Risk in the Resource Management Act 1991: How should the Environment Court of New Zealand predict the future?

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I   Introduction

> Confronting risk and uncertainty is unavoidable in our daily lives, and in planning for the future. We can be absolutely certain about very little; in fact nearly all of our decisions are made in the face of either recognised or unrecognised uncertainty.[1]

Decision-making within the context of resource management will always be fraught with inherent uncertainty.[2] The Resource Management Act 1991 (RMA) empowers a variety of bodies to make decisions concerning the use, development or protection of natural and physical resources.[3] These decisions are guided by provisions in the RMA in an attempt to ensure that each outcome achieves the forward-looking purpose of sustainable management;[4] in this manner, the law provides direction for the decentralised decision-making system.[5] However, the complex nature of environmental issues and the broad definition of "sustainable management"[6] make it unrealistic for the law to constrain decision-makers in a way that would produce certain results. Instead, the RMA simply sets parameters for the decision-making process in the hope that it will produce a reasonable outcome that accords with the broad purpose of the RMA.[7] This affords the decision-makers with a considerable amount of discretion to achieve this objective.

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[1] Peter Gluckman *Making decisions in the face of uncertainty: Understanding risk* (Office of the Prime Minister's Chief Advisor, Part Two, November 2016) at 5.

[2] Nils Bunnefeld, Emily Nicholson and EJ Milner-Gulland "Introduction" in Nils Bunnefeld, Emily Nicholson and EJ Milner-Gulland (eds) *Decision-Making in Conservation and Natural Resource Management: Models for Interdisciplinary Approaches* (Cambridge University Press, Cambridge, 2017) 1 at 1.

[3] Marie A Brown, Raewyn Peart and Madeleine Wright *Evaluating the environmental outcomes of the RMA* (Environmental Defence Society, June 2016) at 8.

[4] Aidan Cameron "It's a Catastrophe! Unplanned Failure of Activities and Potential Adverse Effects" (2019) RMJ 30 at 30.

[5] Ministry for the Environment *Improving our resource management system. A discussion document* (Ministry for the Environment, February 2013) at 12.

[6] Resource Management Act 1991, s 5.

[7] Section 5.

One such area of decision-making that is governed by a 'checklist' of criteria is the consideration of resource consent (RC) applications.[8] Here, a consent authority has to decide whether or not to allow an activity that would otherwise be illegal under the RMA to go ahead.[9] In making this decision, they must have regard to a number of criteria set out in the RMA before exercising their final discretion in a manner that accords with the broad purpose of the RMA.[10] Of particular importance to this thesis, the consent authority must have regard to the "potential effects" that allowing an activity may have on the environment.[11] This criterion requires the consent authority to predict the future, often against a backdrop of scientific uncertainty and conflicting values.[12]

This thesis aims to analyse how the Environment Court of New Zealand (NZEnvC) has responded to the challenge of attempting to predict future adverse effects when making decisions and explores whether or not this process could be improved. To explore this concept fully, I will focus on how the NZEnvC assesses the criteria of "actual or potential effects" under s 104(1)(a) of the RMA.

Chapter II outlines how the law has approached the requirement to consider future effects. The relevant sections of the RMA itself are relatively limited; s 104 of the RMA sets out the decision-making framework for the consideration of RC applications. Within this section, there is a requirement to "have regard" to "actual and potential effects" of the proposed activity.[13] Neither "actual" nor "potential" are defined in the RMA, however, s 3 of the RMA defines "effect." Although limited, these sections have generated a substantial body of case law.[14] From these cases, the notion of risk analysis has arisen as a pragmatic

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[8] Section 104.

[9] Section 87.

[10] Section 104.

[11] Section 104(1)(a).

[12] Thomas M Quigley, Fred J Everest and Thomas J Mills "Science-based natural resource management decisions: what are they?" (2001) 19 RRJ 10 at 10.

[13] Resource Management Act, s 104(1)(a).

[14] Claire Kirman, Ellis Gould and Catherine Somerville "Carrying the Burden: Considering the appropriate evidential tests in resource management decisions" (2006) RMJ 3.

way to assess future events in a manner that responds to the complex environmental context in which decisions are made.[15] This approach requires the NZEnvC to evaluate expert evidence and make a judgement as to the risk of an effect (such as the extinction of a species) occurring.[16] Estimating risk is not simply a matter of guessing whether something is 'low risk' or 'high risk', rather 'risk' encapsulates a process that consists of two components: the probability of an event transpiring multiplied by the possible consequences on the environment.[17]

Chapters III and IV explore the notion of quantifying, or providing further guidance, for the two components of 'risk'(probability and consequence) and assess whether or not the incorporation of numerical values would be beneficial within the RC decision-making process. Ultimately, this analysis weighs the need to have a clear and consistent framework for the assessment of potential future effects under s 104(1)(a) of the RMA with the realities of the factual ambiguity that the NZEnvC faces. Whilst both chapters make suggestions as to how the components of risk can be assessed in a more consistent and calculable manner, it is recognised that there are other approaches within the extensive risk assessment literature that have given greater thought to this matter; these suggestions merely provide another possible approach to this complex problem.

Chapter III analyses whether the quantification of probability would be compatible with the current common law and the broader purpose of the RMA. Within this chapter, I will briefly outline the merits and disadvantages of using Bayesian statistics to assess and quantify the probability of potential effects occurring. I will then analyse whether or not presenting probability in a numerical form, in general, is appropriate in the context of analysing probability.

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[15] *Shirley Primary School v Christchurch City Council* [1999] NZRMA 66 (EnvC).

[16] *Long Bay-Okura Great Park Society Inc v North Shore City Council* EnvC Auckland A078/2008, 16 July 2008 at [314].

[17] *Clifford Bay Marine Farms Ltd v Marlborough District Council* EnvC Christchurch C131/2003, 22 September 2003 at [55].

Chapter IV first highlights the difficulty associated with valuing the environment and the problems that stem from this inability to provide a set figure to the decision-maker. It is argued that some system of valuation is needed when assessing the second component of risk (the significance of the consequences) so that decision-makers are somewhat constrained by the law when making this assessment. One suggested method for providing guidance in the area of risk is the use of central policy documents; this is a preferred method to attribute relative value to the environment because it allows for all of the relevant values and information to be incorporated at a higher level and can be updated as values or scientific knowledge evolve.[18] However, this chapter will instead focus on how guidance for environmental valuation can be drawn from the current wider legal framework so that decision-makers can refer to a known central source of valuation that accords with national-level values.

This thesis is limited in the sense that it only aims to canvas the analysis of risk that occurs during the consideration of RC applications. This is done in very general terms, but it is recognised that for different classes of environmental problems (hazards, climate change or human activities)[19] there will be different complexities at each stage. Climate change, in particular, poses a unique set of challenges and complexities when considering risk.[20]

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[18] R J Somerville "Risk, Regulation, and the Resource Management Act 1991: The Case of Electricity Generation and Transmission (Vol 2)" (PhD Dissertation, University of Otago, 2001) at 450.

[19] Jon Jackson "Predictions in an Uncertain World – Assessing Effects Under the Resource Management Act 1991" (paper presented to the New Zealand Law Society Continuing Legal Education Programme, October 2016) at 7.

[20] See generally Stephen Schneider "Confidence, consensus and the uncertainty cops- tackling risk management in climate change" in Jim Salinger (ed) *Living in a Warmer World*, (David Bateman, Auckland, 2013) 199 for a detailed discussion of risk-management in the context of climate change. For an assessment of how climate change effects are considered under the RMA see Vernon Rive "New Zealand Climate Change Regulation" in Alastair Cameron (ed) *Climate Change Law and Policy in New Zealand*, (Lexis Nexis, Wellington, 2011) 165.

II Risk Analysis in the Consideration of Resource Consent Applications

The NZEnvC deals with appeals on RC application issues (or, in certain circumstances considers applications for a RC at first instance).[21] When considering appeals the NZEnvC hears the matter de novo and has wide procedural powers that allow it to call for further evidence.[22]

A Statute Law Surrounding the Resource Consent Application Process

Any activity that contravenes pt 3 of the RMA and is not permitted under a rule in a relevant plan requires a RC before it can be carried out.[23] A relevant consent authority makes the final substantive decision as to whether a RC is granted or not;[24] in making this decision the future adverse effects of an activity must be considered.[25]

1 Application for a resource consent

Applicants for a RC must provide an assessment of the proposed activity's actual or potential effects on the environment, along with other information specified in sch 4 of the RMA.[26] The preparation of assessments of environmental effects is influenced by the relevant case law,[27] so the manner in which the NZEnvC approaches the consideration of future effects may be reflected in this process.

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[21] Resource Management Act, s 87D and s 142.

[22] Ceri Warnock "Reconceptualising the Role of the New Zealand Environment Court" (2014) 26(3) J Environ Law 507 at 509.

[23] Resource Management Act, s 87.

[24] The considerations required for this decision-making process vary depending on the classification of the activity that is being proposed. For more information see ss 104A to 104D in the Resource Management Act.

