TECHNICAL REPORT

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Urban Forest Canopy Cover

Applying current global state of knowledge to a New Zealand context

Submitted to Christchurch City Council and Wellington City Council

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This technical report presents independent research conducted by the University of Canterbury as commissioned by the Christchurch City Council and the Wellington City Council. The client brief was to undertake a literature review on urban forest canopy cover and to provide recommendations for canopy cover targets for New Zealand's cities.

Executive Summary

Tree canopy cover (TCC) is the total area of tree crowns projected onto the ground. It expresses canopy area as a percentage of total ground area. TCC is commonly used to describe the amount and horizontal distribution of urban forest canopy within a given city. It is commonly used by various stakeholders, including local authorities, urban foresters, arborists, planners, urban designers, and developers.

Because tree canopy cover has been linked with ecosystem service provision and benefits for local communities, various cities around the world have set targets to increase their urban forest canopy cover. However, these global TCC targets largely appear to be aspirational, rather than being justifiably informed by current research. This technical report uses a comprehensive review of the grey and scientific literature to answer the question of how much tree cover is desirable, or appropriate, in the context of New Zealand's cities.

Results show that research no longer supports a universal tree canopy cover recommendation. Instead, different canopy cover targets should be tailored to individual cities, based on local context. Based on TCC reported by 124 cities around the world, as well as previous research findings, target canopy cover ranges for NZ cities were devised. Cities within forested biomes, which cover much of New Zealand, should aim for a TCC target of 25% (± 20%), or between 20% – 30%. Meanwhile cities within grassland biomes, mainly comprising parts of Canterbury, Otago, and Southland, should aim for a TCC target of 20% (± 20%), or between 16% – 24%. The recommended target ranges do not preclude cities from aspiring to greater canopy cover, though overly-ambitious targets may be unachievable and undesirable for a variety of reasons. The international literature also shows that some cities are moving away from setting a single, city-wide, target, opting instead for different targets across electoral wards, local boards, neighbourhoods, or land uses.

This technical report concludes with eight recommendations to successfully meet canopy cover targets, including identifying baseline canopy cover, setting a SMART tree canopy cover target, monitoring changes in TCC, institutionalising targets in a strategy or management plan, having a vision, identifying plantable space, identifying and mitigating threats to increasing TCC, and forecasting future urban TCC scenarios.

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Tree canopy cover and its importance

Tree canopy cover (TCC) is the total area of tree crowns projected onto the ground, expressed as a percentage of total ground area. It's a two-dimensional measurement of the horizontal surface area of urban forest canopy as seen from a "birds-eye" view. It should not be confused for other similar descriptors, like crown leaf area, because TCC comprises leaves, needles, fruit, cones, flowers, branches, and trunks; in other words, all components of the crown.

TCC is commonly used by local authorities, urban foresters, arborists, planners, urban designers, developers, and local community members to improve their understanding of the amount and horizontal distribution of urban forest canopy. It is also used as a way of communicating the benefits of the urban forest. These benefits are well documented (Roy et al., 2012) and are commonly referred to as ecosystem services. Research has clearly shown that by increasing tree canopy cover, the ecosystem services provided to communities also increase (McPherson et al. 1999). This understanding has led to a desire to increase urban forest canopy cover in the name of maximising public benefit.

Despite its conceptual simplicity, its utility to a variety of stakeholders, and the manifold benefits it provides, the question of how much tree cover is desirable, or appropriate, remains unanswered.

Measuring canopy cover

TCC can be measured in the field or remotely. Field-based approaches require careful measurement of tree crowns, from the ground, within numerous plots spread throughout a city. Those measurements are then scaled up to provide an estimate of tree canopy cover within that city. Remote or non-field-based approaches, also called desktop approaches, fall into two categories: random point sampling and remote sensing methods. Both methods require manual or automated identification of trees in aerial imagery. Increasingly, other remotely-sensed data sources are also used for this task, including lidar data and multi-spectral imagery from an aerial or satellite platforms. There are benefits and drawbacks to all methods and these are discussed, in detail, in the literature (King & Locke, 2013; Parmehr et al., 2016; Ucar et al., 2016).

Canopy cover in cities around the world

Canopy cover values from 124 cities globally were identified from a variety of grey literature sources (Appendix A). The 124 cities were in the United States (n = 43), the UK and Ireland (n = 38), Canada (n = 18), Sweden (n = 9), Australia (n = 8), New Zealand (n = 3), Spain (n = 3), Denmark (n = 1), Mexico (n = 1) (Figure 1). Cities had an average canopy cover of 20.13%, with a range from 3.54% in Belfast, Ireland to 51.2% in Atlanta, Georgia.

