STATSCIENCE

Research

Ngā Haerenga

The Great Rides of the New Zealand Cycle Trails:

Some Benefits in Relation to Costs

A report prepared for the

Ministry of Business, Innovation and Employment

by

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1. Introduction and Executive Summary

This report is a preliminary cost benefit analysis (CBA) of the Great Rides of Nga Haerenga, the New Zealand Cycle Trail (NZCT). There are currently 22 Great Rides, labelled accordingly by the NZ government because of their iconic attributes, such as unique landscapes, spectacular views, cultural and historic connections, and links to local food and beverage specialities. The analysis is based upon data provided by the Ministry of Business, Innovation and Employment (MBIE) and NZ Statistics, findings from previous trail surveys and the opinions of NZ Cycle Trail experts. These sources were combined with findings from published research.

The opinions were sourced mostly from cycle-trail managers, Evan Freshwater and Jonathan Kennett, with proven capability for insight based upon many years of managing and writing about the trails. They are hereinafter referred to as the "managing experts".

The CBA is evaluative of one year, the year 2015 being when estimates of monthly trail visits based upon electronic counts were available for a suitable analysis. A longer time frame, customary of a CBA, was deemed unsuitable given the limited information and the intended scope of a small investigation.

Table 1.1

Summary of Annual Benefits and Costs: The Great Rides of Nga Haerenga, NZCT, In NZ Dollars Year 2015	
Sources of Costs	Amount
Annual Infrastructural Costs, Government-Funded	$ 5,538,140
Provision for Deadweight Losses from Taxation	$ 1,107,628
Annual Co-Funding Costs	$ 3,843,469
Annual Maintenance Costs	$ 3,434,699
Total Costs	$ 13,923,937
Sources of Benefits	
Annual Revenues from International Visitors	$ 17,888,955
Provision for Servicing Costs at 55.23%	-$ 9,880,070
Net Annual Revenues from International Visitors	$ 8,008,885
Producer Surpluses	$ 16,210,049
Consumer Surpluses	$ 13,155,323
Reduced-Mortality Savings from Physical Activity: Non-Commuters	$ 9,280,430
Health Costs Saved from Diseases Associated with Physical Inactivity: Non-Commuters	$ 581,864
Benefits from Commuting, Including Reduced-Mortality and Health Cost-Savings to Commuters	$ 2,183,140
Total Benefits	$ 49,419,690
Benefits Net of Costs	$ 35,495,753
Ratio of Total Benefits to Total Costs	3.5493
Ratio of Net Benefits to Total Costs	2.5493

The costs were based on an announcement by the NZ government in the year 2009, to fund the development of trail infrastructure with the support of co-funding by non-government institutions.

Most of the intended funding has since been expended. But it has not yet been possible to assemble fine details as to the categories of the infrastructure and their share of the funds. Hence, it was necessary to assume a simplification, this being that the funds supported some useful service life. The service-life costs were calculated and then updated to year 2015 in order to make the costs comparable to the annual benefits.

Estimates concerning visits were supplemented by those of unique individuals who would have visited the trails over the entire year. These were required for health-related benefits from being able to exercise on the trails and for being able to use the trails for commuting to work or school.

Benefits were calculated separately for between domestic and international visitors. Domestic visits were further separated for between commuters and non-commuters. This secondary separation was required because of the strong belief that non-commuters, composed mostly of tourists, would be prone to spending for food, accommodation and the like while on the trails, whereas commuters would not be prone to doing so. On the advice of Kennett (2016), this belief was translated into a simplifying assumption: that only non-commuters would be doing any spending on the trails. Thus, for non-commuters, the main benefits would have been the consumer and producer surpluses arising from their spending, while for commuters, there would also have been benefits not related to such surpluses, such as health-related ones.

The total benefits for the year were estimated at around $49.42 million, exceeding corresponding costs of around $13.92 million and implying net benefits of $35.5 million. An annual benefit of $3.55 or a net benefit of $2.55 was earned for every dollar spent on costs.

2. Infrastructure and Maintenance Costs

The funding announced in the year 2009 for the twenty two Great Rides was intended mainly for the development of infrastructure consisting of what the managing experts refer to as “hardware” and “software”. Developing hardware meant forging and surfacing undeveloped portions of the trails, as well as installing signage, toilets, parking, and electronic counters. Software is described as amenities that provide quality to the trail experience. These include the use of government funds for financial record-keeping, stakeholder engagement, governance, marketing and for ensuring quality and safety standards.

Hardware and software are also provided by trail businesses without government funding, for example, for bike rentals, food, coffee, shuttles, campsites and accommodations. The costs incurred for them by the businesses are not treated in this section. They are treated in the section on producer surpluses.

The costs to the government are inferred from a government funding of $50 million, announced in the year 2009. This was subsequently accompanied by co-funding from trusts and non-government organisations of another $34.7 million. It is not known how the funds were specifically allocated across different types of infrastructure. Without this information, simplifying assumptions had to be made for how long the infrastructure would have lasted.

Consideration was thus given to engineering expertise. The useful service life of a trail greatly depends upon the material used for surfacing. Asphalt can last between 7-15 years. Cement can last up to 25 years. More accessible materials like crushed stone, natural earth and woodchips have much shorter lives (Rails to Trails Conservancy, 2016). These durations can be greatly shortened by damage, such as from roots, and from a lack of regular maintenance.

Based upon this and cognisant that infrastructure can also refer to other durables, we assumed that the funding and co-funding would serve a useful service life of ten years. Hence, as a matter of simplification, an annual equivalent for infrastructure costs was calculated for the year 2015 as one-tenth of what was announced in 2009. For the ensuing inflation, a producer price index for construction was selected and this showed an increase in prices of 10.76% between 2009 and 2015. The government-funded portion of the annual infrastructure costs for the year 2015 was thus estimated to be $5.54 million. The co-funded portion was $3.84 million.

Table 2.1

Infrastructural and Maintenance Costs, Annualised to Year 2015							
Trail	Trail kms	Gov't Funding, Announced 2009	Gov't Annual Equivalent, PPI 2015 Dollars	Co-Funding, Announced 2009	Co-Funding, Annual Equivalent, PPI 2015 dollars	Annual Maintenance Imputed, 2015	Total Annual Costs, 2015 Dollars
St James Cycle Trail	64	$ 100,000	$ 11,076	$ 600,000	$ 66,458	$ 13,150	$ 90,684
Hawke's Bay Trails	200	$ 2,600,000	$ 287,983	$ 2,900,000	$ 321,212	$ 261,691	$ 870,887
Old Ghost Trail	85	$ 2,500,000	$ 276,907	$ 3,100,000	$ 343,365	$ 111,219	$ 731,491
Timber Trail	87	$ 2,100,000	$ 232,602	$ 2,900,000	$ 321,212	$ 113,836	$ 667,650
Waikato River Trail	103	$ 3,500,000	$ 387,670	$ 2,200,000	$ 243,678	$ 233,000	$ 864,348
Tasman Great Taste	175	$ 2,300,000	$ 254,754	$ 1,200,000	$ 132,915	$ 228,980	$ 616,650
Otago Central Rail	150					$ 173,183	$ 173,183
Queen Charlotte	70					$ 91,592	$ 91,592
Motu Trails	91	$ 1,900,000	$ 210,449	$ 1,100,000	$ 121,839	$ 19,000	$ 351,288
Alps to Ocean	301	$ 2,800,000	$ 310,136	$ 1,500,000	$ 166,144	$ 393,846	$ 870,126
Mountains to Sea	317	$ 800,000	$ 88,610	$ 1,400,000	$ 155,068	$ 565,000	$ 808,678
Queenstown Trails	120	$ 2,000,000	$ 221,526	$ 2,700,000	$ 299,060	$ 110,000	$ 630,585
Twin Coast Cycle Trail	84	$ 4,000,000	$ 443,051	$ 900,000	$ 99,687	$ 240,572	$ 783,310
Hauraki Rail Trail	80	$ 4,000,000	$ 443,051	$ 2,200,000	$ 243,678	$ 104,677	$ 791,406
Te Ara Ahi Thermal	48	$ 2,000,000	$ 221,526	$ 500,000	$ 55,381	$ 62,806	$ 339,713
Great Lake Trail	71	$ 2,300,000	$ 254,754			$ 92,900	$ 347,655
Rimutaka Cycle Trail	115					$ 94,000	$ 94,000
Dun Mountain	38	$ 500,000	$ 55,381	$ 300,000	$ 33,229	$ 49,721	$ 138,332
West Coast Wilderness	139	$ 3,200,000	$ 354,441	$ 5,000,000	$ 553,814	$ 100,000	$ 1,008,255
Roxburgh Gorge	34	$ 2,000,000	$ 221,526	$ 900,000	$ 99,687	$ 44,488	$ 365,700
Clutha Gold	73	$ 3,800,000	$ 420,899	$ 1,300,000	$ 143,992	$ 95,517	$ 660,408
Around the Mountain	180	$ 4,000,000	$ 443,051	$ 4,000,000	$ 443,051	$ 235,522	$ 1,121,625
Not Trail Specific		$ 3,600,000	$ 398,746				$ 398,746
Announced Funding, 2009		$ 50,000,000		$ 34,700,000			
Annual Equivalent, 2015			$ 5,538,140		$ 3,843,469	$ 3,434,699	
Deadweight Loss at 20%			$ 1,107,628				
Total Annual Funding and Costs, 2015							$ 13,923,937

Because the government-funded portion was raised from general taxation, we added to it the deadweight losses from the taxation, equivalent to 20% of the funding, as recommended by the NZ Treasury for the raising or spending of all government funds (NZ Treasury, 2015). These costs amounted to around $1.1 million.