[25] Resource Management Act, s 104(1)(a).

[26] Section 88.

[27] Marion Read "Landscape boundaries: an examination of the influence of environment court decisions on the practice of landscape assessment in Aotearoa/New Zealand" (Masters Thesis, Massey University, 2012).

2 Consideration of a resource consent application

On consideration of an application for a RC, the consent authority must have regard to or expressly disregard a range of matters listed in s 104(1) of the RMA. This section provides guidance as to what evidence will be legally relevant to the decision-making process and also establishes a decision-making framework.[28] For simplicity, the relevant parts of the section are reproduced below:[29]

> **104 Consideration of applications**
>
> (1) When considering an application for a resource consent and any submissions received, the consent authority must, subject to Part 2, have regard to–
>
> (a) any actual and potential effects on the environment of allowing the activity; and
>
> …
>
> (c) any other matter the consent authority considers relevant and reasonably necessary to determine the application.

Of particular relevance to this thesis, the NZEnvC must have regard to "any actual and potential effects on the environment of allowing the activity" under s 104(1)(a) of the RMA. The question of what constitutes the "environment" is determined prior to the consideration of the potential effects of the proposed activity[30] and is defined in s 2 of the RMA:

> **environment** includes—
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> (a) ecosystems and their constituent parts, including people and communities; and
>
> (b) all natural and physical resources; and
>
> (c) amenity values; and

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[28] Ministry for the Environment "Matters to be Considered- Section 104" (Quality Planning) <https://qualityplanning.org.nz/node/860 >.

[29] Resource Management Act, s 104.

[30] *Royal Forest and Bird Protection Society Inc v Buller District Council* [2013] NZCA 496, (2013) 17 ECRNZ 616 at [23].

(d) the social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) or which are affected by those matters.

After identifying the environment, the NZEnvC identifies and assesses the effects on the environment of allowing the proposed activity.[31] The meaning of the term "any actual and potential effects" under s 104(1)(a) of the RMA is an unsettled subject in the case law. The RMA defines "effects" in s 3 as shown below (emphasis added):

> **3 Meaning of effect**
> In this Act, unless the context otherwise requires, the term **effect** includes—
> (a) any positive or adverse effect; and
> (b) any temporary or permanent effect; and
> (c) any past, present, or future effect; and
> (d) any cumulative effect which arises over time or in combination with other effects—
> regardless of the scale, intensity, duration, or frequency of the effect, and also includes—
> *(e) any potential effect of high probability; and*
> *(f) any potential effect of low probability which has a high potential impact.*

There is disagreement as to whether or not this definition can be imported into s 104(1)(a) of the RMA. In the case of *Dye v Auckland Regional Council* the Court of Appeal found, in obiter, that the meaning of "effect" set out in s 3 of the RMA cannot be used in the context of s 104(1)(a) because it has been displaced by the wording "actual or potential effects" used in the subsection itself.[32] However, this decision has garnered much criticism in the academic sphere[33] and subsequent cases in the NZEnvC have produced a variety of reasoning to effectively import the wider subtleties of the s 3 definition when considering "effects" under s 104(1)(a).[34] Notably, in *Clifford Bay Marine Farms Ltd v Marlborough*

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[31] David Mead "Decision-making Approaches in Planning" in Caroline Miller and Lee Beattie (ed) *Planning Practice in New Zealand*, (LexisNexis, Wellington, 2017) at 98.

[32] *Dye v Auckland Regional Council* [2002] 1 NZLR 337 (CA) at [41].

[33] Philip Milne "When is enough, enough? Dealing with cumulative effects under the RMA" (April 2008) RMJ 19.

[34] See *Cashmere Park Trust v Canterbury Regional Council* EnvC Christchurch C48/2004, 21 April 2004 at [16], where the NZEnvC determined that it was not bound by *Dye v Auckland Regional Council* [2002], above n 32, because s 104(1) of the RMA had been repealed and substituted since that decision (although s

the NZEnvC commented that the restrictive ruling in *Dye* was disjointed from the practicalities of environmental law and went on to distinguish the case on the basis that the inclusive definition of s 3 of the RMA and the option to consider "other relevant matters" under s 104(1)(i) of the RMA suggested that all effects should be considered, regardless of whether or not they fit within ss 3(a)–(e) or s 104(1)(a). This case reflects the approach that will most likely be used in the NZEnvC when assessing effects; given the broad nature of s 3 the NZEnvC will be willing to read into s 104(1)(a) a possible effect of any nature and there tends to be "disquiet"[35] regarding the restrictive obiter in *Dye*.

Regardless of the level of restriction in the definition of "effects" it has been widely accepted that future effects must be considered in some sense.[36] As expressed in *Westfield (New Zealand) Ltd v North Shore City Council* future potential effects can be:[37]

> …something which may or may not happen, as opposed to actual. Depending on context, that can range in the level of certainty from highly probable, more probable than not, reasonably probable, significant or substantial possibility, distinct possibility, something that might well happen – down to slim or faint possibility and on to barely conceivable.

This duty to have regard to actual and potential effects under s 104(1)(a) is "subject to" pt 2 of the RMA, which lays out the broad overall purpose of "sustainable management" of natural and physical resources for the RMA.[38] This wording has been taken to mean that a

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104(1)(a) of the RMA was not substantially altered) and the statement regarding the definition of "effect" was simply inconclusive *obiter dictum.*

[35] *RJ Davidson v Marlborough District Council* [2016] NZEnvC 81 at [177].

[36] *Dye v Auckland Regional Council,* above n 32, at [39]; and *Queenstown Lakes District Council v Hawthorn Estate Ltd* [2006] NZRMA 424 (CA) at [52].

[37] *Westfield (New Zealand) Ltd v North Shore City Council* [2005] NZSC 17 at [182].

[38] Resource Management Act, s104; and Laurie Newhook "Effectiveness and Legitimacy of Dispute Resolution in the New Zealand Environment Court: Proposals for Policy Change, Scope for Improvement and Potential Obstacles" (paper presented to the 14th Annual Colloquium of the IUCN Academy of Environmental Law, Oslo, June 2016) at 2.

consent authority must regard pt 2 where it is appropriate to do so when making RC decisions.[39] The NZEnvC recognises this requirement by using an overall broad judgement at the final stage of the decision-making process.[40] After having regard to all of the matters under s 104, the consent authority exercise their discretion in a manner that aims to fulfil the ultimate goal of adhering to the purpose of the RMA.[41]

It is within this final stage that any "actual or potential" effects that were established under s 104(1)(a) may influence the outcome of the consent authority's decision.[42] Effects of low risk may carry little weight in the final decision, whereas potential adverse effects of high risk may prevent a decision-maker from using their discretion to grant a RC.[43] In *Aquamarine Ltd v Southland Regional Council* the NZEnvC found that the relevant "adverse effects … are probably serious enough by themselves to justify refusing consent".[44] However, the fact that there is a high risk adverse effect will not automatically prevent a RC from being granted; as long as granting the RC accords with the overall aim of achieving sustainable management the decision that is made will be valid.[45]

B   How the Environment Court of New Zealand Assesses Future Effects

As has been established, under s 104(1)(a) the NZEnvC must have regard to future effects. Attempting to predict the future is an uncertain and complex exercise regardless of the qualifications of the decision-maker or the information that is available.[46] This exercise is

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[39] *R J Davidson v Marlborough District Court* [2018] NZCA 316, [2018] 3 NZLR 283 at [72]–[75] which found that if there is a competently prepared plan then a consent authority may feel assured that there is no need to refer to pt 2 of the Resource Management Act. For more information on this point see generally Martin Williams "Part 2 of the RMA – 'engine room' or backseat driver?" (April 2017) RMJ 25.

[40] *Shirley Primary School v Christchurch City Council,* above n 15, at [2].

[41] At [2].

[42] *Aquamarine Ltd v Southland Regional Council* EnvC Christchurch C126/97, 15 December 1997, at 154.

[43] At 154.

[44] At 154.

[45] *Shirley Primary School v Christchurch City Council,* above n 15, at [127].

[46] Mead, above n 31, at 104.

further complicated for the NZEnvC by the tension between the role of law and science,[47] as well as the restrictive nature of legal mechanisms when considering something that deviates from the traditional subject matter of a court.[48] The NZEnvC grappled with these underlying problems when considering how to assess future effects in early case law, but has seemingly accepted the idea of risk analysis— which is explained below— being used when considering whether or not future adverse effects can be established under s 104(1)(a) or when considering future effects in general.[49]

The issue of determining future effects and how this interacts with the traditional standard of proof is covered extensively in academic literature.[50] However, the following explanation of this complex issue offers a simplified summary of how the courts have approached the matter.

3   The development of risk analysis

The prediction of future effects has been implicitly or expressly included in RMA cases from the "early years"[51] of resource management law.[52] Two different approaches to

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[47] Bokyong Mun "The Myth of the De-legislation of Scientific Evidence and Climate Change Adjudication" (LLB (Hons) Dissertation, University of Otago, 2015).

