Cockburn Community Wildlife NatureLink: Identifying the best spatial dimensions, route and landscape form of the Cockburn Community Wildlife Corridor (Perth, WA), based on scientific input and in consultation with stakeholders

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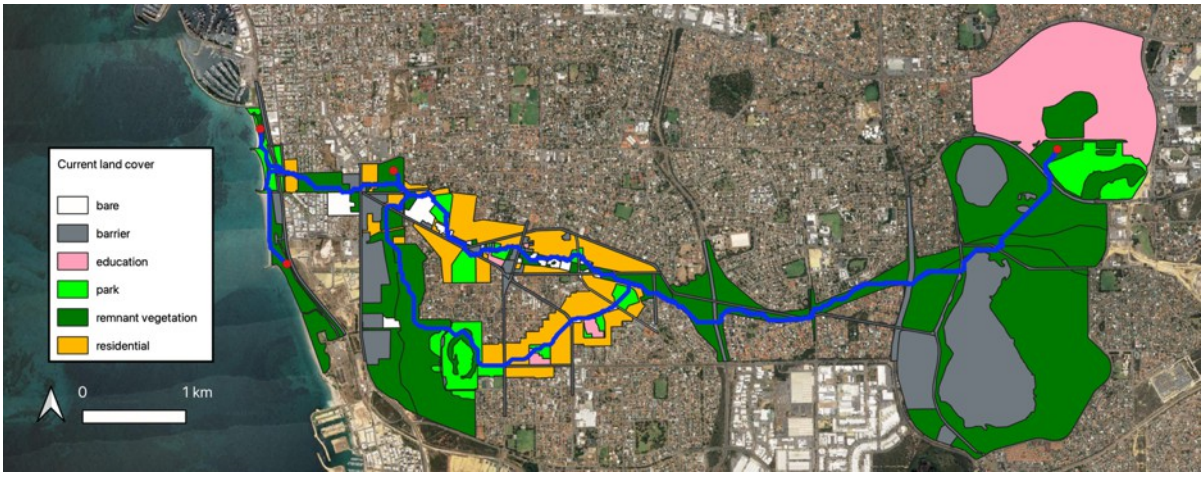

Figure 4: Final spatial footprint of the naturelink from Murdoch University to the Fremantle/Coogee coast based on least-cost path modelling, with land cover information. Satellite imagery: Google Satellite, 2023

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Executive Summary

The Cockburn Community Wildlife Corridor (CCWC) in the southern suburbs of Perth extends from the Beeliar Wetlands to the Fremantle and Coogee coast, encompassing the road reserve known as Roe 8 (east of Stock Road) and Roe 9 (west of Stock Road). Remnant native vegetation within the CCWC is highly valued by the community and Whadjuk traditional owners; it contains federally listed Threatened Ecological Communities (Banksia Woodlands and Tuart Woodlands) and roosting sites for endangered Carnaby's Black Cockatoos and vulnerable Forest Red-Tailed Black Cockatoos. The vegetation in the Roe 8 section of the CCWC (east of Stock Road) is relatively intact, however the vegetation in and around Roe 9 (west of Stock Road) is highly fragmented by urban development.

The CCWC has the potential to be a 'naturelink', an ecological linkage that promotes connectivity between bushland and wetlands sustaining biodiversity and providing multi-functional green spaces that promote human connection with nature. This would facilitate wildlife movement along the original Roe 9 road reserve despite its fragmentation. However, the CCWC currently has no statutory protection or even a definitive, agreed upon spatial footprint to guide management. This became an issue when the Department of Planning, Lands and Heritage (DPLH) conceived a new concept plan for the development of Roe 9/Roe 8 West, which proposed the removal and further fragmentation of some essential natural areas to ecological connectivity. As a result of discussions between DPLH staff and NatureLink Perth, this project aimed to develop a clear route and spatial footprint for the CCWC based on best scientific practice, incorporating the needs of native biodiversity and the local community. This can guide future planning and development to create and maintain a naturelink in perpetuity along the CCWC.

We first identified places of ecological, cultural or community significance within the CCWC, and established the most efficient linkages from Murdoch University to the Fremantle/Coogee coast that incorporated those places. These initial routes were generated in the form of single lines using least-cost path modelling in a geographical information system (QGIS). The routes were then converted into a two-dimensional spatial footprint (Figure 4) by distinguishing the various categories of land use* and land cover** throughout the corridor and mapping their boundaries along the route. An analogy for this process is 'beads on a string', where the least-cost path line is the 'string', and each block of a different land category are the 'beads' that the string passes through, connecting them together with no gaps. This provides urban planners with a specific layout of sites that should be protected, and where modifications to the current land cover should be undertaken to facilitate wildlife movement.

The study identified two paths (Figure 4) to be managed as naturelinks, to maximise connectivity and provide a level of redundancy in case either path is obstructed in the future. Both begin at Murdoch University, move west through the Beeliar Wetlands and along the Roe 8 corridor, cross Stock Road and then split apart at the Blackwood Avenue Bushland. The first path continues west along Roe 9 (the original route of the CCWC), incorporating the significant community sites and Threatened Ecological Community

*Land use: how the space is currently utilised by the community; within this naturelink the categories are residential, education, parkland, commercial/industrial, and transport.
**Land cover: the physical state of the land within its broader usage category, such as grass, native vegetation, roads, or buildings.

patches. It incorporates several commercial areas, schools, grassed parks, and currently undeveloped land, as well as patches of remnant native vegetation. A second path bifurcates to the south primarily through an urban zone along a power corridor, residential areas and schools, to link with Manning Park (Parks and Recreation Reserve). The two routes re-convene at Clontarf Hill and continue to the coastline at South Beach. Overall, the naturelinks are primarily located in the City of Cockburn, with small sections in the Cities of Melville and Fremantle.

The spatial footprint does not have consistent or specific dimensions; these depend on the current land cover and land use of the site that the route passes through. Various sizes, widths, and sometimes buffers of surrounding land types are required to maximise its suitability for wildlife movement. Most of the important community sites and undeveloped land occur within the road reserve, with other sites being either zoned as Urban or Parks and Recreation Reserve.

