FINAL

TTAC Limited

For More Effective Management of Risk and Uncertainty

Risk Comparisons for DOC Visitors and Workers

a report produced for GNS Science

by Tony Taig

TTAC Limited

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This report has been produced by TTAC Limited for the NZ Department of Conservation under a sub-contract to GNS Science

Executive Summary

This is the report of a study for the New Zealand Department of Conservation (DOC) to assemble risk comparisons to help DOC develop guidance on the appropriate response to natural hazard risk for visitors to and staff working on NZ Public Conservation Land (PCL). The study was largely carried out during 2019-20 by GNS Science and TTAC Ltd (UK), under the leadership of Tony Taig (TTAC Ltd).

In parallel, companion reports have been developed by GNS Science and TTAC Ltd to provide guidance on carrying out the natural hazard risk analyses which generate risk information (GNS Science), and to apply that information in risk evaluation and policy (TTAC Ltd).

This report provides

- An introduction (Section 1) and a discussion of the principles for choosing and presenting risk metrics for use as comparators in this context (Section 2)
- An overview of fatality risk levels experienced on NZ Public Conservation Land (PCL) in recent years, by both workers and visitors, as individuals and in aggregate (Section 3)
- Selected information on individual risk in other contexts including
  - those in New Zealand workplaces (Section 4)
  - general and accident mortality for New Zealanders and international visitors (Section 5)
  - outdoor sport and leisure activities for New Zealanders and international visitors (Section 6)
  - travel to and from DOC administered (PCL) locations (Section 7)
  - broadly comparable outdoor activities overseas (Section 8), and
- An overview of aggregate accident fatalities experienced in New Zealand, in terms both of annual total lives lost and frequency of major events of concern (Section 9).

To a large extent this report presents comparative risk information based purely on past experience, and with relatively little comment. No attempt is made to project risk levels forward into the future to take account of possible social, demographic, environmental, technological or other changes. Relevance for DOC and recommended starting points for risk-based decision guidelines are discussed in the companion report mentioned above.

The recommendations and findings of this study are summarised as follows:

1. The most appropriate risk metrics for use by DOC to inform decisions about safety risk on PCL are
   a) For workers: annual individual fatality risk (AIFR)
   b) For visitors: fatality risk per visitor day
   c) For prioritising improvements: total fatalities per year (or weighted total fatalities and injuries as and when reliable data becomes available), and
   d) In considering risk tolerability at a wider than individual level: frequency of specific severe events (for example involving >N fatalities, or involving particular DOC liability).

2. Visual representation of risk metrics, particularly for visitors, can help
   a) Avoid confusion when presenting small numbers in terms such as 10^{-N}, and
   b) Enable the scale and sources of uncertainty and variability in risk levels to be simply represented.

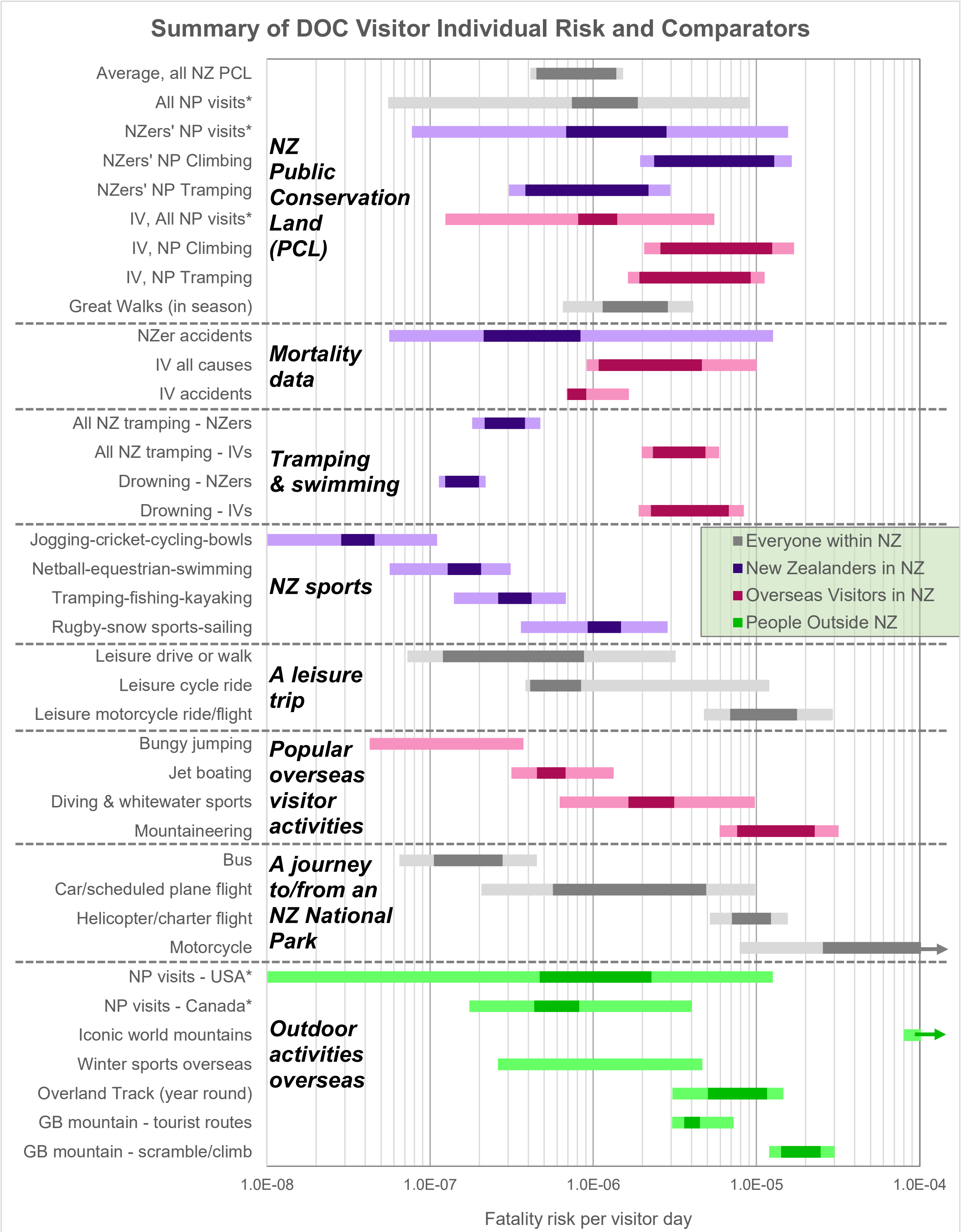
   It is recognised that it is difficult to achieve (b) in a consistent way.

3. Like other employment sectors where most people work in an active, outdoor environment, the Arts & Recreation Services (A&RS) sector of which DOC is part experiences relatively high workplace AIFR, of order 10^{-4}/yr. Though the numbers of staff working for DOC and the associated numbers of deaths are too small to allow conclusions to be drawn of high statistical significance, it appears that
   a) DOC permanent staff (AIFR)fatality risk over the past 20 years has been similar to the A&RS average of about 10^{-4}/yr, though
   b) The main hazard for DOC permanent staff has been travel by helicopter (which is not included in the WorkSafe NZ statistics on which these comparisons are made), and
   c) The fatality risk for temporary and volunteer workers is higher again than that for permanent staff, and could be as high as 10^{-3} per equivalent year worked for some staff.

4. The average individual fatality risk experienced by visitors to PCL over the past decade was between about $3x10^{-7}$ and 10^{-6} per visitor day (or part of a day). More detailed breakdowns were able to be made for visitors to National Parks and are shown in comparison with other risks in Figure ES1. Notable points include
   a) The accident risk per day spent in a National Park is broadly similar to the average accident risk per day spent living in New Zealand for residents, or per day spent in New Zealand for visitors.
   b) Risk levels vary across National Parks, from around 10^{-7} to nearly 10^{-5} per day, with Paparoa and Abel Tasman at the lower end of this range (10^{-7} to 10^{-6} per day) and Kahurangi, Aoraki and Fiordland at the higher (above 10^{-6} per day).
   c) International and domestic overall risk per visitor day on NZ PCL is similar. The risk associated with climbing for both international visitors and New Zealanders is 3-10x higher than the average risk per day spent at National Parks.
   d) The risk per day associated with tramping is about 4-6x higher for international visitors to National Parks than for New Zealanders. Overseas trampers experience a similar risk to climbers, whereas NZ trampers experience no greater risk than do average National Park visitors.
   e) The only other area (swimming) in which it was possible to analyse significant numbers of both international visitor and New Zealander fatalities also suggested that risk for international visitors is substantially greater (by possibly 10x or more per swim) than that for New Zealanders.
   f) The risk per day's participation in most sports for New Zealanders (other than sailing/ boating) appears similar to or lower than that experienced per day spent in National Parks.
   g) Leisure journeys on New Zealand roads may involve lower risk than a day spent in a National Park for safer walkers and drivers, but involve higher risk for less safe drivers or pedestrians and many cyclists – and considerably higher risk for motorcyclists.

   [continued after Figure ES1]

Figure ES1: Summary of Individual Fatality Risk for DOC Visitors and Comparators



***Notes**: IV = International Visitor, NZer = New Zealand resident; see text for details & assumptions.*
** Ranges from lowest to highest risk park; other NZ PCL figures are averages over all parks/walks*

h) Most popular "adventure" activities for visitors to New Zealand involve similar or greater risk per experience than a day spent in a National Park, with climbing/mountaineering risk levels extending well above 10^{-5} per day. A notable exception is bungy jumping which, with no fatalities to date in many millions of jumps, has involved lower risk per jump than that per day spent in any but the safest National Parks.

i) Unless travelling by bus, the risk travelling to and from National Parks is comparable to or greater than that spending a day there for travellers using private cars/vans or scheduled flights in small aircraft. For travellers by charter flight or by motorcycle the risk getting to and from National Parks is substantially greater than that experienced in a day there.

j) The risk per day to NZ National Park visitors is similar to that experienced by visitors to more or less comparable National Parks in North America. The range of risk per day in North American parks extends below that in New Zealand, for example for parks in and around cities where visitors almost all arrive by car and undertake little physical activity. Parks frequented by specialist climbers, divers or participants in other higher risk activities experience similar levels of risk in NZ and in the US and Canada.

k) The risk per day experienced on the New Zealand Great Walks is similar to or lower than that experienced by walkers on comparable iconic walks in Tasmania and Great Britain (noting that the latter include winter while the former are for Great Walk season only).

l) Serious mountaineers overseas (and in New Zealand) involved in high altitude or particularly challenging climbs regularly experience fatality risk at levels in the range 10^{-4} to 10^{-3} per day or higher.

5. The aggregate annual burden of fatalities on NZ PCL is around 22 deaths per year. For New Zealanders the burden of fatalities on PCL is less than 1% of the overall burden of accident fatalities per year. For international visitors it is more significant, as would be expected from their higher proportion of time spent at National Parks.

6. Over the past few decades NZ PCL have experienced about 15 fatal accidents per year (a few percent at most of the NZ total of events killing 1 or more people). The single disaster at Cave Creek contributed 10% of the NZ total of events killing 10 or more people in the last 50 years. Accidents on PCL are a significant contributor to the overall frequency of major events (defined as those killing 5 or more people) in New Zealand. Natural hazards at individual visitor sites have the potential significantly to increase the frequency of major events on PCL.

7. Although all the comparative risks estimated in this report are subject to considerable uncertainty and variability across the population, they provide a more relevant and meaningful basis for setting risk on NZ PCL in context than do literature sources which have focused on risk to the public around hazardous installations.

Tony Taig
TTAC Ltd
February 2022

Contents

1 Introduction

This is the report of a research project for the New Zealand Department of Conservation (DOC) carried out during 2019-20 by GNS Science and TTAC Ltd (UK), under the leadership of Tony Taig (TTAC Ltd). The research has two objectives:

1. To develop suitable risk comparisons to assist DOC in developing guidance on the appropriate response to different levels of natural hazard risk for visitors to and staff working on NZ Public Conservation Land (PCL), and
2. To review practice in areas where risk-based decision making or regulation is well-developed and in other national park management bodies, and develop guidance for DOC on the appropriate response to different risk levels for visitors and workers.

A parallel project led by GNS Science is developing guidance on carrying out the natural hazard risk analyses which generate such risk level information[1].

This is the report on the first of these objectives. It contains

- An introduction explaining what risk metrics need to be compared, for whom, and the presentation used throughout this report (Section 2)
- An overview of the fatality risk levels experienced by visitors and workers in recent years in places DOC manages, which are referred to here as Public Conservation Lands or PCL (Section 3)
- An overview of the risk faced by New Zealanders in the workplace, in particular in workplaces of relevance to DOC (Section 4)

[1] de Vilder S, Massey CI, Power WL, Burbidge DR, Deligne NI, Leonard GS. 2020. Guidelines for natural hazard risk analysis on public conservation lands and waters – Part 1: risk analysis framework. Lower Hutt (NZ): GNS Science. 22 p. Consultancy Report 2020/50. Prepared for: Department of Conservation.

de Vilder SJ, Massey CI. 2020a. Guidelines for natural hazard risk analysis on public conservation lands and waters – Part 2: preliminary hazard and exposure analysis for landslides. Lower Hutt (NZ): GNS Science. 27 p. Consultancy Report 2020/51. Prepared for: Department of Conservation.

de Vilder SJ, Massey CI. 2020b. Guidelines for natural hazard risk analysis on public conservation lands and waters – Part 3: analysing landslide risk to point and linear sites. Lower Hutt (NZ): GNS Science. 52 p. Consultancy Report 2020/52. Prepared for: Department of Conservation.

de Vilder SJ, Massey CI. 2020c. Guidelines for natural hazard risk analysis on public conservation lands and waters – Part 4: a commentary on analysing landslide risk to point and linear sites. Lower Hutt (NZ): GNS Science. 64 p. Consultancy Report 2020/53. Prepared for: Department of Conservation.

Power WL, Burbidge DR. 2020. Guidelines for natural hazard risk analysis on public conservation lands and waters – Part 5: preliminary hazard and exposure analysis for tsunami. Lower Hutt (NZ): GNS Science. 22 p. Consultancy Report 2020/54. Prepared for: Department of Conservation.

Deligne NI, Leonard GS, de Vilder SJ. 2020. Guidelines for natural hazard risk analysis on public conservation lands and waters – Part 6: preliminary hazard and exposure analysis for volcanic and geothermal hazards. Lower Hutt (NZ): GNS Science. 48 p. Consultancy Report 2020/55. Prepared for: Department of Conservation.

- A selection of possible relevant individual fatality risk comparators, including
  - general mortality among residents and international visitors to NZ (Section 5)
  - sport, leisure and outdoor activities(Section 6)
  - travel to and from National Parks (Section 7)
  - broadly comparable national park visits and outdoor activities overseas (Section 8), and
- An overview of aggregate risk levels experienced to date in New Zealand, in terms both of annual total lives lost and frequency of specific events of concern (Section 9).

To a large extent this report presents comparative risk information with relatively little comment. Relevance for DOC and recommended starting points for risk-based decision guidelines are discussed in the companion report on Objective 2 above[2].

[2] A R Taig, "Guidelines for DOC on dealing with Natural Hazard Risk", report for GNS Science, February 2022

2 Risk Comparisons and Guidelines

There are no established risk tolerability guidelines of which I am aware for visitor risk to national parks or other public open spaces. The natural starting point for DOC to develop such guidelines is to compare the natural hazard risk faced by visitors with other risks those visitors might face when participating in relevant activities. This section of the report provides

- a discussion of the general approach to selecting risk comparators, and of the most appropriate metrics for DOC visitors and workers (2.1) and
- an explanation of the approach to selecting and presenting comparators used in this study (2.2).

2.1 General Approach and Choice of Metrics

Although comparing risks can be notoriously difficult, knowledge of risk levels associated with other relevant activities may greatly help DOC both

a) in deciding whether/when to take action to reduce risk, and

b) in communicating risk levels to visitors, to help them make their own decisions.

Different risk metrics and levels may be appropriate for these purposes, and for different visitor groups with different risk appetites and capability to deal with hazards.

In making decisions on what to do about risk, the tolerability of risk framework developed by the UK Health & Safety Executive[3] provides a useful context, dividing risk levels into three:

a) an upper threshold of tolerability, above which the risk level is so high that the risk must be reduced or the activity giving rise to it must be stopped

b) a lower threshold, below which the risk level is small relative to many other comparable risks that people accept in their everyday lives, and for which there is no special pressure to reduce risk further (indeed it may be counterproductive to divert resources that could be better used elsewhere to reducing risk at such levels), and

c) in-between, an area where, though risk levels are not intolerable, it is desirable to reduce risk to the lowest practicable level. Almost inevitably this means prioritising among alternative possible risk reduction actions to achieve the lowest practicable risk level consistent with resources, stakeholder preferences and other factors.

By implication, when conveying information about risk levels at a particular site to visitors, the aim is to help those visitors decide

a) Do I want to go ahead and expose myself (and my party) to this risk at all?

b) If I go ahead and visit, what special hazards should I be aware of and how can I best control them? Or

c) Can I comfortably go ahead visiting this site without taking precautions over and above the general good sense needed when visiting outdoor/remote locations?

[3] Most recently in "Reducing Risks, Protecting People – HSE's Decision Making Process", UKHSE, 2001

While DOC, Ministers or newspapers might have a strong focus on how often accidents occur or how many people get killed, the first consideration for a visitor (if they consider it at all) is likely to be “What risk level will I or my party face?”

Most established risk-based decision guidelines or criteria relate to the protection of people in workplaces and to those outside hazardous installations, and adopt different levels for workers and for members of the public. Such decision frameworks also generally focus first on the level of risk to the individual (the AIFR), giving differential consideration to people depending on factors such as their degree of choice in whether to undertake the activity, their opportunity and/or ability to control the risk, and the benefit they gain from the activity giving rise to it.

In considering risk to workers, DOC can usefully compare the risk its own workers face with the risk faced by workers in other New Zealand or outdoor workplaces in terms of individual fatality risk per year at work[4]. In considering risk to visitors, other guidance on risk to members of the public is less useful, as the context is so different. Table 1 outlines some of the different contextual issues that need to be considered in developing risk comparisons for DOC workers and visitors in comparison with other “hazardous installation” type situations.

Table 1: Some Potentially Important Contextual Issues in Risk Comparisons

Issue	Worker	Member of public near a hazardous installation	DOC Visitor – outdoor hazards generally	DOC Visitor or Worker – Natural hazards
Choice over whether to accept the risk	At DOC or elsewhere, staff can choose where to work	Typically little or no choice	Free to decide whether to visit or not	Not visible and often not really considered when choice is made
Control over the risk	Typically good opportunity to control	Typically little or no opportunity to control	Plenty of advice & guidance available – may ignore it	No control over occurrence; may be able to mitigate outcome but may not know how.
Benefit from the activity	Salary and other benefits of employment	Typically no particular benefits	Highly valued part of many peoples’ lives	None
Acceptance of responsibility for risk control	Generally well recognised	None	Wide range from well recognised to complete unawareness	Even high skilled outdoor adventurers may lack relevant knowledge

[4] For unusual tasks and volunteers whose service is measured by the day it may sometimes be more appropriate to use risk per day as the metric. This is discussed in greater length in the companion Guidance document.

There may also, though, be issues over and above the risk faced by individuals. For example, DOC recently took action to relocate the Mintaro Hut on the Milford Track, which was at risk from rockfalls and landslides. While the individual risk was significant in triggering this decision, it was also highly relevant both

- That when the hut is occupied it generally has 40 people booked in every night through the Great Walk season – so the issue in the event of a landslide is not just "someone might die" but "40 people might all be killed at once", and
- That the hut is a facility owned and maintained by DOC, a department of the NZ government, and visitors might legitimately feel that whatever risks they face out on the track they should be entering a place of safe refuge when they walk through the door.

In deciding what to do about natural hazard risk, DOC thus needs to consider

a) The risk faced by its workers, for which annual individual fatality risk (as is widely used in other risk management frameworks worldwide) is the appropriate metric. Fatality risk per day may also be a useful metric for occasional, higher risk tasks or for volunteers whose service is measured by the day rather than by the year.

b) The risk faced by visitors as individuals

c) Events which might have significance above and beyond the risk to individuals (e.g. where individual life risk is low but the aggregate loss of life or social or economic costs are high)

d) For risks which are significant but not intolerable, what best to do to reduce risk.

As regards the individual risk faced by visitors, annual fatality risk is not particularly relevant, as most visitors will spend only a small proportion of a year visiting PCL. Several recent assessments of visitor risk both on NZ PCL and elsewhere (see Section 3.2) have focused on the individual fatality risk per day and/or per experience of a particular outdoor activity that could be experienced within a day or part of a day. This provides a more relevant and meaningful basis for comparisons between, for example, a day spent tramping in a National Park and a day when a visitor goes jet boating, gliding, swimming or bungy jumping.

Ideally it would be good to include injury as well as death in considerations of what to do about risk. In practice this is difficult, as definitions of injury levels and arrangements for reporting and recording injuries vary so widely from country to country and from one context to another. In developing guidelines on tolerability this report therefore focuses on fatality risk.

In the context of natural hazards it further needs to be noted that risk is a dynamic quantity which varies with, among other factors, time and weather, and is susceptible to change in future as the climate and other factors change.

Returning to the HSE Framework, the metrics proposed in this study for developing guidance on risk tolerability are as follows:

a) For defining upper thresholds of tolerability:

- Individual fatality risk per year (AIFR) for DOC workers, along with individual fatality risk per day for occasional higher risk tasks and/or volunteers
- Individual fatality risk for visitors to PCL per day/visit/experience lasting up to one day (referred to hereafter as "per visitor day"), and
- frequency of specified major events of particular (societal, political, organisational) concern for DOC, the definition of which is discussed in Section 9.

b) For defining lower levels not of particular concern:

- These are not considered particularly relevant for workers or major events.
- For visitors, lower "de minimis" levels of individual fatality risk per day could be useful in avoid unnecessary warnings or actions over low levels of risk[5].

c) In the "ALARP" region, in-between upper and lower levels of visitor individual risk, the totality of harm to visitors and workers needs to be considered as well as individual risk. The simplest metric available for doing this is Probable Lives Lost (per year) or PLL. Comparisons with risks elsewhere are not particularly relevant – the major issue here is internal comparison within DOC of the many opportunities available for risk reduction. This is discussed further in the companion guidance report.

2.2 Presentation of Risk Information

This section considers both what comparisons are relevant and useful for DOC, and how risk information can best be presented.

2.2.1 What Risk Comparisons to Present

Comparing risks from different sources is fraught with difficulty, as people's concerns about risks and hazards incorporate many other attributes beside the numerical level of risk itself. These concerns depend heavily on the activity involved and its context. To ensure as far as practicable that the comparisons here are relevant in context, the first principle adopted is to focus on risks which are directly relevant for DOC's workforce and visitors. This leads us to

- Risk levels workers and visitors already face on NZ Public Conservation Land (PCL) (Section 3), both in terms of general accidents and of natural hazards in particular
- Risk levels faced by the DOC workforce in comparison with other New Zealand workplace risk levels (Section 4)
- General mortality and accident risk for New Zealanders and international visitors, providing broad context (Section 5)
- Risk levels faced by New Zealanders and international visitors participating in popular outdoor sport, leisure and recreational activities (Section 6)
- Risk levels associated with travelling to and from national parks and other NZ PCL (Section 7), and

[5] Providing too many warnings where not needed could have a "crying wolf" effect and lead to reduced effectiveness of warnings in situations where they are really needed.

- Risk levels associated with selected overseas national parks and outdoor activities (Section 8).

For all of the above the focus is on individual fatality risk, per year for DOC workers or per visitor day for visitors[6].

Section 9 deals with risk aggregated over the whole community of visitors and workers, in terms of total annualised loss of life and frequency of specific (multiple fatality) events of concern.

2.2.2 How to Present Risk Information

Presenting risk information in the form of comparisons with other relevant risks is an attractive way of communicating risk levels to visitors. It not only avoids the problems of conveying small numbers such as 10^{-4}, 0.1% etc but also provides for the possibility of using visual comparisons which are not English-language specific and can help convey the uncertain provenance of both the assessed natural hazard risk and any comparator risks.

Visual presentation can also assist in dealing with the inherent difficulties associated with the fact that the risk levels involved are in many cases

- Highly variable across the population, and/or
- Statistically uncertain because activities pursued occasionally by a minority of people among the NZ population lead to relatively small numbers of deaths, and/or
- Uncertain because even if the deaths associated with an activity can be established, the units of activity (typically days/episodes of doing it) cannot be accurately established.

Most if not all of the statistics used to derive risk levels in this study fall into one of three categories:

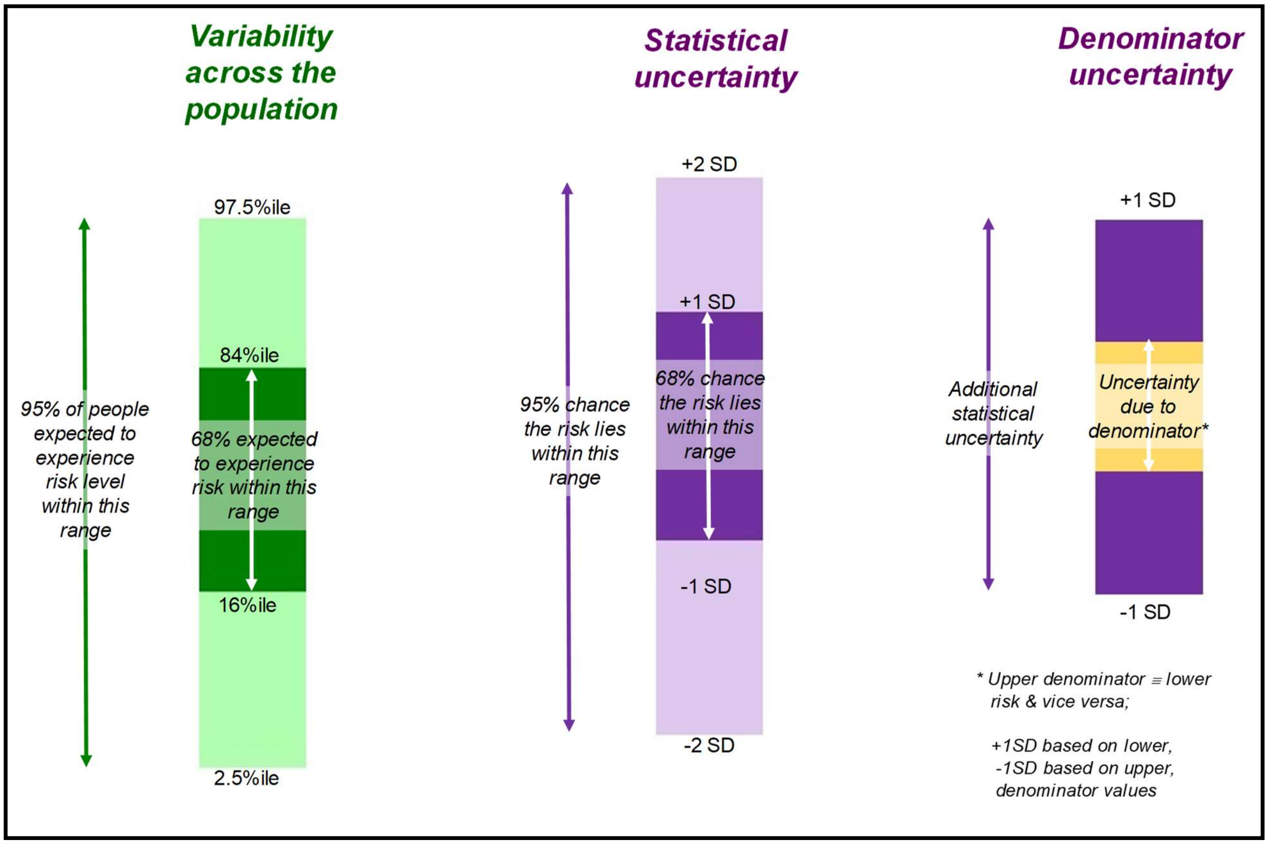
a) Plentiful statistical information (e.g. mortality statistics, motor vehicle crashes), where variability across the population can be analysed and statistical uncertainty is relatively low when analysing in terms of large cohorts of the population, or
b) Fatality statistics are sparse, making it impossible to analyse variability across the population, and making statistical uncertainty correspondingly high, or
c) The denominator statistics (units of activity/participation) are significantly uncertain (for example surveys often ask for people's participation in terms such as "3-4x per week" or "between once a month and once a quarter"), often in combination with (b).

Presenting risk levels as single "point estimate" numbers is unhelpful in that it often leads to a false sense of confidence a) that such numbers apply to everyone, and b) that they imply a degree of precision which is not warranted. The approach adopted to deal with presentation in this report is to present ALL risk levels as ranges of values which correspond to ranges of uncertainty or variability such that a majority of people are likely to experience risk within the inner range,

[6] A visitor day is defined as a single visit lasting up to one calendar day, or a single visitor experience that takes place within a single calendar day.

and most people to experience risk within the outer range. The convention used is illustrated in Figure 1; green is used throughout to denote variability, lilac/purple to denote statistical uncertainty and yellow to denote denominator uncertainty[7]. The inner range corresponds to 16-84 percentiles in the green bars, to +/- 1 standard deviation in the purple bars, and to the range of possible denominator values in the yellow bars. The outer range corresponds to 2.5 to 97.5 percentile in the green bars, to +/- 2 standard deviations in the lilac bars, and to +/- 1 standard deviation over and above the range of denominator uncertainty in the yellow and purple bars.

Figure 1: Convention for Presenting Risk Information Developed for this Report



This convention is used as a simple, visual way to represent the range of values associated with risk levels. It is simplified in some more complex or "busier" charts, which are explained on a case by case basis throughout the report. The values shown in green that vary across the population may of course be uncertain or vary widely within the population groups analysed (e.g. because of lifestyle habits), while the uncertain population average values in lilac/purple/yellow may also vary widely across the population.

The green (variable across different groups within the population) values are derived by

- calculating the mean risk for each population group (typically 2 genders x 18 age bands in 5-yr intervals from 0-4 up to 80-84 plus an 85+ band),
- placing those risk values in order of increasing risk,

[7] Note that the denominator uncertainty is not quantified in percentile terms.

- using population statistics to derive the cumulative % of the population exposed at up to or equal to each risk level,
- interpolating the risk values corresponding to the 16^{th} & 84^{th} percentiles of the population, and
- using the bottom and top of the 18 groups' risk levels to approximate the 2.5^{th} & 97.5^{th} percentiles.

The lilac/purple bands are the values of probability of fatality which would deliver a 2.5%, 16%, 84% and 97.5% chance (corresponding to 97.5, 84, 16 and 2.5 percentiles of risk respectively) of observing N or fewer deaths from M events where N is the actual number of deaths and M the number of days/occasions of exposure. In a few special cases where there are zero deaths the probability P_1 of death per single exposure is estimated as the maximum consistent with a 2.5%, 16% (etc) chance ($P_{0|M}$) of observing zero deaths in M events, given by

$$P_{0|M} = (1-P_1)^M \quad \text{[i.e. probability of surviving all M exposures], so}$$

$$P_1 = 1-P_{0|M}^{1/M},$$

This approach generally provides conservative (i.e. erring on the high side) values; it is in every such case entirely possible that the true value of P_1 is considerably lower than the range indicated.

In cases of significant denominator uncertainty the central band is calculated as the range derived using actual number of deaths with upper & lower possible denominator values (giving lower & upper values of risk respectively). The +1SD value is calculated based on the lower, the -1SD value based on the upper possible denominator value.

Most of the charts in this report plot the vertical axis on a logarithmic scale, so that in this case the risk for volunteers is roughly 10x that for permanent staff. The vertical axes on these charts use the Excel convention for displaying numbers as powers of 10, so

- 1.0E-02 $= 1 \times 10^{-2}$ = 0.01 (or 1/100 or $1/10^2$),
- 1.0E-03 $= 1 \times 10^{-3}$ = 0.001 (or 1/1,000 or $1/10^3$),
- 1.0E-04 $= 1 \times 10^{-4}$ = 0.0001 (or 1/10,000 or $1/10^4$), etc.

Risk information throughout this report is presented in the form of bars to emphasise that risk is uncertain and varies widely across different people and circumstance. The pictorial representation used here is intended to convey the range of uncertainty/ variability and the main contributor to it (green = variability across the population, lilac/purple = statistical, yellow = uncertain denominator).

These bars are derived based on simplified statistical and other analyses and should NOT be interpreted as having any precise statistical significance

In an ideal world a more sophisticated multivariate analysis of both variability and statistical uncertainty might be conducted, but given the provenance of much of the information involved this was not considered necessary or worthwhile for this study.

3 Current Risk Levels on NZ PCL

In any situation of trying to judge whether a risk should be treated as tolerable or otherwise, the first step should be to examine closely the current/historic risk levels associated with the activity in question.

In DOC's case this means combining information on the incidence of deaths and injuries with statistics on numbers of workers and visitors. These are presented in sections based on recent years' actual experience of fatalities and exposure covering:

- individual risk to workers (3.1)
- individual risk to visitors (3.2)
- aggregate risk to workers, visitors and others (3.3)

3.1 Workplace Fatality Risk Experience to Date

DOC workers may include employed staff (mostly permanent, some temporary), contractors, volunteers and concessionaires. Many of these people work in relatively hazardous outdoor environments and fatal accidents do occur from time to time. A summary of fatal events known to have occurred in the past 20 years to DOC employed staff, contractors and volunteers is provided in Table 2. Significant observations include

- All the permanent employee fatalities were in helicopter crashes (which killed 2 pilots in addition to DOC staff)
- Temporary employee and volunteer fatalities were from more varied causes:
  1 fall, 1 heart attack, 1 volcanic event (temporary employees), and
  1 fall, 1 presumed drowned (volunteers).

Note also that one further event involved a motor vehicle crash with a DOC vehicle in which two people in the other vehicle (but no-one in the DOC vehicle) were killed.

Table 3 provides corresponding information on numbers of workers involved over the period, expressed in terms of full-time equivalent people and broken down between permanent employees, temporary employees and volunteers. 220 days equivalent of volunteer work is treated as 1 year of full-time staff equivalent. Ideally contractor equivalent years worked would be included in this table, but the relevant data is not available.

Figure 2 shows the estimated individual fatality risk per year worked for the same 20 year period (2000-2019 inclusive). Because contractor years worked are not available, contractors are not included in the data used to develop this chart.

Table 2: Fatalities involving DOC Workers, 2000-2019

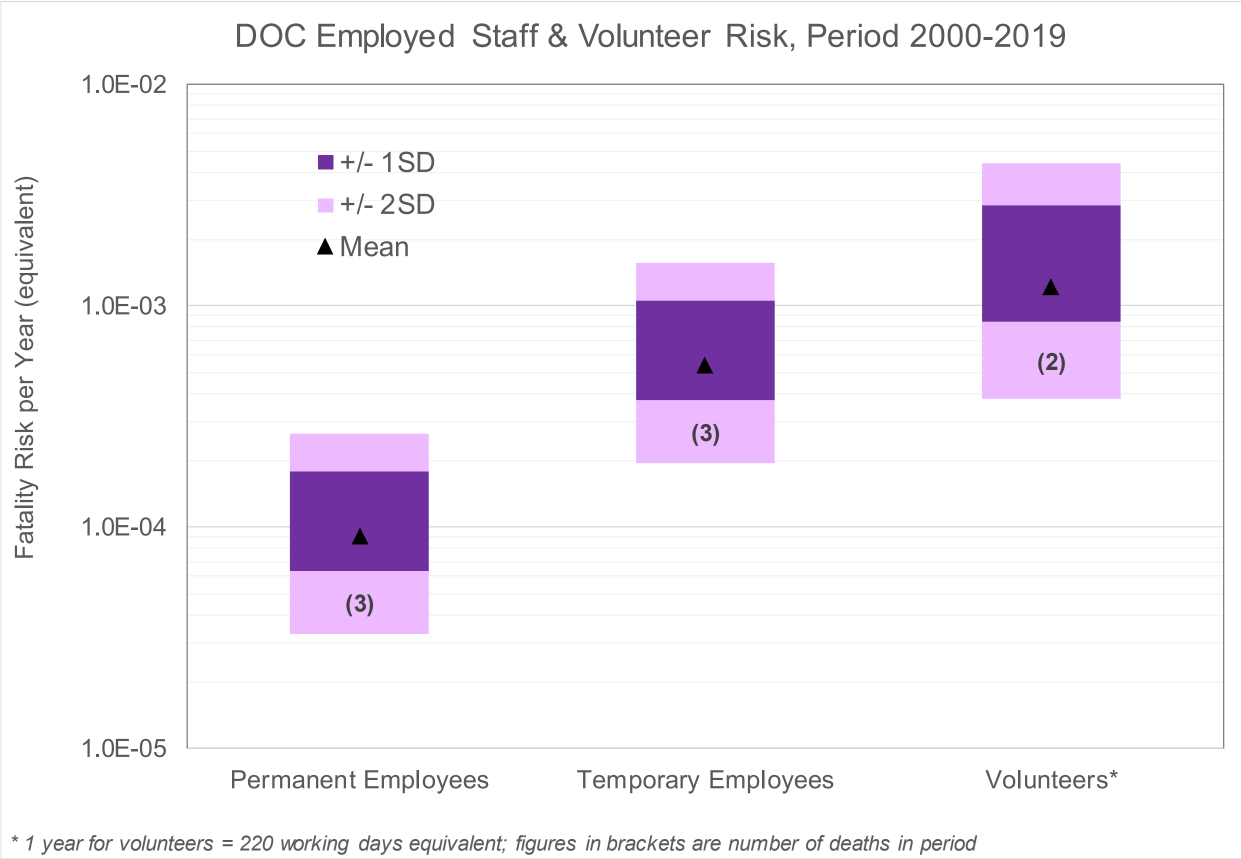
Year	Incident Description	Employment Status	Work Related	Cause of death
2018	Fatal Helicopter Accident	Contractor	Yes	Fatal injuries - transport
2018		Employee	Yes	Fatal injuries - transport
2018		Employee	Yes	Fatal injuries - transport
2017	Hut Warden fall	Volunteer	Unsure	Fatal injuries - fall
2014	SAR Fatality	Temporary	Yes	Fatal injuries - fall
2012	Helicopter crash	Contractor	Yes	Fatal injuries - transport
2012	Vehicle Accident (crash into a DOC vehicle)	Public*	Yes	Fatal injuries - transport
2012		Public*	Yes	Fatal injuries - transport
2012	Missing person, Fishing Rock	Volunteer	Yes	Presumed drowned
2011	Karikari Peninsula Fire: Helicopter Crash	Employee	Yes	Fatal injuries - transport
2011		Contractor	Yes	Fatal injuries - transport
2009	Heart Attack at work	Temporary	Yes	Heart attack
2008	Taupiri Guided Walk	Public	Yes	Heart attack
2006	Volcanic eruption	Temporary	Yes	Volcanic eruption

** Members of the public – included because the incident involved a DOC worker, though they were not the casualty*

Table 3 DOC Employee Numbers, 2000-2019

Year	FTE Permanent Employees at 6 June	FTE Temporary Employees at 6 June	Equivalent volunteer years worked
2019	1819	465	174
2018	1739	385	190
2017	1634	359	164
2016	1600	328	171
2015	1637	305	158
2014	1645	324	160
2013	1599	280	160
2012	1620	211	145
2011	1808	228	148
2010	1824	224	136
2009	1809	254	119
2008	1750	255	126
2007	1742	254	88
2006	1674	280	97
2005	1631	333	143
2004	1568	270	119
2003	1534	229	105
2002	1500	227	111
2001	1428	190	106
2000	1400	179	91

Figure 2: DOC Workforce Individual Risk, Average over period 2000-2019



While the numbers of workers and incidents are too low to make reliable estimates, the risk levels shown in Figure 2 are generally high in relation to other occupations in New Zealand and other developed countries (see Section 4). Annual fatality risk levels for office-based workers are typically around 10^{-6} to 10^{-5}/year or lower. Risk levels for outdoor occupations such as forestry, agriculture and fishing are typically higher, extending well above 10^{-4}/year in New Zealand.

It would be expected that risk associated with different tasks should increase in moving from

a) Desk-based work, to

b) Routine field work carried out in accordance with established processes, to

c) One-off field tasks that may involve significant improvisation "on the job".

This might explain the higher risk for temporary staff and volunteers than for permanent employees, as most temporary staff and volunteers work in the field, often in more "one off" situations than those in which permanent staff work.

If it were possible to split the permanent staff into desk-based and field-based staff I would similarly expect to see lower risk for office-based than for field-based staff. Given the higher proportion of repeated tasks and higher volumes of desk-based work carried out by permanent field staff in comparison with temporary staff and volunteers, I would expect their risk to be intermediate between that for office-based and that for temporary/volunteer staff.

It is useful to consider workplace fatality risk for DOC under three headings:

a) Events outside the direct control of workers (e.g. helicopter crashes, volcanic or other natural hazard events)
b) Events more or less within the control of workers (e.g. falls, vehicles driven by DOC workers), and
c) Medical events.

To deal with the latter first, any large organisation will over time experience worker deaths due to heart attacks or other medical causes. The key issue in DOC's case is that out in the field staff may be remote from medical aid, so that medical incidents may be more likely to result in death than for many other organisations. I would expect this to be addressed by DOC via some form of very simple health screening of employees and volunteers to check that they do not have significantly elevated susceptibility to such medical events, and by appropriate first aid/CPR training and arrangements for access to medical back-up.

Events more or less within the control of workers are what we more generally think of when considering accidents in the workplace. In DOC's case there are clearly important issues involved in working in hazardous outdoor environments. I would also expect that, as for many other large employers whose workers need to travel extensively by road, the risk of motor vehicle crashes would contribute significantly to risk for both field workers and many office-based workers.

As a general principle, in an ideal world the risk to which workers are exposed from events outside their control would be lower than the risk they were able to control, on the basis that they can do something about the latter but not the former. The experience of the last 20 years illustrates the importance both of exposure to natural hazards, and of helicopter flying. The former is the subject of this study; the latter is inherent DOC's need for workers to be able to access remote areas.

The risk from commercial helicopter flights in general is high relative to typical office workplace risks (see Section 7). The use DOC makes of helicopters in the course of its work inevitably involves many of the risk factors that increase helicopter risk above the average (e.g. accessing sites without established landing areas; needing to fly close to natural features such as cliff faces, lakes or trees; needing to carry aerial loads). In previous work for GNS Science (following a near-miss in which 3 scientists – including a DOC staff member - working on a new vent on Tongariro left the site minutes before an eruption) I compared natural hazard risk for volcanologists with the risk of accessing volcanoes by helicopter and concluded that the latter is highly significant even for workers with high exposure to volcanic hazards[8]. This is likely also to be the case for DOC, who I am aware now have tighter controls over helicopter flying, which

[8] "Aircraft Accident Rates for GNS Science Staff", private communication from A R Taig, TTAC Ltd to T Webb, GNS Science, June 2013.

would have prevented the helicopter crashes shown in Table 2 had they been in place and applied.

3.2 DOC Visitors' Individual Risk Experience

This section brings together information on

- Fatalities on NZ Public Conservation Land (PCL, 3.2.1), and
- Visitor numbers and visitor days on PCL, in National Parks in particular (3.2.2), to estimate
- Individual risk per visitor day (3.2.3), for individual National Parks and other NZ PCL generally, with breakdowns
  - for New Zealanders in comparison with international visitors
  - by activity involved at the time, and
  - by cause of death (e.g. falls vs exposure vs medical events)

3.2.1 Visitor Fatalities, 2010-2019

DOC generally relies on the NZ Search and Rescue service (SAR) for records of injuries and fatalities on PCL. There may be some incidents (e.g. involving road crashes) with which SAR are not involved and which they do not record, but the SAR record should be largely complete in terms of all cases of persons on NZ PCL land requiring assistance when remote from a road.

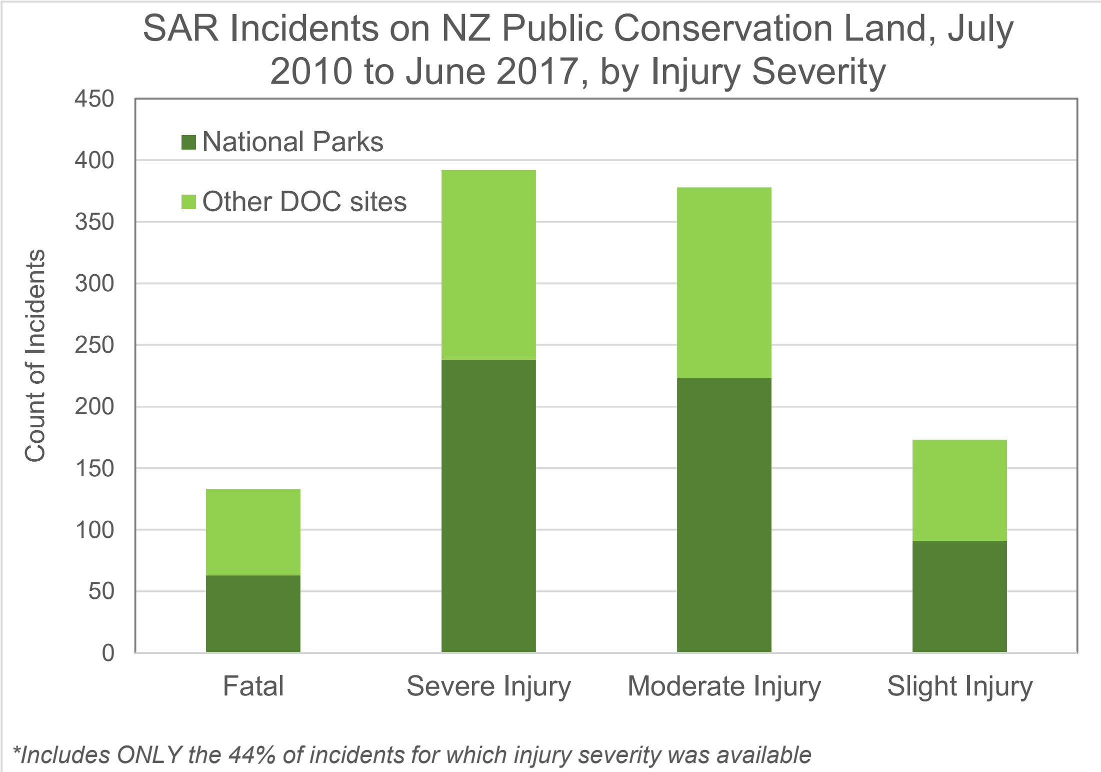
The starting point for this project[9] was a detailed database of SAR incidents covering the period July 2010 to September 2017 and comprising

- 19,441 records in total, corresponding to
- 3,069 unique incidents, of which
- 1,439 took place in National Parks and 2,630 at other PCL sites, including
- 133 fatal incidents involving 150 deaths, of which
- 63 incidents and 71 deaths took place in National Parks.

Figure 3 shows the numbers of incidents, by severity of injury involved and broken down between National Parks[10] and other PCL, contained within this data set for the just over 7 years covered.

[9] Email D Bogie, DOC to T Taig, 19 June 2019
[10] Te Urewera was not counted as a National Park; the Abel Tasman Scenic Reserve was counted as being part of the National Park.

Figure 3: Deaths & Injuries on NZ PCL 2010-2017, from NZSAR Data Set



Unfortunately, because of various reorganisations and changes within the SAR systems in recent years[11], the records currently available via SAR are significantly incomplete. As in many other accident and incident recording systems worldwide, reporting appears from Figure 3 to be less reliable for lower severity incidents (I would expect to see many moderate injury incidents per severe injury, and many slight injuries per moderate injury). Of greater concern was the absence of fields for the most serious (fatal) incidents describing the victims'

- nationality (available for 18 of the 133 fatal incidents)
- behaviour at the time of the incident (available for 101 of the 133 fatal incidents), and
- cause of death (e.g. fall, exposure, shot – available for 28 of the 133 fatal incidents).

SAR responded to a DOC request for more complete information on fatalities by providing a dataset covering all fatal incidents on PCL during the period 2010-2019. While these reliably state where (in terms of which DOC park or site) the incident occurred, they suffered from similar incompleteness in terms of fields relating to nationality, activity and cause of death. A breakdown by tourist status and site type (my assumption is that "PI Tourist" means an international visitor) is shown in Figure 4 and a breakdown by activity and site type in Figure 5.

[11] SAR data was sourced from two merged databases that had different fields and characteristics along with irregularities in the some of the records. Since May 2019 the two older data bases (one Police and one RCCNZ) have been replaced with one national system (SARdonyx) that both agencies use which has tighter data quality rules. This should help considerably in collating records of incidents on NZ PCL in future.

These records were dated only by year and contained no details of location other than the name of the park or other DOC site, so could not be matched to the other datasets available.

Figure 4: Fatalities on NZ Public Conservation Land, 2010-19, by Residency Status

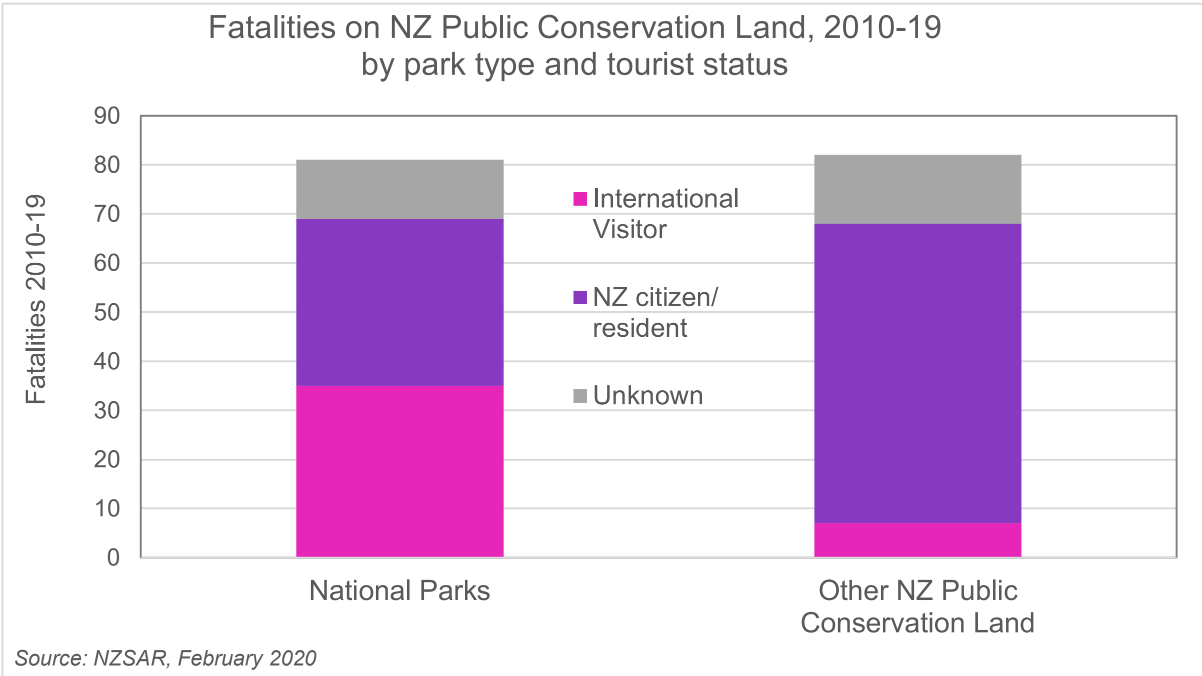
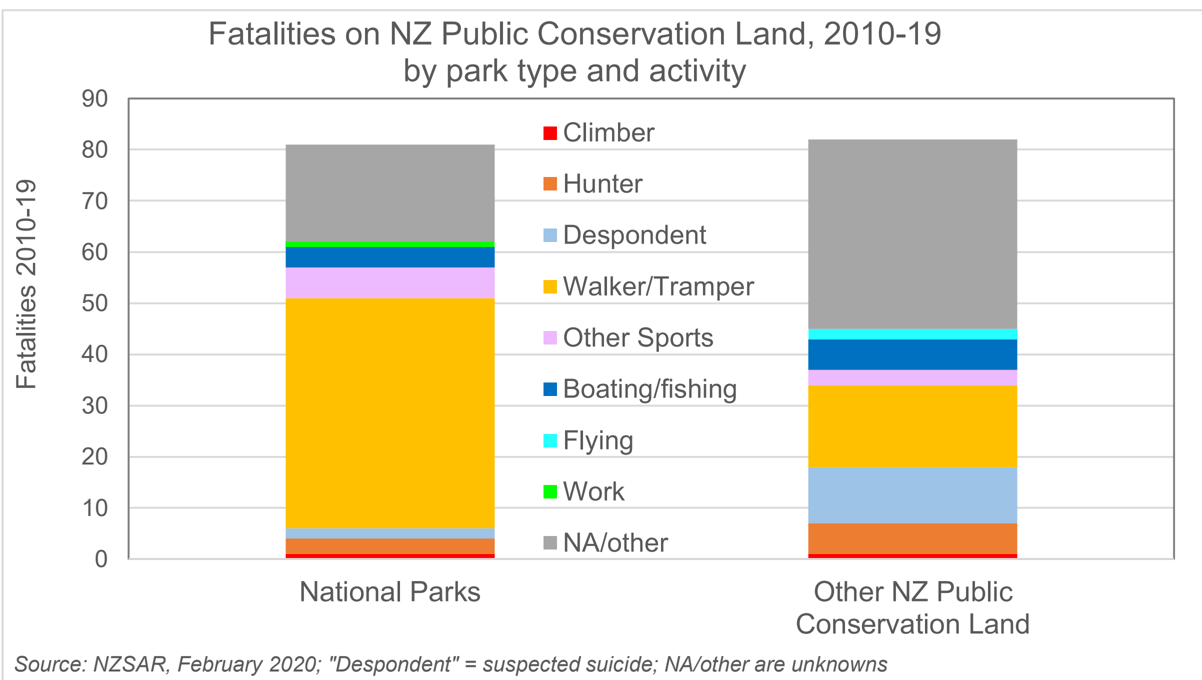


Figure 5: Fatalities on NZ Public Conservation Land, 2010-19, by Activity



Given the importance of establishing a "baseline" of risk on NZ PCL, an internet search was carried out to try and establish the characteristics of incidents in the SAR datasets provided by

DOC, for the period 2010-2019 inclusive. This was confined to National Parks, both to limit the scale of the exercise and because there was less information available for other PCL. Searches were carried out for each park using the combination of

- Park name
- The words "death", "died", "body", "collapsed", and
- Each of the years 2010-2019

In addition to enabling a majority of incidents to have fields filled in corresponding to the victim's nationality, activity at the time and cause of death, this exercise identified a further 17 fatalities within the period covered by the detailed SAR reports (July 2010 to September 2017) and a further 20 fatalities outside that period but between 1 January 2010 and 31 December 2019. There remained, though, numerous gaps, and I am far from confident of having identified all relevant events.