[48] *Long Bay-Okura Great Park Society v North Shore City Council,* above n 16, at [20].

[49] *R J Davidson Family Trust v Marlborough District Council,* above n 53, at [4]; *Shirley Primary School v Christchurch City Council,* above n 15, at [130]; *Clifford Bay Marine Farms Ltd v Marlborough District Council,* above n at 15, at [55]; *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [20]; *Francks v Canterbury Regional Council* [2005] NZRMA 97 (HC) at [16]; and *Golden Bay Marine Farmers v Tasman District Council (Second Interim Report)* EnvC W19/2003 5-9 November 5–9 November 2001, 28–31 January, 1 February 2002, 27 March 2003.

[50] See G Severinsen "Letting our standards slip? Precaution and the standard of proof under the Resource Management Act 1991" (2014) 18 NZJEL 173. In this article, the author comments on how the standard of proof and probability may have been conflated and suggests how the standard of proof should be understood in terms of future effects. See also Greg Severinsen "To Prove or Not to Prove: Precaution, the Burden of Proof and Discretionary Judgment under the Resource Management Act" (2014) 13 Otago LR 351.

[51] *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [312].

[52] At [312].

assessing these effects were employed by the NZEnvC before the matter was settled by the High Court in *R J Davidson Family Trust v Marlborough District Council*.[53]

The early approach to assessing future effects can be seen in the case of *McIntyre v Christchurch City Council,* which considered the issue of whether or not the Planning Tribunal could make a finding of a future effect in a situation where there was a very low probability of a consequence occurring.[54] The Planning Tribunal was tasked with determining if low-level radio frequency that would be emitted by transmissions from a proposed facility could have harmful health effects.[55] On the facts, there was a serious hypothesis that exposure to this level of radiation was potentially harmful to health.[56] Thus, the appellants proposed that an adverse effect on human health could be established as an "effect" of allowing the facility to be built.[57] If this argument succeeded, the Planning Tribunal would be required to consider this adverse effect as part of the s 104 criteria in the RMA.

On the matter of determining whether or not this adverse health effect could be established, the Planning Tribunal concluded that (emphasis added):[58]

> ... the evidence must satisfy us of the fact (i.e. that there will or will not be such an effect) on the *balance of probabilities* and having regard to the gravity of the question.

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[53] *R J Davidson Family Trust v Marlborough District Council* [2017] NZHC 52, [2017] NZRMA 227 at [4]. A later High Court decision affirmed this approach — see *Clearwater Mussels Ltd v Marlborough District Council* [2019] NZHC 961, (2019) 21 ELRNZ 67 at [86].

[54] *McIntyre v Christchurch City Council* [1997] NZRMA 289 (PT).

[55] At 3.

[56] At 14.

[57] At 13.

[58] At 14.

This imported the traditional civil standard of proof, with some scope for regard to the "gravity" of the situation. This approach to assessing future effects was followed in a range of RMA cases by a variety of decision-making bodies, including the NZEnvC.[59] .

On first reading, this test appears to be straightforward and allows flexibility whilst staying aligned with traditional evidential standards. However, in the context of environmental adjudication, there are several problems with determining future effects on the balance of probabilities (or thereabouts).[60] These flaws have been recognised by a line of cases that developed alongside the *McIntyre* approach,[61] and were eventually confirmed to be the appropriate way of addressing future effects by the High Court in *R J Davidson Family Trust (HC)*.[62]

A foundational case for this revised way of thinking is *Shirley Primary School v Christchurch City Council.*[63] This case arose from very similar facts to those in *McIntyre* but took a markedly different approach.[64] Notably, it criticised the idea that "prophesying"[65] what may happen in the future should be proved on the balance of probabilities.[66] Applying this standard could effectively exclude any future effect that had a probability of occurrence below the 50 per cent threshold.[67] The seriousness of this exclusion is exemplified in the later case of *Long Bay-Okura Great Park Society Inc v North Shore City Council,* which considered a (hypothetical) activity that only had a 16.67

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[59] *Contact Energy Ltd v Waikato Regional Council & Anor* (2000) 6 ELRNZ 1 (EnvC) at [42]; *Kiwi Property Management Ltd v Hamilton City Council* (2003) 9 ELRNZ 249 (EnvC) at [74]–[82]; *Winstone Aggregates Ltd v Franklin District Council* EnvC Auckland A80-2002 17 April 2002 at [250].

[60] Kirman, Gould and Somerville, above n 14, at 4.

[61] At 4.

[62] *R J Davidson Family Trust v Marlborough District Council* (HC)*,* above n 53, at [4] and [133].

[63] *Shirley Primary School v Christchurch City Council,* above n 15.

[64] At [135].

[65] *Fernandez v Government of Singapore* [1971] 1 WLR 987 (PC).

[66] *Shirley Primary School v Christchurch City Council ,* above n 15, at [117].

[67] At [135].

per cent probability of occurring but could endanger humans lives.[68] Proving that this potential effect of damage to lives would be more likely than not to occur is impossible given the probability in this fact scenario.[69] Thus, under the civil standard of proof, the future effect of harming lives could not be considered by a court under s 104(1)(a).[70] The impact of excluding an effect such as this is significant to the overall decision-making process; the outcomes of cases have hinged on the weight given to adverse effects of low probability but high consequence.[71]

The NZEnvC in *Shirley Primary School* accordingly rejected the notion of requiring future effects to be proven on the balance of probabilities.[72] Instead, it distinguished the role of fact-finding from that of making predictions.[73] Past or current facts may be subject to a standard of proof in the traditional manner, however, the assessment of future effects requires the decision-maker to carry out an evaluative exercise based on the expert evidence before them to determine whether or not a potential effect is established.[74]

Further support for this approach to assessing future effects was drawn from the definition of "effect" in s 3 of the RMA. In particular, the NZEnvC took the inclusion "any potential effect of high probability" and "any potential effect of low probability which has a high potential impact" in s 3 of the RMA to indicate that the NZEnvC was required to evaluate potential effects that had a low probability of occurring (even if this probability fell below the 50 per cent threshold for the civil standard of proof).[75] If Parliament had intended the NZEnvC to consider any effect of "low probability" in s 3(f) of the RMA then it seems

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[68] *Long Bay-Okura Great Park Society v North Shore City Council,* above n 16, at [310].

[69] At [310].

[70] At [310].

[71] *Aquamarine Ltd v Southland Regional Council*, above n 42, at [154].

[72] *Shirley Primary School v Christchurch City Council*, above n 15, at [136].

[73] At [120].

[74] At [120].

[75] At [120].

counter-intuitive for the NZEnvC to set a requirement that only allowed effects with a 50 per cent (or thereabouts) probability of occurring to be assessed.[76]

Expanding on this finding, the Court in *Shirley Primary School* went on to explain that consideration should also be given to the two components laid out in s 3(f) of the RMA, namely the probability of an effect occurring and the "nature of the impact" of that effect.[77] Decisions after *Shirley Primary School* have focussed on the requirement to analyse both of these components when assessing future effects.[78] Accordingly, the idea that decision-makers must consider the risk (probability of an effect multiplied by the significance of the consequences) posed by an activity, was explained in the case of *Clifford Bay Marine Farms Ltd*:[79]

> In our view the approach the Act requires is that under section 104(1)(a) and (i) of the Act, each potential effect raised in the evidence should be assessed qualitatively, or preferably quantitatively, in the light of the principles of the RMA, and the objectives and policies of the relevant instruments as to:
>
> (a) Probability of occurrence; and
> (b) Force of input.

This approach has been followed by a number of cases when assessing future potential effects.[80] It was restated simply in *Long Bay-Okura Great Park Society Inc* as the

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[76] At [134]–[136].

[77] At [131].

[78] Kirman, Gould and Somerville, above n 14, at 4.

[79] *Clifford Bay Marine Farms Ltd v Marlborough District Council,* above n at 15, at [68].

[80] *R J Davidson Family Trust v Marlborough District Council* (HC), above n 53, at [4]; *Shirley Primary School v Christchurch City Council,* above n 15, at [130]; *Clifford Bay Marine Farms Ltd v Marlborough District Council,* above n at 15, at [55]; *Long Bay-Okura Great Park Society v North Shore City Council,* above n 16, at [20]; *Francks v Canterbury Regional Council* [2005] NZRMA 97 (HC) at [16]; and *Golden Bay Marine Farmers v Tasman District Council (Second Interim Report)* EnvC W19/2003 5-9 November 5–9 November 2001, 28–31 January, 1 February 2002, 27 March 2003.

requirement for the NZEnvC to establish our "best and most accurate belief of the probability of each relevant alleged (future) effect and its consequences."[81]

In summary, the current approach of the NZEnvC when considering "potential effects" under s 104(1)(a) is that of risk analysis. There is no need to prove a potential future effect on the balance of probabilities.[82] Instead, the NZEnvC evaluates the expert evidence before it and uses this information to make a judgement regarding the probability of an event occurring and the significance of the potential consequences of that event.[83] In doing so, it can determine the level of risk for each potential adverse effect and later account for this risk in the overall broad judgement.[84]

4   Problems with the existing approach to risk analysis

The notion of 'risk' provides a pragmatic process for assessing future effects. However, this process is not without its flaws; notably there can be problems if the two components of risk (probability and consequence) are overlooked. The NZEnvC notes in *Clifford Bay Marine Farms Ltd* that there is a danger of "sloppy thinking" if the decision-maker assigns a quantified risk (i.e. "high risk" or "low risk") without first differentiating and considering these two elements.[85] In theory, identifying and assessing the probability and consequence of an occurrence is a simple task. However, in practicality, this process is more complex.[86]

Analysis of both components during risk analysis should be done in a rational and transparent manner.[87] The Court has noted that this assessment is prone to subjectivity;[88] the consent authority is not simply making decisions based on facts, rather the process is a

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[81] *Long Bay-Okura Great Park Society v North Shore City Council,* above n 16, at [20].