As well as identifying the spatial area to be managed as naturelinks, this study provides recommendations of appropriate management actions to facilitate wildlife movement depending on the current land cover. Connected native vegetation is the most essential aspect of a successful naturelink; thus, all remnant bushland and native trees within the designated naturelink spatial area should be preserved to prevent further fragmentation. This especially applies to Threatened Ecological Communities such as the Blackwood Avenue Bushland, Wheeler Park and the surrounding vegetation, Clontarf Hill, and the vegetation at the Stock Road/Forrest Road intersection.

This report also provides suitable treatments for different land cover types including:

1. Planting local native vegetation including understorey, shrubs, and trees within recreational parks,
2. Encouraging residents to plant native verge trees, native verges, and residential gardens, and take measures to reduce cat predation,
3. Revegetation of undeveloped areas,
4. Designing new urban developments to maximise the connected green space available and not disturbing or fragmenting remnant vegetation within the site, and
5. Planting local native trees and vegetation along roads and installing fauna bridges and underpasses across main roads (especially Stock Road) to allow safe crossing.

Appropriate management of the land within the spatial footprint is vital to ensure the naturelink sustains biodiversity, maximises connectivity, and promotes beneficial human-nature interactions. To this end the GIS layers has been provided online as an interactive mapping tool allowing anyone to access the CCWC spatial footprint. This is available on the NatureLink Perth website, currently under ‘Resources’ (https://www.naturelinkperth.org/resources/).

Introduction

Connected natural corridors through urban areas are invaluable to local communities and biodiversity. Green spaces reduce the urban heat island effect, improve air quality, and increase climate resilience of cities (Brown et al., 2018; Imran et al., 2019). Connectivity between natural areas increases the food sources and breeding opportunities for local wildlife, leading to improved genetic diversity and population resilience (Clobert et al., 2012). Living near green spaces improves both physical and mental health (World Health Organisation, 2021); furthermore, these benefits to human wellbeing are enhanced by higher biodiversity in those green spaces (Fuller et al., 2007; Wood et al., 2018).

Australia's only biodiversity hotspot, the Southwest region of Western Australia (Myers et al., 2000), has over 8000 native vascular plants, approximately half of which are endemic (Gioia & Hopper, 2017). Within this biodiversity hotspot, the highest species richness is found in the Perth region (Gioia & Hopper, 2017), which is also the largest urban area in WA. To conserve Perth's unique biodiversity and utilise its benefits to humans and wildlife, it is vital that connected natural areas are protected and incorporated into urban planning. NatureLink Perth aims to create connectivity between bushland and wetlands throughout Greater Perth with multi-functional green spaces that promote human connection with nature, known as naturelinks. Similarly, a wildlife corridor is a connection of natural areas and habitats across a landscape but is specifically designed to provide a route for fauna to access resources.

The Cockburn Community Wildlife Corridor (CCWC) in the southern suburbs of Perth extends from the Beeliar Wetlands to the Fremantle and Coogee coast, spanning approximately 10km east to west and encompassing the road reserve known as Roe 8 (east of Stock Road) and Roe 9 (west of Stock Road). Remnant native vegetation within the CCWC contains Banksia and Tuart Woodlands, both of which are listed as Threatened Ecological Communities at a high risk of extinction under the federal EPBC Act. Banksia Woodlands are also classified as critically endangered under WA's Biodiversity Conservation Act. The Beeliar Regional Park (including Bibra Lake and Manning Park) is protected as Parks and Recreation reserve (Government of Western Australia, 2021), but the rest of the remnant vegetation in the CCWC is currently unprotected.

While most of the bushland fragments in the CCWC are far smaller than nearby protected areas, their benefits to local biodiversity should not be discounted. A higher number of smaller patches encourages more species movement than one larger patch from which fauna are reluctant to travel (Lindenmayer, 2019), and in urban biodiversity hotspots such as Perth, small patches may be all that remains of a particular combination of geological and ecological characteristics (Wintle et al., 2019). Furthermore, this area is beloved by the local community; thousands of people protested the Roe Highway expansion in 2016, which was the culmination of approximately three decades of opposition to the plan (Brady, 2019). The Department of Planning, Lands and Heritage (DPLH) is currently undertaking community consultation and planning regarding the rezoning of the Roe 8 West and Roe 9 road reserve (DPLH, 2023). To inform this process, an exact route for the connected Cockburn Community Wildlife Corridor needs to be mapped out, rationalised, and approved by stakeholders, so that it can be integrated into an urban plan.

A previous study by O'Donnell (2020) provided an overview of naturelink opportunities throughout the Perth and Peel region. These naturelinks were designed to connect protected areas of vegetation according to the current land use; the findings do not necessarily represent linkage opportunities in areas that are undergoing a change of land use, where sites have the potential to become protected in the future. The naturelink from Bibra Lake to Manning Park (Appendix B) follows a similar route to Del Marco's Regional Ecological Linkage 51, mapped in 2004 (Appendix C). This has been deemed a less viable route than the CCWC due to the prominence of residential areas between small public open spaces, which limits the amount of fauna that can utilise the naturelink (Zelinova, 2020). Furthermore, O'Donnell's project did not cover localised factors such as community stewardship and cultural heritage. Even without formal protection, vegetation that is regularly tended to by community groups (as is the case along the CCWC) is highly favourable to biodiversity and fauna movement (Danielson, 2005).

Despite extensive mapping of nature connectivity in the area, a specific spatial footprint of the CCWC based on least-cost path modelling while taking these factors into account has not yet been produced. The aim of this study is to design a naturelink from Murdoch University to the Fremantle coast that supports local biodiversity, accounts for the needs and values of the local community and informs the rezoning process of the Roe 8 West and Roe 9 road reserve to optimise nature connectivity.

Methods

Community and ecological values along the corridor

Information about valued sites along the Roe 9 corridor were found in local community feedback documents in response to the Draft Concept Plan released by DPLH in 2023. The community groups were the Cockburn Community Wildlife Corridor group, the Friends of Clontarf Hill, and the Hamilton Hill Community Group. A draft version of the naturelink was presented to the Cockburn Community Wildlife Corridor group and the Rehabilitating Roe 8 Advisory Committee to receive their insight and feedback. Further information about the corridor was sourced from publicly available spatial datasets updated in the last three years and spatial datasets provided by community groups (Table 1).