At a later stage of the project DOC arranged to share data with the New Zealand Mountain Safety Council (MSC), which over the past several years has carried out in-depth surveys of outdoor activities in New Zealand. Brief accounts of their major publications "There and Back" (2016) and "A Walk in the Park" (2018), along with selected risk estimates based on the latter, are provided in Section 6.1.

The MSC has devoted substantial resources to collating, cleaning and analysing data on accidents and incidents in the New Zealand "great outdoors". Regarding fatalities, MSC used the NZ Coronial Service data as its primary source, while sourcing injury and visitor statistics from many of the same sources used in this study (including ACC, DOC, the NZ International Visitor Survey and Sport New Zealand). MSC provided a data set of 135 fatal accidents within their scope of coverage[12] during the period July 2009 to June 2019. This included 15 deaths not previously identified (9 within, 2 before and 4 after the period covered by the SAR 2010-2017 data set).

I have high confidence that the MSC data is complete within its scope of events covered. There were no verified fatal incidents within the MSC scope identified in the SAR data set or via my internet search activities which did not also appear in the MSC data set[13]. The MSC data also included the name of victims, with the help of which I was able to fill in the vast majority of the incident details of interest (visitor nationality, activity and cause of death in particular) where not already provided in the MSC data set.

Finally, DOC staff at Aoraki/Mt Cook and Tongariro National Parks provided their own records of incidents and usage of parks facilities/tracks, which added a further 3 fatalities to my set of relevant fatal incidents in National Parks (all of them outside the MSC scope). The scope of events defined as relevant for this study includes:

- All of the accidents covered in the MSC study, plus
- Medical events, and
- Events associated with water-based activities.

[12] The MSC focus is on accidents during land-based outdoor activities; their data excludes crime, suicide, medical events, transport accidents and water-based activities.

[13] 13 fatalities originally included in the SAR dataset were removed based on their being out of scope, or on verification that they were absent from both Police and SAR records searched by MSC.

The scope for this study, like the MSC reports, excludes

- Air accidents[14]
- Road crashes
- Suicide, and
- Criminal acts.

This study has, though, included a few vehicle and crime-related events where a motor vehicle crash or the criminal act itself were not involved in the fatality. In particular 2 young men died of exposure in the Tongariro NP in 2017 when they abandoned a car during a police chase and ran off on foot, only to become lost in the bush.

The full set of fatal incidents in National Parks used as the basis for this study comprises 111 fatalities in total, a summary of which is provided in Appendix 1. Almost certainly this dataset is incomplete in terms at least of medical events, which are outside MSC's scope and are less reliably reported in the media than other accidents. The MSC data set was used as it stood to make a comparison between National Parks in general and other NZ PCL.

Figures 6 to 8 show how the overall fatalities in National Parks that were identified and verified in this work are broken down by

- National Park and residency status (Figure 6)
- Activity engaged in at the time of the accident (Figure 7) and
- Cause of death (Figure 8).

[14] Air accident statistics associated with tourist activity are provided in Section 7, but are not included in totals here.

Figure 6: NZ National Park Fatalities 2010-2019, by Park and Residency Status

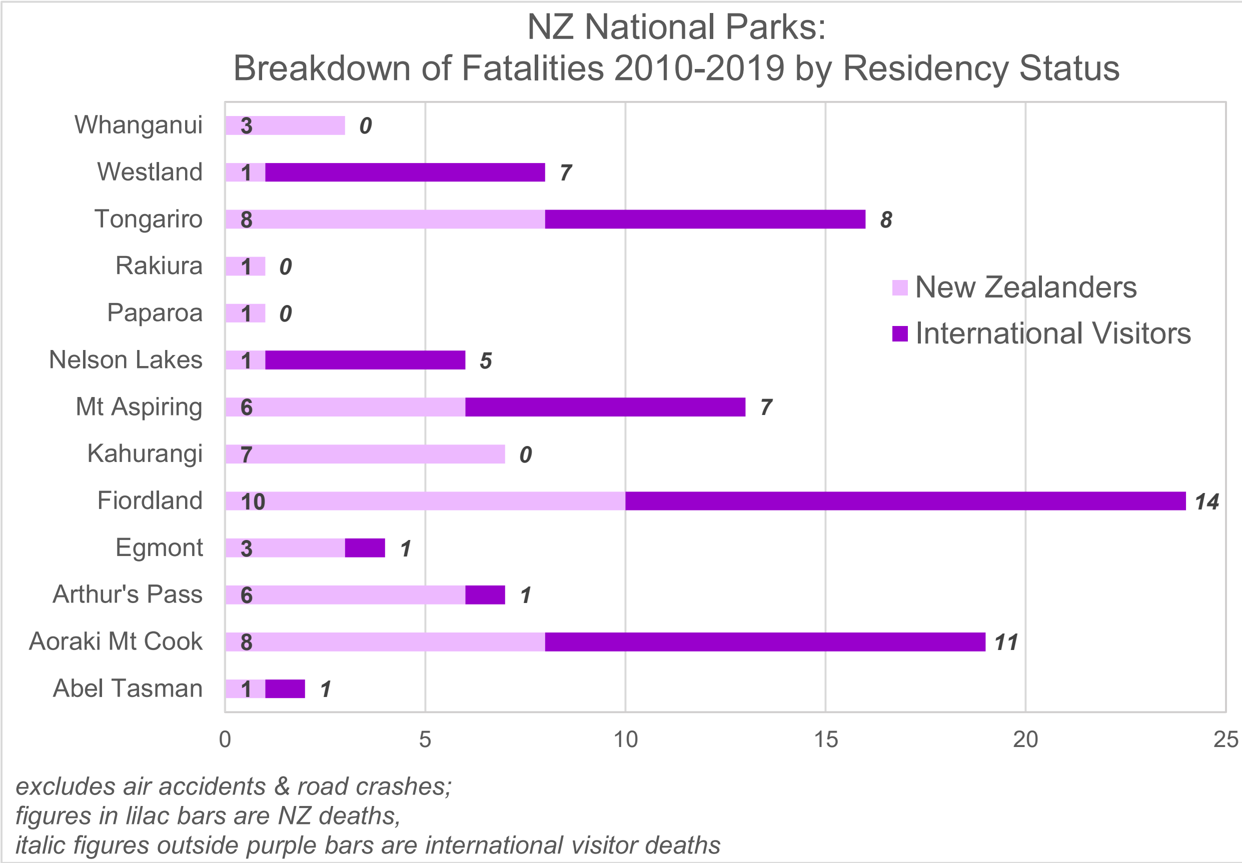


Figure 7: NZ National Park Fatalities 2010-2019, by Activity

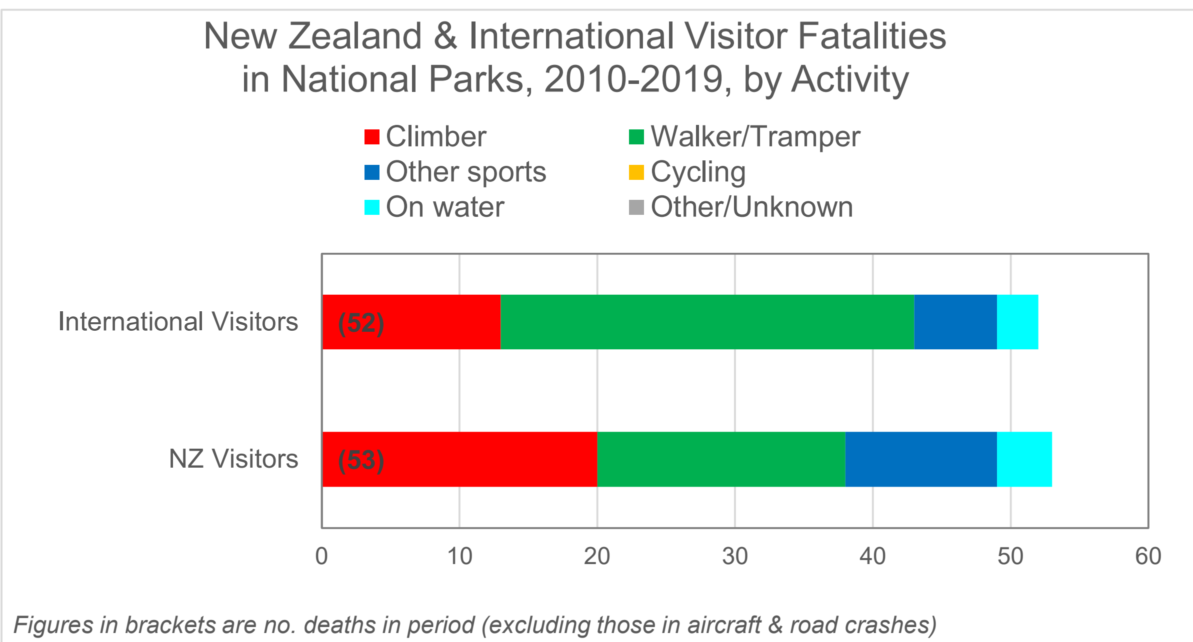
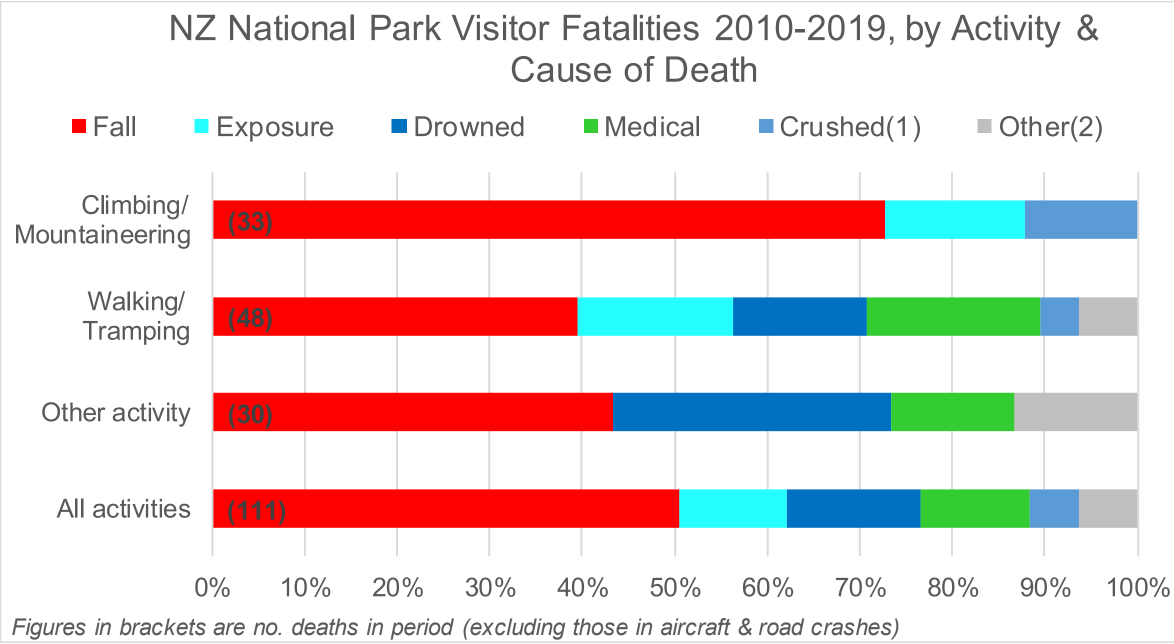


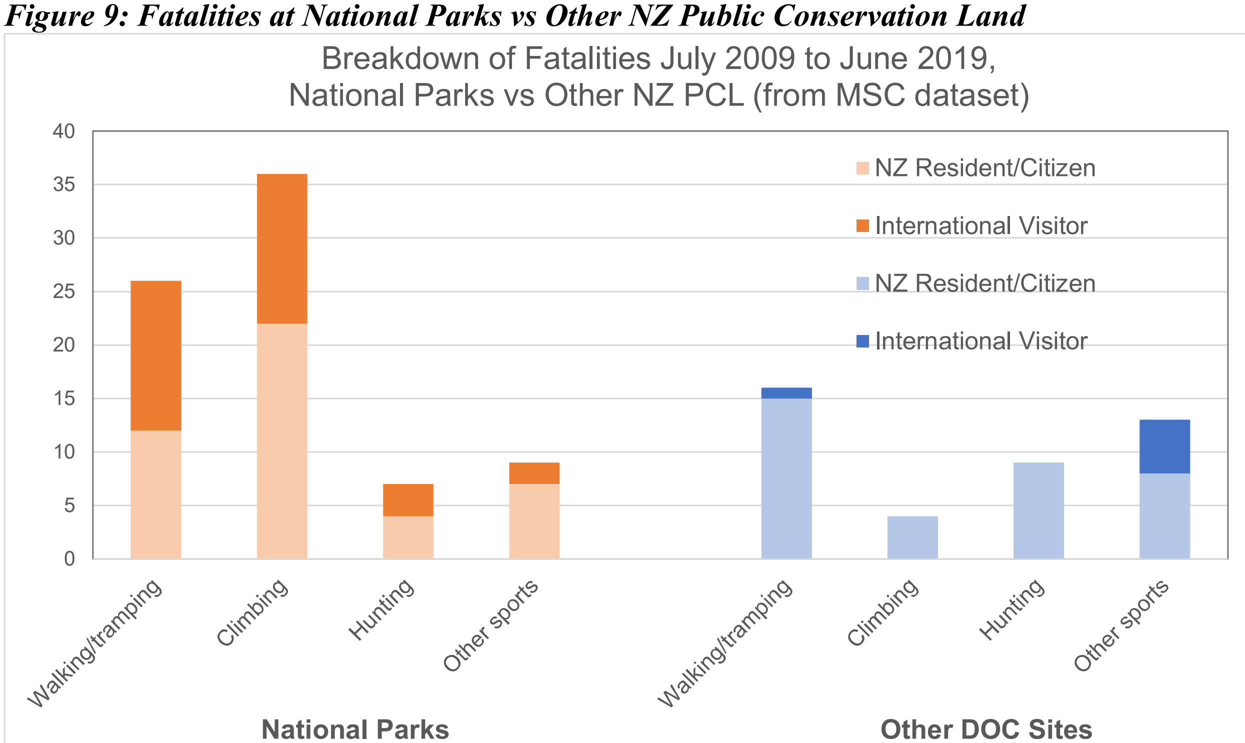
Figure 8: NZ National Park Fatalities 2010-2019, by Cause of Death



Notes on Figure 8:
(1) Includes victims of avalanches & glacier advance
(2) 1 victim shot, 2 skiers killed in collisions, 2 cases where body never found

Figure 9 shows a comparison of fatalities in National Parks with those on other NZ PCL, based on the MSC dataset for the period July 2009 to June 2019.

Figure 9: Fatalities at National Parks vs Other NZ Public Conservation Land



In summary, the assessments of visitor individual risk on NZ PCL made for this study are based on

- A dataset of 111 fatalities in National Parks from 2010-2019, derived from SAR, MSC and DOC local office records, supplemented by internet searches, and
- The MSC dataset of 135 fatalities across all NZ Public Conservation Land from July 2009 to June 2019

Though the MSC study excludes some categories of event of interest for this study it enables a more robust comparison to be made between National Parks and other NZ PCL than can be made using SAR data.

In comparison with the North American organisations who supplied data for this study (see Section 8), DOC's position is weak in terms of having ready access to information on accidents and incidents occurring on PCL. Good quality information on accidents and incidents – and in particular on the most severe ones involving death or severe injury – is fundamental to any evidence-based risk management regime. The MSC has done a superb job in bringing together and cleansing data on a large proportion of visitor fatalities on NZ PCL. There should be good potential going forward for MSC/DOC/SAR substantially to improve the quality and reliability of data available – a necessary prerequisite for more effective risk-based visitor safety management.

3.2.2 Visitor Numbers and Visitor Days

Because access to New Zealand national parks is free and uncontrolled, DOC does not have the same access to visitor numbers and days of visit enjoyed by many overseas park managers. Information is derived from surveys sampling visitor populations, or New Zealanders generally. A general feature of these surveys is that they sample adults only, and tend to measure how many people took part in a particular activity or visited a particular location, rather than visitor days (as needed in this study to estimate individual risk per visitor day). For both international and domestic visitors to NZ PCL, substantial assumptions have to be made to convert estimates of "How many people visited in the past year?" to estimates of "How many person days or parts of a day did people spend there?", which can therefore only be estimated within quite wide ranges.

International visitor numbers are estimated via the International Visitor Survey carried out annually by the Ministry for Business, Innovation and Employment. This includes questions about places visited (including specific national parks) and activities undertaken (including "Going for a walk, hike, trek or tramp").

Numbers of New Zealanders who visit National Parks and other PCL sites are estimated by DOC via Surveys of New Zealanders (SONZ) undertaken specifically for this purpose, of which the most recent were published in 2016 and 2019[15]. The wider scope "KiwisCount" survey has been run since 2007 with only two 1-year gaps within the 2010-19 period of interest, and includes a specific question as to whether respondents have visited a National Park in the past year. For some activities such as tramping and climbing, estimates of participation by the NZ population

[15] "Full Report – Survey of New Zealanders", prepared by Ipsos Mori for DOC, June 2016, and "Survey of New Zealanders 2019", DOC, December 2019

and frequency of activity can be derived from the Sport New Zealand "Active New Zealand" surveys (see Section 6 below), but these are not specific to Public Conservation Land.

For the Great Walks, better quality information on visit duration and numbers is available via hut bookings (for walks requiring overnight stops) and counters (which record all walkers and in some cases bikers, in addition to those on a Great Walk).

The assumptions made and calculations used to derive ranges for visitor days (in all cases for adults aged 18 or over) over the period 2010-2019 were as follows:

For International Visitors:

- DOC provided data on visitor numbers by National Park for the period 2013-2019.
- These were extrapolated to cover the full period 2010-2019 by scaling pro rata to international visitor arrivals (from Stats NZ).
- It was assumed that each park visited by an international visitor was visited once during their visit to New Zealand.
- An upper estimate of the average duration of each visit was estimated by analysing a large sample of IVS microdata on Itineraries and Places, which identifies National Parks visited and nights spent there, on the basis that
  - 0 nights spent at an identified National Park corresponded to 1 day's visit
  - 1 night spent corresponded to 2 days' visit
  - 2 nights spent corresponded to 3 days' visit (and so on).
- This method was unsuitable for providing a lower estimate of average visit duration, as it includes only respondents who mentioned visiting/staying at a National Park, so excludes many day visitors and those passing through who stop for part of a day. Lower estimates were obtained making simple assumptions as to the average days per visit, grouping parks into three according to likely length of visit:
  - H (2.5 days/visit – remote; most visitors are multi-day): Kahurangi, Rakiura
  - M (1.5 days/visit – mix of day & overnight visitors): Mt Aspiring, Nelson Lakes, Whanganui
  - L (1.2 days/visit – predominantly day visitors): all other National Parks
- A large sample of IVS microdata on Activities undertaken was analysed and cross-referenced to accommodation used to estimate the proportion of visitor days spent climbing and tramping in National Parks.

For New Zealanders (citizens and residents):

- After much discussion with DOC, the Kiwis Count surveys were adopted as the most reliable source of information on the proportion of New Zealanders who had visited a National Park in the past year, as they had used a consistent question set and method over the whole period of interest. Figures for the gap years within the period of interest were interpolated from the surveys either side. The DOC Survey of New Zealanders used different methods in 2016 & 2019 (the most recent surveys) and produced significantly different results.

- The DOC Surveys of New Zealanders show a strong correlation between the proportion of people who visit a Park and its proximity to where they live. The surveys for 2016 and 2019 provided the most widely different results available from the SONZ process, and were used to provide upper (2016) and lower (2019) estimates of the ratio of

$$\frac{\text{\% people from each NZ region who had visited a location}}{\text{\% all New Zealanders who had visited a National Park}}$$

  The "locations" analysed were each National Park, and all other NZ PCL (considered together). This produced a table of % from each region who had visited each park, normalised by the % of all NZ-ers who had visited a National Park.

- These were then translated into % people from each NZ Territorial Authority who had visited a location (normalised to the % all NZ-ers who had visited a National Park), based on a) the assumption that everyone across a region had the same % probability of having visited each location, and b) a mapping of regional to TA populations commissioned from Statistics New Zealand. This generated a corresponding table of % from each TA who had visited each park, again normalised to % all NZ-ers who had visited a NP.

- Each National Park was then classified in relation to each TA as one of
  - "Home" (within 30 minutes drive)
  - "Neighbouring" (within 2 hours drive), or
  - "Relatively Remote" (>2 hours drive)

- Visitor numbers were then converted into a range of numbers of visits made to each National Park based on simple assumptions of average visits and days per visit (per person who had visited) as follows:
  - Home: 1.2 to 3 visitor days per year (assumed to be largely day trips)
  - Neighbouring: 1 to 1.5 visits per year, each of 1 to 1.5 days average duration, and
  - Relatively Remote: 1 to 1.5 visits per year, each of 1.2 to 2 days average duration.

- These were summed across TAs to provide estimates of total New Zealander visitor days to each National Park over the decade 2010-2019.

- The 2016 and 2019 SONZ raw data was analysed to estimate the proportion of NZ visitors who climbed and tramped at each National Park. For each park the lower % from the two surveys was used as a lower estimate of % participation, and the higher % from the surveys as an upper estimate of % participation.

- A parallel estimate was prepared of the number of visitor days to all other NZ PCL, based on the assumption that all other PCL should be treated as "Home" regardless of the TA involved, as the SONZ data showed particularly strong correlation between likelihood of visiting and where people lived for sites other than the National Parks.

For Great Walks:

- DOC provided data on visitor numbers for each Great Walk, and visitor nights by month for each Great Walk hut and campsite, for NZ financial years 2008-09 to 2017-2018. This period was chosen as the decade to be analysed as (a) the Great Walk booking system changed after 2018 so that compatible data was not available for 2019, and (b) using the financial years rather than calendar years meant that each year analysed included one whole Great Walk season (for those walks which close in winter).

- Visitor days were estimated on the basis that everyone making an overnight stop had to do some walking on the days either side of that stop, so that the number of visitor days equalled the number of bed nights booked, plus 1 night per visitor.
- The Routeburn, Milford and Abel Tasman Coastal Tracks all have a number of private lodges in addition to DOC accommodation. For the Routeburn and Milford tracks, the operator kindly volunteered estimates of total numbers of walkers (clients and guides) over the decade of interest, which were added to the DOC totals. For Abel Tasman, counter data reveal that the number of people taking shorter walks is large relative to the numbers completing the Coastal Track, but with so many possible start and end points, including using water taxis, the total number of walkers using the track could not simply be split into “Private Great Walkers” and “Others”.
- International and domestic visitors were analysed together; the number of fatalities is so small that any result would have been of little statistical significance.
- Bed night bookings were compared with counter data to provide approximate estimates of the number of walkers using Great Walk tracks in addition to the official “Great Walkers”, both during the Great Walk season and outside it for those parks which close seasonally.

The resulting numbers of visitor days estimated are shown for

- International and domestic visitor days, 2010-19, spent at National Parks and other DOC visitor sites in aggregate (Table 4)
- International visitor days spent at National Parks, 2010-19 (Table 5)
- New Zealander visitor days spent at National Parks, 2010-19 (Table 6)
- Visitor days spent on the Great Walks, 2010-19 (Table 7)
- Walker days in addition to “Great Walkers”, and walker days out of season, based on comparisons of bed night and counter data (Table 8).

Table 4: Total Visitor Days 2010-2019 – National Parks & Other NZ PCL

Location	**New Zealanders**		**International Visitors**		**Total Visitor Days**	
	lower	**upper**	**lower**	**upper**	**lower**	**upper**
National Parks	1.99E+07	8.21E+07	3.91E+07	6.82E+07	5.90E+07	1.50E+08
Other NZ PCL	2.50E+07	7.83E+07	2.50E+06	3.91E+07	2.75E+07	1.17E+08
TOTAL NZ PCL	**4.50E+07**	**1.60E+08**	**4.16E+07**	**1.07E+08**	**8.65E+07**	**2.68E+08**

Note the particularly high uncertainty surrounding visitor days spent at sites other than National Parks.

Table 5: International Visitor Days Spent at NZ National Parks, 2010-2019

National Park	All International Visitor Visitor Days, 2010-2019		Days climbing		Days with >3hr tramping	
	lower	upper	lower	upper	lower	upper
Abel Tasman	2.8E+06	5.7E+06	1.1E+05	2.2E+05	6.5E+05	1.3E+06
Aoraki / Mt Cook	4.9E+06	8.0E+06	1.4E+05	2.3E+05	4.6E+05	7.5E+05
Arthur's Pass	2.9E+06	4.5E+06	1.1E+05	1.6E+05	3.8E+05	5.9E+05
Egmont	1.5E+06	2.2E+06	2.0E+05	3.0E+05	7.9E+05	1.2E+06
Fiordland	6.4E+06	1.1E+07	2.1E+05	3.6E+05	6.2E+05	1.0E+06
Kahurangi	4.9E+05	6.9E+05	7.3E+03	1.0E+04	4.3E+04	6.0E+04
Mt Aspiring	6.0E+06	1.1E+07	1.7E+05	3.1E+05	6.4E+05	1.2E+06
Nelson Lakes	1.5E+06	2.7E+06	4.6E+04	8.1E+04	2.7E+05	4.8E+05
Paparoa	2.9E+06	3.7E+06	1.0E+04	1.3E+04	8.0E+04	1.0E+05
Rakiura	4.9E+05	6.2E+05	*Data not available*			
Tongariro	3.4E+06	7.1E+06	4.0E+05	8.3E+05	1.9E+06	4.0E+06
Westland	3.2E+06	6.2E+06	1.4E+05	2.7E+05	3.2E+05	6.2E+05
Whanganui	2.6E+06	4.7E+06	7.8E+04	1.4E+05	2.9E+05	5.3E+05
National Parks Total	**3.91E+07**	**6.82E+07**	**1.6E+06**	**2.8E+06**	**6.1E+06**	**1.1E+07**

Table 6: New Zealander Visitor Days Spent at National Parks, 2010-2019

National Park	All New Zealanders' Visitor Days, 2010-2019		Days climbing		Days with >3 hrs tramping	
	lower	upper	lower	upper	lower	upper
Abel Tasman	1.9E+06	8.4E+06	2.38E+05	1.77E+06	6.20E+05	4.60E+06
Aoraki Mt Cook	1.5E+06	4.0E+06	6.73E+04	2.93E+05	3.49E+05	1.52E+06
Arthur's Pass	2.2E+06	9.2E+06	8.83E+04	4.28E+05	6.34E+05	3.07E+06
Egmont	2.1E+06	5.5E+06	1.15E+05	3.77E+05	5.35E+05	1.75E+06
Fiordland	1.1E+06	6.2E+06	4.03E+04	2.28E+05	3.73E+05	2.11E+06
Kahurangi	6.9E+05	5.1E+06	8.58E+04	6.62E+05	3.03E+05	2.34E+06
Mt Aspiring	7.1E+05	2.7E+06	5.52E+04	2.76E+05	2.43E+05	1.22E+06
Nelson Lakes	1.7E+06	7.5E+06	6.64E+04	4.15E+05	5.10E+05	3.18E+06
Paparoa	8.1E+05	9.2E+06	2.01E+04	3.67E+05	2.28E+05	4.16E+06
Rakiura	3.4E+05	9.9E+05	3.69E+04	1.51E+05	1.24E+05	5.07E+05
Tongariro	3.8E+06	1.3E+07	3.73E+05	1.73E+06	1.24E+06	5.77E+06
Westland	1.1E+06	7.4E+06	1.15E+05	8.28E+05	3.42E+05	2.47E+06
Whanganui	1.9E+06	3.0E+06	1.77E+05	5.19E+05	4.45E+05	1.31E+06
National Parks Total	**1.99E+07**	**8.21E+07**	**1.48E+06**	**8.04E+06**	**5.95E+06**	**3.40E+07**

Table 7: Visitor Days spent on Great Walks, 2010-19

TRACK	Accommodation used		
	DOC	Private	Total
Abel Tasman Coast Track	1062393		1062393
Heaphy Track	249970		249970
Kepler Track	360408		360408
Lake Waikaremoana Track	222033		222033
Milford Track	288114	278000	566114
Rakiura Track	108204		108204
Routeburn Track	395880	121500	517380
Tongariro Northern Circuit	172529		172529
Whanganui Journey	174540		174540
ALL GREAT WALKS	**3034071**	**399500**	**3433571**

Table 8: Comparison of Bed Nights and Counter Data for Great Walk Tracks

TRACK	Comparison Period		Great Walkers (in season)	Maximum Counter record on track		Max additional walkers as % Gt Walkers
	From	To		Whole period	Outside GW season	
Abel Tasman Coast Track	2014-15	2017-18	165106	418552	NA	154%
Heaphy Track	2008-09	2017-18	64022	125547	NA	96%
Kepler Track	2010-11	2017-18	91974	141282	34872	92%
Rakiura Track	2014-15	2017-18	23924	49147	NA	105%
Routeburn Track	2008-09	2017-18	176813	299361	59436	103%
Tongariro Northern Circuit	2013-14	2017-18	41714	31274	6735	16%

Notes on Table 8:

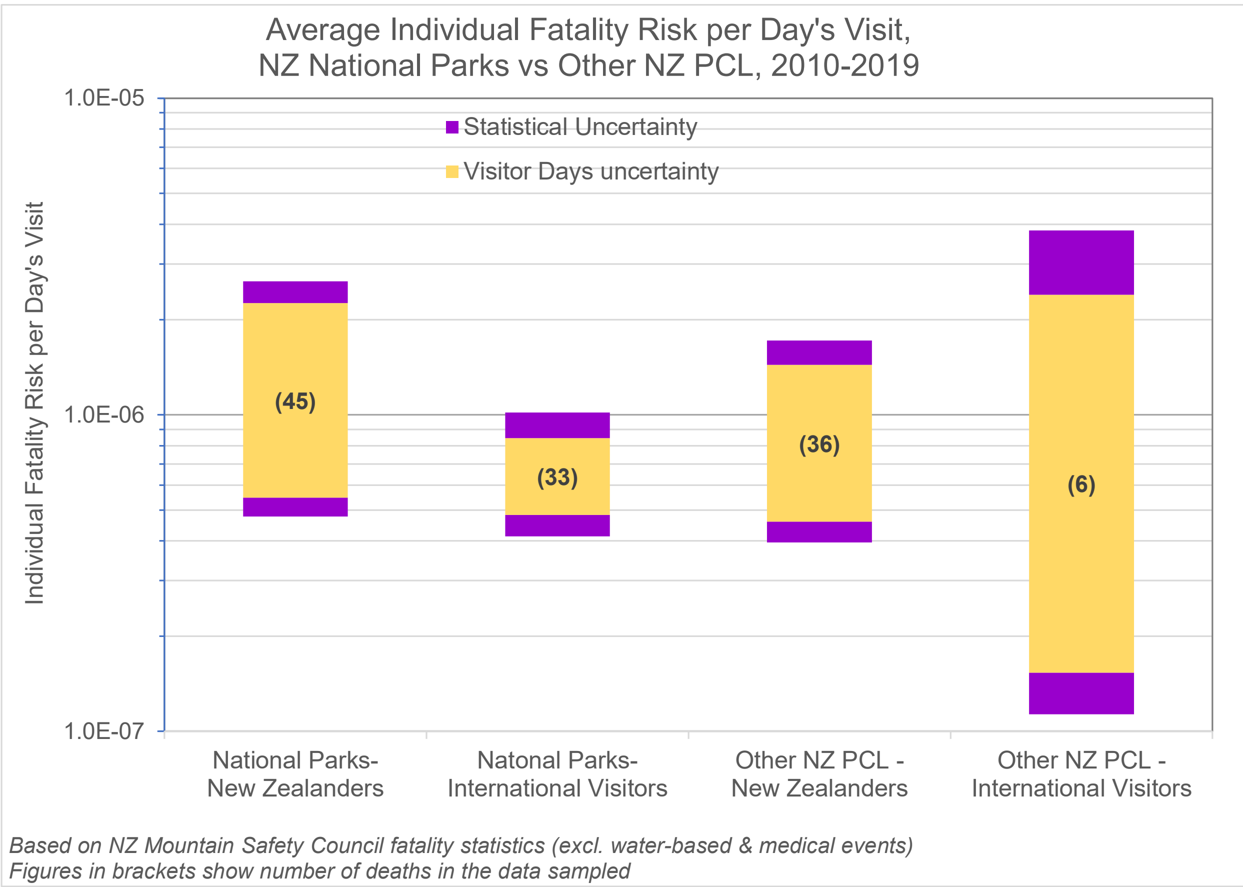
1. *The Abel Tasman, Heaphy and Rakiura Tracks are open all year*
2. *For the other parks, the total walkers outside the GW season is estimated by taking the track counter record for the period shown as a % of the Great Walkers (in season) and applying this to the whole period 2008-9 to 2017-18.*
3. *The "maximum counter record on track" is the total count recorded on the counter on the route which had the highest total of counts passing it over the period shown.*
4. *The "maximum additional walkers" is based on the assumption that each walker passed the counter once. The actual percentage could be as low as half this, if each walker made a return trip passing the counter twice.*
5. *The Great Walks shown are those where 1 or more fatalities occurred during the period 2010-19.*

If DOC chooses to adopt individual risk per visitor day as a key metric of visitor safety (as is recommended by this study) it will be important to ensure that information on visitor days spent at National Parks and other sites can be more readily collected in future.

3.2.3 Visitor Individual Risk on NZ PCL

An overview of individual fatality risk per visitor day, at National Parks and elsewhere on NZ PCL, broken down by international and domestic visitors, is provided in Figure 10. This figure is based on fatality data from the MSC study (which excludes various cases, most notably water-based activities and medical events) as this provided the only reliable source for fatality information not at National Parks over virtually the whole of the period involved. Note that there is a small inconsistency between the period used for estimating visitor days (calendar 2010-2019) and that covered by the MSC data set (July 2009 to June 2019). This is not considered significant.

Figure 10: Overview of Individual Risk per Visitor Day on NZ Public Conservation Land

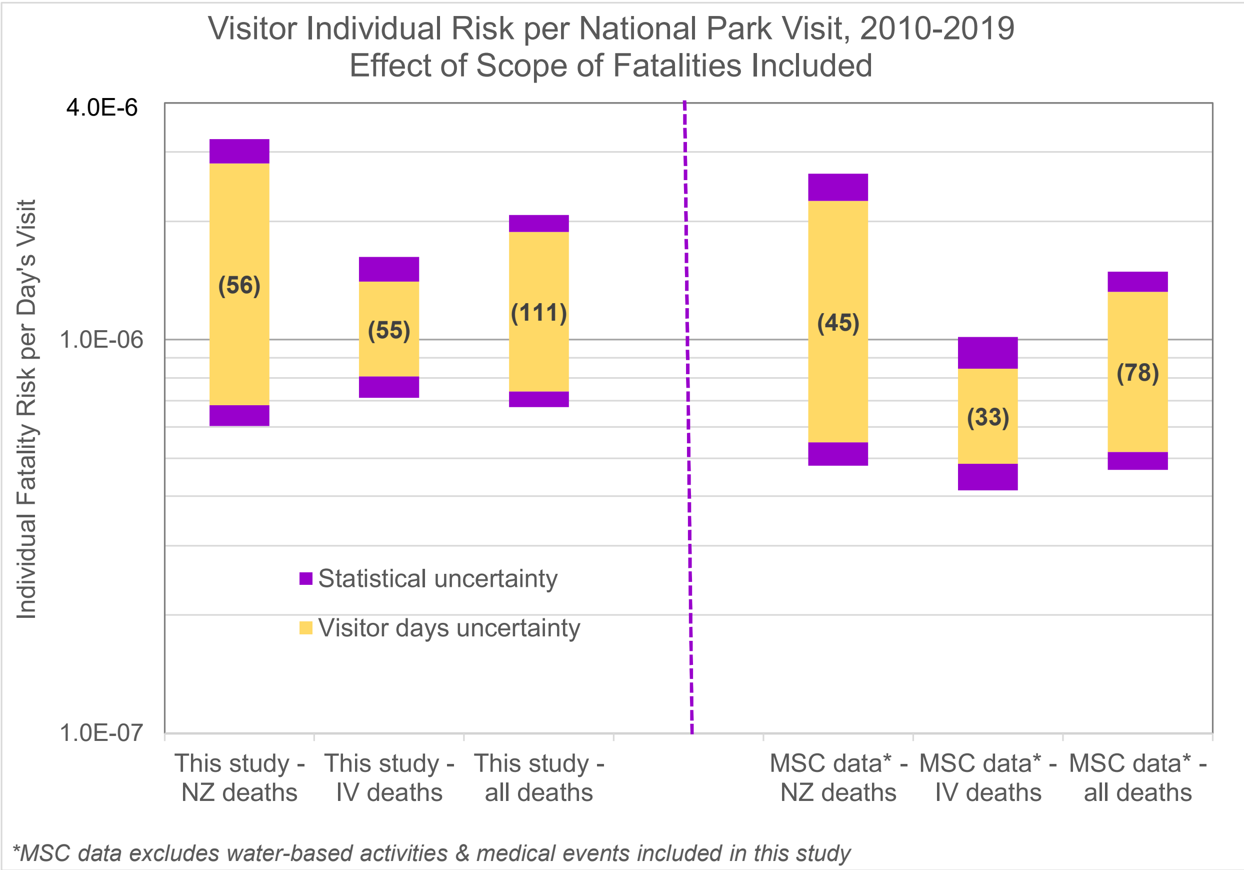


The differences in risk level between New Zealanders and international visitors, and between National Parks and other sites, are significantly smaller than the uncertainties in each. My conclusion is that, so far as can be discerned, the risks for each are of the same order:

- Between about 4 $x10^{-7}$ and $3x10^{-5}$/day for National Parks, and
- Between 10^{-7} and $4x10^{-6}$/day for other NZ Public Conservation Land.

The effect of including the additional fatalities outside the MSC scope in this study is shown in Figure 11, which shows individual fatality risk per day for international and domestic visitors to National Parks from 2010 to 2019, based (a) on the full data set developed for this study, and (b) on the MSC data set alone. The overall effect is to increase the range of average visitor individual risk from about 3×10^{-7} to just under 3×10^{-6} (MSC scope) to about 5×10^{-7} to just over 3×10^{-6} – not a large difference in comparison with the uncertainties involved. Perhaps more interestingly the additional causes of death included in this study appear to involve more international visitors than New Zealanders.

Figure 11: Effect of Including Medical & Water-based Events



Consideration of cause of death will be a significant factor in deciding which comparisons are most appropriate for DOC in the context of natural hazard risk. In general, the "all causes" risks presented below based on this study's dataset are about 20-30% higher than would be the case based only on events included within the MSC scope. There is much discussion about whether medical causes of death, for example, should be included in statistics on fatalities in parks. If the context is that of the hazards from outdoor activity such as tramping and climbing (as in the MSC studies) then I think it better to exclude medical causes. However, in the DOC visitor risk context I consider it better to include them here for two reasons:

a) They provide a more complete picture of the risk visitors face on NZ PCL, and

b) They may provide a useful comparator in their own right for natural hazard risk.

The treatment of risk due to such causes of death in setting guidelines is a separate matter which is addressed in the companion guidance document.

Figure 12 shows the individual risk per visitor broken down by National Park. Note that in this figure the paler lilac bars represent the less statistically significant parks where there were fewer than 5 visitor fatalities in the period. Among the parks with >5 fatalities, the highest risk parks, with risk levels largely above 10^{-6} per visitor day (2-2.5x the average for all parks), are Kahurangi, Aoraki/Mt Cook and Fiordland, followed by Tongariro, Westland, Nelson Lakes and Mt Aspiring all with similar risk levels. In all cases the fatalities are dominated by people engaged in tramping, climbing or other activities taking them into more remote areas. The lowest risk park, by some margin, is Abel Tasman, which, with very large visitor numbers but very few fatalities, has risk levels some 2-6x lower than the average for all parks.

While there is clearly some difference in average risk levels between parks where few people get into really remote, mountainous areas and those where they don't, these single park risk levels represent an average over people engaged in very different types of activity. In both Fiordland and Mt Cook for example, a large majority of visitors get out of a bus or car, spend a little time sightseeing on Milford Sound or in Mt Cook village, then depart. Their risk level is extremely small, while that of visitors who take on challenging climbs or venture into the back country far from help is correspondingly large. This is reflected in the analysis by activity, and the analysis for Great Walks, shown below.

Figure 12: Individual Risk per Visitor Day, by National Park

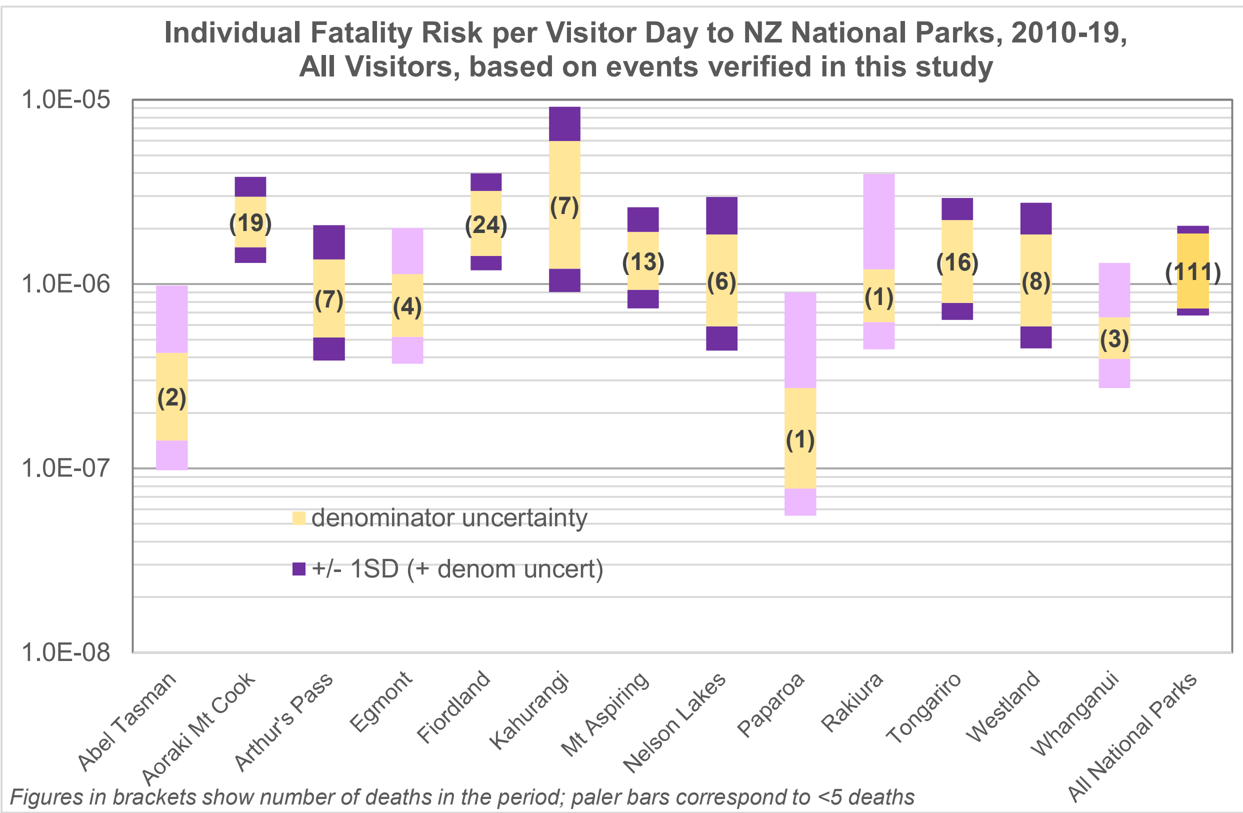
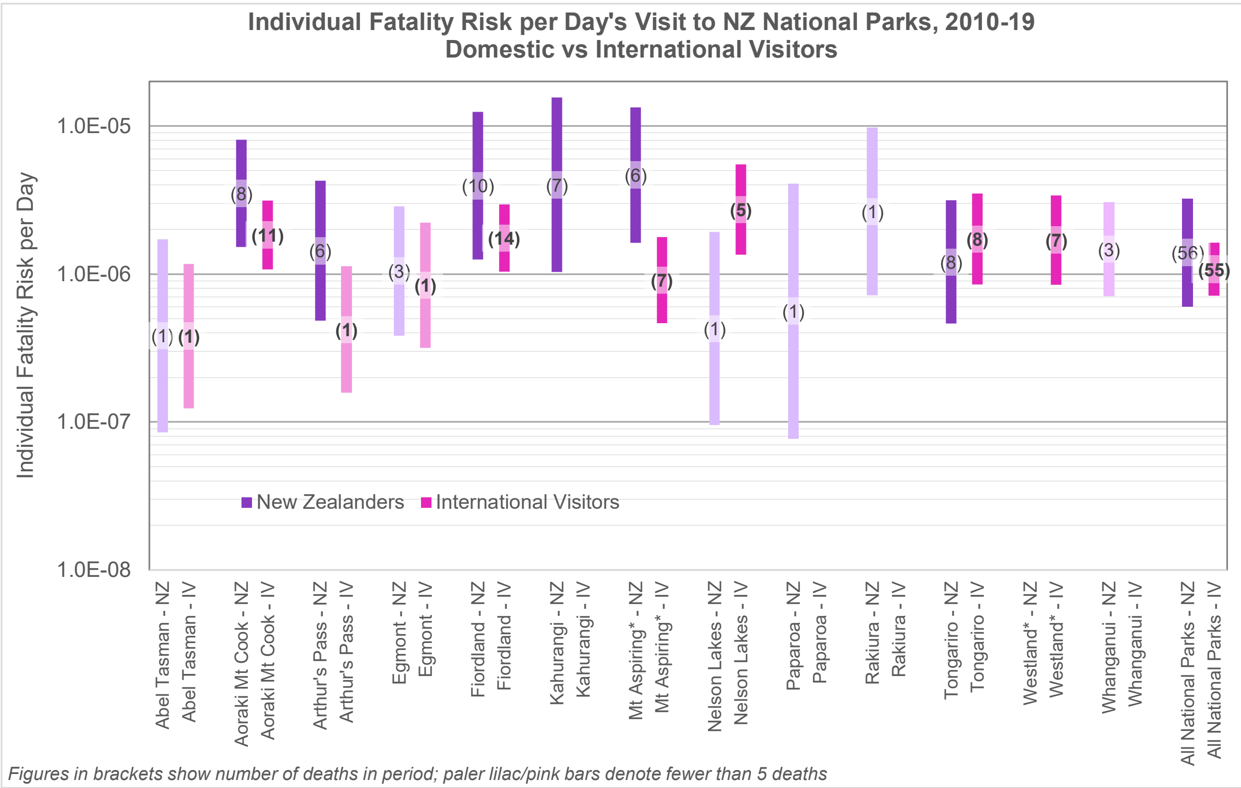


Figure 13 shows the same information, now split between domestic and international visitors. The bars have been simplified in view of the large number on the chart, and show the full range of denominator and statistical uncertainty combined (equivalent to the whole bars in Figure 12).

For the parks with the highest average risk levels from Figure 12, New Zealanders appear to experience higher risk than international visitors, perhaps because a high % of international visitors to Aoraki and Fiordland are day trippers to Mt Cook village or Milford Sound who come by bus to enjoy a few hours' scenic visit, whereas a higher proportion of New Zealanders are engaged in tramping, climbing or other more potentially hazardous activities. Where domestic and international visitor activities are more similar, at Abel Tasman and Tongariro for example, the risk levels are also more similar, as are the overall average risk levels across all parks.

Figure 13: Individual Risk per Visitor Day, by Park and Visitor Nationality



Estimates of visitor days spent walking/tramping and climbing/mountaineering were generated from analysis of activity data in a recent IVS sample of microdata, and from the SONZ raw data for 2016 and 2019[16]. These were used as to generate a rough proportion of visitor days spent climbing and tramping (taken as walks > 3 hours in length) in each park, so that separate individual risk calculations could be carried out for climbing and tramping. Figure 14 shows the results for the parks with most international visitor fatalities, and for all parks in aggregate. Figure 15 provides equivalent information for New Zealand visitors.

[16] "Tramping" in every case was taken as "Walks of 3 hours or more", consistent with MSC. IVS data was analysed unweighted to determine the % of respondents who visited each park who had tramped or climbed. SONZ data was weighted to determine % of the adult population who tramped (2016 & 2019) and climbed (2019 only). The lower % tramping for each park was taken as the lower of the 2016 & 2019 SONZ data; the higher as the higher from the two surveys. The SONZ climbing data for 2019 was assumed to be uncertain by x/÷ the same factor by which the tramping % varied from the geometric mean of its values for the surveys for each park. (So lower % for SONZ 2019 for each park = % from 2019 / SQRT(higher % for tramping / lower % for tramping from the 2 surveys for that park); higher % for SONZ 2019 = % from 2019 x (the same square root).

Figure 14: International Visitor Individual Risk in National Parks – by Activity

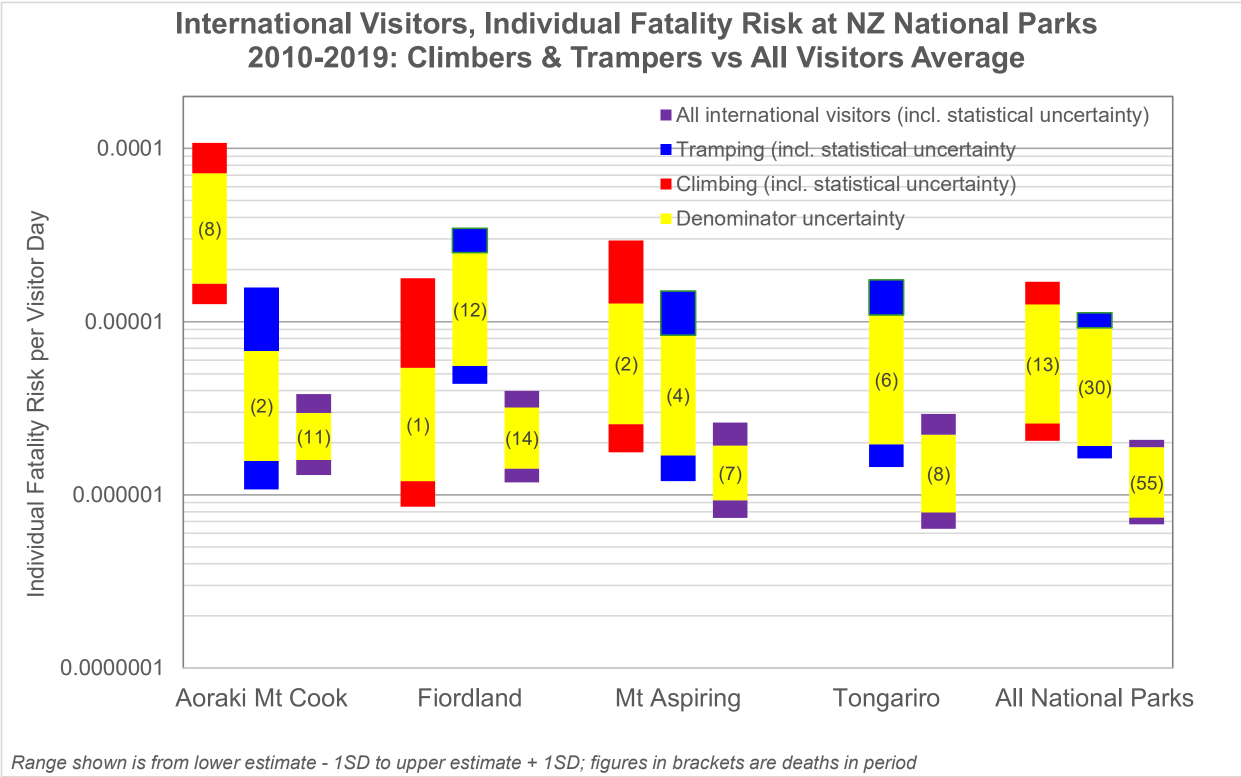
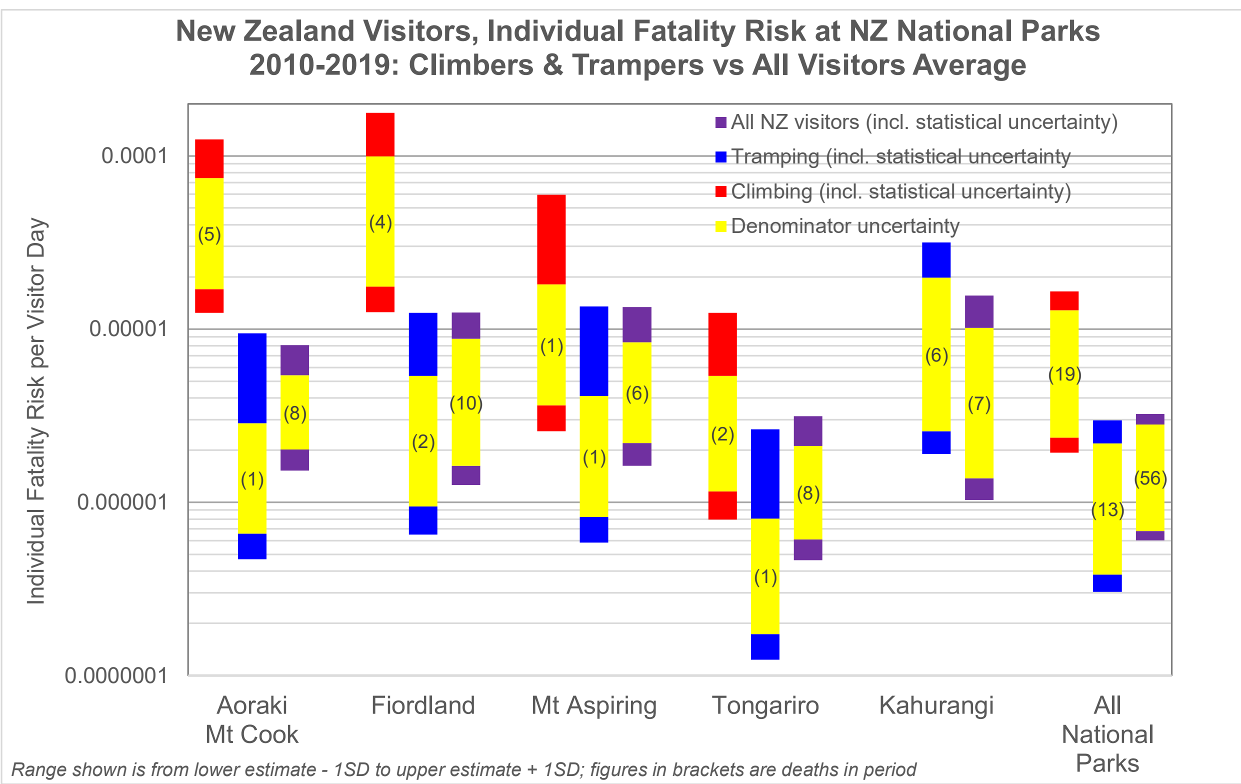


Figure 15: New Zealanders' Individual Risk in National Parks – by Activity



Taking the parks as a whole, Figures 14 & 15 show remarkably similar levels of overall risk per day for both international visitors and New Zealanders. Regardless of residency in NZ or overseas, risk for climbers is considerably (some 3-10x) higher than that for visitors generally.

