating individuals at these remnants were somewhat limited, so an attempt was made to measure all kahikatea at each site rather than using a plot-based methodology. Species richness and composition were also recorded by observations uploaded to iNaturalist. Again, a plot-based methodology was not employed due to the size of the remnants and because many of the understory species at Hillcrest Park and Grove Park were planted and have not naturally regenerated. However, Totara Park's well-established kahikatea saplings demonstrating recruitment were recorded by laterally traversing across the park with a sampling intensity of approximately 40 per cent.

Site assessments were conducted to identify differences in conditions and species assemblages among Te Papanui and the case studies. Research-grade observations of indigenous vascular plant species were downloaded from iNaturalist to assemble species lists for each site. A cautious approach was taken to remove any cultivated plants. The nomenclature follows the New Zealand Plant Conservation Network (NZPCN). This study focused on native vascular species, and while certain troublesome exotic species were noted, comprehensive species lists are not provided, although one has been compiled for the reference site [36].

2.3. Data Analysis

Diameter at breast height (DBH) measurements and counts of saplings were used to construct population structure histograms for each site. Further DBH data were extracted from assessments of the kahikatea at Te Papanui [50] and Totara Park [48]. Age midpoints were predicted using the DBH classes from a previous study [47] and two existing regression equations. For Te Papanui, Hillcrest Park and Grove Park, the J.R. Leathwick (unpublished) regression equation for Berkley, Hamilton was used for most of the size classes encountered. However, the D.A. McLean (unpublished) regression equation was used for the age midpoint of the youngest size class at Te Papanui, Hillcrest Park and Grove Park as it more accurately predicts the age of smaller trees. For Totara Park, the D.A. McLean (unpublished) regression equation was applied to reveal the midpoint of all size classes because it was developed from the park's data and is better suited to its larger population size and smaller age range. Then, the age midpoints were used to compare each kahikatea population structure (Figure 2). Three kahikatea at Hillcrest Park, Grove Park and Totara Park were cored using standard methodology [51] to verify the fit of the DBH-age relationship from the equations. On average, the estimated age of the kahikatea using the coring methodology was six years older than the DBH measurements suggested, with a margin of error less than 10 per cent.

1. Hillcrest and Grove Park Kahikatea Age Equation: $y = 55.127\text{Ln}(x) - 132.240$
2. Totara Park Kahikatea Age Equation: $y = 0.4262x + 24.693$

3. Results

3.1. Age Structures

The DBH of Te Papanui's 371 kahikatea ranged from two to 100 centimetres (cm). The average age was about 60 years, which is younger than Hillcrest Park and Grove Park. Most kahikatea were between 71 and 92 years. Te Papanui's kahikatea structure exhibited a wider range of ages than Totara Park but a similar structure to Hillcrest Park and Grove Park (Figures 2a and 3).

The DBH of Hillcrest Park's 223 kahikatea ranged between four and 127 cm. The average age was 82 years, which is older than Grove Park and Totara Park. The maximum age was estimated to be 135 years. The age structure of this patch shows that most trees are between 80 and 120 years, and the most common age is 118 years (Figures 2b and 3).

The DBH of Grove Park's 64 kahikatea ranged between 14 and 83 cm, with a mean diameter of 42 cm. The average age was 70 years, approximately 12 years younger than Hillcrest Park but 38 years older than Totara Park's kahikatea. From these measurements, the youngest kahikatea was approximately 19 years, and the maximum age was 130 years. Almost 70 per cent of the kahikatea were predicted to be 60 to 100 years, with the 60 to 70-year class containing the most trees (Figures 2c and 3).

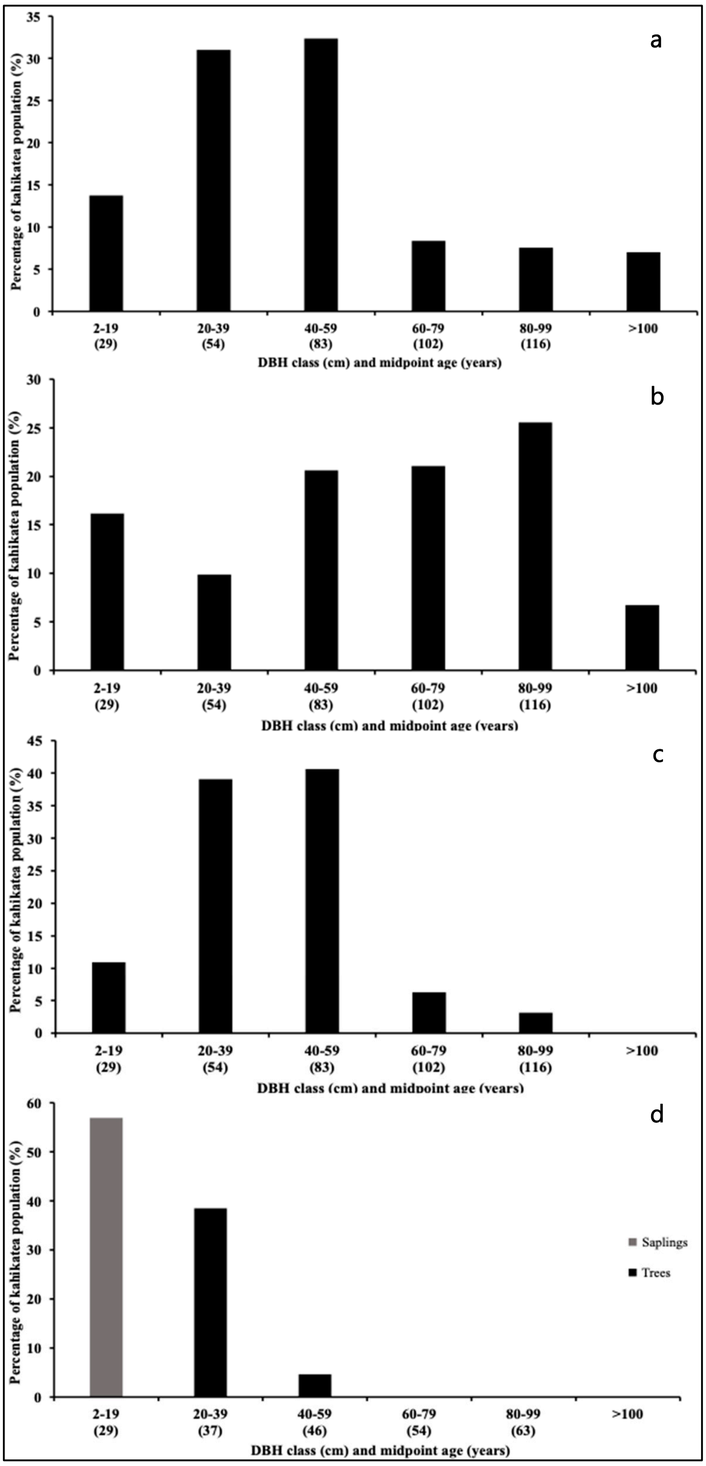

Figure 2. Kahikatea (A.Rich.) de Laub. stand DBH classes (percentage of population) and predicted midpoint age of Te Papanui n = 371 (**a**), Hillcrest Park n = 223 (**b**), Grove Park n = 64 (**c**) and Totara Park n = 65 (**d**). Size class data for Te Papanui (the reference site) was sourced from a previous study [37]. Ages were predicted from the J.R. Leathwick (unpublished) regression equation for Te Papanui, Hillcrest Park and Grove Park, although the midpoint age of their smallest size class was calculated from the D.A. McLean (unpublished) regression equation because it is a better predictor of the age of small kahikatea. Data were used from a previous study [49] for Totara Park's age structure, and ages were predicted using the D.A. McLean (unpublished) regression equation.

