Simplified Estimation of Demand for Nonmotorized Trails Using Geographic Information Systems

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Estimating off-road trail usage by nonmotorized modes is of increasing interest to the transportation community due to the rising importance of both recreational and nonmotorized travel. Demand patterns for two substantial off-road trails in Melbourne, Australia, were examined using survey and modeling methods to establish the potential for higher levels of demand. The two trails were different in two major respects: one was well promoted, well connected, and a destination in its own right; the other had similar potential, but the linkages and promotional activity to market its assets had not yet been undertaken. The characteristics of these two markets were examined using geographic information systems (GIS) methods and demand estimated on a differential basis using GIS tools. The simple method adopted highlighted the critical nature of marketing a connected series of off-road trails as a single unified route and an easily recognized destination area. The study had to be done using existing data, and it provides a means of combining transportation, GIS, and special-purpose off-road trail usage information to estimate potential demand.

The specific aim of this paper is to provide a simple and effective means of estimating the usage of recreational trails by cyclists, toward the estimation of demand response to linking trails to extend the off-road network to a series of recognizable *trail destinations*. As is usual in such cases, there is little information available and no resources to gather new data. The data requirements considered relevant by park operators in Melbourne do not include any aimed specifically at causal demand estimation.

There have been a number of studies of on-road cycling, suggesting that the completion of a full network of connected bicycle facilities is the most effective means of raising cycling demand, but the evidence for expanding linked sets of trails off road is far more limited. One of the few examples is in Eugene, Oregon, where two off-road trails were linked by a bridge (*1*). The associated surveys showed that this led to a rise in overall usage of bicycles on the two routes, and an increase in nonrecreational cycling (to work or school) over the expanded network. These trends are entirely consistent with the surveys and model estimates presented here.

The demand for off-road trails in Australia is considerably less well researched than on-road bicycle demand and provision. Estimating off-road trail usage by nonmotorized modes is of increasing interest to the transportation community due to the rising importance of both recreational and nonmotorized travel. Demand patterns for two substantial off-road trails were examined using survey and modeling methods to establish the potential for higher levels of demand. The two trails were different in two major respects: one was well promoted, well connected, and a destination in its own right; the other had similar potential, but the linkages and promotional activity to market its assets had not yet been undertaken. The examples used are two major trails in metropolitan Melbourne. The Lower Yarra Trail extending over 30 km alongside the Yarra River and the inner-city Maribyrnong Trail, which is not yet fully complete or strongly promoted as a destination. The characteristics of these two markets were examined using geographic information system (GIS) methods and demand estimated on a differential basis using GIS tools. The simple method adopted highlighted the critical nature of marketing a unified trail and an easily recognized destination area.

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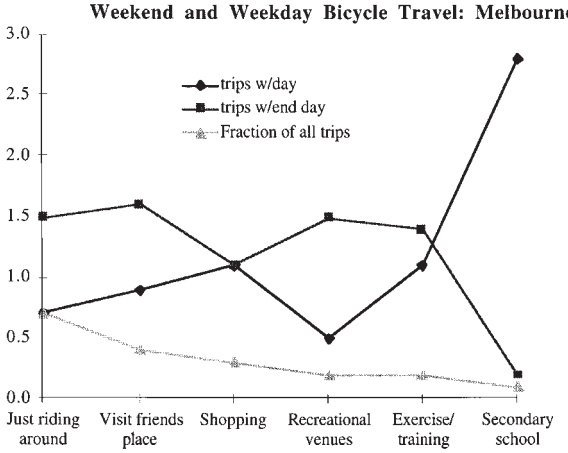
RECREATIONAL TRAIL USAGE DATA

Few sources of detailed off-road trail usage are available, but a number are specified and described in a metadatabase for Australian bicycle-related data, which summarizes both the coverage, quality, availability, and nature of many of the data sources available (*2*). Several data sources contribute to recreational and weekend/weekday usage, which illustrate the importance of recreational and weekend bicycle travel.

The relative importance of bicycle riding to recreational venues (including parks) for one of these sources (*3*) is shown in Figures 1 and 2. Twenty percent of all cycling trips reported by people 12 or older were to these destinations, and weekend trips were nearly three times as frequent as weekday trips, suggesting that this difference would probably be important in parks on their own. A greater distance is traveled to both recreational and exercise venues on weekends—and a slightly greater amount of time is spent traveling to these venues.

