CONNECTED TREED GREENSPACE: A SALVE FOR CLIMATE CHANGE

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Abstract

The rapid expansion of Australian cities presents planning challenges as there are demands to subdivide undeveloped land for housing countered by demands for connected public open space (POS). The lowest socio-economic status (SES) sectors of our society have the poorest access to connected treed greenspace but are the group that needs it most. This paper defines connectivity in relation to its function and estimates the unimpeded connected POS required for recreational purposes on foot, wheelchair, skateboard, scooter, rollerblades or bicycle. It considers the rise in the use of greenspace during covid-19 lockdowns and lessons that might be drawn for valuing treed greenspace as climate changes. Connectivity was measured as the unimpeded distance travelled without retracing the course in the same direction. Distances required ranged from 0.5-20km. Providing connected POS requires careful planning and insight to minimise costs and maximise use and benefits.

Introduction

In 2017 I was invited to a forum that was discussing the planning needs of Greater Melbourne for 2050 and beyond. It was intended that my interest and contribution, if any, would be on urban trees and so it was. However, I was only too aware that urban trees and the urban forest depend on the availability of public open space (POS) and as trees are so large, I was interested in pursuing what I considered to be well-planned and connected treed greenspace which could meet a diversity of environmental and societal needs. It was a large gathering and time for discussion of topics was brief. From my perspective things heated up when a planner commented that the connectivity of POS in the west of the city was "pretty good" and that they had "made good progress." Much to the surprise of the planner, I immediately and strongly disagreed. I considered the connectivity of the greenspaces to be quite poor, to which she replied that there was plenty of connectivity within and over 500m. I laughed and replied that 500m wasn't really connected POS at all..... and we agreed to differ.

I realised that while the term connectivity is commonly used in urban planning research and discussion, there appeared to be a lack of clarity in its meaning. The concept of connectivity when linked to those of accessibility and proximity can lead to confusion as happened in this discussion. My response to the discussion was to do some research and publish a paper (Moore 2020a) that examined some aspects of the meaning and measurement of connectivity in POS which itself is described differently in various parts of the world (Table 1). The research was precipitated by the circumstances of the planning discussion and this conference paper contains extracts from this larger paper, additional data and new discussion.

In many Australian cities, some suburbs have a long history of urban development and the capacity for creating new POS is limited, but cities are growing in population and expanding rapidly and opportunities still exist for creating and connecting POS. In many cities, the most impoverished sectors of society, typically of lower socio-economic status (SES), are the most disadvantaged in their access to and use of POS, which in turn is associated with obesity, poor physical and mental health and social disadvantage (Gies 2006; Maas *et al*. 2006; DHHS 2015; Butler 2016; Braubach *et al*. 2017; Lamb *et al*. 2019). This problem is not unique to Australia, it occurs in many parts of the world despite evidence that greater health benefits accrue to lower SES communities from the provision and use of POS which can be a mechanism for addressing SES related inequality (Gies 2006; Braubach *et al*. 2017). Australian suburbs with lower POS and lower SES have lower household incomes, shorter resident life spans and higher rates of diseases related to high blood pressure, heart health and type-2 diabetes, which link to a lack of physical activity and reduced recreation rates compared to populations in other parts of a city (DHHS 2015; Astell-Burt and Feng 2016).

Not all POS is green space, but treed green POS is often more highly valued by users (Braubach *et al*. 2017; Lamb *et al*. 2019) and in many communities, publicly owned space is more highly valued than privately owned open space (McConnell and Walls 2005). Treed greenspace also has the advantage of increased biodiversity, which in turn increases the benefits to users (Moore 2020b). In planning for expanding Australian cities, there is a commitment to accessibility and connectivity in urban planning processes, but there are disconcerting differences in the use of the terminology and its meaning (Saelens *et al*. 2003; Dill 2004; Brander and Koetse 2011; Wang *et al*. 2013; Mehta 2014). Urban planners have long understood the need to consider open space as a whole that forms a linked system.