For trampers, though, there is a marked difference between international visitors and New Zealanders, with the former experiencing some 4-6x the risk per day than the latter. This perhaps reflects the greater familiarity of New Zealanders with local conditions and hazards, and greater experience and capability in dealing with them. Falls, exposure, avalanches and drowning/ river crossings accounting for 23 of the 30 overseas visitor tramper deaths (6 of the others involved medical causes, the other 1 involved a missing person whose body was never recovered).

The exceptional park in terms of a distinct difference in risk levels between tramping and climbing is Aoraki Mt Cook, where the average climber (overseas or New Zealander) faces an individual risk of death per day about 10x that of a tramper, in the region of 10^{-5} to 10^{-4}. This in turn is an average over larger numbers of people climbing well within their limits at lower levels of risk, and smaller numbers pursuing more extreme challenges such as the ascent of Aoraki itself. A 2001 paper[17] analysed fatalities on Aoraki/Mt Cook alongside visitor nights spent in huts and estimated a range of fatality risk between 0.3 and 6.5 per 1000 per climbing day – another 1-2 orders of magnitude higher than the average shown in Figure 14 for climbers in the park[18].

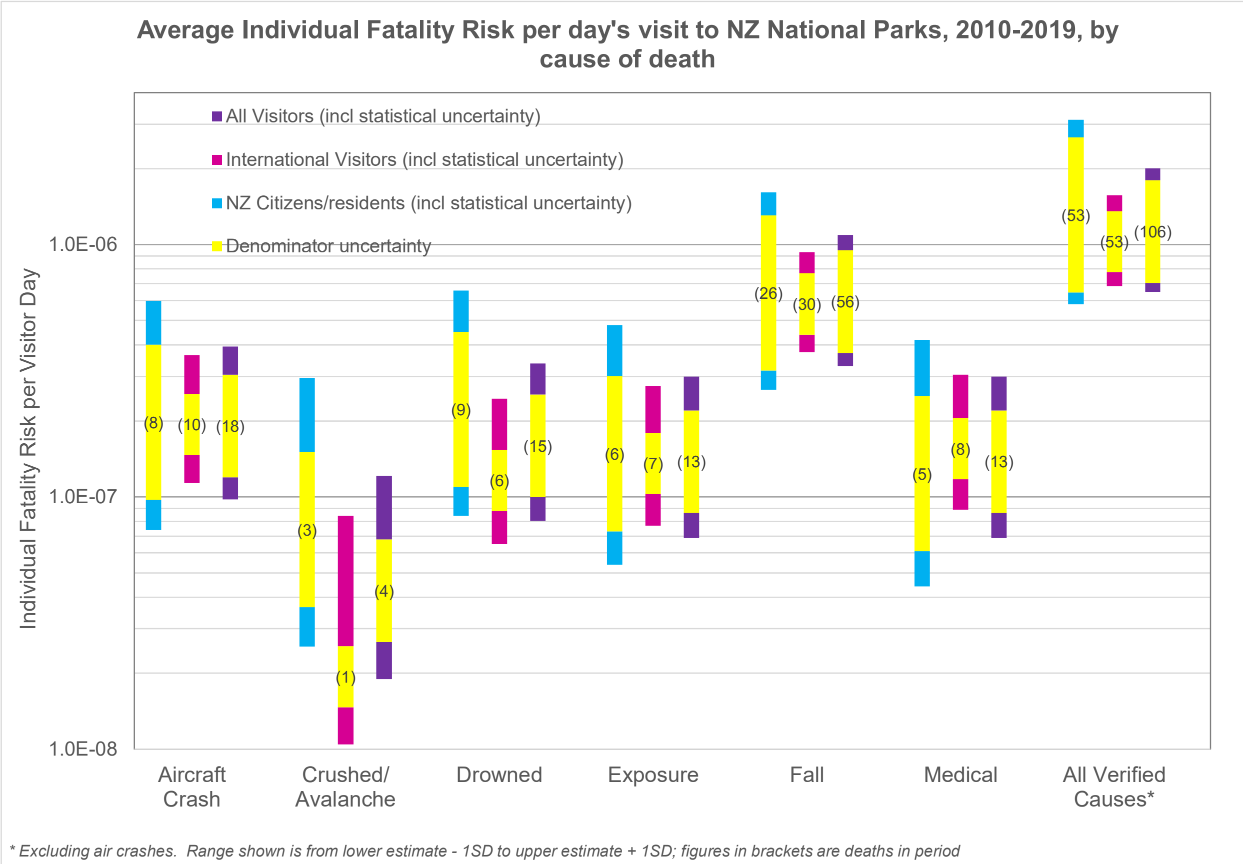
Figure 16 shows the contributors to average individual risk per visitor day in National Parks broken down by cause of death, for both international and domestic park visitors. Although not included within the scope of this study so excluded from the “All causes” bars in Figure 16, aircraft accident deaths (based on the two tragedies at Fox Glacier in 2010 and 2015) are shown for comparison purposes. These are normalised per visitor day to Westland National Park, NOT per person-flight taken (which would lead to very much higher figures – see also Sections 6 & 7).

Falls clearly stand out as the largest single contributor to risk for both domestic and international visitors, accounting for several x 10^{-7}/yr risk contributions. Leaving falls aside, it is interesting to note that crushings/avalanches, drownings (including river crossings generally), exposure and medical causes each contribute of order 10^{-7}/yr individual risk to both domestic and international visitors, somewhat more on average to the latter.

[17] Malcolm, M, “Mountaineering fatalities in Mt Cook National Park”, NZ Medical Journal, 114(1127) 78-80, 2001.

[18] I am advised by mountaineers in NZ that the hut bookings may understate the numbers actually climbing particular routes, so this may be an overestimate of risk. The risk may also have reduced significantly in the last 20 years with improvements in climbing practices & equipment, and the advent of commercially guided ascents of Aoraki/Mt Cook.

Figure 16: National Park Visitor Individual Risk, by Cause of Death



A more reliable estimate of the risk associated with tramping on specific routes can be made for the New Zealand Great Walks, for which more accurate data is available on visitor numbers. Fatalities occurring along the Great Walk routes are identified in Appendix 1 and summarised in Table 9.

Three groups of fatalities are identified by different shadings shown in Table 9:

a) In yellow: 5 people, all aged under 30, who died during winter tramps (outside the Great Walks season, thus not included in the statistics for visitor nights in Table 7),

b) In grey: 2 cases where no body was recovered and there is no certainty where the individual died, of what cause, and whether they were planning a Great Walk, and

c) In white: 4 people who died during the Great Walk season, all men aged over 60, 3 of whom died of medical causes. The 4th suffered a fall from an unknown cause, for which a medical episode was one possible explanation.

Table 9: Fatalities on New Zealand Great Walks, 2010-2019

Incident Date	Year	Great Walk Route	Residency Category	Incident cause category	Gender, Age	Notes
29/01/2012	2012	Milford	International visitor	Medical	M,63	Heart attack
23/02/2013	2013	Milford	International visitor	Medical	M,68	Collapsed on McKinnon Pass
06/08/2013	2013	*Heaphy*	Citizen/resident	Body not found	M,58	Body not found; some remains on beach
19/05/2014	2014	*Milford*	International visitor	Drowned	F,22	River crossing in winter
06/03/2015	2015	Milford	Citizen/resident	Fall	M,69	Fell from McKinnon Pass
09/07/2015	2015	*Kepler*	International visitor	Avalanche	M,23	Caught in avalanche; rangers advised of risk before setting out
09/07/2015	2015	*Kepler*	International visitor	Avalanche	M,23	
03/12/2015	2015	Routeburn	Citizen/resident	Medical	M,65	Death from natural causes
28/07/2016	2016	*Routeburn*	International visitor	Exposure	M,27	Walking in winter against rangers' advice
25/10/2017	2017	*Heaphy*	Citizen/resident	Body not found	M,53	Body not recovered; cause/ location of death unknown
20/10/2019	2019	*TNC*	International visitor	Exposure	F,51	Became detached from group

The latter category (c) are the only deaths definitely to have taken place in the course of Great Walks and their fatality risk is shown in charts as follows:

a) Per Great Walk (Figure 17), and

b) Per day's walking on Great Walks (Figure 18).

Figures 17 (risk per whole walk) and 18 (risk per day) show the "All walks" figure both including and without medical causes, to give a better indication of risk inherent in the Walks rather than the health of the individuals enjoying them. Both figures include only those Walks on which fatalities have occurred in the course of Great Walk journeys, and are based on walker numbers derived from DOC accommodation bookings plus private lodge bookings for the Milford and Routeburn tracks (so do not include many other walkers on other tracks, meaning that the actual risk is likely to be somewhat lower than is shown in the figures).

The other Walks have too few walkers to have generated significant probabilities of fatalities during the period, with the exception of the Abel Tasman coastal track, which had well over 1.1 million walking days over the period, giving confidence that the fatality risk per day is around 1 per million (10^{-6}) or lower. Figure 18 also shows the popular Tongariro Alpine Crossing (not a Great Walk, but with accurate walker numbers from counter data) risk for the same period. Both fatalities on the TAC were from medical causes, though 2 further fatalities, neither from medical causes, occurred in the 6 months following the end of the period.

Figure 17: Great Walks Individual Fatality Risk per Whole Walk

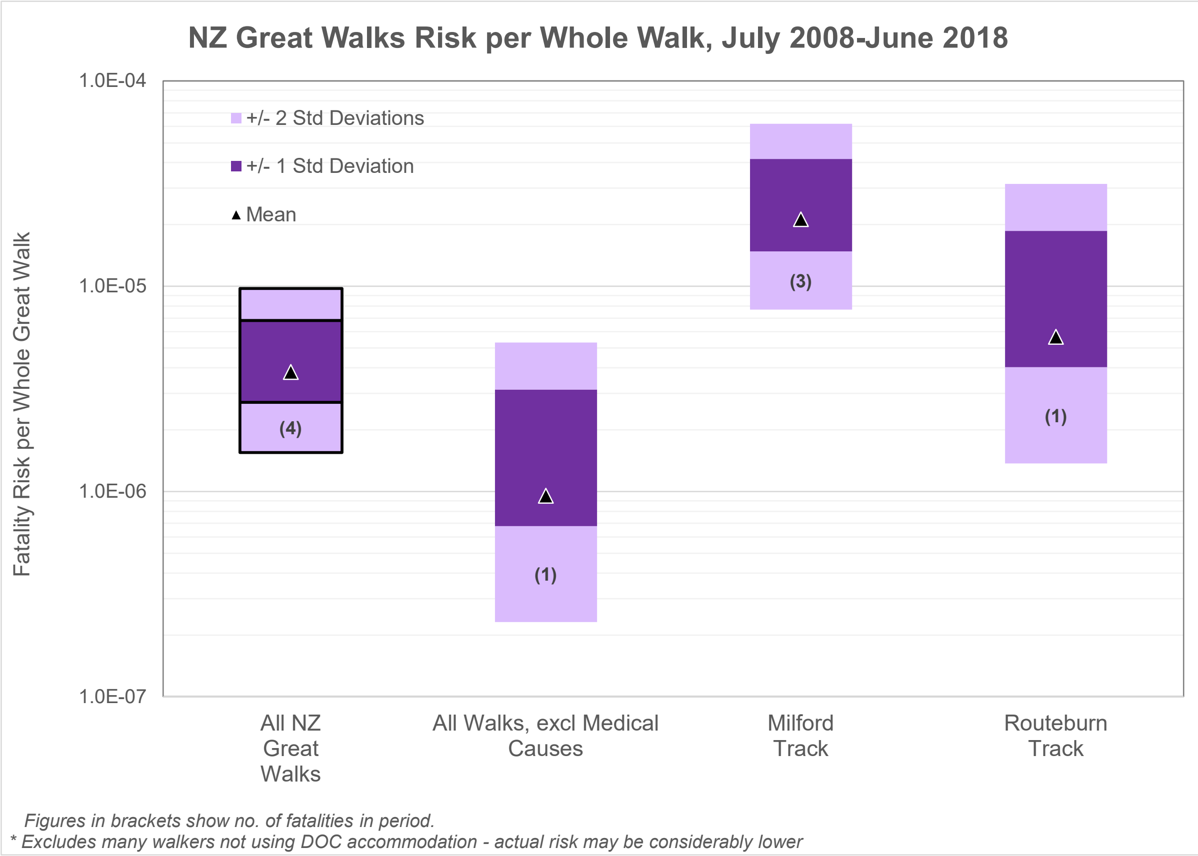
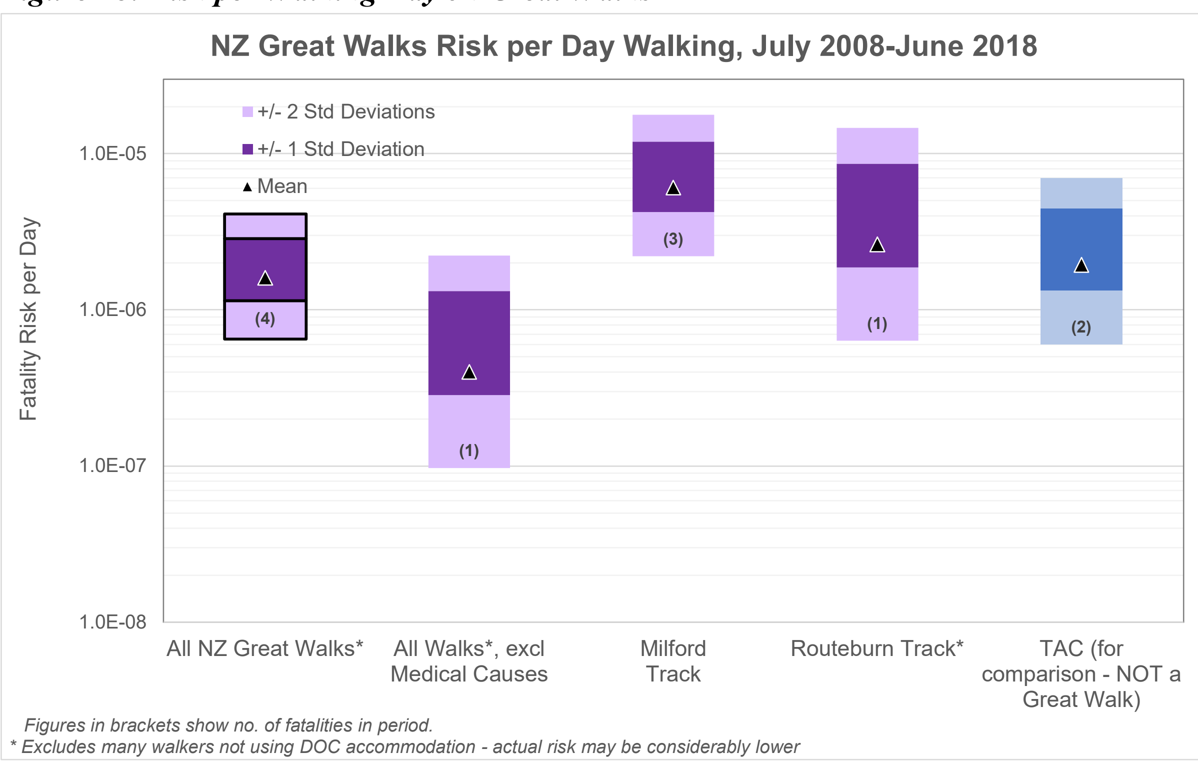


Figure 18: Risk per Walking Day on Great Walks



The fatality risk per whole walk is of order 10^{-5} for the longer, more remote walks; somewhat higher for the Milford Track. The more popular, less remote Abel Tasman Coastal Track bring the average for all Great Walks down well below 10^{-5}; with medical causes removed this drops to around 10^{-6}.

The longer, more remote walks entail risk roughly in the range 10^{-6} to $2x10^{-5}$ per day, which is similar to or marginally higher than, the average rates for trampers in the more remote National Parks (Figure 15). The average for all Great Walks is in the range $1\text{-}4x10^{-6}$ per day, brought down by the significantly lower risk on the popular Abel Tasman Coast Track, on which the risk per day is around 10^{-6} or lower. With medical causes removed the average fatality risk over all Great Walks falls to around 10^{-6} per day or lower. The figures for the TAC suggest that risk per day there is similar to that on other mountainous Great Walks.

Analysis of counter data on the Kepler, Routeburn and TNC Tracks outside the Great Walk season (there are no counters on the Milford Track – in season they are not needed as the number entering each day is known and they each follow an identical itinerary) suggests that the 5 fatalities in Table 9 which occurred outside the Great Walk season were associated with around 300,000 to 500,000 visitor days tramping over the period. This in turn implies an average individual risk in the range (as shown in Figures 17 & 18) $5x10^{-6}$ to $4x10^{-5}$ per day.

The individual fatality risk faced by visitors on NZ PCL can be summarised as follows.

a) The risk lies overall in the range $6x10^{-7}$ to $3x10^{-6}$ per day's visit (Figure 11).

b) The risk cannot reliably be said to be much higher or lower for NZ residents in comparison with international visitors, or in National Parks vs elsewhere on NZ Public Conservation Land (Figure 11), based on deaths excluding natural causes. Reliable statistics on such deaths have been provided by recent NZ Mountain Safety Council (MSC) studies, but visitor numbers rely on surveys for their determination, and are particularly uncertain for locations other than the National Parks.

c) International visitors' overall risk in National Parks appears similar to that for NZ residents (Figures 11, 13, 14, 15) as does the risk for climbers (Figures 14,15). In contrast, the risk associated with tramping is some 4-6x higher per day for international visitors than for New Zealanders.

d) Climbers experience about 3-10x the risk per day of average visitors to National Parks. International trampers experience similar risk levels to climbers, while New Zealand trampers experience no higher risk per day tramping than on other visits to National Parks.

e) The risk varies across parks, varying from around 10^{-6} to 10^{-5} per visit for the parks with greater volumes of remote tramping, climbing and other activities (Kahurangi, Aoraki, Fiordland) down to some 10x lower per visit for popular parks (e.g. Abel Tasman, Paparoa) with large visitor numbers but lower volumes of adventurous activity (Figure 12).

f) Falls are substantially the largest contributor to visitor risk at National Parks, accounting for around half of all deaths. But exposure, drowning, avalanches (& other crushing events) and medical causes each account individually for around 10^{-7} risk per day on average (Figure 16).

g) There have been very few fatalities on Great Walk tracks during the Great Walk season, all in the decade of interest involved men age over 60, and at least 3 of the 4 were attributable to medical causes. The average fatality risk per day's walking is of the order of 10^{-6} including medical causes, significantly lower excluding them.

It needs to be remembered throughout that the risk figures quoted are all averages over large numbers of people. A large proportion of the fatalities involved would have been avoidable with better preparation or decision making, so the element of uncontrollable risk inherent in all these statistics is quite small. Well prepared visitors who do not venture into situations outside their capability will face substantially smaller levels of risk. On the other hand, the ill-prepared who disregard warnings can expect to face substantially higher levels of risk.

3.2.3 Aggregate Risk to DOC Workers, Visitors and Others

The fatality statistics presented in Table 2 and Appendix 1 enable total fatalities to be calculated for the period 2010-2019 as shown in Table 10.

Table 10: Total Fatalities on NZ Public Conservation Land, 2010-2019

Scope of Events	SAR-PCL	MSC	This Study - Min(1)	This Study - Max(2)
Visitors - National Parks	81	108	111	111
Visitors - other DOC sites	82	65	82	112
Workers(3)	9	9	9	9
TOTAL	**172**	**182**	**202**	**232**
plus aircraft accidents	18	18	18	18
Total including air accidents	**190**	**200**	**220**	**250**

(1) The minimum for other DOC visitor sites is taken as the higher of the MSC and SAR-PCL figures
(2) The maximum for other DOC visitor sites is scaled up by the ratio of (this study : SAR-PCL) for National Parks
(3) The crash in which 2 members of the public were killed in collision with a DOC driven vehicle has been excluded

Depending on whether air accidents are included or excluded, the annual burden of fatalities on NZ PCL lies somewhere between 20 and 25 deaths per year. As explained in Section 3.2.1, I am not confident that all deaths associated with some causes (for example medical events) are included in these figures.

An annual casualty burden inclusive of injuries can be estimated using the ratio of severe and moderate injuries to deaths from the SAR data shown in Figure 3. That sample included

- 133 deaths
- 392 severe injuries, and
- 378 moderate injuries.

The relative importance of different injury severities is discussed in the companion guidance document; at the present time the statistics are not sufficiently well known for it to be worthwhile attempting to develop some form of aggregated metric for the casualty burden in $ or other terms.

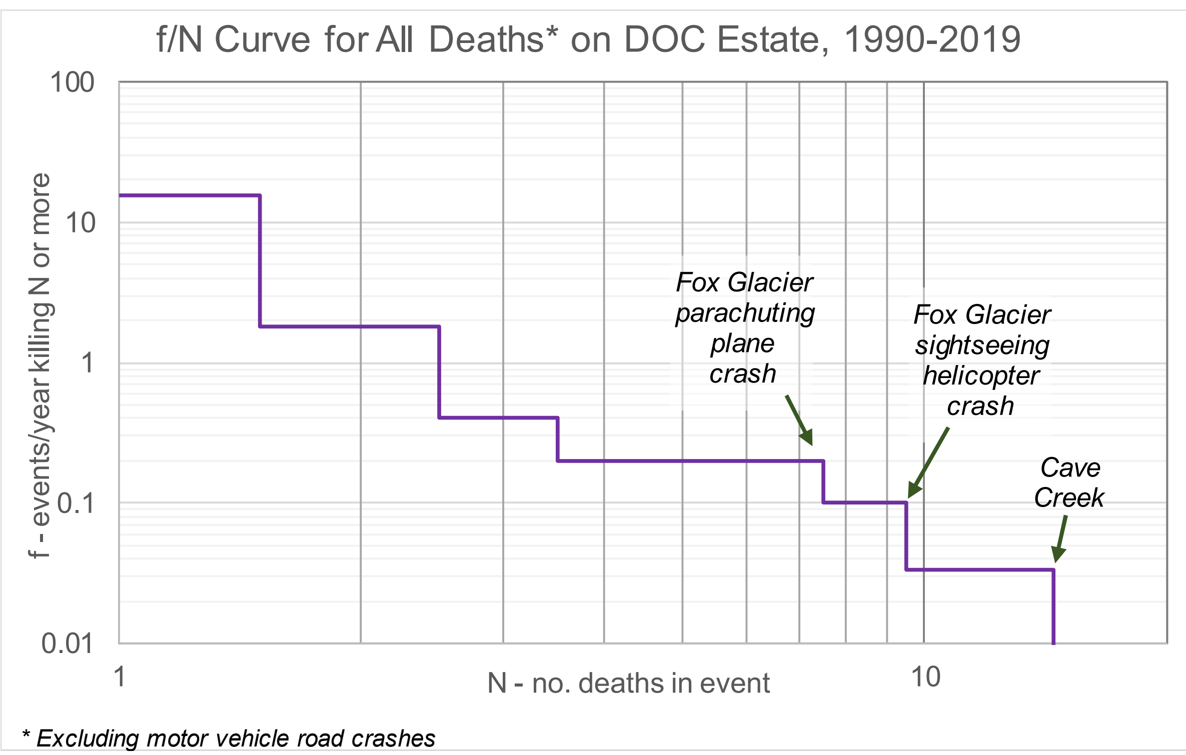
As a starting point for societal risk comparisons, the data from Table 10 was used to derive values of the frequency f of events killing N or more people. The frequency f is simply the number of relevant events in the table divided by 10 (the years in the decade).

A decade is a very short period from which to collect data on rare and severe accidents. The only incidents on NZ Public Conservation Land before this period of which I am aware that might be added in to extend the range of fatalities upwards to 10 or beyond are the Cave Creek tragedy (14 deaths, 1995) and the Tangiwai Disaster (151 deaths, 1953).

The Tangiwai disaster took place over 60 years ago and that specific scenario is no longer credible, but Cave Creek is relatively recent and of high relevance for DOC. I have therefore included Cave Creek in my f/N curve by adding as a data point with N = 14 and an assumed frequency of 1 event per 30 years. In addition to the data generated from Table 10, this generated values of f = 1/30 for all values of N from 10 up to 14.

The resulting f/N chart, including all the events contributing to Table 10 and Cave Creek, is shown in Figure 19.

Figure 19: Societal Risk expressed as an f/N Curve – All Deaths on NZ PCL 1990-2019



Expressed differently, the f/N curve tells us that over the past few decades NZ has experienced, on PCL,

- About 15 fatal incidents (killing 1 or more people) per year
- About 2 incidents killing 2 or more people per year
- About 4 incidents killing 3 or more people per decade, and
- Less than one incident killing 10 or more people per decade.

4 Individual Risk in the Workplace

4.1 Workplace Risk in New Zealand

The NZ health & safety regulator WorkSafe NZ provides leadership and monitoring of workplace health & safety in New Zealand and collates statistics on fatalities and injuries across the workforce. New Zealand has higher workplace fatality rates than the UK, which is unsurprising in view of the much larger proportion of the population involved in industries such as agriculture, forestry and fishing. As in the UK, fatality rates have fallen significantly in recent years, from 4.2 per 100,000 full-time equivalent workers in 2013/14 to 2.1 per 100,000 in 2018/19[19].

In order to make comparisons across different industry sectors, and in particular to help set risk for DOC workers in context, data on fatalities and numbers of people working in different industry sectors was obtained as follows:

- On fatalities from WorkSafe's online data resources. This provided a dataset of all fatal events from 2010 to 2018, characterised by industry sector and sub-sectors, age of victim, region and WorkSafe focus areas (giving substantial information about cause of death).
- On employment by high-level industry sector from the Stats NZ Infoshare system, using Household Labour Force Survey (HLFS) data rather than the Enterprise data also available, as this is considered more reliable and is used by WorkSafe in its analyses).
- On employment broken down within the Arts & Recreation Sector (which is where DOC sits), a custom analysis of HLFS data was commissioned from Stats NZ for this study.

Figure 20 provides an overview of NZ workplace risk across the major sectors of the economy over the period 2010-2018. The Arts & Recreation sector, of which DOC forms part, is highlighted in gold.

Four broad groups of risk levels can be identified in Figure 20:

a) Around 10^{-6}/yr – corresponding to people working in education, retailing, finance, IT and communications – all largely office/classroom based environments (about 0.8m full time equivalent people employed on average over the period)

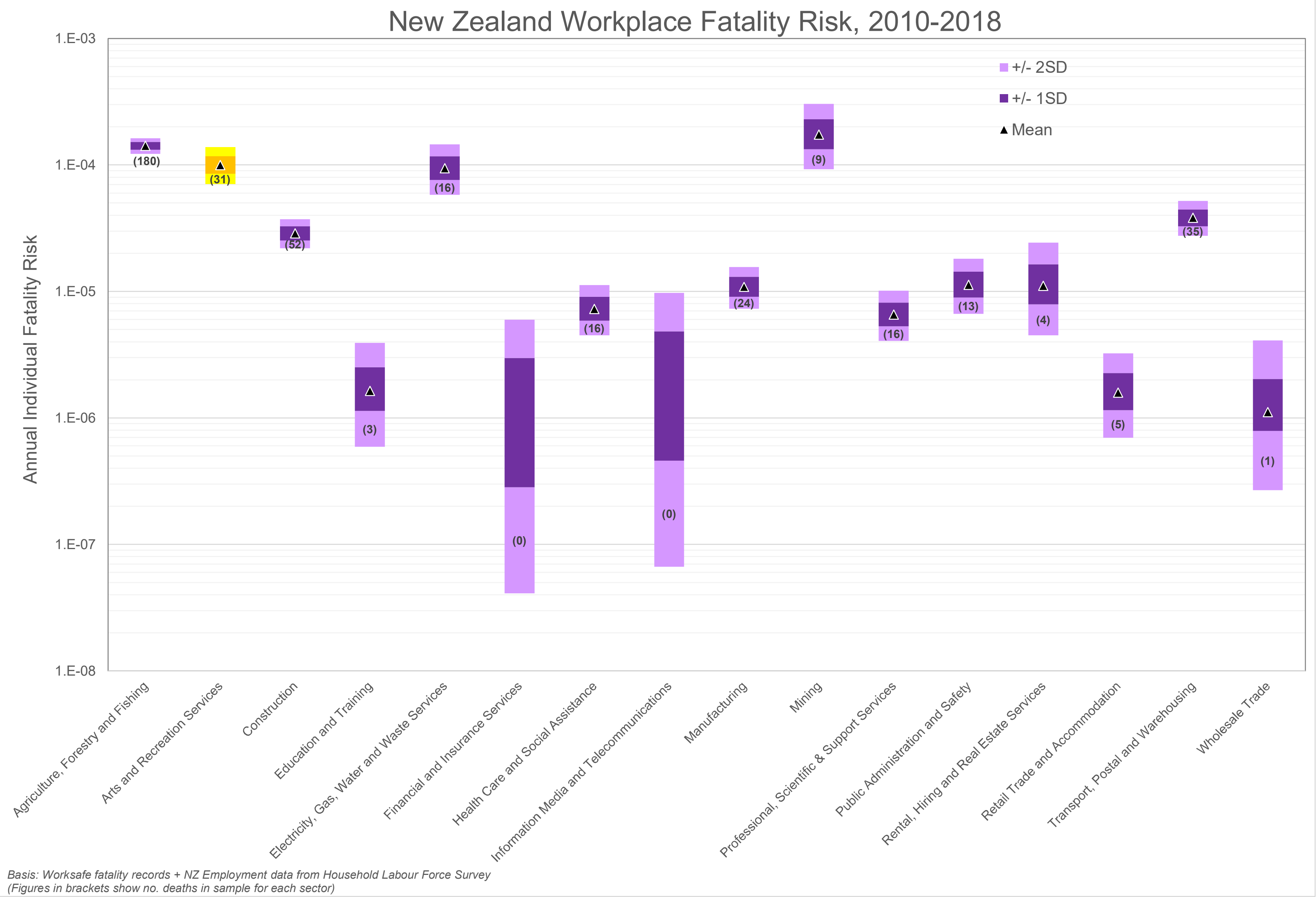
b) Around 10^{-5}/yr – corresponding to healthcare, professional services, manufacturing, public administration and rental/real estate occupations involving a mix of office and other activities (about 1m people on average over the period)

c) Around $2\text{-}5 \times 10^{-5}$/yr – corresponding to the construction and transport/warehousing sectors, where a large majority of the workforce are involved in relatively heavy non-sedentary activity (about 0.3m people on average over the period), and

d) Around 10^{-4}/yr – the highest hazard sectors of agriculture, forestry & fishing, mining, utility services and DOC's own sector, arts & recreation services (about 0.2m people on average over the period).

[19] Worksafe Annual Report, 2018/19

Figure 20: NZ Workplace Fatality Risk, 2010-2018



The conclusion from Figure 20 is that the sector (arts & recreation services) of which DOC forms part is among the top 10% of the NZ workforce in terms of annual individual fatality risk. Another simple conclusion is that, were we to extend this analysis within some of the high hazard sectors, we would almost certainly find some sub-sectors with risk levels well above 10^{-4}/yr.

Within the Arts & Recreation Services sector the HLFS analysis commissioned from Stats NZ enabled the full-time equivalent person-years to be estimated as shown in Table 11 alongside the fatalities information obtained from Worksafe.

Table 11: Fatalities & Employment in NZ Arts & Recreation Services, 2010-18

SIC Code	2-digit subset	3 digit subset	4 digit subset	ANZSIC06 Industry Sector Description	Deaths	FTE yrs
R				Arts and Recreation Services	31	310900
	R91			Sport and Recreation Activities	29	162750
	R89			Heritage Activities	2	43375
		R892		Parks and Gardens Operations	2	22300
			R8921	Zoological and Botanical Gardens Operation	2	3294
			R8922	Nature Reserves and Conservation Parks Operation	0	19006

Note that the deaths shown do not include any of the 9 DOC deaths shown in Table 2, presumably because these fall outside WorkSafe's scope.

The breakdown of risk within the Arts & Recreation Services sector is shown in Figure 21, and that within the Heritage sub-sector (within which DOC lies) in Figure 22.

Figure 21: Workplace Risk within the Arts & Recreation Services Sector, 2010-18

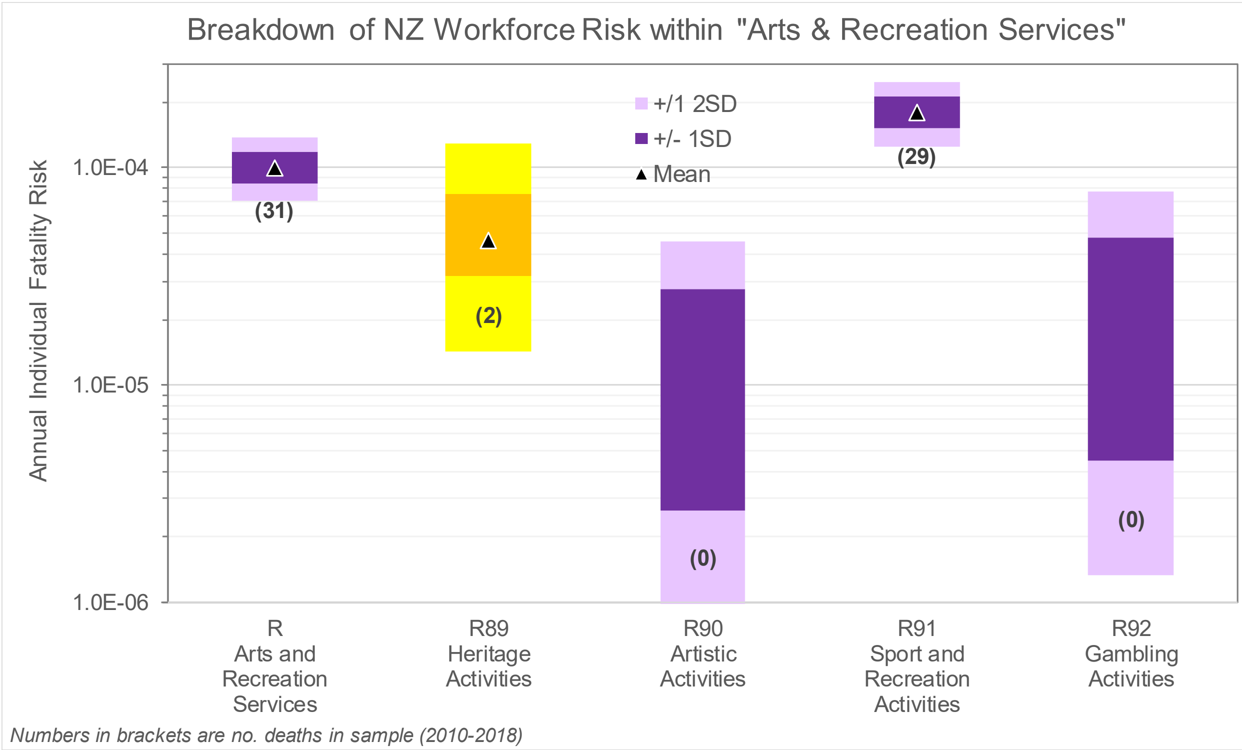
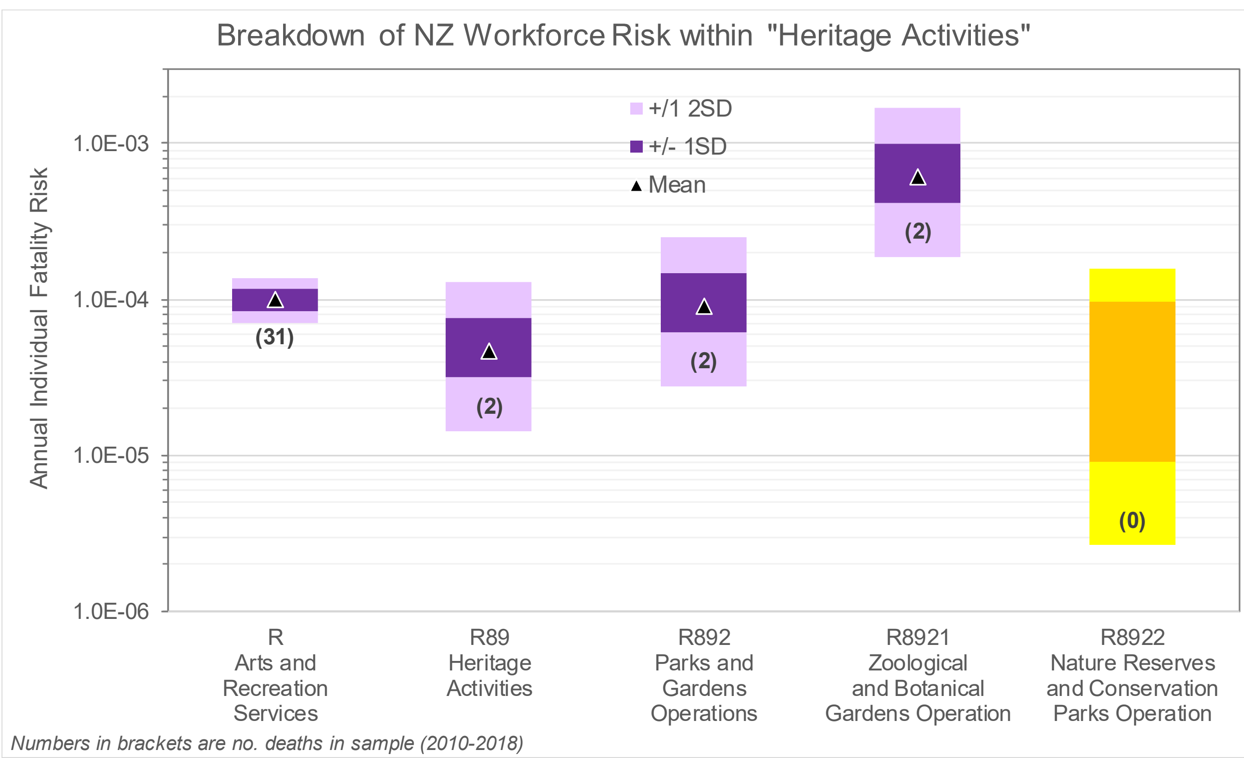


Figure 22: Workplace Risk within the Heritage Sub-Sector, 2010-18



Figures 20, 21 and 22, although they do not include any of the events that actually killed DOC workers, help place DOC workers' risk (as described in Section 3.1) in perspective at the upper end of hazardous occupations in New Zealand.

In conclusion,

- The fatal hazards that have afflicted DOC workers in the past 20 years are rather different from those in NZ workplaces generally, lying largely outside the scope of WorkSafe (i.e. involving transport, by helicopter in particular).
- The Arts & Recreation Services (ARS) sector, which includes DOC, is a high risk segment of New Zealand industry, with average individual fatality risk of order 10^{-4}/year.
- There is too little data confidently to quantify the "Nature Reserves and Conservation Parks Operation" sub-sector risk; the zero fatalities observed from 2010-2018 are consistent with an annual individual fatality risk in the range 10^{-5} to 10^{-4}/yr or lower.
- With the inclusion of events outside the scope of WorkSafe, the DOC workers risks described in Section 3.1 are well above the average individual risk in major high-hazard sectors of the NZ economy – probably consistent with higher risk areas within those sectors.

4.2 UK Workplace Risk Trends

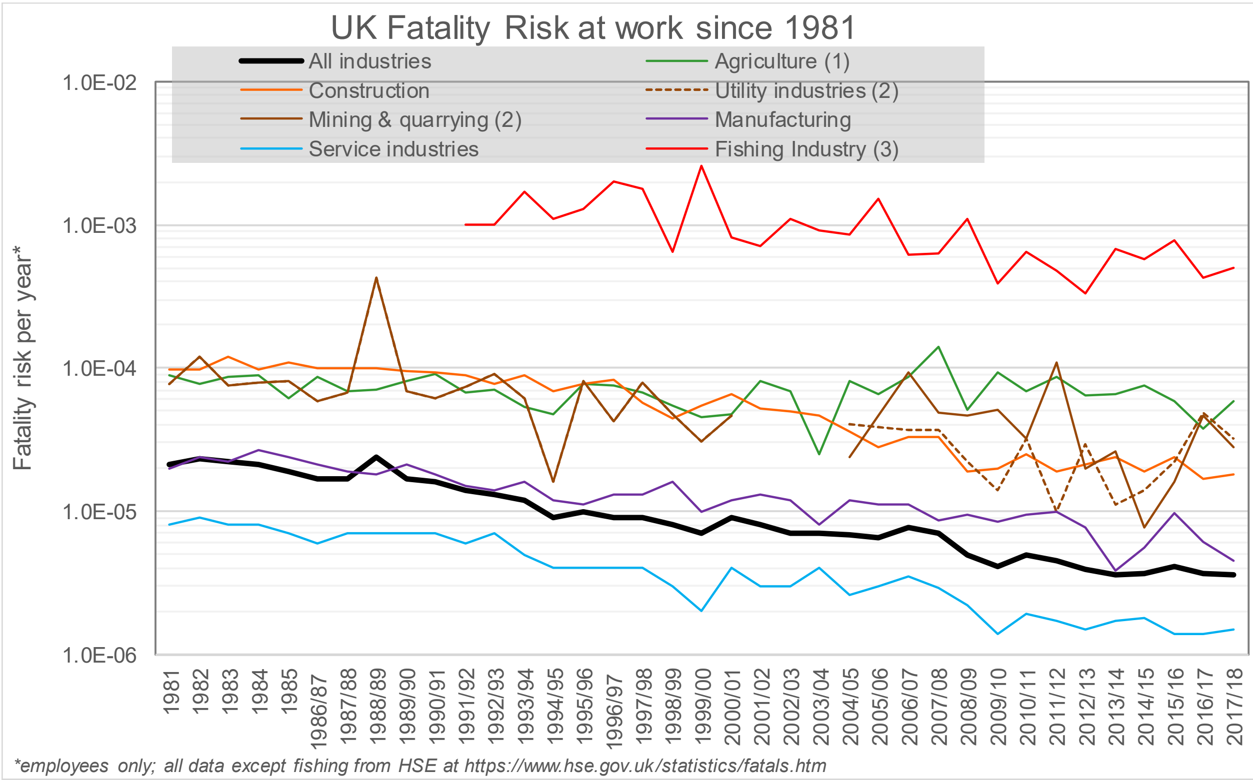
Average risk in the UK workplace is considerably lower than that in New Zealand because of the different mix of employment, and in particular the higher proportion of the population involved in relatively hazardous outdoor occupations in New Zealand. Notwithstanding the significant difference between the UK and NZ, the UK risk trends are relevant because there has been widespread adoption in New Zealand and worldwide of the UK Health & Safety Executive (HSE)'s guidance that annual individual risk to people in their workplace should not exceed 10^{-3} (1 in 1000 per year). This guidance originated in an HSE document[20] published in 1988 and updated in 1992. The intolerable level was derived by reference to existing risks in UK workplaces during the late 1980's, which included significant industries such as deep sea fishing and oil and gas extraction where average workplace fatality risk levels were just over 10^{-3}/year. The average risk in manufacturing workplaces was about 2×10^{-5}/yr, and that in service industries about 6×10^{-6}/yr.

HSE reiterated this guidance and generalised it beyond the nuclear industry early in the new millenium[21]. The highest risk industries referenced included energy materials extraction (oil, gas & coal) at 1.1×10^{-4}/yr, construction, agriculture & forestry (all about 6×10^{-5}/yr). The average risk in manufacturing workplaces had fallen to 1.3×10^{-5}/yr and that in service industries to about 3×10^{-6}/yr. There was, though, awareness that risk levels in the most hazardous occupations such as deep sea fishing and offshore diving was still above 10^{-3}/yr.

As shown in Figure 23, risk levels in UK workplaces have continued to reduce since that time.

[20] "The Tolerability of Risk from Nuclear Power Stations", UK Health & Safety Executive, 1992
[21] "Reducing Risks, Protecting People: HSE's Decision Making Process", UK Health & Safety Executive, 2001

Figure 23: Workplace Risk in the UK – Recent Trends



Notes on Figure 23:

1. *"Agriculture" includes forestry and fishing, except for sea fishing*
2. *Extractive and utility industries reported together to 2000/01; separately from 2004/05*
3. *Fishing industry data to 1996 taken from MAIB review[22]; subsequent data on fatalities from MAIB annual reports and MMO UK fishing statistics[23]*

There are no longer any industries employing substantial numbers of people with risk levels above 10^{-3}/yr in the UK. For the past decade even deep sea fishing has lowered risk to well below this level (the 10-year average to 2018 is just under $6x10^{-4}$/yr), while service industries have levels well below $2x10^{-6}$/yr and the average for all workplaces is just over $3x10^{-6}$/yr. What are generally regarded as high-risk industries (construction, agriculture, mining) involve annual fatality risk levels in a range from about $2x10^{-5}$ to $6x10^{-5}$/yr.

Arguably, these substantial risk reductions reflect a corresponding reduction in UK society's willingness to tolerate risk levels in the workplace as high as 10^{-3}/yr. The key conclusion for this study is that if the HSE guidance were to be updated today, the 10^{-3} upper limit of tolerability would be more likely to be made more restrictive (lower), rather than to be relaxed. Guidance on tolerability of worker risk for DOC is provided in the companion report "Guidelines for DOC on dealing with Natural Hazard Risk".

[22] MAIB, "Analysis of UK Fishing Vessel Safety 1992-2006", UK Marine Accident Investigation Branch, Nov 2008
[23] Published online at https://www.gov.uk/government/collections/maib-annual-reports and https://www.gov.uk/government/collections/uk-sea-fisheries-annual-statistics

5 General and Accident Mortality Data

In considering visitor risk tolerability, a good starting point is the levels of risk faced by the NZ population from other causes generally, and from accidental causes in particular. The NZ Ministry of Health (MoH) publishes mortality data broken down by cause, gender, age band and region of residence. Of particular interest for this project is the region classified as "Overseas and Undefined". While this is no longer published, the tables were still being generated and I am grateful to the Ministry of Health for providing them to assist with this study.

Statistics here are presented

a) For New Zealanders, using the MoH mortality data for the whole NZ population (with "Overseas and Undefined" excluded) along with population data from Stats NZ, to calculate mortality rates by age, gender and cause. Rates are then converted to risks per day for comparison with other visitor risk data (Section 4.1).

b) For international visitors, using the MoH mortality data for "Overseas and Undefined"[24] along with data on nights spent in New Zealand by international visitors obtained from the Ministry of Business, Innovation and Employment's International Visitor Survey (IVS, Section 4.2).

For New Zealanders, the most recent 5 years of available data (2011-2015) was used to provide statistically sensible numbers of deaths for each cause analysed. For international visitors this period was extended to 10 years (2006-2015) as the numbers of deaths are significantly smaller. In each case general mortality comparisons are presented first, followed by comparisons of different contributors to accident mortality.

The numbers of deaths in most cases are substantial and causes of death, gender and age are well characterised on death certificates and coroners' reports. The uncertainty in numbers of deaths is therefore small. The charts presented here thus show the range of risk experienced by different age/gender groups within the relevant population, rather than the statistical uncertainty inherent when very small numbers of deaths are involved.

5.1 New Zealand Citizens and Residents

Population and mortality statistics were taken from the most recent tables published by the NZ Ministry of Health and by Stats NZ. Percentiles of risk were calculated as described in Section 2.2.2.

An overview of annual mortality rates by age is provided in Figure 24. Risk per day is 1/365 of that shown in Figure 24. Figure 25 shows the same information, but now presented as bars showing the percentiles of the population facing different levels of risk per day, to facilitate comparison with other risks in this study.

[24] While this includes a small number of deaths of people whose region could not be defined, the vast majority are international visitors and I was advised by MoH that these would provide an extremely close approximation to overseas visitor deaths.

Figure 24: New Zealanders' Mortality Rates by Major Causes of Death, 2011-2015

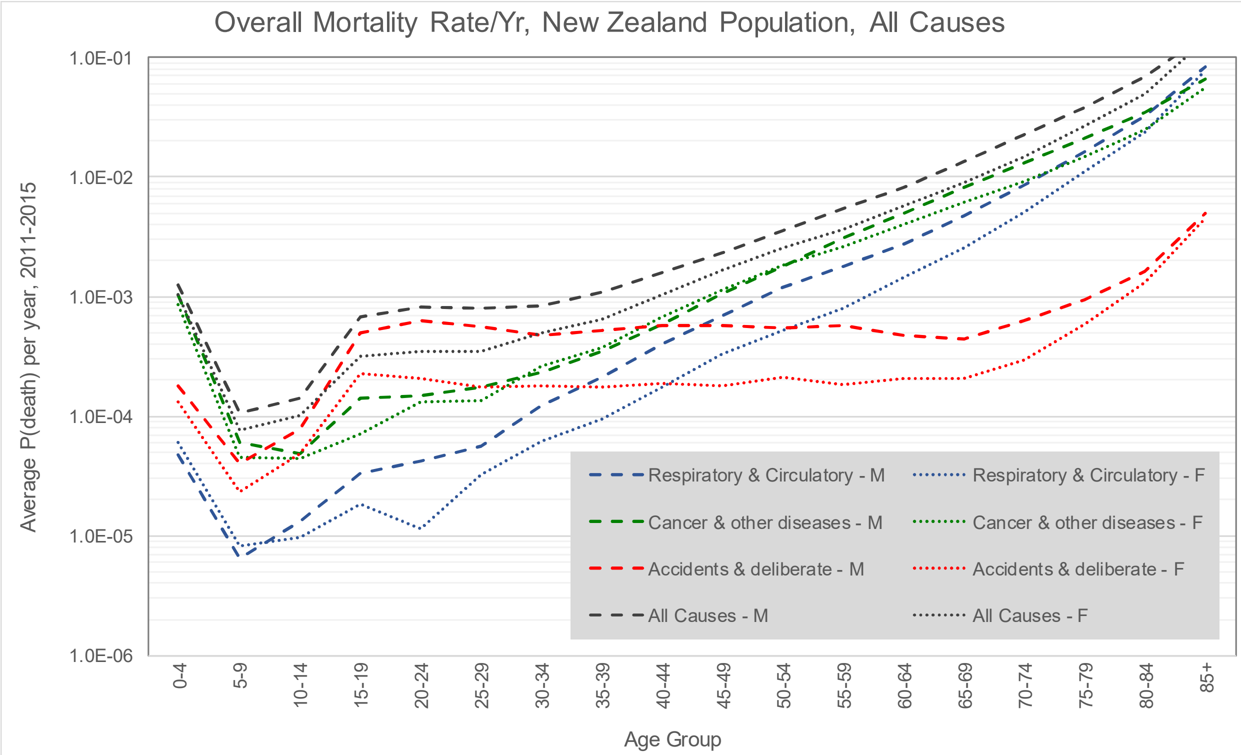


Figure 25: New Zealanders' Daily Mortality 2011-2015, showing Percentiles of Population

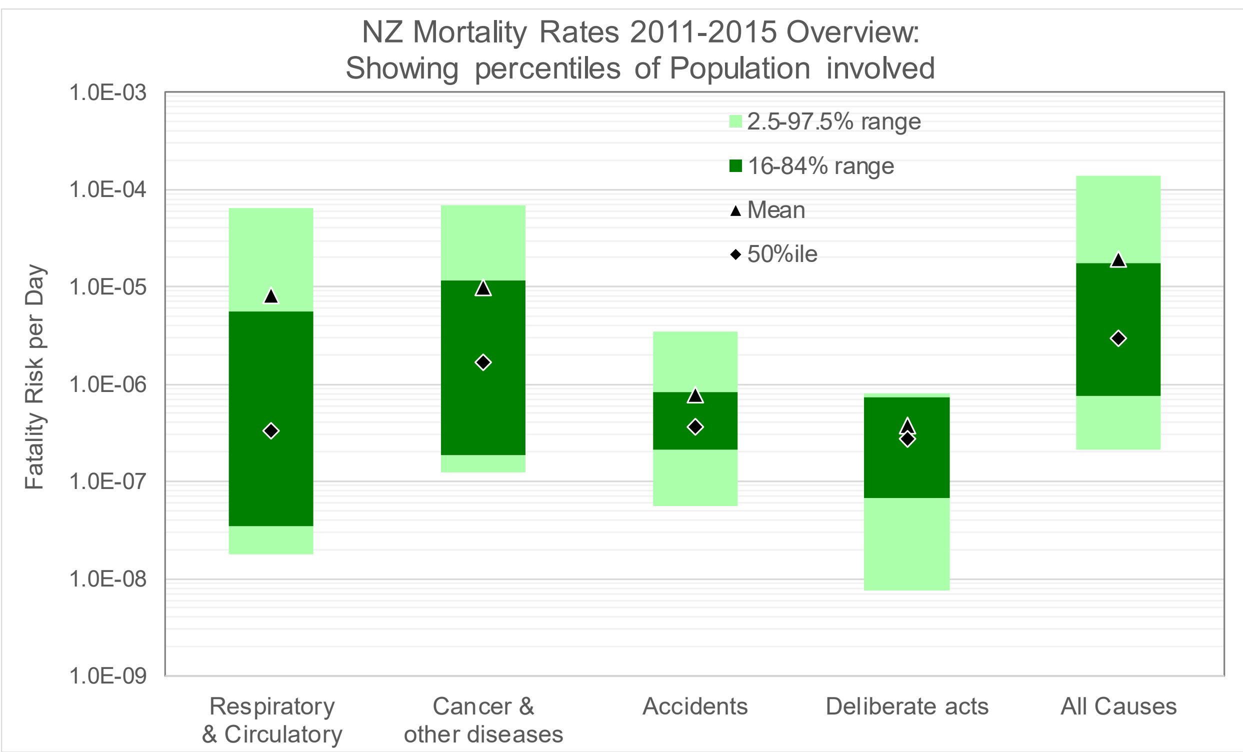


Figure 24 shows that, as would be expected, children have the lowest mortality rates. Accidents are the dominant risk for young adults. Mortality rates generally rise with age throughout adulthood, though accidents show a long "plateau" between the ages of around 20 and 70.