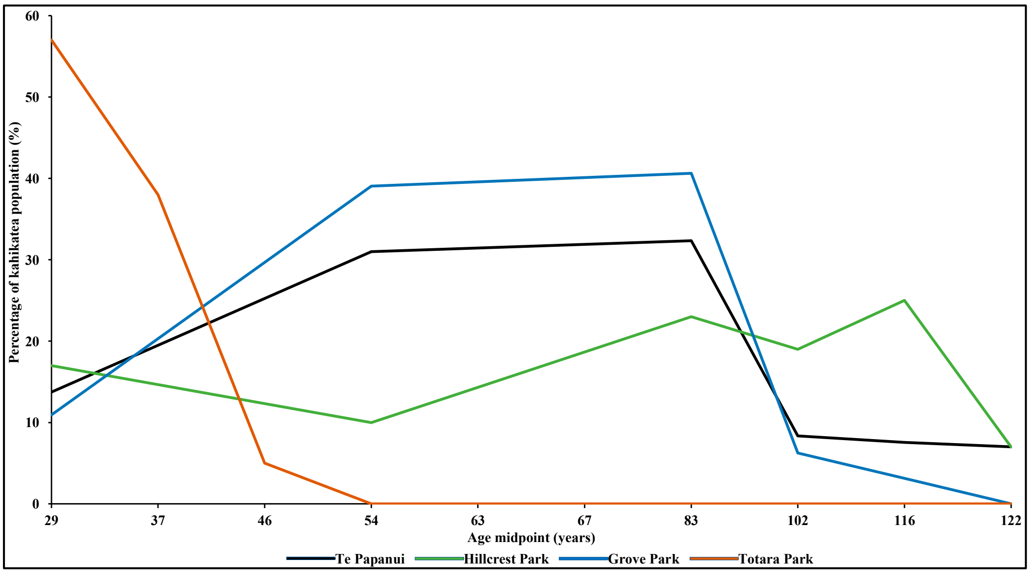

Figure 3. The percentage of kahikatea at each age midpoint for the four remnants. Totara Park is represented by younger age midpoints (29, 37, 46, 54, 63 and 67 years) than Te Papanui, Hillcrest Park and Grove Park (29, 54, 83, 102, 116 and 122 years) due to the use of different DBH-age regression equations. Ages were predicted from the J.R. Leathwick (unpublished) regression equation for Te Papanui, Hillcrest Park and Grove Park, and from the D.A. McLean (unpublished) regression equation for Totara Park.

Comprehensive data collected by Don McLean and Emma Coleman at Totara Park [48] found that the DBH of these kahikatea were between 3 and 47 cm. Totara Park had the youngest kahikatea population of the three sites, with an average age of 32 years. The minimum age was approximately 26 years, and the maximum was 45 years, representing a narrower age range than the other case studies. Fieldwork also identified 25 well-established kahikatea saplings demonstrating recruitment (grey bar in Figure 2d), defined as individuals taller than 135 cm with a DBH less than four centimetres [52]. Hundreds of smaller kahikatea seedlings (<135 cm) were also encountered.

3.2. Comparison of Biophysical Features with a Reference Site

Reference sites provide a model of optimal ecological integrity that have endured minimal degradation for similar sites while planning and evaluating restoration projects [5,34]. Although no two sites are identical, information extracted from a reference site, such as historical and current species composition, threats, and solutions, can guide the restoration of similar sites towards their natural state. Te Papanui is the largest semi-swamp kahikatea remnant in Hamilton City [45]. Therefore, its species composition should indicate species gaps in similar local patches (Appendix A). The ecological integrity of Te Papanui was compared with the three case studies to identify how to improve their condition.

Most of Hamilton City's primary forest has been lost, leaving small secondary forest patches. Primary forest includes mature stands that comprise their natural vegetation composition and have not recently been completed cleared or re-planted [53]. Te Papanui is the only kahikatea remnant in Hamilton City that partly includes primary forest. Conversely, secondary forest refers to stands regenerating through natural processes after substantial anthropogenic or natural disturbances, demonstrating a significant difference in species composition to nearby primary forest [54]. The kahikatea remnants at Grove Park, Totara Park, and Hillcrest Park are secondary forest patches.

General physical conditions that significantly influence the biotic communities of each remnant were also noted. Ecological connectivity is also poor across the sites, with the nearest healthy patch of indigenous vegetation often up to several kilometres away. All sites have been extensively drained where no kahikatea were found regenerating apart from Totara Park. Moderate buffers at Te Papanui, Hillcrest Park and Grove Park suggest their exposure to edge effects, including a less stable microclimate than Totara Park.

Site visits revealed fundamental differences in the condition of the forest tiers and the floristic composition of each remnant. Totara Park has abundant exotic plants in the canopy, shrub and ground cover tiers, while the other case studies have very few. Te Papanui supports the healthiest kahikatea patch with all three forest tiers intact, hosting rich native flora. The emergent kahikatea across all sites are healthy, with minimal yellowing or defoliating. Hillcrest Park has two intact tiers, Grove Park has a healthy canopy, and Totara Park is not dominated by native plants in any of its tiers.

Data collected from iNaturalist suggest that Hillcrest Park has only a handful of naturally established native species, including the canopy species of *Laurelia novae-zelandiae*, kahikatea, *Cordyline australis*, *Beilschmiedia tawa*, *Nestegis lanceolata* and *Elaeocarpus hookerianus*. Most other indigenous species in Hillcrest Park's understory were likely planted. No kahikatea seedlings (<135 cm tall) or saplings (>135 cm tall, with a DBH < four centimetres) were found during the site assessments indicating the lack of regeneration. A few troublesome weeds exist in Hillcrest Park, including *Euonymus japonicus*, *Hedera helix* and *Ligustrum lucidum*. Grove Park has also faced severe disturbances, including drainage and clearance; it is now a depauperate site with sixty kahikatea, one mature *Prumnopitys taxifolia* and a few understory plantings. The introduced species include *Laurus nobilis*, *Berberis glaucocarpa* and *Euonymus japonicus*. Totara Park's gully edge conditions, including increased light and well-drained soils, have enabled the establishment of *Melicytus ramiflorus* and *Cyathea dealbata*. Other common native species at Totara Park include kahikatea, *Cordyline australis*, *Dicksonia squarrosa* and *Geniostoma ligustrifolium*. The site also contains numerous problematic exotic plants, including *Salix cinerea*, *Zantedeschia aethiopica*, *Lonicera japonica* and *Ligustrum sinense*. A mature *Laurelia novae-zelandiae* in the patch signals that it is suitable habitat and an opportunity to reintroduce more individuals.