Table 1. Definitions of public open space (POS) from different parts of the world

Country/State	Definition of Public Open Space (POS)	Source
United Kingdom	• public gardens • land used for the purposes of public recreation • land of disused burial grounds	Town and Country Planning Act 1990
United States of America	• land in public ownership zoned for open space • land which would conserve and enhance natural or scenic resources • land protecting streams or water supply • land that promotes conservation of soils, wetlands, beaches or tidal marshes • land enhancing the value to the public of abutting or neighbouring parks • forest, wildlife preserves, nature reservations or sanctuaries • land enhancing recreation opportunities • land that preserves historic sites or preserves visual quality along road corridors or scenic vistas • land to retain in its natural state tracts of land not less than one acre situated in an urban area and open to public use by the granting authority	US legal 2019
Victoria, Australia	land in public ownership and/or under public management that provides recreation and leisure benefits	DELWP 2015

The large well-treed public parks at the centre of many major cities of the world provide sufficient POS for diverse passive and active recreation. They showcase POS, giving the impression, especially to tourists, of a green and leafy city, but on a regular basis they are only accessible to those who live close by. They are so large that they do not need to be connected to other POS. However, connected POS over longer linear distance provides increased proximity and greater accessibility to the space and opportunities for a more diverse range of activities. Proximity to open space influences its use and the recreational, health and other benefits that people can derive from using the space (Giles-Corti *et al*. 2005; Cohen *et al*. 2007; Astell-Burt and Feng 2016). Proximity is nearness in space and it can be quantified by a linear measurement of the closeness of a site to POS – it is not to be confused with connectivity.

There is considerable research on aspects of proximity, accessibility and connectivity to POS showing that they are related and interconnected (Moore 2020a). Users of connected space are aware of its connectivity and the perception of a more extensive connected open space contributes to the user's satisfaction with the space, increasing both the frequency and extent of use (Wang *et al*. 2013; Mehta 2014). How we measure influences human perception and understanding of distance (Tischendorf and Fahrig 2000). The unit of measurement for proximity to POS should be the metre, as it indicates that access to POS should be over a relatively short distance. The unit of measurement for connectivity of POS should be the kilometre as it conveys the need for an extended and interconnected space.

This paper focuses upon the physical connectivity of POS, particularly of treed parks, gardens, linear parks along rivers and streams and remnant forests, and its role in recreation. The word connectivity is used to provide a measure of uninterrupted and unimpeded connected POS for travel by foot, skateboard, scooter, roller blades

or bicycle (Figure 1). There are no obstructions to those using the connected pathways and the degree of connectivity can be measured linearly as the maximum distance that can be travelled without retracing the course in the same direction. The paper considers the needs of people using POS for recreation and the demands that such use places upon a more extensive and uninterrupted connected POS than often currently exists. Connectivity is defined by specific functions and the length of connected POS needed to fulfil those functions was measured. This approach may aid planners in anticipating the needs of future generations for connected, functional POS rather than having to adopt expensive retro-fitted connections. Finally, the paper examines the impact of covid-19 lockdowns on a connected POS.