Considering this information, the sites undergoing re-zoning in the Draft Concept Plan were ranked according to their protection priority. The highest priority was given to areas that are critical for local biodiversity, have active community stewardship, and should be rezoned as Parks and Recreation or given a similarly high level of protection. Medium priority was given to areas that should be used as local parks or nature-friendly residential areas, and the lowest priority was given to areas where the current land-use forms a barrier for wildlife movement and should be adapted for connectivity.

Updating the cost layers

The naturelink was developed using least-cost path modelling, based on the findings of O'Donnell (2020). In that study on the Perth and Peel region, three separate data layers were

produced representing land use, land cover and movement barriers in the study area. For each category, cost values ranging from 1 to 200 were assigned to each pixel, with lower cost values representing landscape features that are more conducive to fauna movement. These cost layers were then synthesised to inform the least-cost path modelling.

In this study, O'Donnell's cost layers were altered to represent localised community and ecological values of the study area and update the annual and perennial vegetation. All datasets were clipped to approximately 1km north and south of the Roe 8/Roe 9 road reserve (DPLH, 2019); native vegetation or parks that lay partially outside this buffer were included in their entirety. This formed the study area for the modelling.

Important community sites (Table 2) including Aboriginal Heritage Sites were exported from various datasets (Table 1) and assigned a cost of 1 to reflect the community and cultural benefits to biodiversity and wildlife movement in these areas (Danielsen, 2005). The new values were overlayed onto O'Donnell's land use cost layer to replace the original values assigned to those sites.

Annual and perennial vegetation in the study area was re-mapped using O'Donnell's methods to account for changes in vegetation cover since 2020. The normalised difference vegetation index (NDVI was calculated from satellite imagery taken in October 2022 and February 2023 (Table 1); values over 0.25 were taken to be vegetation based on comparison with the satellite imagery. Vegetation present only in October was considered annual vegetation and assigned a cost of 50, while vegetation present in both dates was considered perennial vegetation and assigned a cost of 20. Remnant native vegetation (DPIRD, 2020) was assigned a cost of 1. These new values were overlayed onto O'Donnell's land cover cost layer.

Following O'Donnell's procedure, the new land use and land cover cost layers were combined to show the average cost values for the two categories. O'Donnell's barriers layer was overlayed onto this image, producing the final new cost layer.

Least-cost path modelling

The Least Cost Path tool from the Cost Distance Analysis plugin in QGIS was used to calculate the most efficient linkage routes based the new cost layer. A centroid in the Murdoch Banksia Woodlands was used as the start point, as this is a Threatened Ecological Community fragment that connects to the Beeliar Wetlands in the CCWC, while two centroids were trialled as end points along the length of the coastal vegetation at the end of the CCWC (DPIRD, 2020). The modelling was run on the entire study area and again on a reduced buffer of 500m to determine any difference to the results when negating the presence of large nearby protected areas such as Manning Park.

Producing the spatial footprint

Three separate data layers were produced showing the Metropolitan Region scheme (the legal basis for urban planning, for example road reserve), current land use (for example residential, education, or parkland), and land cover (the physical land type within a broader

land use, for example grass, road, or bare ground). Every community site, vegetation remnant, park, school, or protected area that the least-cost path crossed was considered part of the spatial footprint of both naturelink routes produced. Barriers such as main roads and commercial areas were also included to demonstrate where the naturelink is required to follow a certain route. Minor modifications to the vertices of some polygon datasets were made to better represent the land-cover of a particular site. Land-cover information that was not well-represented in datasets (for example, bare/undeveloped areas) was digitised based on satellite imagery (Bing Satellite, 2023; Google Satellite, 2023).

Where the least-cost path crossed through residential areas, that part of the route was simplified to produce a buffer of equal width and length, representing a specific zone of houses that are included in the naturelink. These zones will undergo treatments (see 'Discussion') to connect the naturelink through residential areas. The edges of these zones were adjusted slightly for simplification (for example, if most of a particular street was part of the zone, the remaining houses on that street were also included). Small residential zones were produced around parks, schools and bare/undeveloped areas to account for gaps in the spatial footprint, the fauna movement cost of the sites nearest to the zone, and to keep the overall width of the naturelink relatively consistent.

Table 1: Datasets used for this study and/or partially displayed in Figures 1-6

Information	**Dataset name**	**Source**	**Year last updated**
Annual vegetation	Sentinel 2B (13/10/2022)	European Space Agency, 2022	2022
Community, cultural, or historical sites	Aboriginal Heritage Places	DPLH, 2019	2023
	Areas Cleared for Roe 8	Moore, 2017	2017
	Cockburn Community Wildlife Corridor (22 Jan 2016)	Moore, 2017	2017
	Heritage List	DPLH, 2021	2023
Current land use (Table 3)	Urban Forest Parcels	DPLH, 2022	2022
Metropolitan Region Scheme (Table 3)	Region Scheme – Zones and Reserves	DPLH, 2019	2023
Native vegetation	Swan Coastal Plain Remnant Vegetation 2020	Department of Primary Industries and Regional Development, 2020	2020
Ecological linkages in Perth and Peel	All Protected Areas Least Cost Path Linkages	O'Donnell, 2020	2020
Cost values previously assigned to land features	Barriers	O'Donnell, 2020	2020
	Land Cover	O'Donnell, 2020	2020
	Land Use	O'Donnell, 2020	2020
Perennial vegetation	Sentinel-2B (20/02/2023)	European Space Agency, 2023	2023
Tuart tree locations	TTM_TreeLocations_23_0113	Tauss, 2023	2023
Tuart Woodland patches	TTM_TECPatch_230113	Tauss, 2023	2023

Results

The 10 important community sites described in community group documents are mostly native vegetation or grassy parks (Table 2). They have at least ten active community groups, and among them is one Aboriginal Heritage Site (Clontarf Hill/Hamilton Hill Swamp Precinct), two heritage-listed buildings (Randwick and Johnson Stables) and two Threatened Ecological Community Patches (Table 2).