However, this still does not tell us the characteristics of travel on trails within these parks, many of which are linear parks extending over a considerable distance. Internal surveys of park users are carried out from time to time across Melbourne (*4*) and shed light on the characteristics of nonmotorized travel within parks, the majority of which may be considered to be on hard- or gravel-surface trails. These surveys can show the characteristics of groups and age distributions (see Figure 3) but still do not directly answer the question of estimating demand for cyclist usage of off-road trails.

Detailed locations of movements from one specific site to another are a primary task of transportation surveys, which are designed to provide matrices of movements by all modes between all locations. Inevitably, the numbers involved in specific pairs of locations will be fairly small, but the additional information gathered about the person, the trip, and the household from which that person comes provides details about the households owning bicycles and the places and purposes for which bicycles are used. However, travel to parks and trails was not covered specifically until recently.



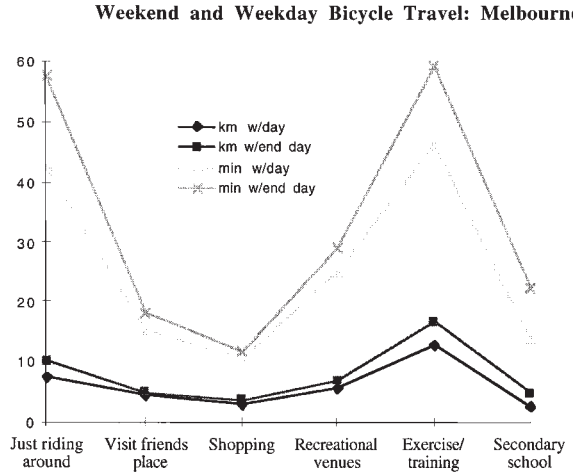
• Vertical axis represents bicycle trips per weekday, and per weekend day, and the fraction that bicycle trips are of all trips (walking, car, etc.) is considered - per person reporting at least one bicycle trip per day.

FIGURE 1 1986 Spectrum State Bicycle Committee survey results for riders in Melbourne aged 12 and over.

The VITAL project is a major continuing household interview survey carried out in Melbourne by the Transport Research Centre since 1994 as a commercial venture. VITAL is the Victorian Transport and Activity survey system, and the only current comprehensive personal travel survey available in Victoria since the early 1980s. It has produced detailed transportation survey results that pinpoint the origins and destinations of bicycle travel to a wide range of destinations, including parks, and is a continuous survey carried out on a commercial basis to provide general transport planning data for Melbourne (*5*). It includes the purpose of each trip and the characteristics of the person, household, and destination involved.

The strength of such surveys is the spatial coverage of the data: the weakness of trails analysis is that there are only a limited number of trips by bicycle to get to the parks—and there is no information clearly distinguishing trips made on the off-road trails within them. Although there are several hundred bicycle access trips to parks, they are not enough to examine access to each park trail segment in detail, and there is no information on the numbers of people who not only travel to parks but also use the trails once they have reached them. Nevertheless, the wide range of information in VITAL means that a great deal of assistance can be given to enhance the generalization of any very detailed surveys that may have been done on trails and within parks.

Table 1 is typical of the available data from different transportation survey sources. It provides modes of transport used to arrive at parks and gardens [which include those responsible—both local government and Melbourne Parks and Waterways (MPW)]. The substantial differences between the figures for 15+ and for all ages, and the large asymmetry between weekdays and weekends, show how broad transport survey information can complement



• Vertical axis represents km per weekday, km per weekend day and minutes spent travelling by bicycle on weekdays and weekend days: all per person reporting at least one bicycle trip per day.

FIGURE 2 1986 Spectrum State Bicycle Committee survey results for riders aged 12 and over.