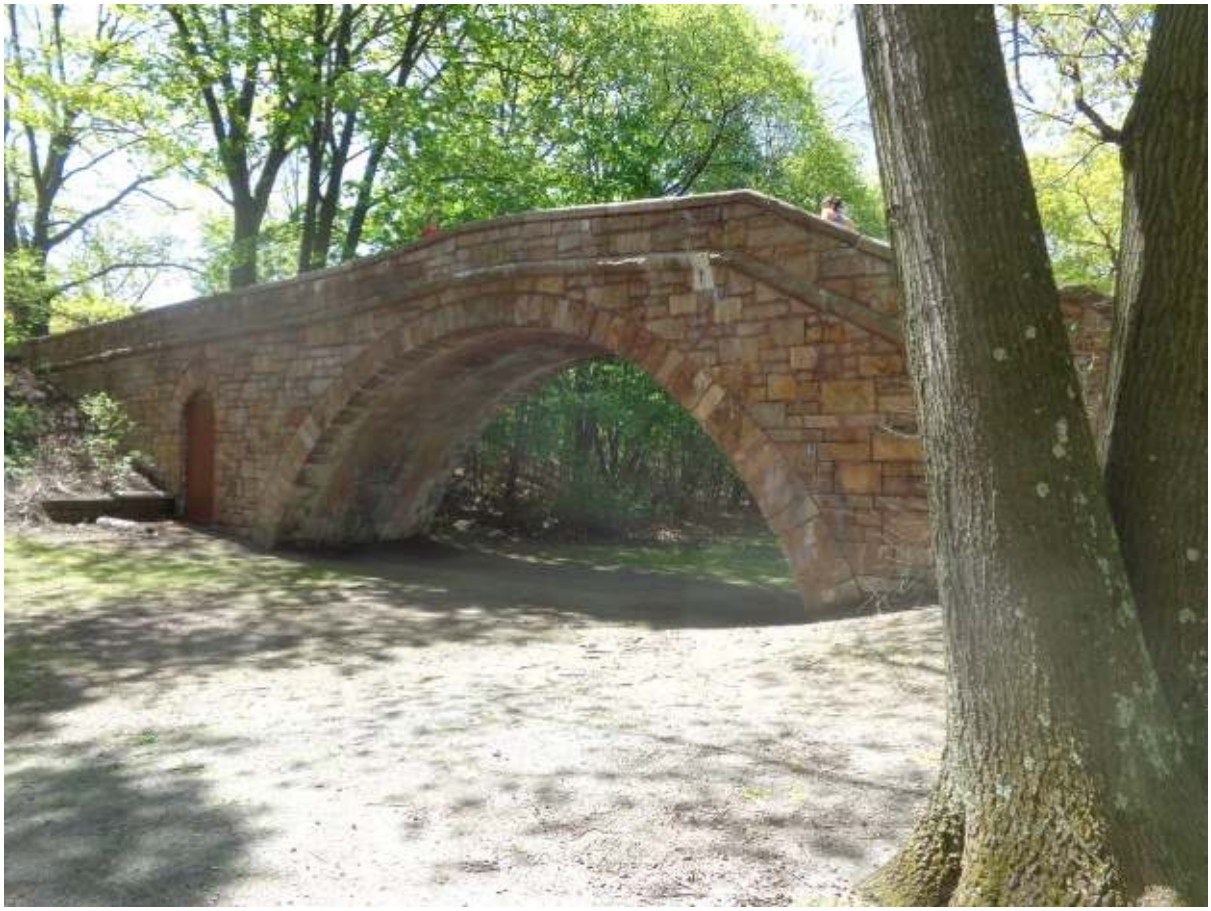

Figure 1. Part of the "Emerald necklace" park system consisting of a 1,100 acre (450 ha) chain of linked parks and waterways in Boston, USA designed by Frederick Law Olmsted, who conceived it as a linear park of walking paths along a gentle stream. There are opportunities for cutting short longer walks if needed. There is excellent connectivity under this bridge. In other places, roads and low bridges obstruct the connectivity of this POS.

Method

The required degree of connectivity should not be determined arbitrarily or result from using available space left after other uses have been fulfilled. The structure of connected POS should relate to its function and will vary with different user needs. In general, the minimum distance of connected POS for a particular function should not be less than half of that required to perform the function for an out and back course:

Walking: 20 people were timed walking distances from 2-5 km in Brimbank Park situated in Keilor, west of Melbourne. All were adults, with an even mix of genders and most came from the western region of Melbourne. While speed varied, the average was just under 5 $kmhr^{-1}$, rounded to 5 $kmhr^{-1}$. Participants were asked how long they intended to walk or what distance they wanted to cover and whether they had a preferred surface for

walking. Most walkers suggested a time but a couple suggested distances. The most common durations nominated were 0.5 or 1.0 hour and distances were from 2-5 km. These data allowed calculation of the minimum connected space required for a walk without retracing the course. The same questions were put to 20 parents walking with infants and toddlers under two years of age. Parents taking babies for a walk or a sleep in prams/strollers were often looking at a period of activity of between 1.0 and 1.5 hours rather than distance. They were generally walking at 4kmhr^{-1} and preferred an option of cutting the circuit short if necessary. Walking with toddlers was a more difficult calculation but walking speed was approximately halved.

Running: 30 participants were asked the same questions as the walkers about time, distance and preferred surface. All were registered with the Victorian State Athletics Association and their abilities ranged from near elite to an average regular running level. The times and distances varied according to their competition interests and training requirements. 30 were sought because of a wider range of speeds. For non-elite runners, the pace may be time and distance dependent with the longer and further the distance, the slower the speed and an average pace of 10 kmhr^{-1} was utilised in this study.

Cycling: The variations in cycling for distance and duration are great and many cyclists prefer roads and trails but recreational level cycling needs were modelled. Distances of 20-40 km were nominated by 30 recreational cyclists at a pace of 20 kmhr^{-1} which would be a safe average speed of travel but some suggested a faster pace and so 30 kmhr^{-1} was also modelled. No competitive cyclists were surveyed.