The least-cost path modelling showed two prospective routes which follow the same path along the Roe 8 corridor and split at the Blackwood Avenue Bushland (Figures 1-5). The southern route, produced with the 1km buffer, follows a power corridor, links two primary schools, and ends at Manning Park. The northern route follows the Roe 9 corridor, linking remnant vegetation and most of the important community sites (Figure 5). A second end point for the southern route was added so that the two routes reconnect at Clontarf Hill before travelling to the coast.

The majority of both naturelink routes travels through current Primary Regional Road reserve or urban zone, although the southern route utilises more Parks and Recreation reserve and urban zone (Figure 2). The dominant land use of the CCWC is residential (Figure 3). The southern route passes through two schools, and both routes travel through a commercial/industrial area before reaching the coast (Figure 3). For land cover, the entire eastern portion of both routes travels through the native vegetation along the Roe 8 corridor (Figure 4). The southern route travels through two large housing zones while the northern route utilises more of the remnant vegetation and bare/undeveloped land (Figure 4). The 10 important community sites described in community group documents were all included in at least one of the naturelink routes (Figure 5). The northern route travels through more important community sites, however the southern route does include Randwick Stables which was missed by the northern route (Figure 5). All of the unprotected Tuart trees and Tuart Woodland patches are found in the sections of the CCWC where the two routes overlap (Figure 6).

All community sites and known Threatened Ecological Community patches were given the highest priority for protection, which made up all of the Roe 8 reserve and about half of the Roe 9 reserve (Figure 7). Grassy parks, schools, and areas of patchy native vegetation were given medium priority, forming the central portion of Roe 9, and the lowest priority was afforded to main roads and commercial/industrial areas (Figure 7).

Table 2: List of stakeholders, land cover type, and cultural/ecological values of important sites along the Roe 8 and Roe 9 corridors, numbered from west to east according to Figure 1.

No.	Site name	Dominant land cover type	Community groups/stakeholders	Cultural and ecological values/other notes
1	Hollis Park	Native vegetation; bare/undeveloped land	Friends of Hollis Park; CCWC	Contaminated (DWER, 2023)
2	Clontarf Hill	Native vegetation	Traditional owners (Nyungar community); Friends of Clontarf Hill; Friends of Hollis Park; CCWC	Registered Aboriginal Heritage Site 18332 – massacre, camping, hunting, ceremonial, mythological, artefacts (DPLH, 2021); last old-growth tuart trees and natural limestone hill in Fremantle area (CCWC, 2023); Tuart Woodlands (Threatened Ecological Community) (Figure 5)
3	Randwick Stables	Grassy area; building	Randwick Stables Community Garden; CCWC; Friends of Clontarf Hill; Hamilton Hill Community Group	Heritage-listed buildings (DPLH, 2023); oldest horse stables in Perth (est. 1923)
4	Dixon Reserve/Hamilton Hill Swamp Precinct	Grassy area; bare/undeveloped land	Traditional owners (Nyungar community); Friends of Clontarf Hill; CCWC; Hamilton Hill Community Group	Former wetland; Registered Aboriginal Heritage Site 18332 (DPLH, 2021); Traditional Owners requested no infrastructure in the undeveloped western portion; community recreational space; contaminated soil (DWER, 2023)
5	Johnson Stables	Grassy area; building	CCWC	Heritage-listed building (DPLH, 2023)
6	Wheeler Park	Grassy area	Friends of Blackwood Avenue Bushland; CCWC; Friends of Clontarf Hill;	Tuart Threatened Ecological Community (Figure 5); feeding ground for endangered Carnaby's and Red-tailed Black Cockatoos (Tauss, 2022)
7	Vegetation north of Blackwood Avenue to Wheeler Park	Native vegetation	Friends of Blackwood Avenue Bushland; CCWC; Hamilton Hill Community Group	Tuart Woodlands (Threatened Ecological Community) (Figure 5); feeding ground for endangered Carnaby's and Red-tailed Black Cockatoos and other Priority Fauna (Tauss, 2022); rare geology 'Spearwood red' loam (Griffin, 2022); unusual mix of Marri, Jarrah, Tuart, Nuytsia, Allocasuarina, Quandong and Banksia as over-storey trees (Tauss, 2022)
8	Blackwood Avenue Bushland	Native vegetation	Friends of Blackwood Avenue Bushland; CCWC; Hamilton Hill Community Group; Friends of Clontarf Hill	Tuart Woodlands (Threatened Ecological Community) (Figure 5); feeding ground for endangered Carnaby's and Red-tailed Black Cockatoos and

				other Priority Fauna (Tauss, 2022); nesting ground for Rainbow Bee-Eaters (CCWC, 2023); rare species *Pittosporum lingustrifolium* (Tauss, 2022); rare geology 'Spearwood red' loam (Griffin, 2022); unusual mix of Marri, Jarrah, Tuart, Nuytsia, Allocasuarina, Quandong and Banksia as over-storey trees (Tauss, 2023)
9	Stock Rd/Forrest Rd Intersection	Native vegetation	CCWC; Rehabilitating Roe 8; Friends of Clontarf Hill; Hamilton Hill Community Group	Tuart Threatened Ecological Community (Figure 5); feeding ground for endangered Carnaby's and Red-tailed Black Cockatoos; nesting ground for Rainbow Bee-Eaters; rare species *Pittosporum lingustrifolium*; rare geology 'Spearwood red' loam; unusual mix of Marri, Jarrah, Tuart, Nuytsia, Allocasuarina, Quandong and Banksia as over-storey trees (Tauss, 2023)
10	Rehabilitating Roe 8 project	Native vegetation	Rehabilitating Roe 8 (City of Cockburn); CCWC; Conservation Council WA; Coolbellup Community Association; Hamilton Hill Community Group; Save Beeliar Wetlands; Wildflower Society	10-year Rehabilitation Management Plan prepared in collaboration with scientists, community, State government and the City of Cockburn; Banksia Woodlands (Threatened Ecological Community)