3.3. Life Forms and Epiphytes

The life form analyses using iNaturalist data found that Te Papanui hosts the most groups, followed by Totara Park, Grove Park and Hillcrest Park (Figure 4). The selected life forms included 13 categories of ferns and fern allies, gymnosperm trees, dicot trees, dicot shrubs, dicot lianes, dicot herbs, monocot trees, orchids, grasses, sedges, rushes, monocot herbs and monocot lianes [36]. Te Papanui supports species of all life forms except dicot herbs and rushes, also absent from the case studies. The dominant life forms at Te Papanui were ferns and fern allies and dicot trees. This trend is primarily consistent with the other sites. Totara Park's native flora includes eight life forms, not including monocot herbs, grasses, monocot lianes, dicot herbs or rushes. Grove Park's assessment identified six life forms but lacked dicot lianes, orchids, grasses, monocot lianes, sedges, dicot herbs and rushes. Finally, Hillcrest Park supported five life forms but lacked dicot lianes, monocot herbs, orchids, dicot shrubs, monocot lianes, sedges, dicot herbs and rushes.

Although counted separately, epiphytes play a prominent role in ecosystem functioning via biomass and nutrient partitioning [55] and are influenced by stand density and microclimate [56,57]. An epiphyte grows upon a host, is unconnected to soils and is not parasitic [58]. Life forms commonly containing epiphytes include ferns and fern allies, shrubs, herbs and orchids. Totara Park hosted the most epiphytes (nine), followed by Te Papanui (six), Hillcrest Park (one), and none were observed at Grove Park. The nine native epiphytes at Totara Park included eight ferns and fern allies (*Asplenium flaccidum*, *Asplenium oblongifolium*, *Asplenium polyodon*, *Microsorum pustulatum*, *Phlegmariurus varius*, *Pyrrosia eleagnifolia*, *Tmesipteris elongata* and *Tmesipteris lanceolata*) and one orchid (*Earina mucronata*). Comparably, the epiphytes at Te Papanui included four epiphytic ferns (*Arthropteris tenella*, *Blechnum filiforme*, *Microsorum scandens* and *Pyrrosia eleagnifolia*), one monocot herb (*Astelia hastata*) and one orchid (*Earina mucronata*). The fern *Pyrrosia eleagnifolia* was the only epiphyte found at Hillcrest Park.

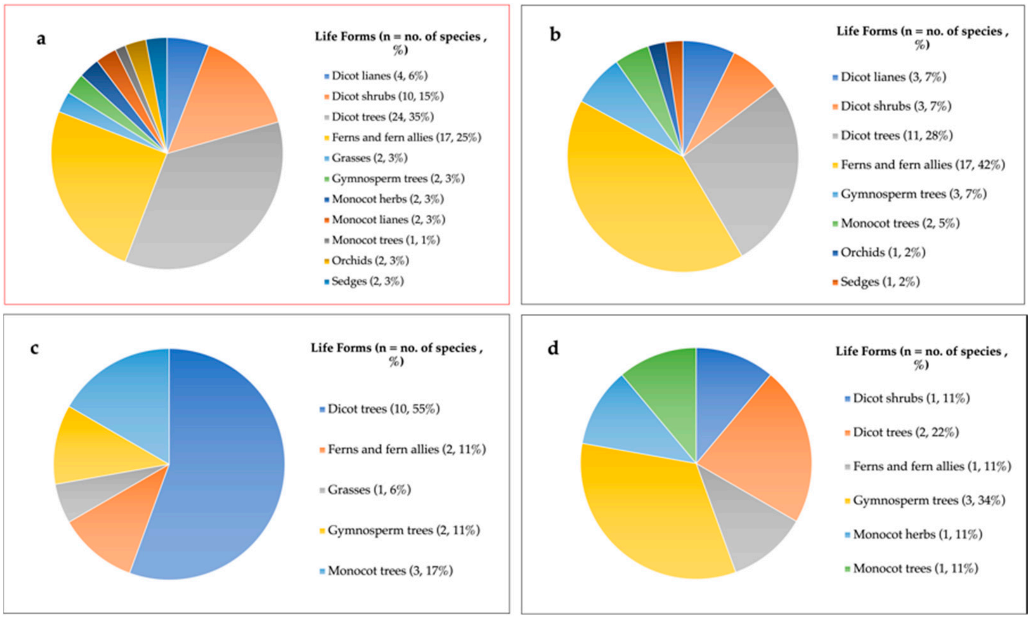

Figure 4. Life form analyses of Te Papanui (reference site; (**a**)) and three kahikatea remnants, including Totara Park (**b**), Hillcrest Park (**c**) and Grove Park (**d**). The life forms considered in this analysis included ferns and fern allies, gymnosperm trees, dicot trees, dicot shrubs, dicot lianes, dicot herbs, monocot trees, orchids, grasses, sedges, rushes, monocot herbs and monocot lianes [19].

Totara Park and Te Papanui support different epiphytic species apart from *Earina mucronata* and *Pyrrosia eleagnifolia*, which grow on a wide range of hosts. One explanation for the different assemblage of epiphytes at Te Papanui may be the loss of *Dicksonia squarrosa* (whekī), which was abundant in the mid-1900s [36]. Whekī is a ubiquitous tree fern found throughout New Zealand, which provides a prominent microsite for epiphytes [59,60]. For example, *Asplenium flaccidum*, *Asplenium oblongifolium*, *Phlegmariurus varius*, *Tmesipteris elongata* and *Tmesipteris lanceolata* were all found growing on whekī in Totara Park. The damp, cool microclimate of Totara Park also sets it apart from the other sites. Furthermore, epiphytes such as *Arthropteris tenella*, *Blechnum filiforme*, and *Microsorum scandens* that were not seen at Totara Park have typically colonised lower forest tiers in Te Papanui. The limited presence of epiphytic species at Hillcrest Park and Grove Park is likely due to their drainage and low humidity, which are not conducive to epiphytes [61].

4. Discussion

All three remnants provide significant restoration opportunities where mature kahikatea can act as nuclei for extending and connecting patches. The assortment of features at each site should guide the selection of restoration strategies and their application over time. For example, Hillcrest Park encompasses the oldest kahikatea and has the largest area available to restore, covering three different ecological units. Grove Park supports a secondary stand of kahikatea, with the smallest available restoration area of the three case studies. However, it contains the severely under-represented alluvial plains and is a key natural feature of the western side of the city. Totara Park is the best example of regenerating kahikatea in Hamilton City and offers a considerable area for restoration. The persistence of locally rare species in this remnant necessitates a sustained manipulation restoration strategy.