Skateboarding/Scooters/Roller blades: The ranges of speeds for commuting, recreational and speed focused skateboarders, scooters and roller bladers were wide but typically scooter speeds were up to three times faster than walking. The estimates of speed for everyday, as opposed to elite or competitive users of skateboards, scooters and roller blades, ranged from 15-30 kmhr^{-1}. Twenty participants were sampled from Brimbank Park and from the Yarra River Trail, Burnley.

As part of the data gathered, the numbers of users along a 3 km transect through Brimbank Park were counted prior to, during and after covid-19 lockdowns in Melbourne. Users could enter the linear transect from either end but care was taken to ensure that they were counted once only. The numbers were counted over a one hour period either on Sunday or a weekday (Tuesday or Wednesday).

Results

The average walking pace of 5 kmhr^{-1}meant that if people wished to walk for half an hour, a circuit of 1.25 km would suffice and for an hour a 2.5 km circuit (Table 2). Walkers with prams and toddlers required a minimum circuit of about 4 km, preferably with the option of cutting the circuit short if the need arose. Walkers expressed a strong preference for paved over unpaved surfaces, not distinguishing between paved surfaces (Table 3).

For runners, pace and distance varied (Table 2) but a distance of 5 km or half an hour of running at 10 kmhr^{1} requires an out and back circuit of 2.5 km, while for a marathon of 42.2 km, a 30 km training “long run” requires a 15 km route (Table 2). Unsolicited, several of the runners requested an accurate 400 m circuit for speed work or interval training. The runners had a mixed view of surfaces. Many wanted a paved surface with bitumen preferred over concrete, but for those running in excess of 20 km, and particularly those over the age of 50 years, a level but softer unpaved surface was preferred (Table 3).

The requirements for cycling are shown in Table 2. The surface preferences of cyclists (Table 3) were for a smooth all season path but some preferred an unpaved surface. For skateboarding, scooter use and roller blading, the wide range of speeds made it impossible to consider all the permutations. High speed and lower speed scenarios over two different distances using a paved surface were modelled (Tables 1 and 2).

Multiple figure-eight or looped configurations increased the number of different possibilities enormously. The general formula for the number of variations that can be obtained from interconnected circuits is 2^n, where n is the number of loops. For a single circuit there are two variations based on travelling in different (opposite) directions, for three loops there are eight and for four loops there are 16 variations possible.

Table 2. Length of connected open space required for a range of activities

ACTIVITY	Distance (km)	Time (hr)	Pace ($kmhr^{-1}$)	Required connected length (km)
Walking	2.5	0.5	5	1.25
	5.0	1.0	5	2.5
Walking with toddlers	1.0	0.5	2	0.5
	2.0	1.0	2	1.0
Walking Pram/Stroller	2.0	1.0	4	1.0
	6.0	1.5	4	3.0
Running Recreational	5.0	0.5	10	2.5
	10	1.0	10	5.0
Half Marathon	20	2.0	10	10.0
Marathon	30	3.0	10	15.0
	40	4.0	10	20.0
Cycling	20	1.0	20	10.0
	30	1.0	30	15.0
	40	2.0	20	20.0
Skateboarding/roller blading/scooter	15	1.0	15	7.5
	30	2.0	15	15.0
	15	0.5	30	7.5

Table 3. Surface preferences (%) of users of connected open space required for a range of activities, (N is the number of participants).

ACTIVITY	N	Surface preferences (% of users)				
		Smooth	Paved			Unpaved
			Bitumen	Concrete	None	
Walking	20	75	15	15	45	25
Walking with toddlers	20	100	15	25	60	0
Walking Pram/Stroller	20	100	40	40	20	0
Running Recreational	30	80	13.3	6.7	60	20
Half Marathon	30	75	20	13.3	33.3	33.3
Marathon	30	60	40	6.7	13.3	40
Cycling	30	90	30	26.6	33.3	10
Skateboarding/roller blading/ scooter	20	100	35	35	30	0

Use of POS changed significantly during covid-19 lockdowns in many Australian cities and Melbourne had more and longer lockdowns than other cities. Use of POS noticeably increased on all days during lockdowns, but the greatest increase was on Saturdays and Sundays (Table 4). The use on one Sunday was 21 times higher than pre-covid-19 lockdown use, while use on weekdays increased by up to 8 times. Post lockdown use declined but remained higher than before lockdowns, being over double pre-covid-19 use.