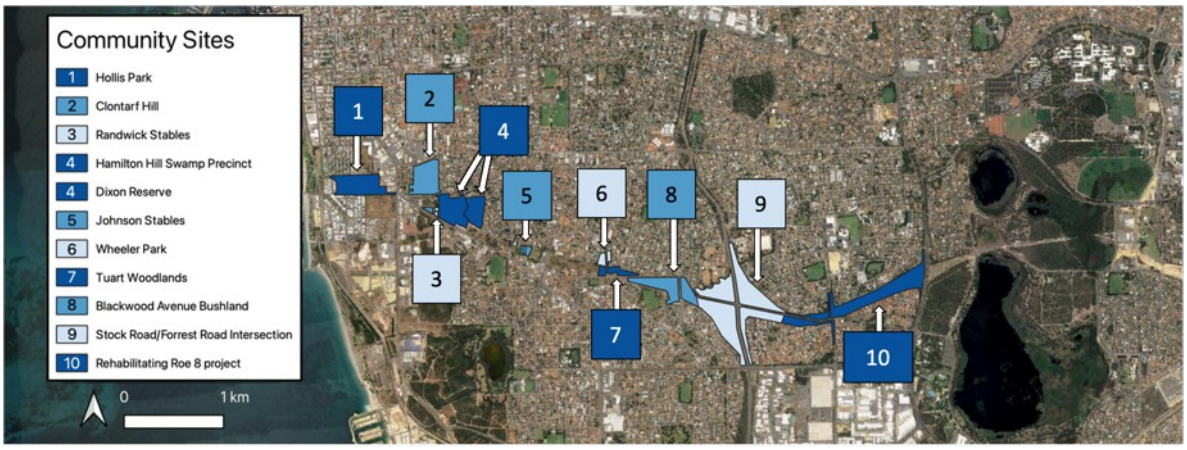

Figure 1: Important community sites (Table 1) along the Roe 8 and Roe 9 corridors. Satellite imagery: Google Satellite, 2023

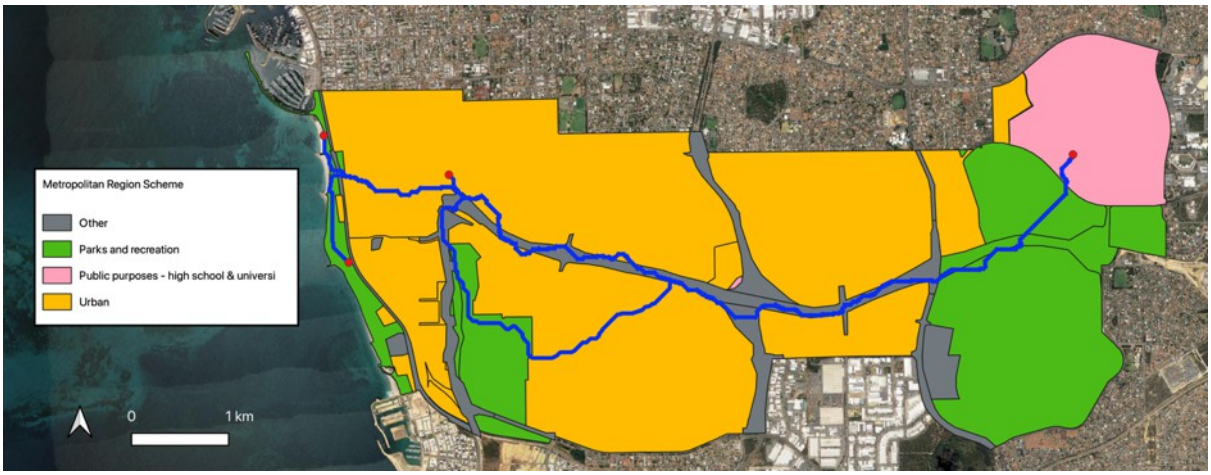

Figure 2: Results of least-cost path modelling from Murdoch University to the Fremantle/Coogee coastline, underlaid by the MRS Scheme (DPLH, 2023). Satellite imagery: Google Satellite, 2023

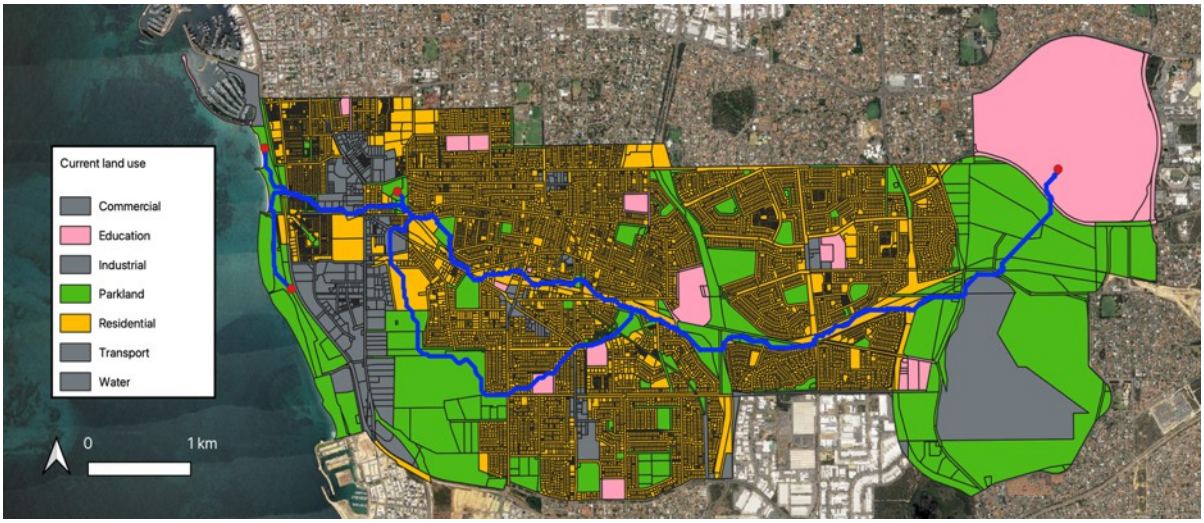

Figure 3: Results of least-cost path modelling from Murdoch University to the Fremantle/Coogee coastline, underlaid by land use information (DPLH, 2022). Satellite imagery: Google Satellite, 2023