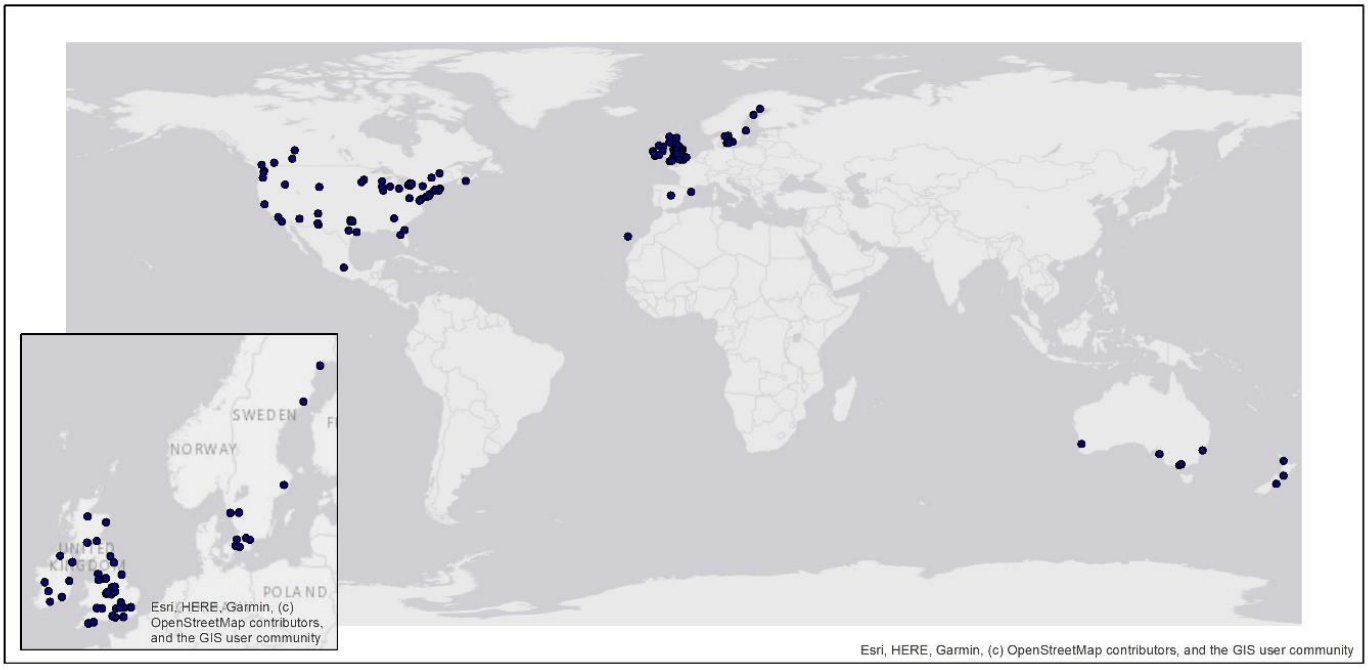

Figure 1 – Locations of cities for which canopy cover data were identified.

Previous global studies have shown that canopy cover can be expected to differ according to biome. Urban tree cover in cities from around the world was greatest in forest biomes, averaging 30.4 %, which was significantly greater than in grassland biomes (18.2 %), which, in turn, was significantly greater than in deserts (12.0 %) (Nowak and Greenfield, 2020). The same pattern was found for 58 American cities where tree cover was greatest in cities that developed in naturally forested areas (31%), followed by grassland cities (19%) and desert cities (10%) (Nowak et al. 1996). This was largely a consequence of natural regeneration, whereby in "forested regions, vacant or unmanaged lands will tend to regenerate with trees and increase tree cover. In drier grasslands and deserts, these unmanaged lands will often not readily regenerate with trees, and will tend to have lower tree cover unless tree planting and watering programs are established to enhance tree cover" (Nowak, 2012). In the 124 cities reviewed herein, canopy cover didn't differ as much between biomes as in previous studies, though cities in forests and grasslands both had greater canopy cover than in desert biome (Figure 2).

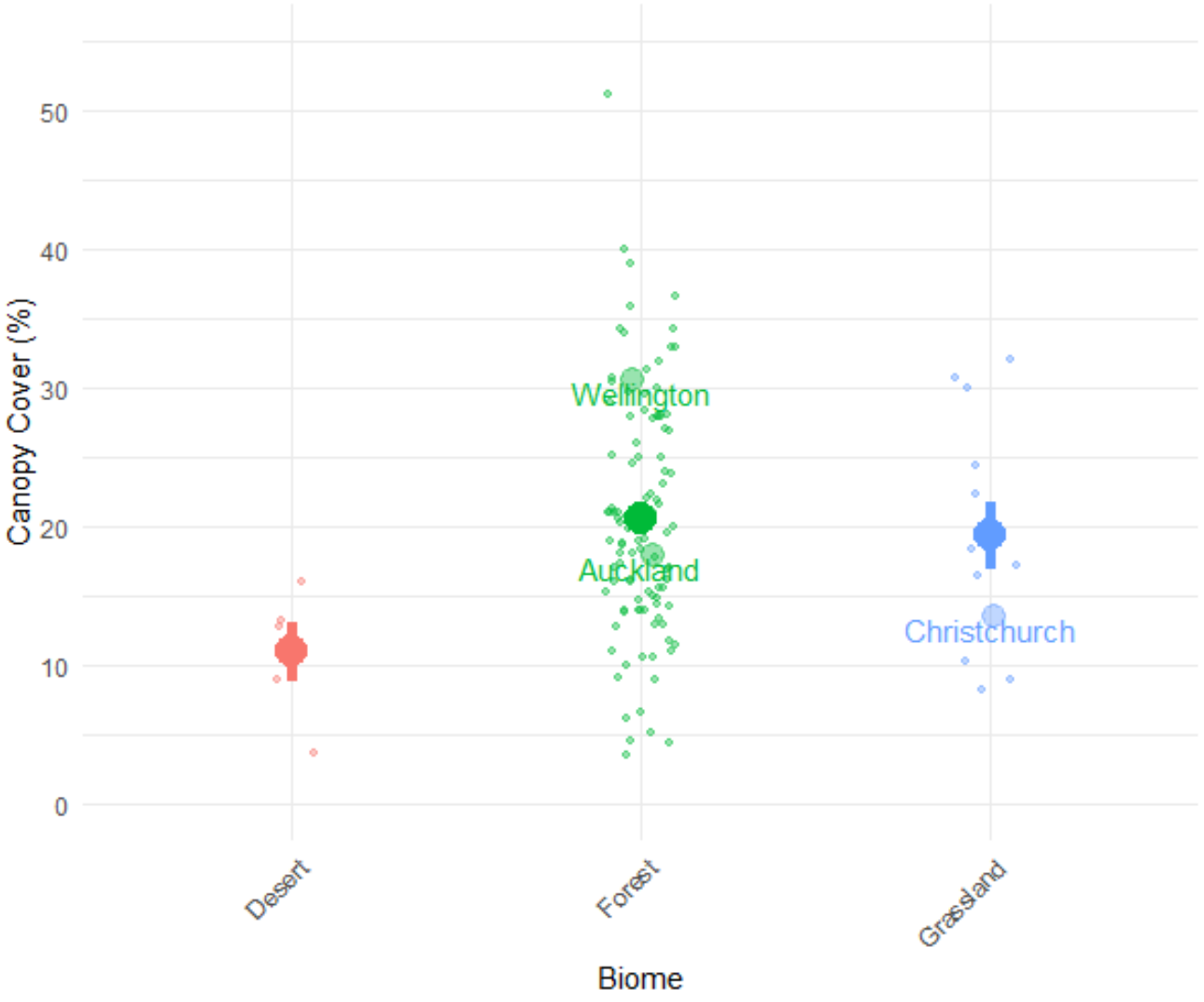

Figure 2 – Canopy cover for 124 cities in differing global biomes. Small, filled points show individual canopy cover values reported for each city. Medium, light, filled circles show canopy cover for Auckland, Christchurch, and Wellington. Large, dark, filled circles represent means; lines extending from these represent one standard error from the mean. Biomes based on Olson et al. 2001.