We also added to these costs, maintenance-related ones that would have been completely dissipated for the year. The source was independent reports provided by trail managers and staff.

Some of the costs related to the work of volunteers whose unpaid wages represented real opportunity costs. Reports were available for nine selected trails. For those trails with no reports, an average maintenance cost of $1,309 per kilometre was calculated from the available reports and then multiplied by known trail distances. Maintenance costs were estimated at around $3.43 million. The total of infrastructural and maintenance costs for the year 2015 was thus estimated at $13.92 million.

3. Visitor Counts and Distinctions

Estimates of monthly and annual visits for the year 2015 were provided by MBIE through Kennett (2016) based upon counts reported from electronic counters. Kennett adjusted the counts to remove possible inaccuracies arising from unavoidable contaminations, such as from mechanical failures, unwanted animal activities, and from an occasional double-count from backtracking.

Visits also encompassed those undertaken by non-cyclists, defined as anyone not using the trails with a bicycle, these being runners, walkers, sightseers and passers-by. According to Kennett (2016), such non-cyclists were just as likely to be spending on the trails as cyclists. Also, they would have been given equal importance in surveys spending patterns even though most surveys referred only to “cyclists”. One “visit” was defined as a single instance of use by someone on any given day while allowing for that same person to visit on other days. The term is used interchangeably with “visitor” such as when referring to spending per “visitor” per day (pvpd).

By definition, it was entirely possible for a visitor to be counted several times in the course of a year if multiple visits were undertaken during that period. Such multiple visits pointed to the importance of distinguishing between visits (or visitors) and unique individuals, particularly because any benefits related to improved health could only be calculated on the basis of unique individuals.

Because the numbers for unique individuals could not be reported by counters, a way had to be found for them to be inferred from the numbers for the visits. One earlier study of the Hauraki Trail (Ryan et al, 2013) had categorised visitors according to historical types such as “infrequent cyclists” versus “frequent cycling enthusiasts”. The categories suggested to us that a frequency of visits for the year could be heuristically assigned to each type. The managing experts provided opinions for the frequencies. These were combined with reported shares of use by each type in order to obtain an average frequency for non-commuters and for commuters. We then divided the annual visits by these averages in order to estimate numbers for unique individuals.

Because of the strong belief that commuters were unlikely to be doing any spending while on the trails, we had to estimate their share of all visits. The managing experts were asked to indicate their opinions concerning share of use on a trail-by-trail basis. Their opinions ranged from between 0% and 40%. These were used to estimate the numbers for commuters, versus non-commuters, for each trail. On average, the managing experts thought that around 17% of all visits were undertaken by commuters, the remaining ones (83%) being by non-commuters.

This average proportion for commuters’ share of use was not applied to supplementary numbers provided by Kennett (2016) concerning “uncounted visits”, those that would not have been captured by electronic counters such as for popular trail segments in-between some counters. For these, there were thought to be around 276,000 commuting visits and 65,000 non-commuting ones.

Table 3.1

Visits to the 22 Great Rides, Year 2015. Source: Jonathan Kennett, MBIE, June 2016. Commuters Estimated by Managing Experts.															
Counted visits are based on corrected electronic counts. Uncounted visits are for popular areas not monitored by counters.															
Trail	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Counted Annual Visits	Annual Visits by Non-Commuters	Annual Visits by Commuters
St James Cycle Trail	332	280	240	200	160	0	0	80	120	160	200	320	2092	2092	0
Hawke's Bay Trails	28048	24052	18986	19055	12924	10997	11591	17127	10888	16253	18373	19425	207719	145616	62103
Old Ghost Road	618	462	375	513	245	144	122	119	339	419	571	799	4726	4726	0
Timber Trail	926	783	809	934	413	82	64	74	221	532	483	678	6000	6000	0
Waikato River Trail	3958	2485	1904	1569	1194	994	1139	1382	1869	2035	2621	4682	25833	24803	1030
Tasman Great Taste	12151	8701	8236	8271	7320	5522	5863	5936	6777	7673	7930	11590	95971	79233	16738
Otago Central Rail	3483	2436	3300	3279	452	122	151	99	562	1107	1437	736	17164	16480	684
Queen Charlotte	2200	2124	1974	857	300	100	50	50	200	500	800	1400	10555	10187	368
Motu Trails	3165	1590	1396	1955	1001	643	703	519	719	964	1910	3241	17805	17184	621
Alps to Ocean Trail	2789	2219	1918	1793	1102	815	845	862	1079	1457	1307	1976	18163	17258	905
Mountains to Sea	5125	3873	3984	2435	1328	664	775	553	885	1660	2213	2435	25931	24639	1292
Queenstown Trails	31910	20785	21270	17650	9762	7691	8828	10875	14797	17725	21369	29239	211901	180224	31677
Twin Coast Cycle Trail	1403	1357	1321	1268	1112	1083	1151	1337	918	1109	1109	1350	14517	13432	1085
Hauraki Rail Trail	12578	7953	6335	9200	5535	3623	4474	4488	7628	6403	5506	8164	81888	77808	4080
Te Ara Ahi Thermal	2390	2341	3279	2082	1719	1398	1348	1259	1426	2200	2379	2604	24424	21990	2434
Great Lake Trail	3886	2436	3233	2285	1935	856	988	904	2999	1661	1290	2362	24836	23970	866
Rimutaka Cycle Trail	11443	8854	10352	8634	7089	7358	7787	6543	6923	5622	10246	7809	98659	64246	34413
Dun Mountain	500	379	263	273	128	73	107	52	139	189	197	130	2430	2369	61
West Coast Wilderness	2281	2034	1767	1774	1245	1007	1059	1166	1395	1421	874	1547	17570	16694	876
Roxburgh Gorge	2619	1211	1085	1096	768	876	630	709	773	1525	2123	1003	14417	14058	359
Clutha Gold	1078	1054	1188	793	600	280	200	200	280	403	714	1082	7871	7636	235
Around the Mountain	1537	1150	933	1273	610	358	303	296	843	1043	1420	1987	11754	11403	351
Total Counted Visits													942227	782048	160179
Uncounted Non-Commuters and Commuters														65000	276000
Total Uncounted Visits															341000
Total Non-Commuters versus Commuters														847048	436179
Total Counted and Uncounted Visits															1283227

4. Domestic versus International Visitors

It was also necessary to distinguish between visits by NZ residents (domestics) and visits by non-residents (internationals) for reasons related to the treatment of their spending. The spending of internationals is wholly beneficial to New Zealanders because they are drawn from incomes that are external to the NZ economy. Furthermore, almost by definition, internationals do not commute to either work or school.

By comparison, the spending by domestics is drawn from internal sources of income rather than external ones. Being internal, the spending would have implied some level of foregone spending on other parts of the NZ economy were it not for the existence of the trails. We refer to this level of foregone spending as "economic displacement" and we estimated the proportion of it based upon opinions expressed by survey participants in a four month survey of four trails by Angus and Associates (A&A, 2013).

For discerning visits by internationals, we relied upon their purported shares of use in A&A, as follows: the Motu Trails (11%), Mountains to Sea (13%), Queenstown (46%) and the Hauraki Trails (4%). For the trails that were not surveyed by A&A, we asked the managing experts to assign their own estimates, to which they responded with one of the following percentages: 0, 5, 10, 30 or 40%. The result was a count-weighted average of 18% for the share of use by internationals.

We complemented this average by giving equal weight to an estimate of 9% international provided by NZ Statistics concerning cycling tourism. The basis were the years between 1999 and 2012, which was when NZ residents were asked to identify whether cycling was an attraction or an activity that they engaged in, among many other activities, while undertaking a tourism-related trip during the year. That information, provided as Domestic Travel Statistics (DTS), showed an annual average of 686 thousand cycling-related trips (around 97.5 million trips in December 2012, less than half a percent of all trips). Similar information, provided as International Visitor Statistics (IVS), showed an annual average of 64 thousand trips undertaken by international cycling tourists (slightly higher than half a percent of all their trips). As a share of all cycling-related visits, the ones undertaken by internationals were therefore 9%.

Thus, international visitors were inferred as having an average share of use equal to 13.5% (the average of 9% and 18%) of all visits. Domestics were inferred as the remaining equivalent of between 81% and 92%, the average of these being 86.5%. The trail-specific estimates provided by the managing experts were adjusted so as to conform to these average constraints.

5. Sources for Cycle-Trail Spending

Only a few of the cycle trails were previously surveyed in regard to spending by visitors. Information from cycling tourism statistics and from the NZ Ministry of Tourism was helpful for identifying spending per cycling-related trip, but not for identifying spending on the trails. The amounts for these were also typically in the order of several thousand dollars per trip, rather than in the hundreds of dollars expected of trail spending, per visitor per day (pvpd). An exception was information provided by MBIE Sector Trends concerning international visitors, which was used to calculate international spending, pvpd.

