Clean Air and Urban Landscapes Hub

National Environmental Science Programme

Climate Adaptation Synthesis

Clean Air and Urban Landscapes Hub

July, 2020

Australian Government | National Environmental Science Programme | The University of Melbourne | RMIT University | The University of Western Australia | University of Wollongong Australia

About the Clean Air and Urban Landscapes Hub

The Clean Air and Urban Landscapes Hub (CAUL) is a consortium of four universities: The University of Melbourne, RMIT University, the University of Western Australia and the University of Wollongong. The CAUL Hub is funded by the Australian Government's National Environmental Science Program. The task of the CAUL Hub is to undertake research to support environmental quality in our urban areas, especially in the areas of air quality, urban greening, liveability and biodiversity, and with a focus on applying research to develop practical solutions.

www.nespurban.edu.au

Contents

Introduction

This report provides a summary of the research activities that relate to climate-change adaptation, undertaken by the CAUL Hub between 2015 and 2020. It covers research on the vulnerability of tree species to climate change, strategies to reduce air pollutant emissions and recommendations to protect animals and their urban habitats under future climates.

Three common themes emerge throughout the report:

1) Adaptations that help people and other biota cope with climate change impacts by reducing other pressures (not in and of themselves climate change impacts) such as local air pollutants.

2) Adaptations directly aimed at helping people and urban ecosystems cope with climate change impacts, such as a navigation platform prioritising cooler routes and increasing urban green spaces.

3) The co-benefits of various actions, such as the advantages of urban greening for people and biodiversity. These point towards 'no-regrets' policy options.

Air Quality

While Australian cities enjoy cleaner air compared to some of the world's other major cities, a warming climate will impact air quality. Hotter days are predicted to increase the frequency of temperature inversions that act like a lid to trap pollution close to the ground where we can breathe it [Ji et al,2019]. Episodes of ozone pollution are also likely to accompany extreme heat days [Utembe et al, 2018], which can trigger a wide range of health problems including respiratory irritation. On the other hand, greenhouse gases are often co-emitted with other air pollutants, therefore drive climate change. Research from Project 7 has identified major sources of indoor and outdoor air pollution and strategies to reduce emissions of key air pollutants.

Sources

Ji, F.; Evans, J.P.; Di Luca, A.; Jiang, N.; Olson, R.; Fita, L.; Argüeso, D.; Chang, L.T.-C.; Scorgie, Y.; Riley, M. Projected change in characteristics of near surface temperature inversions for southeast Australia. Climate Dynamics 2019, 52, 1487-1503.

Utembe, S.R.; Rayner, P.J.; Silver, J.D.; Guérette, E.-A.; Fisher, J.A.; Emmerson, K.M.; Cope, M.; Paton-Walsh, C.; Griffiths, A.D.; Duc, H., et al. Hot Summers: Effect of Extreme Temperatures on Ozone in Sydney, Australia. Atmosphere 2018, 9, 466.

A Clean Air Plan for Sydney

Project 7

A Clean Air Plan for Sydney, led by the CAUL Hub, draws together the current understanding of air quality in Australia's biggest city, the latest air quality research, and evidence-based recommendations [Paton Walsh et al, 2019]. Like in many Australian cities, concentrations of air pollutants in Sydney are dominated by anthropogenic emissions from sources including traffic fumes, wood-burning heaters and hazard reduction burns.

There are a number of ways that government, industry and the community can work together to reduce air pollution and people's exposure to it, including:

- Phasing out the use of wood heaters in urban areas and some regional areas. The chemical makeup of smoke from wood fires is very similar to smoke produced by bushfires;
- New policies, infrastructure and services to reduce the number of vehicles on roads, including better pedestrian and cycle paths, more public transport, and congestion taxes;
- Incentives to encourage a rapid move to low-emission vehicles, including electric vehicles; to improve fuel efficiency, fuel quality and emission standards; and to phase out diesel vehicles. The Hub's emissions modelling framework, to be released in 2020, will help agencies to estimate reductions of greenhouse gases and air pollution with different rates of electric vehicle use;
- Encouraging individuals to exercise away from main roads, and preventing the construction of pre-schools, childcare centres, schools, hospitals and aged-care homes near traffic hotspots. PM2.5 increases significantly near busy roads and was found to be 50% higher in the morning rush hour than the evening.