[82] *R J Davidson Family Trust v Marlborough District Council* (HC), above n 53, at [4].

[83] *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [316].

[84] *Aquamarine Ltd v Southland Regional Council*, above n 42.

[85] *Clifford Bay Marine Farms Ltd v Marlborough District Council,* above n 17, at [55].

[86] *Shirley Primary School v Christchurch City Council*, above n 15, at [127].

[87] *Clifford Bay Marine Farms Ltd v Marlborough District Council,* above n 42, at [61].

[88] At [61].

matter of judgement based on the evidence before them.[89] This leaves any value judgements within the assessment of probability and the significance of potential consequences to the decision-maker.[90] Thus, inevitably, "there is inconsistency in environmental decision-making addressing the risk of [future environmental effects]"[91]

This thesis aims to address this inconsistency; the analysis of risk determines whether an effect is established under s 104(1)(a) and the level of risk (whether low or high risk) can later influence the overall outcome of the decisions on whether or not to grant a RC.[92] For such an important criteria, it would be beneficial to have a clearer framework as to how both components of risk should be assessed so that there is increased calculability for those interested in the process and the decision-makers themselves can have consistent sources of guidance to draw from. The following discussion aims to discuss theoretical guidelines on how to assess the probability and significance of the consequences.

[89] *Shirley Primary School v Christchurch City Council*, above n 15, at [117]; and *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [313].

[90] *Clifford Bay Marine Farms Ltd v Marlborough District Council,* above n 17, at [71]–[72].

[91] Somerville, above n 18, at 491.

[92] *Aquamarine Ltd v Southland Regional Council*, above n 42, at [154].

III The First Element of Risk: Probability (Likelihood)

As has been established, the NZEnvC has accepted that risk can be found by multiplying the probability of an activity occurring with the significance of the consequences of that event.[93] It is clear that this description of risk is incredibly simplified and that there are other, more advanced, ways to describe the matter.[94] Indeed, in *Clifford Bay Marine Farms Ltd*, the NZEnvC suggested that when estimating the probability (or likelihood) of an adverse effect occurring the "sensitivity of the species or resources" and "duration of exposure to the activity" should also be considered.[95]

These suggestions to the development of 'risk' recognise the environmental complexities that the NZEnvC faces and the detailed information on risk assessment that is available.[96] However, even the simple formula of probability multiplied by consequence necessitates further investigation.[97] This chapter aims to provide further discussion on this oversimplified version of risk by exploring whether quantification or further guidance would be beneficial to the NZEnvC when estimating the likelihood of harm. In particular, the possibility of using Bayesian statistics to provide further clarity to this component is discussed.

Statistics can be used when giving evidence on a matter of uncertainty, such as the probability of a future effect occurring.[98] It is a tool that (among other things) can interpret

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93 *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [20] and [45]; and *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [55].

94 Terje Aven and others *Uncertainty in Risk Assessment: The Representation and Treatment of Uncertainties by Probabilistic and Non-Probabilistic Methods* (John Wiley & Sons, United Kingdom, 2014) at 5.

95 *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [72(3)].

96 Gluckman, above n 1; and Peter Gluckman *Making decisions in the face of uncertainty: Understanding risk* (Office of the Prime Minister's Chief Advisor, Part One, May 2016).

97 Mark Christensen and David Kirkpatrick "Scientific Uncertainty and Environmental Decision Making" (paper presented to the New Zealand Law Society Environmental Law Intensive Conference, November 2019) 107 at 124.

98 Jackson, above n 19, at 15.

data to help our understanding of the past, present or future state of the world.[99] A well-known example of the use of statistics in the legal setting is the presentation of forensic evidence.[100] Here, statistics can be used when a possible match between a crime stain and potential suspect has been identified.[101] If there is uncertainty surrounding this match, then statistical analysis attempts to establish a likelihood that the crime stain has come from the potential suspect rather than another person (or animal).[102]

In the context of RC applications before the NZEnvC, it is "unusual" to have precise statistics presented on an issue.[103] If evidence is given in statistical terms it is usually done so using the frequentist approach to statistics[104] or by inviting the NZEnvC to infer that statistical results found for an allegedly similar scenario will apply to the current fact scenario before the Court.[105] However, the use of Bayesian statistics could enable the NZEnvC to increase the amount of situations in which probability is given in a quantified form for a potential future effect.[106]

Bayesian statistics has attracted much controversy in the realm of evidence law;[107] some suggest that it is "likely to lead to development of the law of evidence over the next 50 years".[108] However, there is debate about whether or not it is appropriate or beneficial to

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[99] P Driscoll, F Lecky and M Crosby "An introduction to statistical inference" (2000) 17(5) J Accid Emerg Med 357 at 357.

[100] Devon Helm "Digesting the Double Helix: Receptions and Misconceptions of DNA Evidence in the New Zealand Criminal Trial" (LLB (Hons) Dissertation, University of Otago, 2015).

[101] Cameron A Price "DNA Evidence: How reliable is it? An analysis of Issues Which May Affect the Validity and Reliability of DNA Evidence" (LLB (Hons) Dissertation, University of Auckland, 1994) at 15. See this source generally for further information on the use of statistics in criminal law.

[102] At 15.

[103] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [64(3)].

[104] *R J Davidson Family Trust v Marlborough District Council* (EnvC), above n 35, at [43].

[105] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [64(3)].

[106] Jackson, above n 19, at 14–17.

[107] Stephen E Fienberg and Joseph B Kadane "The Presentation of Bayesian Statistical Analyses in Legal Proceedings" (1983) 32 J Royal Stat Soc 88 at 89.

[108] Jackson, above n 19, at 14.

incorporate this statistical approach into a legal setting.[109] This chapter will briefly cover some of main benefits and problems in regards to using Bayesian statistics in the context of resource management law. Importantly, this chapter only focusses on how Bayesian statistics can be used in relation to the assessment of probabilities of future effects. It does not attempt to analyse how Bayesian statistics can theoretically be used when making the final overall broad judgement.[110]

If the probability of a future effect occurring can be quantified using Bayesian statistics, this then raises the more general question of whether or not this quantification is desirable. Arguably, having a numerical value that is determined using a method designed specifically to deal with probabilistic reasoning is a better way of finding a probability than relying on the "global intuition"[111] of a court. However, there is debate as to whether or not this precision is necessary to establish probability before the NZEnvC.[112] Additionally there is concern that quantification may give the decision-maker a false sense of accuracy when ascribing probability.[113]

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[109] Norman Fenton, Martin Neil and Daniel Berger "Bayes and the Law" (2016) 3(1) Annu Rev Stat Appl 51 at [52]–[53].

[110] *Infinity Investment Group Holdings Ltd v Queenstown Lakes District Council* [2010] NZEnvC 234, [2011] NZRMA 310 at [42] — the NZEnvC found that a hypothesis suggested by counsel could not be used because (among other reasons) it came too close to answering the ultimate question. See also Robert M Dorazio and Fred A Johnson "Bayesian Inference and Decision Theory — A Framework for Decision Making in Natural Resource Management" (2003) 13(2) Ecol Appl 556 for information on the use of Bayesian statistics in decision-making.

[111] *Dunedin City Council v Saddle Views Estate Ltd (final decision)* [2016] NZEnvC 199 at [37]. See *Infinity Investment Group Holdings Ltd v Queenstown Lakes District Council*, above n 110, at [43] for an explanation of some of the more nuanced and contested points of the "global intuitive" approach; I use it here as a heuristic.

[112] *Orica Mining Services New Zealand Ltd v Franklin District Council* EnvC Wellington W 32-2009, 5 May 2009 at [29].

[113] Christensen and Kirkpatrick, above n 97, at 111.