The kahikatea at Hillcrest Park are in reasonable condition, with plantings in the understory and a narrow buffer. The canopy layer is in the best state, with healthy kahikatea. Only one mature *Laurelia novae-zelandiae*, *Nestegis lanceolata*, and *Elaeocarpus hookerianus* still exist in the stand. The dense *Freycinetia banksii* understory tier described as a prominent feature of the stand in the 1960s [32] has been completely eradicated. The liane *Ripogonum scandens* has not been seen in the remnant since the 1990s [62]. Additionally, while community groups have restricted exotic plants from establishing and enabled native plants to dominate with an intact canopy tier, naturalised native plants, including *Pseudopanax* crassifolius × *lessonii* and *Hoheria populnea* [23], have established, and *Asplenium* × *lucrosum* has also been planted. Hillcrest Park's ground cover has been severely degraded, with clearance exacerbating unfavourable conditions like lower humidity and greater light penetration. The shrub layer also lacks several species, with a scarce dicot shrub life form aside from a few mature *Melicytus ramiflorus*. For example, characteristic small-leaved coprosma species are absent, including *Coprosma propinqua*, *Coprosma rotundifolia* and *Coprosma rhamnoides*. Other dicot shrubs typical of kahikatea forest that could be planted at Hillcrest Park include *Coprosma tenuicaulis* and *Melicytus micranthus*. *Teucridium parvifolium* is an at-risk characteristic shrub species that would suit the dry kahikatea patch [30]. Hillcrest Park's missing life forms included lianes and orchids, which would require improved semi-swamp conditions to establish. Characteristic species in Te Papanui included lianes such as *Freycinetia banksii*, *Metrosideros perforata*, *Parsonsia heterophylla*, *Passiflora tetrandra* and *Ripogonum scandens* and orchids such as *Earina mucronata* and *Microtis unifolia*. Only one epiphyte (*Pyrrosia eleagnifolia*) was found at Hillcrest Park. Extending Hillcrest Park's buffer alongside ground cover and shrub tier plantings would reduce its exposure and enhance its ecological integrity.

Modest plantings at Grove Park since 2003 and the control of exotics have contributed significantly to its health. However, artificial drainage has also considerably modified the physical conditions of the patch from its original state. Like Te Papanui, it is unlikely that a high-water table will be re-established at Grove Park, given its proximity to residential properties. The canopy is relatively intact with a healthy kahikatea population, one *Prumnopitys taxifolia*, and planted *Carpodetus serratus*, *Aristotelia serrata* and *Alectryon excelsus*. However, there is minimal ground cover with just one native fern (*Blechnum parrisiae*). The shrub tier currently comprises a few planted species like *Coprosma robusta*, *Melicytus micranthus* and *Geniostoma ligustrifolium*. Life forms missing from this stand include grasses, sedges, herbs and rushes from the ground cover tier and lianes and orchids from the shrub and canopy tiers. Characteristic ground cover species of kahikatea forests that may be planted include sedges like *Carex uncinata*, *Carex dissita*, *Carex lambertiana* and *Uncinia uncinata*. Epiphytes typically found in kahikatea forest include *Astelia hastata* and *Blechnum filiforme*. Further planting of appropriate shrub species such as *Coprosma areolata*, *Coprosma tenuicaulis*, *Melicytus micranthus* and *Melicytus ramiflorus* should improve its ecological integrity. *Teucridium parvifolium*, a characteristic species that grows in dry conditions, has already been planted at Grove Park. Planting additional individuals could improve its population viability while contributing to the stand's diversity. The restoration of Grove Park would provide numerous benefits, including strengthened ecological linkages from the southwest of the city to other native patches and gullies. Extending Grove Park's buffer and planting its ground cover and shrub layers would reduce the edge effects, increase its diversity and improve its ecological health.

Totara Park provides an exceptional example of the effect of a functional flooding regime on the persistence of native species that are otherwise rare throughout the city. In contrast to Te Papanui, Totara Park comprises *Tmesipteris lanceolata*, *Tmesipteris elongata*, *Dicksonia fibrosa* and *Rhopalostylis sapida*, which prefer its sheltered, damp and cool microclimate. Its richer epiphytic diversity than Te Papanui and the other case studies highlight the value of restoring Totara Park to protect these species and encourage the establishment of others. Epiphytic species such as *Griselina lucida*, *Pittosporum cornifolium* and *Astelia solandri* could be reintroduced to the site and protected while carefully managing the profusion of troublesome weeds at Totara Park. Some of the troublesome weeds include grey willow, *Lonicera japonica*, *Ligustrum sinense*, *Tradescantia fluminensis*, and *Euonymus japonicus*. Suddenly removing all exotic species could alter the cool, damp and sheltered conditions that have enabled the locally rare native species to persist. Despite the abundance of exotic plants in Totara Park, the grey willow-kahikatea patch supports the most native species per forest tier of the three case studies. Its native dicot trees include *Aristotelia serrata* and *Schefflera digitata*. The natural establishment of mature *Melicytus ramiflorus* on the northern edge and one *Laurelia novae-zelandiae* suggest it may be practical to plant more individuals of these species. Another characteristic tree that would likely thrive in this environment is *Syzygium maire*. The shrub layer includes *Coprosma robusta*, *Coprosma autumnalis* and *Geniostoma ligustrifolium*, which could be enriched to include species such as *Coprosma areolata*, *Coprosma tenuicaulis* and *Melicytus micranthus*. The orchid *Earina mucronata* persists in the patch, and if restored, epiphytes currently at Te Papanui such as *Arthropteris tenella*, *Astelia hastata*, *Blechnum filiforme*, and *Microsorum scandens* may eventually establish (see Appendix B for planting zone maps for the case studies). Optimising the ecological potential of Totara Park requires the adoption of a manipulation strategy to progressively release native plants from the competition of abundant exotic species and encourage the persistence of uncommon native species in the other forest tiers. This strategy would be labour-intensive, requiring the careful control of exotics to gradually allow kahikatea to dominate the canopy.

Implications for Management

Kahikatea forest was once ubiquitous in the lowland basins of New Zealand. With less than two per cent of its original extent remaining nationally, one per cent in the Waikato region and only 15 ha in Hamilton City, it urgently requires protection and enhancement. Restoring kahikatea forest patches to their original state requires the careful selection of characteristic species that should be based on sites that have experienced minimal anthropogenic disturbance to achieve as full a species occupancy as practicable. Planting species from the missing life forms could fill functional gaps at each site. The leading threat facing kahikatea swamp forests is artificial drainage, which continues to modify the physical and biotic traits of Hillcrest Park and Grove Park. As seen at Totara Park, reinstating a functional flooding regime can substantially enhance the health of kahikatea forest. Plant pest control will be vital for the successful restoration of Totara Park, requiring a labour-intensive manipulation strategy. All three patches are also highly exposed to unfavourable edge conditions because of their small size. Extending the buffer at each site would likely mitigate forest edge effects and stabilise the microclimate by reducing light intensity and air temperature and increasing the humidity. Regardless of the limited size of these patches, they provide some of the last opportunities to conserve kahikatea semi-swamp forest in Hamilton City.

The restoration of the extant kahikatea remnants in Hamilton City would require substantial resources. Aside from four sites, all remaining kahikatea forest in the city is found in patches of less than one hectare. Given the wet conditions that kahikatea require for regeneration, it would be pragmatic to prioritise the few sites that provide these conditions (such as Totara Park) to conserve kahikatea semi-swamp forest. It would also be practical to focus on restoring the city's gully floors which are predicted to have supported kahikatea-pukatea-swamp maire forest [18]. Gullies also face less threat from artificial drainage and can provide conditions conducive to kahikatea forest. For example, relic kahikatea on the narrow floors of the Mangaonua and Kirkiriroa (Onukutara) gullies signal significant restoration opportunities. Future studies may consider the restoration potential of these sites and how they could contribute to a reconnected network of kahikatea patches, like Hillcrest Park, Totara Park and Grove Park, throughout the city.