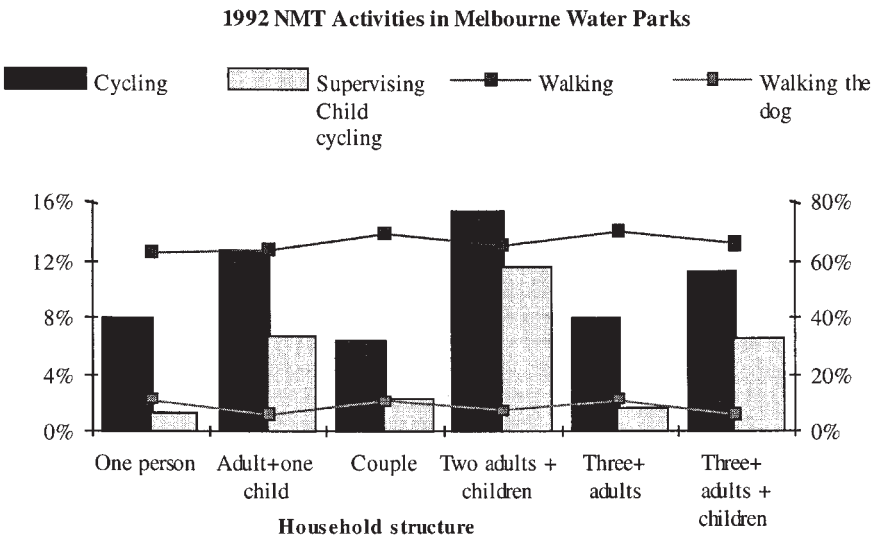


FIGURE 3 Melbourne Parks and Waterways parks and open spaces survey: cycling and walking patterns.

special-purpose surveys and location-specific surveys. It must be noted that this category includes ovals, local government, state government department, and MPW parks as a single group, but these broad implications are the best available to assess the implications of park operator (here MPW) data, and the consequent biases built into any model that may be built based on it.

Park authorities collect data for their own purposes, but their detailed studies of trail usage within parks usually omit the attitudinal and other data required to estimate demand. Few of the surveys commissioned by parks have yet to cover the attitudinal and sociodemographic factors required, and none to date have included stated preference experiments or destination choice information on which choice models could be based. The requirements of park management have recently become more specific, as the levels of demand on the best known Melbourne trail (the Lower Yarra Trail) have begun to lead to capacity problems due to the growing success of these facilities, and issues of user satisfaction and conflict are, therefore, becoming important. The issues of linking unconnected trails and park segments with new trails and promoting them as new destinations and opportunities are emerging. These cannot be directly addressed using the available data. However, recent surveys have been done on trail users and are very helpful when assessing the current levels of off-road trail demand.

In August 1994, a broad survey was made of all primary parks for MPW; it was repeated in January 1995 for a total of 4,535 interviews of people 15 years of age or older (*6*). People arriving by car stayed an average of 2 hours and 31 minutes, whereas those arriving by bicycle or foot stayed only 1 hour and 22 minutes. However, those arriving by car visited an average of 21 times a year, whereas those arriving on foot or bicycle visited 84 times a year. For all parks combined, only 4 percent reported arriving by bicycle, 6 percent by foot, and 1 percent by public transport—whereas 88 percent arrived by

TABLE 1 VITAL Destination Data Scaled to Represent Melbourne for Weekend and Weekday Days

Destination			Visits/ average day	Weekend	Weekday	DoB[a] 1977-	
Parks and gardens			90,842	143,263	66,615	56,656	
Recreation (not sport)			20,363	44,284	13,174		
Parks and gardens	Raw Counts[b]	%	Average Visits/day	Visits/ W/end	Visits/ W/day	DoB[a] 1977-	Visits/ W/end	Visits/ W/day
Bicycle	*32*	*9*	6,100	13,600	2,600	2,100	4,900	700
Walk	*162*	*43*	8,500	55,300	32,200	26,000		
Drive	*74*	*20*	17,300	27,300	12,400	17,300		
Passenger	*104*	*28*	25,100	42,800	15,600	9,400		
Bus	*4*	*1*	1,800	0	1,800	1,000		

[a] Date of Birth: this corresponds to an age of 15+ in this dataset.
[b] Raw Counts: refers to the number of survey responses; the rest of the table refers to the scaled up results.

car. These figures represent the entire range of parks, but those in the more urbanized areas showed far higher arrival rates by foot and bicycle and correspondingly lower arrival rates by car.

One possible explanation is the widely varying population densities in the areas surrounding many of the parks, as well as the differing levels of attractiveness. This provides a basis for modeling and estimating trail demand in a simple and straighforward manner using population, location, and distance factors related to different trails. This can be done conveniently using GIS methods.

A survey of users of two trails (Lower Yarra and Lower Maribyrnong) was carried out early in 1994 by TQA Pty Ltd. (*7*) and is currently still the best available basis for analyzing trail demand in Melbourne. It should be noted that this survey covered only users of trails within the parks who were aged *15 years and older:* there were no observations of younger trail users, and these data give a usage picture biased toward those aged 15 years or older and do not cover the full range of cyclist trail usage. By defining the usage in this way, the role of commuter cycling and regular users may well have been substantially overestimated.