CAUL's air quality research has assisted the NSW Department of Planning, Industry and Environment (DPIE) in expanding air quality monitoring by guiding choices on monitoring, for example at roadside stations, and by improving DPIE air quality forecasting through the NSW Air Quality Forecasting Framework. The increased awareness of air quality issues in Sydney raised by CAUL has seen further consideration of these issues incorporated into NSW Government strategies such as the Net Zero Plan, Future Transport 2056 and the NSW Electricity Strategy.

In the final year of research for the Hub, researchers will consider the impacts of biogenic emissions from trees and shrubs, which react with traffic emissions to increase ozone and fine particulate matter in the atmosphere. An improved understanding of these emissions will lead to better air-quality forecasting and climate simulations.

Sources

Paton-Walsh, C.; Rayner, P.; Simmons, J.; Fiddes, S.L.; Schofield, R.; Bridgman, H.; Beaupark, S.; Broome, R.; Chambers, S.D.; Chang, L.T.-C., et al. A Clean Air Plan for Sydney: An Overview of the Special Issue on Air Quality in New South Wales. Atmosphere 2019, 10, 774

Haynes, A., R. Popek, M. Boles, C. Paton-Walsh and S. A. Robinson (2019). Roadside Moss Turfs in South East Australia Capture More Particulate Matter Along an Urban Gradient than a Common Native Tree Species. Atmosphere 10(4): 224.

Popek, R., A. Haynes, A. Przybysz and S. A. Robinson (2019). How much does weather matter? Effects of rain and wind on PM accumulation by four species of Australian native trees. Atmosphere.

Hanigan IC, Rolfe MI, Knibbs LD, Salimi F, Cowie CT, Heyworth J, Marks GB, Guo Y, Cope M, Bauman A, Jalaludin B, Morgan GG. 2019. All-cause mortality and long-term exposure to low level air pollution in the45 and up study cohort, Sydney, Australia, 2006–2015. Environment International 126: 762-770.

Dirgawati M, Hinwood A, McCaul K, Nedkoff L, Hankey G, Yeap BB, Flicker L, Almeida O, Nieuwenhuijsen M, Brunekreef B, Heyworth J. 2019. Long term exposure to low air pollutant concentrations and the relationship with all-cause mortality and stroke in older men. Epidemiology. 30 Suppl 1:S82-S89.

Indoor air quality

Subproject 7.3

In Australia, more than 90% of our exposure to hazardous air pollutants occurs indoors: in our homes, workplaces, schools, and other buildings. Although attention on air pollution and climate change has been focused historically on outdoor air quality, of growing concern and recognition are the effects of climate change on indoor air quality [Steinemann et al. 2017]. For instance, measures to reduce energy use can lead to lower ventilation rates, more tightly sealed buildings, increased reliance on air conditioning, and less use of open windows, which can increase pollutant concentrations indoors. Climate-related hazards, such as bushfires, can drive people to spend more time indoors, which can also increase pollutants indoors through greater use of emitting products. Therefore, because indoor exposures will likely increase under climate change, due to both increased pollutant concentrations and increased time indoors, reducing sources of indoor pollutants becomes even more important as a climate adaptation measure.

A primary source of indoor air pollutants is fragranced consumer products, such as air fresheners and laundry supplies. Fragranced products emit a range of volatile organic compounds (VOCs), including hazardous air pollutants. In addition, common fragrance VOCs, such as terpenes, react with ozone to generate secondary pollutants, such as formaldehyde. Moreover, in urban areas, fragranced products now constitute a dominant source of fossil fuel VOCs that lead to the generation of smog. Reducing the use of fragranced consumer products can reduce emissions of fossil fuel VOCs into the atmosphere, which can improve both indoor and outdoor air quality.