C The Approach to Probability (Likelihood) taken by the Environment Court of New Zealand

As explained previously, when the NZEnvC assesses risk it is not making a finding of 'fact' in the legal sense; rather, it is a matter of judgement as to the likelihood of an event occurring and the significance of the consequences that will stem from this event.[114] The probability that an event will occur is drawn from evidence about past or current facts.[115] To try and explain this further, the NZEnvC in *Long Bay Okura Great Park Society Inc* found that for "practical purposes a probability is simply a statement of our uncertainty when making a prediction".[116]

5 Probability (likelihood) defined

Probability is simply defined as the measure of the chance (the likelihood) of an event occurring.[117] From that calculation, you can quantify the uncertainty surrounding the prediction that a future event (for example, the extinction of a species) will occur.[118] This probability is expressed as a numerical value from 0–1, or more commonly in everyday life, as a percentage.[119] If you were to toss a coin the probability that it lands on heads would be 0.5 (50 per cent).

In risk assessment terms "probability" holds the same meaning— "a measure of the chance of occurrence".[120] The chance of something happening is also expressed in risk analysis terminology by using the word "likelihood", which has the same broad meaning as probability but encompasses objective or subjective measurements and can be given in a

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[114] *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [314].

[115] *RJ Davidson v Marlborough District Council* (HC), above n 53, at [133].

[116] *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [314].

[117] Driscoll, Lecky and Crosby, above n 99, at 358.

[118] At 358.

[119] At 358.

[120] "ISO/Guide 73:2009(en)   Risk   management —   Vocabulary"   (Online   Browsing   Platform) <https://www.iso.org/obp/ui/#iso:std:iso:guide:73:ed-1:v1:en > at 3.6.1.4.

qualitative or quantitative manner.[121] A coin toss would have a "medium likelihood" of landing on heads. Unless explicitly stated, this chapter will use the risk assessment terminology to mirror the NZEnvC's approach when discussing likelihood.[122]

6   How the Environment Court of New Zealand determines probability (likelihood)

The NZEnvC tends to find the likelihood of an adverse effect occurring with assistance from expert evidence given in a qualitative or quantitative form, or a combination of both.[123] However, "[p]recise quantification of the risk is usually impossible. Far more likely are the qualitative assessments usually given to the Court."[124] In most cases this determination is guided by relevant methodology set out in the literature specific to the field of study that the evidence is within (for example, documents such as the Ecological Impact Assessment Guidelines for New Zealand).[125]

This process is exemplified in the NZEnvC decision of *RJ Davidson v Marlborough District Council* where the Court was considering whether or not a proposed mussel farm should be allowed.*[126]* Here, the NZEnvC assessed the likelihood of the potential future effects of this proposal on the habitat of the New Zealand King Shag based on expert evidence that describes the morphology of the bird, population size, habitat, feeding patterns, and how the proposed mussel farm may impact these aforementioned factors.[127] After giving this evidence detailed consideration, the Court found that there was adequate information to make conclusions on what relevant effects may occur and the probability of this occurrence: namely that it is "as likely as not there will be adverse effects on the

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[121] At 3.6.1.1.

[122] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17 at [73]. This does not provide direct authority for following the technical risk assessment language provided in ISO/Guide 73:2009(en), above n 120, but does use more general qualitative language.

[123] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17 at [68].

[124] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [64].

[125] Christensen and Kirkpatrick, above n 97, at 124.

[126] *RJ Davidson v Marlborough District Council,* above n 16.

[127] At [88]–[135] and [196]–[210].

population of King Shag and their prey"[128] and that there is "a low probability … that the King Shag will become extinct as a result of this application".[129]

Evidence of the probability of a potential effect occurring can also be presented to the NZEnvC in a quantified form, although this is less common.[130] An attempt to quantify probability was made in *Orica Mining Services New Zealand Ltd v Franklin District Council*[131] when an expert witness estimated that the probability of an Ammonium Nitrate Emulsion tank exploding was "one in 10 million per year"; in this case the NZEnvC still took a more intuitive approach and qualified the probability based on other evidence, but this example demonstrates the possibility of providing evidence in a numerical form.[132] As has been discussed, probabilities such as this that fall below 0.5 (50 per cent) can be considered by the Court when determining whether or not adverse effects can be established because there is no need to prove these predictions on the balance of probabilities.[133] It is also accepted that probabilities may be presented as a range (for example 0.23 to 0.37), rather than an exact number.[134]

(a) Language of the Environment Court of New Zealand

To promote consistency in language when referring to probability and likelihood, as well as allowing the NZEnvC to convert between the two, the case of *Clifford Bay Marine Farms Ltd* identified a helpful Table (see Appendix 1) that compares legal and scientific terminology for probability and likelihood.[135] In this decision (*Clifford Bay Marine Farms*

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[128] At [126].

[129] At [126].

[130] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [64].

[131] *Orica Mining Services New Zealand Ltd v Franklin District Council*, above n 112, at [23].

[132] At [29].

[133] *R J Davidson Family Trust v Marlborough District Council* (HC), above n 53, at [4] and [133].

[134] *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [322].

[135] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, Schedule. The Table is taken from Charles Weiss Table 3 in "Expressing scientific uncertainty" (2003) 2 Law Probab Risk 25 at 30.

Ltd), the NZEnvC aimed to use language that aligned with the IPCC scale of scientific uncertainty.[136] This Table has been referred to in subsequent cases.[137]

D   Statistics and the Law

The interplay between statistics and the law has a long history that is driven by a need for evidence based decision-making.[138] Both criminal and civil proceedings have relied upon statistics in some sense, but this relationship has had varying degrees of success.[139] Some of the earlier cases that attempted to use statistics employed "bad statistics" when giving evidence.[140] This has resulted in a slow uptake on the use of statistical evidence in the courts.[141] However, as the use of statistics in evidence has increased over the years, it has mostly been frequentist statistics that is employed (other than in the field of forensic science).[142]

E   The Potential Incorporation of Bayesian Statistics

Bayesian statistics can be used to produce a probability for a hypothesis in regards to an effect.[143] An example of this in an ecological context is using evidence of the current environment to predict water quality.[144] Evidence of factors that are known to impact

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[136] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [73].

[137] *R J Davidson Family Trust v Marlborough District Council* (EnvC), above n 35, at [42]; and *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [322].

[138] John McEldowney and Sharron McEldowney *Environmental Law & Regulation* (Blackstone Press, London, 2001) at 29.

[139] Fenton, Neil and Berger, above n 109, at [52].

[140] Norman Fenton "Improve statistics in court" (2011) 479 Nature 36 at 1.

[141] Fenton, Neil and Berger, above n 109, at [52].

[142] At 52.

[143] *Infinity Investment Group Holdings Ltd v Canterbury Regional Council,* above n 110, at [40]; and David N Barton and others "Bayesian networks in environmental and resource management" (2012) 8(3) Integr Environ Asses and Management 418 at 2.

[144] This example is loosely constructed based on information from Scarlett E Graham, Anthony A Chariton and Wayne G Landis "Using Bayesian networks to predict risk to estuary water quality and patterns of benthic

water quality (such as nitrogen, phosphorous, turbidity and temperature) can be collected to calculate the probability of a certain water quality endpoint.[145] It has been noted that the Bayesian approach is particularly useful in ecological contexts such as these:[146]

> Using prior knowledge and data, BNs [Bayesian Networks] can calculate the probability of a specific response occurring as well as the associated uncertainty. They are particularly useful for ecosystem scale modelling because they easily integrate many different types of information from different research efforts into a single integrated model.

Evidence from an expert witness could (assumedly) be given in this Bayesian manner if a study was conducted to collect all of the relevant information related to an environmental effect. However, more interestingly, the NZEnvC has suggested that it may be possible for counsel to create an appropriate hypotheses about a future effect so that the NZEnvC can then assess the probability of this in a logical manner by regarding all of the evidence on this issue (from both the respondent and defendant) sequentially to inform their belief as to whether or not the event will occur.[147] The outcome of this process would be that the NZEnvC has an updated belief in the probability of the relevant hypothesis.[148] However, this suggestion has not yet been successfully adopted in a NZEnvC case.[149] The following analysis of Bayesian statistics (in comparison to the more classical frequentist method which is used to give evidence) is predominantly applicable to this suggested use of Bayesian statistics by the NZEnvC. However, it also applies in more general terms.

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environmental DNA in Queensland" (2019) 15(1) Integr. Environ. Assess. Manag 93 at 101. But this hypothetical example is in no way representative of the study.

[145] At 101.

[146] At 94.

[147] *Dunedin City Council v Saddle Views Estate Ltd* (199), above n 111, at [35].

[148] *Infinity Investment Group Holdings Ltd v Canterbury Regional Council,* above n 110, at [40].

[149] See *Dunedin City Council v Saddle Views Estates Ltd* [2016] NZEnvC 107 at [53]–[61]; *Dunedin City Council v Saddle Views Estate Ltd (final decision),* above n 111, at [35]–[36]; *RJ Davidson v Marlborough District Council,* above n 35, at [43]*;* and *Infinity Investment Group Holdings Ltd v Canterbury Regional Council,* above n 110, at [38]–[45].

7   The difference between Bayesian and frequentist statistics

Both Bayesian and frequentist statistics can be used to make predictions about future effects based on past or current facts.[150] In a more technical sense, both approaches allow someone to evaluate evidence about competing hypotheses.[151]

These two approaches differ from one another in a few fundamental aspects.[152] It is these core differences that may make one of these approaches more suitable in a the context of environmental law or could cause controversy when that approach is used.