For surveys of visitor spending, we turned to the findings of A&A which were based upon the direct responses of trail visitors, and which also distinguished between domestics and internationals. A&A found that domestics typically spent less than internationals, for example, $166 and $215 respectively of the Mountains to Sea Trails. We also turned to another 2013 survey of the Hauraki Rail Trail by Ryan et al (2013) which provided spending information, even though that survey did not distinguish between domestics and internationals. We updated the spending estimates to year 2015 using the CPI index for tourism goods and services, which showed inflation of just over two percent in the two intervening years.

We complemented these estimates with a 2015 survey of the Otago Central Rail Trail of three other trails: Otago, Roxburgh Gorge and Clutha (Otago District Council, 2015). The spending figures there, of $177, $208 and $280 on average pvpd respectively, also did not distinguish between domestics and internationals. To create a distinction, we calculated how the domestic and international spending estimates in A&A might have deviated from their respective averages. We found that the domestic estimates were approximately 16 percent below their averages, while the international ones were approximately 14 percent above. We applied these deviations to the averages of the Hauraki Rail Trail and of the three other trails in order to create differences

6. The Economic Impact of International Visits

The spending information from the seven trails was then used to extrapolate figures for the remaining fifteen others. In the absence of any alternatives, we used trail distance in kilometres, as a predictor for the spending. A count-weighted average figure for spending pvpd was calculated on a per kilometre basis. This was found to be $1.33 per kilometre pvpd for domestics and $1.83 for internationals. We multiplied these by the known trail distances to fill in the missing figures while not replacing the ones obtained from the surveys. On the advice of Kennett (2016), the amount of $50 pvpd, was used for the unknown spending of uncounted non-commuters.

Upon inspection, the predicted international spending seemed too high for five trails: Mountains to Sea ($579.64), Alps to Ocean ($550.39), Hawkes Bay ($365.70), Around the Mountain ($329.13) and Tasman Great Taste ($319.99). In the opinion of Walter (2016), none of these trails were within the range of spending-driven tourist destinations. Hence, after considering inflation, the prediction for Mountains to Sea was replaced by $331.50. For the four other trails, the predictions were changed to a constant of $280 pvpd, representing the sum of $120 for accommodation, $60 for food and beverages and perhaps $100 for all other expenditures such as bike hire and transport.

Table 6.1

Estimated Annual Revenues from International Visitors, Year 2015								
Trail	Trail Distance (kms)	Annual Visits by Non-Commuters	Annual Visits by Internationals (at 13.5% Overall Average)	International Spending Pvpd, Surveys	Annual Revenues from International Visits, Surveys	International Spending Pvpd, MBIE	Annual Revenues from International Visits, MBIE	Average of Annual Revenues
St James Cycle Trail	64	2092	72	$ 117.03	$ 8,433	$ 98.52	$ 7,099	$ 7,766
Hawke's Bay Trails	200	145616	10032	$ 280.00	$ 2,808,908	$ 98.52	$ 988,334	$ 1,898,621
Old Ghost Road	85	4726	391	$ 155.42	$ 60,725	$ 98.52	$ 38,492	$ 49,608
Timber Trail	87	6000	413	$ 159.08	$ 65,757	$ 98.52	$ 40,724	$ 53,240
Waikato River Trail	103	24803	1709	$ 188.34	$ 321,826	$ 98.52	$ 168,348	$ 245,087
Tasman Great Taste	175	79233	8188	$ 280.00	$ 2,292,600	$ 98.52	$ 806,668	$ 1,549,634
Otago Central Rail	150	16480	4541	$ 274.28	$ 1,245,587	$ 98.52	$ 447,411	$ 846,499
Queen Charlotte	70	10187	1404	$ 128.00	$ 179,655	$ 98.52	$ 138,282	$ 158,968
Motu Trails	91	17184	1302	$ 166.40	$ 216,685	$ 98.52	$ 128,295	$ 172,490
Alps to Ocean Trail	301	17258	2378	$ 280.00	$ 665,807	$ 98.52	$ 234,269	$ 450,038
Mountains to Sea	317	24639	2207	$ 331.50	$ 731,507	$ 98.52	$ 217,400	$ 474,454
Queenstown Trails	120	180224	57114	$ 219.42	$ 12,532,088	$ 98.52	$ 5,626,865	$ 9,079,477
Twin Coast Cycle Trail	84	13432	925	$ 153.60	$ 142,131	$ 98.52	$ 91,166	$ 116,649
Hauraki Rail Trail	80	77808	2144	$ 146.28	$ 313,649	$ 98.52	$ 211,241	$ 262,445
Te Ara Ahi Thermal	48	21990	757	$ 87.77	$ 66,482	$ 98.52	$ 74,626	$ 70,554
Great Lake Trail	71	23970	1651	$ 129.83	$ 214,384	$ 98.52	$ 162,689	$ 188,536
Rimutaka Cycle Trail	115	64246	4426	$ 210.28	$ 930,713	$ 98.52	$ 436,056	$ 683,384
Dun Mountain	38	2369	163	$ 69.48	$ 11,342	$ 98.52	$ 16,082	$ 13,712
West Coast Wilderness	139	16694	2300	$ 254.16	$ 584,641	$ 98.52	$ 226,620	$ 405,631
Roxburgh Gorge	34	14058	968	$ 62.17	$ 60,210	$ 98.52	$ 95,414	$ 77,812
Clutha Gold	73	7636	526	$ 133.48	$ 70,217	$ 98.52	$ 51,825	$ 61,021
Around the Mountain	180	11403	1964	$ 280.00	$ 549,904	$ 98.52	$ 193,488	$ 371,696
Uncounted Non-Commuters		65000	8775	$ 50.00	$ 438,750	$ 98.52	$ 864,513	$ 651,632
Proportion of International Visits to Non-Commuters			13.50%					
Total Annual International Visits			114351					
Average Spending pvpd, Count-Weighted				$ 207.23		$ 98.52		
Total Annual Revenues from International Visits					$ 24,512,001		$ 11,265,908	$ 17,888,955

Finally, for spending by internationals, we gave equal weight to a nationwide electronic survey of those who specifically visited the trails in the year 2015 by MBIE's Sector Trends. Based upon the responses of 166 such international cycle-tourists, an average of $4,512 was spent per trip, and each trip lasted an average of 45.8 days. Dividing the former by the latter, an international visitor would thus have spent $98.52 pvpd. The managing experts regarded this as being quite low. But we gave it equal importance because of the reliability by which it was obtained.

The final average spending by internationals was $207.23 pvpd. The one for domestics was $173.13. For annual revenues from the internationals, the average was $17.89 million, the range being quite large. This was obtained by taking the product of a spending per visitor per day (pvpd), and a number for annual international visits. By way of background, what we found of the internationals was but a small fraction of what an international cycling tourist would have spent for a NZ trip. According to Tourism NZ, this averaged $3,800 per trip for between the years 2008 and 2012. (Tourism NZ, 2013).

For the opportunity costs of servicing the international revenues, we used a subsequent calculation concerning the level of business costs associated with servicing domestic revenues (Section 8). We estimated this level to have been around 55.23% of the revenues from domestic spending. Applying this, the costs of servicing the international revenues would have been $9.88 million.

7. Domestic-Visitor Spending: Displacements and the Economic Impact

For estimating the economic displacement of domestic spending, we hypothesised what proportion of the spending would nonetheless have materialised if, as a counterfactual, the trails were completely shut down. A zero level of economic displacement was unreasonable to assume, as that would have implied no reduction whatsoever in total domestic spending. Equally unreasonable was a displacement of 100%, as that would have implied that all former domestic visitors would have given up all of their spending. What seemed reasonable was some proportion in-between, seeing that visitors would have found suitable alternatives by which to continue to spend on the NZ economy. Such alternatives would have included informal mountain trails, public parks and roads.

The findings in A&A provided some hints as to an appropriate level of displacement. In the survey, respondents were asked whether the trail was their “only reason to visit”, their “main reason to visit” or as only one of many reasons to visit, to include “we were visiting the region anyway”. Only 33% responded to the defining question of whether the trail was their “only reason” to visit. The majority (67%) described themselves as between visiting the trail as either a “main reason to visit” or as only one of many reasons to visit.

In the absence of any other discerning survey, we decided to use these findings to pre-suppose a displacement level of 67%. To put it differently, our best estimate was that a complete shutdown of the trails would lead to a complete disappearance equal to 33% of the domestic spending, the proportion corresponding to the trails being an “only reason to visit”.

A displacement level of 67% could not be directly corroborated by cycling research. Understandably, the notion of displaced spending is more popularly investigated in the context of macroeconomic spending rather than in small microeconomic ones. However, we found some support from a study conducted by Optimal Economics (2012). For three weeks in the year 2012, 450 British respondents were queried as to how marketing initiatives might have influenced their decision to engage in tourism activities. Questions included deciding to take a holiday instead of staying at home, visiting England instead of another country, or choosing a different place to visit in England. The responses indicated that the initiatives displaced between 50-75% of the spending. This led us to think that a level of 67% was reasonably justified, being in the middle of the range.