CAUL's work has increased our understanding of sources and concentrations of VOCs within indoor environments in Australia, and ways to reduce VOC emissions. Our research found that discontinuing the use of air fresheners can reduce ambient concentrations of potentially hazardous fragrance chemicals by up to 96% within two weeks. In addition, switching from fragranced to fragrance-free laundry products can reduce dryer-vent emissions of potentially hazardous fragrance chemicals by up to 99%. [Goodman et al. 2019a, Goodman et al. 2019b.]

Sources

Steinemann A, Wargocki P, Rismanchi B. 2017. Ten Questions Concerning Green Buildings and Indoor Air Quality. Building and Environment 112:351–358.

Goodman N, Nematollahi N, Agosti G, Steinemann A. 2020. Evaluating air quality with and without air fresheners. Air Quality, Atmosphere and Health. 13(1):1-4.

Goodman NB, Wheeler AJ, Paevere PJ, Agosti G, Nematollahi N, Steinemann A. 2019. Emissions from Dryer Vents During Use of Fragranced and Fragrance-Free Laundry Products. Air Quality, Atmosphere and Health 12(3):289–295.

Urban Greening and liveability

Climbing temperatures, frequent heatwaves, increased droughts and extreme weather events will continue to affect life in Australia. Heatwaves, for example, can increase morbidity and mortality rates (particularly for vulnerable members of our urban populations) and impact our day-to-day social and economic activities. [Bush, 2017., Hatvani-Kovacs et al. 2018]

Green cities are healthier and more pleasant places to live. But what will climate change mean for our urban forests? Trees, including common varieties we see along our streets, are at risk from rising temperatures [Kendal et al., 2017]. Our urban forests also play an important role in buffering against climate change by cooling our cities and absorbing carbon dioxide from the atmosphere [Kendal et al., 2018]. But growing populations and calls for increased density place urban tree canopy cover at substantial risk.

CAUL research from Project 3 has explored the vulnerability of tree species to climate change and outlined a number of climate adaptation measures. Research from Project 4 is improving our understanding of the relationship between heat and urban vegetation and how we can use urban vegetation mapping to shape future decisions about our urban forests.

Sources

Bush, J. (2017). Cooling cities with green space: policy perspectives. (PhD Thesis), The University of Melbourne, Melbourne.

Hatvani-Kovacs, G., Bush, J., Sharifi, E., & Boland, J. (2018). Policy recommendations to increase urban heat stress resilience. Urban Climate, 25, 51-63.

Kendal, D., Farrar, A., Plant, L., Threlfall, C. G., Bush, J., & Baumann, J. (2017). Risks to Australia's urban forest from climate change and urban heat. Report for the Clean Air and Urban Landscape hub of the National Environmental Science Program.

Kendal, D., Dobbs, C., Gallagher, R. V., Beaumont, L. J., Baumann, J., Williams, N. S. G., & Livesley, S. J. (2018). A global comparison of the climatic niches of urban and native tree populations. Global Ecology and Biogeography, 27(5), 629-637.

Urban forests in Melbourne and other Australian cities

Subproject 3.4

As part of its Urban Forest Strategy, the City of Melbourne commissioned the CAUL Hub to research the vulnerability of tree species currently planted in the city to climate change [Kendal & Baumann, 2016]. Of the 375 tree species planted in the City of Melbourne, 19% of trees (39% of species) were found to be moderately or extremely vulnerable to the existing temperatures observed across the city; which are 1.9°C hotter, on average, than those observed during the 1950s. This figure increases to 35% of trees (48% of species) under an emissions limited climate-change scenario (a further 0.8°C increase by 2040), and to 62% of trees (78% of species) under a business as usual climate-change scenario (a further 3°C increase by 2090).