(a)   Philosophical differences between Bayesian and frequentist statistics

The philosophical differences between Bayesian and frequentist approaches are subject to some debate.[153] However, the common understanding is that frequentists have a notion of finding the absolute truth that exists in the world and their analysis revolves around this.[154] Comparatively, Bayesians' view the world from their perspective based on evidence that is available to them.[155] Their opinion can be updated reasonably with new data.[156] This philosophical difference can lead many to perceive Bayesian statistics as subjective, which has caused some resistance to it being incorporated into legal analysis where there is an expectation that statistics will be objective and able to deliver impartial information.[157] However, no statistical approach is truly objective in the strictest sense of the word; all

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[150] Jeremy Orloff and Jonathan Bloom "Comparison of frequentist and Bayesian inference" (18 May 2014) <http://www-math.mit.edu/~dav/05.dir/class20-prep.pdf> at 2.

[151] At 1.

[152] Alan Jessop *Let the Evidence Speak: Using Bayesian Thinking in Law, Medicine, Ecology and Other Areas* (Springer International Publishing AG, Switzerland, 2018) at 99.

[153] M J Bayarri and J O Berger "The Interplay of Bayesian and Frequentist Analysis" (2004) 19 Stat Sci 58.

[154] At 1.

[155] Cassi Kozyrkov "Statistics: The Complete Mini-Course" Decision Intelligence <https://decision.substack.com/p/statistics-the-complete-mini-course >.

[156] At 1.

[157] Fenton, Neil and Berger, above n 109, at [70].

statistical methodology is based on some underlying assumptions about the prior state of the world.[158] Bayesian statistics simply "exposes such reliance rather than conceal it".[159]

Additionally, it may be the case that the philosophy behind Bayesian statistics complements the operation of law, whereas the frequentist approach does not. In *Canterbury Regional Council v Canterbury Frozen Meat Co Ltd* evidence presented in a frequentist form was reviewed and it was noted that:[160]

> … we need to remember that our function is not so much to find the condition of the effluent in the sense that scientists might seek after absolute truth about a subject. Our function is a judicial one, to make findings on the evidence before us.

Here, the frequentist approach to seek the truth clashes with the operation of the law; the role of a court to deliver a final decision based on the facts before it is contrary to a frequentist's endless search for the absolute truth.[161] Comparatively, the Bayesian philosophy of a personal belief being updated by evidence may provide less tension with the role of law (this is discussed in more detail at a later stage).

(b) The operation of Bayesian statistics compared to frequentist statistics

Within the case of *Infinity Investment Group Holdings Ltd v Canterbury Regional Council* Bayesian statistics is described as a method for "updating our belief in the probability of the relevant hypothesis in the light of a piece of evidence … repeated for further evidence".[162] This explanation can be supplemented by a simple example.[163] If Sarah lost

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[158] Neil Chilson "Bayesian Analysis as a Framework for (Legal) Thinking" (2016) 1 Geo L Tech Rev 89.

[159] At 1.

[160] *Canterbury Regional Council v Canterbury Frozen Meat Co Ltd* (Decision A 14/94), 3 NZPTD 368 at [13] cited in *McIntyre v Christchurch City Council,* above n 54, at [6].

[161] Mun, above n 47, at 5.

[162] *Infinity Investment Group Holdings Ltd v Canterbury Regional Council,* above n 110, at [40].

[163] Mike Lee and Benedict King "Bayes' Theorem: the maths tool we probably use every day, but what is it?" (24 April 2017) The Conversation <https://theconversation.com/bayes-theorem-the-maths-tool-we-probably-use-every-day-but-what-is-it-76140 >.

her phone whilst at home, before she even starts looking for it she will have some prior knowledge as to where it could be because she knows the places where she usually leaves her phone (so it is unlikely to be the shower or freezer).[164] This knowledge would be the prior probability in Bayesian terms.[165] Sarah then hears the phone ring and is able to tell that it is coming from one side of the house.[166] With this in mind she combines her prior knowledge with this new evidence to update her belief as to where the phone is.[167] In Bayesian terms, this combination creates the posterior probability.[168] Sarah is simply updating her prior belief in the probability of the relevant hypothesis (that her phone is in a certain location) in light of new evidence.

Comparatively, frequentists do not operate using this prior knowledge that is updated by new evidence.[169] A more typical example to demonstrate frequentist statistics would be if Sarah was trying to find out whether or not there was a difference in height between males and females. Importantly, she would not let any of her prior knowledge about this influence the analysis.[170] Instead, Sarah would set up two different hypotheses and collect data to 'support' one of these.[171] This is done by creating a null hypothesis and an alternative hypothesis.[172] The null hypothesis is that there is no difference in height between the groups, whereas the alternative hypothesis is that there is a difference. If the data disproves the null (no difference) hypothesis, then you can accept that the alternative hypothesis (there is a difference) is true.[173] Importantly, Sarah would only be able to conclude that she

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[164] At 1.

[165] At 1.

[166] At 1.

[167] At 1.

[168] At 1.

[169] Judith L Anderson "Embracing uncertainty: The interface of Bayesian statistics and cognitive psychology" (1998) 2(1) Ecol Soc 1 at 1.

[170] Anderson, above n 169, at 1.

[171] See generally Driscoll, Lecky and Crosby, above n 99, at 358. This example is drawn from this information, but is not representative of the studies mentioned in the source.

[172] At 357.

[173] At 358.

can reject the null hypothesis with a certain level of confidence; this is not a conclusion as to the probability of a hypothesis being true.[174]

8   How has the Environment Court of New Zealand responded to the Bayesian approach?

The NZEnvC noted in *RJ Davidson v Marlborough District Council* that most expert evidence that does attempt to quantify the future effects of activities does so using frequentist statistics.[175] Accordingly, it is common to see frequentist notions of confidence intervals and p-values in evidence before the NZEnvC when statistical analysis is presented.[176] However, there have been recent cases that indicate support for the use of Bayesian statistics (notably within Judge Jackson's division of the NZEnvC).[177]

In *R J Davidson (EnvC)* the Court invited the parties to make submissions on the "application of the probabilistic principle known as Bayes Rule to evidence (and hypotheses about future effects) but neither counsel nor the witnesses took up the opportunity".[178] Bayesian statistics was also discussed within the case of *Infinity Investment Group Holdings Ltd* where the Court outlined some of the merits of using Bayesian statistics before ultimately finding that the hypothesis submitted by counsel was incorrectly formulated.[179] Despite the incorrect hypotheses, the NZEnvC went on to qualitatively assess the probabilities of each alleged effect by employing the reasoning that underpins Bayes Theorem: the NZEnvC updated its beliefs "as to the answers to the questions in the light of the evidence".[180] Two further related cases have mentioned the issue of Bayesian statistics, however this was not followed through.[181] Despite the failure

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[174] J Ghazoul and M McAllister "Communicating complexity and uncertainty in decision making contexts: Bayesian approaches to forest research" (2003) 5(1) Int For Rev 9 at 1.

[175] *R J Davidson Family Trust v Marlborough District Council* (EnvC), above n 35, at [43].

[176] See *Canterbury Regional Council v Canterbury Frozen Meat Co*, above n 160, at [13].

[177] Christensen and Kirkpatrick, above n 96, at 125.

[178] *R J Davidson Family Trust v Marlborough District Council* (EnvC), above n 35, at [43].

[179] *Infinity Investment Group Holdings Ltd v Canterbury Regional Council,* above n 110*,* at [38]–[45].

[180] At [45].

[181] *Dunedin City Council v Saddle Views Estates Ltd*, above n 149, at [53]–[61]; and *Dunedin City Council v Saddle Views Estate Ltd (final decision),* above n 111, at [35]–[36];

of these cases to use Bayesian statistics to produce a probability, there has been detailed discussion on the merits of this approach provided by the NZEnvC.[182] This discussion has been incorporated into the following analysis of the benefits that using Bayesian statistics in the NZEnvC may provide.

9   What are the benefits associated with Bayesian statistics?

(c) The cohesion between Bayesian statistics and the expectation of the Environment Court of New Zealand

One of the main benefits of Bayesian statistics is the fact that the final number being presented to the NZEnvC is able to directly answer the question that the Court is asking[183] and is more accessible to non-scientists.[184] The NZEnvC is trying to determine the probability of an event occurring, given the evidence before it.[185] Bayesian statistics achieves this by separately analysing each piece of evidence related to the overall hypotheses in order to produce a probability for each of these hypotheses that relate to the possible effect.[186] Comparatively, frequentist statistics tends to be presented using the more confusing terminology of "confidence intervals" to the NZEnvC, which are often misinterpreted and do not directly relate to the probability of an event occurring.[187]

(d) The relative usefulness of Bayesian statistics

The NZEnvC in *R J Davidson* noted that frequentist statistics often fails to produce a conclusion that is of actual use to the NZEnvC.[188] This may be because in resource management cases it is common that there is too much uncertainty—due to low levels of data—to reach a level of confidence where the null hypothesis can be rejected and the more

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[182] Christensen and Kirkpatrick, above n 97, at 25–26.