The ratio of weekend to weekday usage by cyclists will, therefore, also probably have substantial biases, as the bicycle trip rates are highest in the younger teenage groups. The data collection in the TQA survey does not pay attention to this function and ignores the supervised child cyclist who is a valid trail user.

The VITAL data confirmed that the restriction to older users significantly altered the patronage levels and weekday/weekend ratios for the overall category " recreation/park/gardens."

Trip length distributions via distances from the trails and the postcode of the trip origin were derived for the raw data. The major characteristics of the TQA data set (restricted to people aged 15 years and older) include

- Frequency of visits to use the trail,
- Mode of travel to the trail,
- Time on the trail, and
- Distance covered.

Group sizes are included for

- Recreational cycling,
- Solo recreational walking,
- Recreation with friends/family,
- Dog walking,
- Jogging,
- Walking,
- Commuter cycling,
- Noncycle commuting, and
- People involved with specific sporting events.

Figure 4 summarizes the distribution of the age groups (15–70+) interviewed (*7*). The demographic characteristics of the surveyed users of the two trails differ, with more older people using the Maribyrnong trail. As the Lower Yarra trail draws from a far wider region, this difference reflects both the characteristics of the area immediately surrounding the two trails and also the characteristics of the population drawn to the Lower Yarra trail from further afield. In both cases, people under 15 years of age were excluded from the surveys.

Figures 5 and 6 show the locations of the two trails, and the distribution of arrivals by bicycle. The major differences between the two trails are apparent from the arrivals by modes other than walking and cycling, as these indicate the extent to which the trails are perceived as marketable destinations to a wider trail market.

It is easier to appreciate the differences between the range of origins from which people come to these two trails by examining how many come from various distances and by converting these into a trip length distribution (Figure 7), for which the shapes can be compared directly.

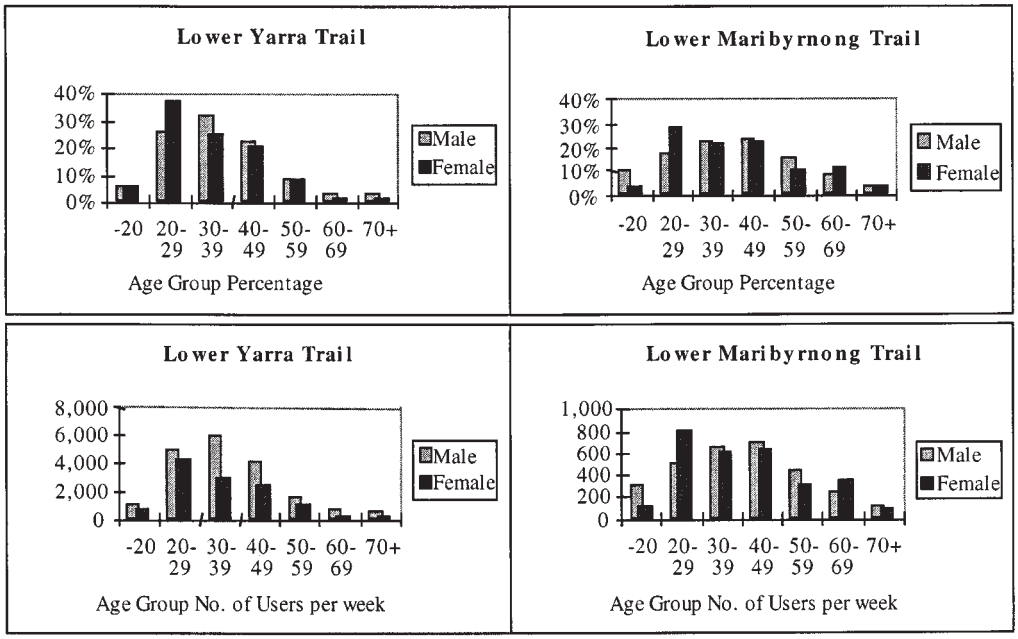


FIGURE 4 Demographics of those aged 15+ surveyed on the Lower Yarra and Maribyrnong Trails in metropolitan Melbourne.