Two broad groups of tree species were found to be particularly vulnerable: species from colder climates such as those from northern Europe or the north-eastern United States, and native species with a narrow range of climate tolerances. Given the cultural and ecological importance of these species, engagement with relevant stakeholders will be a vital part of managing the way the City of Melbourne uses these species.

The City of Melbourne study also considered 976 species planted in other cities around the world, and a further 753 native species of trees not currently planted in Melbourne. Of these 1,729 species, 674 were well-suited to Melbourne's projected climate under a moderate scenario, and 389 were well-suited to the projected climate under an extreme scenario. While further research needs to be undertaken to ensure that these species are suitable in other contexts (such as horticultural performance, impact on biodiversity, and cultural considerations), these species provide an opportunity to shape the city's future urban forest in a way that is well-adapted to the expected climate.

This research was subsequently extended to cover 29 local government areas across Australia [Kendal et al., 2017]. The research found that 14% of public trees in these areas were at high risk in an emissions-limited scenario, with 24% of public trees at high risk under a business as usual emissions scenario. The report suggested several strategies to assist urban forest managers in adapting to increased temperatures, including improving environmental conditions through irrigation and pest management, careful site selection for vulnerable species, and selecting trees that are better suited to future climates.

Sources

Kendal, D. and Baumann, J. (2016), The City of Melbourne' future urban forest: Identifying vulnerability to future temperatures. The Clean Air and Urban Landscapes Hub and the City of Melbourne.

Kendal, D., Farrar, A., Plant, L., Threlfall, C., Bush, J., and Baumann, J. (2017), Risks to Australia's urban forest from climate change and urban heat. The Clean Air and Urban Landscapes Hub.

Royal Botanic Gardens Victoria

Subproject 3.4

In collaboration with the Royal Botanic Gardens Victoria and as part of its Landscape Succession Strategy 2016-2036, the CAUL Hub explored the vulnerability of tree species in the living collection of the Melbourne Gardens to different climate-change scenarios [Kendal & Farrar, 2017]. This was assessed by comparing the temperature of locations where each species occurs (either naturally or through

cultivation) to projected climate scenarios for Melbourne.

This study found that under a emissions limited climate scenario (RCP4.5, equating to a 1.7°C mean annual temperature increase in Melbourne by 2050), 15% of tree taxa and 20% of other taxa are considered to be at high risk; while under a business as usual climate scenario (RCP8.5, equating to a 3.0°C mean annual temperature increase in Melbourne by 2070), 20% of tree taxa and 26% of other taxa would be at high risk. Using a mapping overlay of the Melbourne Gardens, areas within the Gardens were assessed for their vulnerability to increased temperatures under each scenario.

The study suggested a number of adaptation measures for the Gardens, including:

- Choose tree species at lower risk, especially for long-lived species;
- Improve the resilience of existing high-value, at-risk species through appropriate management actions (e.g. irrigation, mulching, improved soil conditions);
- Use mapping overlay, to find the best locations for new plantings of high-value, at-risk species (for example, by identifying the most optimal microclimates within the Gardens); and
- Exchange plant information with national and international botanic gardens to facilitate ongoing learning opportunities.

A follow-up study, also in collaboration with the Royal Botanic Gardens Victoria, went on to assess over 12,000 threatened plant species [sourced from the IUCN Red List and statutory federal and state government conservation lists; Kendal, 2018]. This study identified over 3,300 species in the emissions limited climate scenario and 2,900 species in the business as usual climate scenario that are likely to be well suited to Melbourne's future climate. These projected conditions can be used to source new species and collections of threatened species for the Melbourne Gardens, while also allowing coordination with other botanic gardens to conserve threatened species in the current collection in more suitable locations.

Sources

Kendal, D. and Farrar, A. (2017), Assessment of the climate change risk to the living plant collections in the Melbourne Gardens. Royal Botanic Gardens Victoria.

Kendal, D. (2018) Climate risk assessment of potential threatened species for the living plant collections in the Melbourne Gardens. Royal Botanic Gardens Victoria.