Such site assessments should consider the implications for stakeholders and include extensive consultation to obtain consensus on priorities for restoration implementation.

5. Conclusions

Restoring native forest remnants is a common goal for many urban restoration projects globally [63]. Identifying differences in species and physical features among urban remnants and a reference site can reveal species gaps and key threats to inform management decisions and enhance biodiversity in cities [64,65]. This study has presented a simple framework to improve the ecological integrity of sites, consistent with a national framework [66], by revealing differences in life forms across sites and, therefore, functional gaps that could be filled [67,68]. Similar studies could employ these methods of identifying species and life form gaps among urban remnants and reference sites to guide the selection of appropriate restoration strategies in other cities.

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Appendix A

Table A1. Indigenous vascular plant species recorded in Te Papanui (reference site; (**1**) and the case study kahikatea remnants, including Totara Park (**2**), Hillcrest Park (**3**) and Grove Park (**4**). Data was extracted from iNaturalist NZ on 3 February 2022, and the nomenclature follows the New Zealand Plant Conservation Network (NZPCN).

Scientific Name	Family	Common Name	Life Form	Site(s)
Adiantum cunninghamii	Pteridaceae	Maidenhair	Ferns and fern allies	1
Alectryon excelsus	Sapindaceae	Titoki	Dicot trees	1, 3
Alseuosmia quercifolia	Alseuosmiaceae		Dicot shrubs	1
Aristotelia serrata	Elaeocarpaceae	Wineberry	Dicot trees	1, 2
Arthropteris tenella	Tectariaceae	Climbing fern	Ferns and fern allies	1
Asplenium bulbiferum	Aspleniaceae	Hen and chickens fern	Ferns and fern allies	1
Asplenium flaccidum	Aspleniaceae	Drooping spleenwort	Ferns and fern allies	2
Asplenium oblongifolium	Aspleniaceae	Shining spleenwort	Ferns and fern allies	1, 2
Asplenium polyodon	Aspleniaceae	Sickle spleenwort	Ferns and fern allies	2
Astelia hastata	Asteliaceae	Tank lily	Monocot herbs	1
Beilschmiedia tawa	Lauraceae	Tawa	Dicot trees	1, 3
Blechnum chambersii	Blechnaceae	Rereti	Ferns and fern allies	2
Blechnum filiforme	Blechnaceae	Thread fern	Ferns and fern allies	1
Blechnum novae-zelandiae	Blechnaceae	Kiokio	Ferns and fern allies	2
Blechnum parrisiae	Blechnaceae	Rasp fern	Ferns and fern allies	1, 4
Calystegia sepium	Convolvulaceae	Hedge bindweed	Dicot lianes	2
Calystegia tuguriorum	Convolvulaceae	New Zealand bindweed	Dicot lianes	2
Carex secta	Cyperaceae	Pukio	Sedges	2
Carex uncinata	Cyperaceae	Bastard grass	Sedges	1
Carpodetus serratus	Rousseaceae	Putaputaweta	Dicot trees	1
Coprosma areolata	Rubiaceae	Aruhe	Dicot shrubs	1

Table A1. *Cont.*

Scientific Name	Family	Common Name	Life Form	Site(s)
Coprosma autumnalis	Rubiaceae	Kanono	Dicot shrubs	1, 2
Coprosma lucida	Rubiaceae	Shining karamu	Dicot shrubs	1
Coprosma rigida	Rubiaceae		Dicot shrubs	1
Coprosma robusta	Rubiaceae	Karamu	Dicot shrubs	1, 2, 4
Cordyline australis	Asparagaceae	New Zealand cabbage tree	Monocot trees	1, 2, 3, 4
Cordyline banksii	Asparagaceae	Forest cabbage tree	Monocot trees	3
Corynocarpus laevigatus	Corynocarpaceae	Karaka	Dicot trees	1
Cyathea dealbata	Cyatheaceae	Silver fern	Ferns and fern allies	1, 2, 3
Cyathea medullaris	Cyatheaceae	Mamaku	Ferns and fern allies	1,2
Cyperus ustulatus	Cyperaceae	Coastal cutty grass	Sedges	1
Dacrycarpus dacrydioides	Podocarpaceae	Kahikatea	Gymnosperm trees	1, 2, 3, 4
Dacrydium cupressinum	Podocarpaceae	Rimu	Gymnosperm trees	2
Dianella nigra	Xanthorrhoeaceae	New Zealand blue berry	Monocot herbs	4
Dicksonia fibrosa	Dicksoniaceae	Wheki-ponga	Ferns and fern allies	2
Dicksonia squarrosa	Dicksoniaceae	Wheki	Ferns and fern allies	2
Diplazium australe	Athyriaceae	Austral lady-fern	Ferns and fern allies	1, 2
Earina mucronata	Orchidaceae	Peka-a-waka	Orchids	1, 2
Elaeocarpus hookerianus	Elaeocarpaceae	Pokaka	Dicot trees	1
Freycinetia banksii	Pandanaceae	Kiekie	Monocot lianes	1
Geniostoma ligustrifolium	Loganiaceae	Hangehange	Dicot shrubs	1, 2
Hedycarya arborea	Monimiaceae	Pigeonwood	Dicot trees	1, 3
Histiopteris incisa	Dennstaedtiaceae	Water fern	Ferns and fern allies	1
Hoheria populnea	Malvaceae	North Island lacebark	Dicot trees	1,2
Knightia excelsa	Proteaceae	Rewarewa	Dicot trees	1
Laurelia novae-zelandiae	Atherospermataceae	Pukatea	Dicot trees	1, 2, 3
Litsea calicaris	Lauraceae	Mangeao	Dicot trees	1
Lomaria discolor	Blechnaceae	Crown fern	Ferns and fern allies	1
Melicytus ramiflorus	Violaceae	Mahoe	Dicot trees	1, 2, 3
Metrosideros perforata	Myrtaceae	Climbing rata	Dicot lianes	1
Microlaena avenacea	Poaceae	Bush rice grass	Grasses	1, 3
Zealandia pustulatum	Polypodiaceae	Hound's tongue fern	Ferns and fern allies	2
Microsorum scandens	Polypodiaceae	Fragrant fern	Ferns and fern allies	1
Microtis unifolia	Orchidaceae	Maikaika	Orchids	1
Mida salicifolia	Nanodeaceae	Maire taiki	Dicot trees	1
Muehlenbeckia australis	Polygonaceae	Pohuehue	Dicot lianes	1, 2
Myrsine australis	Primulaceae	Mapou	Dicot trees	1, 2, 3, 4