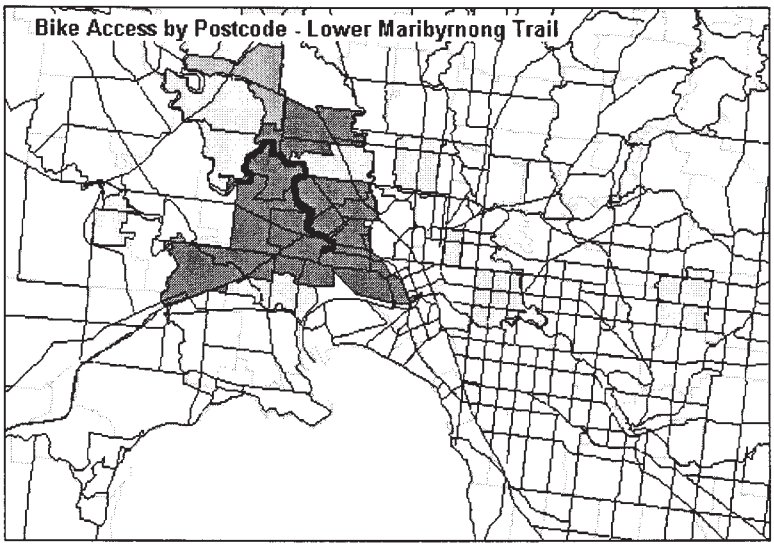


FIGURE 5 Origins of people arriving at the Lower Maribyrnong Trail by bicycle.

The marked increase in people coming some distance from the trail, in the case of the Lower Yarra Trail, is visible, and the cumulative trip length distribution (Figure 8) is even more effective in showing how the two trails differ. The Lower Yarra Trail attracts more people from a far wider range of distances than the Lower Maribyrnong does.

BUILDING THE MODEL

To build a model based on this information requires several different types of data:

- Trip length distributions,
- Numbers of patrons from different postcode areas,
- Populations in postcode regions at various distances from the trail, and
- Distances from the trail to the different postcode area centroids.

The first stage is to plot the number of people arriving from different distances from each of the two trails. These are far from smooth curves and are averaged over a three-point moving average. To check how accurately the smoothed curves reproduce the same information, the Lower Maribyrnong bicycle user numbers were reestimated using these smoothed curves and yielded within 3 percent of the original numbers. Little information is lost in obtaining a smoothed trip length distribution that can be applied more generally without propagating the minor variations peculiar to the data collected in every subsequent application.

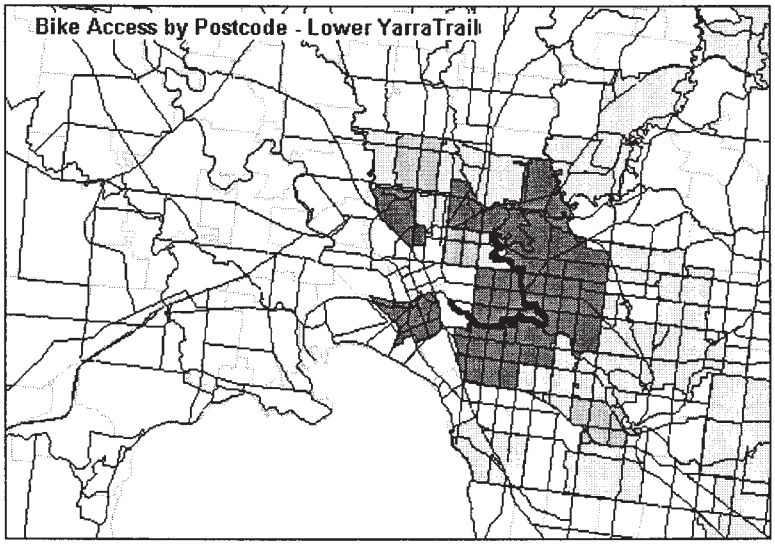


FIGURE 6 Origins of people arriving at the Lower Yarra Trail by bicycle.