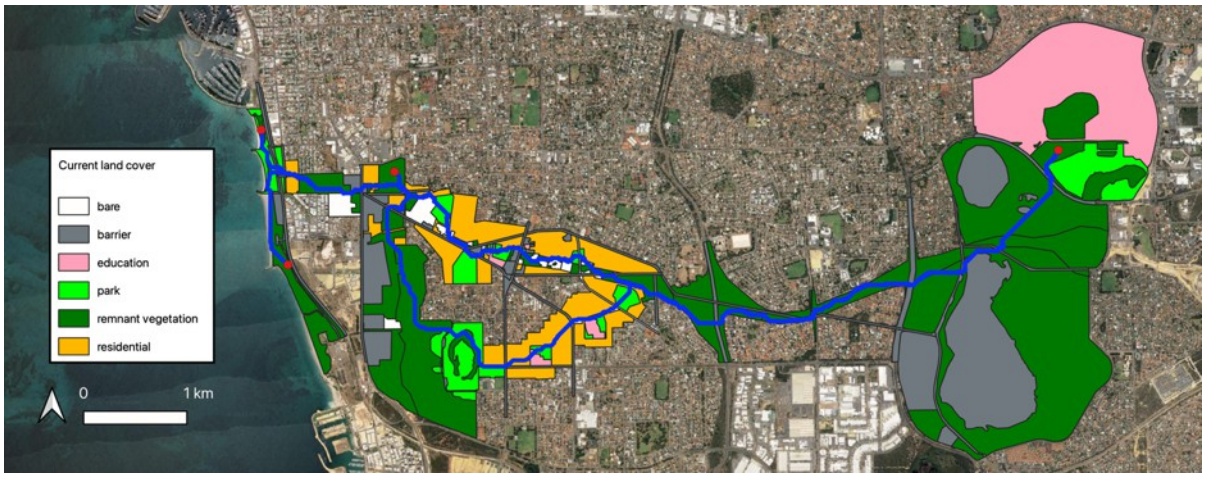

Figure 4: Final spatial footprint of the naturelink from Murdoch University to the Fremantle/Coogee coast based on least-cost path modelling, with land cover information. Satellite imagery: Google Satellite, 2023

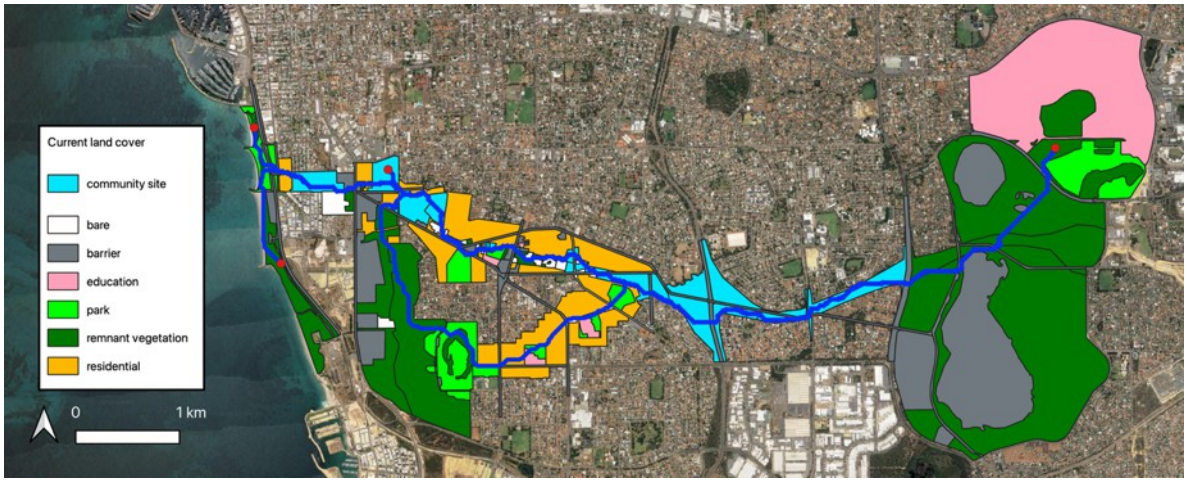

Figure 5: Modified version of Figure 4 overlaid by important community sites (Table 1). Satellite imagery: Google Satellite, 2023

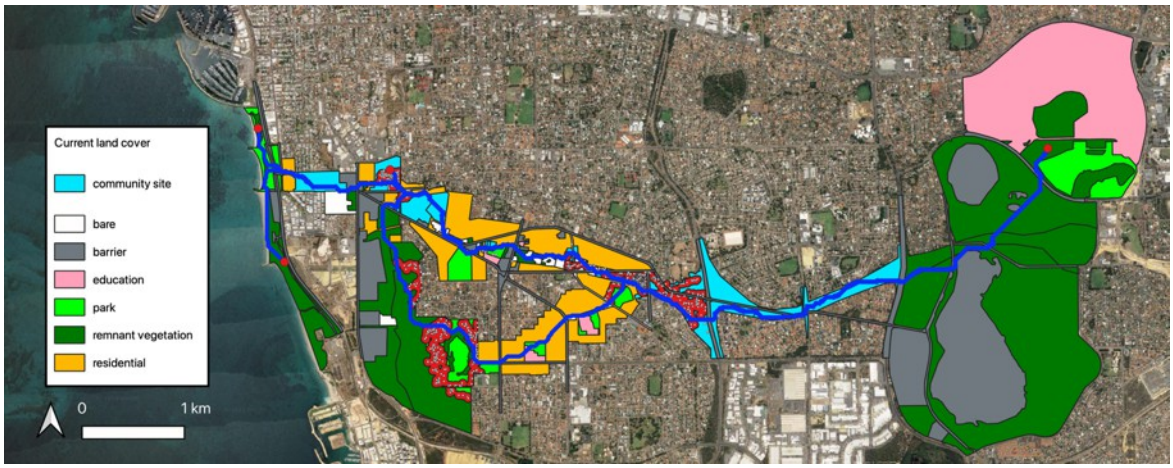

Figure 6: Modified version of Figure 5 showing Tuart Threatened Ecological Community patches (red) and tuart tree locations (grey) along the western section of the CCWC (Tauss, 2023). Satellite imagery: Google Satellite, 2023

Figure 7: Modified version of the Draft Concept Plan (Appendix A) showing the protection priority of sites along the Roe 8 and Roe 9 corridor according to ecological, cultural, and community values. Green = highest priority, orange = medium priority, red = lowest priority.