Canopy cover in NZ's cities

Canopy cover for Auckland, Christchurch, and Wellington, New Zealand have recently been estimated (Golubiewski et al., 2021; Morgenroth, 2021, 2022). Wellington has the greatest canopy cover, with 30.61%, while Auckland has 18% canopy cover and Christchurch has 13.56%. While Wellington's TCC exceeds the average in forested biomes, Auckland and Christchurch's TCC values are both below the average for forested and grassland biomes, respectively (Figure 2).

Canopy cover targets in cities around the world

Increasing the extent of urban tree canopy cover has become a popular goal for many cities around the world. The review identified 35 cities that described their current canopy cover and set a canopy cover target (Figure 3). These targets were reported in grey literature, such as urban forest strategy or vision documents, or urban forest master plans, action plans, or management plans (Appendix B). The average current canopy cover for these cities was 20.4% (range: 8.25% - 32%) and the average target was 28.6% (range: 15% - 40%). Cities gave themselves an average of 21.9 years (range: 6 - 50 years) to achieve their targets. Relative to current canopy cover, this would require an average increase of 1.83% per year (range: 0.34% - 11.1% per year).

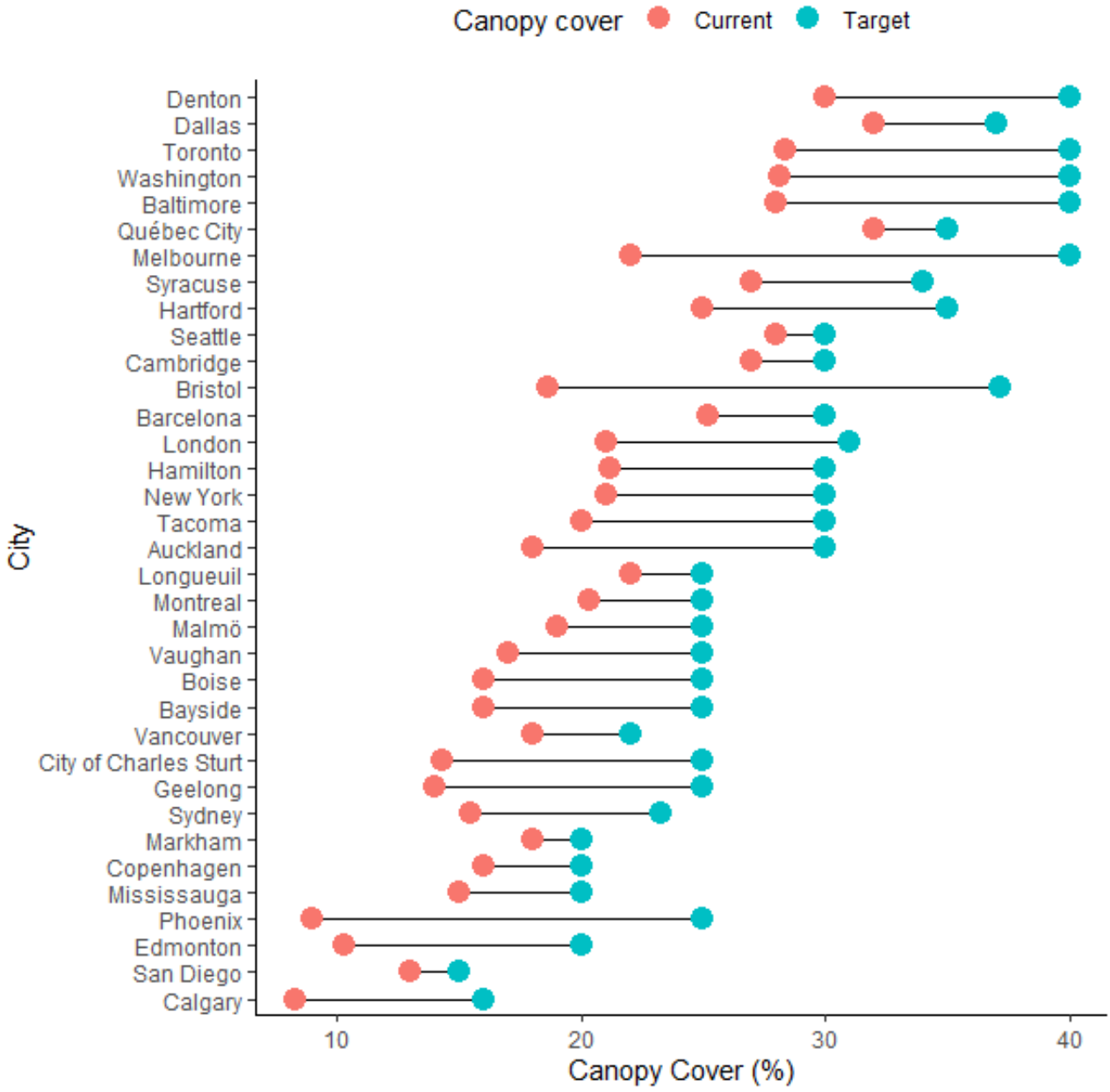

Figure 3 – Current and target canopy cover values for the 35 cities reviewed.

The effect of current canopy cover on targets

Cities tend to set more challenging targets the lower their current canopy cover. In some extreme examples, some cities have set targets that would require them to roughly double their current canopy cover, e.g., Calgary, Alberta +94%; Edmonton, Alberta +94%; Bristol, UK +100%; Phoenix, Arizona +177%. All but one of these four extreme examples has current canopy cover of 10.3% or lower. In contrast, only 1 of 18 cities with greater than 20% canopy cover set a target that would require more than a 50% increase in canopy.