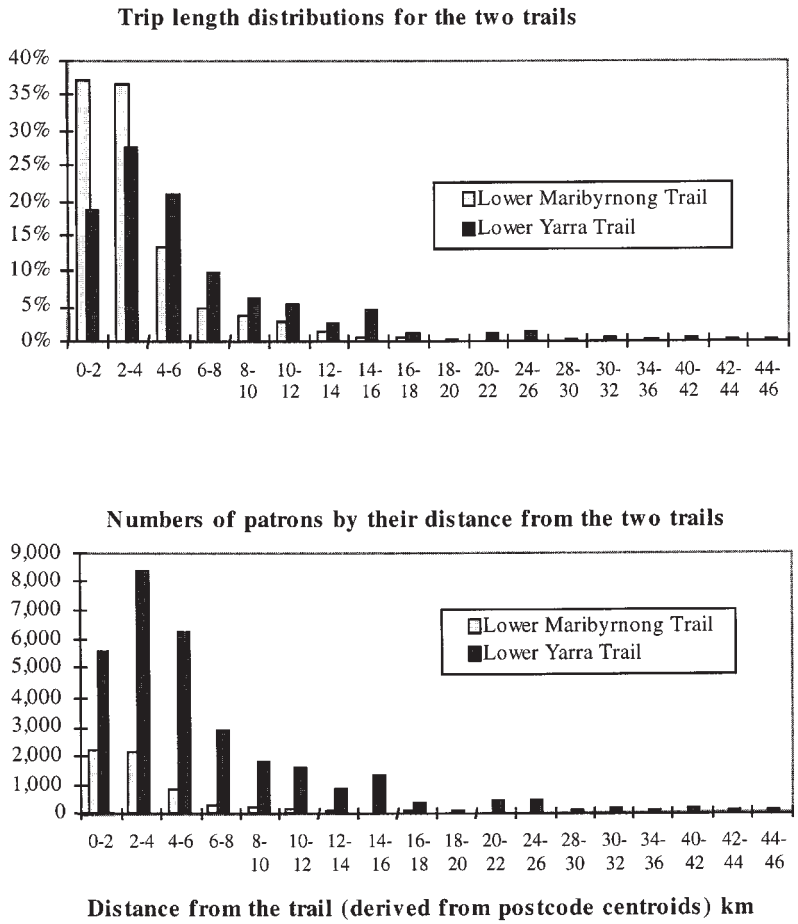


FIGURE 7 Patronage by distance from home and trip length distributions for the two trails.

The distribution of the population by distance from each of the trails was derived from the postcode centroids of each of the areas using the CData91 CD-ROM produced by the Australian Bureau of Statistics. Figure 9 shows the distribution for the Maribyrnong Trail. Combining the trip length information with the probability of a person in a particular postcode traveling to a trail by a specific mode then yields the probability of travel to the trail by a specific mode as a function of distance (also shown in Figure 5).

The model is then simply to apply the probabilities derived from the Lower Yarra Trail to the corresponding populations surrounding the Lower Maribyrnong Trail. The results are shown in Figure 10 and Table 2.

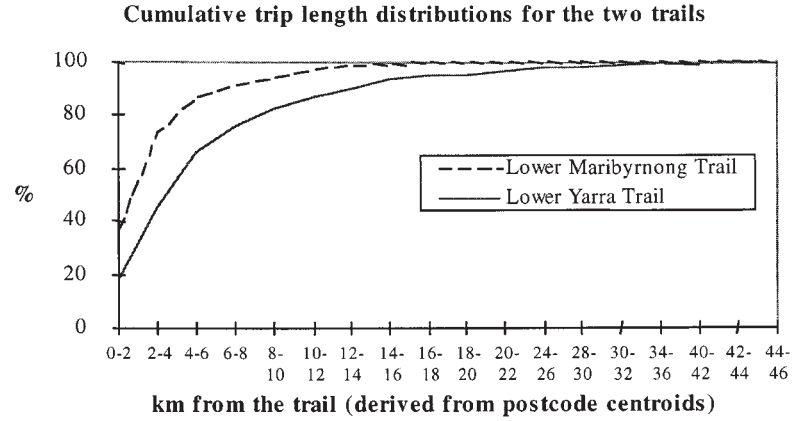


FIGURE 8 Cumulative trip length distributions for the two trails.

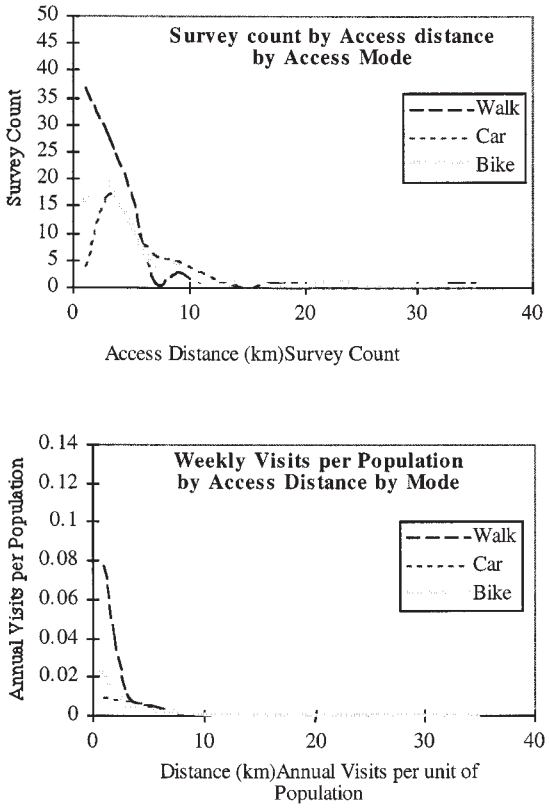


FIGURE 9 Lower Maribyrnong Trail access by distance by mode by population.