Table 4. Numbers of users along a 3 km transect through Brimbank Park over one hour prior to, during and after covid-19 lockdowns in Melbourne.

	Prior to lockdown		**During lockdown**		**After to lockdown**	
	Range	Average	Range	Average	Range	Average
Sunday	2-5	3	32-69	41	6-12	8
Weekday	0-4	2	8-16	11	2-6	5
	Sunday	**Weekday**	**Sunday**	**Weekday**	**Sunday**	**Weekday**
Walkers	2-5	0-2	12-32	4-10	3-7	2-5
Runners	1-4	0-3	6-9	3-6	1-6	3-6
Cyclists	2-5	0-2	8-15	5-9	3-7	3-8

Discussion

While the distances of connected treed POS to effectively undertake the activities explored in this paper (Table 2) seem unattainably long, they are required for populations living in cites now and will be needed more in the future (Moore 2020a). Covid-19 lockdowns saw use of POS rise dramatically as people needed time away from their homes and opportunities for recreation in space that catered for their physical, mental and social wellbeing. Use remained high after lockdowns ceased and we have been given an insight into how important treed POS will be as climate changes - a glimpse into the future. Recreational and health needs are going to increase in the years ahead and the impetus for increased connected open space is likely to be economic – the increased health costs of populations where obesity is already a major problem, compounded by the effects of an ageing population (Astell-Burt and Feng 2016). The question that immediately arises is, "How can lengthy and functional POS connectivity be achieved?"

The 5 $kmhr^{-1}$ average pace for walking was consistent with other research and people walk slower with a pram/stroller or carrying a young child. For the other activities, there is a wide range of paces and distances with skateboarders reaching speeds up to 100 $kmhr^{-1}$ and typically scooter speeds are three times faster than walking. For these and other activities, such as running and cycling, it is likely that the faster you go, the shorter the circuit required. Long distance runners and cyclists require longer circuits (Table 2), but fortunately their needs are similar - a circuit of between 10-20km. There is a temptation to think that if you meet the longest need for connectivity then you automatically meet all needs, but this is not necessarily the case as long, linear loops such as those along rivers, freeways and railways need to have crossing points at distances that are appropriate for the shorter requirements.

One of the more obvious ways of providing long and unimpeded connectivity would be to ensure that there is access for passive recreation as part of all bridges that span rivers, roads or railways. This can be relatively easily and cost-effectively done at the time of construction or renovation but it is difficult and often prohibitively costly to do retrospectively. It is far more cost effective to implement connected POS in anticipation of need rather than being forced to retro-fit under the pressure of subsequent demand (Figure 2).

Opportunities to find adequate space to expand and improve the connectivity of POS are usually limited, particularly in highly developed older suburbs where land value is at a premium in most Australian cities. We must be prepared for changes in modes of transport (Croeser 2021). Autonomous vehicles (AV) and particularly electric AVs will bring dramatic change to the way people travel around cities. It is highly likely that such vehicles would not necessarily be owned by individuals, but rather offered as a pick-up and drop-off service. If this is the way things develop, there would be a need for multiple pick-up and drop-off points, but there would be a reduction in the need for individual vehicle parking spaces.