Mapping our urban forest

Subproject 4.2

A recent report published by the CAUL Hub describes the impact that development, particularly on private land, is having on urban vegetation. Conducted in collaboration with CSIRO and the Victorian Department of Environment, Land, Water, and Planning, this research found that Melbourne's tree cover has reduced by approximately 2000 hectares over four years [Hurley et al., 2019].

So how do we ensure we have thriving and extensive urban vegetation as our cities continue to develop, consolidate and grow? This is one of the key urban challenges of Australian cities, and one that the CAUL

Hub is examining in several ways: from individual sites of revegetation and restoration, new methods for engagement with green infrastructure, to whole metropolitan regions and sub-regions.

The data being collected is enabling comprehensive assessment of the nature and distribution of urban vegetation, and its relationship to urban land use and development. This evidence base will build our understanding of where vegetation is, where it is being lost and gained, and what drivers influences change. Findings show that while planning policy can reduce loss and stimulate gain, the social and economic fabric of our neighbourhoods is also strongly correlated with the amount of vegetation found within our communities.

In partnership with CSIRO, CAUL-Hub researchers have developed a model that puts some of these findings into practice in order to help planners assess the impact of proposed developments on urban forest cover. Researchers, for example, have used recent modelling to predict the effect of increased housing densities on tree canopy cover in a prominent Perth suburb in 30 years' time based on proposed re-zoning [Saunders et al., 2020]. The model can help planners to deliver more sustainable designs and plan for ways to mitigate the loss of urban vegetation, particularly on private land.

Sources

Hurley, J., Saunders, A., Both, A., Sun, C., Boruff, B., Duncan, J., Amati, M., Caccetta, P. and Chia, J. (2019) Urban Vegetation Cover Change in Melbourne 2014 - 2018, Centre for Urban Research, RMIT University, Melbourne, Australia.

Saunders, A., Duncan, J., Hurley, J., Amati, M., Caccetta, P., Chia, J., Boruff, B. (2020). Leaf my neighbourhood alone! predicting the influence of densification on residential tree canopy cover in Perth. Landscape and Urban Planning 199

Greening on private land

Subproject 4.5

In Australian cities, many local government strategies and policies are aimed at retaining and planting trees in public spaces. However, they have limited control over private land where a significant portion of trees and other urban vegetation exists.

Through a project funded by Hort Innovation, CAUL researchers are conducting a global review of measures to make private property greener. Early research shows some of the tools that local governments in Australia could use. These include a mixture of regulatory mechanisms, such as tree removal permits, maintaining significant tree registries, applying compensatory value formulas, or requiring arborist reports or building standards; as well as educational and social mechanisms, such as sponsoring volunteer programs and tree-give-away programs [Ordóñez. et al., 2019].

Source

Ordóñez, C.; Bush, J.; Livesley, S.L.; Amati, M.; Hurley, J.; English, A.; Callow, D.; Hertzog, K.; Caffin, M.; Frank, S. (2019). Global review of incentive schemes for the retention and successful establishment of trees on private urban land (interim report). Hort Innovation.

Liveability in urban areas

Subproject 4.3

The CAUL Hub undertook a literature review on the benefits of urban green space in supporting health and wellbeing for the Heart Foundation, the South Australian Government (Department for Health and Ageing, Department of Environment, Water and Natural Resources, and the Office for Recreation and Sport), and the South Australian Local Government Association [Davern et al, 2017].

The review found that green space contributes to the resilience of cities during sudden weather shocks such as heat waves and storms (which are predicted to increase as a result of climate change). Green space is also linked to improved mental and physical health, urban biodiversity, and social interaction. Increasing tree-canopy cover can also mitigate climate change by sequestering carbon. In addition, shade trees can significantly reduce energy use in cities with hot summers by reducing the use of air conditioners.

Source

Davern, M., Farrar, A., Kendal, D., and Giles-Corti, B (2017), Quality green public open space supporting health, wellbeing and biodiversity: A literature review. University of Melbourne: Victoria.