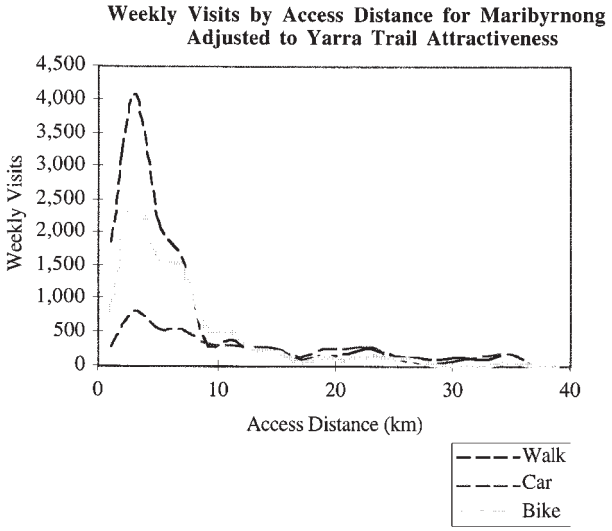


FIGURE 10 Predicted visits by mode for the Lower Maribyrnong trail, based on the attractiveness rates derived for the Lower Yarra Trail.

The estimation of the numbers of arrivals at a trail is simply the first stage in estimating trail usage demand. If people arrive on foot, they are extremely likely to walk or run on the trail (as that is where the surveys on which this model is based were taken). It is also very likely that the vast majority of bicycle riders arriving at the park on a bicycle will cycle on the trail, but there is also a fair chance that some will choose to run or walk. If they arrive by car, they might ride, walk, run, or use roller blades (sometimes referred to as *in-line skates*). Public transport users are likely to walk or run but may, in some cases, have brought a bicycle to ride or have chosen to rent a bicycle at the trail.

Having attracted people to the park, what is the chance that they will use the trail at all? This question cannot be answered using the model presented here, as it is based solely on the people who *did* use the trail.

However, for those who do use the trail, it is possible from the present work to determine the probabilities that they will ride, walk, run, or roller-blade on the trail. Using a broader model for estimating overall attractiveness of parks, the trail use data can then be placed in the larger context of determining how likely people are to use a particular park, and the conditional probability that they will then use a trail once they reach a park. This could be done based on the overall park attractiveness models using the gravity models or other methods.

Table 3 shows the numbers of weekly visits made to the Lower Yarra and Lower Maribyrnong Trails by the various arrival modes and the numbers who then chose to walk, run, ride, or roller-blade along the trail. There were no recorded examples of current trail users arriving at the Lower Maribyrnong by public transport.

The probabilities of people arriving by one mode (the first line, for example, is arrival by walking to the trail) and going on to use the

TABLE 2 Actual 1995 and Estimated Potential Visits by the Modes Common to the Two Trails

Access Mode	Walk	Car	Bike	Transit	Total
Actual:					
Lower Yarra Trail	16,327	6,739	11,384	(ignored)	34,450
Actual:					
Lower Maribyrnong Trail	2,875	1,656	1,298	0	5,829
Potential:					
Lower Maribyrnong Trail based on the Lower Yarra Trail levels of attractiveness and access	12,500	5,179	8,621	(assumed to be zero)	26,300

TABLE 3 Weekly 1995 Off-Road Trail Usage by Mode Used To Access the Trail

Access Mode	Walk	Jog, Run	Cycle	Roller blade	Grand Total
Lower Yarra					
Walk	6,907	1,788			8,695
Jog, Run		4,469			4,469
Car, etc	3,119	536	1,986	74	5,715
Train, etc	557	179	441		1,177
Bicycle	56		10,075		10,131
Roller Blade				74	74
Grand Total	10,639	6,972	12,502	148	30,261
Access Mode	Walk	Jog, Run	Cycle	Roller blade	Grand Total
Maribyrnong					
Walk	2,235	185			2,420
Jog, Run	62	518			580
Car, etc	1,055	370	146		1,571
Bicycle	0	37	1,207		1,244
Roller Blade				21	21
Grand Total	3,352	1,110	1,353	21	5,836

trail in various ways can then be deduced. For example, 20 percent of all walkers arriving at the Lower Yarra Trail then go for a run along the trail. Similarly, 35 percent of the car arrivals at the trail chose to ride bicycles. These two tables can be used to convert the arrivals at the trails by mode into users of the trail by mode of trail usage.