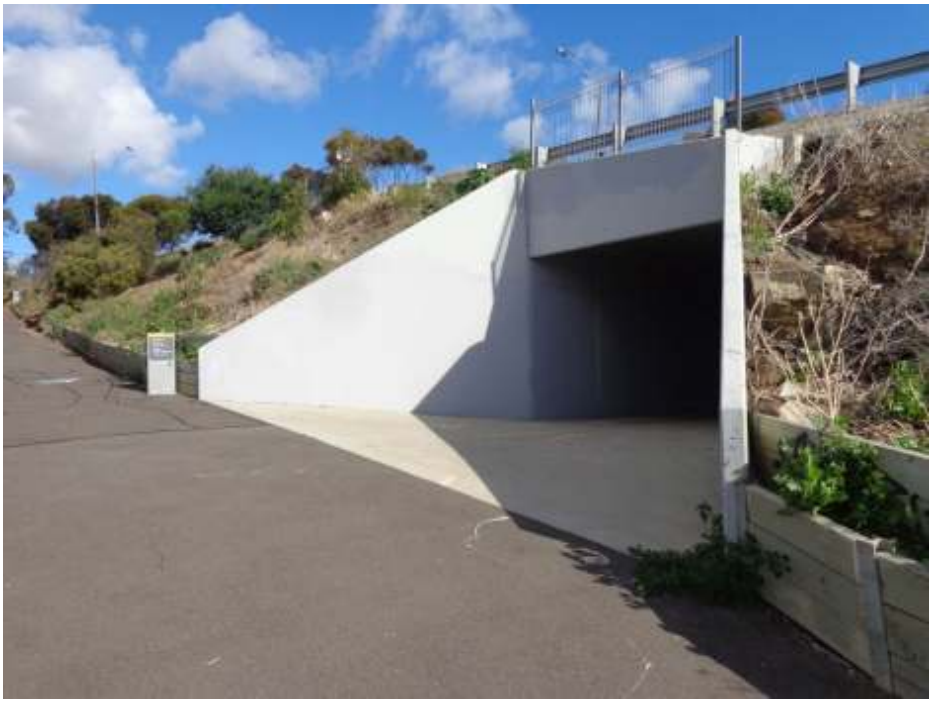

Figure 2. An expensive retrofitted tunnel providing access under a busy suburban road for non-vehicular users. The tunnel addressed major user safety concerns, but at very high cost.

Under this scenario, there would be a very significant drop in the demand for both carpark and roadside parking spaces. In most cities the impacts of this will be two-fold. Many local government agencies will suffer a major revenue decline, but very significant areas of publicly owned and controlled parking space would be freed for other uses. Many of these parking spaces were formerly green and treed POS that were cleared and allocated to parking to meet public demand. The land is still POS even if its original green component has long gone. Not only will there be considerable space made available for conversion to greenspace and perhaps much-needed sporting facilities, but much of it is located in parts of cities where it could be considered for extending the connectivity of treed green POS. This presents a once in a century opportunity for extending treed POS in many established parts of Australian cities. This chance to plan for properly connected POS that meets societal needs now but more importantly well into the future cannot be squandered. It represents an opportunity to improve tree numbers and canopy cover on POS at a time when both are declining on private land in many Australian cities. With climates changing, it is an opportunity that could make a massive difference to the liveability and sustainability of our cities.

This land has considerable value and already there are parties looking to use these spaces for domestic housing and commercial activities. Many of the parking spaces are in prime real estate locations and those already lobbying for access are very well connected and resourced. One of the potential uses for car parking spaces is to use them for micro-homes and offices that will be built in modules to suit the space available and to utilise services already on site or below the road pavement. The micro-homes could be prefabricated like shipping containers and may be two or more levels high. Such plans are well advanced, so if connected treed POS and greenspace is desired then it must be considered now as delay may lose the opportunity.

One common and sometimes recurring obstruction to connectivity for some users is steps. These are not a barrier to most walkers, but can be to cyclists, runners and skateboarders, roller-bladers and scooters. Over recent years, ramps have been incorporated into designs for disabled access and these could afford opportunities for runners, cyclists and skateboarders, but frequently the design accommodates a single purpose or user group only when with a little more thought, all users could be satisfied.

Other limitations to the use of well-connected open spaces can be the absence of basic facilities such as toilets, access to drinking water, proper signage and distance markers, which can present as effective barriers to the use of the whole connected POS. The presence of shade over summer months can expand both the extent and frequency of use of a space (Butler 2016). This places a premium on treed connected POS in summer when routes shaded by trees are more frequently used. Sometimes the separation of activities utilising connected open space needs to be considered. Unnecessary separation can be costly and shared use and higher usage rates can give a greater sense of safety due to the "safety in numbers" phenomenon (Figure 3). For safety, separating traffic in key places, such as sharp bends, atop rises, through tunnels and across bridges may be all that is required (Moore 2020a).

The materials from which the paths of POS are made vary depending on climate, soil type, usage and risks such as fire or flooding and may either facilitate or act as a barrier to use. Surfaces need to be durable and non-slip, but the same surface does not necessarily meet all user needs. A softer material (gravel or granitic sand sometimes mixed with site soil) may be preferred by runners as it has a lower impact than concrete or bitumen and is less likely to cause leg injuries. Distance runners will travel considerable distances to take their "long run" on a softer track and especially if the route is treed and shaded in warmer months. In parks, there are often desire-line tracks parallel to paved surfaces made by runners with a view to avoiding the harder surfaces. They are testament to the need for walkers and runners to have a softer surface, and to the fact that this need is unmet.