[183] *Dunedin City Council v Saddle Views Estates Ltd,* above n 149, at [57].

[184] Ghazoul and McAllister, above n 150, at 1.

[185] *Long Bay-Okura Great Park Society v North Shore City Council,* above n 16, at [314].

[186] *Dunedin City Council v Saddle Views Estates Ltd,* above n 149, at [57]–[59].

[187] Fenton, Neil and Berger, above n 109, at [52].

[188] *R J Davidson Family Trust v Marlborough District Council* (EnvC), above n 35, at [43].

'interesting' (and useful to the court) alternative hypothesis is accepted.[189] Comparatively, Bayesian statistics is still able to use this evidence to assess the probabilities of potential events because it has high predictive accuracy,[190] despite low levels of data, so can still provide information to the NZEnvC when there are high levels of uncertainty.[191]

(e)   The issue of the prior

The prior probability is best described as the probability that the hypothesis is true before any new evidence is considered.[192] In the example of Sarah and her lost phone, the prior probability would be the knowledge she has about where she usually leaves her phone before she hears it ring. Setting this prior is arguably one of the more controversial stages when Bayesian statistics is used in a legal context because it has the ability to influence the final posterior probability.[193] Thus, the prior probability must be chosen in a justified manner that will not favour either side in a way that contradicts the evidential standard in that case.[194] In criminal cases, especially when a jury is involved, there is debate about whether or not "beyond reasonable doubt" could ever truly be quantified.[195] However, for a civil case where the standard of proof is on the balance of probabilities, it was suggested

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[189] At [43].

[190] Carmel A Pollino and Christian Henderson *Bayesian networks : A guide for their application in natural resource management and policy* (Landscape Logic, Technical Report No. 14, March 2011) at 18.

[191] Brian J Halstead and others "Bayesian adaptive survey protocols for resource management" (2011) 75(2) J Wildlife Manage 450 at 2.

[192] Colin Aitken, Paul Roberts and Graham Jackson *Fundamentals of Probability and Statistical Evidence in Criminal Proceedings: Guidance for Judges, Lawyers, Forensic Scientists and Expert Witnesses* (eBook ed, Royal Statistical Society, 2010) at 40.

[193] Fienberg and Kadane, above n 107, at 88.

[194] At 88.

[195] Fienberg and Kadane, above n 107, at [88] and [93]; and Tony O'Hagan "Bayes' Theorem, and Its Role in the Law" (2007) 47 Med Sci Law 18 at [18]–[19]. See also Dorothy K Kagehiro and W Clark Stanton "Legal vs Quantified Definitions of Standards of Proof" (1985) 9 Law Hum Behav 159 for research on the effectiveness of quantifying standards of proof; it was found that quantified definitions of standard of proof can convey the intended meaning effectively.

by the NZEnvC in *Dunedin City Council v Saddle Views Estate Ltd* that a prior probability of 0.5 is appropriate:[196]

> At the very start of the fact-finding process in a civil proceeding the initial probability Pr(H) of the plaintiff's hypothesis H is usually assumed to be 0.5 (the balance of probabilities) but it changes as each piece of evidence is considered.

Within the context of RC applications, a prior probability of 0.5 would be appropriate for past or present facts that need to be proved under s 104(1)(a).[197] However, potential future effects have no applicable standard of proof so this matter is somewhat complicated.[198] In an extra curial paper written in 2016, Judge Jackson suggests that base rates may be used as a prior for future effects; this is the idea that basic statistics on the effects of some activities may already exist and can be used as the prior knowledge.[199] A hypothetical example for this, in the context of mining, would be where coal mining fatality statistics may already be known. This number could then be used as a prior probability and further evidence (such as the type of mine, the safety measures in place and the environment it is operating in) may be used to update this prior knowledge as to the probability of fatality. As well as using western scientific knowledge as a prior, there is a growing recognition that indigenous or local knowledge can be used when creating a prior probability in Bayesian models;[200] this is a developing area of ecology that could also be incorporated by courts when establishing base information.[201] However, in some cases it is impossible to

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[196] *Dunedin City Council v Saddle Views Estate Ltd*, above n 149, at [57].

[197] See *R J Davidson Family Trust v Marlborough District Council* (EnvC), above n 53, at [312] for an explanation of how past or present facts are subject to a traditional standard of proof.

[198] Jackson, above n 19, at 16.

[199] At 16.

[200] Rowenna Gryba " How Indigenous Knowledge is helping us fine-tune statistical models" UBC Science <https://medium.com/ubcscience/stats-660805dd930a>.

[201] Marc Girondot and Anna Rizzo "Bayesian Framework to Integrate Traditional Ecological Knowledge into Ecological Modeling: A Case Study" (2015) 35(2) Journal of Ethnobiol 337.

find prior information that can be quantified in a simple way, so Bayesian statistics may not always be appropriate for assessing future effects.[202]

(f) The cohesion between Bayesian statistics and legal reasoning

Arguably, all humans naturally reason using Bayesian logic.[203] As an individual we hold our own beliefs that we have gained from past experiences.[204] These are our own prior probabilities.[205] As we go through life, these are updated by further evidence that can change our belief in the state of the world.[206] This theory about human reasoning faces challenges at a broader theoretical scale due to limitations of a human being (such as imperfect memory capability).[207] However, in a legal context, it is possible that the NZEnvC is simply using this approach when they determine the probability (likelihood) of a past or future fact.[208] As explained in *Dunedin City Council v Saddle Views Estate Ltd (final decision)*:[209]

> It is likely that Bayes Rule simply describes what courts are doing (intuitively) in civil proceedings anyway, with a simple initial prior probability of 0.50.

Thus, using Bayesian statistics is likely to be theoretically consistent with judicial reasoning in the NZEnvC because it aligns with the method that the NZEnvC is already intuitively taking.[210] In the context of making predictions about a future effect, a human

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[202] At 15.

[203] Josh Horgan "Bayes's Theorem: What's the Big Deal?" (4 January 2016) Scientific American <https://blogs.scientificamerican.com/cross-check/bayes-s-theorem-what-s-the-big-deal/>.

[204] Mike Oaksford and Nick Chater "Precis of Bayesian Rationality: The Probabilistic Approach to Human Reasoning" (2009) 32 Behav Brain Sci 69 at 76.

[205] At 76.

[206] At 76.

[207] Robert Bain "Are our brains Bayesian?" (2016) 13(4) Significance 14 at 19.

[208] *Dunedin City Council v Saddle Views Estate Ltd (final decision),* above n 111, at 14 (footnote 31)*.*

[209] At 14, n 31.

[210] At 15, n 31.

cannot seek the absolute 'truth', we (and likely Judges) are simply making an informed decision about our belief in the probability that an event will occur.[211] Using Bayesian statistics therefore naturally aligns with the realities of environmental law.

However, in determining future effects, this analogy between the NZEnvC's reasoning and the way that Bayesian statistics operates is again complicated by the issue of prior probability; the NZEnvC does not start with an explicit prior belief, such as 0.5, when assessing future effects because there is no set standard of proof.[212] This then raises the question of what the NZEnvC's prior belief is before hearing evidence about a future effect. It is unlikely that a court will always start with a 'blank slate' before listening to the expert witnesses.[213] Humans have a tendency for bias and having some vague knowledge about the nature of a case could engage this.[214] As a hypothetical example, someone who has survived a factory explosion may be influenced when considering the probability that a storage facility for dynamite will explode. Bayesian statistics cannot mimic the NZEnvC in this manner. Instead it may improve upon it. By using the aforementioned base rates (for example the knowledge about mining fatalities that the NZEnvC holds before any new evidence is raised) as a prior probability, this prior belief is made explicit and the impact that it could have on the case is clear (contrary to any hidden human bias).[215]

(g) The benefit of updating the posterior probability

Another benefit of using Bayesian statistics that was identified by the NZEnvC in *Dunedin City Council (final decision)* is that it considers each piece of relevant evidence (regardless of who presented it) objectively and separately.[216] This means that the only question being asked is how the evidence updates the belief in the probability of a hypothesis.[217] This

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[211] Bain, above n 207, at 15.

[212] Jackson, above n 19, at 16.

[213] See Christensen and Kirkpatrick, above n 95, at 110 for a summary of cognitive biases.

[214] At 110.

[215] Chilson, above n 158, at 1.

[216] *Dunedin City Council v Saddle Views Estate Ltd (final decision),* above n 111, at [35].

[217] At [57].

analysis can draw an answer from the evidence in a potentially more objective way than a human's intuition because it is not influenced by the identity of the party presenting the evidence.[218]

10   What are the problems associated with using Bayesian statistics?

In theory, the use of Bayesian statistics to assess probability could provide advantageous. However, it is important to acknowledge the practical barriers to using Bayes theorem in court.