Table A1. *Cont.*

Scientific Name	Family	Common Name	Life Form	Site(s)
Nestegis cunninghamii	Oleaceae	Black maire	Dicot trees	1
Nestegis lanceolata	Oleaceae	White maire	Dicot trees	1
Oplismenus hirtellus imbecillis	Poaceae		Grasses	1
Parapolystichum microsorum	Dryopteridaceae	Creeping shield fern	Ferns and fern allies	1
Parsonsia heterophylla	Apocynaceae	Kaihua	Dicot lianes	1
Passiflora tetrandra	Passifloraceae	Kohia	Dicot lianes	1
Pellaea rotundifolia	Pteridaceae	Button fern	Ferns and fern allies	1
Phlegmariurus varius	Lycopodiaceae	Hanging clubmoss	Ferns and fern allies	2
Phormium tenax	Asphodelaceae	Harakeke	Monocot herbs	1
Piper excelsum	Piperaceae	Kawakawa	Dicot shrubs	1
Pittosporum eugenioides	Pittosporaceae	Tarata	Dicot trees	2
Pittosporum tenuifolium	Pittosporaceae	Kohuhu	Dicot trees	1, 2
Pneumatopteris pennigera	Thelypteridaceae	Gully fern	Ferns and fern allies	2
Podocarpus totara	Podocarpaceae	Totara	Gymnospern trees	2, 3, 4
Prumnopitys taxifolia	Podocarpaceae	Matai	Gymnosperm trees	1, 4
Pseudopanax arboreus	Araliaceae	Five finger	Dicot trees	1
Pseudopanax crassifolius	Araliaceae	Lancewood	Dicot trees	1, 2
Pseudopanax crassifolius x lessonii	Araliaceae		Dicot trees	1, 2, 3, 4
Pseudopanax lessonii	Araliaceae	Houpara	Dicot trees	1, 2
Pteris macilenta	Pteridaceae	Sweet fern	Ferns and fern allies	1
Pteris tremula	Pteridaceae	Shaking brake	Ferns and fern allies	1
Pyrrosia eleagnifolia	Polypodiaceae	Leather-leaf fern	Ferns and fern allies	1, 2
Rhopalostylis sapida	Arecaceae	Nikau palm	Monocot trees	2, 3
Ripogonum scandens	Ripogonaceae	Supplejack	Monocot lianes	1
Schefflera digitata	Araliaceae	Pate	Dicot trees	1, 2
Solanum laciniatum	Solanaceae	Poroporo	Dicot shrubs	1
Streblus heterophyllus	Moraceae	Small-leaved milk tree	Dicot trees	1, 3
Tmesipteris elongata	Psilotaceae	Fork fern	Ferns and fern allies	2
Tmesipteris lanceolata	Psilotaceae	Fork fern	Ferns and fern allies	2
Veronica stricta	Plantaginaceae	Koromiko	Dicot shrubs	1
Vitex lucens	Lamiaceae	Puriri	Dicot trees	1

Appendix B

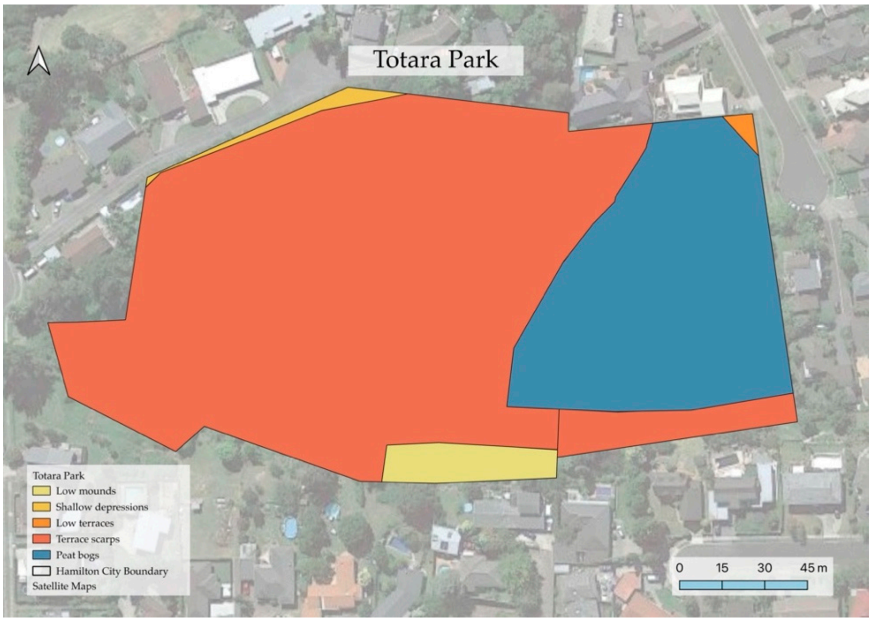

Figure A1. Totara Park's planting zones. Low mounds (mixed conifer-broadleaf forest); shallow depressions (kahikatea semi-swamp forest); low terraces (totara-matai-kowhai forest); terrace scarps (totara-matai-kowhai forest) and peat bogs (shrub sedgeland). In the terrace scarps ecological unit, appropriate species to plant include *Blechnum chambersii*, *Dacrydium cupressinum*, *Podocarpus totara*, *Prumnopitys taxifolia*, *Olearia rani* and *Knightia excelsa*. Restoration of the open grassy area to the east of the grey willow-kahikatea patch would require less effort. The space could be planted with suitable species for the shrub sedgeland ecological unit, including *Leptospermum scoparium*, *Cordyline australis*, *Coprosma propinqua*, *Machaerina teretifolia*, *M. rubiginosa*, *Phormium tenax* and *Carex secta* [18].

Figure A2. Hillcrest Park's planting zones. Hilly land (rimu/tawa forest); low rolling hills—footslopes (pukatea-kahikatea forest); low mounds (mixed conifer-broadleaf forest) and shallow depressions (kahikatea semi-swamp forest). Pioneer species of the alluvial plains include *Cordyline australis*, *Melicytus ramiflorus*, and *Myrsine australis*. Alternatively, pioneer species of the hills include *Hedycarya arborea*, *Podocarpus totara* and *Alectryon excelsus* [18].

Figure A3. Grove Park's planting zone. The shallow depressions ecological unit suggests that planting kahikatea semi-swamp forest species around the remnant could be appropriate. Some of the appropriate species for planting the grassy areas of this shallow depressions ecological unit include *Cordyline australis*, *Myrsine australis*, and *Melicytus ramiflorus*. Species suited to the understory of this ecological unit include *Beilschmiedia tawa*, *Syzygium maire* and *Laurelia novae-zelandiae* [18].