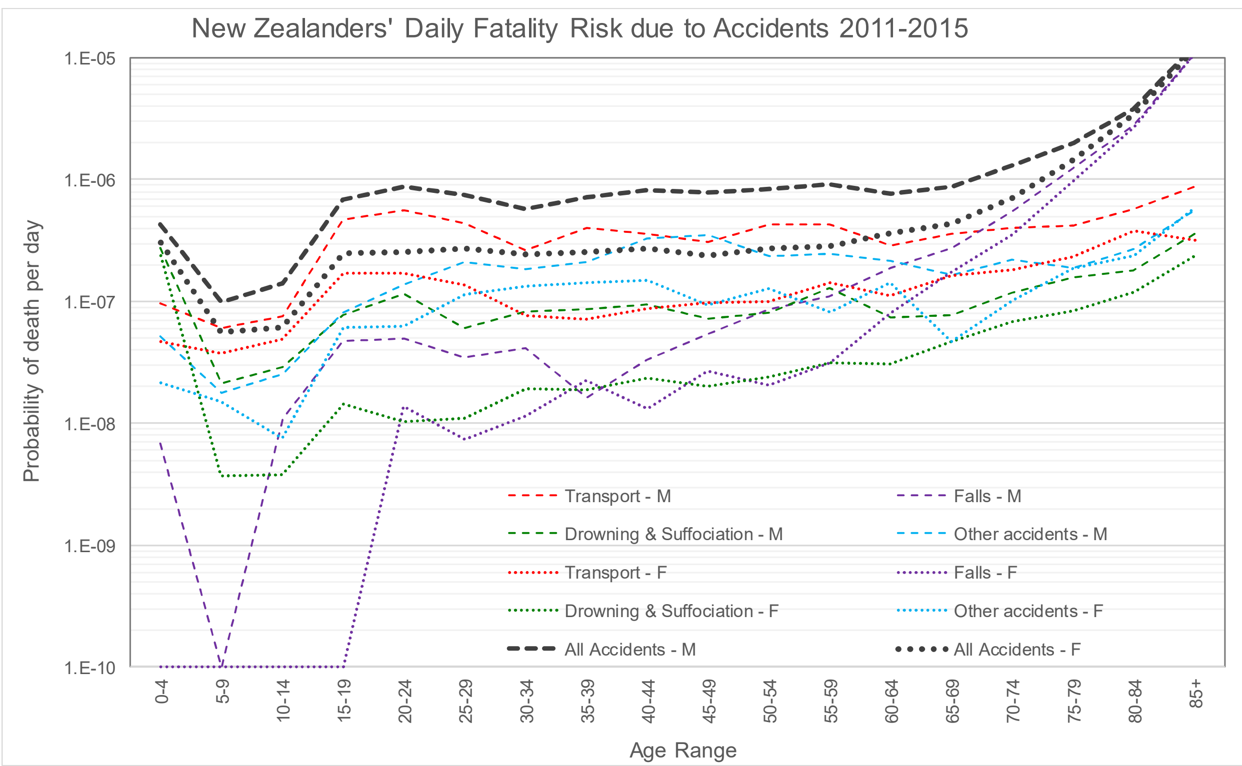
Figure 25 provides an interesting alternative perspective and illustrates that, for example

- About 2/3 of New Zealanders have a daily probability of death between 10^{-6} and $2x10^{-5}$ (those below this range being the younger, those above it the older members of the population).
- Over 2/3 of New Zealanders have a daily probability of death from accidental causes between about $2x10^{-7}$ and 10^{-6}; for over half of them it is higher than $3x10^{-7}$.
- Well over 10% of New Zealanders have a daily probability of death from circulatory and respiratory disease in excess of 10^{-5}.

While accidental causes of death are the main focus of interest for this study, it is also relevant that a small subset of the circulatory and respiratory deaths involve sudden onset events such as heart attacks or strokes. Such events are very much more likely to prove fatal if the victim is in a remote location on public conservation land than if they have access to communications and emergency services.

Figure 26 provides a breakdown of daily accident risk by age in a format similar to Figure 24.

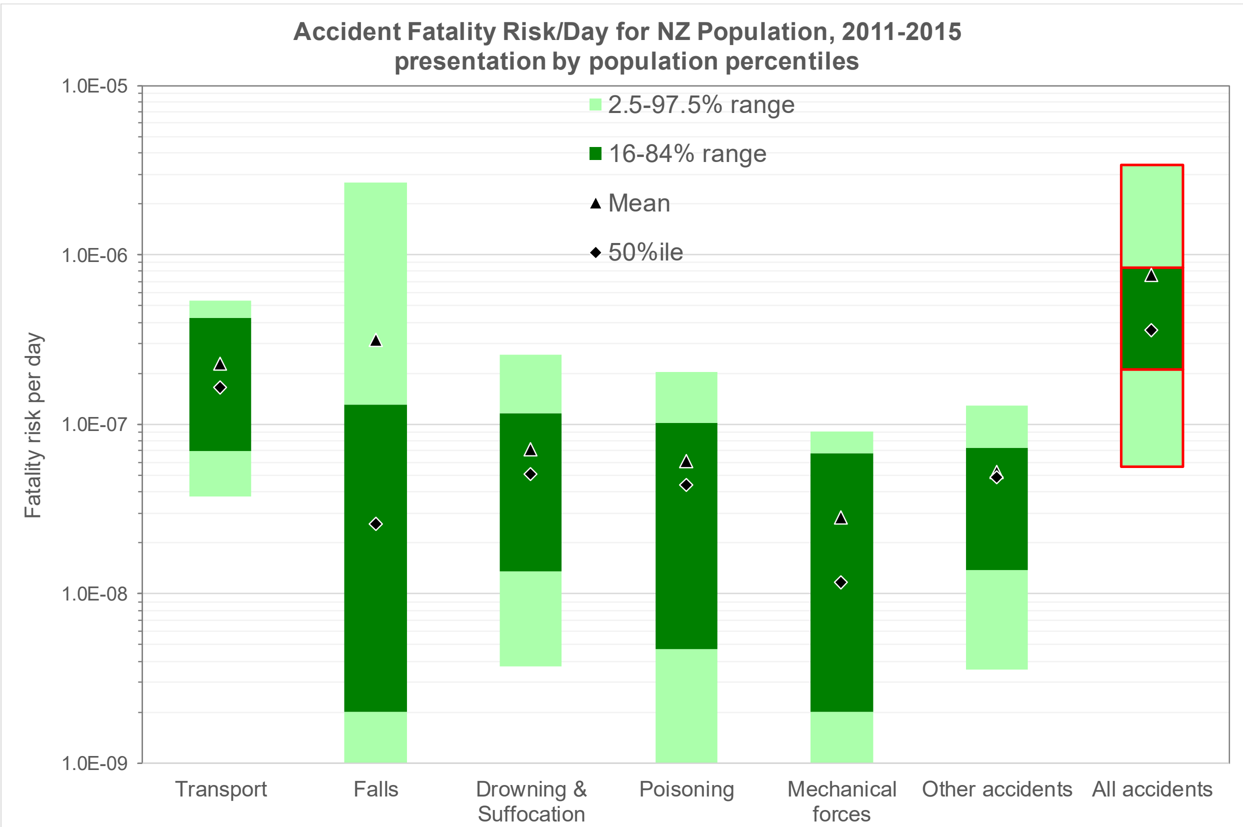
Figure 26: Breakdown of New Zealanders' Daily Accident Mortality Rates, 2011-2015



The pattern is broadly similar for all accidental causes of death, with the minimum being experienced by young children (girls in particular) and rates in most cases rising with age. For very young infants, suffocation is the dominant accidental cause of death, while from school age onwards transport dominates (with a distinct "blip" for younger drivers in their late teens and twenties) until, somewhere in the 60's to 70's falls become the dominant risk contributor.

Figure 27 provides a similar breakdown, presented in terms of percentiles of the population as was Figure 25.

Figure 27: Contributors to New Zealanders' Daily Risk of Accidental Death, 2011-2015



This form of presentation is helpful in making comparisons; it can be noted that, for example

- The average risk from transport accidents (largely motor vehicle crashes on the roads) is just over $2x10^{-7}$ per day.
- The majority of New Zealanders experience daily risk between 10^{-8} and 10^{-7} per day from each of the other groups of causes shown in Figure 30.
- While transport contributes the majority of the average risk, well over half of New Zealanders experience daily risk greater than 10^{-7} from other accidental causes.

We now turn to consider the equivalent mortality rates for international visitors to New Zealand.

5.2 International Visitors

Visitor nights spent in New Zealand by age group were derived from the Ministry of Business, Innovation and Employment's International Visitor Survey tables published via Stats NZ. The tables characterise length of stay in terms of exact numbers of nights (from 1 to 14), then in terms of:

- 2 weeks to 4 weeks
- 1 month to less than 2 months
- 2 months to less than 3 months
- 3 months to less than 6 months, and
- 6 months to less than 12 months

A range of visitor days was calculated corresponding to the numbers of visitors at either end of each range. It should be noted that

a) It is not possible to separate out nights spent in NZ by gender, so all the analysis here is based on statistics for men and women combined, and

b) Because the IVS surveys only adult respondents, no separate statistics are available for children[25]. The youngest age group that can be analysed is "Under 20's".

c) The very elderly are less represented among international visitors than among the NZ population; the oldest age group that can be analysed is "Over 75's".

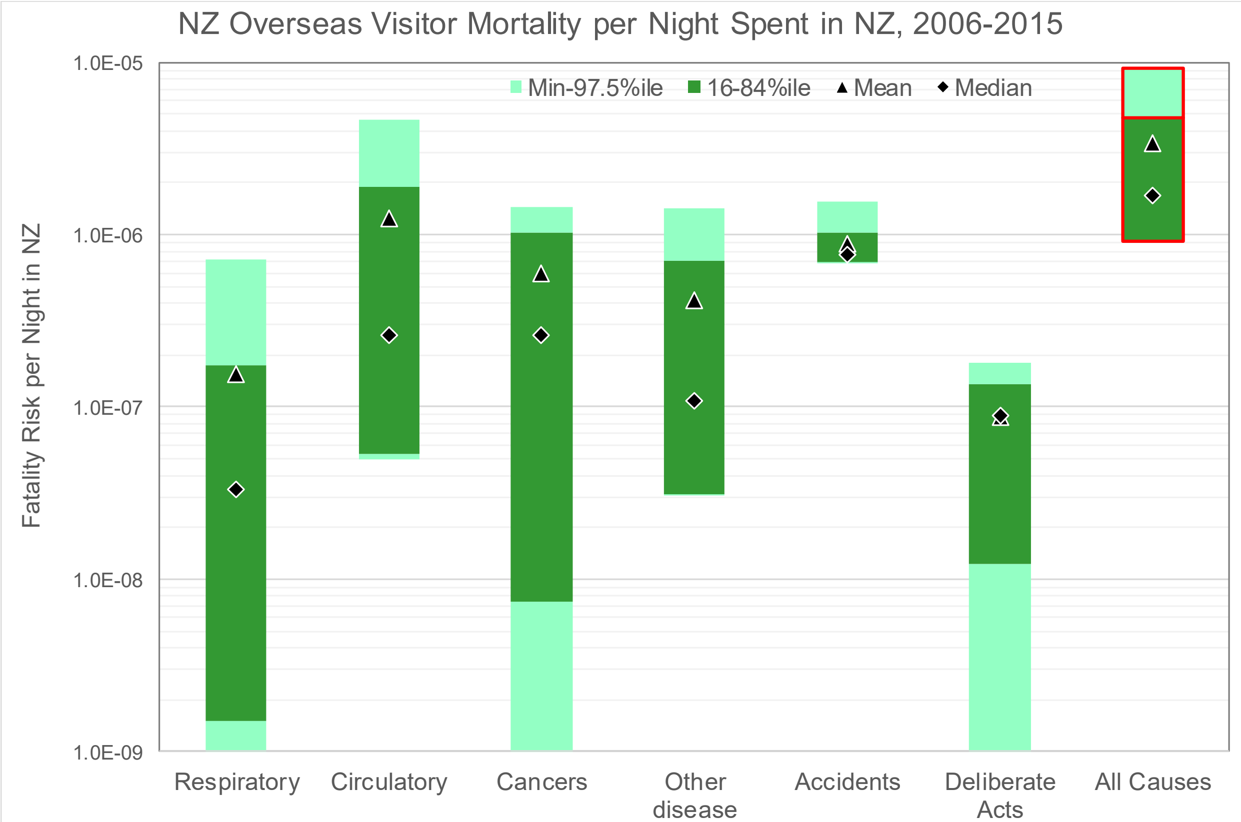
d) Given the smaller number of population groups that could be analysed, there is a greater degree of extrapolation and interpolation used to deduce percentiles of the population facing different levels of fatality risk per day/night spent in NZ.

Mortality data up to 2015 was provided specifically for this study by the Ministry of Health, who segment the main tables used in Section 4.1 by region, including a separate region for "Overseas and Other". I am advised by MoH that, though an occasional fatality may be from an "other or unknown" region, the vast majority relate to international visitors, and the figures can be used to provide a confident approximation of overseas visitor risk.

Figure 28 provides a breakdown of overall mortality rates per day among international visitors.

[25] Inclusion or exclusion of children and teenagers makes little difference to risk estimates for the adult or total population. According to Stats NZ under-20's made up 4,076,475 out of 31,316,856, or 13% of visitor arrivals from 2010-19, while according to MoH statistics under-20's accounted for 64 out of 1,432, or 4.5% of international visitor deaths in NZ over the same period. Thus the whole population average risk would be expected to be a little lower than that for adults only, with U-20's or U-18's excluded.

Figure 28: NZ Overseas Visitor Mortality per Night Spent in NZ, 2006-2015

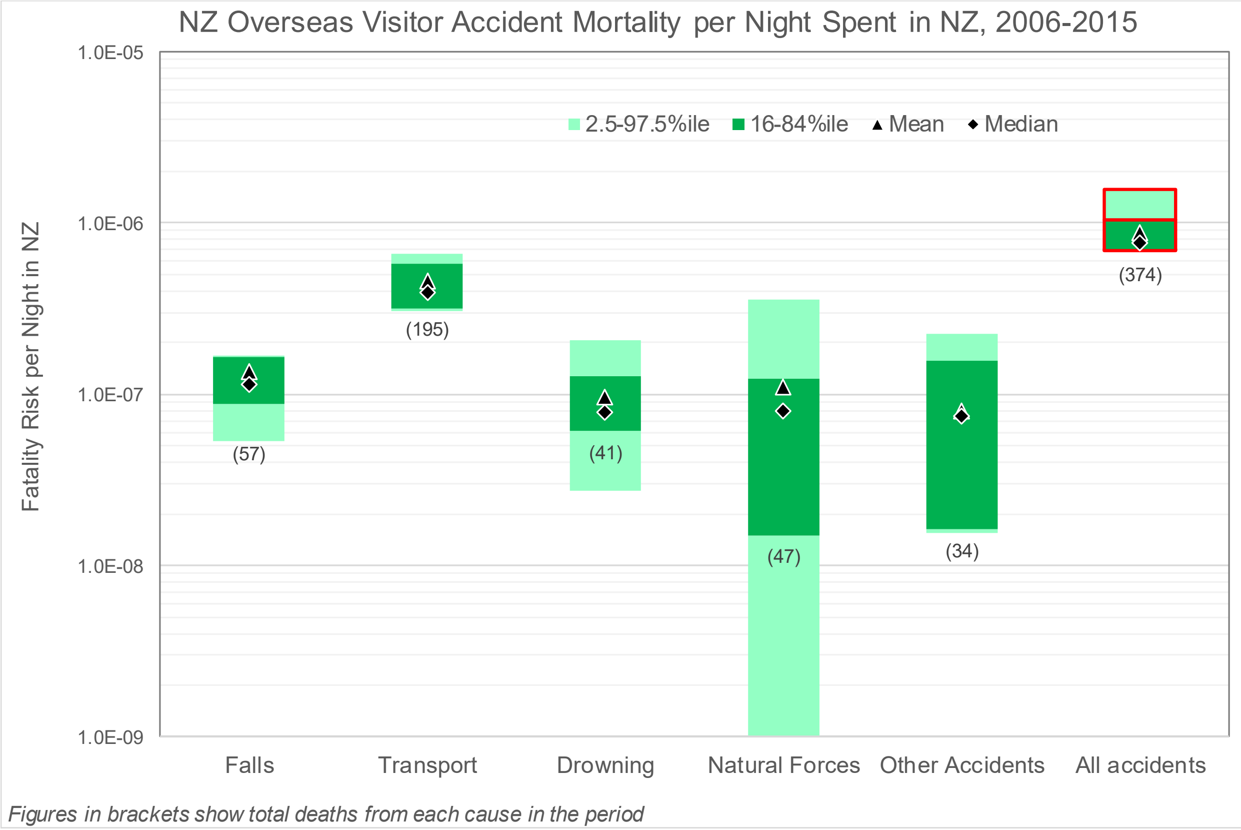


The charts for international visitors are shown per visitor night, which is assumed equivalent in all cases to a risk per full day spent in New Zealand.

The ranges of values for all causes of death other than accidents are significantly narrower than the ranges for New Zealanders, reflecting the relative absence among international visitors of both the very young (the lowest risk groups) and the very frail/elderly (the highest risk groups). Most visitors experience an overall fatality risk above 10^{-6}/night.

The accident risk experienced by international visitors spans a relatively narrow range either side of 10^{-6}/night, with the mean and median both around 8×10^{-7}/night. It needs to be borne in mind that the numbers of deaths involved are not large. Figure 29 shows similar percentiles for various contributors to the risk of accidental death, and shows the total number of deaths (in brackets) associated with each cause over the 10 year period.

Figure 29: Contributors to NZ Overseas Visitor Accident Mortality, 2006-2015



There are some interesting comparisons with risk faced by New Zealanders:

a) Transport dominates, as it does for New Zealanders, but the risk per day/night is roughly twice that experienced by residents.

b) Risk associated with drowning and with natural forces are higher than for New Zealanders (but note that 34 of the 47 ‘natural forces’ deaths were victims of the 22/2/11 Christchurch earthquake).

c) Risk associated with falls is substantially lower than for New Zealanders; the international visitor figures include hardly any household accidents (which account for a large majority of NZ residents’ fall deaths) and occur mostly outdoors.

Overall, most international visitors experience an accident fatality risk around 10^{-6} per day spent in New Zealand. Transport is the dominant contributor, accounting for about half of this risk, but drowning, natural forces and falls each also contribute around 10^{-7} fatality risk per day.

6 Sport and Leisure Activities

This section considers the risk associated with some popular sport and leisure activities, focusing on outdoor activities in particular. It covers

- Tramping in New Zealand (6.1)
- Drownings in New Zealand (6.2)
- New Zealanders' sporting activities (6.3), and
- Other leisure activities (6.4)

A general issue here is that, while the number of fatalities involved with particular activities is in many cases well defined, the number of person-days per year spent on each activity is not.

The primary sources of information used on participation are the Sport New Zealand "Active New Zealand" survey[26] for New Zealanders, and the International Visitor Survey for international visitors. In the former, respondents (all aged 16 and over) were asked to select a frequency with which they participate in each sporting activity from a menu comprising

a) 5-7 times per week	➔ min 260,	max 365	days/yr
b) 3-4 times per week	➔ min 156,	max 209	days/yr
c) 1-2 times per week	➔ min 52,	max104	days/yr
d) 1-2 times per month	➔ min 12,	max 24	days/yr
e) Less than once a month	➔ min 1,	max 12	days/yr

These were used to generate lower and upper estimates of number of days of participation per year corresponding to the proportion of responses (a-e) and the minimum and maximum days/yr associated with each. These proportions were then scaled to the average NZ population aged 16+ over the period concerned[27]. Parallel estimates were made from the 2017 survey, which asked how often in the past 7 days people had participated in each sport. Estimates of number of occasions of participation per person per year from each survey were then scaled up to the total population years over the 2010-19 study period.

The International Visitor Survey in most cases (with the exception of National Park visits and walking/tramping which were analysed in Section 3.2, and cycling, fishing and hunting) provides information only on the proportion of visitors who participated in an activity, not on how many times or on how many days it was undertaken. Simple assumptions have therefore been used as to the minimum and maximum number of days on which an international visitor might undertake each activity in the course of a visit to New Zealand.

[26] "Sport and Active Recreation in the life of New Zealand Adults – 2013/14 Active New Zealand Survey Results," Sport New Zealand, 2014.
[27] The more recent Active New Zealand Survey 2017 also includes young people, but the analysis in this study focuses on adults only; I am not aware of any child deaths in NZ National Parks over the period analysed.

6.1 Tramping and Climbing – the MSC Studies

The NZ Mountain Safety Council (MSC) studies "There and Back"[28] and "A Walk in the Park"[29] have provided rigorously researched, extensive, in-depth analysis of outdoor activities in New Zealand. The latter document in particular provides a wealth of information on incidents and fatalities involved in tramping (see also Section 3.2). The MSC collated information on deaths that occurred as a result of tramping (so did not include deaths due to medical events, or some of the other causes included in Section 3.2 of this study).

The MSC studies use the same information sources as this study (the Active New Zealand survey and International Visitor Survey) on participation in tramping, and include some approximate estimates of numbers of tramping trips taken, but do not estimate the number of days spent tramping. I have used the MSC's information

a) to compare tramping risk per day across New Zealand with that on the NZ Great Walks (see 3.2.3), and

b) to provide a breakdown of risk to NZ and overseas trampers by age (taking advantage of the MSC's wider dataset of tramping deaths across the whole of NZ rather than just in National Parks.

To do this I have estimated lower and upper values for the number of visitor days spent tramping (defined by MSC as involving 3 hours or more walking) as follows:

For New Zealanders:

- 322,000 New Zealanders aged 16 and over participated in tramping during the survey year (April 2013 to March 2014)[22]
- Their frequency of participation was as follows[30]:

5-7 times per week	1.2% (of the 322,000)
3-4 times per week	2.7%
1-2 times per week	15.3%
1-2 times per month	41.7%
<1/month	39.1%

- Combining all the lower and all the upper ends of these ranges gives a range of total person-days spent tramping in 2013 of 6.6×10^6 (lower) to 1.2×10^7 (upper).
- Scaling up to the 10 years from July 2007 to June 2017 requires a factor of 10.006[31], giving lower and upper estimates of total tramping days over the MSC study period of 6.6×10^7 (lower), to 1.2×10^8 (upper).

[28] "There and Back - An exploration of outdoor recreation incidents in New Zealand", NZ Mountain Safety Council, July 2016.
[29] "A Walk in the Park – A deep dive into tramping incidents in New Zealand", NZ Mountain Safety Council, 2018.
[30] Note that this is the original analysis based on the 2013-14 Active NZ survey results. The 2017 survey results were made analysed in full later in the study (see Section 6.3) following discussion with DOC leading to a preference for surveys asking for participation within the past few days/weeks. As the 2017 estimate of tramping days per person per year fell well within the range from 2013-14 it was not considered necessary to re-do this analysis.
[31] From Stats NZ – this is the total person years of people aged 16 and over in NZ over the 10 year period, divided by that for the calendar year 2013.

For International Visitors:

- 17.1 million visitors went tramping from July 2007 to June 2017 (IVS Activity tables),
- (Lower estimate)
  x 27.6% were walks of 3 hours or more (average for the 4 years quoted by MSC)
  x 1.39 lower estimate of average days spent per walk of 3 hours or more[32]
- (Upper estimate)
  x 46% might have been walks of 3 hours or more[25]
  x 1.75 upper estimate of average days spent per walk of 3 hours or more[26]
- ➔ Total person days tramping (07/2007 – 06/2017) = $6.6x10^6$ to $1.4x10^7$.

Combining these figures on days spent tramping with the MSC numbers of deaths yields the risk values per day's tramping shown in Figure 30 for New Zealanders, international visitors and both combined. The risks per day estimated for the NZ Great Walks and for tramping in National Parks (Section 3.2.3) are shown in the figure for comparison, with medical events excluded.

One of the most notable features of Figure 30 is the considerably higher average risk per day for international visitors than for New Zealanders (deaths on the Great Walks are too scarce for any meaningful conclusion to be drawn about their relative risk).

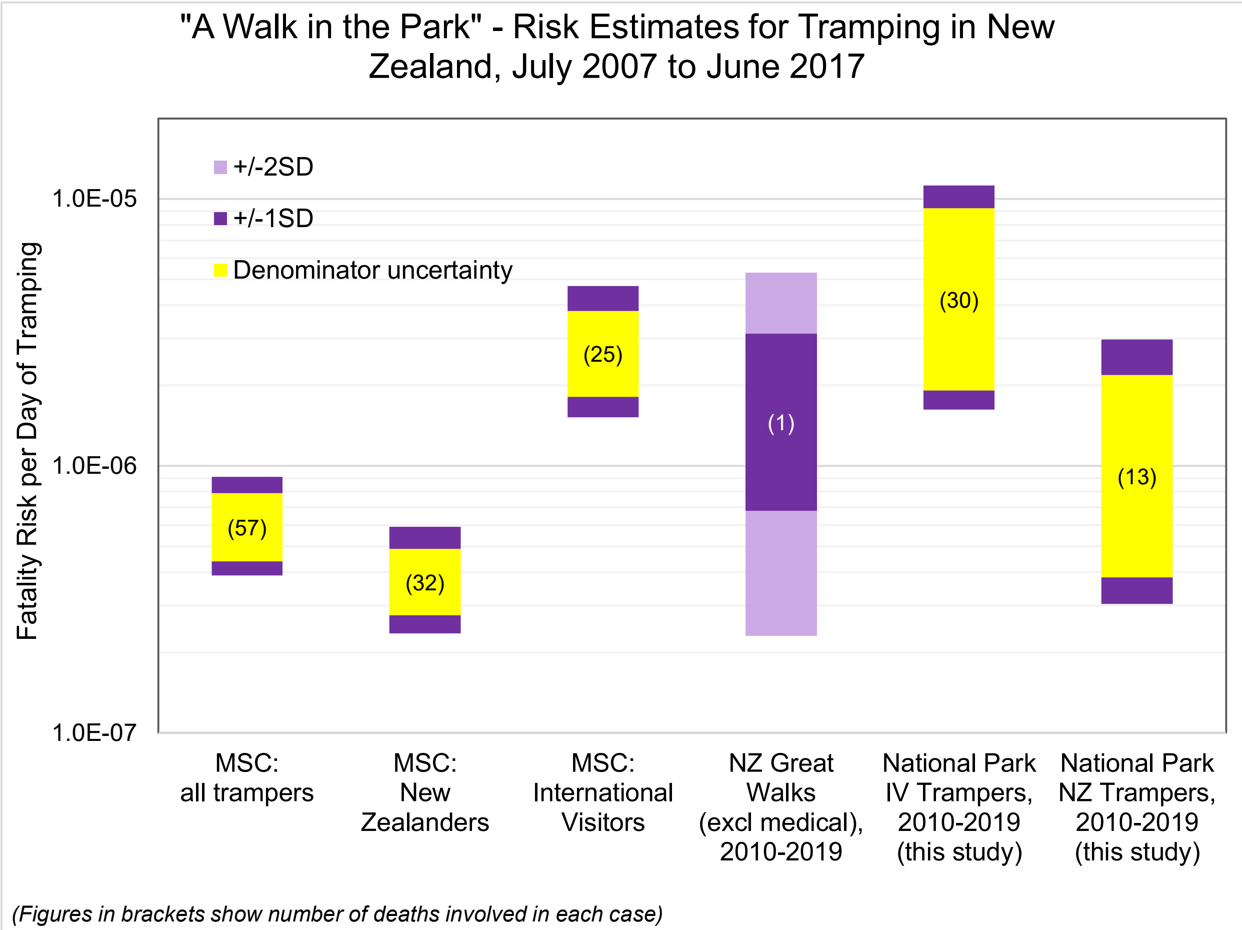
There are several possible reasons for the higher risk for international visitors, including

a) Lower understanding of, and ability to cope with, NZ weather and other conditions,
b) Determination to push ahead and enjoy their planned tramping experience even if conditions are not really suitable, and
c) Some systemic difference between the estimates of visitor days based on the Active New Zealand, SONZ and International Visitor surveys.

While I consider it entirely possible that there IS some systemic difference between the tramping days estimates based on the two different surveys, I do not consider it credible that this could account for the full factor of 10 difference shown in Figure 30. I thus conclude that international visitors do experience an inherently higher risk per day's tramping than do New Zealanders, possibly for some mix of reasons (a), (b) and (c) above (none of these hypotheses have been tested).

[32] Based on analysis of a sample of 1,000,000 IVS survey activity responses from IVS microdata downloaded in November 2019

Figure 30: Risk from Tramping throughout the Whole of New Zealand (NZMSC)



The MSC study analysed deaths by year within the 10 year period, observing a modest decline in deaths of New Zealanders and increase in deaths of international visitors, but the period is too short to be confident in any trend.

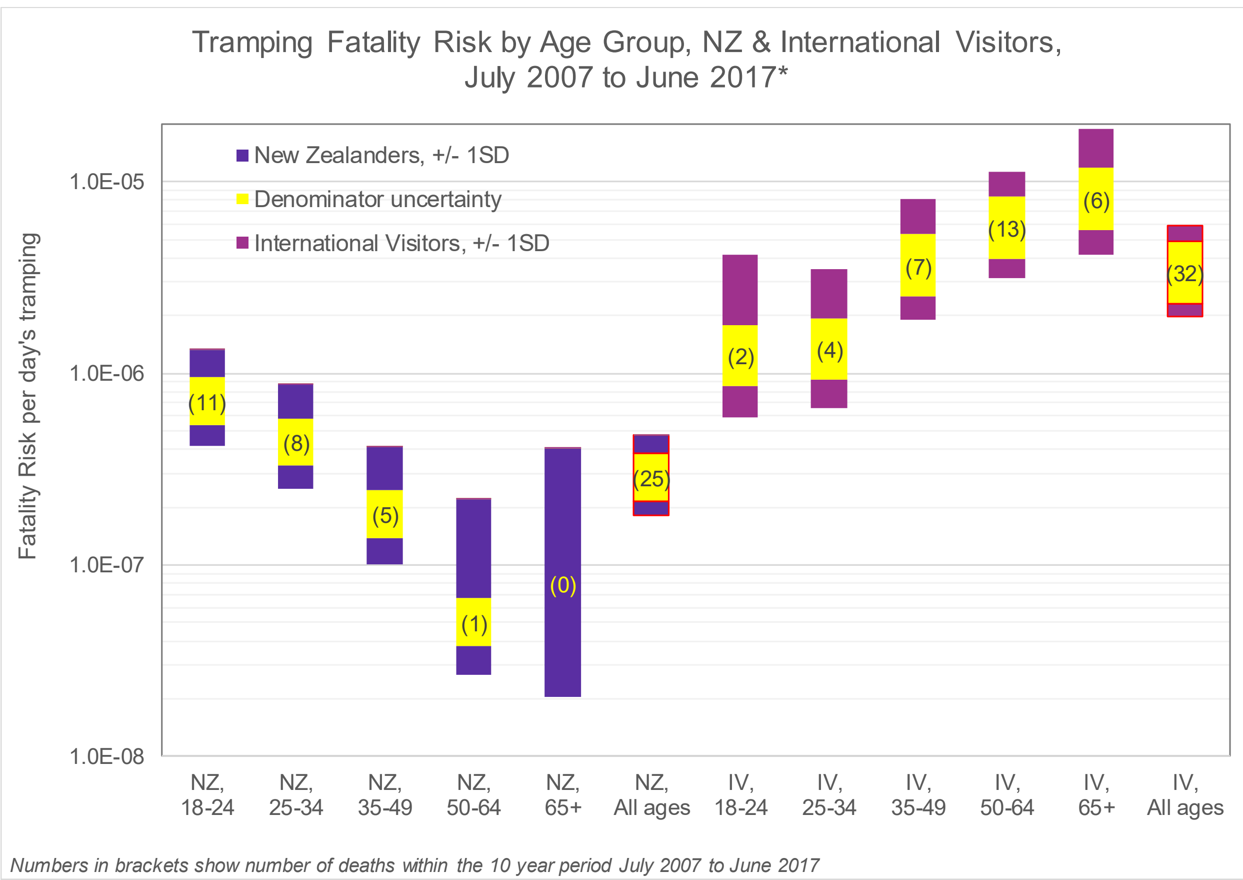
Of greater interest for this study, the MSC study included enough deaths to carry out a reasonable analysis of deaths and risk by age group. Table 12 shows the data for New Zealanders and international visitors broken down into broad age bands, and Figure 31 shows the resulting risk levels.

Table 12: Deaths and % of Tramping Participants by Age Band

Age Group	New Zealander fatalities	International Visitor fatalities	% NZ participation	% IV participation
18-24	11	2	0.18	0.17
25-34	8	4	0.21	0.32
35-49	5	7	0.31	0.2
50-64	1	13	0.23	0.24
65+	0	6	0.07	0.08
Total	**25**	**32**		

Figure 31 shows a marked difference between the risk for New Zealanders, which decreases with age, and that for international visitors, which does the opposite. The risk levels for the younger age groups differ only by a factor of about 1.5 to 3, whereas the difference for the oldest age groups is more like a factor of 100. A possible explanation is that older NZ trampers have accumulated a lifetime's experience and capability to deal with NZ conditions, whereas most older international visitors will be making their first trip to New Zealand and many who go on a tramping trip will have little or no experience in NZ (or possibly anywhere else for that matter).

Figure 31: Tramping Risk in NZ by Age Group and Residency Status



The MSC reports contain a wealth of further information, including extensive analysis by region and by causal factors. There is insufficient information on days tramping to be able to break down and analyse risk in further detail, but some of the interesting insights into fatalities include

a) Gender: men account for 70% of fatalities (but also participate more than women – 55% of participants are male; it is possible there is also a significant difference in annual tramping days per participant)

b) Cause of death: as in National Parks, falls are the dominant cause of death (31 out of 57). River crossings are next highest (11) followed by hypothermia (6).

c) Travelling solo or in a group: just under 50% (27 out of 55 where this could be determined) of deaths were to people tramping alone, or separated from their group.

d) Insights into when fatalities occur – by season, by weekday vs weekend, by overnight vs day trips.

e) Causal factors – the most commonly occurring (each associated with a third or more of fatalities) factors were inexperience, overambitious route choice, desire to push on to reach a goal/destination, and steep terrain.

I cannot commend the NZ MSC too highly for their work on these reports – they have provided a solidly researched foundation to inform both visitors and organisations planning preventive and rescue activities. Hopefully they will also provide a solid starting point for ongoing collation of reliable statistics on incidents and fatalities, enabling the picture of risk in the New Zealand outdoors to be progressively improved and extended.

6.2 Drownings in New Zealand

Another extremely thorough and well-researched set of data on fatal incidents is the Drownbase database maintained by Water Safety New Zealand, who kindly shared that data in support of this study. The total numbers of deaths from drowning among persons of 16 years of age and older (for consistency with the Active NZ participation data) over the 10 years from 2009 to 2018 are shown in Table 13.

Table 13: Drowning Deaths in New Zealand, 2009-2018

Situation	All drownings		Drownings while swimming	
	New Zealanders	International Visitors	New Zealanders	International Visitors
Fresh water	190	25	45	10
Salt water	380	36	65	13
Man-made pools	28	4	15	3
Total	**598**	**65**	**125**	**26**
Grand total	**663**		**151**	

Note – Table 13 excludes 7 drownings (1 whilst swimming) of persons of unknown residency

It is not possible to estimate how many days of activity involving water in general were associated with the totality of drowning deaths. It is possible, though, to estimate the number of occasions on which people went swimming, using the Active NZ and International Visitor surveys as discussed above. For New Zealanders (but not for international visitors) it is possible further to break down swimming participation in terms of fresh water, salt water and man-made pools. Estimates of occasions of participation were made as follows.

For New Zealanders:

- 1,000,000 people (30.2% of the population aged 16+) participated in swimming during the 2013/14 survey year[33].
- Their frequency of participation was as follows[28]:
  5-7 times per week 6.1% (of the 1,000,000 participants)
  3-4 times per week 13.2%
  1-2 times per week 40.1%
  1-2 times per month 31.4%
  <1 per month 9.1%
- Combining all the lower and all the upper ends of these ranges gives a range of total person-days spent swimming in 2013/14 of 61 million (lower) to 99 million (upper).
- Scaling up to the 10 years from 2009-2018 requires a factor of 10.21[34], giving lower and upper estimates of total swimming days from 2009-2018 of 62 million and 101 million respectively.
- 77.6% of participants swam in man-made facilities, while 61% swam in natural waters. The relative frequency of swimming in each is not known[35]; I have assumed that
  77.6 / (77.6 + 61) of all swims took place in man-made pools (56%), and
  61 / (77.6 + 61) of all swims took place in natural waters (44%).
- Among the natural settings, the survey distinguished between
  - in or on the sea, or at a beach/by the sea (41.9% and 19.5% of participants respectively)
  - in a lake, in a river, or by either (13.6%, 10.7%, 1.8%, 0.8%)
  - in the bush, at a park or on farmland (0.3%, 0.1%, 0.1%)
  I have assumed that the number of occasions swimming in natural water divides between salt and fresh water in proportion to the total of responses for each (i.e. 41.9+19.5 or 61.4 for salt, vs 13.6+10.7+1.8+0.8 or 26.9 for fresh), ie.
  61.4 / (61.4 + 26.9) of all natural water swims took place in salt water (69%), and
  26.9 / (61.4 + 26.9) of all natural water swims took place in fresh water (31%).

[33] "Sport & Active Recreation Profile – SWIMMING. Findings from the 2013/14 Active New Zealand Survey", Sport NZ, 2014. As for the MSC analysis in Section 6.1, the Active NZ 2017 survey gave a result for participation days within the range from the 2013-14 survey, so it was not considered necessary to re-do this analysis.
[34] From Stats NZ – this is the total person years of persons aged 16 and over in NZ over the 10 year period, divided by that for the calendar year 2013.
[35] There are arguments both for and against more frequent swimming in pools. On one hand, many people swim in pools for their regular exercise and do so year-round, whereas natural water swims are mostly in summer. On the other, many people only really enjoy swimming in natural water and swim there more frequently than in pools.

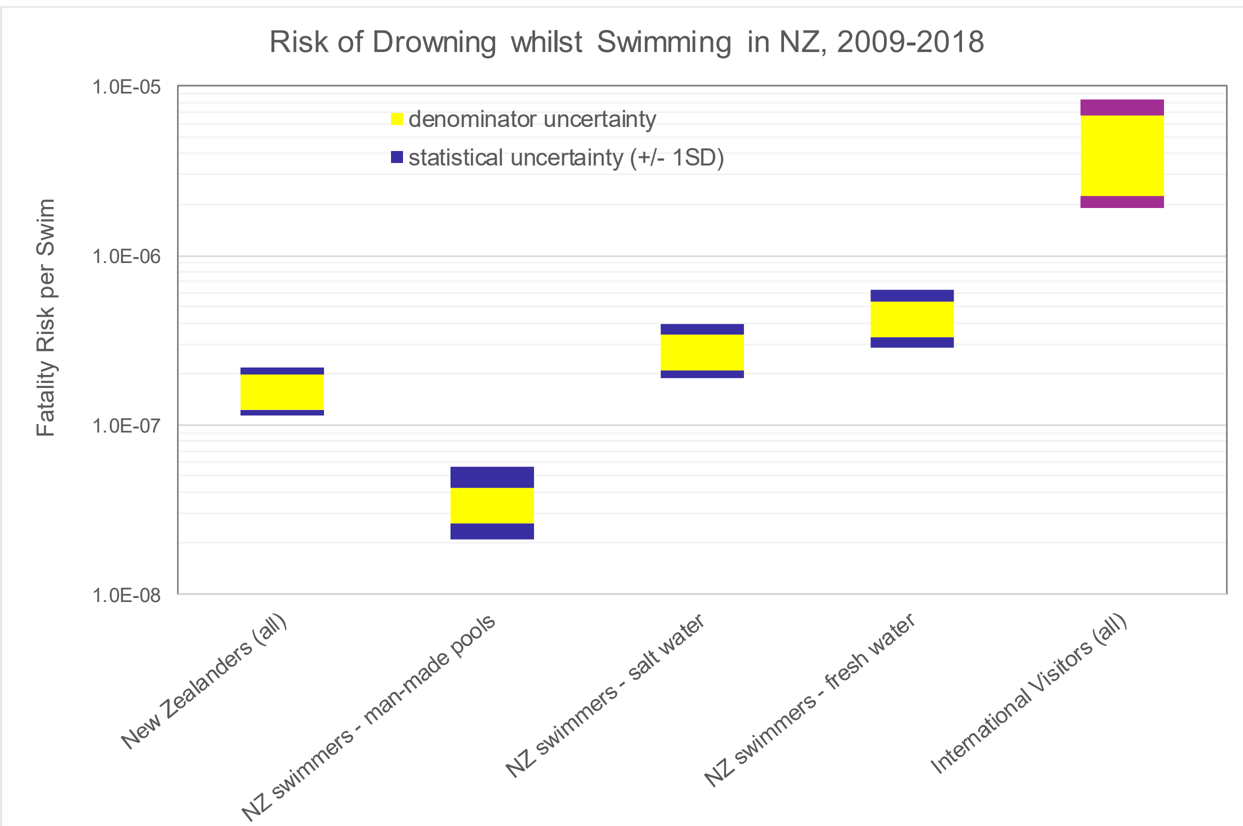
- On this basis the total number of occasions swimming by New Zealanders during the period 2009-2018 was (note that figures are rounded so do not sum exactly):
  All swims: 63 to 101 million
  Swims in man-made pools: 35 to 57 million
  Sea water swims: 19 to 31 million
  Fresh water swims: 8.5 to 14 million

For international visitors:

- 3.84 million international visitors went swimming during their visits to New Zealand between 2009 and 2018 (IVS Activity tables, from Stats NZ)
- I have made a very simple assumption that the minimum number of swims made by those visitors who swam was 1, and the maximum, averaged over all such visitors, was 3.
- On this basis there were between 3.8 and 11.5 million occasions of international visitors swimming in NZ between 2009 and 2018.

Combining these figures on numbers of occasions swimming with the numbers of deaths in Table 13 gives the risk levels shown in Figure 32.

Figure 32: Drowning Risk associated with Swimming in New Zealand, 2009-2018



Given the large uncertainties in numbers of swims, and in particular the sweeping assumptions made as to the partitioning of NZ swims between pools, salt and fresh waters, the following seem reasonable conclusions to be drawn from Figure 32:

a) The overall risk faced by New Zealanders per swim is well below 1 in a million (around 1-2 per 10 million swims).

b) The risk experienced by international visitors is around 20x or more greater than that for New Zealanders (between 2 and 8 per million swims – subject to similar caveats made for tramping in Section 6.1).

c) For New Zealanders,
- the risk swimming in man-made pools is several times less than the average (around 1 in 50 million to 1 in 20 million swims), while
- the risk swimming in open water is several times higher than the average (around 1 in 5 million to 1 in 1.5 million swims).

6.3 New Zealanders' Sporting Activity

I am grateful to the Accident Compensation Commission for providing data on deaths among New Zealanders participating in sports between 2009 and 2018. Estimates of days participating in each sport were made as for tramping and swimming in sections 6.1 and 6.2, based on the Sport New Zealand Active NZ surveys for 2013/14 and for 2017 by combining

- Total participants in the sport during the Active NZ survey year with frequencies of participation in terms of estimated times per week over the year, from the relevant Active NZ Sport Profile (2013-14 survey), along with a scaling factor of 10.21 to extrapolate from the 2013/14 population to the total adult person-years in the ten year period 2009-2018.
- Proportion of New Zealanders who participated in the sport during the Active NZ survey year with frequencies of participation in terms of times participated in the past 7 days (2017 survey), scaled up to the total adult population years for the ten year period 2009-2018.

The resulting statistics for days involving participation and number of deaths are shown in Table 14. The participation figures for 2014 reflect that survey respondents selected one from a group of categories such as "5-7x per week"; the minimum combines the lower value in each category while the maximum combines upper values from each category. In 2017 the question was simply "How many times did you participate in this sport in the last 7 days" so yielded a single number for days per person per year rather than a range.

Table 14: New Zealander Participation & Deaths in Selected Sports, 2009-2018

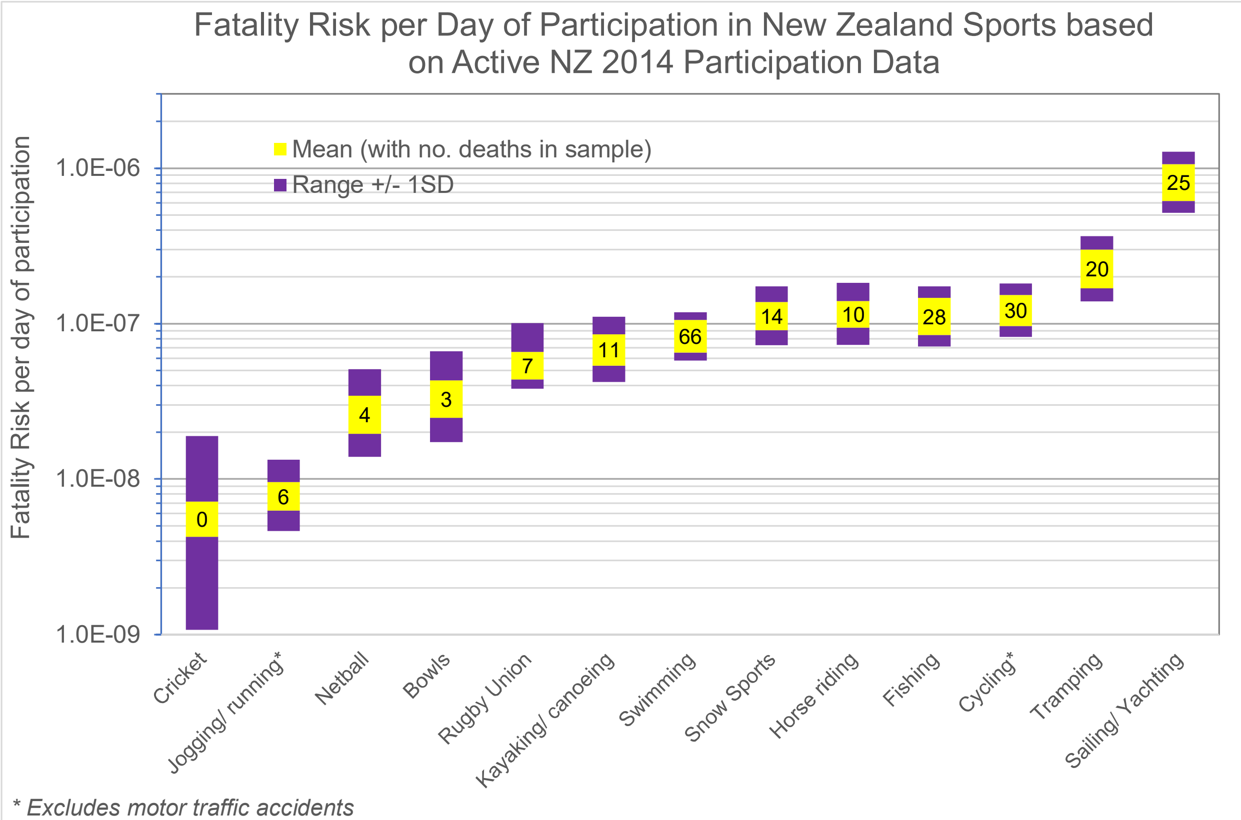
Sport	Participation days 2009-2018			Deaths 2009-2018
	2014 Min	2014 Max	2017	
Kayaking/ canoeing	1.28E+08	2.05E+08	2.62E+07	11
Tramping	6.69E+07	1.18E+08	9.17E+07	20
Swimming	6.26E+08	1.01E+09	3.41E+08	66
Snow Sports	1.01E+08	1.55E+08	1.31E+07	14
Sailing/ Yachting	2.35E+07	4.05E+07	1.31E+07	25
Fishing	1.91E+08	3.32E+08	7.86E+07	28
Rugby Union	1.07E+08	1.60E+08	1.31E+07	7
Equestrian/ horse riding	7.16E+07	1.06E+08	5.24E+07	10
Jogging/ running	6.28E+08	9.56E+08	9.44E+08	6
Cricket	9.69E+07	1.62E+08	2.62E+07	0
Bowls	6.96E+07	1.21E+08	5.24E+07	3
Netball	1.16E+08	2.04E+08	3.93E+07	4
Cycling	1.96E+08	3.10E+08	5.50E+08	30

The participation figures for 2014 include a number of apparent anomalies. For example the days of participation in kayaking and rugby appear very high in comparison with those spent tramping.

Note that the number of fatalities involved in tramping and swimming are lower than those collected by the MSC and Water Safety NZ. This is to be expected, as not every fatal accident is necessarily the subject of an ACC claim. Note also that these figures for jogging/running and for cycling do not include motor vehicle crashes (which are considered in subsequent sections).

The figures in Table 14 translate into risk levels as shown in Figure 33(a) based on 2013-14 participation data, and Figure 33(b) based on 2017 participation data (the range of uncertainty in participation days for 2017 was taken in each case to be equal to the average across all sports in Table 14 for 2013-14).

Figure 33(a): NZ Sports Fatality Risk, 2009-2018 – Active NZ 2013/14 Participation

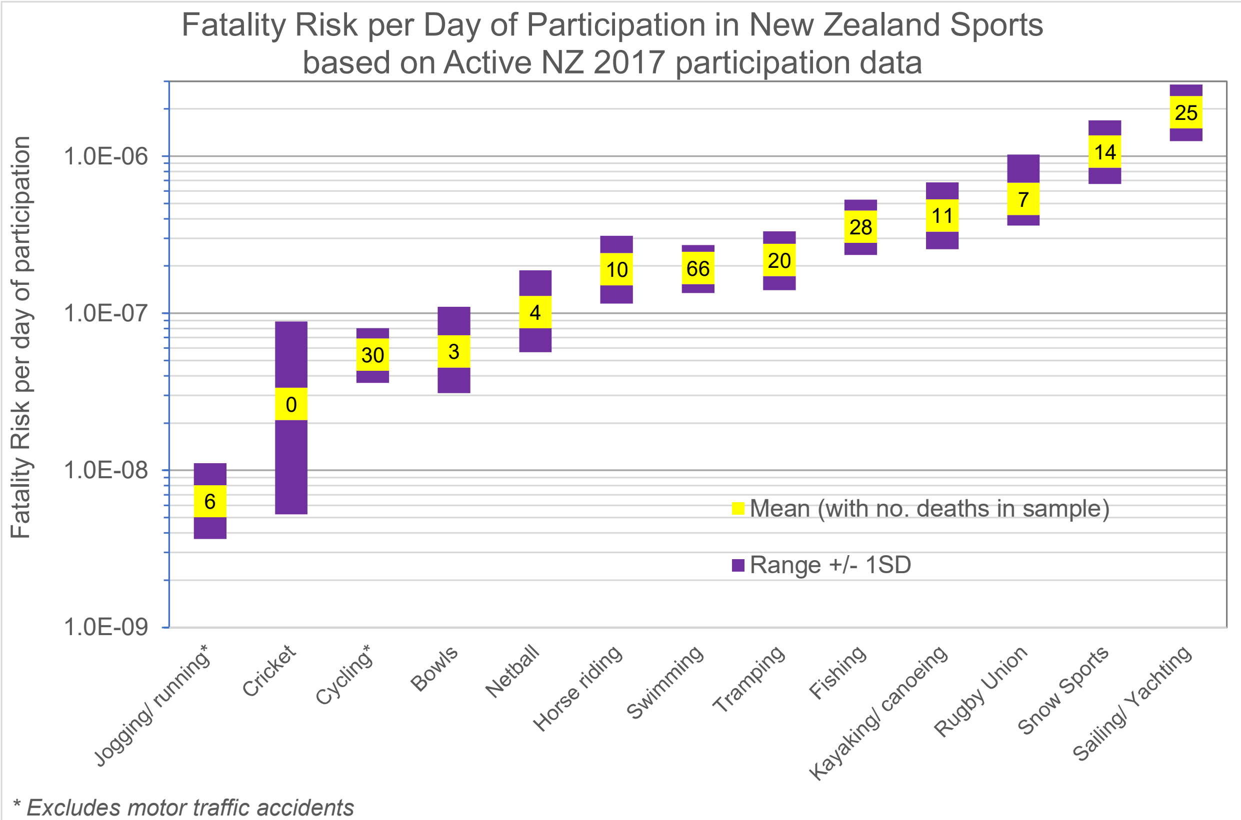


The apparent anomalies in 2013-14 participation frequency data feed through to Figure 33(a) as apparent anomalies in risk, with rugby in particular appearing surprisingly low, and tramping surprisingly high.