Shadeways

Subproject 4.2

As Australian summers become hotter and harsher, access to shaded cycling and walking paths to enable active transport and maintain our outdoor lifestyles is increasingly important. Partnering with the regional City of Greater Bendigo in an experiential case study, CAUL researchers developed digital heat maps and made them available to city residents.

Shadeways is similar to navigation apps like Google Maps, only instead of searching for the fastest route, it finds the coolest route allowing residents to avoid the worst of the heat. Since its launch, the platform has been used more than 6,000 times.

As well as providing alternative pathways for walking and cycling, the urban heat maps can be used to improve strategies to adapt towards future hazardous climate conditions. The maps allow city planners to automatically identify the features of a city that influence temperature, including the amount of concrete or asphalt, trees or shrubs. Using this information, planners can easily identify hot and cool areas and prioritise tree planting to reduce heat. While Shadeways is currently only available to Bendigo residents, the concept has influenced similar projects. The City of Melbourne's Cool Routes project is using similar modelling to gather data on hot spots. A shadeway with instruments for monitoring micro-climates has also been built as part of a new residential development in outer Melbourne.

Sources

Deilami, K, Shooshtarian, S., Rudner, J., Butt, A., Amati, M. (2020) Resilience and adaptation strategies for urban heat at Regional, City and Local Scales, in Disaster Risk Reduction for Resilience: Climate Change and Disaster Risk Adaptation, London: Springer (forthcoming)

Amati, M. Butt, A. Sun, C., Deilami, K., Williams, G., Romeijn, H., Rudner, J., Leone, C. (2019). Smart Active Transport – Urban Heat Maps for Bendigo. Final Report for the City of Greater Bend igo.

Climate adaptation for urban ecology

According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), extinctions are at an all-time high [Karki et al., 2018]. Cities are crucial for protecting biodiversity, with one third of threatened species living in urban areas [Ives et al., 2016]. With its value stated as inestimable [Kiley et al., 2017], the ways biodiversity contributes to human health and wellbeing include air and water quality, mitigation against the impacts of climate change, mental wellbeing, and culture.

A warming climate will continue to impact plant and animal life. Changes in climate impacts species distribution by forcing animals out of the warmer regions of their native and human-created geographic ranges [e.g., Kendal et al, 2017]. In January 2019, we witnessed how extreme heatwaves can result in abrupt biodiversity losses when heat stress killed hundreds of native flying foxes in Victoria [ABC, 2019]. The combined effect of climate change and urban heat island (UHI) effect can also impact how plants produce fruits and flowers, which has impacts on the availability of food resources for wildlife.

CAUL research is contributing to knowledge supporting the management of animals and their habitats, including under a changing climate. Project 6 has demonstrated the co-benefits of urban greening for biodiversity and people. While Project 5's work has included the baselining of vulnerable urban biodiversity, novel approaches to urban conservation and tools enabling land managers to make effective decisions under future climates. Importantly, CAUL research is also highlighting the value of Indigenous ecological knowledge and cultural practices in responding to climate change.

Sources

Karki M, Senaratna Sellamuttu S, Okayasu S, et al. (2018). Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Asia and the Pacific of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES secretariat, 41.

Ives CD, Lentini PE, Threlfall CG, et al. (2016). Cities are hotspots for threatened species. Global Ecology and Biogeography 25: 117-126.

Kiley HM, Ainsworth GB, van Dongen WFD, et al. (2017). Variation in public perceptions and attitudes towards terrestrial ecosystems. Science of The Total Environment 590-591: 440-451.

The Living Pavilion

Subproject 5.5

The Living Pavilion (held in May 2019) was an arts/science event specifically aimed at illuminating the importance of Indigenous knowledge and perspectives. The three-week event highlighted Aboriginal

people's custodianship and knowledge of Country and how this deep knowledge can be a vital tool in addressing many of the challenges of climate change.