Appropriate canopy cover targets for New Zealand's cities

While some may find it desirable to set a single canopy cover target for cities in NZ, there is no scientific basis to do so. There was a time where many cities in the United States targeted 40% canopy cover; this was due to a recommendation by American Forests, a highly respected non-profit conservation organisation (Kenney et al., 2011). However, American Forests has since backed away from that recommendation, stating that "research no longer supports a universal 40 percent tree canopy recommendation" (Leahy, 2017). Instead, different canopy cover targets should be tailored to individual cities, with due consideration to local context and resources, geography, and available planting space (Locke et al., 2013). With this in mind, it's suggested that New Zealand's cities target canopy cover extents consistent with cities in comparable biomes overseas.

So, based on the data in Figure 2, as well as the previous findings by Nowak et al. (1996) and Nowak and Greenfield (2020), NZ cities within a forested biome should aim for a target of 25% (± 20%), or between 20% – 30%. Meanwhile NZ cities within a grassland biome should aim for a TCC target of 20% (± 20%), or between 16% – 24% (Figure 4).

The TCC target value range, rather than a single TCC target value, allows cities to set targets that reflect their local context and resources, while at the same time avoiding the extreme canopy cover values seen in some cities globally (Figure 2). The range is also an acknowledgement that, while biome has a strong effect on canopy cover, it is not the only factor affecting tree canopy cover. As previous research has demonstrated, TCC is influenced by a raft of spatial and temporal factors including economic, human, and biophysical mechanisms (Hilbert, Koeser, et al., 2019).

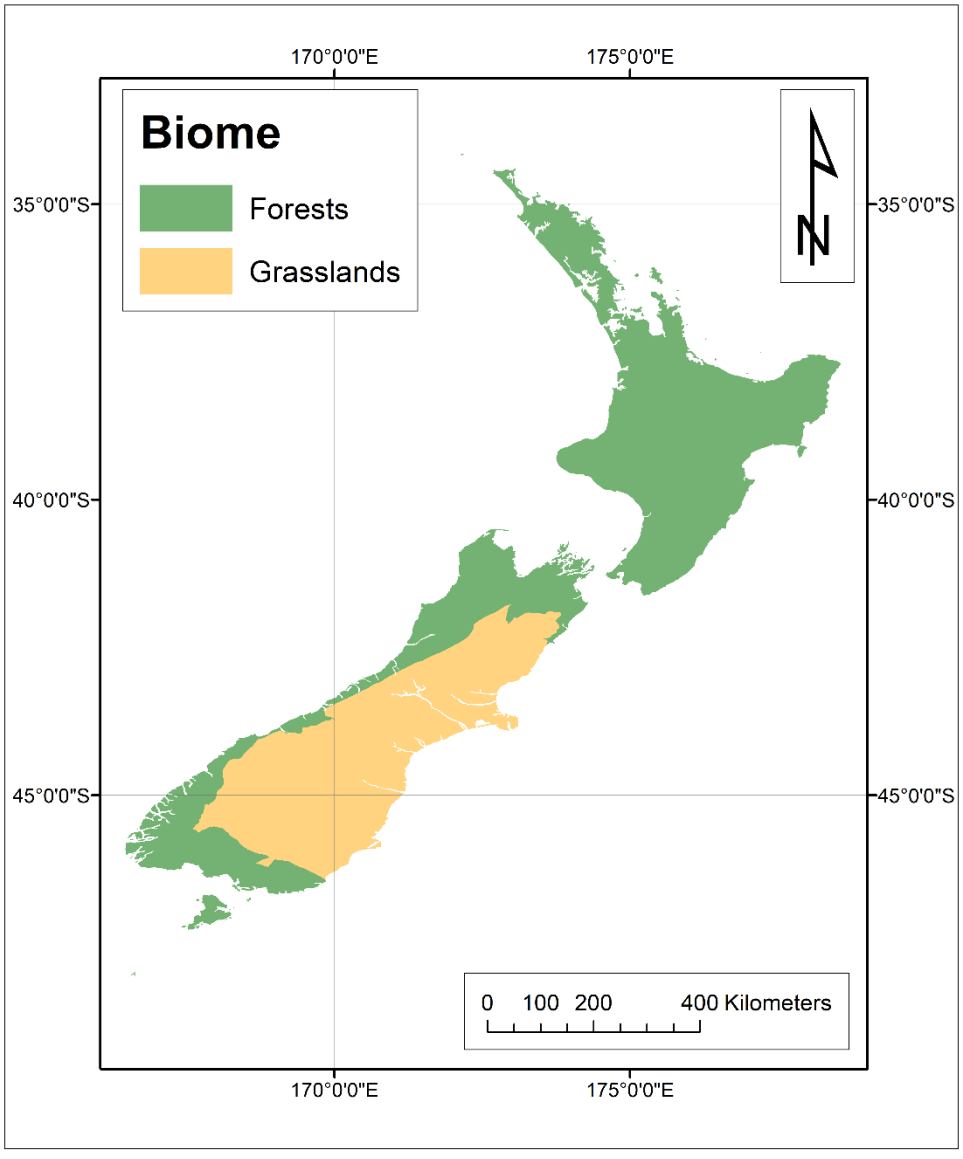

Figure 4 – The biomes of New Zealand. Biomes were simplified forms of the biomes in Olson et al. (2001).

The target ranges are based on existing canopy cover in cities around the world. They are, arguably, conservative as they are largely below the average canopy cover target of 28.6% for the 35 cities in this report (Figure 3). However, the recommended target ranges do not preclude cities from aspiring to greater canopy cover, though it should be noted that overly-ambitious targets may be unachievable, for a variety of reasons.

Indeed, many cities have set TCC targets that are, debatably, over-ambitious (Figure 3). Such targets will require rigorous planting schemes (Hilbert, Koeser, et al., 2019) which may be impractical or unattainable, as well as a combination of incentives and regulations to minimise tree removal (Ordóñez-Barona et al., 2021). Other factors resulting in tree mortality will also have to be identified and mitigated (Hilbert, Roman, et al., 2019). Moreover, cities will need to ensure the long-term resources required to manage the expanding urban forest. Finally, focusing solely on achieving overly-ambitious canopy cover targets can result in ignoring other strategic and more comprehensive approaches to urban forest management (Kenney et al., 2011).