References

1. Standish, R.J.; Hobbs, R.J.; Miller, J.R. Improving city life: Options for ecological restoration in urban landscapes and how these might influence interactions between people and nature. *Landsc. Ecol.* **2013**, *28*, 1213–1221. [CrossRef]
2. Xie, L.; Bulkeley, H. Nature-based solutions for urban biodiversity governance. *Environ. Sci. Policy* **2020**, *110*, 77–87. [CrossRef]
3. Handel, S.N.; Saito, O.; Takeuchi, K. Restoration ecology in an urbanizing world. In *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*; Springer: Dordrecht, The Netherlands, 2013; pp. 665–698.
4. Nilon, C.H.; Aronson, M.F.J.; Cilliers, S.S.; Dobbs, C.; Frazee, L.J.; Goddard, M.A.; O'Neill, K.M.; Roberts, D.; Stander, E.K.; Werner, P.; et al. Planning for the future of urban biodiversity: A global review of city-scale initiatives. *BioScience* **2017**, *67*, 332–342. [CrossRef]
5. Gann, G.D.; McDonald, T.; Walder, B.; Aronson, J.; Nelson, C.R.; Jonson, J.; Hallett, J.G.; Eisenberg, C.; Guariguata, M.R.; Liu, J.; et al. International principles and standards for the practice of ecological restoration. *Restor. Ecol.* **2019**, *27*, S1–S46. [CrossRef]
6. Mata, L.; Ramalho, C.E.; Kennedy, J.; Parris, K.M.; Valentine, L.; Miller, M.; Bekessy, S.; Hurley, S.; Cumpston, Z. Bringing nature back into cities. *People Nat.* **2020**, *2*, 350–368. [CrossRef]
7. Newman, A. Inclusive urban ecological restoration in Toronto, Canada. In *Human Dimensions of Ecological Restoration*; Island Press: Washington, DC, USA, 2011; pp. 63–75.
8. Bonilla-Rodríguez, M.; Arroyo-Lambaer, D.; Castillo, A.; Zambrano, L.; Cano-Santana, Z. Urban Ecological Restoration: Setting Priorities for Restoring Native Vegetation in Lava Field Remnants in Mexico City. *Front. Sustain. Cities* **2021**, *3*, 709357. [CrossRef]
9. Roni, P.; Hanson, K.; Beechie, T. Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. *N. Am. J. Fish. Manag.* **2008**, *28*, 856–890. [CrossRef]
10. Mumaw, L.; Bekessy, S. Wildlife gardening for collaborative public–private biodiversity conservation. *Australas. J. Environ. Manag.* **2017**, *24*, 242–260. [CrossRef]
11. Barton, J.; Pretty JU LE, S. Urban ecology and human health and wellbeing. *Urban Ecol.* **2010**, *12*, 202–229.
12. Viezzer, J.; Schmidt MA, R.; dos Reis AR, N.; Freiman, F.P.; de Moraes, E.N.; Biondi, D. Restoration of urban forests to reduce flood susceptibility: A starting point. *Int. J. Disaster Risk Reduct.* **2022**, *74*, 102944. [CrossRef]
13. Gross, M.; Hoffmann-Riem, H. Ecological restoration as a real-world experiment: Designing robust implementation strategies in an urban environment. *Public Underst. Sci.* **2005**, *14*, 269–284. [CrossRef]
14. He, J.; Wan, Y.; Tang, Z.; Zhu, X.; Wen, C. A developed framework for the multi-district ecological compensation standards integrating ecosystem service zoning in an urban area in China. *Sustainability* **2019**, *11*, 4876. [CrossRef]

15. Fitzimons, J.A.; Antos, M.J.; Palmer, G.C. When more is less: Urban remnants support high bird abundance but diversity varies. *Pac. Conserv. Biol.* **2011**, *17*, 97–109. [CrossRef]
16. Crossman, N.D.; Bryan, B.A.; Ostendorf, B.; Collins, S. Systematic landscape restoration in the rural–urban fringe: Meeting conservation planning and policy goals. *Biodivers. Conserv.* **2007**, *16*, 3781–3802. [CrossRef]
17. Clarkson, B.D.; Kirby, C.L. Ecological restoration in urban environments in New Zealand. *Ecol. Manag. Restor.* **2016**, *17*, 180–190. [CrossRef]
18. Clarkson, B.D.; Clarkson, B.R.; Downs, T.M. Indigenous Vegetation Types of Hamilton Ecological District. CBER Contract Report 58; Centre for Biodiversity and Ecology Research, Department of Biological Sciences, School of Science and Engineering, The University of Waikato: Hamilton, New Zealand, 2007. Available online: www.waikato.ac.nz/eri/reports/cber (accessed on 29 September 2022).
19. Singers, N.; Crisp, P.; Spearpoint, O. *Forest Ecosystems of the Wellington Region*; Greater Wellington Regional Council: Wellington, New Zealand, 2018.
20. Waikato Regional Council (WRC). Kahikatea Forest Fragments: Managing a Waikato Icon. Available online: www.waikatoregion.govt.nz/assets/WRC/WRC-2019/Forest-Fragment-factsheet-6.pdf (accessed on 22 November 2021).
21. McGlone, M.S. The Polynesian settlement of New Zealand in relation to environmental and biotic changes. *N. Z. J. Ecol.* **1989**, *12*, 115–129.
22. Griffiths, J.W.; McAlpine, K.G. Aerial glyphosate application reduces grey willow (*Salix cinerea*) canopy cover, increases light availability, and stimulates kahikatea (*Dacrycarpus dacrydioides*) growth. *N. Z. J. Ecol.* **2017**, *41*, 234–239. [CrossRef]
23. Dingwall, P. New Zealand: Saving some of everything. *Ambio* **1982**, *11*, 296–301.
24. Derhé, M.A.; Murphy, H.; Monteith, G.; Menéndez, R. Measuring the success of reforestation for restoring biodiversity and ecosystem functioning. *J. Appl. Ecol.* **2016**, *53*, 1714–1724. [CrossRef]
25. Laughlin, D.C.; Chalmandrier, L.; Joshi, C.; Renton, M.; Dwyer, J.M.; Funk, J.L. Generating species assemblages for restoration and experimentation: A new method that can simultaneously converge on average trait values and maximize functional diversity. *Methods Ecol. Evol.* **2018**, *9*, 1764–1771. [CrossRef]
26. Laughlin, D.C. Applying trait-based models to achieve functional targets for theory-driven ecological restoration. *Ecol. Lett.* **2014**, *17*, 771–784. [CrossRef] [PubMed]
27. Dawson, J.; Lucas, R. *Field Guide to New Zealand's Native Trees*; Craig Potton: Nelson, New Zealand, 2016; pp. 18–19.
28. Philipson, W.R.; Molloy BP, J. Seedling, shoot, and adult morphology of New Zealand conifers The genera Dacrycarpus, Podocarpus, Dacrydium, and Prumnopitys. *N. Z. J. Bot.* **1990**, *28*, 73–84. [CrossRef]
29. Smale, M.C.; Ross, C.W.; Arnold, G.C. Vegetation recovery in rural kahikatea (*Dacrycarpus dacrydioides*) forest fragments in the Waikato region, New Zealand, following retirement from grazing. *N. Z. J. Ecol.* **2005**, *29*, 261–269.
30. Burns, B.R.; Smale, M.C.; Merrett, M.F. *Dynamics of Kahikatea Forest Remnants in Middle North Island: Implications for Threatened and Local Plants*; Department of Conservation: Wellington, New Zealand, 1999.
31. Bryan, C.L. Barrett Bush Management Plan. 2012. Available online: www.waikato.ac.nz/eri/reports (accessed on 29 September 2022).
32. de Lange, P.J. The indigenous flora of the 'dry' kahikatea forest remnants of the southeastern Hamilton Basin. *Wellingt. Bot. Soc. Bull.* **2014**, *55*, 2–31.
33. Waikato Regional Council (WRC). Biodiversity Inventory Metadata. 2021; unpublished.
34. Clewell, A.; Aronson, J.; Winterhalder, K. *The SER International Primer on Ecological Restoration*; Society for Ecological Restoration International Science & Policy Working Group: Tucson, AZ, USA, 2004. Available online: www.ser.org (accessed on 29 September 2022).
35. Cockayne, L.; Turner, E.P. *The Trees of New Zealand*, 4th ed.; Inform; NZ Forestry Service: Wellington, New Zealand, 1958.
36. Cornes, T.S.; Clarkson, B.D. Assessment of Vegetation Condition and Health at Claudelands Bush; Jubilee Bush/Te Papanui. Centre for Biodiversity and Ecology Research, Department of Biological Sciences, School of Science and Engineering, The University of Waikato: Hamilton, New Zealand, 2010; Available online: www.waikato.ac.nz/eri/reports/cber (accessed on 29 September 2022).
37. Waikato Regional Council (WRC). "Kahikatea Forest Green Wheel"—Developing a Tool to Assess Ecosystem Recovery of Kahikatea Remnants in the Waikato Region. Available online: www.waikatoregion.govt.nz/assets/WRC/WRC-2019/TR201901.pdf (accessed on 1 December 2021).
38. Landcare. Kahikatea Fragment Enhancement Project. Available online: www.landcare.org.nz/completed-project-item/kahikatea-fragment-enhancement-project (accessed on 15 January 2022).
39. Wilcox, F.J. Vegetation Recovery and Management of Kahikatea (*Dacrycarpus dacrydioides*)-Dominated Forest Remnants in the Waikato Region. Master's Thesis, University of Waikato, Hamilton, New Zealand, 2010.
40. Hamilton City Council (HCC). Jubilee Park Management Plan. Available online: www.hamilton.govt.nz/our-council/strategiesandplans/Pages/Reserve-Management-Plans.aspx (accessed on 15 April 2022).
41. Statistics New Zealand. Hamilton City. Available online: www.stats.govt.nz/tools/2018-census-place-summaries/hamilton-city (accessed on 25 April 2021).
42. Hamilton City Council. Council Open Agenda: LTP 2021–2031. Available online: www.hamilton.govt.nz/our-council/10-year-plan (accessed on 24 April 2021).