This event saw 40,000 indigenous plants specific to the eastern Kulin Nation installed in one small area of the University of Melbourne's Parkville campus. This living lab focussed specifically on Aboriginal plant uses and knowledge and how cultural practices built over millennia may inform modern issues of sustainability and adaptability.

Through community events, workshops, symposia, art, music and dance performances, public talks and detailed signage, participants were invited to learn about Aboriginal ways of knowing Country. Research was conducted on site to gauge people's understanding of and interest in Indigenous culture and knowledge but also to examine the ecological and biodiversity value of the site due to the huge influx of indigenous plants.

Science communication events, such as The Living Pavilion, work to empower and educate participants, inviting them into a safe and healing space to learn and share ideas about our individual and collective responsibilities in meeting the challenges we are facing. It was also focussed on breaking down silos and providing ideas and perspectives of how we may tackle environmental problems through more holistic approaches.

Looking at climate change through the arts is a highly effective science communication tool which encourages people to reflect and act on their role as custodians of Country and empower them to understand and embrace their role in meeting challenges.

The Living Pavilion was a co-production and collaboration with the CAUL Hub, THRIVE Hub (Faculty of Architecture, Building and Planning), the New Student Precinct of the University of Melbourne's Parkville campus, and CLIMARTE's ART+CLIMATE=CHANGE 2019 Festival. The project co-producers were Tanja Beer, Cathy Oke and Zena Cumpston.

Source

Beer, T., Hernandez-Santin, C., Cumpston, Z., Khan, R., Mata, L., Parris, K., Renowden, C., Iampolski, R., Hes, D. and Vogel, B. (2019). The Living Pavilion Research Report. The University of Melbourne, Victoria, Australia.

Climate adaptation for conservation

Subproject 5.4

CAUL-Hub researcher Sarah Bekessy contributed to a paper which found that in the face of rapid climate change and other human impacts on the environment, classical approaches to conservation (which attempt to restore a disturbed ecosystem to its natural state) may no longer be applicable [Bowman et al, 2017]. These approaches include setting aside protected areas, habitat restoration, and community programs for biodiversity conservation. Instead, the authors propose that 'renewal ecology' should focus on adaptation opportunities to global environmental change that benefit both biodiversity and human systems. This would minimise any collateral damage to biodiversity of human adaptation.

The authors also suggest a number of human modifications to natural systems that can reduce negative impacts of climate change, including construction of coastal ecosystems (or 'living coastlines'), modifying natural vegetation in urban areas to mitigate against increased fire danger, and modifying agricultural practices to combine climate adaptation with improved biodiversity outcomes.

Source

Bowman, D. M. J. S., Garnett, S. T., Barlow, S., Bekessy, S. A., Bellairs, S. M., Bishop, M. J., Bradstock, R. A., Jones, D. N., Maxwell, S. K., Pittock, J., Toral-Granda, M. V., Watson, J. E. M., Wilson, T., Zander, K. K., and Hughes, L. (2017). Renewal ecology: Conservation for the Anthropocene, Restoration Ecology, vol. 25, no. 5, pp. 674-680, September 2017

National actions for local biodiversity conservation

Subproject 5.6

Hub researchers Caragh Threlfall, Kylie Soanes and Cristina Ramalho conducted interviews across Australia with land managers, conservation organisations and community groups, to evaluate different types of biodiversity conservation actions. The national inventory of local actions is the first of its kind in Australia.

As well as identifying current case studies, the work revealed opportunities for future biodiversity conservation in urban Australia, including projects that specifically address climate change. One practitioner discussed the need to understand how to manage and restore urban remnant vegetation in a changing climate and assess if their current approaches would need to be revised to be relevant in future climates. Ongoing research that further identifies actions that land managers could implement to conserve biodiversity, with considerations for future climates, is underway.

Sources

Research report: Threlfall, C.G., Soanes, K., Ramalho, C.E., Aiyer, A., Parris, K., Maller, C. (2019) Conservation of urban biodiversity: a national summary of local actions. Report prepared by the Clean Air and Urban Landscapes Hub.