Other considerations in setting canopy cover targets

In recent years, cities have moved away from setting a single, city-wide, target for TCC (Leahy, 2017), choosing instead to identify targets for different electoral wards, local boards, neighbourhoods, or land uses. The City of Austin, TX has a goal to "identify canopy goals according to site, land use designation and ecosystem capacity" (Austin's Urban Forest Plan, 2013), while Mississauga, Canada expects that their "canopy cover meets or exceeds 15% (i.e., the current city-wide average) in at least 95% of the City's residential areas and in 50% to 75% of the city's other land use categories" (Mississauga's Urban Forest Management Plan, 2014). Likewise, Halifax, Canada doesn't provide a single canopy cover goal, instead opting to provide goals for different management units (e.g. parks 40%, waterways 80%) and neighbourhoods due to "unique historical impacts and pre-existing conditions such as soil quality, topography, and climate" (Halifax Regional Municipality, 2013). New Zealand's cities should strongly consider complementing city-wide TCC targets with a set of canopy cover targets for different land use types, electoral wards, or other geographic boundaries. Such targets can focus planning and operational efforts on specific areas and can minimise inequities in canopy cover within cities.

Another consideration is related to timeframes. Increases in canopy cover cannot be achieved over short time periods. Newly planted trees require years to establish before they make meaningful contributions to canopy cover. So, while some short-term milestones may be appropriate (e.g., annual tree planting targets), meeting city-wide tree canopy cover targets should be considered a medium- to long-term goal. This is supported by many of the 35 cities setting relatively long timeframes in their urban forest strategies or management plans (Appendix B); those cities had an average time of nearly 22 years to achieve their targets, with some setting targets for up to 50 years in the future.

A final consideration is what to do when canopy cover meets or exceeds the identified target for a given city. Meeting overall city-wide targets should not signal the end of urban forest management activities. Cities should continue striving to meet any other canopy cover targets they've identified for sub-city scale units, like electoral wards, local boards, or others, as detailed previously. Likewise, cities may endeavour to identify and work towards more complex targets, like ensuring minimum cover in different tree height, age, or species strata. The city-wide canopy cover target, if it is set, should only be one milestone within an urban forest management plan or strategy.

Recommendations for success

Achieving canopy cover targets, even conservative ones, requires organisation, planning, monitoring, and consistently effective management. Eight recommendations for success include:

1. **Identify baseline canopy cover** – prior to setting a target, cities should have an understanding of their current canopy cover and its distribution. This can be achieved using field-based methods, or alternatively as a desktop exercise, using point-based sampling or remote sensing methods.
2. **Set a SMART tree canopy cover target** – the target should be specific, measurable, achievable, relevant, and time-bound.
3. **Monitor changes in tree canopy cover** – canopy cover should be measured at regular or semi-regular intervals. If using point-based or remote sensing methods, monitoring can be aligned to the acquisition cycle of aerial imagery or lidar data. Monitoring can help determine whether policies and management associated with increasing TCC are effective.
4. **Institutionalise targets in a strategy or management plan** – this will ensure canopy cover goals remain a priority as time passes or as personnel or leadership changes. Moreover, doing so will help secure appropriate funding to support the planting and maintenance of urban trees.
5. **Have a vision** – A vision statement or document can complement internal strategy and management plans by communicating canopy cover targets to a wider, largely external, audience. Such a document can inspire citizens, communities, industry, politicians, and other stakeholders to actively engage with cities to meet targets.
6. **Identify plantable space** – this may include land currently owned or managed by local authorities or the Crown, e.g., in parks and reserves, in street catchments, or in riparian setbacks adjacent to waterbodies. This may also include private land where local authorities can exert influence.
7. **Identify and mitigate threats to increasing canopy cover** – increasing urban TCC can be threatened by a number of regulatory and non-regulatory factors. Increases in TCC can suffer from high urban tree mortality (Hilbert, Roman, et al., 2019), adverse site conditions leading to slow establishment and growth of new transplants (Harris, 2007), and impermeable land covers stifling natural regeneration (Nowak & Greenfield, 2020). Further to that, development and redevelopment can result in significant canopy loss (Guo et al., 2019; Morgenroth et al., 2017).
8. **Forecast future urban TCC** – modelling the effect of differing tree planting plans and mortality rates on future urban forest canopy cover can help identify the most effective ways to meet targets. This was effectively illustrated for Bristol, England, whereby 16 different scenarios were modelled to determine which would most likely lead to achieving the ambitious canopy cover target set by the city (Walters & Sinnett, 2021).

These eight recommendations will aid cities with the challenging task of increasing urban forest canopy cover to meet their stated target(s).

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Appendices

Appendix A

Canopy cover values for all 124 cities included in this report.

CITY	COUNTRY	CANOPY COVER (%)	SOURCE
ABERDEEN	Scotland	10	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
ALBUQUERQUE	USA	13.3	https://www.itreetools.org/documents/398/ALB_Community_Forest_Assessment_final_12.6.14.pdf
ARLINGTON	USA	22.4	https://www.itreetools.org/documents/298/Arlington%20TX%20Analysis.pdf
ATLANTA	USA	51.2	https://doi.org/10.1016/j.cities.2014.06.012
ATLANTIC BEACH	USA	30	https://www.itreetools.org/documents/299/Atlantic_Beach_Fl_Canopy_Assessment_Report.pdf
AUCKLAND	New Zealand	18	https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/topic-based-plans-strategies/environmental-plans-strategies/Pages/urban-ngahere-forest-strategy.aspx
AUSTIN	USA	30.8	https://www.itreetools.org/documents/300/Austins_Urban_Forest_report.pdf
BALTIMORE	USA	28	https://www.fs.usda.gov/features/baltimores-urban-tree-canopy-flourishes#:~:text=Baltimore%20City's%20tree%20cover%20increased
BARCELONA	Spain	25.2	https://www.itreetools.org/documents/302/Barcelona%20Ecosystem%20Analysis.pdf
BAYSIDE	Australia	16	https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.bays-yoursay.files/6216/2927/8166/Draft_Urban_Forest_Strategy_2021.pdf
BELFAST	Ireland	3.54	https://www.itreetools.org/documents/347/The_green_signature_of_Irish_cities.pdf
BIRMINGHAM	England	23	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
BLACKPOOL	England	4.4	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
BOISE	USA	16	https://issuu.com/thekeystoneconcept/docs/2013_treasure_valley_utc_project_re
BOLTON	Canada	17	https://www.itreetools.org/documents/336/Peel_Urban_Forest_Strategy.pdf
BORÅS	Sweden	24	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
BOSTON	USA	22.3	https://www.itreetools.org/documents/382/iTreeEcoProv2014.pdf