These anomalies are not apparent in Figure 33(b), and the Active NZ 2017 participation data is thus preferred as the basis for comparisons[36].

[36] After completion of this analysis I had much discussion with DOC about the preferred way of eliciting better information on the frequency of people's visits to National Parks. I agreed with DOC that it would be preferable to ask people how often they had visited parks within the past 7 days rather than to ask about parks visited in the past year. I also received from Sport New Zealand the raw data from the Active NZ 2017 survey providing information on the proportion of activities carried out in National Parks and other places. Using this data, the Active NZ 2017 survey provided good consistency with my estimates from the DOC SONZ 2019 of the number of days per year spent tramping in National Parks by New Zealanders. This strengthened my preference for using participation frequency information derived from surveys collecting information on frequency of participation in the immediate past (e.g. 7 days) rather than the longer term (e.g. 1 year).

Figure 33(b): NZ Sports Fatality Risk, 2009-2018 – Active NZ 2017 Participation



The sports can be grouped as follows (based on Figure 33b, i.e. on my preferred Active NZ 2017 survey participation data):

- Very low risk (around 1 per 10 million days participating or lower): - jogging, cricket, cycling and bowls (note this excludes motor traffic crashes)
- Low risk (around 1 to 3 per 10 million days participating): netball, horse riding and swimming
- Medium risk (several per 10 million days participating): tramping, fishing and kayaking, and
- More significant risk (up to or greater than 1 per million days): rugby, snow sports and saling.

Many New Zealanders take part in team sports, which are generally low risk, and many more in individual sports involving medium risk levels, but where the hazards are generally well understood. Sports towards the right hand side of Figure 33(b) tend to involve both/either

a) activity-specific hazards (falls and river crossings while tramping; collisions in rugby and snow sports; drowning while boating, kayaking or fishing), and/or

b) remoteness from help, making serious incidents more likely to escalate to fatality.

For tramping, the risk level appears consistent with that for New Zealanders in National Parks derived in this study (Figure 15) and on Public Conservation Land more generally derived from MSC data (Figure 30), providing further corroboration of the observation that New Zealanders experience a substantially lower risk per day tramping than do international visitors.

6.4 Other Leisure Activities

This section addresses two types of leisure activities:

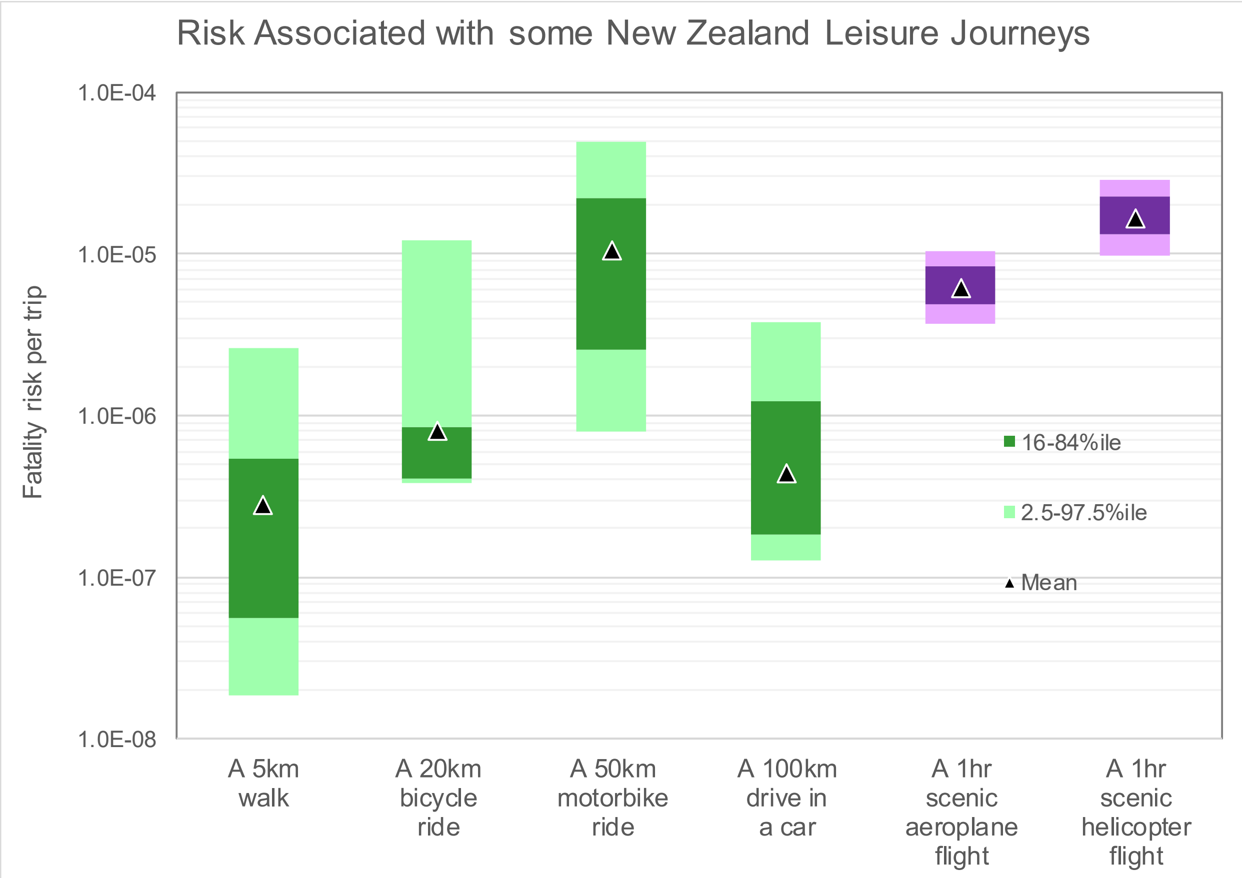
a) travel undertaken for leisure purposes (going for a walk, a ride, a drive), and
b) other popular tourist activities in New Zealand.

For the former, the readily available data covers all crashes in New Zealand, so risk estimates are based on averages across New Zealanders and international visitors alike. For the latter there is limited information on the extent of participation by New Zealanders (other than for the sport and outdoor activities addressed in Sections 3.5.1, 3.5.2 and 3.5.3), whereas the International Visitor Survey provides information on visitor participation in a wide range of activities.

The risk involved in typical leisure trips in NZ is represented in Figure 34 for the following:

- A walk of 5km
- A cycle ride of 30km
- A motorcycle ride of 50km
- A drive of 100km in a car
- A scenic flight of 1 hour in a light aeroplane, and
- A scenic flight of 1 hour in a helicopter.

Figure 34: Risk Associated with some NZ Leisure Journeys



Note on Fig 34 – periods over which unit risks of travel are estimated vary – see Section 7 for details. All land based journeys are assumed to be made on average New Zealand roads. The car risk shown is that for an average driver; that for a passenger would be somewhat lower.

The fatality risk associated with the walk, bicycle ride and drive in a car is for most people in the range 10^{-7} to 10^{-6} per trip. For the motorcycle ride and the scenic flights it is in the region of 10^{-5} per trip. While most people are well aware of the particular hazards involved in motorcycling or flights in small aircraft, many people undertake such leisure trips without giving the risk a great deal of thought.

The activities considered for international visitors, along with the source of information on fatalities, the period used as the basis of the analysis, the number of international visitors estimated to have participated in the activity during that period (from the IVS) and the assumed number of occasions on which visitors (on average) participate in each activity are shown in Table 15.

Table 15: International Visitor Activities and Associated Fatalities

ACTIVITY	Data collection period	Fatalities data source(s)	Deaths within period	IVS participants	Assumed average days per visitor		Notes
					lower	upper	
Geothermal parks & pools	2009-18	This study - internet research	3	13447942	1	1.5	*1*
Air activities	2009-18	NZ CAA reports; internet research	3 or 4	1221772	1	1.2	*2*
Bungy jumping	1999-2018	Internet research	0	4095490	1	1.2	
Cycling	2006-2015	NZ MoH Mortality tables	6	986432	1	2	
Fishing or hunting	1/7/07 - 31/12/14	NZ MSC "There & Back"; Drownbase	3	1013682	1	3	*3*
Jet-boating	1999-2018	Maritime NZ reports; internet research	3	4434382	1	1.5	
Mountaineering	July07-Dec14	NZ MSC "There & Back"	11	481989	1	3	*4*
Other water activity	1999-2018	Water Safety NZ Drownbase	1	763393	1	1.5	*5*
Whitewater sports	1999-2018	Whitewater NZ; Maritime NZ; internet research	14	3425068	1	2	*6*
Scuba diving or snorkelling	2009-2018	Water Safety NZ Drownbase	2	499795	1	2	
Snow sports	2009-2018	This study; internet research	10	1218527	1	3	*7*

Notes on Table 15
1. Combination of activities "A geothermal park (hot mud and possibly geysers)" and "Hot pools"
2. Includes activities such as paragliding, hang gliding, ballooning, skydiving; 4th fatality was an overseas citizen very recently arrived to live in NZ
3. Hunting fatalities from MSC "There & Back"; fishing fatalities from Water Safety NZ Drownbase
4. Includes mountain climbing, rock climbing, caving & abseiling
5. Includes water skiing & river boarding (the activity associated with the single fatality in the period)
6. Includes rafting, kayaking & canoeing (on lakes as well as rivers)
7. Includes skiing, snowboarding and other winter sports

The assumed average days of participation per visitor are necessary to translate "number of visitors who participated" into "visitor days/occasions of participation" as used throughout this study. In every case the lower assumption is 1 (everyone who responded must have done it at least once). The higher assumptions depend on the activity and range from

- Just above 1 for one-off "bucket list" type activities which are relatively expensive and for most visitors are likely to be a one-off during their NZ visit, to
- 3 for activities (climbing, white water sports and snow sports) which may be the main theme of a visit to NZ for considerable numbers of visitors[37]).

The risk levels corresponding to the data in Table 15 are shown in Figure 35.

[37] While many visitors will spend more days on a holiday/visit specifically for one of these purposes, this figure is an average over ALL visitors, many of whom try climbing, kayaking or skiing for a day in the course of a varied mix of activities during their visit to NZ.

Figure 35: International Visitor Risk Associated with some Popular Outdoor Activities in NZ

While some "high thrill" activities are actually rather low risk (bungy jumping and jet boating are around the 10^{-7} to 10^{-6} level per occasion), most of the other popular activities involve risk in the range 10^{-6} to 10^{-5} per day/occasion. Mountaineering is in a class of its own, involving risk around or above 10^{-5} per day; given that this is an average over all visitors, there will certainly be some experiencing many times this level.

7 Travel to and from DOC Locations

This section considers the most popular ways of travelling to and from National Parks: by road and by air. Unit risks of travel per km (roads) or per hour (air) are derived in Section 7.1. These are then applied to typical journey lengths for visitors making return trips to DOC land in Section 7.2.

7.1 Risks of Road and Air Travel in New Zealand

Extensive data on accidents, injuries and volumes of travel are maintained by the NZ Ministry of Transport (MoT) and the NZ Civil Aviation Authority (CAA). This section considers in turn:

- Road users:
  - Visitors driving their own vehicles (cars and light vans)
  - Vulnerable road users (pedestrians, cyclists and motorcyclists), and
  - Visitors travelling by bus, then
- Visitors travelling by air.

For visitors travelling by road the metric used is fatality risk per km of travel. For visitors travelling by air it is fatality risk per hour of travel.

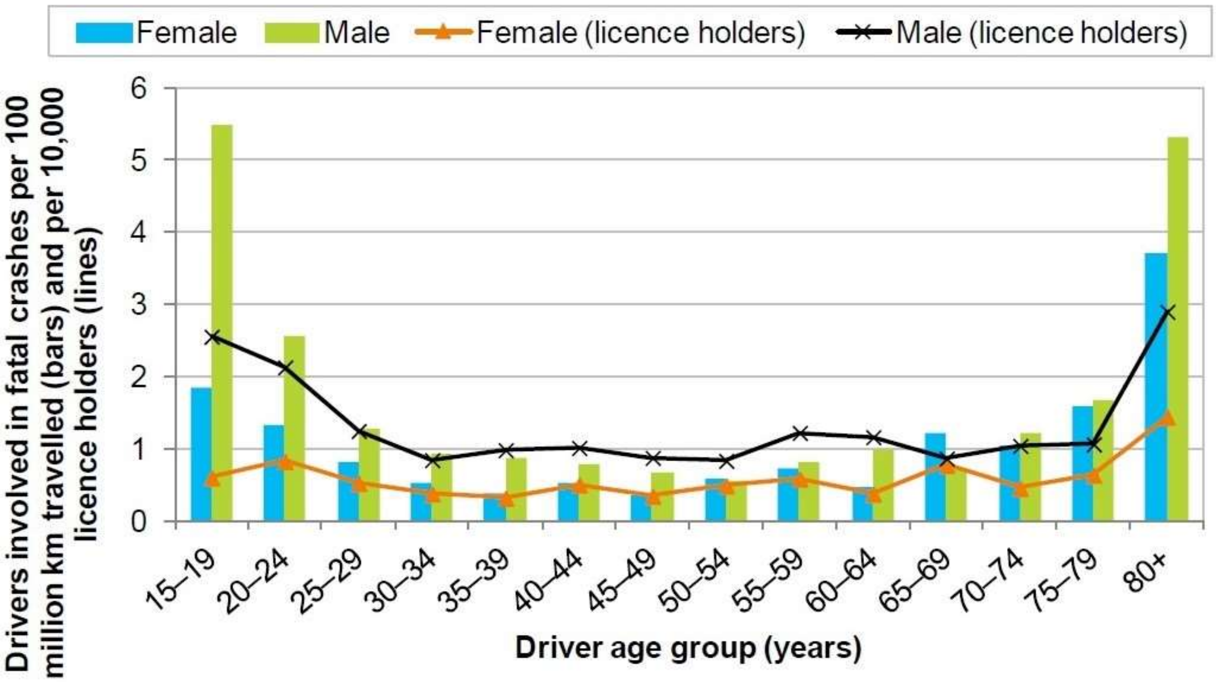
7.1.1 Unit Risk for Road Users

Data on fatalities and other injuries on New Zealand roads are collected in the MoT's Crash Analysis System (CAS). The extent of travel by New Zealanders is regularly estimated via the MoT's Household Travel Survey (HTS), in terms of numbers of trips, time spent travelling and distance travelled. In order to enable different journeys to be compared across modes, I have used distance travelled as the denominator for risk throughout most of Section 7. For international visitors there is currently no direct way of estimating the extent of travel; some estimates are made in this study in order to compare international visitors' and New Zealanders' risk per km travelled.

The kilometres travelled on New Zealand roads are, as in most developed countries, dominated by cars and light vans. For these, there is sufficient data on both fatalities and travel distances to make separate estimates for each gender, across age groups similar to those used in the general mortality analysis in Section

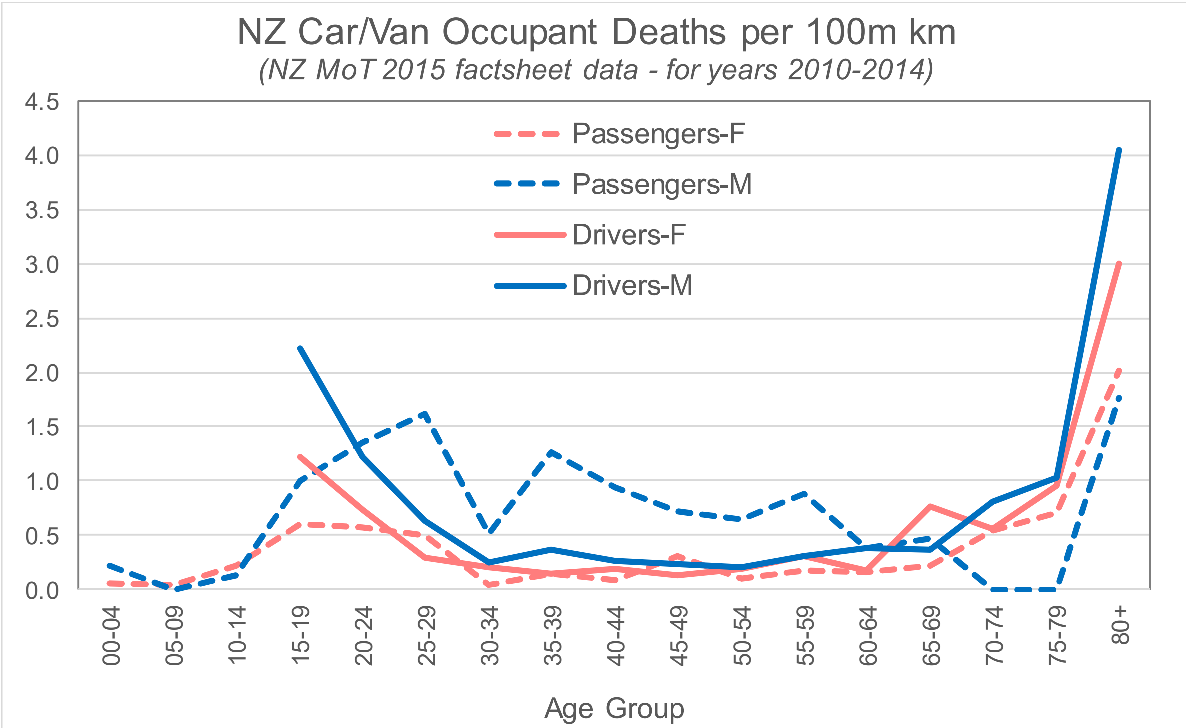
As might be expected, the wide range of drivers is reflected in a wide range of risk. Figure 36 shows the variability of driver involvement in fatal accidents with age and gender.

Figure 36: NZ Light 4 Wheeled Vechicle Driver Involvement in Fatal Crashes *(reproduced from Figure 4 of NZ MoT factsheet "Risk on the Road: Drivers and their Passengers", August 2015)*



I am indebted to NZ MoT who provided substantial assistance to this study, both in discussing the best approach to be used in estimating the ranges of risk experienced by road users, and in providing data. They provided the data on which Figure 36 is based, along with the relevant information on numbers of fatalities and distances and times travelled by each gender/age group, for both drivers and passengers in cars and light vans (which are considered together in NZ as in many other countries' road accident statistics). This allowed separate curves for fatality risk per km to be developed for drivers and passengers, as shown in Figure 37.

Figure 37: NZ Car/Van Occupant Risk by Age Group and Gender



The data is too sparse to be reliable for several of the age groups, but gives a good impression of the wide variability across the population of car users. The figures for young children as passengers give a good idea of how much of this risk is linked to (and avoidable by) driver behaviour – when people are driving with small children, the risk for the occupants of their vehicle is around 0.1 per billion km or even lower.

Pedestrians, cyclists and motorcyclists are often referred to as vulnerable road users in light of their relative lack of protection in the event of a crash. Each has been the subject of detailed fact sheets produced by MoT in recent years[38], which make it clear that,

a) Fatalities for all three modes appear to be on a medium-long term downward trend

b) While walking is relatively safe per hour travelling, the risk per km travelled by all three modes (motorcycling in particular) is substantially higher than that for motor vehicle occupants

c) There is considerably variability in risk per hour or per km travelled with factors such as age and gender.

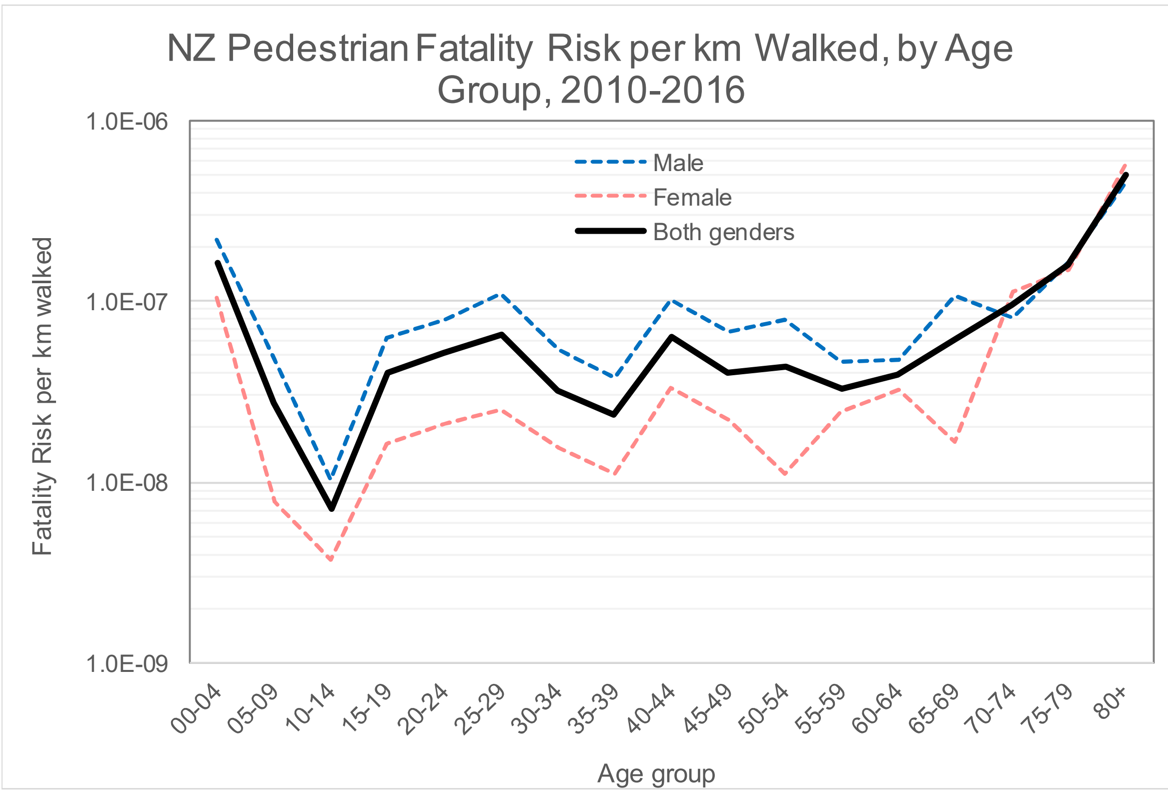
There are considerably lower volumes of both travel and deaths for all three modes than are available for motor vehicle accidents. For this study, data on fatalities and volumes of travel from 2000 to the most recent available were analysed. MoT again assisted by providing recent data on volumes of road use in the form of Household Travel Survey data. Fatality statistics were downloaded from CAS, and were compared with corresponding annual fatalities from the

[38] See "Pedestrians 2017", "Cyclists 2017" and "Motorcyclists 2017", all published by the NZ Ministry of Transport.

Ministry of Health mortality data. The mortality statistics reveal higher numbers of fatalities than does CAS, as they include crashes not reported by the police, and were adopted as the basis of this study so as to provide the best picture of the totality of risk faced by these road users.

For all three modes, age and gender were analysed as drivers of risk variability. For pedestrians, it was possible to construct a picture of risk per km travelled as a function of age group and gender (analogous to Figure 37) using data for the period 2010 to 2016 (the most recent year for which MoH mortality data was available for this study), as shown in Figure 38.

Figure 38: NZ Pedestrian Risk per km, 2010-2016



For both cycling and motorcycling, the analogous picture contained several gaps, and the approach adopted to explore the variation by age and gender was as follows:

a) For both cycling and motorcycling, a longer data period (2007-2016) was adopted so as to increase the set of accidents available for analysis

b) For cycling, the male and female risk per km cycled were broadly similar; gaps were filled in by combining data for both genders (meaning the highest and lower risk groups in this case corresponded to rather more than 2.5% of the population in each).

c) For motorcycling, data was combined for both riders and passengers. While the data for females is particularly sparse, it does appear generally to be considerably below that for males (Figure 40). A distribution across age group and genders was thus developed by i) using deaths and km travelled for both genders combined to calculate risk for each age group, then

ii) weighting male and female risk levels for each band pro rata to the ratio of male to female risk, averaged over the whole population.

The resulting distributions of risk by age and gender are shown in Figures 39 and 40.

Figure 39: NZ Cycling Risk per km, 2007-2016

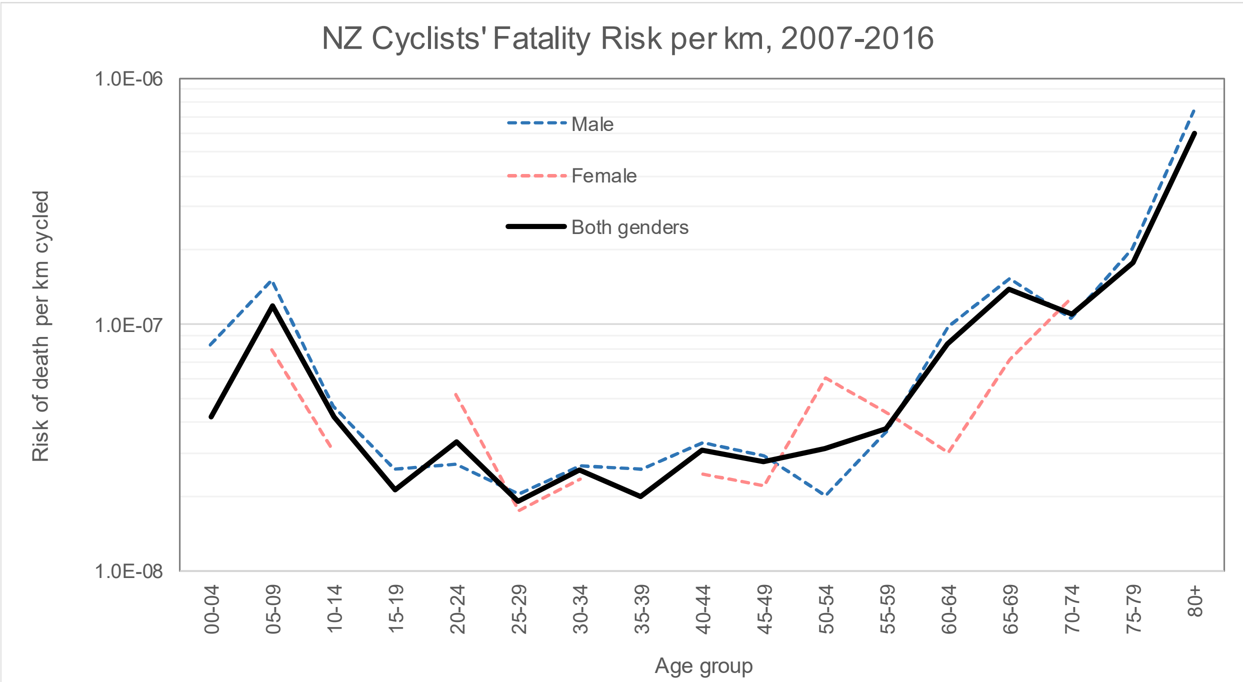
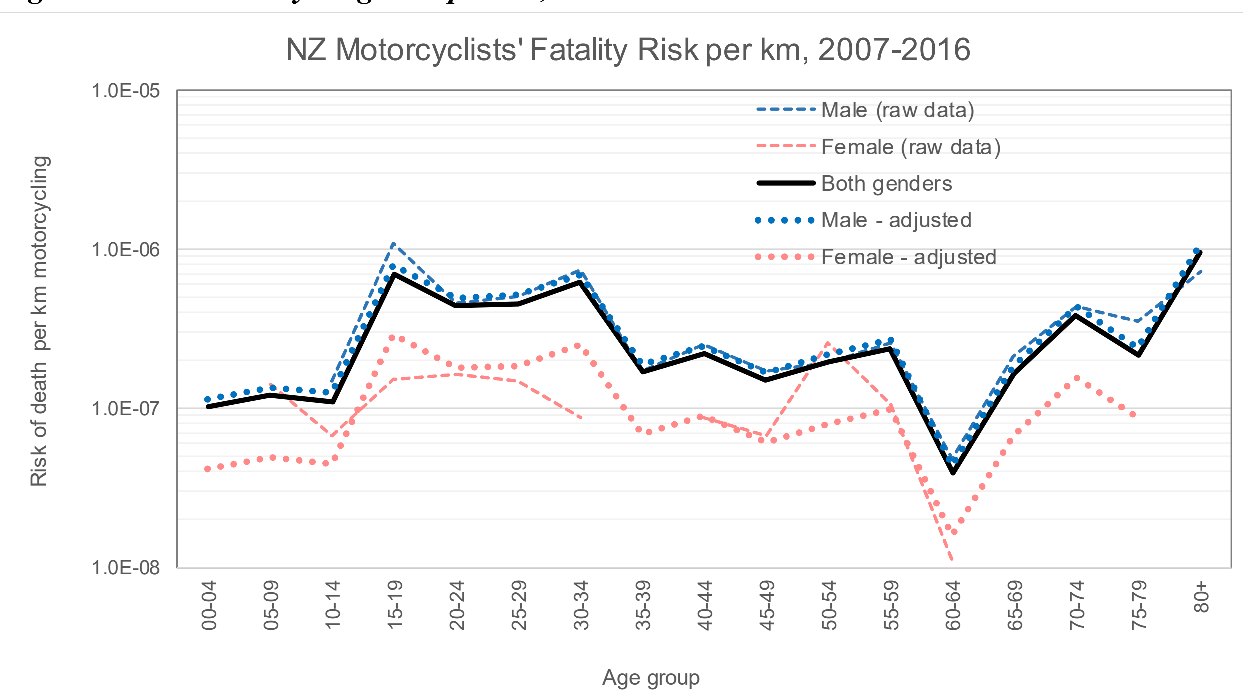


Figure 40: NZ Motorcycling Risk per km, 2017-2016



Buses are a safe method of travel, with very few deaths occurring in New Zealand. MoT provided data on bus crash fatalities from 1981 to 2019. As the HTS data relates to NZ residents only, deaths known to have been international visitors were subtracted from these totals. Thirty years of data, from 1989 to 2018 were used for this study.

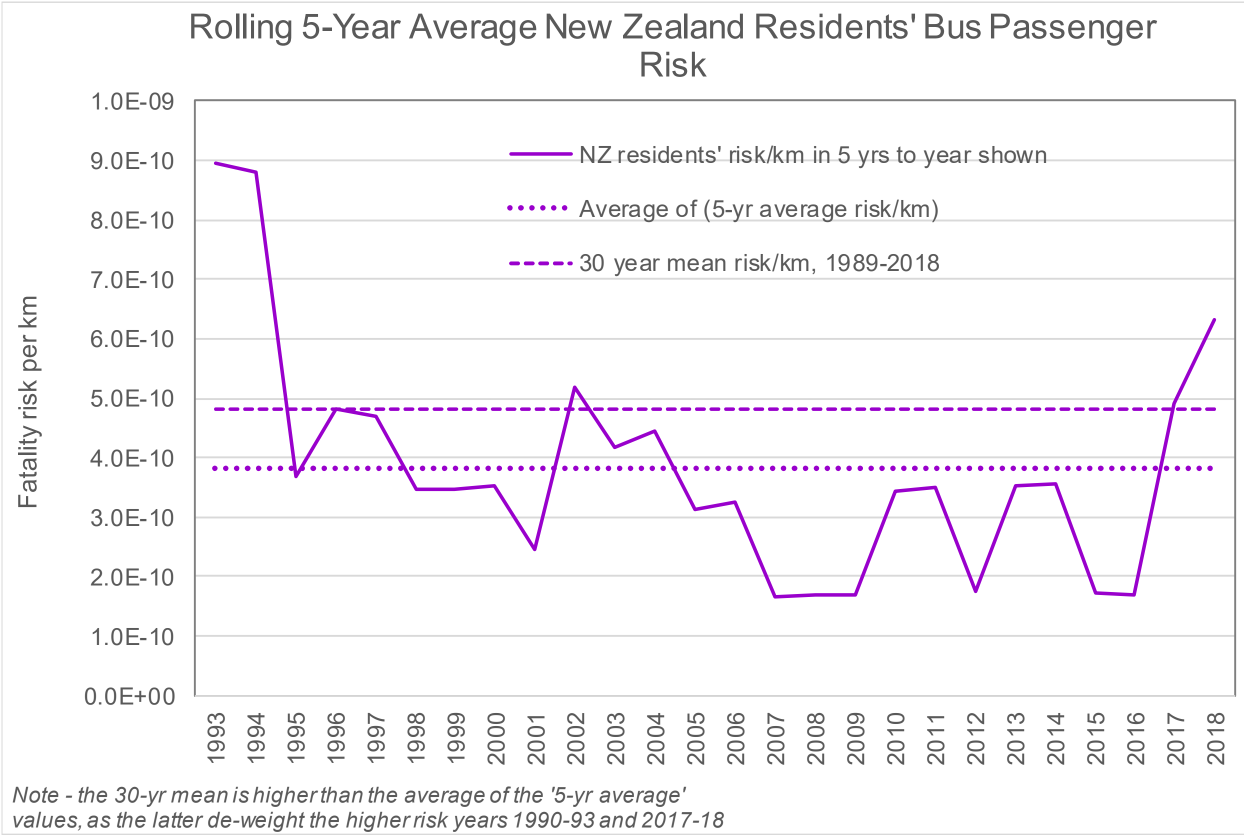
Bus crash rates are sensitive to drivers and vehicles, not passengers (though there may be some variability in likelihood of dying in a crash with age as, for example, more frail passengers are more likely to die in a crash). With such sparse statistics and no particular reason to analyse by passenger details, the approach taken here was to examine the variability of the 5-year average risk per passenger km over the 30 year period 1989 to 2018. The relevant statistics are shown in Table 16, and the moving 5-year average risk is shown graphically in Figure 41.

Table 16: Bus Fatality and Travel Statistics, 1989-2018

Year	Deaths				100m bus psgr km[1]	5-year average		
	Total	Known to be NZ residents	Known to be overseas visitors	Assumed to be NZ residents		NZ resident deaths	100m bus psgr km	NZ risk per km
1989	0	0	0	0	15.2			
1990	5	0	0	5	15.2			
1991	0	0	0	0	15.6			
1992	0	0	0	0	15.9			
1993	2	1	0	2	16.3	7	78.1	9.0E-10
1994	0	0	0	0	16.6	7	79.6	8.8E-10
1995	1	0	0	1	17.0	3	81.4	3.7E-10
1996	1	0	0	1	17.3	4	83.1	4.8E-10
1997	0	0	0	0	17.7	4	84.9	4.7E-10
1998	1	0	0	1	17.7	3	86.4	3.5E-10
1999	0	0	0	0	16.6	3	86.3	3.5E-10
2000	1	1	0	1	15.5	3	84.8	3.5E-10
2001	0	0	0	0	14.3	2	81.8	2.4E-10
2002	2	2	0	2	13.2	4	77.3	5.2E-10
2003	0	0	0	0	12.1	3	71.7	4.2E-10
2004	0	0	0	0	12.1	3	67.2	4.5E-10
2005	0	0	0	0	12.1	2	63.9	3.1E-10
2006	0	0	0	0	12.1	2	61.6	3.2E-10
2007	1	0	0	1	11.5	1	59.9	1.7E-10
2008	1	0	1	0	11.5	1	59.3	1.7E-10
2009	1	0	1	0	11.5	1	58.7	1.7E-10
2010	1	0	0	1	11.5	2	58.1	3.4E-10
2011	0	0	0	0	11.2	2	57.2	3.5E-10
2012	0	0	0	0	11.2	1	56.9	1.8E-10
2013	1	0	0	1	11.2	2	56.6	3.5E-10
2014	0	0	0	0	11.2	2	56.3	3.6E-10
2015	0	0	0	0	12.9	1	57.7	1.7E-10
2016	3	0	3	0	12.9	1	59.4	1.7E-10
2017	2	1	0	2	12.9	3	61.0	4.9E-10
2018	2	2	0	2	13.5	4	63.3	6.3E-10

Note 1: The passenger km, derived from NZ Household Travel Survey data, do not include international visitors' substantial tourist travel. Both the deaths and the HTS passenger km include a large proportion of shorter commuting/social/everyday journeys relative to the tourism travel of greatest interest here.

Figure 41: Rolling Average Bus Passenger Crash Risk per km, NZ 1989-2018



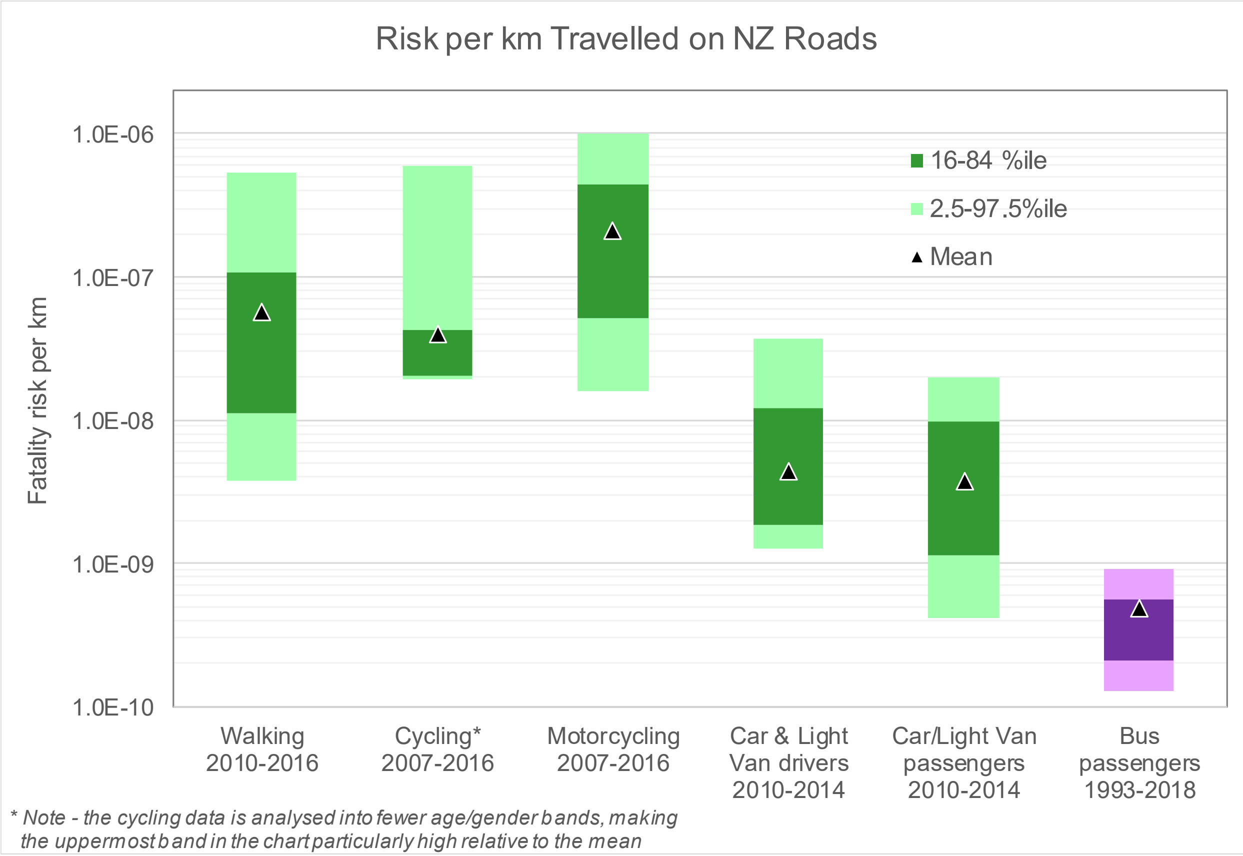
The 5-year rolling average was assumed to be log-normally distributed and the standard Excel function was used to calculate the associated standard deviation.

These bus statistics illustrate how sensitive to details of definition and period these numbers can be; none of the four worst bus accidents in terms of number of deaths in the past 25 years are included in the figures[39]. These four incidents between them resulted in 25 deaths.

Percentiles of risk levels corresponding to Figures 39 to 43 are shown in Figure 42.

[39] 8 people died in a house bus crash on Mohaka bridge in 1997 (not a public transport bus). A minibus/van (not strictly a bus) crash in 2005 killed the 9 occupants. Tragedies killing 3 international visitors in 2016 and 5 international visitors in 2019 are outside the MoT scope as they did not involve any New Zealand resident fatalities.

Figure 42: Percentiles of Road User Risk per km in NZ



There has been considerable interest and research into road crashes involving international visitors to New Zealand, which have increased considerably in recent years as visitor numbers have risen. MoT has carried out substantial research into this area, including correlating crashes with international visitor arrivals (IVA) data[40]. Having observed significant differences in fatality rates for international visitors and New Zealanders in previous sections, I was keen to explore whether there was a significant difference in road fatality rates per km travelled.

The first step in this process was to analyse road deaths pro rata to population (in terms of total person-years spent in New Zealand). The only road user group with sufficient statistics to make this analysis worthwhile is car & van occupants. Table 17 shows relevant numbers of road deaths and of person-years in New Zealand, aggregated over the 4 year period from 2012 to 2015, and broken down by New Zealanders and international visitors. Deaths are based on MoH statistics, to enable this disaggregation to be made more easily.

From Table 17, International visitors account for only 2.6% of person years, but 5.6% (over twice that proportion) of road deaths. This suggests the possibility of a significant difference in risk per km travelled between New Zealanders and international visitors. However, this difference might instead be attributable to other factors such as the age profile of drivers and total km driven.

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[40] “Overseas drivers in crashes, including matched crash and visitor arrival data”, NZ Ministry of Transport, March 2018

Table 17: New Zealander & International Visitor Parameters, 2012-2015 combined

Parameter	**Values for period 2012 to 2015**		
	All road users	**New Zealanders**	**International Visitors**
Car occupant deaths	714	673	41
Van occupant deaths	92	86	6
NZ resident population-years		17.97 million	
International visitor nights spent	(millions)		176 million
International equivalent person-years	(millions)	17.97	0.483
% share of car & van deaths		94.2%	5.8%
% share of person-years		97.4%	2.6%

The next step was to analyse the age profile of car and van users so that the % of travel for each age group could be combined with the NZ average risk per 100km for each age group (as in Figure 37) to calculate an expected number of fatalities per 100km driven by the whole population. The percentage of travel was calculated:

- For New Zealanders, based on the age distribution across the population
- For New Zealanders, based on the distribution of car/van travel across age groups, and
- For international visitors, based on the distribution of nights spent in NZ across age groups.

The international visitor nights could not be disaggregated by gender, so this analysis was carried out with the genders combined. The results are shown in Table 18; the estimated average fatalities per 100m km (note that the NZ figure is slightly higher than the average based on Figure 37 as the MoH data include sdeaths not reported by the police from road crashes) are

- 0.41 for New Zealanders, based on the HTS distribution of km travelled
- 0.48 for New Zealanders, based on km travelled distributed pro rata to population
- 0.47 for international visitors, based on km travelled pro rata to visitor nights in NZ.

The conclusion of this exercise is that the age profile of international visitors and of New Zealanders would not, of itself, account for significant differences in death rates. This leaves kilometres travelled as a possible explanatory factor to be researched.

Table 18: Age distribution of Travel and Car/Van Occupant Risk for New Zealanders and International Visitors

Parameter	Age group												
	U-20	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 - 69	70 - 74	O-75	Whole population
NZ Population - person yrs	4.9E+06	1.3E+06	1.2E+06	1.1E+06	1.1E+06	1.3E+06	1.3E+06	1.3E+06	1.1E+06	9.8E+05	8.4E+05	6.3E+05	1.1E+06	**1.80E+07**
% NZ person years	27.3%	7.2%	6.5%	6.2%	6.2%	7.0%	7.0%	7.0%	6.1%	5.4%	4.7%	3.5%	6.0%	**100.0%**
NZ total 100m km/yr travelled	90.9	31.9	32.7	32.7	37.1	45.1	43.0	44.0	35.9	28.5	21.0	11.8	12.1	**4.67E+02**
% NZ km travelled	19.5%	6.8%	7.0%	7.0%	7.9%	9.7%	9.2%	9.4%	7.7%	6.1%	4.5%	2.5%	2.6%	**100.0%**
International Visitor nights	8.9E+06	2.6E+07	2.7E+07	1.8E+07	1.2E+07	1.0E+07	1.1E+07	1.3E+07	1.5E+07	1.6E+07	1.2E+07	4.9E+06	3.1E+06	**1.76E+08**
% International Visitor nights	5.0%	14.5%	15.1%	10.5%	7.1%	5.7%	6.1%	7.4%	8.4%	8.9%	6.8%	2.8%	1.8%	**100.0%**
Risk/100m km (MoT data)	0.38	0.98	0.57	0.21	0.31	0.25	0.22	0.20	0.31	0.29	0.44	0.64	1.90	
Expected contributions to average deaths per 100m km travelled by whole population														
New Zealanders, pro rata to population	0.10	0.07	0.04	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.11	**0.48**
New Zealanders, pro rata to km travelled	0.07	0.07	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05	**0.41**
International Visitors, pro rata to nights spent in NZ	0.02	0.14	0.09	0.02	0.02	0.01	0.01	0.01	0.03	0.03	0.03	0.02	0.03	**0.47**

Note: Risk per 100km travelled is the average over all drivers and passengers within each age group

There are no directly available statistics on the distances travelled by international visitors to New Zealand. In the absence of data, these distances were estimated in two ways, both involving the use of IVS data.

In the first method, IVA data on the proportion of international visitor nights associated with different purposes of visit was combined with simple assumptions as to the upper and lower km likely to be travelled by visitors using a car or van, as shown in Table 19.

Table 19: International Visitors km travelled by Car/Van, estimated from IVA Purpose of Visit

Purpose of Visit	N arrivals 2015	% of arrivals	Estimated average km driven		Contribution to km/ average visitor*	
			lower	upper	lower	upper
Holiday	1460608	52.6%	1000	2000	526	1052
Visiting friends & relatives	927248	33.4%	500	1000	167	334
Business	270432	9.7%	100	200	10	19
Education	60064	2.2%	500	1000	11	22
Conferences & conventions	58464	2.1%	100	200	2	4
Total	**2776816**	**100.0%**			**716**	**1431**

** Based on the assumption that the proportion who drive cars/vans is independent of purpose of visit*

In the second method, a sample of 100 international visitors was selected from the IVS Itinerary/ Places microdata. Each visitor was cross-referenced to the IVS Transport microdata to identify those who had travelled by car or van at some point in their journey. Each such person was then checked against the IVS Transport and Activity microdata to test whether they had also used bus or other land transport during their visit, so as to identify a minimum likely sub-set of the identified places that could have been visited by car or van. This subset of identified places visited were then arranged into a minimum travel distance itinerary, and the minimum road distance required to complete that itinerary was derived from Google maps. The results are shown in Table 20.

Table 20: Minimum International Car/Van Users km Travelled in NZ

Range of km travelled	Count	Minimum km travelled		
		Total	Average over car/van users	Average over all visitors
1000-2500	25	42072	1683	1245
500-1250	33	22909	694	514
200-500	12	2747	229	169
0-200	4	400	100	74
	74	**68128**	**921**	**681**

Based on IVS Itinerary/Places microdata downloaded June 2019

The average falls well within the range estimated in Table 19. The minimum distances in Table 20, though, clearly need to be scaled up to account for longer possible routes travelled (other places visited but not mentioned in the IVS response, and routes other than the minimum possible being used between places) and for local mileage around the places visited. A scaling factor of between 1.1 and 1.5 has therefore been applied in order to estimate the actual average km travelled per car/van user.

To complete the comparison of km travelled by New Zealanders and international visitors during the period 2012-2015 the following statistics are used:

- Total km/yr travelled by New Zealanders by car/van = 46.7 billion (MoT, HTS)
- Total international visitors/year to NZ = 6.51 million (IVS)
- % international visitors using car/van = 67.6% (IVS Transport microdata[41])

The resulting estimates of international visitors' share of NZ km travelled by car or van are summarised in Table 21.

Table 21: International Visitor Share of Car/Van km Travelled in NZ, 2012-15

Car/Van travel data for 2012-2015	**lower**	**upper**
% of International visitors/yr using cars/vans	67.6%	
Total International visitors/yr using cars/vans	4.40E+06	
Ave km/visitor using car/van (IVA, purpose of visit)	716	1431
Ave km/visitor using car/van (IVS, travel/activity)	1013	1381
Total km/yr (IVA, purpose of visit)	3.15E+09	6.30E+09
Total km/yr (IVS, travel/activity)	4.46E+09	6.08E+09
Total km/yr travelled by New Zealanders (HTS)	4.67E+10	
International visitor % of total km travelled	6.3%	11.9%

The international visitor share of car and van deaths was 5.8%, which is just below their share of % kilometres travelled. This suggests that the average risk of death per km for international visitors in cars or vans is no greater than, or might possibly be lower than, that faced by New Zealanders.

As a sense check on this conclusion, the average visit duration for international visitors to NZ is about 17 days, giving an average km travelled per day's visit (for car and van users) of between 42 and 84 km per day. The corresponding figure for New Zealanders is 28.5 km per day (for all members of the population). These figures seem entirely plausible – a substantial majority of international visitors to NZ wish to see diverse interesting places and a car or van is the most practicable and economical way to reach many of them. It is therefore unsurprising that such visitors would travel further per day on average than would New Zealanders (whose day to day car/van travel on the whole is relatively local) and would suffer a proportionately higher share of road deaths per day/night spent in New Zealand than do residents.

[41] Based on analysis of a sample of 324,809 responses from IVS Transport microdata downloaded June 2018. Note that the transport table on Stats NZ gives an equivalent figure of 30.6%, but this is based on a single mode per respondent, so does not include the many visitors who use multiple modes of transport during their stay.

7.1.2 Unit Risk for Aircraft Passengers

Many visitors to National Parks and other attractions in New Zealand use an internal flight to cover the substantial distances involved quickly. While some journeys may involve scheduled flights in relatively large aircraft, many also involve small aeroplanes or helicopters. Large aeroplanes are relatively very safe; we focus here on smaller aeroplanes and helicopters which involve more significant levels of risk to passengers.

All commercial operators are required as a condition of their licence to report seat hours flown each year to the NZ Civil Aviation Authority (CAA). Either the CAA or the Transport Accident Investigation Commission investigate, and publish a report into, every fatal commercial aircraft accident (and many other non-commercial accidents). I am grateful to the NZ CAA for their assistance in locating and interpreting relevant data. Table 22 summarises seat hours and deaths from 2009-2018 for the relevant categories of aircraft.

Table 22: Seat Hours[42] and Deaths[43], NZ Smaller Aircraft, 2009-2018

Safety Outcome Target Group	**Seat hrs**	**Deaths**
Airline Operations - Small Aeroplanes	1.2E+06	**1**
Airline Operations - Helicopters	1.4E+06	**10**
Sport Transport	1.0E+06	**17**
Other Commercial Operations - Aeroplanes	2.3E+06	**14**
Other Commercial Operations - Helicopters	7.8E+05	**13**
Agricultural Operations - Aeroplanes	4.3E+05	**4**
Agricultural Operations - Helicopters	8.4E+05	**5**
Private Operations - Aeroplanes	4.9E+05	**7**
Private Operations - Helicopters	4.3E+05	**8**
Private Operations - Sport	2.6E+06	**38**

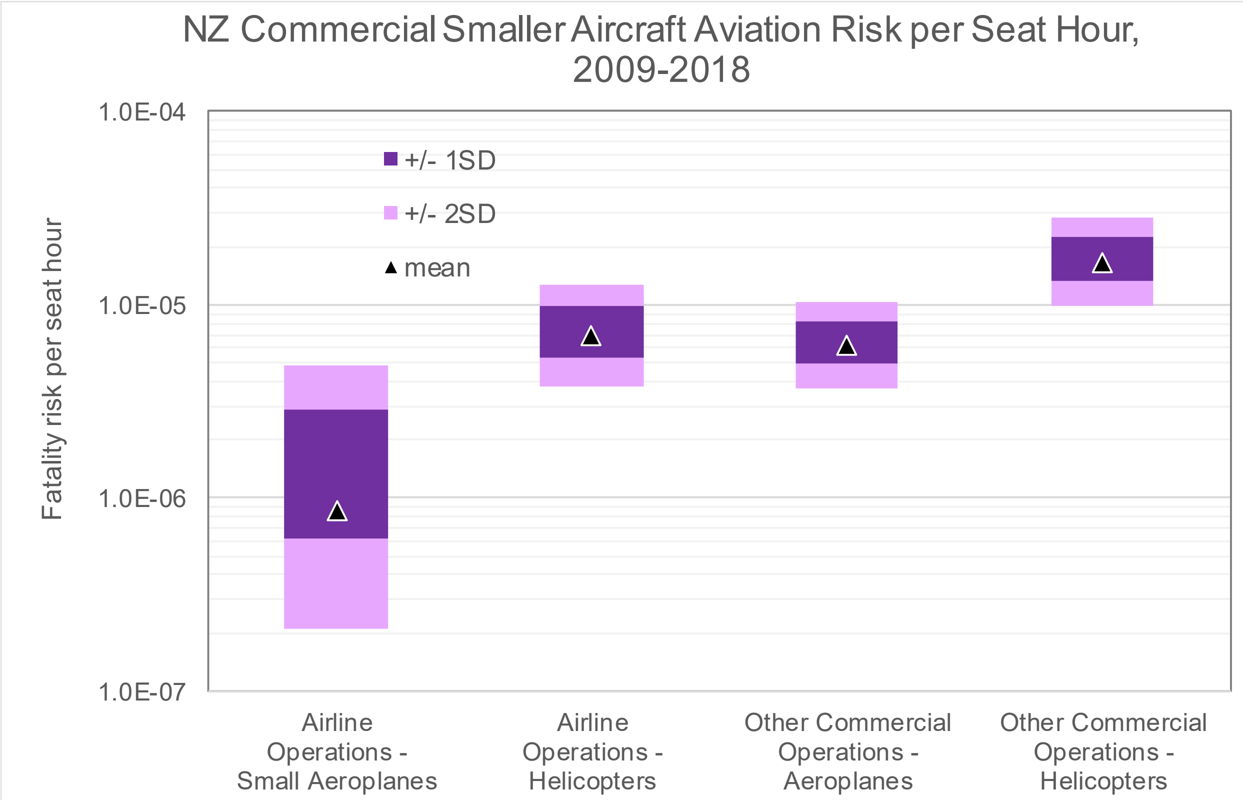
Corresponding risk levels per seat (passenger) hour are shown for the relevant classes of aircraft (those which might potentially carry paying visitors to/from NZ PCL) in Figure 43. Airline operations are those running scheduled flights; "other commercial" operations would include any kind of charter or one-off flights.