Figure 3. An opportunity taken for separating cycle and pedestrian traffic along the trail adjacent to the Yarra River in Melbourne.

In places like waterways or along railway lines, it may be possible to meet both requirements by paving one side of the river or tracks and leaving the other unpaved. Connected circuits have the advantage that you can take them in different directions. It is amazing how different the user experience can be when the same path is taken from the opposite direction. New things are seen, view points are different and there is even a different sense of distance travelled. In relation to connected POS along railway lines, the planting of trees to improve amenity, provide shade and sequester carbon is often thwarted by engineering demands for clearances and safety, but in other parts of the world these transport networks are green corridors with trees growing much closer to infrastructure than occurs in many parts of Australia (Figure 4). Perhaps Australians are more risk averse or environmental and health concerns matter less, or are we clinging to a paradigm of an earlier era that focused on a very narrow definition of health, safety and risk that needs to be reconsidered in light of climate change?

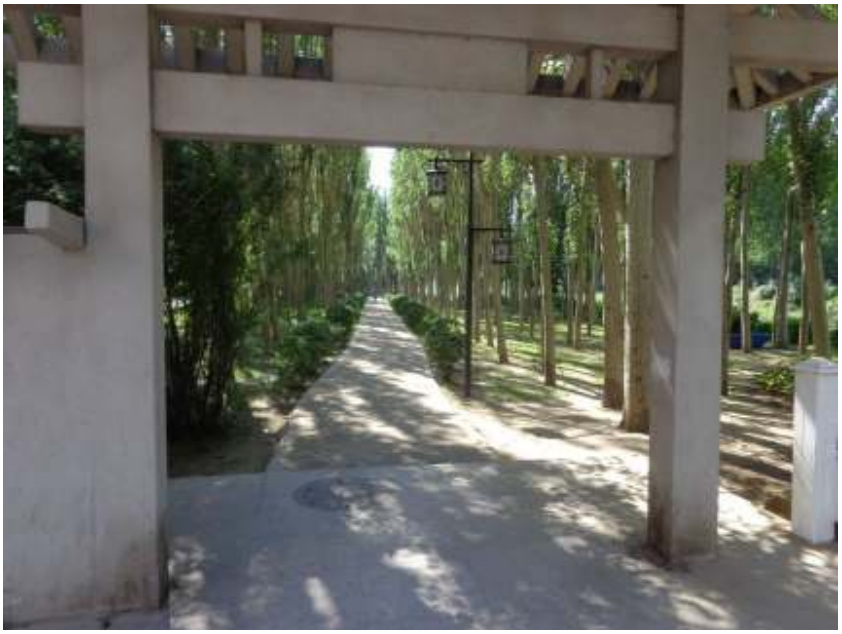

Figure 4. The value of shade is seen in increased use and user satisfaction in summer months in warmer parts of China.

Provision of benches for resting at appropriate distances, especially for younger and older users, and in numbers suitable for the volume of user traffic will facilitate use (Astell-Burt and Feng 2016). Shading seating with appropriate tree plantings will increase summer comfort levels and increase use and user satisfaction. Lighting can both extend the time of usage and greatly improve the sense of user safety early in the morning or later into the night. Extreme weather events, either seasonal or occasional, need to be considered as flash flooding can impose a barrier to connected POS and pose danger, especially to children. Drainage that prevents flooding and improves user safety is often a necessity. The possibility of fires occurring in connected POS must be considered for user safety and as a potential risk of fire spreading from the POS and posing a hazard to life and property.

Conclusion

In many other disciplines, connectivity is a term that is clearly defined and used with a metric. For recreational POS, connectivity should refer to linear distance that is unimpeded or unobstructed, measured as linear kilometres, and long circuits of up to 20 km are required to meet user needs. In urban planning, a key objective of POS should be improved and extensive connectivity for specific purposes for future generations of city dwellers. Planning must aim to achieve the maximum possible connectivity for new urban works and when renovating old infrastructure where connectivity was not previously considered.

For future generations, the health needs of urban populations are going to be major drivers of urban design and planning. The capacity for increased and meaningful active and passive recreation over long distances will be the hallmarks of sustainable and liveable cities. Appropriately long circuits of connected POS are going to be essential urban infrastructure under conditions of increased urban population density and climate change, not as a luxury for a privileged minority but as a vital component of a sustainable economy for the majority and a right of all citizens. Connectivity of POS is not an option, it is essential, as societies cannot afford it to be otherwise!

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