BRAMPTON	Canada	11	https://www.itreetools.org/documents/336/Peel_Urban_Forest_Strategy.pdf
BRIGHTON	England	14.4	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
BRISTOL	UK	18.6	https://bristoltreeforum.files.wordpress.com/2018/03/doick-et-al_canopy-cover-of-englands-towns-and-cities_revised220317_combined.pdf
BURNSIDE	Australia	31.28	https://www.itreetools.org/documents/305/BurnsideAUS_iTreeCanopy_2016.pdf
CALEDON EAST	Canada	29	https://www.itreetools.org/documents/336/Peel_Urban_Forest_Strategy.pdf
CALGARY	Canada	8.25	https://www.sprawlcalgary.com/calgary-urban-forest
CAMBRIDGE	Canada	27	https://www.cambridge.ca/en/learn-about/resources/Cambridge-Urban-Forest-Canopy-Asssessment-maps-part-1-.pdf
CAMPBELLTOWN	Australia	18.76	https://www.itreetools.org/documents/306/CampbelltownCanopyReport_27July18.pdf
CARDIFF	Wales	21	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
CASPER	USA	8.9	https://www.itreetools.org/documents/310/Casper%20-%20Assessing%20Urban%20Forest%20Effects%20and%20Values.pdf
CHICAGO	USA	17.2	https://www.itreetools.org/documents/311/Chicago's%20Urban%20Forest.pdf
CHRISTCHURCH	New Zealand	13.56	https://doi.org/10.26021/m6sm-mr11
CITY OF CHARLES STURT	Australia	14.28	https://www.itreetools.org/documents/294/2016_SeedConsultingServices_TreeCanopyCoverInTheCityOfCharlesSturt-BenchmarkingAssessment.pdf
COPENHAGEN	Denmark	16	https://kk.sites.itera.dk/apps/kk_pub2/pdf/1653_EyzOS8ePZx.pdf
CORK	Ireland	9.12	https://www.itreetools.org/documents/347/The_green_signature_of_Irish_cities.pdf
COVENTRY	England	20.6	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
CRYSTAL RIVER	USA	39	https://www.itreetools.org/documents/314/Crystal_River_Canopy_Assessment.pdf
DALLAS	USA	32	https://dallascityhall.com/projects/forestry/DCH%20Documents/City%20of%20Dallas%202021%20Urban%20Forest%20Master%20Plan.pdf
DENTON	USA	30	https://www.itreetools.org/documents/295/2016_State_of_the_Denton_Urban_Forest_Preservation_Tree.pdf
DERBY	England	13	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being

DERRY	Ireland	16.2	https://www.itreetools.org/documents/347/The_green_signature_of_Irish_cities.pdf
DETROIT	USA	30.8	https://doi.org/10.1016/j.cities.2014.06.012
DUBLIN	Ireland	4.52	https://www.itreetools.org/documents/347/The_green_signature_of_Irish_cities.pdf
DUDLEY	England	20.5	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
EALING	UK	16.9	https://www.itreetools.org/documents/315/EalingEco2018.pdf
EDINBURGH	UK	19.6	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
EDMONTON	Canada	10.3	https://www.edmonton.ca/public-files/assets/document?path=PDF/Urban_Forest_Management_Plan.pdf
EL PASO	USA	5.1	https://www.itreetools.org/documents/401/El_Paso_Community_Forest_Assessment_final_11.26.pdf
FREEHOLD	USA	34.4	https://www.itreetools.org/documents/382/iTreeEcoProv2014.pdf
GALWAY	Ireland	6.64	https://www.itreetools.org/documents/347/The_green_signature_of_Irish_cities.pdf
GEELONG	Australia	14	https://www.geelongaustralia.com.au/common/Public/Documents/8d30153dfee2a6c-Urban%20Forest%20Strategy.pdf
GLASGOW	Scotland	14.9	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
GÖTEBORG	Sweden	40	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
GRAND RAPIDS	USA	34	https://issuu.com/planitgeoissuu/docs/modeling_urban_forest_scenarios_and
GREEN BAY	USA	25	https://www.itreetools.org/documents/365/WDNR_GreenBay_Metro.pdf
HALIFAX	Canada	34.3	https://www.itreetools.org/documents/319/FosterDuinker_2017_iTreeEcoForHalifax_Feb2017.pdf
HAMILTON	Canada	21.2	https://www.hamilton.ca/sites/default/files/media/browser/2021-01-25/urban-forest-strategy-draft-report.pdf
HARTFORD	USA	25	https://www.gardenclubofnewhaven.org/uploads/9/3/4/3/9343583/hartford_treecanopyactionplan_final_june_2020_low-res.pdf
HÄSSLEHOLM	Sweden	33	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
HELSINGBORG	Sweden	14	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
HOUSTON	USA	18.4	https://www.itreetools.org/documents/321/HoustonUrbanForest2015.pdf
HULL	England	13.4	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_an