Discussion

The least-cost path produced in a 1km buffer around the road reserve was very similar to the naturelink produced by O'Donnell in 2020 (Appendix B). Linking Bibra Lake to Manning Park remained the priority for the modelling due to its size, whereas the sites along Roe 9 are much smaller and more disjointed. By reducing the study area to 500m around the road reserve, the modelling was forced to ignore the presence of Manning Park and follow the Roe 9 corridor. Although the southern route has a lower cost according to the modelling, the northern route will be more suited to fauna movement if the currently bare/undeveloped areas are revegetated. In the likely scenario of new developments occurring in these spaces, nature-friendly designs will still allow for a strong outcome. NatureLink Perth advocates for the implementation of both routes to optimise the benefits of each.

Appropriate management of the land within the spatial footprint is vital to ensure the naturelink sustains biodiversity, maximises connectivity, and promotes beneficial human-nature interactions. Best-practice treatments for each land cover type are outlined below. This study may help to inform future naturelink implementation, especially in areas undergoing a land-use change. In all cases the priority should be to retain the existing tree canopy and native vegetation by either protecting remnant bushland or incorporating that bushland into residential development.

All remnant bushland and native trees within the naturelink should be preserved.

The most critical aspect of a naturelink is native vegetation, which supports far greater biodiversity than any other type of green space (Davis et al., 2013; Prendergast et al., 2022; Ramalho et al., 2014). This is of particular relevance to the Blackwood Avenue Bushland and the vegetation linking it to Wheeler Park (Figure 1), which is highly valued by both scientists and the local community for its ecological and geological significance (Table 2). It also contains a Tuart Woodland patch (Figure 6), which is a Threatened Ecological Community under the federal EPBC Act. Despite this, most of this area has been proposed for residential development in the Draft Concept Plan (Appendix A). Although some level of residential development in this corridor is inevitable, valuable remnants of bushland such as threatened ecological communities and feeding grounds for priority fauna should not be considered as development sites. Further remnant bushland patches that should not undergo urban development are Clontarf Hill and the Stock Road/Forrest Road Intersection (Table 2).

Parks and schools should incorporate continuous corridors of local native vegetation to allow wildlife passage along the naturelink.

Local native vegetation including understorey, shrubs and trees should be planted along two or more edges of all parks within the spatial footprint of the naturelink without interfering with the current land use (for example, sports fields) of the central areas. The vegetation corridors should be at least 5m in width and can complement walking trails and cycle paths for the local community. They do not need to be straight line strips but can be landscaped to provide the most aesthetic shape and best use of the land and topography. Plantings should focus on native plant communities indigenous to the local area (see Links: SERCUL).

Local councils are encouraged to educate and incentivise current residents in the naturelink to plant native verge trees, native verges, and residential gardens, and take measures to reduce cat predation.

The Cities of Cockburn and Fremantle both currently offer their residents subsidies for native plants. To encourage residents within the naturelink to take part in this, councils should consider education programs such as letter drops to spread awareness about their role in contributing to the naturelink and offer higher subsidies, free verge garden preparation (removal of weeds and soils preparation), or free native plants to those residents.

Education programs should include information about how to design gardens to suit a greater variety of fauna, especially to support pollinators. Woody meadows of local native species are well-suited to road verges as they provide high aesthetic value, high shrub cover and high diversity (see Links: University of Melbourne). Species such as *Banksia menziesii* and *Allocasuarina fraseriana* are food sources for endangered Black Cockatoos (Johnston et al. 2016) and should be promoted as good choices for native gardens, along with habitat for other priority fauna. Councils are encouraged to partner with ReWild Perth, or promote residents to join ReWild Perth, to take advantage of their programs and resources. Further information about native garden design and plant choices can be found on their website (see Links: Rewild Perth).

Pet cat predation has a devastating impact on urban wildlife populations (Legge et al., 2020). South Beach Reserve is already a cat-free zone (City of Fremantle, 2023), but the City of Cockburn, which encompasses the majority of the naturelink, has no formal cat roaming restrictions. To reduce predation on native fauna, the City of Cockburn is encouraged to restrict pet cat roaming and consider enforcing cat-free zones within the naturelink (Legge et al., 2020).

Bare/undeveloped areas should be revegetated with high local native species diversity and native wildlife habitat.

Revegetation will increase the total area of remnant vegetation patches, improve connectivity across the naturelink and therefore support greater biodiversity and wildlife movement. This is the best way to utilise power corridors in the spatial footprint (low understorey plantings are appropriate where access or height restrictions are in place). The Hamilton Hill Swamp Precinct should be restored to its original wetland environment with no further developments in the western portion of the site, as per the request of the traditional Nyungar owners (Terra Rosa Consulting, n.d.).

Where developments take place, they should be designed to maximise the connected green space available to residents and native wildlife.

NatureLink Perth has previously worked with Development WA to show how naturelinks can be incorporated into new developments (Arangio, 2022). All developments should seek to maximise the connectivity of the naturelink by not disturbing or fragmenting remnant

vegetation within the site. Instead, buildings should be designed taller rather than wider which maximises the amount of native, quality, established waterwise green areas.

An efficient way to increase green spaces in urban design is to install green roofs, walls, laneways, and rooftops gardens. Green roofs and walls increase insulation and lower the roof temperature; furthermore, studies have shown they are compatible with solar panel installation and even make them more efficient (Fleck et al., 2021). Green spaces should incorporate roosting posts, water sources that suit the needs of different fauna (for example, birds prefer to drink from high perches to avoid predation, whereas ground-dwelling fauna prefer to drink under the cover of shrubs) and aim for tree retention and connectivity with the rest of the naturelink (Thomson et al., 2022).