After removing the displacement, trail revenues from domestic spending amounted to an average of $36.21 million for year 2015. They ranged from between $33.91 and $38.91 million, depending upon the share of use assumed of domestics, which was either 81% or 92%.

Table 7.1

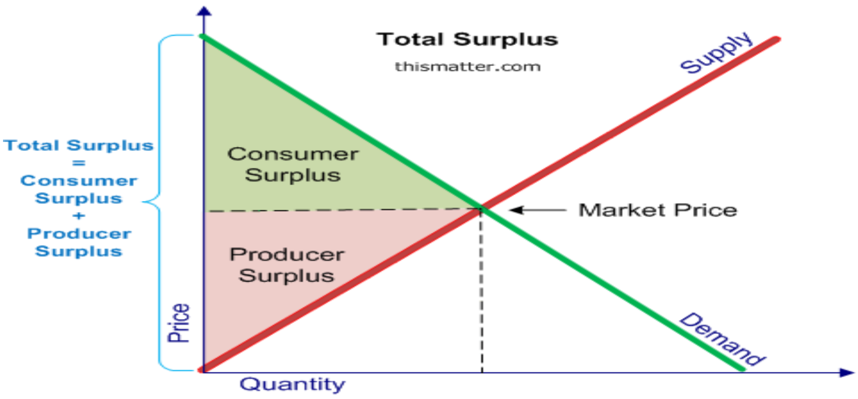
Estimated Annual Revenues from Domestic Spending after a Counterfactual							
Annual domestic visits after displacement are 33% of annual visits by non-commuters.							
Trail	Annual Visits by Non-Commuters	Annual Visits by Domestic Non-Commuters	Annual Visits By Domestic Non-Commuters After 67% Displacement	Domestic Spending Pvpd, Surveys	Annual Domestic Spending at 81% of Visits After Displacement	Annual Domestic Spending at 92% of Visits After Displacement	Annual Domestic Spending, Average After Displacement
St James Cycle Trail	2092	2020	667	$ 85.4	$ 46,110	$ 52,372	$ 49,241
Hawke's Bay Trails	145616	135584	44743	$ 266.87	$ 9,671,913	$ 10,985,382	$ 10,328,648
Old Ghost Road	4726	4335	1431	$ 113.42	$ 131,435	$ 149,285	$ 140,360
Timber Trail	6000	5587	1844	$ 116.09	$ 173,358	$ 196,901	$ 185,129
Waikato River Trail	24803	23095	7621	$ 137.44	$ 848,444	$ 963,665	$ 906,055
Tasman Great Taste	79233	71045	23445	$ 233.51	$ 4,434,540	$ 5,036,762	$ 4,735,651
Otago Central Rail	16480	11938	3940	$ 148.54	$ 474,020	$ 538,393	$ 506,207
Queen Charlotte	10187	8783	2898	$ 93.41	$ 219,294	$ 249,075	$ 234,185
Motu Trails	17184	15882	5241	$ 136.22	$ 578,258	$ 656,787	$ 617,523
Alps to Ocean Trail	17258	14880	4910	$ 401.64	$ 1,597,517	$ 1,814,463	$ 1,705,990
Mountains to Sea	24639	22432	7403	$ 170.01	$ 1,019,419	$ 1,157,859	$ 1,088,639
Queenstown Trails	180224	123110	40626	$ 152.60	$ 5,021,730	$ 5,703,693	$ 5,362,711
Twin Coast Cycle Trail	13432	12507	4127	$ 112.09	$ 374,707	$ 425,593	$ 400,150
Hauraki Rail Trail	77808	75664	24969	$ 137.24	$ 2,775,652	$ 3,152,593	$ 2,964,122
Te Ara Ahi Thermal	21990	21232	7007	$ 64.05	$ 363,509	$ 412,875	$ 388,192
Great Lake Trail	23970	22318	7365	$ 94.74	$ 565,191	$ 641,945	$ 603,568
Rimutaka Cycle Trail	64246	59820	19741	$ 153.45	$ 2,453,683	$ 2,786,899	$ 2,620,291
Dun Mountain	2369	2206	728	$ 50.71	$ 29,902	$ 33,963	$ 31,933
West Coast Wilderness	16694	14394	4750	$ 185.48	$ 713,638	$ 810,552	$ 762,095
Roxburgh Gorge	14058	13089	4319	$ 174.48	$ 610,475	$ 693,380	$ 651,928
Clutha Gold	7636	7110	2346	$ 235.13	$ 446,848	$ 507,531	$ 477,190
Around the Mountain	11403	9439	3115	$ 240.19	$ 606,001	$ 688,298	$ 647,149
Uncounted Visits	65000	56225	18554	$ 50.00	$ 751,447	$ 853,496	$ 802,471
Average Spending pvpd				$ 173.13			
Totals	847048	732697	241790		$ 33,907,094	$ 38,511,761	$ 36,209,427

8. Cost Margins and Benefits from Producer Surpluses

In cost-benefit analysis, producer surpluses are defined as benefits to businesses resulting from them choosing a level of providing goods or services that is profit-maximising. Almost undoubtedly, the businesses on the trail would have been profit-maximising, though other motives might also have been in place.

Producer surpluses are normally calculated by an econometric modelling of the businesses' incremental costs along a supply curve, known as marginal costs, in relation to a market-based average unit price. Such a modelling was way beyond the scope of this report. Hence, a way had to be found for calculating the surpluses less complicatedly. (Diagram courtesy of thismatter.com/economics.)

Table (Graph) 8.1



Producer surpluses are a form of gross profits that tend to vary with levels of service. They vary because some costs vary with the level of service. Known as variable costs, they differ from costs that are known as fixed, which are incurred and which remain unchanged even if the service level were altered such as to the extent of non-provision. Thus, instead of using modelling techniques for obtaining producer surpluses, we estimated the variable costs associated with the domestic spending and then inferred producer surpluses from what remained.

We first tried estimates from the operating surplus components of NZ gross domestic product (GDP). We found the variable costs from these to be too low, in the order of 10-15%, mainly because they would have treated the incomes of many trail workers as part of the variable costs rather than as part of income. This treatment could not be justified because many trail workers are themselves the owners of the businesses.

Hence, we turned instead to NZ Statistics' estimates of gross profit margins for businesses in relevant categories for the year 2014. These margins were derived from the sum of operating surpluses and wages. We matched the recorded business categories with those surveyed by A&A, for which the shares of total business were also available.

Table 8.2

Producer Surpluses Based on Gross Profit Margins, 2015				
A&A Business Categories matched with NZStatistics Industry Statistics.				
Gross Profit Margins are Operating Surpluses plus Wages divided by Total Income Year 2014				
Business Categories, by A&A	Share of Trail Businesses	Gross Profit Margins, NZ Statistics, 2014	Gross Profits at Spending of $33.91 million	Gross Profits at Spending of $38.51 million
Accommodation	35.66%	39.50%	$ 13,393,302	$ 15,212,146
Visitor Activities/Attractions	11.19%	41.75%	$ 14,156,212	$ 16,078,660
Retail (including Services)	8.39%	46.75%	$ 15,851,566	$ 18,004,248
Cafe/Restaurant/Bar	8.39%	59.75%	$ 20,259,489	$ 23,010,777
General Tours	4.90%	50.50%	$ 17,123,082	$ 19,448,439
Other Transport Services	4.90%	50.50%	$ 17,123,082	$ 19,448,439
Cycle Hire	4.20%	39.50%	$ 13,393,302	$ 15,212,146
Cycle Transport/Shuttle Services	3.50%	39.50%	$ 13,393,302	$ 15,212,146
Site/Visitor Information Services	3.50%	41.75%	$ 14,156,212	$ 16,078,660
Vineyard	2.80%	53.75%	$ 18,225,063	$ 20,700,071
Specialised Cycle Tours	2.10%	39.50%	$ 13,393,302	$ 15,212,146
Other	10.49%	50.50%	$ 17,123,082	$ 19,448,439
Average Gross Profit Margin, Share-Weighted		44.77%		
Implied Average Cost Margin, Share-Weighted		55.23%		
Producer Surpluses All Trails, Share-Weighted		44.77%	$ 15,179,352	$ 17,240,746
Average of Producer Surpluses, All Trails				$ 16,210,049

For example, the NZ Statistics industry category "Retail Trade and Accommodation" for which gross profits were 39.5%, was matched with "Accommodation" which accounted for 35.66% of all businesses on the trails. The margins were applied to the domestic spending of between $33.91 and $38.51 million, while accounting for business share.

Using this approach, we estimated the producer surpluses to have been between $15.18 and $17.24 million, the average of which was around $16.21 million.

Given this average, the corresponding margin for the costs of the businesses would have been 55.23%. This cost margin was used to reflect the opportunity costs of servicing the revenues from international visitors, there being no compelling reason for those revenues to be serviced any differently.

9. Consumer Surpluses: Preliminaries

Consumer surpluses are defined in context as dollar indications of satisfaction-related benefits to domestic visitors resulting from a positive difference between what they would have been willing to pay in relation to what they actually paid. The consumer surpluses of internationals are excluded because they are external to New Zealand.