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INVERNESS	Scotland	21	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
JERSEY CITY	USA	11.5	https://www.itreetools.org/documents/382/iTreeEcoProv2014.pdf
KELOWNA	Canada	12.8	https://www.yumpu.com/en/document/read/23802907/kelownas-urban-forest-city-of-kelowna
KRISTIANSTAD	Sweden	14	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
LAS CRUCES	USA	3.7	https://www.itreetools.org/documents/403/Las_Cruces_Community_Forest_Assessment_final_12_4_14.pdf
LEICESTER	England	15.2	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
LIMERICK	Ireland	10.6	https://www.itreetools.org/documents/347/The_green_signature_of_Irish_cities.pdf
LIVERPOOL	England	16.2	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
LONDON	UK	21	https://www.london.gov.uk/sites/default/files/londonurbanforestplan_final.pdf
LONGUEUIL	Canada	22	https://cms.longueuil.quebec/sites/default/files/medias/documents/2021-12/politique_de_larbre_vf_brpdf%20%281%29.pdf
LOS ANGELES	USA	20.8	https://doi.org/10.1016/j.landurbplan.2010.08.011
LULEÅ	Sweden	14	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
LUTON	England	17.8	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
MADRID	Spain	26	https://www.itreetools.org/documents/549/Valor_Bosque_Urbano_Madrid.pdf
MALMÖ	Sweden	19	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
MANCHESTER	England	21.1	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
MARKHAM	Canada	18	https://www.york.ca/wps/wcm/connect/yorkpublic/b2d2d00f-9736-4ae5-b459-b67c55da8f97/York_Region_Forest_Management_Plan+2017.pdf?MOD=AJPERES
MELBOURNE	Australia	22	https://www.melbourne.vic.gov.au/SiteCollectionDocuments/urban-forest-strategy.pdf
MESQUITE	USA	24.4	https://www.itreetools.org/documents/325/Mesquite_Texas_EcoStudy2012.pdf
MEXICO CITY	Mexico	12.8	https://doi.org/10.3390/f11040423

MIDDLESBROUGH	England	11	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
MILWAUKEE	USA	21.6	https://www.itreetools.org/documents/327/Milwaukee%20Ecosystem%20Analysis.pdf
MINNEAPOLIS	USA	33	https://doi.org/10.1007/s11252-012-0224-9
MISSISSAUGA	Canada	15	https://www.itreetools.org/documents/336/Peel_Urban_Forest_Strategy.pdf
MONTREAL	Canada	20.3	https://ville.montreal.qc.ca/pls/portal/docs/PAGE/GRANDS_PARCS_FR/MEDIA/DOCUMENTS/PAC_JUIN_2012_FINAL.PDF
MOORESTOWN	USA	28	https://www.itreetools.org/documents/382/iTreeEcoProv2014.pdf
MORGANTOWN	USA	35.9	https://www.itreetools.org/documents/382/iTreeEcoProv2014.pdf
NEW YORK	USA	21	https://www.fs.fed.us/nrs/pubs/rb/rb_nrs117.pdf
NEWCASTLE UPON TYNE	England	10.6	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
NOTTINGHAM	England	15.2	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
OAKLAND	USA	19	https://joa.isa-arbor.com/request.asp?JournalID=1&ArticleID=2582&Type=2
OAKVILLE	Canada	27.8	https://www.oakville.ca/assets/general%20-%20culture%20recreation/itree-growing-livability-report.pdf
OLDHAM	UK	11.8	https://www.itreetools.org/documents/334/Oldham_iTreeEco_2017.pdf
PERTH	Australia	8.9	https://doi.org/10.1016/j.landurbplan.2020.103804
PHILADELPHIA	USA	20	https://www.phila.gov/media/20200210173518/Tree-Canopy-Assessment-Report-12-03-19.pdf
PHOENIX	USA	9	https://www.itreetools.org/documents/405/Phoenix_Community_Forest_Assessment_1.2.15-Final.pdf
PLANO	USA	16.4	https://www.itreetools.org/documents/340/Plano_Urban_Forest_Ecosystem_Analysis_2014.pdf
PLYMOUTH	England	21.4	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
PORTLAND	USA	29.8	https://www.portland.gov/sites/default/files/2022/tree-canopy-monitoring-2020.pdf
PORTSMOUTH	England	14.7	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
PROVIDENCE	USA	23.9	https://www.itreetools.org/documents/382/iTreeEcoProv2014.pdf

QUÉBEC CITY	Canada	32	https://www.ville.quebec.qc.ca/apropos/planification-orientations/environnement/milieuxnaturels/docs/vision_arbre_2015_2025.pdf
READING	England	18.4	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
SAN DIEGO	USA	13	https://www.sandiego.gov/sites/default/files/final_adopted_urban_forestry_program_five_year_plan.pdf
SANTA CRUZ DE TENERIFE	Spain	19.1	https://www.itreetools.org/documents/673/20-01_Value_of_Santa_Cruz_de_Tenerifes_Urban_Forest.pdf
SEATTLE	USA	28	http://www.seattle.gov/documents/Departments/UrbanForestryCommission/Resources/UFMPv11_100620.pdf
SLOUGH	England	13.8	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
SOUTHAMPTON	England	19.8	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
SOUTHEND-ON-SEA	England	15.6	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_and_Cities_baselining_and_setting_targets_to_improve_human_health_and_well-being
SPRINGFIELD	USA	36.6	https://www.itreetools.org/documents/383/iTree_Canopy_Spfld_Citywide_Aug2014.pdf
ST PETER	USA	30.4	https://doi.org/10.3390/rs12111820
STOCKHOLM	Sweden	21	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
SYDNEY	Australia	15.5	https://www.cityofsydney.nsw.gov.au/strategies-action-plans/urban-forest-strategy
SYRACUSE	USA	27	https://issuu.com/syracuseinnovationteam/docs/syracuse_ufmp_final
TACOMA	USA	20	https://www.tacomatreeplan.org/post/phase-2-primary-framework-the-urban-forest-management-plan
TORBAY	UK	24.63	https://doi.org/10.1080/03071375.2020.1767968
TORONTO	Canada	28.4	https://www.toronto.ca/legdocs/mmis/2021/ie/bgrd/backgroundfile-173552.pdf
UMEÅ	Sweden	28	https://www.itreetools.org/documents/654/i-Tree_Sweden.pdf
VANCOUVER	Canada	18	https://vancouver.ca/files/cov/urban-forest-strategy.pdf
VAUGHAN	Canada	17	https://www.york.ca/wps/wcm/connect/yorkpublic/b2d2d00f-9736-4ae5-b459-b67c55da8f97/York_Region_Forest_Management_Plan+2017.pdf?MOD=AJPERES
WALSALL	England	17.3	https://www.researchgate.net/publication/322337570_The_Canopy_Cover_of_England's_Towns_an

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WASHINGTON	USA	28.1	https://www.itreetools.org/documents/379/Washington%20DC%20Analysis%202010.pdf
WATERFORD	Ireland	6.14	https://www.itreetools.org/documents/347/The_green_signature_of_Irish_cities.pdf
WELLINGTON	New Zealand	30.61	http://dx.doi.org/10.26021/11224
WOODBRIDGE	USA	29.5	https://www.itreetools.org/documents/382/iTreeEcoProv2014.pdf

Appendix B

Canopy cover targets for all 35 cities included in this report.