Local road verges should be planted with native trees and vegetation to promote connectivity, but main roads present a high risk of mortality and should have fauna access controlled with bridges or underpasses installed to allow safe crossing. Wildlife crossings with reduced speed limits and signs may provide a secondary option. Pedestrian and cycle-only streets should be increased throughout the urban footprint, which can then incorporate native vegetation.

Roads pose one of the biggest dangers to wildlife and impede their movement through the landscape (Ramp et al., 2006). As one of the highest-volume roads in the study area, a fauna bridge across Stock Road would be particularly valuable to connect the eastern and western sections of the naturelink for pollinators and large fauna. Culverts can be converted into fauna underpasses; these require adequate predator control or shelter from predators within them, and the openings should connect into habitat areas on either side (Chambers & Bencini, 2015). Tree-lined streets are one of the most important contributors to urban tree canopy and provide shelter for wildlife at what is otherwise a barrier to their movement.

An effective way to mitigate barriers to wildlife movement is to reduce the amount of land dedicated to cars. Narrower streets reserved for pedestrian and cycling traffic allow for more vegetation and deep-rooted trees on either side. The concept of ‘biophilic streets’ should be considered in new and existing developments, where streets are seen as multifunctional corridors that incorporate wildlife habitat and maximise water drainage and retention (Thomson et al., 2022).

Conclusion

A naturelink can only succeed with the support of the local community. The process of designing a naturelink has to account for a combination of ecological, cultural, and community values; furthermore, consulting with local community groups can provide valuable insight into the area of study that would not be possible without this engagement. This project illustrated how a naturelink could be implemented in the existing urban landscape, as well as integrating the naturelink footprint into new developments at the planning stage to prevent unnecessary vegetation loss. The rezoning of the Roe 8 and Roe 9 corridor provides the perfect opportunity to implement this naturelink and protect the unique ecological, community, and cultural values along the Cockburn Community Wildlife Corridor for current and future generations to appreciate.

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Links

NatureLink Perth https://www.naturelinkperth.org/

Rewild Perth. https://rewildperth.com.au

SERCUL. Fertilise Wise and Grow Local Plants Guides. https://www.sercul.org.au/publications/#fertilise-wise-and-grow-local-plants-guides

University of Melbourne. Woody Meadow. https://woodymeadow.unimelb.edu.au/

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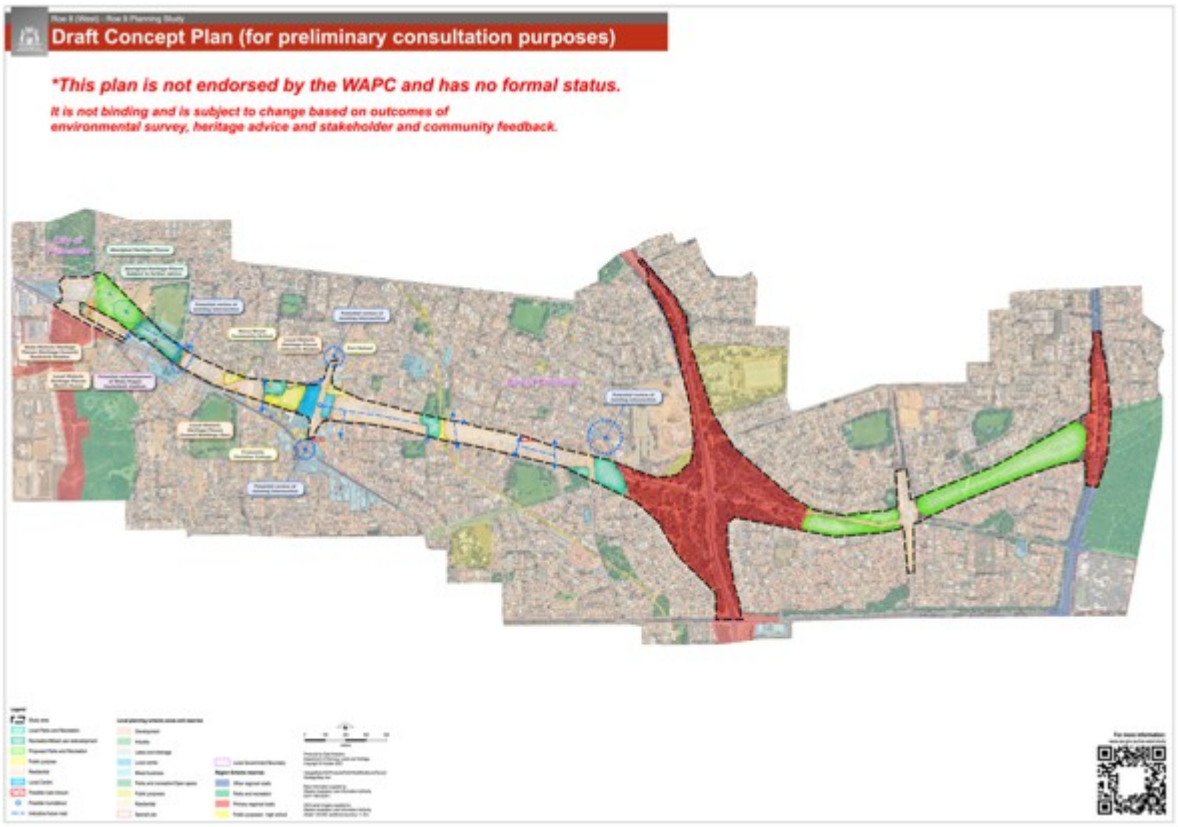
Appendices



Appendix A: Draft Concept Plan showing proposed zoning and land-use changes along the Roe 8 and Roe 9 road reserve (Department of Planning, Lands and Heritage, 2022).

Appendix B: Naturelinks mapped by O'Donnell (2020) based on least-cost path modelling throughout the Perth and Peel region, WA. Satellite imagery: Google Satellite, 2023

Appendix C: Regional Ecological Linkages mapped by Del Marco (2004) in the southern suburbs of Perth, WA. Satellite imagery: Google Satellite, 2023.