The justification for consumer surpluses is the idea that visitors will only use a facility if their enjoyment exceeded the costs to them of doing so. Their costs include not just monetary expenses but also the opportunity costs of their time. This view is supported by the opinions of the managing experts, for which cycling on the trails is supposed to be an activity that is meant to be enjoyment-oriented rather than driven by more important other means.

Some unintended evidence for such surpluses was reported by trail surveys. In the A&A survey for example, when respondents were asked how satisfied they were with their overall experience with the trails*,* they replied with very high levels of enjoyment that seemed to indicate an excess over their costs. On a five scale rating between very dissatisfied to very satisfied with neutral in the middle, between 68-81% of all respondents reported that they were very satisfied with their overall experience, as compared to between only 1-5% being very dissatisfied.

The calculation of consumer surpluses usually requires respondent-level data concerning willingness to pay (such as for the monetary equivalent of time sacrificed) complemented by important influences bearing upon the decision to visit, such as age, income and fitness. Econometric methods are then applied in order to isolate the effect of unit prices upon trail visits, the unit prices in this case being spending pvpd.

In percentage terms, this effect is known as a price elasticity of demand, trail visits being what are demanded. That elasticity is then used to construct a demand curve and to calculate consumer surpluses as an area below such a curve.

10. Consumer Surpluses: The Literature

In place of respondent data, which were unavailable, we invoked the findings of cycling-related studies concerning the price-elasticity of demand in order to uncover a hidden demand behind the visits.

The first study, by the University of Vermont Transportation Research Center, investigated the effect upon a counterpart for the visits, which were instead cycling trips from a community-funded programme. The programme initially gave away a US$10 shopping voucher on the condition that a member-cyclist completed a certain number of required trips to school or work (Kolodinsky and Roche, 2008). After a period of six months, the shopping voucher was increased to US$15, as a way of increasing the incentive to cycle. That increase was equivalent to a fall in the price of cycling because by acting as a reward, it effectively decreased the opportunity costs, in time and money, of having to cycle.

The study provided strong evidence that the demand for cycling is like the demand for many other goods or services. A fall in its price leads to an increase in quantity demanded. In the study, the estimated increase in quantity demanded was 0.13 percent for a one-percent decrease in price, an elasticity of 0.13. However the increase in quantity was defined in terms of the *probability* of cycling, rather in terms of the *quantity* of trips undertaken. Hence, we regarded the finding as useful but dependent upon another study.

That other study, by the UK's Brunel University, analysed the demand for sports and exercise among sixty respondents, some of whom were cyclists (Anokye et al, 2012). The quantity demanded was defined as hours expended on exercise rather than, ideally for us, as hours spent on cycling-related trips or visits. Because the respondents had different levels of money to be spent on sports and exercise, it was possible to estimate how the quantity demanded for hours would have changed if the price, as money to be spent, were to increase. The study found that a one-percent increase in price would have decreased quantity demanded by 0.25 percent, an elasticity of 0.25.

While this differed from an elasticity of 0.13 found of the previous study, both numbers were significantly less than one percent. In cost-benefit analysis, an elasticity that is less than one percent pertains to a category of similar goods or services that are classified as *inelastic*. It would have been disappointing if either of the studies instead uncovered an elasticity that was greater than one percent, since that would have meant a lack of any consensus concerning the nature of demands related to trail visits.

11. Consumer Surpluses: Findings Applied and Estimated

We gave equal weight to the two estimates for elasticity, one being deficient in defining our preferred definitions of quantity demanded, and the other being deficient in our preference for isolating trail-related visits from a demand for sport and exercise. Simplifying assumptions were required for calculating the consumer surpluses.

First, the point of reference for using the elasticity was an imaginary axis, for which the vertical portion was for recorded domestic spending pvpd, to represent a unit price. The horizontal portion was for recorded visits, to represent a quantity demanded. Second, the underlying demand curve was assumed to be linear rather than curved.

Third, the highest price that the visitors would have been willing to pay (the vertical intercept of their demand curve) was constrained to be $3000 pvpd. This constraint was based upon an understanding of what it would have cost to purchase luxurious goods and services on trails intended for high-income visitors. Nothing higher than this unit price was considered even though there might have been visitors who would certainly have been willing to pay more.

To calculate the surpluses we took the difference between $3000 and the recorded spending for each trail as a hypothesized change in unit price. A change in visits was then calculated as an elasticity response to this price change.

Table 11.1

Estimated Consumer Surpluses at a Demand Elasticity of either 0.13 or 0.25									
Trail	Annual Visits by Domestic Non-Commuters after Displacement	Domestic Spending pvpd, Surveys	Difference From Maximum Spending	Percent Deviation from Maximum	Pct Change in Visits at Elasticity of 0.13	Change in Visits at Elasticity 0.13	Consumer Surpluses at Elasticity of 0.13	Change in Visits at Elasticity 0.25	Consumer Surpluses at Elasticity of 0.25
St James Cycle Trail	667	$ 85.40	$ 2,914.60	3313%	4.31%	29	$ 41,836	55	$ 80,454
Hawke's Bay Trails	44,743	$ 266.87	$ 2,733.13	924%	1.20%	538	$ 734,561	1034	$ 1,412,617
Old Ghost Road	1,431	$ 113.42	$ 2,886.58	2445%	3.18%	45	$ 65,631	87	$ 126,214
Timber Trail	1,844	$ 116.09	$ 2,883.91	2384%	3.10%	57	$ 82,396	110	$ 158,453
Waikato River Trail	7,621	$ 137.44	$ 2,862.56	1983%	2.58%	196	$ 281,169	378	$ 540,709
Tasman Great Taste	23,445	$ 233.51	$ 2,766.49	1085%	1.41%	331	$ 457,309	636	$ 879,440
Otago Central Rail	3,940	$ 148.54	$ 2,851.46	1820%	2.37%	93	$ 132,869	179	$ 255,518
Queen Charlotte	2,898	$ 93.41	$ 2,906.59	3012%	3.92%	113	$ 164,927	218	$ 317,168
Motu Trails	5,241	$ 136.22	$ 2,863.78	2002%	2.60%	136	$ 195,351	262	$ 375,675
Alps to Ocean Trail	4,910	$ 401.64	$ 2,598.36	547%	0.71%	35	$ 45,359	67	$ 87,229
Mountains to Sea	7,403	$ 170.01	$ 2,829.99	1565%	2.03%	151	$ 213,049	290	$ 409,710
Queenstown Trails	40,626	$ 152.60	$ 2,847.40	1766%	2.30%	933	$ 1,327,809	1794	$ 2,553,479
Twin Coast Cycle Trail	4,127	$ 112.09	$ 2,887.91	2476%	3.22%	133	$ 191,862	256	$ 368,964
Hauraki Rail Trail	24,969	$ 137.24	$ 2,862.76	1986%	2.58%	645	$ 922,722	1240	$ 1,774,465
Te Ara Ahi Thermal	7,007	$ 64.05	$ 2,935.95	4484%	5.83%	408	$ 599,555	785	$ 1,152,991
Great Lake Trail	7,365	$ 94.74	$ 2,905.26	2967%	3.86%	284	$ 412,599	546	$ 793,459
Rimutaka Cycle Trail	19,741	$ 153.45	$ 2,846.55	1755%	2.28%	450	$ 641,019	866	$ 1,232,730
Dun Mountain	728	$ 50.71	$ 2,949.29	5716%	7.43%	54	$ 79,785	104	$ 153,433
West Coast Wilderness	4,750	$ 185.48	$ 2,814.52	1417%	1.84%	88	$ 123,177	168	$ 236,879
Roxburgh Gorge	4,319	$ 174.48	$ 2,825.52	1519%	1.98%	85	$ 120,533	164	$ 231,794
Clutha Gold	2,346	$ 235.13	$ 2,764.87	1076%	1.40%	33	$ 45,364	63	$ 87,238
Around the Mountain	3,115	$ 240.19	$ 2,759.81	1049%	1.36%	42	$ 58,617	82	$ 112,725
Uncounted Visits	18,554	$ 50.00	$ 2,950.00	5800%	7.54%	1399	$ 2,063,511	2690	$ 3,968,290
Averages	10,513	$ 173.13	$ 2,826.87	1998%	2.60%	544	$ 774,386	1046	$ 1,489,203
Visits and Consumer Surpluses	241,790					6,279	$ 9,001,010	12,074	$ 17,309,636
Average of Consumer Surpluses									$ 13,155,323

We multiplied the difference in price (for example, of $2915 on the St. James Trail) against the implied change in quantity (of 29 visits on that trail) and divided the product by two. The division was required for calculating a consumer surplus (e.g. of $41836 for the St. James Trail), which is equivalent to a triangular area embedded below a demand curve. We then summed the consumer surpluses across all trails.

The sum of the consumer surpluses was between $9.0 and $17.31 million, the average being $13.16 million.

12. Health Benefits: Reduced Mortality Risks

For benefits from exercising along the trails, we turned to a seminal investigation of physical activity among a sample of over 30,000 Copenhagen men and women (Andersen et al, 2000). We applied some of the investigation's findings for exercise-related reductions in mortality risk, seeing comparable similarities between the Copenhagen subjects and New Zealanders in terms of age, ethnicity and country economic characteristics.