CITY	COUNTRY	CANOPY COVER TARGET (%)	SOURCE
AUCKLAND	New Zealand	30	https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/topic-based-plans-strategies/environmental-plans-strategies/Documents/urban-ngahere-forest-strategy.pdf
BALTIMORE	USA	40	http://actrees.org/files/Newsroom/TreeBaltimore%20Urban%20Forest%20Management%20Plan.pdf
BARCELONA	Spain	30	https://ajuntament.barcelona.cat/ecologiaurbana/sites/default/files/Pla-director-arbrat-barcelona-ENG.pdf
BAYSIDE	Australia	25	https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.bays-yoursay.files/6216/2927/8166/Draft_Urban_Forest_Strategy_2021.pdf
BOISE	USA	25	https://www.cityofboise.org/media/4257/boiseforestryplan_final_040616_lowres.pdf
BRISTOL	UK	37.2	https://www.bristolonecity.com/wp-content/uploads/2021/06/Bristol-One-City-Plan-2021-2050-1.pdf
CALGARY	Canada	16	https://www-prd.calgary.ca/content/dam/www/csps/parks/documents/management-plans/urban-forestry-strategic-plan.pdf
CAMBRIDGE	Canada	30	https://www.cambridge.ca/en/learn-about/resources/Accessible-PDFs/Cambridge-Urban-Forest-Plan-2015-2034.pdf
CITY OF CHARLES STURT	Australia	25	https://hdp-au-prod-app-ccs-yoursay-files.s3.ap-southeast-2.amazonaws.com/6916/3771/6816/GROWING_GREEN_-_TREE_CANOPY_IMPROVEMENT_STRATEGY__2021-_2045.pdf
COPENHAGEN	Denmark	20	https://kk.sites.itera.dk/apps/kk_pub2/pdf/1653_EyzOS8ePZx.pdf
DALLAS	USA	37	https://dallascityhall.com/projects/forestry/DCH%20Documents/City%20of%20Dallas%202021%20Urban%20Forest%20Master%20Plan.pdf
DENTON	USA	40	https://lfpubweb.cityofdenton.com/PublicWeblink/DocView.aspx?id=27632&dbid=4&repo=Public&cr=1
EDMONTON	Canada	20	https://www.edmonton.ca/public-files/assets/document?path=PDF/Urban_Forest_Management_Plan.pdf
GEELONG	Australia	25	https://www.geelongaustralia.com.au/common/Public/Documents/8d30153dfee2a6c-Urban%20Forest%20Strategy.pdf
HAMILTON	Canada	30	https://www.hamilton.ca/sites/default/files/media/browser/2021-01-25/urban-forest-strategy-draft-report.pdf

HARTFORD	USA	35	https://www.gardenclubofnewhaven.org/uploads/9/3/4/3/9343583/hartford_treecanopyactionplan_final_june_2020_low-res.pdf
LONDON	UK	31	https://www.london.gov.uk/sites/default/files/londonurbanforestplan_final.pdf
LONGUEUIL	Canada	25	https://cms.longueuil.quebec/sites/default/files/medias/documents/2021-12/politique_de_larbre_vf_brpdf%20%281%29.pdf
MALMÖ	Sweden	25	https://una.city/nbs/malmo/tree-strategy-malmo
MARKHAM	Canada	20	https://www.york.ca/wps/wcm/connect/yorkpublic/b2d2d00f-9736-4ae5-b459-b67c55da8f97/York_Region_Forest_Management_Plan+2017.pdf?MOD=AJPERES
MELBOURNE	Australia	40	https://www.melbourne.vic.gov.au/SiteCollectionDocuments/urban-forest-strategy.pdf
MISSISSAUGA	Canada	20	http://www7.mississauga.ca/departments/rec/parks/nhufs/pdf/final_ufmp.pdf
MONTREAL	Canada	25	https://ville.montreal.qc.ca/pls/portal/docs/PAGE/GRANDS_PARCS_FR/MEDIA/DOCUMENTS/PAC_JUIN_2012_FINAL.PDF
NEW YORK	USA	30	https://forestforall.nyc/wp-content/uploads/2021/06/NYC-Urban-Forest-Agenda-.pdf
PHOENIX	USA	25	https://www.phoenix.gov/parkssite/Documents/PKS_Forestry/PKS_Forestry_Tree_and_Shade_Master_Plan.pdf
QUÉBEC CITY	Canada	35	https://www.ville.quebec.qc.ca/apropos/planification-orientations/environnement/milieuxnaturels/docs/vision_arbre_2015_2025.pdf
SAN DIEGO	USA	15	https://www.sandiego.gov/sites/default/files/final_adopted_urban_forestry_program_five_year_plan.pdf
SEATTLE	USA	30	http://www.seattle.gov/documents/Departments/UrbanForestryCommission/Resources/UFMPv11_100620.pdf
SYDNEY	Australia	23.25	https://www.cityofsydney.nsw.gov.au/strategies-action-plans/urban-forest-strategy
SYRACUSE	USA	34	https://issuu.com/syracuseinnovationteam/docs/syracuse_ufmp_final
TACOMA	USA	30	https://www.tacomatreeplan.org/post/phase-2-primary-framework-the-urban-forest-management-plan
TORONTO	Canada	40	https://www.toronto.ca/wp-content/uploads/2017/12/8e0e-Strategic-Forest-Management-Plan-2012_22.pdf
VANCOUVER	Canada	22	https://vancouver.ca/files/cov/urban-forest-strategy.pdf
VAUGHAN	Canada	25	https://www.york.ca/wps/wcm/connect/yorkpublic/b2d2d00f-9736-4ae5-b459-b67c55da8f97/York_Region_Forest_Management_Plan+2017.pdf?MOD=AJPERES
WASHINGTON	USA	40	https://doee.dc.gov/sites/default/files/dc/sites/ddoe/page_content/attachments/Draft_Urban_Tree_Canopy_Plan_Final.pdf