Figure 43 shows that, as might be anticipated,

- Airline operations are somewhat less risky than other commercial operations, and
- Aeroplanes are somewhat less risky than helicopters.

[42] CAA Intelligence, Safety & Risk Analysis Unit, "Aviation Safety Report, 1 Jan to 31 Dec 2018"
[43] From the author's own digest of CAA and TAIC individual accidents and annual reports.

Figure 43: NZ Commercial Small Aircraft Fatality Risk per Seat Hour



7.2 Risk Associated with Travel to & from NZ PCL

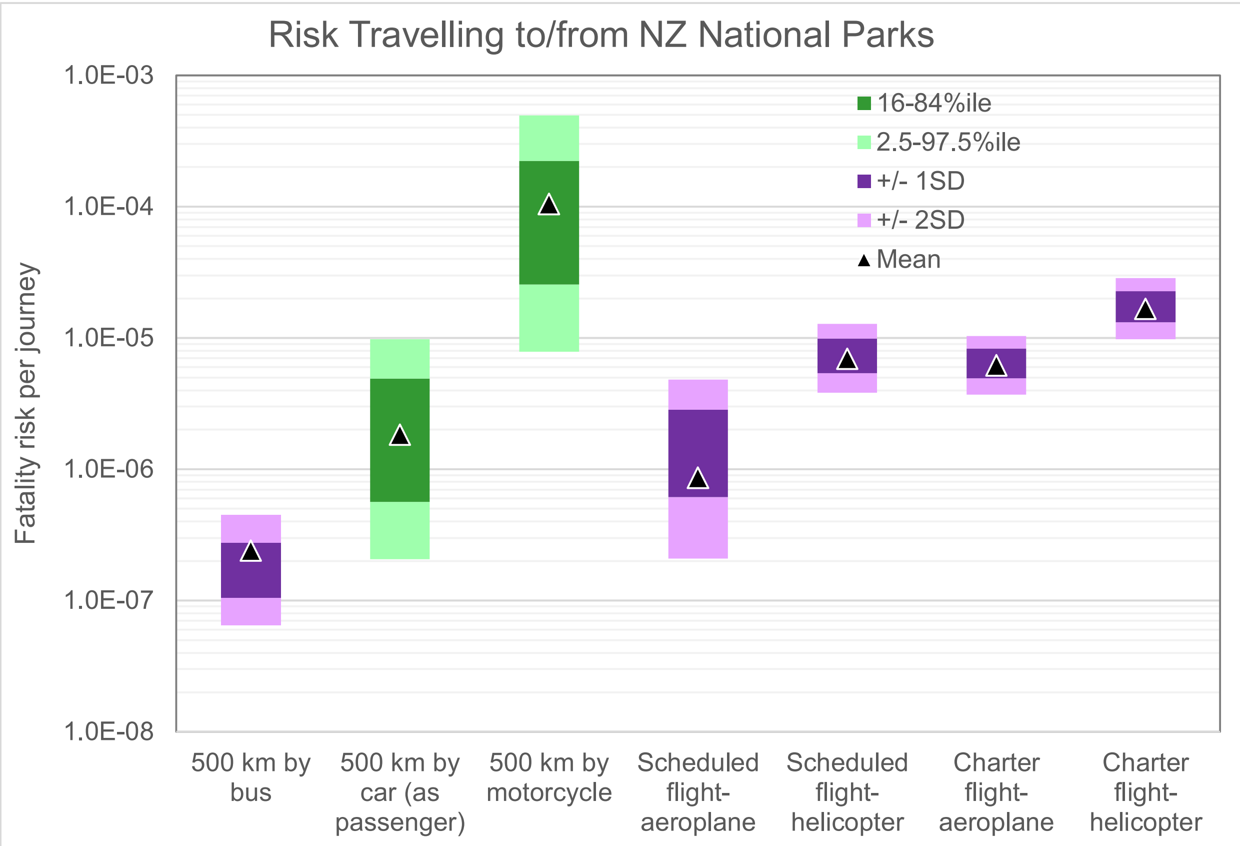
In order to be able to compare risk while on NZ PCL with the risk of getting there, we need to postulate some typical journeys visitors might make. The majority of visitors are likely to travel to a National Park, starting their journeys at or around one of the major cities (Auckland, Christchurch, Wellington, Hamilton), international airports (which adds Queenstown to the list) or ferry ports (which adds Picton). Some typical journeys to popular DOC locations would involve one-way travel distances by road as follows:

- Auckland to Tongariro NP 332 km
- Wellington to Tongariro NP 296 km
- Picton to Abel Tasman NP 266 km
- Christchurch to Paparoa NP 380 km
- Christchurch to Mt Cook village 328 km
- Queenstown to Fox Glacier 322 km
- Queenstown to Milford Sound 281 km

A typical road journey to and from a National Park is conservatively estimated as 500km to illustrate the scale of risk involved. A typical journey by air is estimated to involve 1 hour, but not necessarily to involve a return trip as many visitors travel 1-way through NZ or one way by air and one way by road.

With these assumptions and unit risk as in Figures 42 and 43, the risk per journey to and from a typical DOC visitor site is as shown in Figure 44.

Figure 44: Fatality Risk of Example Journeys to/from DOC Visitor Sites



Note – the risk shown by car is that as a passenger; the risk as a driver is somewhat higher

In increasing order of risk, the journeys involve fatality risk levels of

- Well below 1 in a million (10^{-6}) per journey (bus)
- Around 1 in a million; could be considerably higher or lower (car, scheduled aeroplane)
- Approaching 10 in a million or higher (helicopters, charter aeroplane)
- Around 100 in a million (motorcycle).

8 Outdoor Activities Overseas

This section presents some comparator risks:

- Per day's visit to North American National Park Service sites, and
- Per day or per ascent for some overseas climbs and hill walks.

8.1 National Park Visits

The US National Parks Service (USNPS) granted in full my freedom of information request for data on deaths at all of their sites[44]. Visitor access at USNPS is controlled, so accurate visitor numbers are available and are published on the USNPS web site[45]. Appendix 2 provides charts for each of 6 ranges of risk per day (spanning the range at USNPS sites), and providing a breakdown of deaths by cause of death and by activity at the time in addition to charts showing risk per day's visit.

Figure 45 shows the risk per visit for selected US sites spanning the whole range of risk, along with NZ National Parks (chosen to span the NZ range of risk per day's visit).

Interesting features of Figure 45 include

a) The US sites span a much wider range of risks than do the NZ National Parks.

b) The higher risk at the US parks at the top of the chart is unsurprising. The North Cascades and Denali (Mt McKinley) have a high proportion of visitors who are serious climbers tackling remote and challenging mountain ascents; the majority of deaths here are due to falls and exposure (see Appendix 2). Dry Tortugas and the Virgin Islands both have a high proportion of visitors who engage in diving and other hazardous water sports; the majority of deaths here are due to drowning (see Appendix 2).

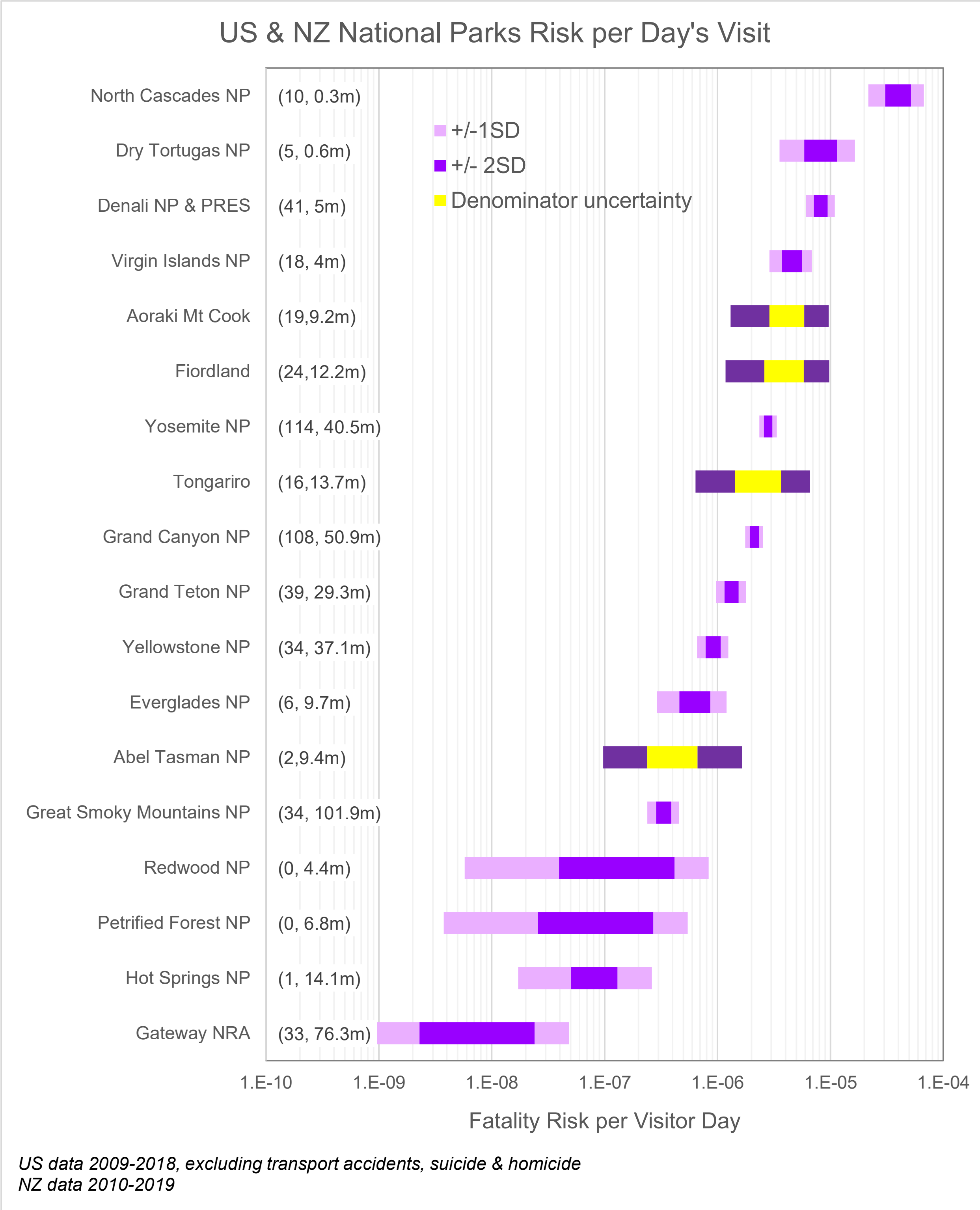
c) The lower risk at US parks at the bottom of the chart is also unsurprising. The Gateway NRA is a collection of harbour gateway coastal areas in the heart of New York city; although it suffers several deaths a year (mostly drownings and medical events) it enjoys massive visitor numbers and the risk per visit is very small. Hot Springs is similarly very much a city centre park; though it, Petrified Forest and Redwood NPs all have some beautiful hiking trails, a large majority of visitors come (by car) to enjoy the iconic main features, and do not venture far from the car parks.

d) The New Zealand parks sit very much within the range that would be expected for parks with a wide mix of general tourism and more adventurous tramping and climbing activity. Abel Tasman lies somewhere between the lower US parks and Great Smoky Mountains, Tongariro is in-between Yellowstone and Grand Canyon, while Aoraki/Mt Cook and Fiordland are within a similar range to Grand Canyon and Yosemite. All of the NZ parks and the US parks with similar risk levels have a diverse mix of ordinary tourists taking little part in hazardous activities, along with serious trampers, water sports and climbing enthusiasts.

[44] Personal communication from USNPS Freedom of Information Act office to A R Taig, 4 December 2019

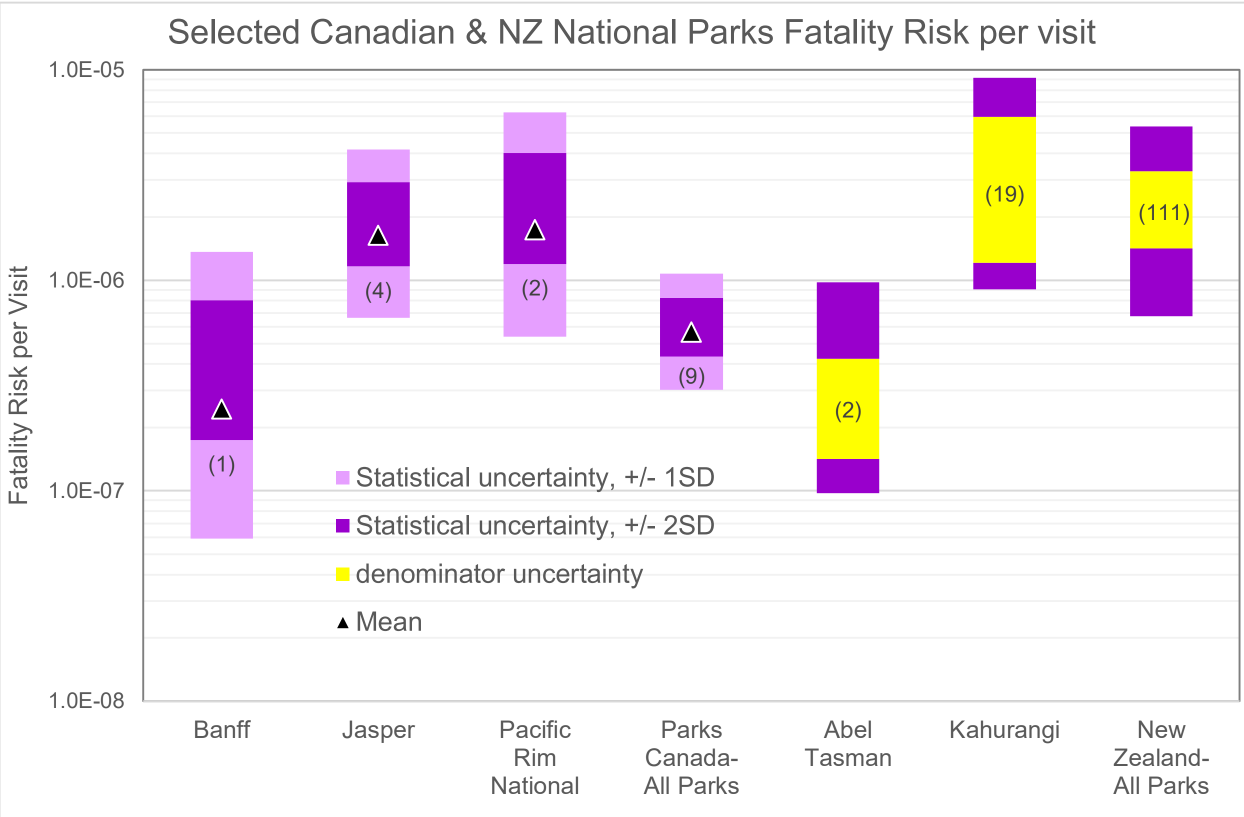
[45] Downloaded in December 2019 from https://irma.nps.gov/STATS/Reports/National; statistics used are for recreational visitors.

Figure 45: Selected US National Park Service & NZ National Parks Sites' Risk per Day's Visit



Parks Canada kindly provided fatalities data at their sites[46]. Visitor access is controlled, as it is at the US parks, so accurate visitor numbers are also available, though unfortunately could only be obtained for the single year April 2018 to March 2019[47]. The data for selected parks and for all Canadian parks (excluding transport accident deaths to improve comparability with the NZ data) are shown in Figure 46 alongside the corresponding New Zealand data for the lowest and highest risk parks (Abel Tasman and Kahurangi) and for all New Zealand national parks combined.

Figure 46: Canadian and NZ National Park Visitor Fatality Risk per Day's Visit



Canadian Parks data for single year April 2018-March 2019 (excl. transport accidents)
NZ data for 2009-2018 decade. Deaths in period shown in brackets

Although there is limited data for the Canadian parks, Figure 46 suggests that the risk levels per visitor day across Parks Canada are broadly similar to those across the New Zealand National Parks.

[46] Personal communication, S. Marcoux (Parks Canada Visitor Safety and Compliance Advisor) to A R Taig, 23/1/2020
[47] Available online at https://www.pc.gc.ca/en/docs/pc/attend

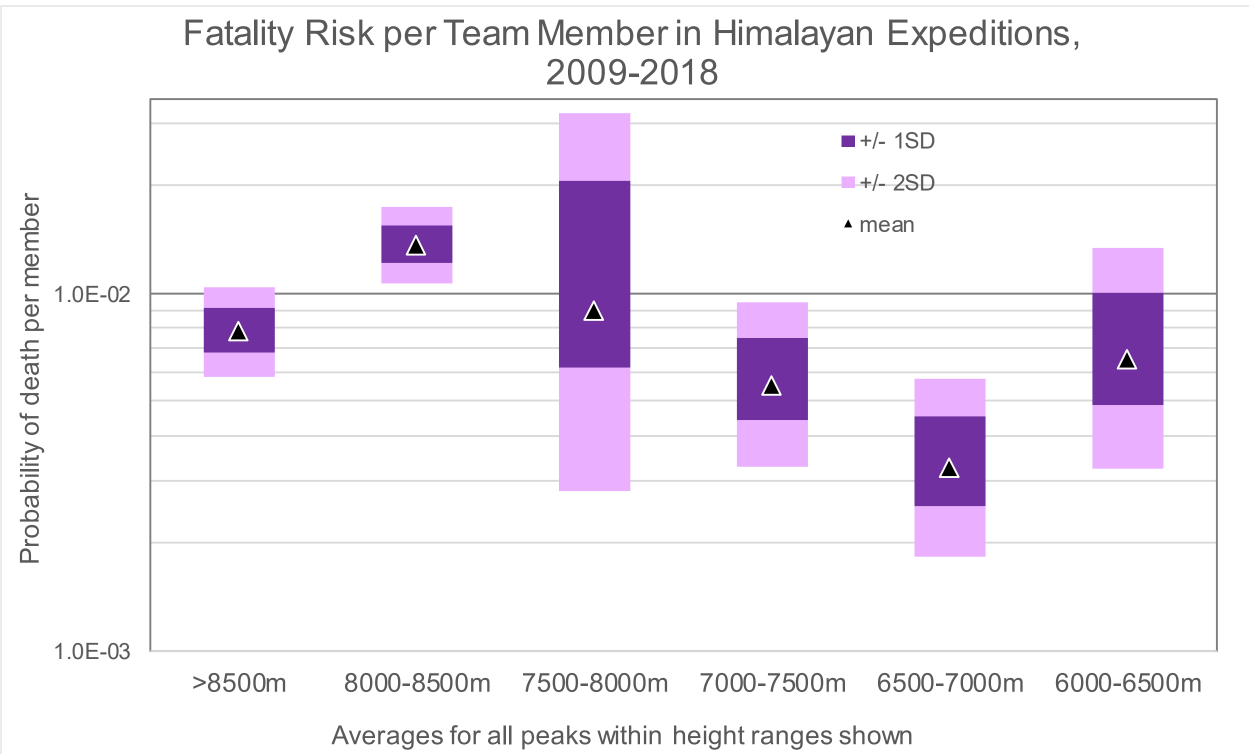
8.2 Specific Tramping/Climbing Routes

This section provides a range of comparators, starting with some of the highest risk mountains in the world and progressing towards tramping routes more comparable with NZ great walks and tramping generally. The comparators are

- Himalayan high altitude ascents
- Iconic world mountains
- Winter and summer mountain pursuits, and
- Popular British and Tasmanian hill/mountain walks.

From the earliest days of Himalayan mountaineering, Elizabeth Hawley, a far-sighted Kathmandu-based journalist, interviewed every expedition setting out for and returning from the Himalayas and established an archive which has been maintained and provides a high quality database of expedition numbers, deaths, days duration and many other statistics. The archive is available freely online[48]. Figures 47 and 48 show respectively the fatality risk per expedition member, and the fatality risk per person-day, for groups of peaks in different altitude ranges over the period 2009-2018. The fatalities here are to expedition members only; the fatality rates on the highest peaks to hired staff are somewhat higher.

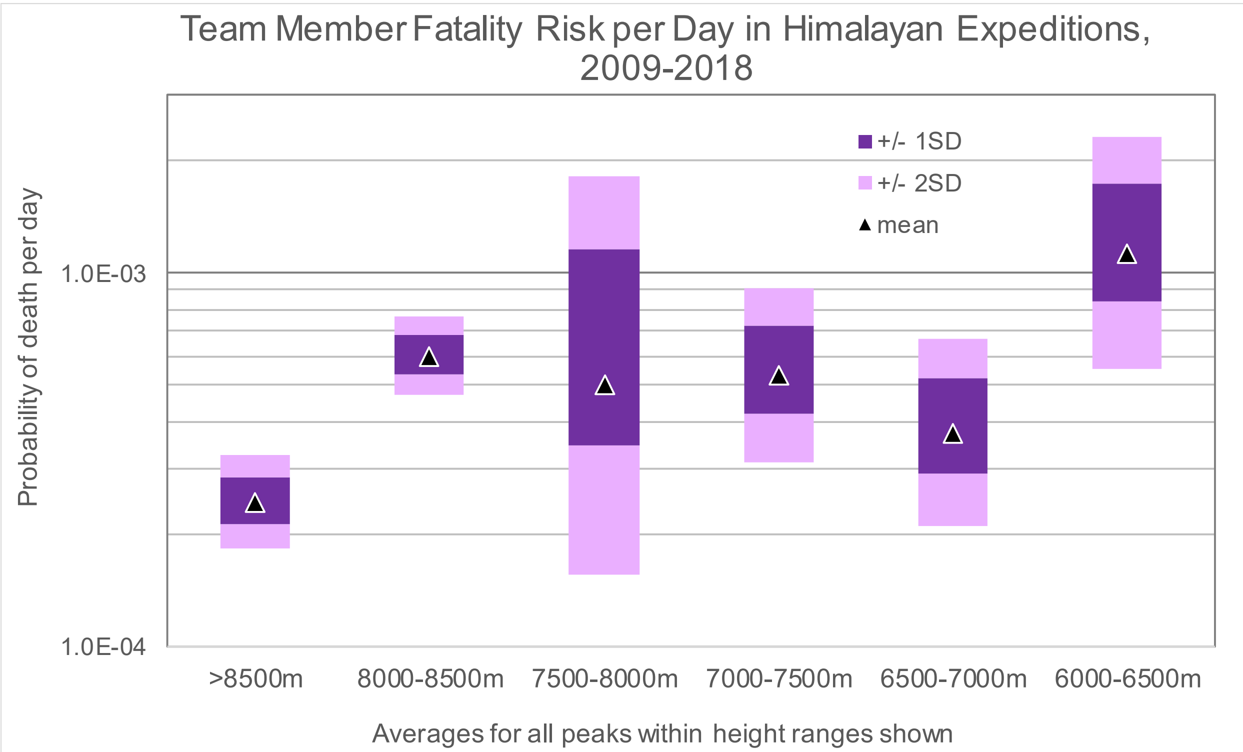
Figure 47: Himalayan Expedition Fatality Risk per Expedition Member, 2009-2018



[48] http://www.himalayandatabase.com/

Perhaps somewhat surprisingly, the risk on the very highest peaks (>8000m) is lower than that on the next highest (8000-8500m). This is perhaps because the >8500m statistics are dominated by Mt Everest, where a large proportion of ascents are now commercially guided.

Figure 48: Himalayan Expedition Fatality Risk per Day, 2009-2018



The highest peaks tend to involve longer duration expeditions with more time for acclimatisation as well as for straightforward travel to the site. This contributes (along with the "guided tours up Everest" effect) to the lower daily risk for the highest peaks.

Figure 49 shows a comparison of fatality rates for ascent of specific globally well-known mountains. Data for the Aoraki/Mt Cook National Park, showing the range of risk per day's climbing across a range of popular huts associated with major ascents (with days climbing estimated from hut nights' bookings) are taken from the published paper of Malcolm[49]. These figures are now over 20 years old and the risk today may be considerably lower. The figure for general "climbing" from this study (Figure 15), which includes a wide variety of scrambling and other activity less hazardous than the ascents covered in the Malcolm study) is also shown for comparison. Figures for Denali are based on the annual mountaineering summary reports and climbing statistics available online[50]. Figures for Mont Blanc are taken from a recent paper summarising experience of hazardous events on the mountain[51].

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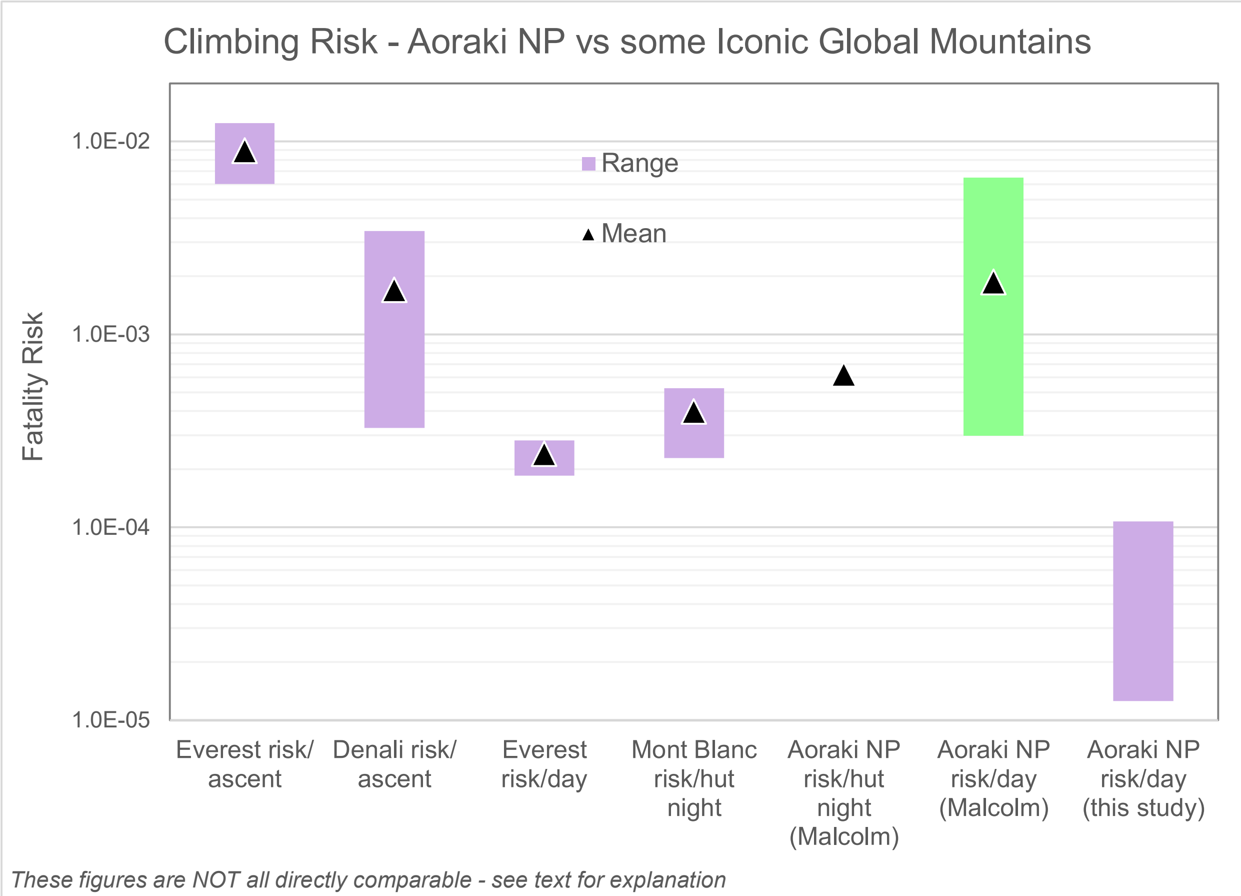
[49] Malcolm M, "Mountaineering fatalities in Mt Cook National Park", N Z Med J. 2001 Mar 9;114(1127):78-80
[50] https://www.nps.gov/dena/planyourvisit/mountaineering.htm
[51] Mourey J, "Accidentology of the normal route up Mont Blanc between 1990 and 2017", Petzl Fondation, May 2018. Available online at https://www.petzl.com/fondation/Etude-Accidento-Gouter_1990-2017_EN_web.pdf?v=2

Figure 49: Fatality Risk Climbing in Aoraki/Mt Cook NP vs Selected Global Mountains



The risk of climbing major peaks in Aoraki/Mt Cook National Park is broadly similar to that associated with Denali and probably somewhat higher than that for Mont Blanc (where many guided ascents are made). The risk per day for Everest is not directly comparable as typical expeditions involve long periods without serious climbing; the risk per day's climbing near the summit is probably comparable with or higher than that on the Aoraki/Mt Cook major peaks. Note that the right hand bar for this study includes a wide variety of activities less hazardous than attempting to scale a high altitude peak.

A simple conclusion from Figures 14 & 15 and Figures 47 to 49 is that there is a big difference between a day's scrambling or low altitude climbing in an NZ National Park, where the fatality risk is within the range 10^{-6} to 10^{-4} per day, and ascents of difficult, high altitude mountains where the fatality risk extends well above 10^{-3} per day.

Two recent papers by an Austrian/Italian/Swiss team of researchers provide useful overviews and selected statistics on risk associated with mountain activities both in winter[52] and in summer[53].

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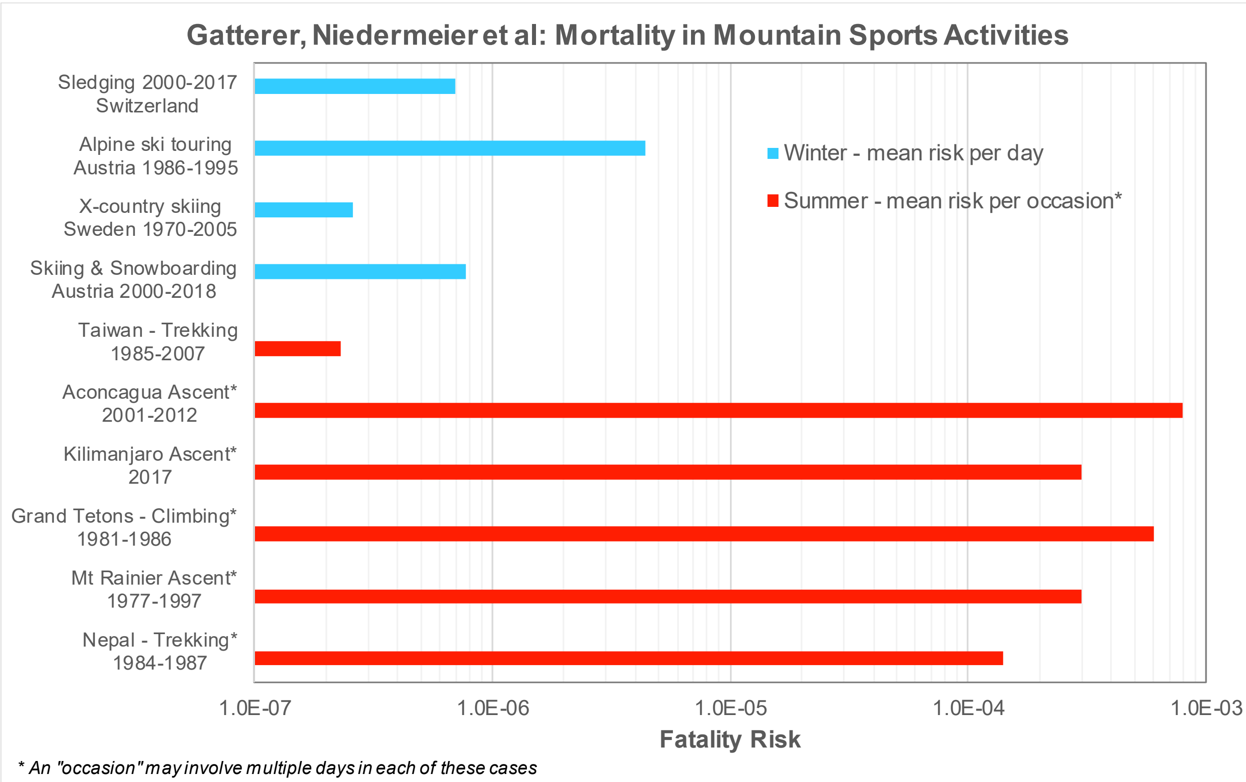
[52] Niedermeier N et al, "Mortality in Different Mountain Sports Activities Primarily Practiced in the Winter Season—A Narrative Review", Int. J. Environ. Res. Public Health 2020, **17**, 259
[53] Gatterer H et al, "Mortality in Different Mountain Sports Activities Primarily Practiced in the Summer Season—A Narrative Review, Int. J. Environ. Res. Public Health 2019, **16**, 3920

The risk associated with a selection of the activities for which risk per day or per occasion of carrying out the activity is presented in these two papers is shown in Figure 50.

Figure 50: Mortality in Mountain Activities (from Niedermeier[51] and Gatterer2[52])



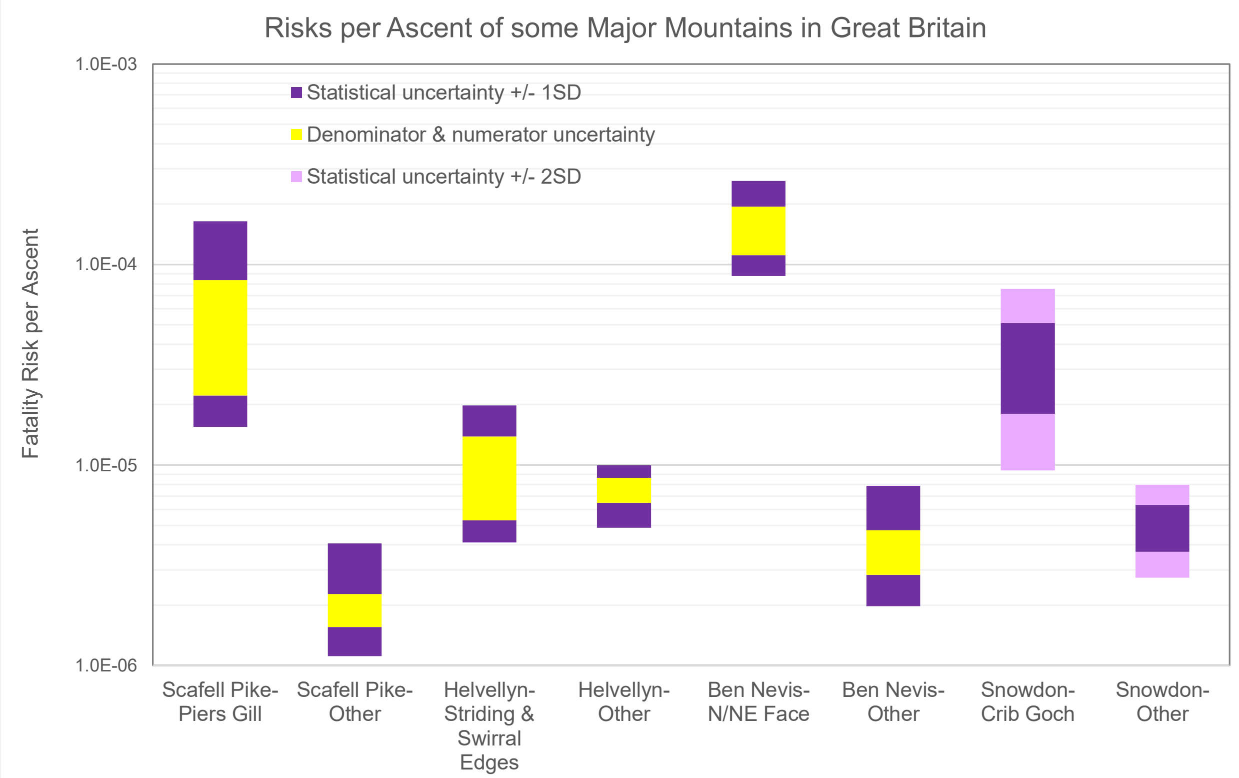
Note that Figure 50 is a simple bar chart – the top/right hand side of the bar corresponds to the mean value, and the length of the bar does NOT convey any information about uncertainty.

With the exception of alpine ski touring (where the risk is between 10^{-6} and 10^{-5} per day), the winter activities all involve fatality risk between 10^{-7} and 10^{-6} per day. The Taiwanese (summer) trekking risk also lies in this range, whereas the other summer activities (all involving high altitude ascents/tramping) involve considerably higher risk, of order 10^{-4} per day (taking into account that these are multi-day activities).

Figures 47 to 49 and most of the summer activities in Figure 50 relate to activities far beyond what most visitors to a DOC visitor site in New Zealand have in mind. To provide something more comparable with NZ tramping and climbing experiences, data has been assembled for a selection of major British mountains and is shown in terms of risk per day in Figure 51. Each of the British mountains in question has relatively straightforward "tourist" tramping routes to the summit, and other more adventurous routes involving scrambling or technical climbing. Data was obtained as follows:

- For Snowdon (Wales), via the Snowdonia National Park Authority[54] (visitor numbers via counters on all major routes) and the Mountain Rescue Services (fatalities)[55]
- For Ben Nevis (Scotland), via the John Muir Trust[56] (visitor numbers via a counter on the main tourist path, and on local knowledge for other routes)
- For Scafell Pike and Helvellyn (England), visitor numbers via the National Trust[57] (Scafell Pike) and based on approximate historic equivalence of people ascending each
- For fatalities on all British mountains except Snowdon – via the author's own research, informed in large part by annual reports and incident reports from the relevant local Mountain Rescue Services[58])

Figure 51: British Mountain Risks per Ascent



Based on period 2010-2018 (Scafell Pike, Helvellyn, Ben Nevis) and 2013-2018 (Snowdon)

Ascents for all these mountains are comfortably carried out (up and down again) within one day, so the figures can be directly compared with other risks per day in this report. The fatality statistics include medical causes as well as falls (a large majority of deaths) and exposure/ hypothermia. Only for Snowdon do I have accurate statistics for both fatalities and ascents; for all the others the number of ascents is known only within a range (hence the different colour bars

54 Personal communication, Snowdonia National Park Access Officer to A R Taig, October 2019
55 Personal communication, UK Mountain Rescue Statistics Officer to A R Taig, December 2019
56 Personal communications, A Austin & N Berrie to A R Taig, January 2020
57 https://www.nationaltrust.org.uk/wasdale/features/scafell-pike---restoring-the-summit-cairn
58 http://www.ldsamra.org.uk/ (Scafell Pike & Helvellyn. https://www.lochabermrt.co.uk/ - Ben Nevis)

for Snowdon and others). The risk for all the "other" routes (which are largely relatively straightforward walking/tramping tracks) is in all cases between 10^{-6} and 10^{-5} per ascent. The risk associated with the highlighted individual routes is significantly higher, and follows a pattern which is entirely consistent with the hazards involved:

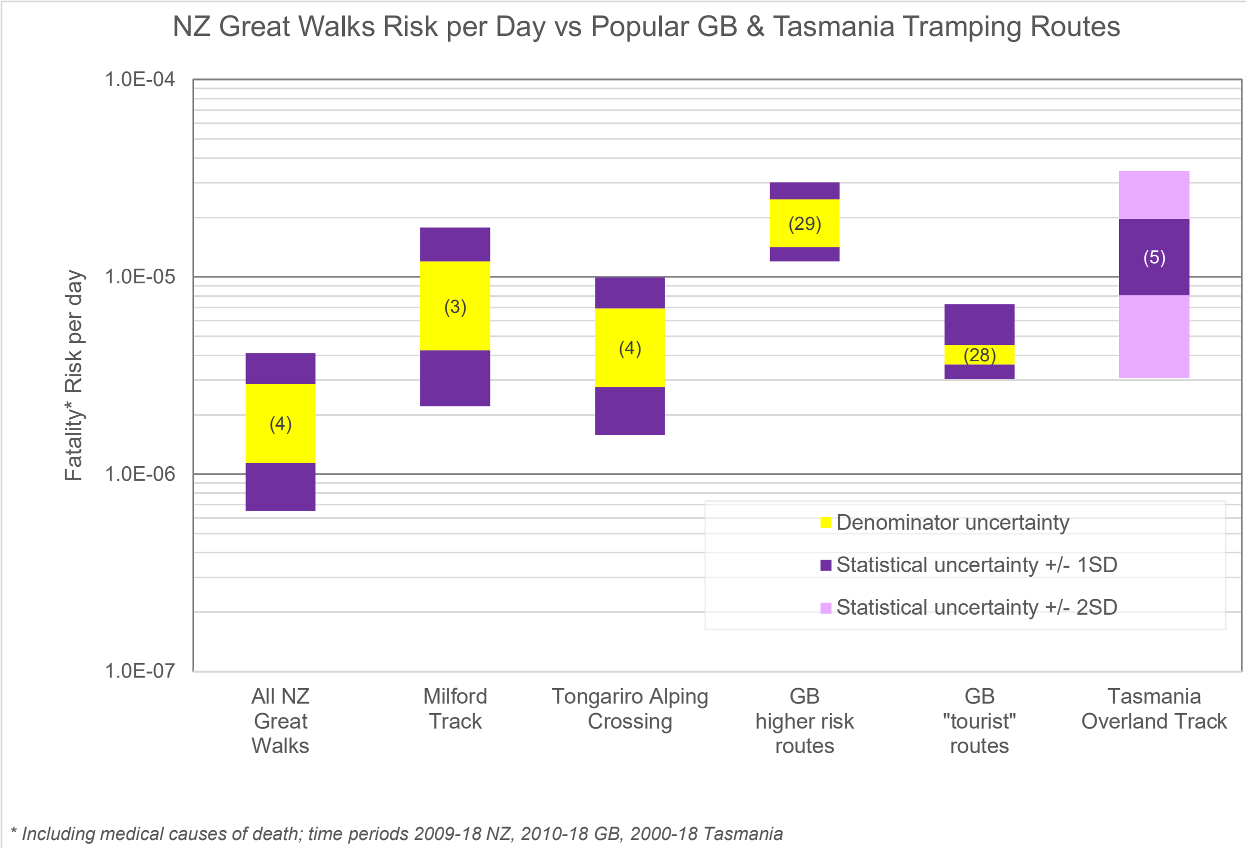
- On Helvellyn, Striding Edge[59] is the most popular route to the summit, and involves a walk with modest scrambling along a ridge with long, steep falls either side. The hazard is clear and obvious but the risk not too severe – plenty of families with primary school children take this route.
- The Crib Goch ridge approach to Mt Snowdon involves another long ridge with steeper sides than Striding Edge. Popular with scramblers and serious walkers, it is not the sort of place to take young children, and would be expected to have a higher rate of falls, and higher mortality risk per fall, than Striding Edge.
- Piers Gill on Scafell Pike is a well-known accident hot spot where the local Mountain Rescue team are used to making several rescues each year. The casualties are almost all, if not entirely, people who had no intention to go there but took a wrong turn on the descent from the summit. Instead of a straightforward track down the mountain, this leads to a steep-sided stream which has caused many serious falls, particularly in low visibility.
- The North face of Ben Nevis is steep and rocky, contains a wide variety of climbing routes of different degrees of difficulty, and is a magnet for serious climbers from the UK and overseas. Also included in the fatality statistics here are some tougher tramping/ scrambling routes up the N and NE faces of the mountain, so the bar in Figure 51 almost certainly includes significant numbers of people at both higher and lower levels of risk.

Finally, Figure 52 sets the New Zealand Great Walks' risk per day in context against some of the British walks in Figure 51 and against the Overland Track in Tasmania[60]. The relativities of risk in Figure 52 are much as might be expected given the nature of the routes in question:

- Risk on the Milford Track and the Overland Track in Tasmania is very similar; both involve a high degree of remoteness and some falling hazards in places (note that the Milford deaths are dominated by medical causes).
- The GB higher risk routes[61] involve risk towards the top end of that for Milford and the Overland Tracks, which in turn are very much at the top end of NZ Great Walks risk levels. This is unsurprising given the clearly more hazardous nature of the GB routes involved.
- The Tongariro Alpine Crossing risk is broadly similar to that of the GB "tourist" routes.
- The NZ Great Walks average risk is below all the others, which is again unsurprising in light of the design of the walks to be accessible to a wide range of trampers.

[59] Note – the Striding Edge statistics here also include deaths on Swirral Edge, a popular continuation of the walk along Striding Edge to the Helvellyn summit.
[60] Fatalities and visitor numbers received via personal communication, M Bryce, Director Landscape Programs, Tasmania Parks and Wildlife Service to A R Taig, September 2019
[61] Piers Gill (Scafell Pike), Striding Edge (Helvellyn), Crib Goch (Snowdon) and Ben Nevis N/NE face

Figure 52: NZ Major Walks alongside popular GB and Tasmania Tramping Routes



9. Aggregate Fatality Risk in New Zealand

This section considers metrics extending beyond individual risk, focusing on

- Aggregate lives lost per year (9.1) and
- Frequency of events of major concern, and multiple fatality events in particular (9.2).

9.1 Aggregate Lives Lost per Year in New Zealand

Table 23 summarises the lives lost in New Zealand per year, for New Zealanders and international visitors wherever possible, from

- All causes, and accidents in particular
- Contributors to accident risk
- Natural hazards, and
- Accidents on NZ Public Conservation Land

Table 23: Average Lives Lost per Year in New Zealand

Causes of Death	New Zealanders	International Visitors
All Causes 2011-2015	**30487**	**146**
of which		
All other causes	29237	106
Accidents 2011-2015	1250	39.4
of which		
Falls	509	5.2
Transport	352	18.8
Drowning	53	4.2
Natural Forces*	39	8.4
Other Accidents	309	2.8
as compared with		
Natural Hazards 1999-2018	**17.85**	
of which		
Earthquakes	9.45	
All other natural hazards	8.4	
and compared with		
NZ Public Conservation Land 2010-2019	**22**	
of which		
National Parks Visitors	5.6	5.5
Other NZ PCL Visitors	8.2	
DOC staff & contractors	0.9	
Air accidents on NZ PCL	0.9	1
Numbers above 50 are rounded to the nearest whole number		

The annual deaths on NZ Public Conservation Land are lower than the number due to natural hazards, for the periods shown (note that without the Christchurch earthquake of February 2011 the reverse would have been the case). Perhaps most interesting from Table 23, though, is the perspective it gives on the place that visits NZ PCL play in accident risk for international visitors as opposed to New Zealanders. For residents, risks on NZ PCL make up around 1% of the total accident fatalities burden. For international visitors, they make up around 15%. While this might seem high one needs to consider that

a) A large proportion of international visitors come to NZ to enjoy nature and the National Parks in particular (based on the estimates in this study between 20% and 40% of all visitor nights in NZ are spent at or around National Parks). Moreover
b) the demographic of international visitors virtually excludes large groups of people at high risk of accidents (e.g. elderly people whose falls in the home make up nearly 40% of the whole NZ accident fatality burden). Thus the overall mortality rate for visitors is smaller than that for residents (and thus the deaths on NZ PCL make up a higher percentage of that total than do those for New Zealanders).

Visitor deaths on NZ PCL can be put further in perspective by making a simple estimate of the collective risk from travelling to and from parks and other areas. For this simple estimate it is assumed

- annual visits to NZ PCL are the average of the lower and upper estimates used throughout Section 3
- each visit involves 500km travel by car (some people will use buses, which are much lower risk, but many more will drive, and will typically drive substantially further – see example journey lengths in Section 7.2)
- each visitor will experience the NZ average risk of death per km travelled (averaged over all car drivers and passengers).

The resulting estimated deaths per year travelling to and from DOC visitor sites are shown in Table 24.

Table 24: Estimated Deaths/year Travelling to/from DOC Visitor Sites by Car

	New Zealanders	International Visitors
Million visits to DOC sites per year (average of lower & upper estimates)	2.35	3.04
Average km travelled per visit	500	
Average fatality rate per 100m km travelled (drivers & passengers combined)	0.41	
Expected deaths/year travelling to and from DOC sites	4.8	6.3

The estimates for both overseas visitors and New Zealanders are comparable with the number of deaths occurring annually while on Public Conservation Land. The combined fatality burden for international visitors, of visiting and travelling to DOC visitor sites, would make up over 30% of the accident fatalities suffered by such visitors whilst in New Zealand. Given that a primary reason for many visits to NZ is to experience the wonders of nature on NZ Public Conservation Land, the high proportion of visitor nights spent at National Parks and that few visitors are of the demographic most vulnerable to accidents other than transport, this is to be expected.

9.2 Frequency of Major Events

Events killing 10 or more people are relatively well catalogued and this was used as the starting point in the draft version of this report. While the draft report was being discussed and reviewed within DOC and elsewhere the inquiry into the tragic eruption at Whakaari on 9 December 2019 and related studies focused on major events as those killing 5 or more people. In preparing the final version of this report a section has therefore been added to extend the risk comparisons here down to numbers of deaths less than 10, and specifically to focus on event killing 5 or more people. The initial version of the comparisons is presented unchanged as Section 9.2.1, while the work to provide a particular focus on events killing 5 or more people is presented as Section 9.2.2

9.2.1 Major Events Killing 10 or More People

A list of events killing 10 or more people in New Zealand (or in NZ waters or on NZ territory) in the last 100 years (1920 to 2019) is provided in Table 25[62].

The information in Table 25 includes aggregated isolated deaths in episodes of severe weather but does not include deaths due to epidemic or pandemic disease. The information is presented in the form of an f/N curve for the 100 years from 1920-2019 in Figure 53, and for the 50 year period from 1970-2019 in Figure 54. The natural hazards curves show events with fewer than 10 deaths whereas the man-made events are shown only for 10 or more deaths (the frequency of man-made events such as road crashes killing 1 or more people per year is many hundreds per year; the frequency of all accidents killing 1 or more people per year is a large proportion of the totals shown in Table 23). The Mt Erebus air disaster of 1978, which killed 257 people, has not been included as it took place remotely from the occupied islands of New Zealand.

The most obvious difference between the longer period shown in Figure 53 and the more recent Figure 54 is the generally lower frequencies of major events involving 10 or more deaths. A large proportion of such events from 1920 to 1969 involved shipwrecks, which are nowadays far less frequent (fewer, larger, safer vessels). Natural hazards, though, have also reduced in frequency killing 10 or more people, while severe weather hazards have also reduced significantly in terms of the maximum number killed. These reductions reflect better siting of and improved standards of buildings, along with better warning and evacuation arrangements for severe weather hazards. What has not changed between the two curves is that geological hazards remain the dominant contributor to very high severity events, while man-made hazards dominate the frequency of lower N (N<10) events by a large margin.