43. Wallace, K.J.; Clarkson, B.D.; Farnworth, B. Restoration Trajectories and Ecological Thresholds during Planted Urban Forest Successional Development. *Forests* **2022**, *13*, 199. [CrossRef]
44. Clarkson, B.D.; Downs, T.M. Hamilton Gully Restoration: Integrating Ecology, Propagation, and Planting. In Proceedings of the Combined Proceedings—International Plant Propagators Society, IPPS, Carlisle, PA, USA; 2001; Volume 51, pp. 98–105.
45. Cornes, T.S.; Thomson, R.E.; Clarkson, B.D. Key Ecological Sites of Hamilton City: Volume 1. Centre for Biodiversity and Ecology Research, The University of Waikato: Hamilton, New Zealand, 2012. Available online: www.waikato.ac.nz/eri/reports/cber (accessed on 29 September 2022).
46. Cornes, T.S.; Thomson, R.E.; Clarkson, B.D. Key Ecological Sites of Hamilton City: Volume 2. Centre for Biodiversity and Ecology Research, The University of Waikato: Hamilton, New Zealand, 2011. Available online: www.waikato.ac.nz/eri/reports/cber (accessed on 29 September 2022).
47. Kelly, G. A Case Study of the Urban Forest in Hamilton: Grove Park—Dinsdale. 1997; Unpublished manuscript.
48. Coleman, E.J. Mechanisms of Interference between Kahikatea and Grey Willow in the Waikato. Master's Thesis, University of Waikato, Hamilton, New Zealand, 2010.
49. Downs, T.M.; Clarkson, B.D.; Beard, C.M. *Key Ecological Sites of Hamilton City*; CBER Contract Report No. 5; Centre for Biodiversity and Ecology Research, University of Waikato: Hamilton, New Zealand, 2000.
50. Whaley, P.T.; Clarkson, B.D.; Smale, M.C. Claudelands Bush: Ecology of an urban kahikatea (*Dacrycarpus dacrydioides*) forest remnant in Hamilton, New Zealand. *Tane* **1997**, *36*, 131–155.
51. Norton, D.A. *Impacts of Tree Coring on Indigenous Trees*; Department of Conservation: Christchurch, New Zealand, 1998.
52. Champion, P.D. The Ecology and Management of Kahikatea *Dacrycarpus dacrydioides*. Doctoral Dissertation, University of Waikato, Hamilton, New Zealand, 1988.
53. Margono, B.A.; Potapov, P.V.; Turubanova, S.; Stolle, F.; Hansen, M.C. Primary forest cover loss in Indonesia over 2000–2012. *Nat. Clim. Change* **2014**, *4*, 730–735. [CrossRef]
54. Chokkalingam, U.; De Jong, W. Secondary forest: A working definition and typology. *Int. For. Rev.* **2001**, *3*, 19–26.
55. Hofstede, R.G.; Dickinson, K.J.; Mark, A.F. Distribution, abundance and biomass of epiphyte-lianoid communities in a New Zealand lowland Nothofagus-podocarp temperate rain forest: Tropical comparisons. *J. Biogeogr.* **2001**, *28*, 1033–1049. [CrossRef]
56. Hietz, P. Diversity and conservation of epiphytes in a changing environment. *Pure Appl. Chem.* **1999**, *70*, 1–11.
57. Wallace, K.J.; Laughlin, D.C.; Clarkson, B.D. Exotic weeds and fluctuating microclimate can constrain native plant regeneration in urban forest restoration. *Ecol. Appl.* **2017**, *27*, 1268–1279. [CrossRef] [PubMed]
58. Moffett, M.W. What's "Up"? A critical look at the basic terms of canopy biology 1. *Biotropica* **2000**, *32*, 569–596. [CrossRef]
59. Brock, J.M.; Burns, B.R. Patterns of woody plant epiphytism on tree ferns in New Zealand. *N. Z. J. Ecol.* **2021**, *45*, 1–10. [CrossRef]
60. Page, C.N.; Brownsey, P.J. Tree-fern skirts: A defence against climbers and large epiphytes. *J. Ecol.* **1986**, *74*, 787–796. [CrossRef]
61. Oliver, W.R.B. New Zealand epiphytes. *J. Ecol.* **1930**, *18*, 1–50. [CrossRef]
62. Clarkson, B.D. Notes on Hillcrest Park's Flora. **1993**, Unpublished data.
63. McKinney, M.L. Urbanization, Biodiversity, and ConservationThe impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems. *Bioscience* **2002**, *52*, 883–890. [CrossRef]
64. Johnson, L.R.; Handel, S.N. Restoration treatments in urban park forests drive long-term changes in vegetation trajectories. *Ecol. Appl.* **2016**, *26*, 940–956. [CrossRef]
65. Guntenspergen, G.R.; Levenson, J.B. Understory plant species composition in remnant stands along an urban-to-rural land-use gradient. *Urban Ecosyst.* **1997**, *1*, 155–169. [CrossRef]
66. McGlone, M.S.; McNutt, K.; Richardson, S.J.; Bellingham, P.J.; Wright, E.F. Biodiversity monitoring, ecological integrity, and the design of the New Zealand Biodiversity Assessment Framework. *N. Z. J. Ecol.* **2020**, *44*, 1–12. [CrossRef]
67. Carignan, V.; Villard, M.A. Selecting indicator species to monitor ecological integrity: A review. *Environ. Monit. Assess.* **2002**, *78*, 45–61. [CrossRef]
68. Alberti, M. Maintaining ecological integrity and sustaining ecosystem function in urban areas. *Curr. Opin. Environ. Sustain.* **2010**, *2*, 178–184. [CrossRef]