In the Copenhagen study, participants were first classified into four medically-accepted categories of exercise intensity known as the Satin-Grimby Physical Activity Level Scale (SGPALS). The categories were originally proposed in 1968 concerning middle-aged and old former athletes. (see e.g. Grimby et al, 2015). They are numerically described as follows, according to increasing categories of physical intensity 1-4:

Table 12.1

1. Physical inactivity: to pertain to those participants who were mainly sedentary;

2. Some light physical activity: for (light) physical activity lasting at least four hours a week such as for walking, gardening, fishing, etc.;

3. Regular physical activity and training: for spending time doing heavy gardening, running, swimming, playing tennis, badminton, calisthenics and similar activities, for at least 2-3 hours a week;

4. Regular hard physical training for competitive sports: for spending time running, skiing, swimming, playing football, handball etc. several times a week.

In the Copenhagen study, participant deaths were recorded for each category over an observation period of fourteen years. As mortality rates, these deaths were found to be significantly lower for subjects with greater exercise intensities. For women in category 1 (physically inactive women), the mortality rate was 28% (919 of 3235 participants died during the observation period). For men in the same category, the mortality rate was 39% (1190 of 3024 participants died during the same period). By comparison the mortality rates for women in categories 2-4 were 19%, 17% and 11%. For men, the mortality rates were 31%, 28% and 16%, respectively.

In the study, a ***relative risk*** of death was obtained by choosing the mortality rate for category 1 (physical inactivity) as a base by which to divide the mortality rates for categories 2, 3 and 4. Thus, the relative risks of death for women would have been 68% for some light activity (19% divided by 28%); decreasing to 61% for regular physical activity (17% divided by 28%); and to 39% for regular hard physical training. For men they would have been 79%, 72% and 41%. These relative risks were eventually refined to control for the indirect consequences of age, education, body mass, and risk factors such as smoking, blood pressure and cholesterol level. After these factors were controlled for, the relative risks for women were concluded to be 68%, 65% and 59%, for categories 2-4 respectively. For men they were 79%, 72% and 71%.

The study was also particularly relevant because it included an investigation of commuters who cycled to work (22% of all respondents). Among women, the relative risk of death for those who cycled to work was not statistically-different from the risk of those who did not. However, among men, the relative risk for those who cycled to work was comparable to the one found for category 3 (regular physical activity).

13. Applying the Relative Risks: Research Impediments

We applied the above relative risks to domestic visitors, non-commuters and commuters. But three important impediments needed to be overcome. First, we had to estimate the number of unique individuals behind the reported numbers for visits, in order to align the data with research on individuals.

The numbers for unique individuals were obtained by postulating a frequency for how many times a certain kind of visitor might have visited the trail over a given year. The frequency depended upon types of cyclists that were self-described in Ryan et al, 2013. We used these types despite the limitation that they may not have applied to non-cyclists. For example, if a certain type took to the trail about twice a year, the annual visits for such types would have had to be divided by 2 in order to obtain a number unique individuals belonging to that type.

Second, we had to decide what proportion to use when attributing benefits from reductions in the relative risk of death. One reason was the previously-stated argument for a counter-factual: given a hypothetical closing-down of the trails, users might have found suitable other venues, thereby narrowing what range of benefits could be attributed to the trails. Another reason was that most individuals on the trails were likely to have been physically active in their hidden lifestyles, once again narrowing what range of benefits could be assigned. Finally, we had to make assumptions concerning how the SGPALS exercise categories could be applied in context.

14. Obtaining Estimates of Unique Individuals

An ideal choice for types would have been those used by Tourism New Zealand concerning Australian and American tourists, which canvassed active considerers and placed them on eight categories ranging from "having no interest in learning how to cycle" to being "a hard-core cyclist who travels to be in cycling events". However, to our knowledge, such a categorization was never surveyed of domestic (New Zealand) cyclists, either as nearby residents or tourists. (see e.g. NZ Ministry of Tourism, 2014). Also, the use of such a categorization would have overlooked the fact that domestic NZ users do not have to travel overseas in order to experience the locally-available trails, even though they may do so in the counter factual of the trails being closed.

Thus we decided to rely upon a choice of types used by Ryan et al (2013) in their study of the Hauraki Rail Trail. The history of how these types were chosen is not known. But the managing experts have suggested that they go back to New Zealand in the 1960's when there were debates about how the cycle trails were to be funded.

Table 14.1

Estimated Average Frequency of Visits: Non-Commuters vs. Commuters, All Trails, Year 2015		
Source: Ryan et al (2013) and Managing Expert Opinions		
Cyclist Type	Share of All Trail Visits	Frequency: Visits Per Year
Infrequent Leisure Cyclist	29.84%	1
Frequent Leisure Cyclist	29.05%	2
Leisure Cycling Enthusiast	13.31%	4
Commuter Cyclist, Counted Once per Commute	16.52%	12
Mountain Biker (6.36%) or Cycle Trail Searcher (3.14%)	9.50%	4
Competitive Cyclist	1.78%	8
Average Frequency Among Commuters		12.00
Average Frequency Among Non-Commuters		4.03
Average Frequency for All Types		3.92

For the frequency of visits per year, the opinions of the managing experts were solicited. The frequencies were then associated with the reported shares of use initially found by Ryan et al (2013) of the Hauraki Trail which were subsequently adjusted by the experts for a better representation of all 22 trails.

The share-weighted average was an annual frequency of 4.03 visits among non-commuters and 12 visits among commuters, assuming each commuting visit to be a return trip from school or work on the same day.   The seemingly-low frequency among commuters considered how commuting might be an irregular activity for many, being subject to weather conditions, physical well-being, competing alternatives and other important influences.

We used these averages as a denominator for estimating unique individuals. On their basis we estimated that there would have been around 60,030 unique non-commuters and 11,995 unique commuters for all trails in the course of the entire year.

Table 14.2

Estimated Unique Individuals from Annual Visits, Year 2015							
Trail	Annual Visits by Non-Commuters	Annual Visits by Domestic Non-Commuters before Displacement	Annual Visits by Domestic Non-Commuters after Displacement	Annual Visits by Commuters Before Displacement	Annual Visits by Commuters after Displacement	Unique Individual Non-Commuters at 4.03 Visits per Year	Unique Individual Commuters at 12 Visits per Year
St James Cycle Trail	2092	2020	667	0	0	165	0
Hawke's Bay Trails	145616	135584	44743	62103	20494	11108	1708
Old Ghost Road	4726	4335	1431	0	0	355	0
Timber Trail	6000	5587	1844	0	0	458	0
Waikato River Trail	24803	23095	7621	1030	340	1892	28
Tasman Great Taste	79233	71045	23445	16738	5523	5821	460
Otago Central Rail	16480	11938	3940	684	226	978	19
Queen Charlotte	10187	8783	2898	368	121	720	10
Motu Trails	17184	15882	5241	621	205	1301	17
Alps to Ocean Trail	17258	14880	4910	905	299	1219	25
Mountains to Sea	24639	22432	7403	1292	426	1838	36
Queenstown Trails	180224	123110	40626	31677	10453	10087	871
Twin Coast Cycle Trail	13432	12507	4127	1085	358	1025	30
Hauraki Rail Trail	77808	75664	24969	4080	1347	6199	112
Te Ara Ahi Thermal	21990	21232	7007	2434	803	1740	67
Great Lake Trail	23970	22318	7365	866	286	1829	24
Rimutaka Cycle Trail	64246	59820	19741	34413	11356	4901	946
Dun Mountain	2369	2206	728	61	20	181	2
West Coast Wilderness	16694	14394	4750	876	289	1179	24
Roxburgh Gorge	14058	13089	4319	359	119	1072	10
Clutha Gold	7636	7110	2346	235	78	582	6
Around the Mountain	11403	9439	3115	351	116	773	10
Uncounted Visits (Individuals)	65000	56225	18554	276000	91080	4607	7590
Total Visits	847048	732697	241790	436179	143939		
Total Unique Individuals						60030	11995

15. Isolating Mortality-Reduction Benefits

We initially considered assigning the physical fitness categories according to the types in Ryan et al (2013). But we decided that such assignments might be misleading. For example, while commuters may generally be physically active, we could not say whether they were more active than frequent cyclists. Not even if we relied upon hours spent on the trail. Someone who cycled longer than others may actually be less fit because of an inability to complete a trail within a targeted duration.

For these reasons we decided instead to match the fitness categories 2, 3, or 4, against known levels of physical difficulty associated with each trail, such as for steepness of terrain and smoothness of surface. The count-weighted average was a fitness category of 2.79, which typified the average individual to be in the upper bounds of undertaking “light physical activity” (category 2) but below the level of undertaking "regular physical activity" (category 3). We regarded this average as consistent with research expectations. By way of background, the average commuter cyclist in the Copenhagen study fitted into category 3 and they were regarded in that study as being much fitter than average.

16. Obtaining a Population Attributable Fraction (PAF)

Extending from the Copenhagen study, we applied each relative risk to a calculation of a population attributable fraction (PAF), which is defined by the World health Organization as the proportional reduction in the mortality *of a given population* if exposure to a risk factor were reduced to an ideal exposure scenario (World Health Organisation, 2016. See also Greenland and Robins, 1988). In this case, the risk factor was physical inactivity and the reduction in mortality risk was hypothesised as having been associated with the availability of the trails. Such an approach was recently used in a NZ study of illnesses associated with physical inactivity. (Wellington Regional Strategy, et al, 2013).