[62] Sources: GNS Science & NIWA for natural hazards; Wikipedia & author's own research for remainder

Figure 53: f/N Curve for Major Events in New Zealand, 1920-2019

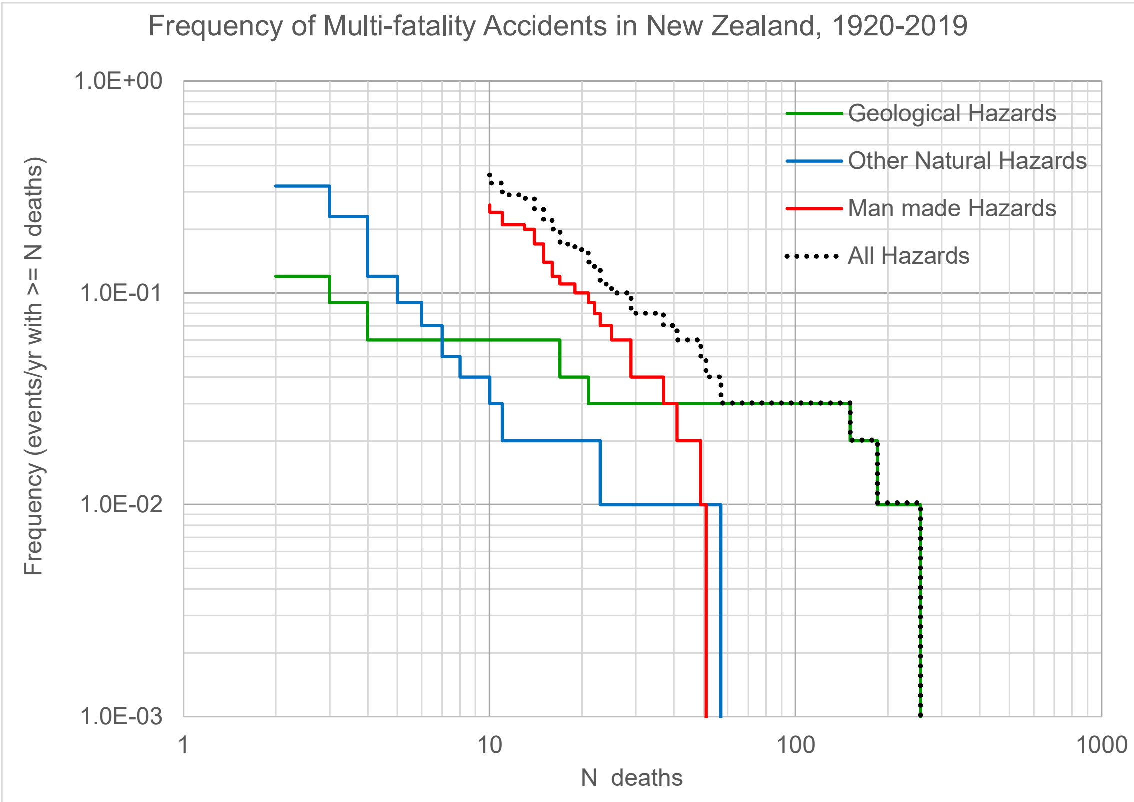


Figure 54: f/N Curve for Major Events in New Zealand, 1970-2019

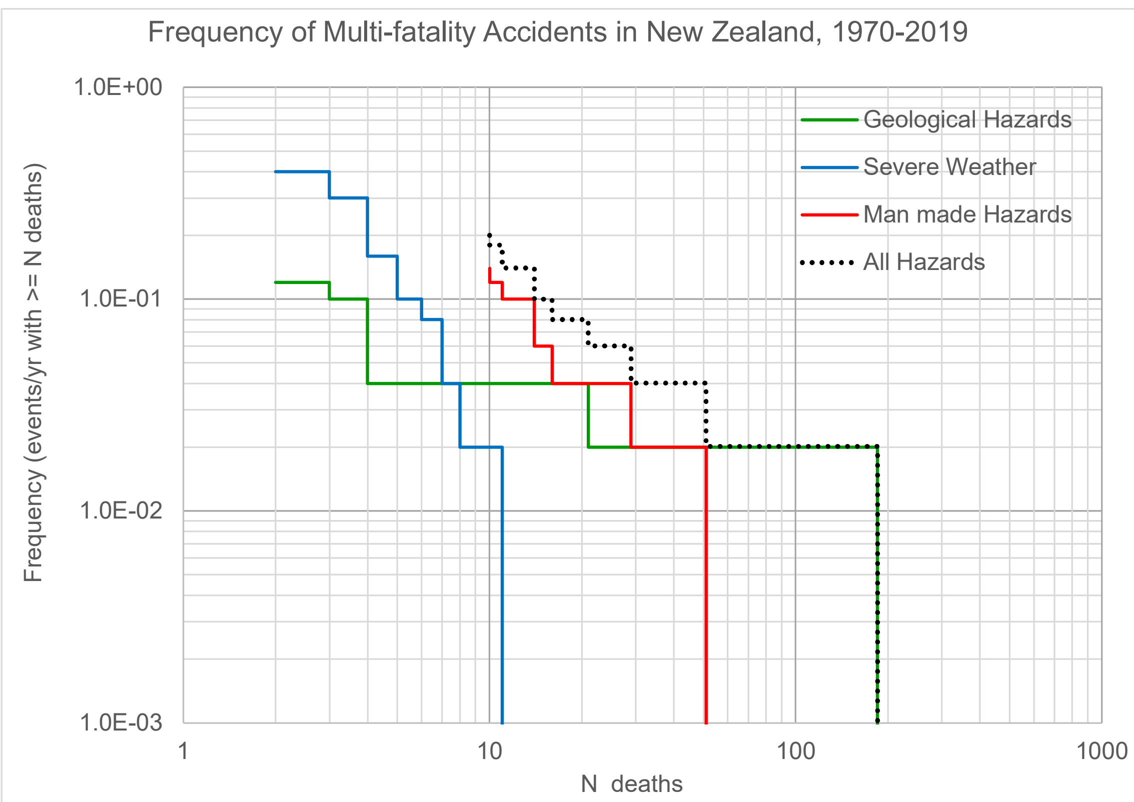


Table 25: Events causing 10 or More Deaths in New Zealand, 1920-2019

Event Type	Event	Year	Deaths
Man-made	Christchurch mosque shootings	2019	51
Geological	Whakaari/White Island eruption	2019	21
Man-made	2012 Carterton hot air balloon crash	2012	11
Geological	Christchurch earthquake February 2011	2011	185
Man-made	Pike River Mine disaster	2010	29
Severe Weather	April 1999 New Zealand Snow and Marine Inundation	1999	11
Man-made	Cave Creek disaster	1995	14
Man-made	Aramoana massacre	1990	14
Man-made	Aspiring Air Britten-Norman Islander, collided with terrain	1989	10
Man-made	Air New Zealand Flight 901	1979	257
Man-made	Capitaine Bougainville	1975	16
Severe Weather	Ex-tropical Cyclone Giselle (incl. TEV Wahine)	1968	57
Man-made	Strongman Mine	1967	19
Man-made	MV Kaitawa	1966	29
Man-made	New Zealand National Airways Corporation Flight 441	1963	23
Man-made	Brynderwyns bus accident	1963	15
Man-made	MV Holmglen	1959	15
Man-made	MV Joyita	1955	25
Geological	Tangiwai disaster (lahar)	1953	151
Man-made	Husky and Argo lost to storm in yacht race	1951	10
Man-made	launch Ranui	1950	22
Man-made	Lockheed Lodestar airliner crash	1949	15
Man-made	NAC Electra air crash	1948	13
Man-made	Ballantyne's store disaster	1947	41
Man-made	Two Hudson bombers lost off the New Zealand coast	1944	14
Man-made	Featherston Prisoner of war camp riot	1943	49
Man-made	Hyde railway disaster	1943	21
Man-made	1943 Liberator crash at Whenuapai	1943	16
Man-made	Seacliff Lunatic Asylum	1942	37
Man-made	B17 bomber crash	1942	11
Man-made	Glen Afton No. 1 mine	1939	11
Severe Weather	February 1938 Eastern North Island Flooding	1938	23
Severe Weather	February 1936 North Island Ex-tropical Cyclone	1936	10
Geological	Hawkes Bay Earthquake 1931	1931	256
Geological	Murchison Earthquake 1929	1929	17
Geological	Ongarue train derailment - landslip	1923	17

During the 10-year period from 2010-2019 for which fatalities on PCL were analysed in detail for this study there were 8 incidents involving 2 deaths, a single incident involving 3 deaths and no incidents involving more than 3 deaths. In 2008, though, the Mangatepopo tragedy killed a teacher and 6 students in the Tongariro National Park, while the 1995 Cave Creek tragedy killed a teacher and 13 students in Paparoa National Park.

In summary, over the past 50 years New Zealand has experienced

- events killing 1 or more people many 100's of times per year (a large majority of the 1,250 accident deaths per year shown in Table 23 were in single fatality events)
- events killing 10 or more people about twice per decade (dominated by man-made events with a few % contributed by natural hazards; note that one of the 10 or so events in the period was the Cave Creek disaster)
- events killing 20 or more people about once per decade (dominated by man-made events with about 40% contributed by geological hazards)
- events killing 50 or more people 3 times in 50 years (1 air crash, the 2011 earthquake and the 2019 mosque shootings in Christchurch), and
- events killing 100 or more people once in 50 years (the February 2011 earthquake in Christchurch).

At the N=1 point on the f/N curve (the overall frequency of fatal accidents), deaths on NZ Public Conservation Land are a small contributor in New Zealand terms, with around 15 events/year in comparison with many hundreds, possibly over 1000/year in New Zealand as a whole. So DOC's contribution is perhaps 2% at most of the NZ total.

At the N=10 point, the single contributing event on NZ PCL was the Cave Creek disaster, which on its own contributed about 10% to the national frequency of such events shown in Figure 54. The potential for significant contributions from events on NZ PCL at this level was further illustrated very recently (February 2020) in the prolonged severe rainfall which trapped dozens of walkers in Fiordland, and caused a landslide which hit the Howden Hut when there were 30+ visitors inside; fortunately none suffered major injuries.

The Cave Creek event illustrates the importance of other factors than just the number killed in defining "events of major concern", as it involved DOC being responsible for the construction of the viewing platform whose collapse caused the accident. This issue is discussed further in the companion report in support of the development of guidelines for DOC decisions in relation to safety on PCL.

9.2.2 Major Events Killing 5 or More People

In the public inquiry and MBIE research following the tragedy at Whakaari (White Island) in December 2019, a "major event" has been discussed and defined in terms of an event killing 5 or more people. DOC therefore requested that I reconsider the framing of guidance around "Major events" to take into account this difference from the interpretation used in my draft report.

Clearly events that kill 5 or more people at once are more likely to occur than those killing 10 or more.

To estimate the frequency of such events a number of sources of information were added and/or re-examined in order to expand on the risk comparisons (in terms of frequency vs number of deaths, N) in the range from N=5 to N=10. Such comparisons are considered in turn for

a) Outdoor and adventure activities in New Zealand (from all causes, not just natural hazards)
b) Natural hazard events globally, in developed countries generally and in NZ in particular
c) Quantitative natural hazard risk assessments that have been carried out for a number of specific hazards/locations within NZ, and
d) Some other more familiar hazards in the New Zealand context.

In order to collect statistically meaningful information it has in several cases been necessary to extend the time period considered beyond the 20 years used throughout most of this report. While enabling data points to be added to f/N curves for rarer, more severe events this exacerbates the problem that data from longer ago may be of reduced relevance to today's circumstances. In each case f/N curves for various hazards are shown, followed by an overview of what they collectively tell us about the frequency of Major Events in New Zealand.

Figure 55 shows f/N curves for outdoor activities in New Zealand for the period 1990-2019. This was developed by combining the information on incidents on Publicly Controlled Land (PCL) from 2000-2019 collated in this report with the information on adventure and other outdoor incidents in the MBIE research[63] carried out in support of the post-Whakaari debate. Note that this figure does not provide a complete picture for New Zealand as it does not include events outside Worksafe's scope other than those on PCL. There is also some overlap between the curves as events on PCL AND within the scope of Worksafe appear within each curve.

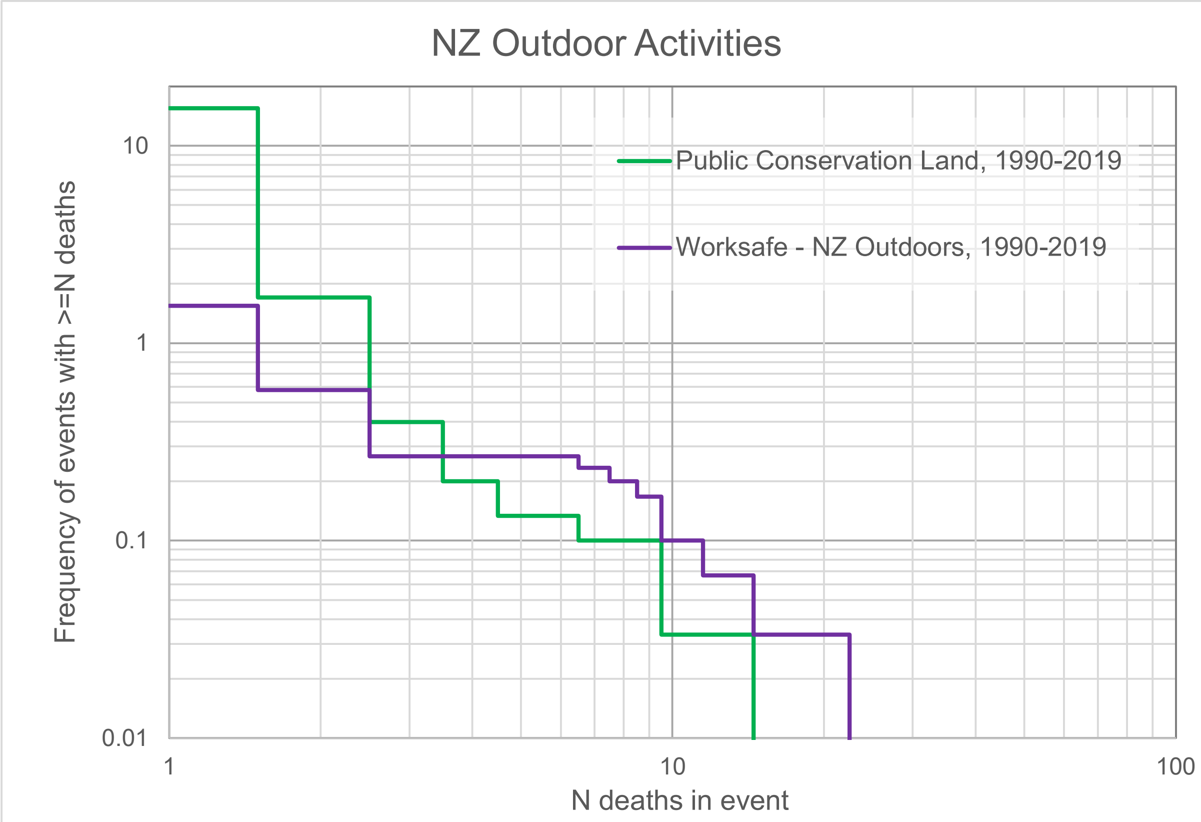
As would be expected, the frequency of individual and small group fatal incidents on PCL is substantially higher than the frequency of similar scale workplace events, as the vast majority of the incidents on PCL involve people at leisure, rather than in a workplace or participating in a commercial activity that would fall within Worksafe's scope. Towards the right hand side of the figure the frequency of events in Worksafe's scope exceeds that on PCL, but it should be noted that only a very few events are involved[64].

With so few major events there is clearly significant statistical uncertainty involved in estimating the frequency of events killing 5 or more people. This is addressed across the various hazards considered here after each group of f/N curves has been presented in turn.

[63] "Adventure Activities – keeping it safe", consultation document published by NZ Ministry of Business, Information and Employment, August 2021

[64] Only 3 events involved 10 or more deaths: the 1995 Cave Creek platform collapse, the 2012 Carterton balloon crash and the 2019 Whakaari eruption. All three fall within Worksafe's scope, but only the first was on PCL.

Figure 55: New Zealand Outdoor Activities on PCL & within Worksafe scope



Figures 56 to 58 show f/N curves for earthquake, volcanic and landslide hazards respectively. Each figure contains three separate curves: one for global events, one for events in developed countries (defined in this instance as members of the OECD) and one specifically for New Zealand. In each case the New Zealand "curve" involves a longer data collation period than do the others. The figures in all cases should be taken as indicative rather than definitive; it is extremely difficult collecting data globally on smaller events, particularly from less developed or less open countries. In every case where there was a range of fatalities cited for an event the smallest available credible estimate was adopted. The information sources used were:

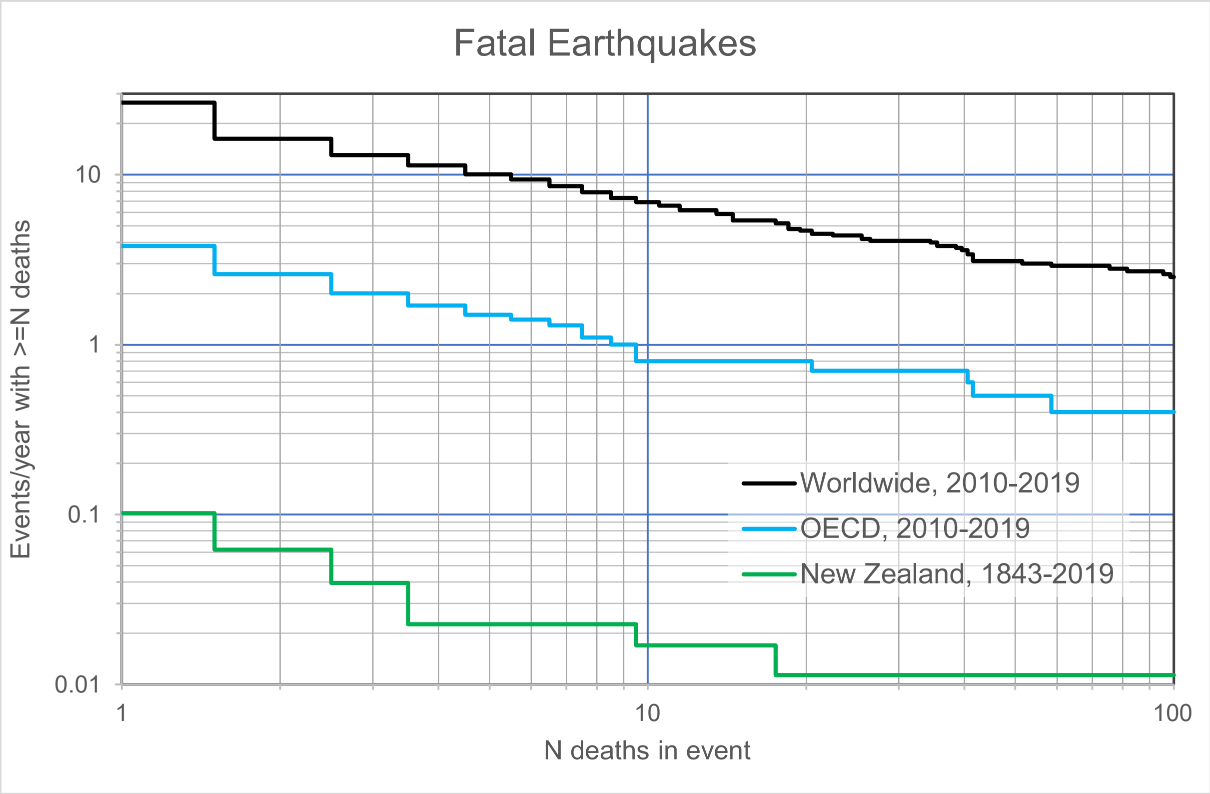
Earthquakes: For global/OECD data (2010-2019) - Wikipedia lists of fatal earthquakes by year, each checked by the author against specific sources. For NZ data (1843-2019) – the author's own list, compiled in working over several years with GNS and cross-checked against GNS lists.

Volcanic Events: For global/OECD and NZ data – a draft version of the dataset developed by Brown et al[65] was supplied by GNS. A longer period was used for NZ data to include more severe and rarer events. NZ landslides triggered by volcanic activity are treated as volcanic, rather than landslide events.

[65] S Brown et al, "Volcanic fatalities database: analysis of volcanic threat with distance and victim classification", Journal of Applied Volcanology volume 6, Article number: 15 (2017).

Landslide Events: For global and OECD data – the database from 2004 to 2016 compiled at the University of Sheffield[66]. For NZ data the landslide data set in compilation by GNS[67] (it should be noted that the likelihood of events today is almost certainly very much less than that indicated in the 100 years of data represented for NZ in Figure 59. There is some potential overlap between "landslide" and "earthquake/volcanic" events, particularly outside NZ.

Figure 56: f/N Curves for fatal Earthquakes



Figures 56 and 57 exhibit the well-known phenomenon that the f/N curves for geological hazards are relatively "flat" – that is, their slope on a log-log plot is significantly less than -1. This means that for each factor of increase in N deaths a significantly smaller factor of decrease in frequency is observed. Another interesting and important result of this shape is that it means that the overall contribution to expected annual risk in terms of deaths lost or damage sustained per year increases for each band of frequency that we reduce (i.e. the risk contribution from events occurring every 20-40 years is greater than that from events occurring every 10-20 years which is greater than that from events occurring every 5-10 years and so on).

Even with the relatively sparse data involved the shape of the NZ curves is in this respect very similar to that of the global and OECD curves.

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[66] M J Froude & D N Petley, "Global fatal landslide occurrence from 2004 to 2016", Nat. Hazards Earth Syst. Sci., 18, 2161–2181, 2018

[67] Z Bruce & E McSaveney, "Version 1 of the New Zealand landslide fatalities database, 1760 – 2020", GNS Science report (draft in preparation).

Figure 57: f/N Curves for Fatal Volcanic Events

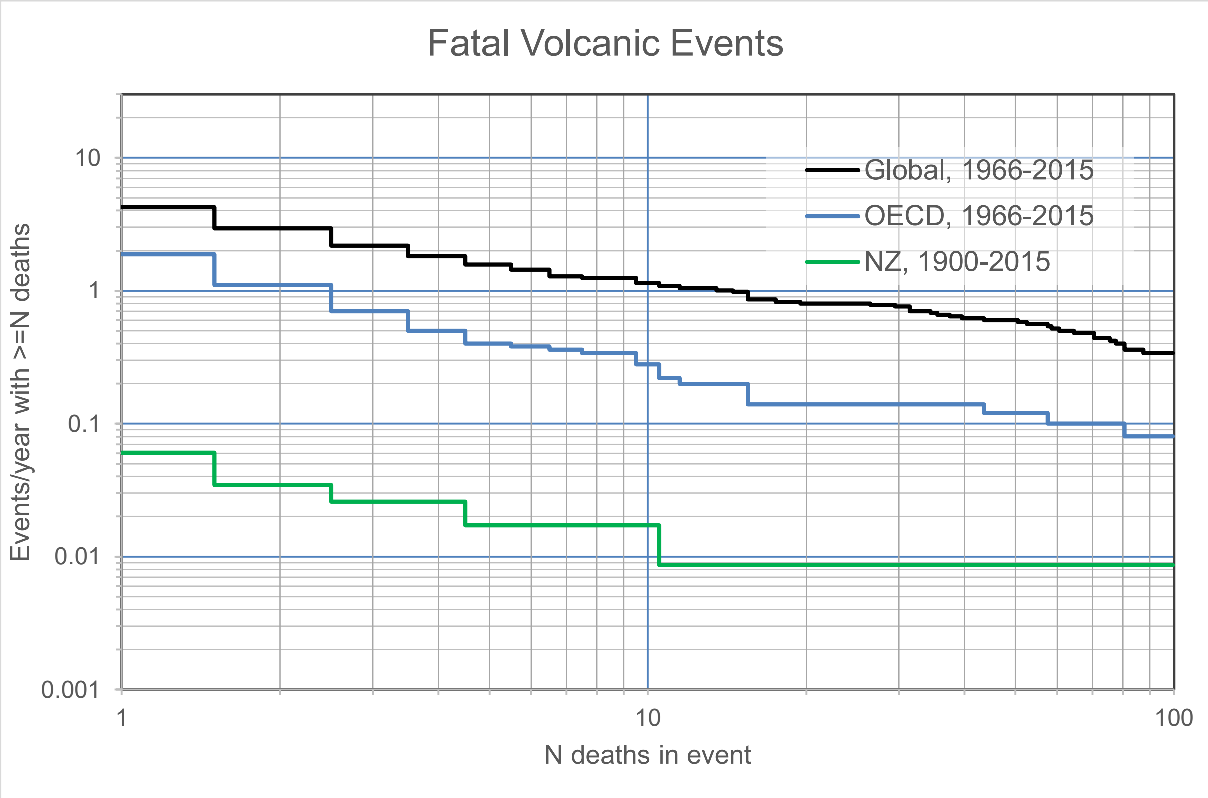
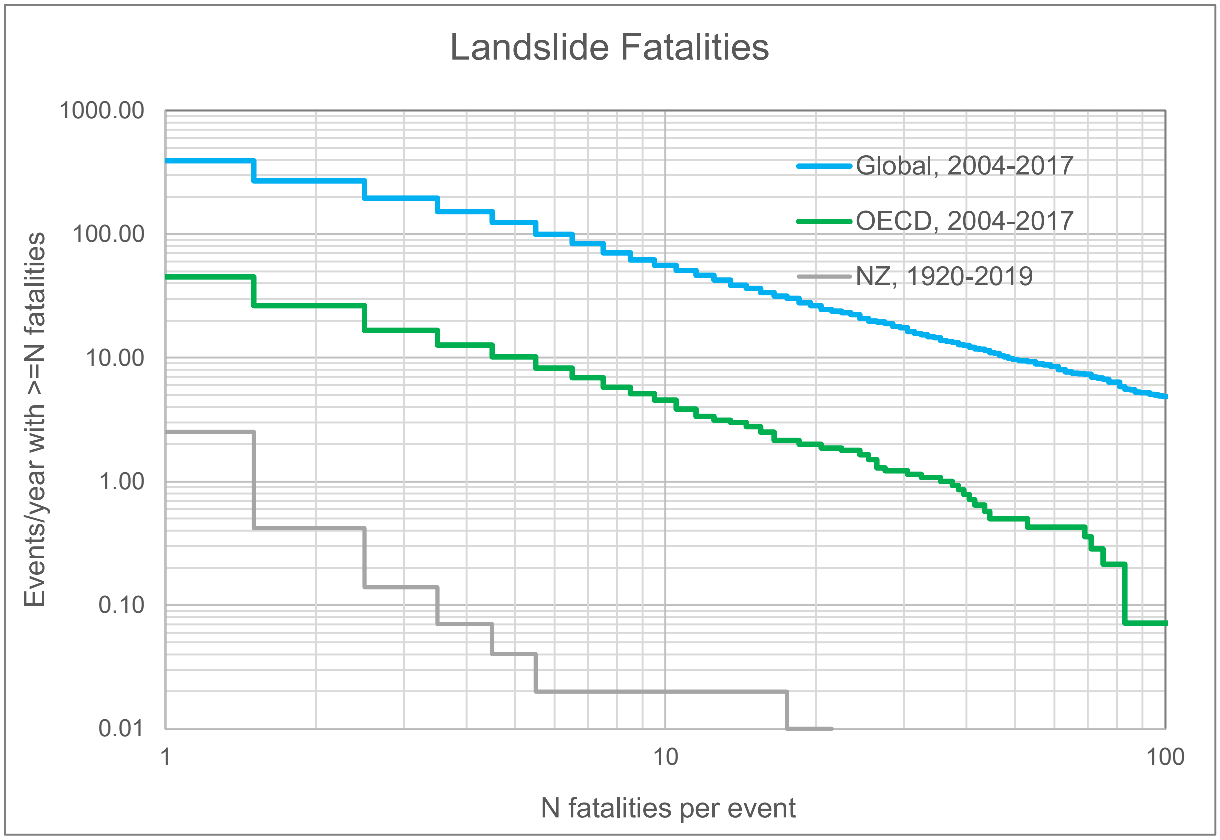


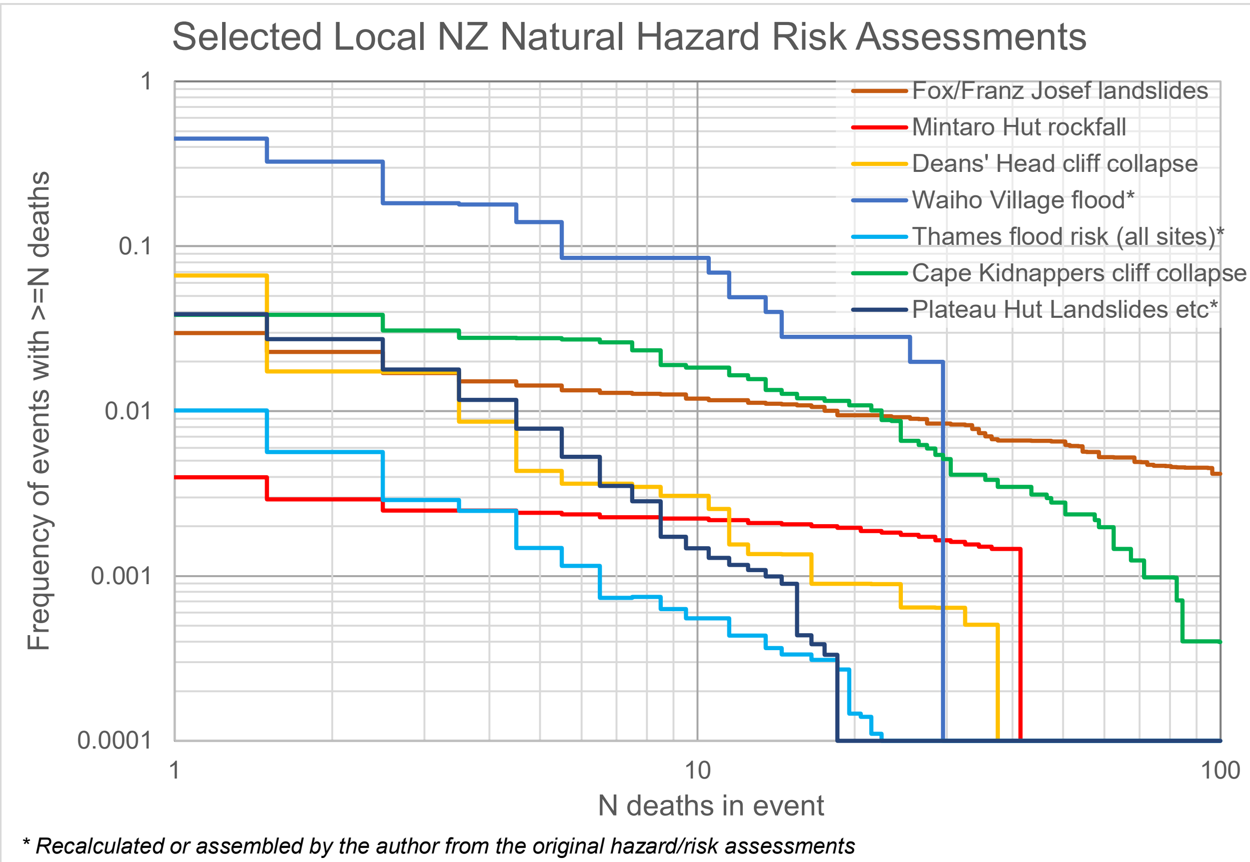
Figure 58: f/N Curves for Fatal Landslides



Interestingly, the curves for landslides are steeper than those for earthquakes and volcanic events. On the log-log plot their slope is close to -1, meaning that for each factor the number of fatalities is increased, the frequency of events decreases by a similar factor.

Figure 59 shows f/N curves resulting from a number of quantitative natural hazard risk assessments that have been carried out for particular locations in New Zealand in recent years. To make the risk estimates as nearly comparable as possible the f/N curves have in several cases been recalculated by the author from the hazard/frequency and occupancy information provided in the source reports. In all cases the assessments are based on conditions BEFORE a well-recognised hazard had been addressed and the risk reduced, so are not indicative of risk levels today.

Figure 59: f/N Curves from Selected Natural Hazard Risk Assessments

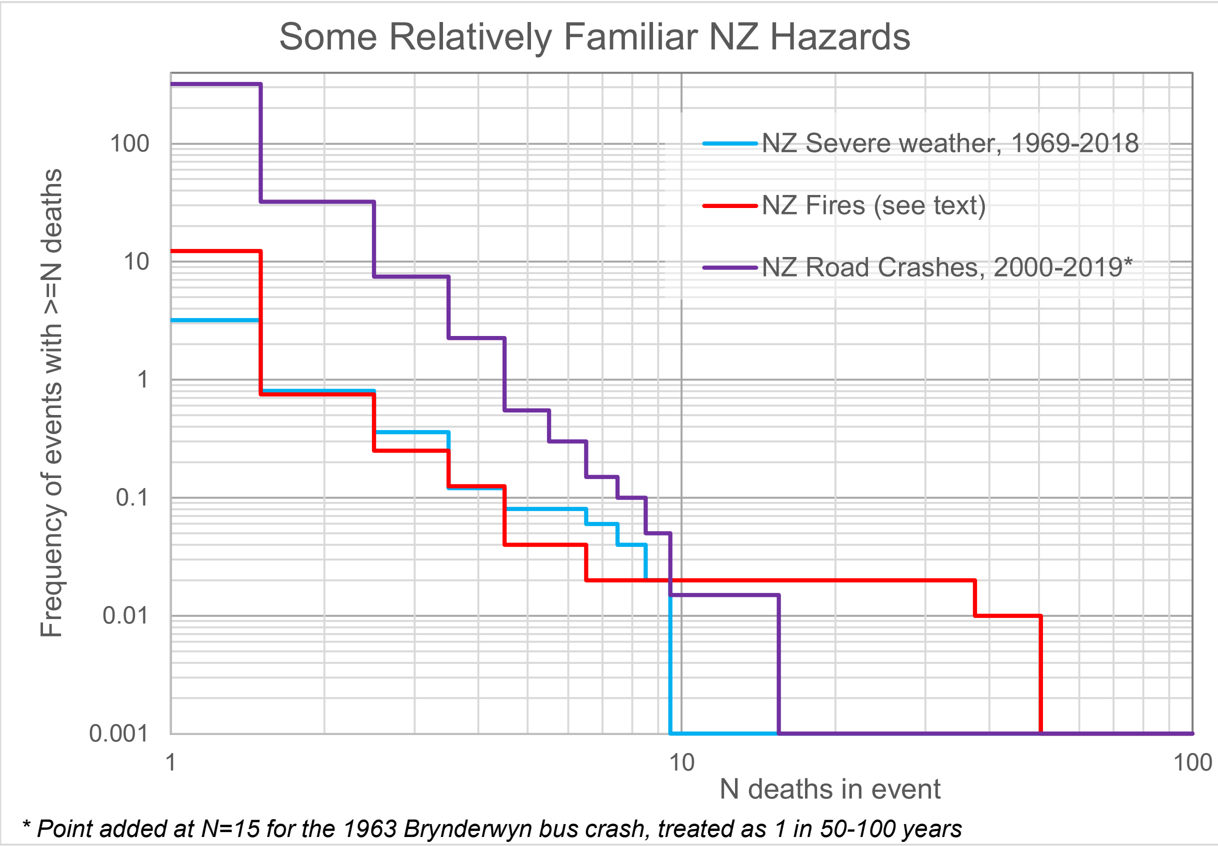


The shape of these curves is to some extent an artefact of the simplifying assumptions made in the face of partial information about numbers of people present and at risk for different proportions of the time. Even so, some distinctly different shapes are observable. On the one hand there are quite "flat" curves (for the Mintaro Hut and for Fox/Franz Josef landslides). These correspond to situations where the risk is dominated by scenarios with a lot of people present. The other curves, which have substantial contributions to risk from scenarios with a range of different numbers present, tend to be steeper. With the exception of the Waiho village flooding (where the risk was recognised to be exceptional and was rapidly reduced) the assessed frequency of events killing 5 or more people is in the region of once in 1000 to once in 30-40 years.

References for Figure 59 are summarised below[68].

Figure 60 shows f/N curves for some more familiar New Zealand hazards: road crashes, severe weather, and fires. Note that some substantial assumptions (explained below the figure) have been made in assembling these curves and extending them up to and beyond the N=5 range.

Figure 60: f/N Curves for some Familiar New Zealand Hazards



Note the much wider range on the vertical axis than in Figures 55-59. These are all hazards where a large majority of deaths occur in events killing one person at a time, and where the likelihood of events drops off steeply as the number killed increases.

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[68] C. Massey et al, "Landslide hazard and risk assessments for the Fox and Franz Josef Glacier Valleys", GNS Science consultancy report 2018/206, May 2019

A. Taig, "Mintaro Hut – Risk Comparison for Existing & Proposed Sites", letter report for DOC, Feb 2019

C Massey et al, "Canterbury Earthquakes 2010/11 Port Hills Slope Stability: Risk assessment for Deans Head", GNS Science consultancy report 2014/77

A Milligan et al, "Waiho River flooding risk assessment", OptimX report 80295/2 for MCDEM, August 2002

G Ashby et al, "Thames Coast Flood Risk Assessment", URS report for Environment Waikato and Thames-Coromandel DC, July 2003

C Massey et al, "Landslide risk analysis for Clifton Beach, Cape Kidnappers, Hawkes Bay, GNS Science consultancy report 2020/28, May 2020.

S Cox, "Updated assessment of rock avalanche hazard and risk as Plateau Hut, Aoraki/Mount Cook National Park", GNS Science consultancy report 2021/83, November 2021

Notes on Figure 60:

(a) Severe weather events are considered as multi-fatality ONLY when deaths occurred at a single location (e.g. a storm killing one person in Auckland and one in Hamilton would be treated as 2 x N=1 events rather than 1 x N=2 event). Data is from the New Zealand Historic Weather Events catalogue maintained by NIWA (with grateful thanks to NIWA for extracting the set of all recorded fatal events back to 1846).

(b) For fires the f/N curve was constructed as follows:
For N=1-4, based on the data provided in a relatively recent Fire & Emergency Services research report into accidental domestic fires[69];
For N>4, the Auckland fire which killed 4 in 2009 was widely reported as New Zealand's worst fire since the 1970's, when a fire killed 6 people (5 in the fire, one attempting to escape the building). This is treated as a single data point for N=6 with frequency once in 50 years. For higher N, the Ballantynes fire of 1947 which killed 41, and the Seacliff fire of 1942 which killed 37, were added as points with frequency once in 100 years.

(c) For road crashes the data for 2000-2019 was obtained from the NZ Transport Agency Crash Analysis System (https://cas.nzta.govt.nz/), which provided information on crashes killing up to 9 people in a single event. A single data point was added for New Zealand's worst ever road crash, the Brynderwyn bus crash, which killed 15 people in 1963. This was treated as having frequency in the range once every 50-100 years (represented in the f/N curve as once in 75 years).

Summary – Frequency of Major Events in New Zealand: An overview of the estimated frequencies of events killing 5 or more people across all the hazards and information sources above is provided in Figure 61. For consistency with earlier individual risk comparisons the associated uncertainty is indicated by the extent of the bars in Figure 60. For the historically derived frequencies the range shown corresponds roughly to a statistical 10-90%[70] confidence interval. For the frequencies estimated from quantitative risk assessments the range shown spans a factor of 10, distributed evenly around the central estimate from the assessment (i.e. a factor of √10 either side of the central estimate). The term "major event" is used in the following summary to mean "an event killing 5 or more people".

Among the statistically observed hazards:

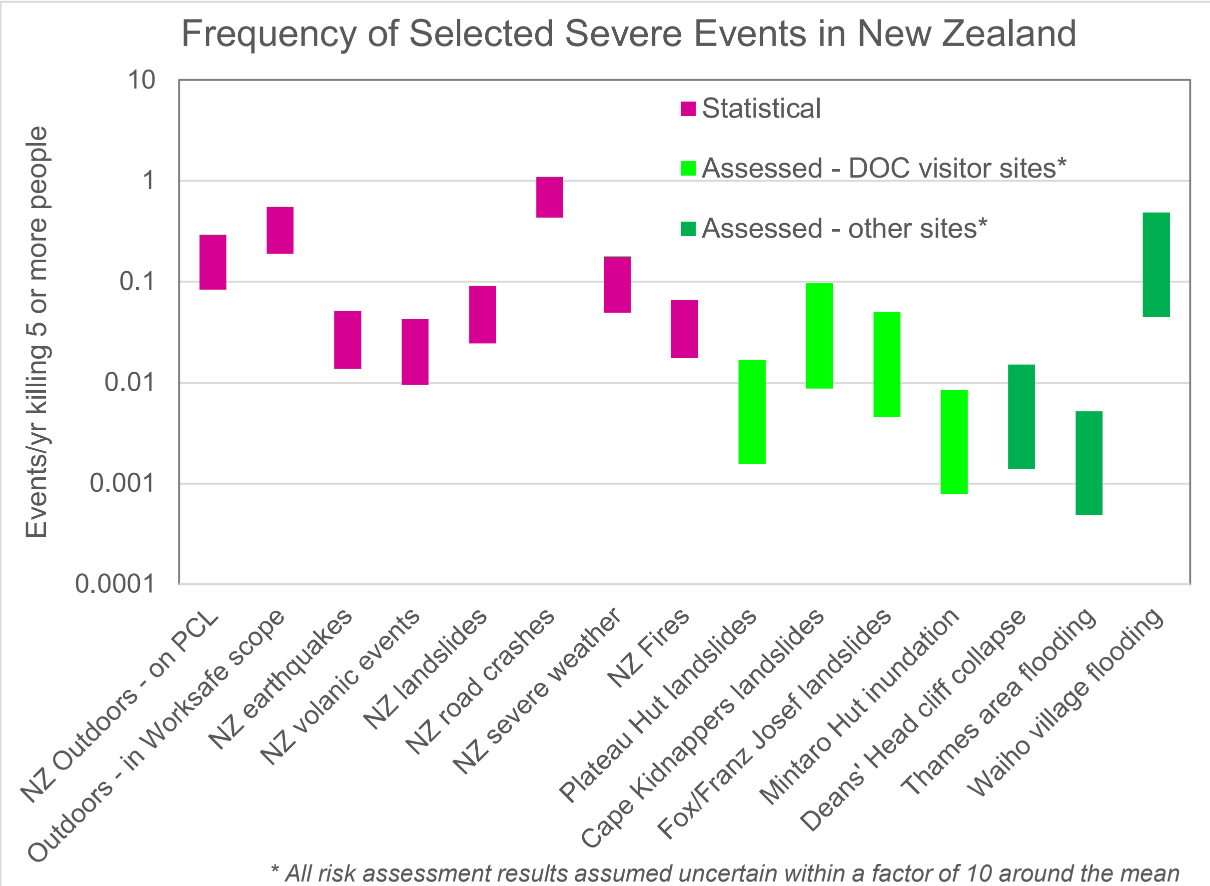
1. Road crashes have the largest frequency of occurrence, with a "major event" crash to be expected every few years.
2. Severe weather is the most likely natural hazard to cause a major event, with such an event to be expected around once a decade based on the past 50 years' data (hopefully improvements in forecasting and resilience have reduced this frequency in comparison with this average, from the past 50 years).

[69] R Lilley et al, "Unintentional domestic fire-related fatal injury in New Zealand: 2007-2014", University of Otago, Fire and Emergency New Zealand Research Report No. 167, June 2018

[70] The lower estimate is such that there would be a 10% chance of experiencing the observed number, or more, of events killing 5 or more people in the time period of interest. The upper estimate is such that there would be a 10% chance of experiencing the observed number, or fewer, of events killing 5 or more people.

3. The other natural hazards associated with New Zealand's dynamic landscape (earthquake, volcanic activity and landslides) could each be anticipated based on the past century or so of experience to lead to a major event every few decades, and collectively to cause a major event around once a decade. Again it is to be hoped that improvements in forecasting and management of these hazards mean that the frequency today is somewhat less than this historic average rate.
4. It should be noted that, while the frequencies of major events defined as "killing 5 or more" due to severe weather and to other "dynamic landscape" hazards are similar, the scope for much larger events is very much higher for the "dynamic landscape" events. There is no experience in New Zealand of severe weather events killing 10 or more people in the past 100 years, whereas in that time there have been 7 "dynamic landscape" events killing 10 or more people, of which 3 killed over 100 people.
5. A major event involving outdoor activities in New Zealand can be anticipated every 3-10 years on PCL, and every 2-5 years across NZ for events associated with commercial adventure activities. Given that this chart does not include non-commercial events other than on PCL, major events associated with all NZ outdoor activities might perhaps be anticipated every 1-3 years.
6. Most of the major event risks estimated in quantitative risk assessments for specific hazards and locations are around or lower than the historic average national risk for the individual "dynamic landscape" hazards. This suggests that natural hazard events associated with individual visitor locations such as Plateau Hut, the Mintaro Hut and Cape Kidnappers could be making very significant contributions to national natural hazard risk (though note that in all these cases the risk is that assessed BEFORE allowing for actions taken to reduce it).
7. As with natural hazards, similar assessed major event risks associated with "killing 5 or more people" can differ widely in character for different locations and hazards. At Mintaro Hut and the Fox/Franz Josef glaciers for example the potential for a major event to extend to substantially higher numbers of fatalities is considerably greater than that for Plateau Hut or Deans' Head.
8. The exception in terms of assessed risk at an individual location is that for Waiho Village, where the estimated major event frequency was around 10x or more that at other individual locations. This was recognised at the time of the assessment as an exceptional situation and action followed swiftly to reduce the risk substantially.
9. Adding together the historic frequencies of events for all the darker bars shown in Figure 61 produces an estimate of 0.8 to 1.5 major events per year. Note that this does not include a number of potentially important further contributors to frequency of major events, such as transport accidents (other than on roads), industrial accidents and deliberate events. The overall frequency of major events across New Zealand is likely to be well over 1 per year based on historic experience; it is not straightforward to estimate how much lower this might be to take into account improvements in reducing hazard frequencies and mitigating their effects might have had on this historic estimate.

Figure 61: Collation of Frequencies of Events Killing 5 or More People



Conclusions:

1. Major events, defined as those killing 5 or more people, can be expected around once a year or more in New Zealand from all causes.
2. Natural hazards are a significant contributor to the frequency of such events, accounting for perhaps 10-20% of their total frequency.
3. Outdoor activities also contribute significantly to the national frequency of major events, with activities on and around PCL leading to a major event every 3-10 years.
4. Natural hazard risk at individual DOC visitor sites had the potential (prior to those risks being assessed and reduced) significantly to add to the risk of major events on PCL.
5. This highlights the importance of DOC being able to screen and identify visitor sites with significant potential for natural hazard risk, and to assess those risks appropriately.
6. There are significant quantitative as well as qualitative differences between “major events” in terms both of their potential to involve much larger numbers of casualties, and their significance in terms of their degree of attributability to and avoidability by DOC.

10 Summary

The recommendations and findings of this study are summarised as follows:

1. The most appropriate risk metrics for use by DOC to inform decisions about safety risk on PCL are
   a) For staff: annual individual fatality risk per year
   b) For visitors: fatality risk per visitor day
   c) For prioritising improvements: total fatalities per year (or weighted total fatalities and injuries as and when reliable data becomes available), and
   d) In considering risk tolerability at a wider than individual level: frequency of specific major events (for example involving >N fatalities, or involving particular DOC liability).

2. Visual representation of risk metrics, particularly for visitors, can help
   a) Avoid confusion when presenting small numbers in terms such as 10^{-N}, and
   b) Enable the scale and sources of uncertainty and variability in risk levels to be simply represented.

   It is recognised that it is difficult to achieve (b) in a consistent way.

3. Like other employment sectors where most people work in an active, outdoor environment, the Arts & Recreation Services (A&RS) sector, of which DOC is part, experiences relatively high workplace risk, of order 10^{-4}/yr. Though the numbers of staff working for DOC and the associated numbers of deaths are too small to allow conclusions to be drawn of high statistical significance, it appears that
   a) DOC permanent staff fatality risk over the past 20 years has been similar to the A&RS average of about 10-4/yr, though
   b) The main hazard for DOC permanent staff has been travel by helicopter (which is not included in the WorkSafe NZ statistics on which these comparisons are made), and
   c) The fatality risk for temporary and volunteer staff is higher again than that for permanent staff, and could be as high as 10^{-3} per equivalent year worked for some staff.

4. The average individual fatality risk experienced by visitors to PCL over the past decade was between about 3×10^{-7} and 10^{-6} per visitor day (or part of a day). More detailed breakdowns were able to be made for visitors to National Parks and are shown in comparison with other risks in Figure 62. Notable points include
   a) The accident risk per day spent in a National Park is broadly similar to the average accident risk per day spent living in New Zealand for residents, or per day spent in New Zealand for visitors.
   b) Risk levels vary across National Parks, from around 10^{-7} to nearly 10^{-5} per day, with Paparoa and Abel Tasman at the lower end of this range (10^{-7} to 10^{-6} per day) and Kahurangi, Aoraki and Fiordland at the higher (above 10^{-6} per day).
   c) International and domestic overall risk per visitor day on NZ Public Conservation Land is similar. The risk associated with climbing for both international visitors and New Zealanders is 3-10x higher than the average risk per day spent at National Parks.

d) The risk per day associated with tramping is about 4-6x higher for international visitors to National Parks than for New Zealanders. Overseas trampers experience a similar risk to climbers, whereas NZ trampers experience no greater risk than do average National Park visitors.

e) The only other area (swimming) in which it was possible to analyse significant numbers of both international visitor and New Zealander fatalities also suggested that risk for international visitors is substantially greater (by possibly 10x or more per swim) than that for New Zealanders.

f) The risk per day's participation in most sports for New Zealanders (other than sailing/ boating) appears similar to or lower than that experienced per day spent in National Parks.

g) Leisure journeys on New Zealand roads may involve lower risk than a day spent in a National Park for safer walkers and drivers, but involve higher risk for less safe drivers or pedestrians and many cyclists – and considerably higher risk for motorcyclists.

h) Most popular "adventure" activities for visitors to New Zealand involve similar or greater risk per experience than a day spent in a National Park, with climbing/mountaineering risk levels extending well above 10^{-5} per day. A notable exception is bungy jumping which, with no fatalities to date in many millions of jumps, has involved lower risk per jump than that per day spent in any but the safest National Parks.

i) Unless travelling by bus, the risk travelling to and from National Parks is comparable to or greater than that spending a day there for travellers using private cars/vans or scheduled flights in small aircraft. For travellers by charter flight or by motorcycle the risk getting to and from National Parks is substantially greater than that experienced in a day there.

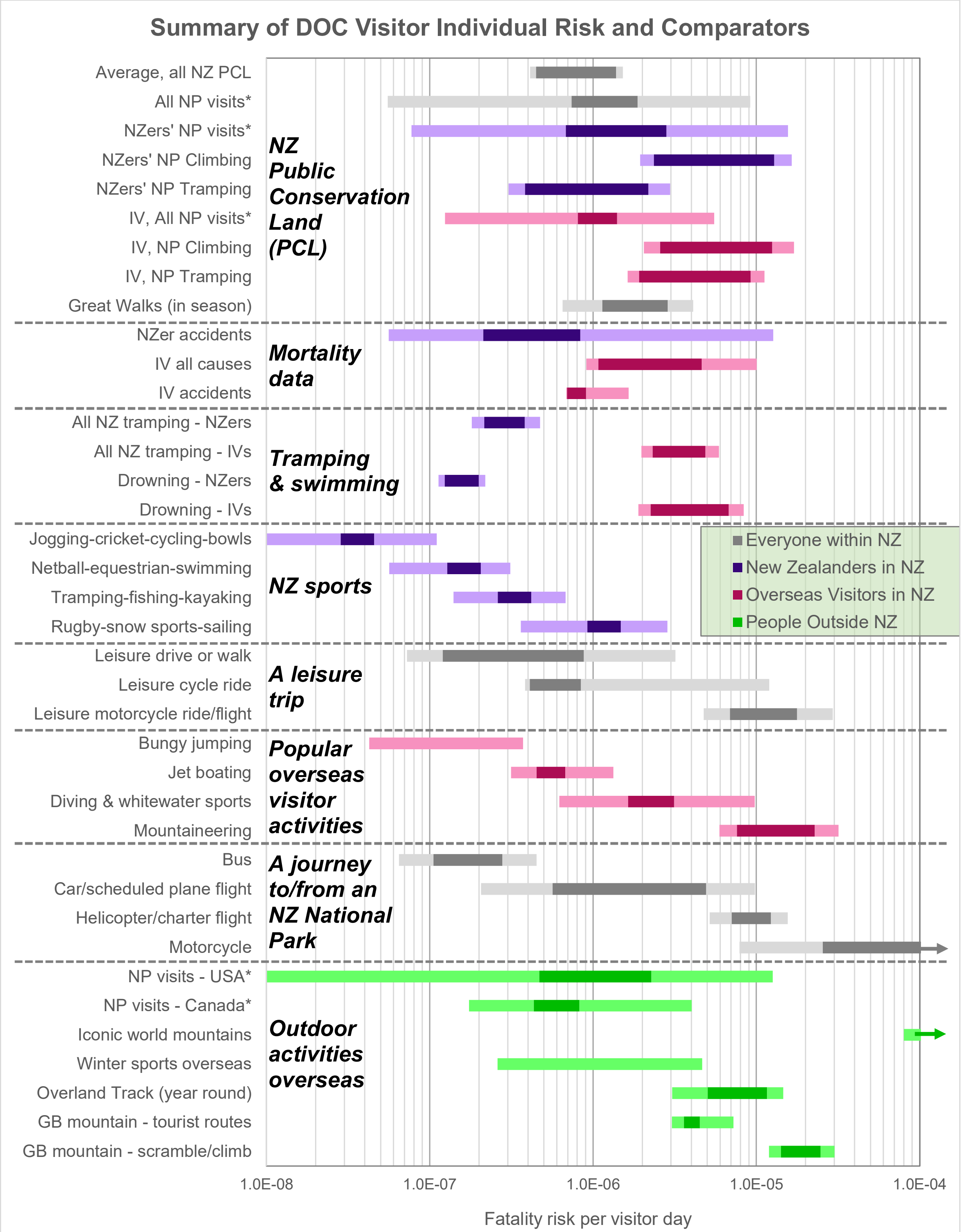
j) The risk per day to NZ National Park visitors is similar to that experienced by visitors to more or less comparable National Parks in North America. The range of risk per day in North American parks extends below that in New Zealand, for example for parks in and around cities where visitors almost all arrive by car and undertake little physical activity. Parks frequented by specialist climbers, divers or participants in other higher risk activities experience similar levels of risk in NZ, the US and Canada.

k) The risk per day experienced on the New Zealand Great Walks is similar to or lower than that experienced by walkers on comparable iconic walks in Tasmania and Great Britain (noting that the NZ data are for Great Walk season only while the others are all-season).

l) Serious mountaineers overseas (and in New Zealand) involved in high altitude or particularly challenging climbs regularly experience fatality risk at levels in the range 10^{-4} to 10^{-3} per day or higher.

5. The aggregate annual burden of fatalities on NZ PCL is around 22 deaths per year. For New Zealanders the burden of fatalities on PCL is less than 1% of the overall burden of accident fatalities per year. For international visitors it is more significant, as would be expected from their much higher proportion of time spent at National Parks. *(continued after Figure 62).*

Figure 62: Summary of Individual Fatality Risk for DOC Visitors and Comparators



***Notes**: IV = International Visitor, NZer = New Zealand resident; see text for details & assumptions*
** Ranges from lowest to highest risk park; other NZ PCL figures are averages over all parks/walks*

6. Over the past few decades about 15 fatal accidents per year have occurred on NZ PCL (a few percent at most of the NZ total of events killing 1 or more people). The single disaster at Cave Creek contributed 10% of the NZ total of events killing 10 or more people in the last 50 years. Accidents on PCL are a significant contributor to the overall frequency of major events (defined as those killing 5 or more people) in New Zealand. Natural hazards at individual visitor sites have the potential significantly to increase the frequency of major events on PCL.