Factsheet: Understanding local actions to conserve urban biodiversity

Threatened species in urban areas

Subproject 5.1

In this cross-hub project, researchers from the CAUL and Threatened Species Recovery Hubs investigated the distribution of EPBC-listed species and discovered 347 terrestrial species currently overlapped with urban areas. Of these, 114 are also threatened by a changing climate, either through the increased frequency of extreme events (such as heatwaves, cyclones, fire, drought) or permanent changes in habitat availability (such as inundation, changed temperatures or precipitation, permanent drying of wetlands). This research provides a baseline for exploring the role of urban environments in providing refuge for these species under future climate scenarios, and identifying the adaptations that might be required to allow species to persist in urban environments.

Sources

Webpage: Threatened Species in Urban Areas

Linking nature in Melbourne

Subproject 5.2

A team of urban researchers from RMIT University, the University of Melbourne and the University of Western Australia collaborated with the City of Melbourne to measure ecological connectivity across the City of Melbourne. Ecological connectivity has implications for the successful restoration of biodiversity within urban spaces as healthy wildlife populations require free movement across various landscape scales.

The researchers developed a simple framework which can be used by local governments to evaluate changes in connectivity for wildlife and help target restoration activities. A second project was undertaken to test the sensitivity of the framework to underlying assumptions about animal movement across an urban landscape. Researchers also demonstrated how the method can be used to prioritise which road segments should be targeted for biodiversity-focussed actions as the City of Melbourne works to achieve targets laid out in its Nature in the City Strategy (2017).

This framework included a clear guide for implementation to support the City of Melbourne (and other end users) to assess connectivity impacts for future actions or scenarios, including actions targeted toward climate adaptation.

Sources

Report: Kirk H, Threlfall C.G, Soanes K, Ramalho C, Parris K, Amati M, Bekessy SA, Mata L. (2018) Linking nature in the city: A framework for improving ecological connectivity across the City of Melbourne. Report prepared for the City of Melbourne Urban Sustainability Branch.

Kirk H, Threlfall C.G, Soanes K, Parris K. (2020) Linking nature in the city Part II: Applying the connectivity index. Report prepared for the City of Melbourne Urban Sustainability Branch. Currently under review.

Fact sheet: Linking Nature in the City

Understanding the social, cultural and biodiversity benefits of urban greening

Project 6

Contact with nature through urban greenspaces has a myriad of benefits to human health and wellbeing, as documented by previous research [e.g. Maller et al., 2019]. These will become increasingly valuable under global heating and climate change scenarios that will be exacerbated in urban contexts. However, few studies have evaluated projects that attempt to benefit biodiversity, as well as the health and wellbeing of local residents who live near parks, community gardens and other types of urban greening.

With varying types of integrated urban greening sites, including the transformation of street verges and the revitalisation of informal green or open spaces, Project 6 research is providing an evidence base for

the benefits of improving biodiversity, the health and wellbeing of residents, and enhancing connections to urban nature [Mata et al., 2019; Farahani et al., 2018; Farahani and Maller, 2019; Farahani and Maller, 2018].

In providing socio-ecological insights into urban greening, the research offers a detailed understanding of how residents can benefit from increased access to greenspace, trees and shaded areas and opportunities to interact with wildlife in these places. It also provides evidence of how improving habitat through urban greening can encourage native animal species to return to urban areas as well as supporting remnant populations.

Aside from producing new knowledge, the project's conceptual and methodological approach will establish tools for ongoing monitoring beyond the life of the Hub to inform future policy making, research and greening action under climate change.

Sources

Maller C, Mumaw L and Cooke B. (2019). Health and social benefits of living with 'wild' nature. In: du Toit JT, Pettorelli N and Durant SM (eds) Rewilding. Cambridge: Cambridge University Press, 165-181.

Mata L, Garrard GE, Fidler F, et al. (2019). Punching above their weight: the ecological and social benefits of pop-up parks. Frontiers in Ecology and the Environment 17: 341-347.