The reduction in exposure to physical inactivity was unknown. What was estimable was the current proportion of those on the trails who might have been physically inactive. In the opinion of the managing experts, this would have been small. A large percentage could not be justified because anyone physically inactive would probably have never visited the trails.

It was also not known whether the trails might have changed prior exercise attitudes. There was no clear consensus as to whether facilities like cycle trails actually have an effect on exercise attitudes. Some researchers emphasise that their availability can have a strong influence upon activities like cycling (Parkin, 2012). Others say that such facilities only create opportunities for exercise, with any effects being instead the result of individual and social factors (Corti et al, 2002). Thus, a decision was made to assign only a small change, of one percentage point, to the number of individuals switching from being inactive to being active as a consequence of the trails being available for them to use.

Following a PAF approach, we defined the relevant population as all unique on the trails for the year 2015. A one percent change in exercise attitudes meant starting with some percentage for the physically inactive which we decided upon as 3%, before being reduced by the trails to a level of 2%. A PAF was calculated following the guidelines of the World Health Organization (2016), as described below.

PAF = (p1*RR – p2*RR) / (p1*RR)

The value for p1 is 98%, the proportion of unique individuals believed to be physically-active. The value for p2 is a hypothesised proportion of physically-active individuals "before-or-without" the-trails. With a one-percentage point reduction in physical inactivity, the value for p2 is therefore 97%. The value for RR is the reduction in relative mortality risks associated with an SGPALS physical-activity category of either 2, 3, or 4. For example, the St. James Trail was categorised as a level 3 trail, one that conformed to use by someone who engaged in regular physical activity and training.

18. Using a Statistical Value for Life

Each of the calculated PAFs was multiplied by an *annual* equivalent to a statistical value of life (SVOL). This equivalent was $177,880 based upon a year 2015 SVOL of $4.06 million (NZ Ministry of

Transport, 2016). It was obtained by applying a procedure, shown below, proposed by Aldy and Viscusi (2006) in research concerning how the SVOL should follow the shape of an inverted-U if tracked across age.

Annual SVOL = 0.07*(SVOL) / (1 – (1.07)$^{-(L)}$)

In the procedure, a discount rate (of 7% in this case, following NZ Treasury guidelines) was used to annualise the SVOL before dividing the result by a discount factor based upon remaining life-years, L. (See also Clough et al, 2015).

We averaged the SVOLs in Aldy and Viscusi (2006) across the different age groups. We found this average to be $6.575 million. Then we did the same for the annual SVOLs, for which we found an average of $296 thousand. We took the ratio of the annual equivalents to the SVOLs, of 4.38%, to predict an annual equivalent of $177,880 corresponding to a NZ SVOL of $4.06 million.

The SVOL estimate did not seem to us to be remarkably different from recommended best practice in Australia, which was to apply an annual equivalent of $151,000 for a SVOL of $3.5 million (Australian Department of Prime Minister and Cabinet, 2014). Had we followed this recommendation, the annual equivalent to the SVOL would instead have been $175,160.

Table 18.1

Savings from Decreased Mortality Rates: Domestic Non-Commuters versus Commuters						
Cycling is 11.5% of Top Ten Sporting Activities. Men versus Women are split 54/46. The Annual SVOL is $177,880.						
Trail	Saltin Grimsby Average Physical Level to the Nearest Digit	Relative Risks RR to Inactivity (Category 1), Copenhagen Males	Relative Risks RR to Inactivity (Category 1), Copenhagen Females	PAF Among Both Sexes: WHO Approach at 1% Exposure	Benefits from Reduced Mortality Risks: Domestic Non-Commuters	Benefits from Reduced Mortality Risks: Commuters
St James Cycle Trail	3	0.72	0.61	0.00755037	$ 25,561	$ -
Hawke's Bay Trails	2	0.79	0.68	0.00813280	$ 1,848,077	$ 284,127
Old Ghost Road	4	0.41	0.39	0.00562014	$ 40,836	$ -
Timber Trail	3	0.72	0.61	0.00755037	$ 70,695	$ -
Waikato River Trail	3	0.72	0.61	0.00755037	$ 292,248	$ 4,374
Tasman Great Taste	2	0.79	0.68	0.00813280	$ 968,386	$ 76,576
Otago Central Rail	2	0.79	0.68	0.00813280	$ 162,727	$ 3,130
Queen Charlotte	3	0.72	0.61	0.00755037	$ 111,146	$ 1,564
Motu Trails	3	0.72	0.61	0.00755037	$ 200,973	$ 2,638
Alps to Ocean Trail	2	0.79	0.68	0.00813280	$ 202,823	$ 4,141
Mountains to Sea	3	0.72	0.61	0.00755037	$ 283,865	$ 5,488
Queenstown Trails	2	0.79	0.68	0.00813280	$ 1,678,055	$ 144,923
Twin Coast Cycle Trail	2	0.79	0.68	0.00813280	$ 170,471	$ 4,964
Hauraki Rail Trail	2	0.79	0.68	0.00813280	$ 1,031,334	$ 18,668
Te Ara Ahi Thermal	2	0.79	0.68	0.00813280	$ 289,409	$ 11,136
Great Lake Trail	3	0.72	0.61	0.00755037	$ 282,425	$ 3,680
Rimutaka Cycle Trail	3	0.72	0.61	0.00755037	$ 756,984	$ 146,166
Dun Mountain	4	0.41	0.39	0.00562014	$ 20,781	$ 191
West Coast Wilderness	3	0.72	0.61	0.00755037	$ 182,150	$ 3,719
Roxburgh Gorge	3	0.72	0.61	0.00755037	$ 165,637	$ 1,526
Clutha Gold	3	0.72	0.61	0.00755037	$ 89,968	$ 1,000
Around the Mountain	2	0.79	0.68	0.00813280	$ 128,659	$ 1,608
Uncounted Visits	3	0.72	0.62	0.00294187	$ 277,221	$ 456,763
Total Benefits From Reduced Mortality Risks					$ 9,280,430	$ 1,176,381

Only a proportion of the SVOL was made attributable to the trails. The proportion was 11.5% based upon the share of cycling among the top ten sporting activities, year 2013/14. (Sport New Zealand, 2014). This adjustment was necessary because it was unacceptable to assume that trail visitors obtained all of their exercise benefits solely from cycling, with no consideration at all as to the other major sporting activities such as walking, swimming, or golf.

The top ten rather than the top twenty of all activities was chosen because cycling would have ranked highly in the minds of the visitors, otherwise they would not have gone through the trouble of visiting the trails.

Finally, we multiplied the PAF-adjusted SVOL by the number of unique domestic cyclists (UDC's) on the trails. For all trails, the reduced-mortality savings was $9.28 million for among non-commuters, and $1.18 million for among commuters.

19. Savings in Health Costs

Exercise while cycling on the trails would also have averted health costs from diseases associated with physical inactivity. The most important of these diseases are coronary heart disease, hypertension and stroke, two types of cancer (colorectal and breast), type II diabetes, osteoporosis, and depression (The British Heart Foundation, 2014). These costs are different from those associated with mortality risks because they relate to caring for patients with such diseases.

For the health costs, we referred to the NZ-applicable sources used by the Wellington Regional Strategy (WRS, 2013). These were updated to year 2015 using the health index component of the NZ consumer price index. For the cancers, the costs included primary consultations, public hospital charges, outpatient attendance, laboratory and pharmacy expenses, and national travel assistance for the year 2012 over a typical treatment period of six years. (Ministry of Health, 2011).

For type 2 diabetes, the costs included the treatment of all complications, hospitalisations, and the provision of specialist diabetes services (NZ and PriceWaterHouse Coopers, 2001).

For osteoporosis, they included the treatment of hip, vertebrae and other types of fractures, and the subsequent management of them. (School of Population Health, University of Auckland, 2007).

For coronary heart disease, hypertension and stroke, we divided the national estimates in WRS (2013) by case numbers derived from hospital discharges.

The estimated annual costs per incidence of the disease are shown below. The relative risks of acquiring each type of disease were provided by WRS based upon international epidemiological studies. We constructed a PAF for each type of disease based upon these and the assumption of a one-percent previous exposure to physical inactivity.

The use of a relative incidence for each disease makes for the estimated health savings to be quite low. It is entirely possible that more than one of these diseases would co-exist in one individual, a co-existence known as co-morbidity. Hence, the taking of an average cost from all of them would be low if a several diseases were to occur simultaneously. But neither was it justifiable to sum up all of the individual disease costs, as that would have assumed that all of the diseases would be co-morbid. Until epidemiologists come to some agreement as to which of the diseases are co-morbid and which are not, we decided it appropriate to average the different disease costs according to relative incidence.

The savings in health costs were obtained with the continued assumption that exercising on the trails was only one of many other exercise opportunities. Thus, initial estimates were multiplied by the share of cycling among the top ten sporting activities, which was 11.5%. After applying these calculations, the estimated total savings for all 22 trails was around $582 thousand among non-commuters and $116 thousand for commuters.