7. Although all the comparative risks estimated in this report are subject to considerable uncertainty and variability across the population, they provide a more relevant and meaningful basis for setting risk on NZ PCL in context than do literature sources which have focused on risk to the public around hazardous installations.

Tony Taig

TTAC Ltd

February 2022

Appendix 1: Fatal Incidents in NZ National Parks, 2010-2019

Notes: *1. does not include road or other transport accidents, suicide or homicide.*

2. Great Walk routes in italics indicate incidents outside the Great Walk season (not counted in Great Walk statistics)

3. The Tongariro Alpine Crossing, though not a Great Walk, is identified in the Great Walk column where relevant.

Source	Incident Date	Incident Location	Great Walk Route	N deaths	National Park	Residency Category	Activity Category	Incident cause category	Gender, Age
MSC	01/03/2010	Off track		1	Fiordland	Citizen/resident	Walker/Tramper	Exposure	M,39
Google	05/04/2010	Mitre Peak		1	Fiordland	Citizen/resident	Climber	Fall	F,46
MSC	27/04/2010	Copland Track area (Douglas Roberts Hut)		1	Westland	International visitor	Climber	Fall	M,40
Google	12/06/2010	Franz Josef glacier		1	Westland	International visitor	Other/NK	Medical	M,38
SAR	07/08/2010	Grand Gully, Whakapapa		1	Tongariro	Citizen/resident	Climber	Fall	M,34
SAR	05/10/2010	KAUKORE STREAM		1	Whanganui	Citizen/resident	Other/NK	Fall	M,76
SAR	17/11/2010	Rolling River		1	Kahurangi	Citizen/resident	Other sports	Medical	M,?
SAR	01/12/2010	Roberts Point Track		1	Westland	International visitor	Walker/Tramper	Fall	M,31
SAR	15/12/2010	SOUTH WEST RIDGE OF MT ASPIRING		1	Mt Aspiring	International visitor	Climber	Fall	M,21
SAR	07/01/2011	McKenna Creek		1	Westland	Citizen/resident	Walker/Tramper	Fall	M,58
SAR	21/01/2011	Barrier Knob, Fiordland		1	Fiordland	International visitor	Walker/Tramper	Fall	M,48
SAR	23/01/2011	Merain wall Tasman valley		1	Aoraki Mt Cook	Citizen/resident	Walker/Tramper	Medical	M,71
SAR	04/02/2011	Lake Rotoroa		1	Nelson Lakes	International visitor	On water	Drowned	M,27

Source	Incident Date	Incident Location	Great Walk Route	N deaths	National Park	Residency Category	Activity Category	Incident cause category	Gender, Age
MSC	12/03/2011	Shift Creek, Travers Valley		1	Nelson Lakes	International Visitor	Other sports	Fall	M,25
SAR	23/03/2011	Unnamed Glacier below Mt Revelation		1	Fiordland	International visitor	Climber	Fall	F,38
SAR	17/06/2011	Cascade Saddle		1	Mt Aspiring	International visitor	Walker/Tramper	Fall	M,23
MSC	05/08/2011	Whakapapa Ski Field		1	Tongariro	Citizen/resident	Other sports	Other	M,38
SAR	09/12/2011	nr Adelaide Tarn, Kahurangi National Park		1	Kahurangi	Citizen/resident	Walker/Tramper	Fall	M,63
SAR	09/12/2011	Waiho River		2	Westland	International visitor	Walker/Tramper	Drowned	F,31
SAR	09/12/2011	Waiho River			Westland	International visitor	Walker/Tramper	Drowned	F,28
MSC	31/12/2011	Off track		1	Mt Aspiring	Citizen/resident	Walker/Tramper	Fall	M,52
SAR	07/01/2012	Rob Roy Valley		1	Mt Aspiring	Citizen/resident	Other sports	Fall	M,23
SAR	29/01/2012	MILFORD TRACK	Milford	1	Fiordland	International visitor	Walker/Tramper	Medical	M,63
SAR	23/02/2012	nr Homer Saddle above Homer Tunnel W portal		1	Fiordland	Citizen/Resident	Climber	Fall	M,50
SAR	13/03/2012	Mt Arthur		1	Kahurangi	Citizen/resident	Walker/Tramper	Fall	F,56
SAR	12/10/2012	SH48 Mt Ruapehu		1	Tongariro	International visitor	Other sports	Fall	M,25
SAR	21/12/2012	Lake Te Anau		1	Fiordland	International visitor	On water	Drowned	M,22
SAR	23/12/2012	Mt Owen, Kahurangi National Park, Nelson		1	Kahurangi	Citizen/resident	Walker/Tramper	Other	M,54
SAR	29/11/2012	Cascade Saddle track		1	Mt Aspiring	International visitor	Walker/Tramper	Fall	M,38
SAR	07/01/2013	Te Anau		1	Fiordland	Citizen/Resident	Other sports	Medical	M,75

Source	Incident Date	Incident Location	Great Walk Route	N deaths	National Park	Residency Category	Activity Category	Incident cause category	Gender, Age
SAR	23/02/2013	MacKinnon Pass, Milford Track	Milford	1	Fiordland	International visitor	Walker/Tramper	Medical	M,68
SAR	14/06/2013	Hawdon Shelter		1	Arthur's Pass	Citizen/resident	Other/NK	Other	M,51
MSC	13/07/2013	Mt Ruapehu		1	Tongariro	International visitor	Other sports	Fall	M,18
SAR	06/08/2013	Heaphy Track	*Heaphy*	1	Kahurangi	Citizen/resident	Walker/Tramper	Body not found	M,58
MSC	17/08/2013	Bowen Falls Walk		1	Fiordland	International visitor	Walker/Tramper	Fall	M,18
SAR	31/08/2013	Whakapapa		1	Tongariro	Citizen/resident	Other sports	Fall	F,44
SAR	13/09/2013	Tasman Saddle Hut		1	Aoraki Mt Cook	Citizen/resident	Climber	Fall	M,36
SAR	14/09/2013	Sefton Biwy		1	Aoraki Mt Cook	International visitor	Walker/Tramper	Fall	M,31
SAR	28/10/2013	Mt Taranaki		2	Egmont	Citizen/resident	Climber	Exposure	F,29
SAR	28/10/2013	Mt Taranaki			Egmont	Citizen/resident	Climber	Exposure	M,31
SAR	03/11/2013	Aoraki Mt Cook		1	Aoraki Mt Cook	International visitor	Climber	Fall	M,32
SAR	15/12/2013	Lake Constance/Te Araroa trail		1	Nelson Lakes	International visitor	Walker/Tramper	Fall	M,41
MSC	25/02/2014	Travers-Sabine Circuit		1	Nelson Lakes	International Visitor	Walker/Tramper	Other	M,19
Google	27/02/2014	nr Kahurangi Lighthouse		1	Kahurangi	Citizen/resident	Walker/Tramper	Fall	M,72
SAR	19/05/2014	Clinton River	*Milford*	1	Fiordland	International visitor	Walker/Tramper	Drowned	F,22
MSC	24/06/2014	Wanganui River		1	Whanganui	Citizen/resident	Other sports	Drowned	M,40
SAR	16/07/2014	Grand Plateau		1	Aoraki Mt Cook	International visitor	Other/NK	Fall	M,44

Source	Incident Date	Incident Location	Great Walk Route	N deaths	National Park	Residency Category	Activity Category	Incident cause category	Gender, Age
SAR	24/08/2014	Mt Aspiring		1	Mt Aspiring	Citizen/resident	Climber	Fall	M,21
SAR	13/12/2014	East Ridge Aoraki, Mt Cook		1	Aoraki Mt Cook	Citizen/resident	Climber	Fall	M,28
SAR	20/12/2014	Mt Ngauruhoe		1	Tongariro	International visitor	Walker/Tramper	Medical	M,51
SAR	29/12/2014	Grand Plateau, Aoraki, Mt Cook		3	Aoraki Mt Cook	International visitor	Climber	Exposure	M,53
SAR	29/12/2014	Grand Plateau, Aoraki, Mt Cook			Aoraki Mt Cook	International visitor	Climber	Exposure	M,58
SAR	29/12/2014	Grand Plateau, Aoraki, Mt Cook			Aoraki Mt Cook	International visitor	Climber	Exposure	M,27
Google	04/01/2015	Wilkin river gorge		1	Mt Aspiring	Citizen/resident	Walker/Tramper	Drowned	M,41
MSC	15/01/2015	Mt Earnslaw		1	Mt Aspiring	Citizen/resident	Climber	Fall	M,33
SAR	10/02/2015	Bark Bay		1	Abel Tasman	International visitor	On water	Medical	M,30
Google	06/03/2015	MacKinnon Pass, Milford Track	Milford	1	Fiordland	Citizen/resident	Walker/Tramper	Fall	M,69
SAR	23/03/2015	Abrahams Hut Paterson Inlet		1	Rakiura	Citizen/resident	Other sports	Other	M,24
SAR	25/03/2015	Devils Staircase	TAC	1	Tongariro	International visitor	Walker/Tramper	Medical	M,63
SAR	30/03/2015	Homer saddle		1	Fiordland	International visitor	Walker/Tramper	Fall	F,38
Google	25/04/2015	Young river track, nr Gillespie Pass		1	Mt Aspiring	International visitor	Walker/Tramper	Drowned	F,20
SAR	03/05/2015	Muriwai Beach		1	Paparoa	Citizen/resident	On water	Drowned	M,51
Google	09/07/2015	Kepler track	*Kepler*	2	Fiordland	International visitor	Walker/Tramper	Avalanche	M,23
Google	09/07/2015	Kepler track	*Kepler*		Fiordland	International visitor	Walker/Tramper	Avalanche	M,23

Source	Incident Date	Incident Location	Great Walk Route	N deaths	National Park	Residency Category	Activity Category	Incident cause category	Gender, Age
SAR	26/11/2015	Hooker Glacier		1	Aoraki Mt Cook	Citizen/resident	Climber	Crushed/Avalanche	M,52
SAR	03/12/2015	Routeburn Track	Routeburn	1	Mt Aspiring	Citizen/resident	Walker/Tramper	Medical	M,65
SAR	09/12/2015	Waterfall Face, Rabbit pass		1	Mt Aspiring	International visitor	Walker/Tramper	Fall	F,24
Google	23/12/2015	Footstool Mountain		1	Aoraki Mt Cook	International Visitor	Climber	Fall	F,29
Google	28/12/2015	Mt Silberhorn		2	Aoraki Mt Cook	International Visitor	Climber	Fall	M,42
Google	28/12/2015	Mt Silberhorn			Aoraki Mt Cook	International Visitor	Climber	Fall	F,35
SAR	03/01/2016	Deception River		1	Arthur's Pass	Citizen/resident	Other sports	Drowned	F,32
SAR	07/01/2016	Whakapapaiti Stream		1	Tongariro	Citizen/resident	Walker/Tramper	Drowned	F,29
SAR	01/02/2016	Otira Slide route		1	Arthur's Pass	Citizen/resident	Climber	Fall	M,31
SAR	08/03/2016	Fiordland		1	Fiordland	International visitor	Walker/Tramper	Fall	M,31
SAR	20/03/2016	Ketetahi track	TAC	1	Tongariro	International visitor	Walker/Tramper	Medical	M,53
SAR	07/06/2016	Mt Taranaki		1	Egmont	International visitor	Climber	Fall	M,25
SAR	28/07/2016	Ocean Peak	*Routeburn*	1	Fiordland	International visitor	Walker/Tramper	Exposure	M,27
Google	01/12/2016	Camp Spur approach to Mt Harper		1	Arthur's Pass	Citizen/resident	Climber	Fall	M,69
Google	28/12/2016	NW ridge, Mt Aspiring		1	Mt Aspiring	International visitor	Climber	Fall	M,25
SAR	10/01/2017	Gertrude Valley		1	Fiordland	International visitor	Walker/Tramper	Fall	F,53

Source	Incident Date	Incident Location	Great Walk Route	N deaths	National Park	Residency Category	Activity Category	Incident cause category	Gender, Age
Google	23/04/2017	Marian Peak, Darran Mountains		2	Fiordland	Citizen/resident	Climber	Fall	M,22
Google	23/04/2017	Marian Peak, Darran Mountains			Fiordland	Citizen/resident	Climber	Fall	M,27
MSC	13/05/2017	Regina Creek		1	Westland	International visitor	Other sports	Fall	M,27
Google	31/05/2017	Fox glacier, Karangarua Range		1	Westland	International visitor	Other/NK	Fall	M,66
SAR	27/06/2017	Mt Taranaki		1	Egmont	Citizen/resident	Climber	Fall	M,22
DOC local	15/08/2017	nr Mangatawai Stream		2	Tongariro	Citizen/resident	Walker/Tramper	Exposure	M,26
DOC local	15/08/2017	nr Mangatawai Stream			Tongariro	Citizen/resident	Walker/Tramper	Exposure	M,21
Google	28/09/2017	Ruapehu crater lake		1	Tongariro	Citizen/resident	Other sports	Drowned	M,39
MSC	25/10/2017	Heaphy Track	*Heaphy*	1	Kahurangi	Citizen/resident	Walker/Tramper	Body not found	M,53
Google	18/03/2018	Temple Basin		1	Arthur's Pass	International Visitor	Other sports	Fall	F,38
MSC	15/04/2018	Gertrude Saddle		1	Fiordland	International visitor	Walker/Tramper	Fall	M,28
Google	11/07/2018	Mt Robert Ridge		1	Nelson Lakes	International visitor	Walker/Tramper	Exposure	M,25
Google	22/09/2018	Slope near Bonar Glacier		1	Mt Aspiring	International visitor	Other sports	Fall	M,35
MSC	22/09/2018	Ruapehu crater lake		1	Tongariro	Citizen/resident	Climber	Fall	M,32
Google	01/10/2018	Betweeen Red & Blue craters	TAC	1	Tongariro	International visitor	Walker/Tramper	Exposure	M,54
Google	22/10/2018	Camp Spur approach to Mt Harper		1	Arthur's Pass	Citizen/resident	Climber	Fall	M,31

Source	Incident Date	Incident Location	Great Walk Route	N deaths	National Park	Residency Category	Activity Category	Incident cause category	Gender, Age
Google	31/10/2018	Mt Hicks		2	Aoraki Mt Cook	Citizen/resident	Climber	Crushed/Avalanche	M,50
Google	31/10/2018	Mt Hicks			Aoraki Mt Cook	Citizen/resident	Climber	Crushed/Avalanche	M,50s
MSC	10/11/2018	Rameka Track		1	Abel Tasman	Citizen/resident	Other sports	Other	M,52
Google	24/11/2018	Red Crater	TAC	1	Tongariro	International Visitor	Walker/Tramper	Medical	M,56
Google	29/11/2018	Eugenie Glacier below Footstool Peak		1	Aoraki Mt Cook	International Visitor	Climber	Crushed/Avalanche	M,40
DOC local	02/12/2018	Going to Mueller Hut		1	Aoraki Mt Cook	Citizen/resident	Walker/Tramper	Medical	M,?
Google	09/03/2019	Ball Pass Crossing Track		1	Aoraki Mt Cook	Citizen/resident	Other sports	Fall	M,55
Google	17/03/2019	Bridge to Nowhere track		1	Whanganui	Citizen/resident	Driving/cycling	Fall	F,71
Google	18/03/2019	Hollyford River		1	Fiordland	Citizen/resident	On water	Drowned	M,50
Google	13/04/2019	Base of Lancelot Bluffs		1	Arthur's Pass	Citizen/resident	Climber	Fall	M,40
Google	26/05/2019	Lake Haurako		2	Fiordland	Citizen/resident	On water	Drowned	M,65
Google	26/05/2019	Lake Haurako			Fiordland	Citizen/resident	On water	Drowned	F,65
Google	01/06/2019	Mt Robert Ridge		1	Nelson Lakes	Citizen/resident	Walker/Tramper	Exposure	F,55
Google	20/10/2019	Red crater	TNC	1	Tongariro	International visitor	Walker/Tramper	Exposure	F,51
Google	13/12/2019	bottom of Haast Ridge		1	Aoraki Mt Cook	International Visitor	Walker/Tramper	Fall	M,50

Appendix 2: Visitor Risk at US National Parks

This appendix provides data on visitor risk at selected US National Parks, grouped into bands of individual fatality risk per day's visit. Three charts are provided for each group of Parks, showing

- Visitor Fatality Risk per day
- Deaths broken down by activity, and
- Deaths broken down by cause of death.

All data is presented for the period 2009-2018 inclusive. The risk and deaths data shown exclude transport accidents, suicide and homicide. Numbers of deaths and of millions of visitor years associated with each park over the period are shown on the first (risk) chart for each group of parks. The groupings are as follows:

a) Risk per visitor day $< 10^{-7}$

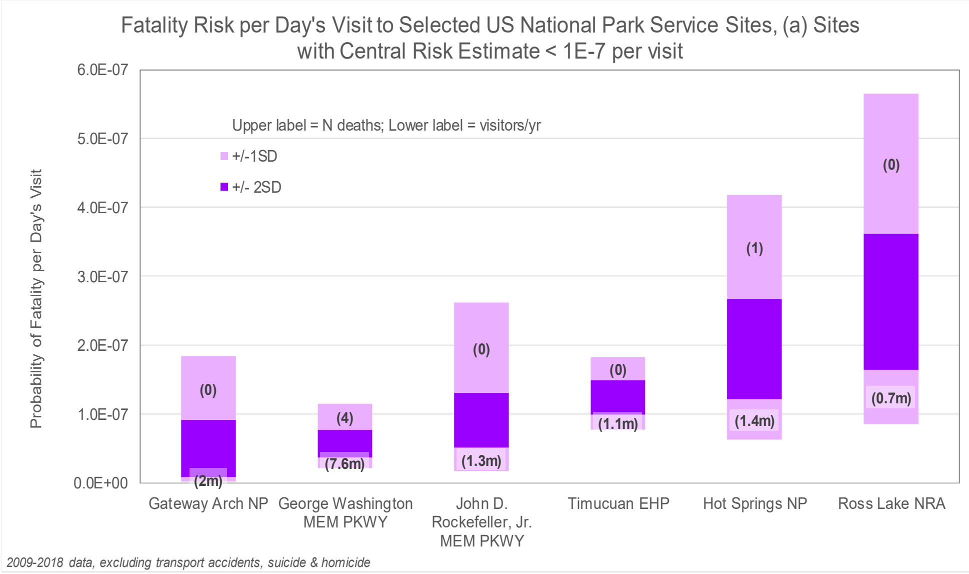
b) 10^{-7} $<$ Risk per visitor day $< 3\text{x}10^{-7}$

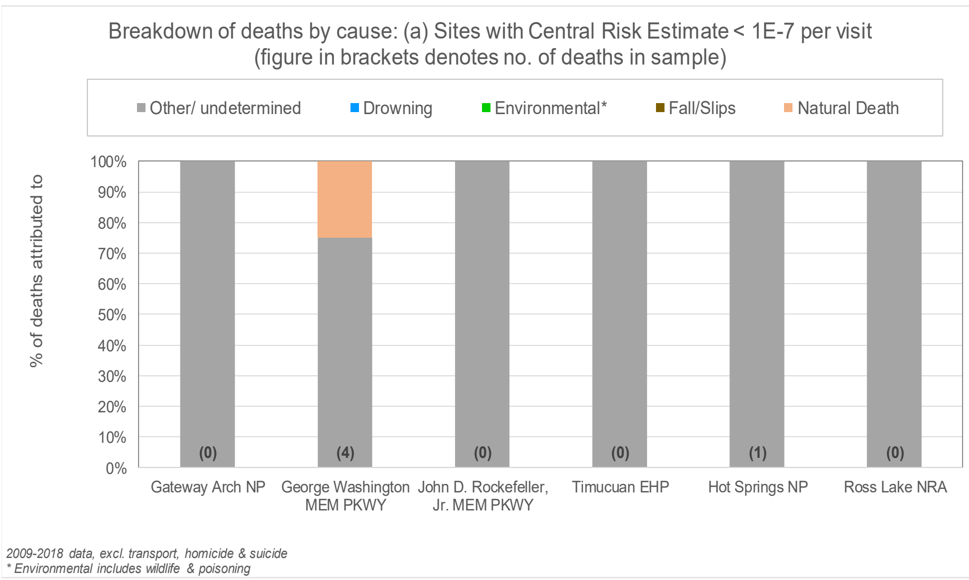
c) $3\text{x}10^{-7}$ $<$ Risk per visitor day $<10^{-6}$

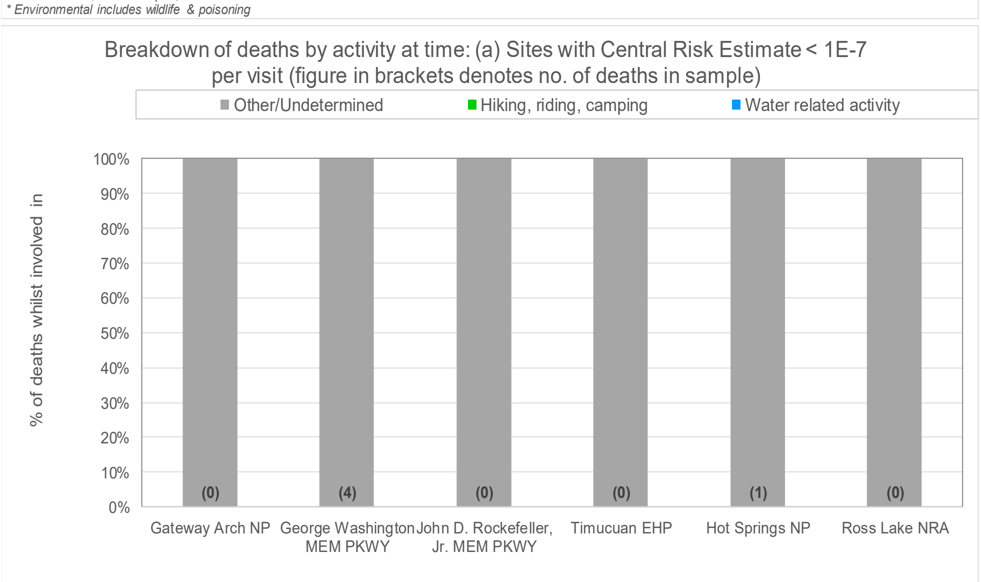
d) 10^{-6} $<$ Risk per visitor day $<3\text{x}10^{-6}$

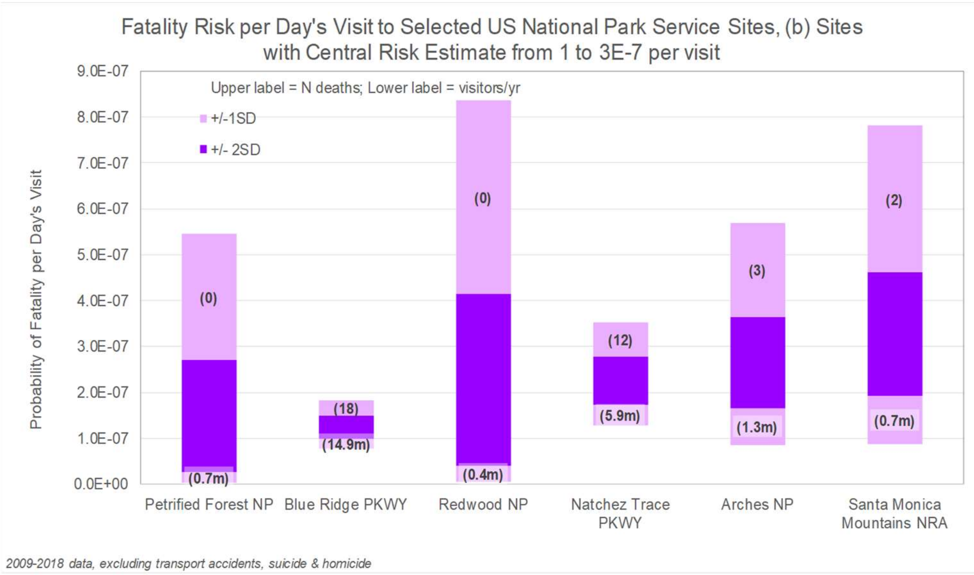
e) $3\text{x}10^{-6}$ $<$Risk per visitor day $<10^{-5}$

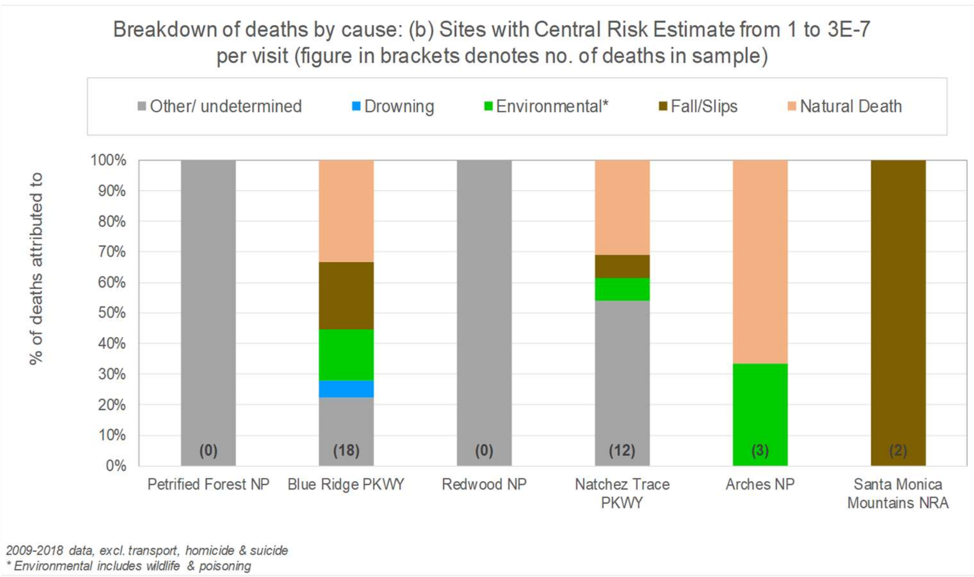
f) Risk per visitor day $>10^{-5}$.

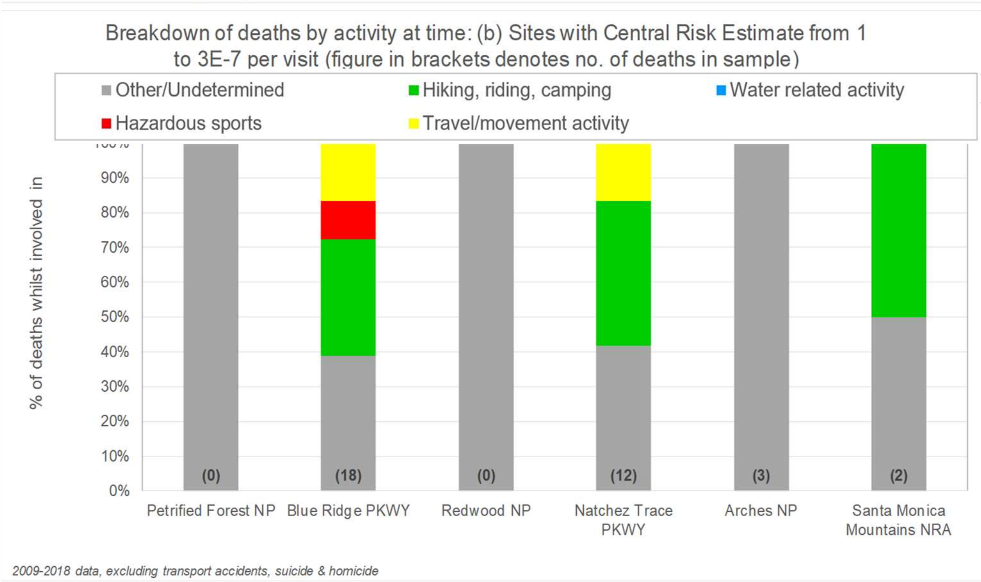

Fatality Risk per Day's Visit to Selected US National Park Service Sites, (a) Sites with Central Risk Estimate < 1E-7 per visit
Upper label = N deaths; Lower label = visitors/yr
+/-1SD
+/- 2SD
Probability of Fatality per Day's Visit
6.0E-07
5.0E-07
4.0E-07
3.0E-07
2.0E-07
1.0E-07
0.0E+00
(0)
(2m)
(4)
(7.6m)
(0)
(1.3m)
(0)
(1.1m)
(1)
(1.4m)
(0)
(0.7m)
Gateway Arch NP
George Washington MEM PKWY
John D. Rockefeller, Jr. MEM PKWY
Timucuan EHP
Hot Springs NP
Ross Lake NRA
2009-2018 data, excluding transport accidents, suicide & homicide

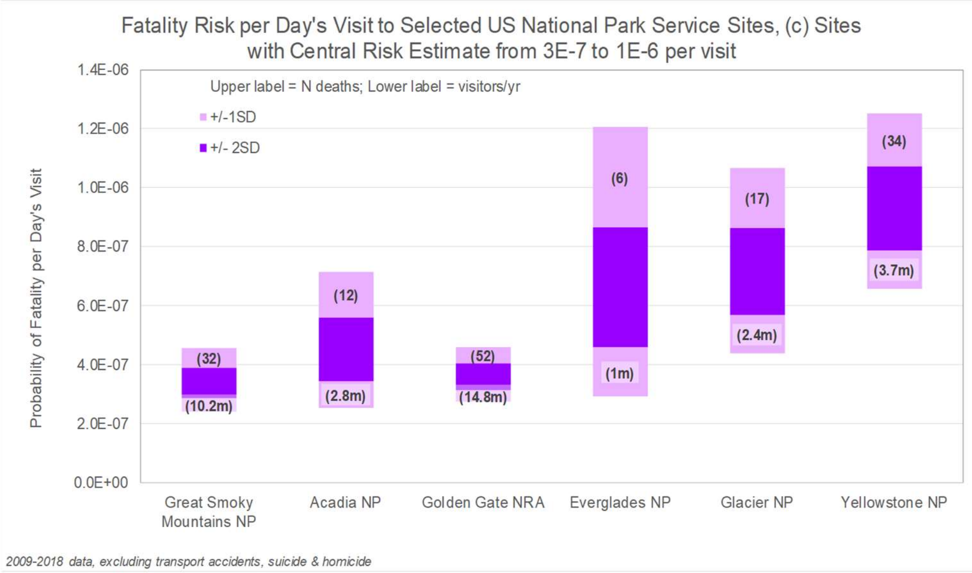

Breakdown of deaths by cause: (a) Sites with Central Risk Estimate < 1E-7 per visit (figure in brackets denotes no. of deaths in sample)
Other/ undetermined
Drowning
Environmental*
Fall/Slips
Natural Death
% of deaths attributed to
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(0)
(4)
(0)
(0)
(1)
(0)
Gateway Arch NP
George Washington MEM PKWY
John D. Rockefeller, Jr. MEM PKWY
Timucuan EHP
Hot Springs NP
Ross Lake NRA
2009-2018 data, excl. transport, homicide & suicide
* Environmental includes wildlife & poisoning

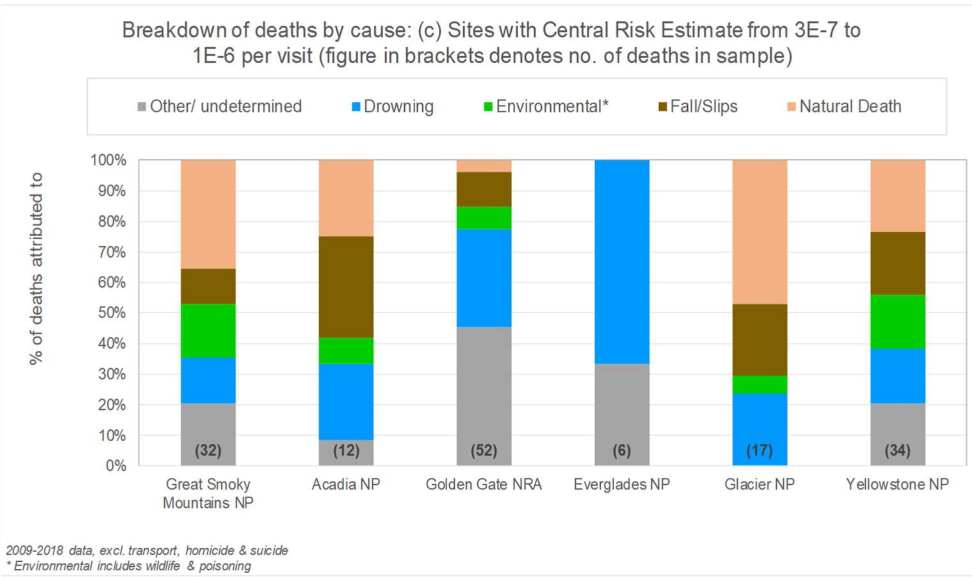

Breakdown of deaths by activity at time: (a) Sites with Central Risk Estimate < 1E-7 per visit (figure in brackets denotes no. of deaths in sample)
Other/Undetermined
Hiking, riding, camping
Water related activity
% of deaths whilst involved in
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(0)
(4)
(0)
(0)
(1)
(0)
Gateway Arch NP
George Washington MEM PKWY
John D. Rockefeller, Jr. MEM PKWY
Timucuan EHP
Hot Springs NP
Ross Lake NRA
2009-2018 data, excluding transport accidents, suicide & homicide

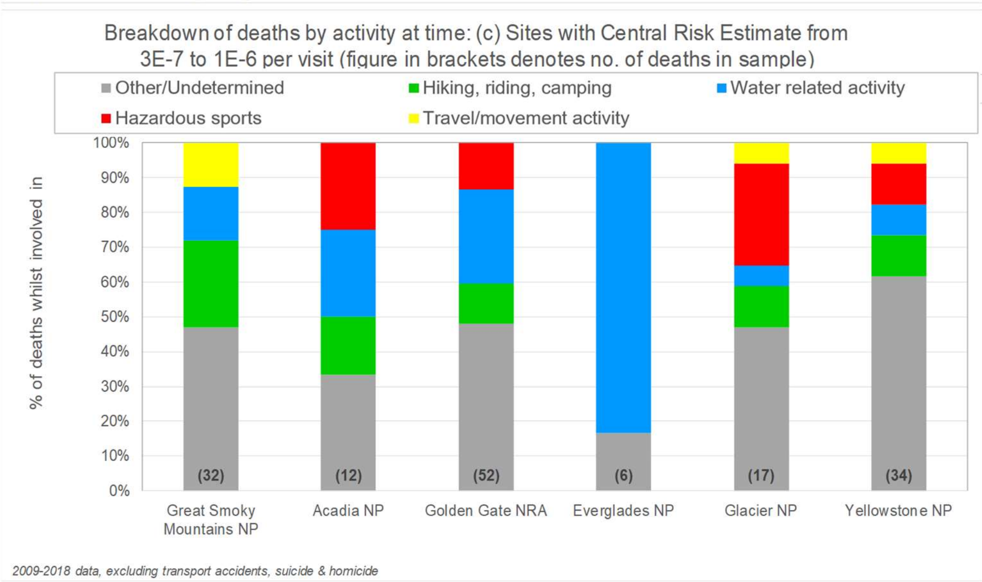

Fatality Risk per Day's Visit to Selected US National Park Service Sites, (b) Sites with Central Risk Estimate from 1 to 3E-7 per visit
Upper label = N deaths; Lower label = visitors/yr
+/-1SD
+/- 2SD
Probability of Fatality per Day's Visit
9.0E-07
8.0E-07
7.0E-07
6.0E-07
5.0E-07
4.0E-07
3.0E-07
2.0E-07
1.0E-07
0.0E+00
(0)
(0.7m)
(18)
(14.9m)
(0)
(0.4m)
(12)
(5.9m)
(3)
(1.3m)
(2)
(0.7m)
Petrified Forest NP
Blue Ridge PKWY
Redwood NP
Natchez Trace PKWY
Arches NP
Santa Monica Mountains NRA
2009-2018 data, excluding transport accidents, suicide & homicide


Breakdown of deaths by cause: (b) Sites with Central Risk Estimate from 1 to 3E-7 per visit (figure in brackets denotes no. of deaths in sample)
Other/ undetermined
Drowning
Environmental*
Fall/Slips
Natural Death
% of deaths attributed to
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(0)
(18)
(0)
(12)
(3)
(2)
Petrified Forest NP
Blue Ridge PKWY
Redwood NP
Natchez Trace PKWY
Arches NP
Santa Monica Mountains NRA
2009-2018 data, excl. transport, homicide & suicide
* Environmental includes wildlife & poisoning

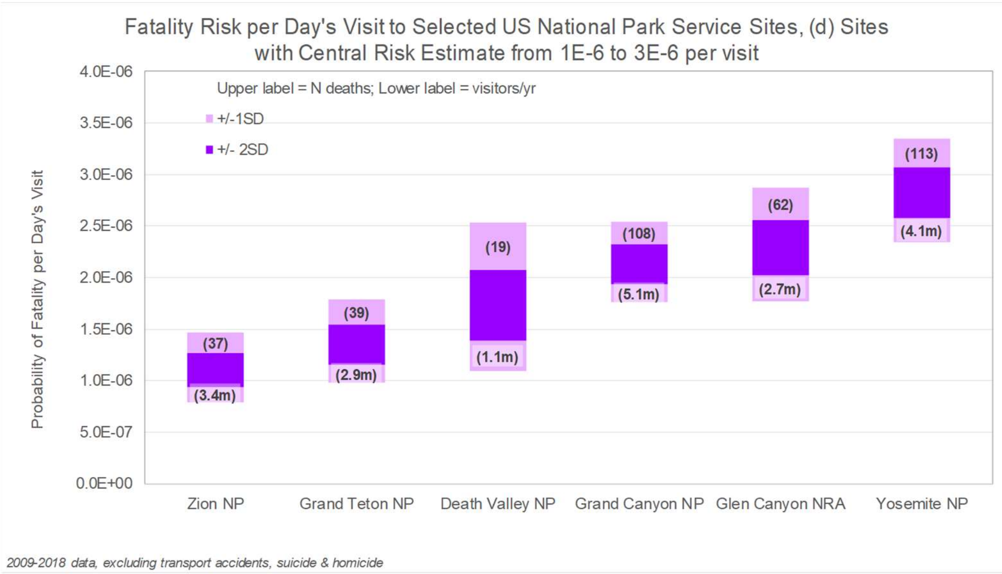

Breakdown of deaths by activity at time: (b) Sites with Central Risk Estimate from 1 to 3E-7 per visit (figure in brackets denotes no. of deaths in sample)
Other/Undetermined
Hiking, riding, camping
Water related activity
Hazardous sports
Travel/movement activity
% of deaths whilst involved in
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(0)
(18)
(0)
(12)
(3)
(2)
Petrified Forest NP
Blue Ridge PKWY
Redwood NP
Natchez Trace PKWY
Arches NP
Santa Monica Mountains NRA
2009-2018 data, excluding transport accidents, suicide & homicide

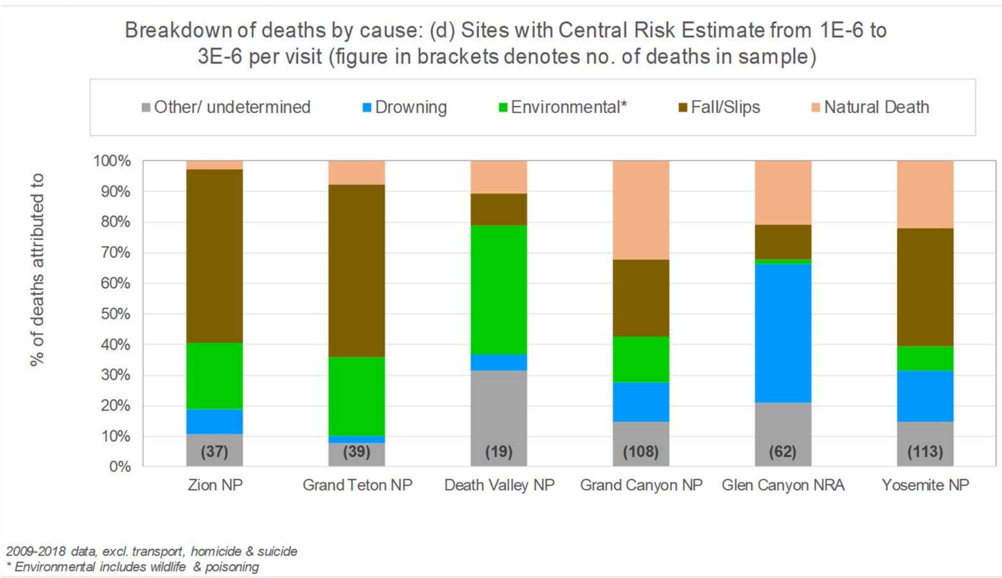

Fatality Risk per Day's Visit to Selected US National Park Service Sites, (c) Sites with Central Risk Estimate from 3E-7 to 1E-6 per visit
Upper label = N deaths; Lower label = visitors/yr
+/-1SD
+/- 2SD
Probability of Fatality per Day's Visit
1.4E-06
1.2E-06
1.0E-06
8.0E-07
6.0E-07
4.0E-07
2.0E-07
0.0E+00
(32)
(10.2m)
(12)
(2.8m)
(52)
(14.8m)
(6)
(1m)
(17)
(2.4m)
(34)
(3.7m)
Great Smoky Mountains NP
Acadia NP
Golden Gate NRA
Everglades NP
Glacier NP
Yellowstone NP
2009-2018 data, excluding transport accidents, suicide & homicide

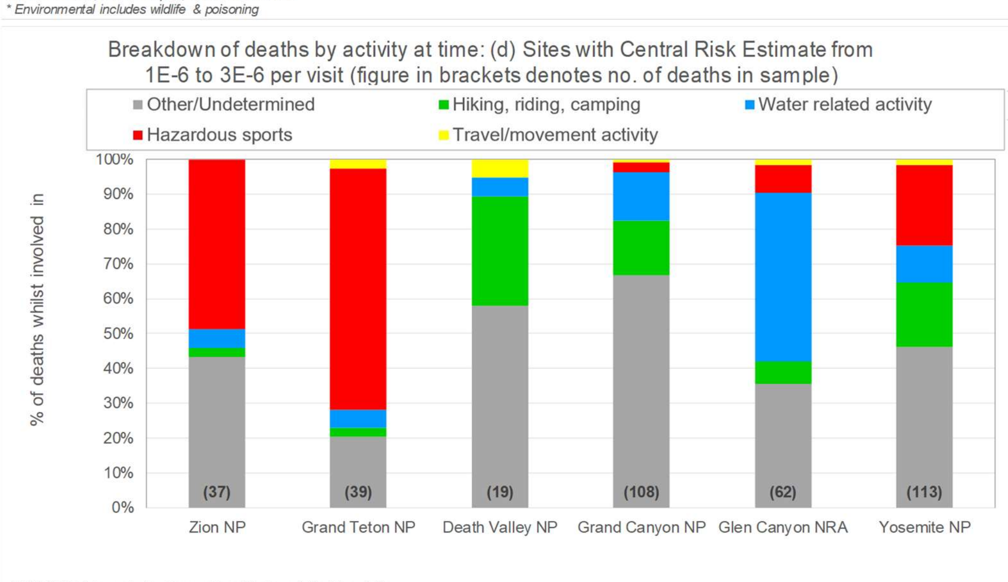

Breakdown of deaths by cause: (c) Sites with Central Risk Estimate from 3E-7 to 1E-6 per visit (figure in brackets denotes no. of deaths in sample)
Other/ undetermined
Drowning
Environmental*
Fall/Slips
Natural Death
% of deaths attributed to
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(32)
(12)
(52)
(6)
(17)
(34)
Great Smoky Mountains NP
Acadia NP
Golden Gate NRA
Everglades NP
Glacier NP
Yellowstone NP
2009-2018 data, excl. transport, homicide & suicide
* Environmental includes wildlife & poisoning

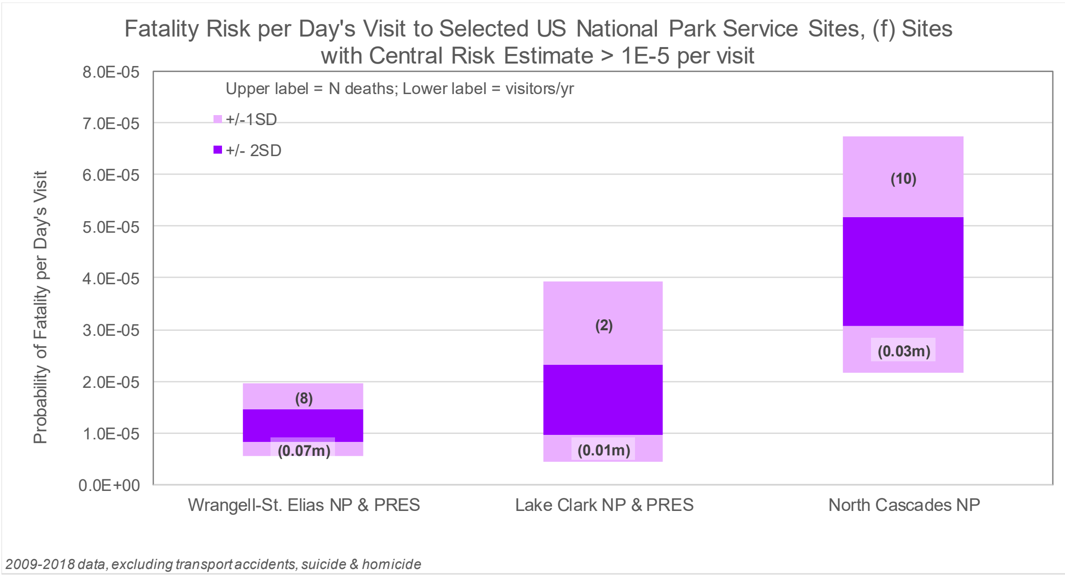

Breakdown of deaths by activity at time: (c) Sites with Central Risk Estimate from 3E-7 to 1E-6 per visit (figure in brackets denotes no. of deaths in sample)
Other/Undetermined
Hiking, riding, camping
Water related activity
Hazardous sports
Travel/movement activity
% of deaths whilst involved in
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(32)
(12)
(52)
(6)
(17)
(34)
Great Smoky Mountains NP
Acadia NP
Golden Gate NRA
Everglades NP
Glacier NP
Yellowstone NP
2009-2018 data, excluding transport accidents, suicide & homicide

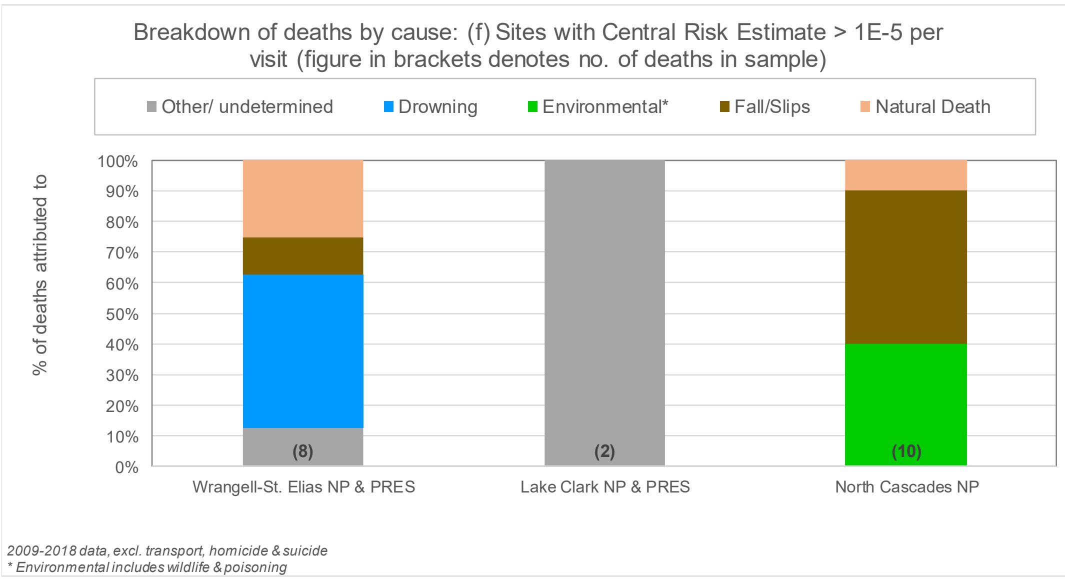
x

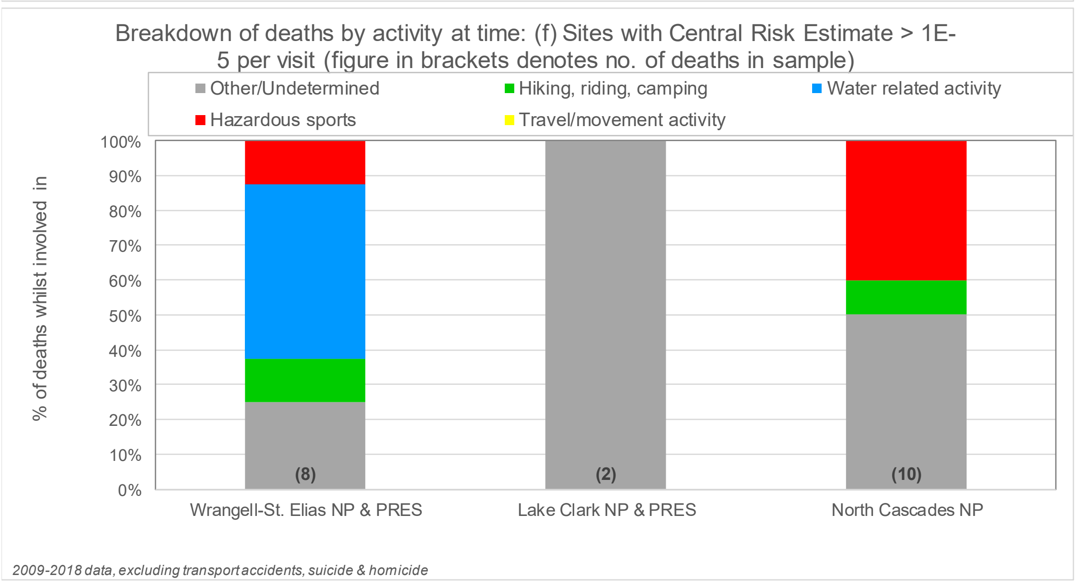

Fatality Risk per Day's Visit to Selected US National Park Service Sites, (d) Sites with Central Risk Estimate from 1E-6 to 3E-6 per visit
Upper label = N deaths; Lower label = visitors/yr
+/-1SD
+/- 2SD
Probability of Fatality per Day's Visit
4.0E-06
3.5E-06
3.0E-06
2.5E-06
2.0E-06
1.5E-06
1.0E-06
5.0E-07
0.0E+00
(37)
(3.4m)
(39)
(2.9m)
(19)
(1.1m)
(108)
(5.1m)
(62)
(2.7m)
(113)
(4.1m)
Zion NP
Grand Teton NP
Death Valley NP
Grand Canyon NP
Glen Canyon NRA
Yosemite NP
2009-2018 data, excluding transport accidents, suicide & homicide


Breakdown of deaths by cause: (d) Sites with Central Risk Estimate from 1E-6 to 3E-6 per visit (figure in brackets denotes no. of deaths in sample)
Other/ undetermined
Drowning
Environmental*
Fall/Slips
Natural Death
% of deaths attributed to
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(37)
(39)
(19)
(108)
(62)
(113)
Zion NP
Grand Teton NP
Death Valley NP
Grand Canyon NP
Glen Canyon NRA
Yosemite NP
2009-2018 data, excl. transport, homicide & suicide
* Environmental includes wildlife & poisoning


Breakdown of deaths by activity at time: (d) Sites with Central Risk Estimate from 1E-6 to 3E-6 per visit (figure in brackets denotes no. of deaths in sample)
Other/Undetermined
Hiking, riding, camping
Water related activity
Hazardous sports
Travel/movement activity
% of deaths whilst involved in
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(37)
(39)
(19)
(108)
(62)
(113)
Zion NP
Grand Teton NP
Death Valley NP
Grand Canyon NP
Glen Canyon NRA
Yosemite NP
2009-2018 data, excluding transport accidents, suicide & homicide


Fatality Risk per Day's Visit to Selected US National Park Service Sites, (f) Sites with Central Risk Estimate > 1E-5 per visit
Upper label = N deaths; Lower label = visitors/yr
+/-1SD
+/- 2SD
Probability of Fatality per Day's Visit
8.0E-05
7.0E-05
6.0E-05
5.0E-05
4.0E-05
3.0E-05
2.0E-05
1.0E-05
0.0E+00
(8)
(0.07m)
(2)
(0.01m)
(10)
(0.03m)
Wrangell-St. Elias NP & PRES
Lake Clark NP & PRES
North Cascades NP
2009-2018 data, excluding transport accidents, suicide & homicide


Breakdown of deaths by cause: (f) Sites with Central Risk Estimate > 1E-5 per visit (figure in brackets denotes no. of deaths in sample)
Other/ undetermined
Drowning
Environmental*
Fall/Slips
Natural Death
% of deaths attributed to
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(8)
(2)
(10)
Wrangell-St. Elias NP & PRES
Lake Clark NP & PRES
North Cascades NP
2009-2018 data, excl. transport, homicide & suicide
* Environmental includes wildlife & poisoning


Breakdown of deaths by activity at time: (f) Sites with Central Risk Estimate > 1E-5 per visit (figure in brackets denotes no. of deaths in sample)
Other/Undetermined
Hiking, riding, camping
Water related activity
Hazardous sports
Travel/movement activity
% of deaths whilst involved in
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(8)
(2)
(10)
Wrangell-St. Elias NP & PRES
Lake Clark NP & PRES
North Cascades NP
2009-2018 data, excluding transport accidents, suicide & homicide