The overall results of applying these conversions from arrivals to trail users are shown in Table 4. The results for the Lower Maribyrnong are given in two forms: including and excluding public transport as a trail arrival mode.

There would appear to be at least a 500 percent increase potential from the current low levels of usage from developing, linking, and promoting the Lower Maribyrnong Trail.

Although it might be argued that a newly integrated and well-marketed Lower Maribyrnong Trail might well attract public transport arrivals, the current trail does not. The determinants of public transport access to a trail deserve further investigation, as the demographics are likely to differ substantially from the overall population and the role of the (currently excluded) people 15 years old or younger may be proportionately more important.

Nevertheless, under this series of conservative assumptions, the potential for the Lower Maribyrnong is very substantial and could be well over 500 percent, given appropriate upgrading and promotion as a destination.

The application of this model to other trails in Melbourne can provide a valuable estimate of the potential patronage for these trails, not only for bicycle trail riders but also for joggers and walkers. It can also be used to estimate the car-parking requirements for trail users in such areas.

DISCUSSION

The model developed in this report is based on the differences in usage and overall levels of service. Although this approach gives a reasonable estimate of the potential patronage of the Lower Maribyrnong Trail and provides values that reflect the same degree of perception and attractiveness as the Lower Yarra currently enjoys, it is necessary to consider whether the potential of the Lower Yarra has yet reached its peak.

There are complaints about bicycle users by pedestrians and about pedestrians and dogs by bicycle users: these provide a measure of the levels of interference between the two types of trail user. However, if the capacity of the Lower Yarra Trail were to be enhanced by adopting centerline delineation (as has been successfully done in Westerfolds Park), then these conflicts would take place at higher levels of patronage than at present. Currently, the maximum bicycle flows observed on sections of both trails are very similar (at over 240 bicycles/hr). The difference between the trails lies in the number of sections reaching such flows and the amount of time that these flows are achieved. The uneven distribution of flows along the Lower Maribyrnong Trail is easily explainable by a physical check along this trail. Currently, it is not signed consistently; sections are under major repair; and, in one case, it is very poorly linked through an unsigned link involving a steep hill. The two trails analyzed are both located in inner suburban areas, which might be taken to limit the applicability of the results. However, the wide range of distances from which people come to ride on the Lower Yarra extends out into the middle and outer suburbs. This suggests that the approach will yield reasonable results over a wide area of Melbourne.

A conservative view is taken that the Lower Yarra has already reached its full marketing potential. It is widely appreciated as a major connected route by its full potential market, and that the signage on the route was already at a standard that permitted full appreciation of the scale of the trail to those who are riding on it. Neither of these assumptions are fully supported, and improvements are clearly possible in both areas. However, in a practical sense, the Lower Yarra is well known to a significant range of potential users, and the levels of usage are sufficient to engender a number of conflict complaints and concerns under the current capacity management measures.

TABLE 4 Lower Maribyrnong Trail Usage Potential, With and Without a Public Transport Component, Matching the Current Attractiveness of the Lower Yarra

Maribyrnong Potential arrivals				Adding a public transport potential	Excluding a public transport potential
Walk	Car	Bike	Transit	Bike Trail Users	Bike Trail Users
12,500	5,179	8,621	1,177	10,814	8,845

These suggest that the marketing and signage of the Lower Yarra have reached a level at which the problems are now those of success (i.e., substantial levels of usage) rather than failure (i.e., low levels of usage of available capacity). These factors support the premise that the model presented here is conservative and may be used as a practical estimate of the marketing potential of other routes.

The 1995 survey used covered only those aged 15 years or older who use the trails, so the subsequent analyses based on these survey data will depend on this as a definition of patronage and of a user. The data from the other park surveys demonstrate that a correction factor will be needed to estimate the amount of cycle riding along the trails by people younger than 15 years of age, and, thus, the use of the 15 years and older age group patronage is a further conservative factor in the model estimates.

On the basis of this initial work, such differential usage surveys could be used effectively for assessing the market potential and levels of perception of trails in a marketing sense—an issue well worth closer and focused attention—as well as enhanced choice-based surveys aimed at monitoring the perceptions and levels of knowledge of trail opportunities that are now clearly a central issue for trail usage planning and management.

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