Table 19.1

Estimated Savings in Health Costs: Non-Commuters versus Commuters							
Cycling is 11.5% of top ten sporting activities. Disease costs are averaged according to their relative incidence.							
Disease	Treatment Cost in 2015 dollars	Relative Risks, WRS Estimates	PAF among Unique Domestic Visitors: At 1% Exposure	Health Costs Saved Per Individual Disease	Relative Incidence of Disease in NZ	Savings in Health Costs: Domestic Non-Commuters	Savings in Health Costs: Commuters
Colorectum cancer	$ 27,556	1.66	0.4445%	$ 122.48	4.52%	$ 38,256	$ 7,644
Breast cancer	$ 31,163	1.21	0.0450%	$ 14.02	6.79%	$ 6,576	$ 1,314
Diabetes II	$ 8,946	1.5	0.2551%	$ 22.82	42.36%	$ 66,732	$ 13,334
Osteoporosis	$ 15,818	1.59	0.3552%	$ 56.19	20.37%	$ 79,029	$ 15,791
Coronary heart disea	$ 14,490	1.45	0.2066%	$ 29.94	5.07%	$ 10,485	$ 2,095
Hypertension	$ 8,483	1.3	0.0918%	$ 7.79	1.05%	$ 564	$ 113
Stroke	$ 89,287	1.6	0.3673%	$ 327.99	16.63%	$ 376,605	$ 75,251
Depression	$ 20,464	1.28	0.0800%	$ 16.37	3.20%	$ 3,617	$ 723
Estimated Savings in Health Costs, Domestic Non-Commuters versus Commuters						$ 581,864	$ 116,265

20. Commuting Estimates

It is well known that commuting by bicycle typically takes longer than some alternatives, such as by car, and that this is one its main disadvantages. But for how much longer, we relied upon the Hauraki Rail Trail Survey (Ryan et al 2013) for estimates of distances and times. A total of 551 respondents were asked the planned distances and durations of their rides during a day of interviews. Around 15 percent planned to cycle within a distance of 20 km while a cumulative majority of just over 50 percent planned to cycle within 40 km. Around 21% planned to cycle up to two hours while a cumulative majority of 65% planned to cycle up to four hours. On average, the plan was to cover an average distance of 36 kms over a completion period of just over 3 hours. Average cycling speed, which we used for commuting, would thus have been just over 11 kms per hour.

Table 20.1

Hauraki Trail: Planned Distances and Times to Completion					
Planned Distance for the Day	Respondents	Percent	Planned Time	Respondents	Percent
Up to 10 kms	11	1.90%	1 hr or less	25	4.10%
Between 10 to < 20 kms	70	12.70%	Between 1 to < 2 hrs	103	16.90%
Between 20 to < 30 kms	151	27.41%	Between 2 to < 3 hrs	137	22.40%
Between 30 to < 40 kms	44	7.98%	Between 3 to < 4 hrs	131	21.40%
Between 40 to < 50 kms	206	37.38%	Between 4 to < 5 hrs	69	20.60%
Between 50 to < 60 kms	23	4.17%	5 Hours and over	33	13.60%
60 kms and over	46	8.34%			
Total	551	99.88%	Total	498	99.00%
Average Planned Distance, kms		35.76			
Average Planned Time to Completion, hrs		3.19			
Average Speed, kms per hr		11.21			

We used this average speed to infer an average amount of time for a trail commute. In a study of commuting patterns in year 2006, NZ Statistics found a median distance covered of 3.3 kms per cycle commute. (NZ Statistics, 2006). Using this, the average speed found of the Hauraki Trail Survey would have translated to around 0.19 kms per minute.

On this basis, the average commuting trail-cyclist would thus have taken around 18 minutes to commute to either work or school from home.

21. The Cost Advantages of Commuting by Bike versus by Car

We used these inferences to uncover any cost advantages to commuting by bike versus commuting by car. Commuting by public transportation and other modes was ignored. As a comparator, we assumed that the car would instead be travelling at a higher average speed of 40km per hour, implying a shorter commute time of around 5 minutes for the distance of 3.3 kms to be covered.

We valued the longer time it took to bike (of around 13 minutes) by an hourly wage of $29.40, as reported for the year 2015. (Trading Economics, 2016). The equivalent of this was $8.25 per commute, shown in the table below.

The difference between this and the lower time-related cost to commuting by car is shown as a negative number (a disadvantage). Assuming 24 commuting instances for 12 return frequencies among all unique individuals, the time disadvantage translated to $1.79 million for the year.

Nevertheless, we made an exception to treating commutes as a complete waste of time. This treatment had come from the traditional assumption of commutes being harsh experiences, what with cars, buses, traffic lights and road rage. It did not wholly apply to the trails, which in the opinion of the managing experts was supposed to be an experience of leisure, judging even from the primary reasons for why they were built.

We accepted this dissenting view by assigning a leisure benefit that was also equal to $8.25 per commute. The equality was justified by microeconomic theory, which proposes that leisure time is chosen until its benefit has become equal to a foregone wage. Over identical assumptions concerning frequencies and unique individuals, the leisure benefit amounted to around $2.49 million. This, in addition to benefits from reduced mortality risks ($1.18 million) and from reduced health costs ($116 thousand).

For maintenance costs, we assumed an annual operating cost of $300 for maintaining a bike, versus $2290 for that of a car in the year 2015. The car operating cost was sourced from NZ Transport Agency statistics for year 2012, of $2422, deflated to year 2015 by 5.5% because of a fall in overall transport prices (NZ Transport Agency, 2012). The car cost included petrol costs, repair and maintenance, insurance and registration but not the fixed purchase costs, as there was no compelling reason to believe that the car would be completely replaced by a bike. For this type of cost comparison, commuting by bike had a cost advantage of around one cent per commute.

Yet another disadvantage to commuting by bike was the higher relative risk of accidental death, of 0.1012 by bike versus 0.1006 by car, on account of unprotected vulnerabilities (De Hartog et al, 2010). However, the managing experts indicate that this risk is mitigated by the fact that only ten percent of the Great Rides are shared with cars, the primary source of accidental deaths. We took this into consideration while calculating a PAF for the higher relative risk and monetised it at by hourly wage of $29.40, to find a small disadvantage.

Table 21.1

The Cost Advantages or Disadvantages of Commuting by Bicycle versus Car, Year 2015						
Summed over Unique Individual Commuters						
Average Commuting Distance of 3.3 kms	Bicycle at 11 km per hour			Car at 40 km per hour	Bicycle Cost Advantage Per Commute	Bicycle Advantage (+) or Disadvantage (-)
Exercise Benefits from Reduced Mortality Risks						$1,176,381.15
Benefits from Reduced Health Costs						$116,265
Average Time Spent Per Commute, Minutes	17.66			4.95	-12.71	
Cost of Time at NZ$29.40 Hourly Wage	$8.6527			$2.4255	-$6.2272	-$1,792,672
Leisure Benefit at NZ$29.40 Hourly Wage	$8.6527			$0.0000	$8.6527	$2,490,920
Bike/Car Operating Costs Per Commute	0.0101			$0.0216	$0.0115	$3,307
Relative Mortality Risk While Commuting: Only 10% of Trails Shared with Cars	0.10120			0.1006	-0.0006	-$173
Air Pollution Costs of 0.004 Euro per Car km: NZ$ 1.66 to 1	$0.00			$0.0219	$0.0219	$6,308
Climate Change Cost at 0.005 Euro Cer km	$0.00			$0.0274	$0.0274	$7,885
Noise Pollution at 0.048 Euro per Car km	$0.00			$0.2629	$0.2629	$75,696
Road Deterioration at 0.001 Euro per Car km	$0.00			$0.0055	$0.0055	$1,577
Congestion Costs at 0.062 per car km	$0.00			$0.3396	$0.3396	$97,774
Bicycle Cost Advantage To Car: Negative for Disadvantage						$2,183,140

Obvious advantages to commuting by bike lay in the prevention of social costs from air and noise pollution, climate change, road deterioration and congestion. We estimated these in 2015 NZ dollars per commute based upon costs originally provided in euro per kilometre by de Hartog et al (2010). We assumed an exchange rate of NZ$1.66 per euro and identical previous assumptions as to commuting distance, commuting instances and unique individuals per year. In the overall, commuting by bike had a cost advantage of $2.18 million a year over commuting by car.

22. Concluding Remarks

We would have gone on to estimate other benefits, had there not been insurmountable constraints as to funding and survey-information. As an example of other possible benefits, the trails were also routinely used by families and friends for picnics and special occasions, rather than as a place to cycle, run or walk. There would have been social-interaction benefits to these gatherings.

The benefits could be priced according to an average wage, since leisurely activities are supposed to be undertaken up to the value of foregone work. However, one would need more information than currently provided by even the managing experts, such as the number of such families and friends and the demographic characteristics pertaining to their employment, income and age.

Also for further study would be a suitable time frame, over one year, by which to consider the trails' benefits and costs. Such a time frame was outside of scope, even though it is customary of a CBA. The choice of such a frame should not only consider the trails' future incomes, capitalisations, costs and risks, both geographical and political. It should also intertwine the life of the trails with the expected life expectancies of a cohort of users. Because a time frame based upon the life expectancy of inanimate infrastructures would not be as pertinent as one based upon the life expectancies of their users.

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