Research has found that expert witnesses are more familiar and comfortable with the idea of using frequentist statistics as opposed to the Bayesian approach.[219] This familiarity is likely due to the fact that technology has only recently reached the stage where Bayesian statistics can be used in any practical sense;[220] those who were educated before this time would naturally be more inclined to use the frequentist approach.[221] Regardless of the reasons, this unfamiliarity of expert witnesses means that even if the NZEnvC calls for evidence to be presented in a Bayesian form, the witness may not be able to comfortably carry this out.[222]

At a broader level, there is a widely shared difficulty in understanding Bayesian statistics.[223] The NZEnvC has noted that lawyers generally struggle with understanding the logic behind Bayes theorem.[224] In the case of *Dunedin City Council (final decision)* both counsel declined to use the Bayesian approach that the NZEnvC had laid out in a prior

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[218] *Dunedin City Council v Saddle Views Estates Ltd (107),* above n 149, at [57] and [58].

[219] Stephen E Fienberg and Michael O Finkelstein "Bayesian Statistics and the Law" in JM Bernado and others (Eds) *Bayesian Statistics* (5th ed, Oxford University Press, Oxford, 1996) 129 at 3.

[220] Chilson, above n 158, at 1.

[221] Eiki Satake and Amy Vashlishan Murray "Teaching an Application of Bayes' Rule for Legal Decision-Making: Measuring the Strength of Evidence" (2014) 22(1) J Educ Stat 1 at 1.

[222] Fienberg and O Finkelstein, above n 219, at 6.

[223] Fenton, above n 140, at 36.

[224] *Dunedin City Council v Saddle Views Estate Ltd*, above n 149, at [58].

interim decision, and there was some criticism directed towards it.[225] Judges have also been found to ignore statistical evidence when determining a case (although this empirical study was not carried out in New Zealand).[226] This overall reluctance to engage in Bayesian statistics presents a very real challenge that is yet to be overcome in the NZEnvC.[227]

Another related issue to this is whether or not it is possible to introduce this widely misunderstood approach into a realm where not everyone is required to have mathematical training.[228] The problems that can arise from this are highlighted in a series of criminal cases from the Courts of England and Wales where flawed statistical analysis was used at trial and only corrected on appeal.[229] These cases resulted in a wide mistrust surrounding the use of statistics in law, especially the use of the Bayesian approach.[230] There have been calls to address this misunderstanding of statistics in the law by teaching law students and judges the basics of Bayes theorem[231] or improving the way that statistics is communicated in court.[232] However, for now, the inclusion of Bayes in legal analysis seems to carry the risk of being misinterpreted.

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[225] *Dunedin City Council v Saddle Views Estate Ltd,* above n 111*,* at [36].

[226] Fienberg and O Finkelstein, above n 219, at 26. This study was carried out within the American legal system.

[227] All three instances in which the NZEnvC has encouraged the use of Bayesian statistics have not succeeded in this desired result due to some error in the framing of the hypotheses or reluctance from the parties involved. See *Dunedin City Council v Saddle Views Estates Ltd*, above n 149, at [53]–[61]; *Dunedin City Council v Saddle Views Estate Ltd (final decision),* above n 111, at [35]–[36]; *RJ Davidson v Marlborough District Council,* above n 35, at [43]*;* and *Infinity Investment Group Holdings Ltd v Canterbury Regional Council,* above n 110, at [38]–[45].

[228] Resource Management Act, s 249.

[229] Fenton, Neil and Berger, above n 109, at 52.

[230] Angela Saini "A formula for justice" (2 October 2011) *The Guardian* (online ed, 2 October 2011).

[231] Bernard Robertson and Tony Vignaux "Don't teach Statistics to Lawyers" (paper presented at the Fifth International Conference on Teaching of Statistics, Singapore, 1998).

[232] Anderson, above n 169, at 2.

11   Conclusion on the benefits of Bayesian statistics

Following this detailed discussion of assessing probability using Bayes theorem, it is important to emphasise that not everything can be quantified. As has already been noted in the case of *Clifford Bay Marine Farms Ltd,* "[p]recise quantification of the risk is usually impossible. Far more likely are the qualitative assessments usually given to the Court".[233] However, in cases where the evidence is available to support statistical analysis, it seems that the use of Bayesian statistics should be preferred (assuming that those involved are comfortable enough to use it) because this approach delivers evidence on the probability of a future effect occurring in a manner that the decision-maker intuitively expects when seeking a probability.[234]

F   Is Quantifying Probability (in General or Using Bayesian Statistics) Desirable?

Whether or not quantification is necessary or desirable is a subsequent issue that warrants discussion. Providing a numerical probability for a potential effect occurring can clearly give a set value to the NZEnvC rather than relying on an intuitive approach where humans are required to draw a probability from the evidence based on their judgement.[235] This may eliminate some of the subjectivity that was highlighted as a possibility when determining probability in *Clifford Bay Marine Farms Ltd.[236]*

However, there appears to be disagreement as to whether or not this level of precision is necessary.[237] In the case of *Orica Mining Services New Zealand Ltd,* in which the applicant was seeking a RC to allow it to store Ammonium Nitrate Emulsion, an expert witness estimated that there was "one in 10 million per year" chance of explosion.[238] When determining the likelihood of this explosion (and subsequent damage) occurring, the

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[233] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [64(3)].

[234] Fienberg and O Finkelstein, above n 219, at 129.

[235] Jackson, above n 19, at 34.

[236] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [61] and [72(3)].

[237] Christensen and Kirkpatrick, above n 97, at 111.

[238] *Orica Mining Services New Zealand Ltd v Franklin District Council*, above n 112, at [29].

NZEnvC found that because the industry deemed some sort of safety regulation necessary when manufacturing and storing Ammonium Nitrate Emulsion, some low level of probability must exist to justify these measures.[239] After making this observation, the NZEnvC then went on to comment that it did not need to concern itself with attempting to use statistical analysis to determine the exact numerical figure of this probability.[240] Instead, the NZEnvC continued to attribute qualitative labels, such as, "above something that is negligible"[241] and "foreseeable, even if at the low end of the spectrum of probability"[242] when talking about the likelihood of explosion. This indicates the reluctance of the NZEnvC to delve into the often tricky area of finding a quantitative value and the more general hesitancy that people have in quantifying beliefs such as this.[243]

Additionally, providing probability in a numerical form may also put the decision-maker at risk of precision bias.[244] This is a cognitive bias where the use of a seemingly precise numerical figure or range leads someone to believe that a number is accurate.[245] In the context of probability, this argument becomes more complex as probability is simply a "guess" surrounding the quantification of uncertainty. However, the fact that decision-makers may be lulled into a false sense of security if precise numbers are presented must be acknowledged.[246]

G   Overall Conclusion

In terms of providing a clear and consistent framework to the assessment of probability, Bayesian statistics appears to be a useful tool to quantifying or otherwise providing more guidance to the this process. Importantly, it can introduce objectivity to many stages of the

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[239] At [29].

[240] At [29].

[241] At [29].

[242] At [30].

[243] Franco Taroni and others *Bayesian Networks for Probabilistic Inference and Decision Analysis in Forensic Science* (2nd ed, John Wiley & Sons, United Kingdom, 2014) at 1.

[244] Christensen and Kirkpatrick, above n 97, at 112.

[245] At 112.

[246] At 112.

assessment; when setting the prior probability the number that is used can be explicitly recognised,[247] the assessment of evidence will be carried out without regarding the identity of the party presenting it,[248] and the final probability will be determined using a repeatable and recorded method that goes beyond pure "intuition".[249] There may be further debate on whether or not this quantification is desirable in a legal context, however, if this quantification is taken with the understanding that it is the 'best guess' that the evidence can provide, then I suggest that it is an appropriate methodology to enable the NZEnvC to assess probability when predicting the future.

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[247] Jackson, above n 19, at 16.

[248] *Dunedin City Council v Saddle Views Estate Ltd (final decision),* above n 111, at [35].

[249] Jackson, above n 19, at 34.

IV The Second Element of Risk: The Consequences on the Environment

Attributing significance to the predicted consequence of an activity is a complex exercise that is carried out in the process of risk analysis.[250] This chapter will briefly highlight the difficulties associated with valuing the environment and explain how the NZEnvC currently assesses the significance of a consequence by using expert evidence. As with determining probability, it has been acknowledged that within this process, a value judgement is made by the NZEnvC that may have an element of subjectivity.[251] Given this possibility of subjectivity, the NZEnvC should aim to assess the significance of the environment in the most consistent and clear manner possible so that their reasoning is transparent to those who are involved in the process or are otherwise invested in the outcome of the decision. If possible, this assessment of environmental value should be guided by set principles or reference points.

It is important to acknowledge that this assessment will always be underpinned by the values that people attribute to the environment.[252] Ideally, the NZEnvC would be able to capture society's ever-evolving values[253] in regards to the environment and use these to place a significance on the potential consequences that they are assessing (along with economically and scientifically attributed value).[254] However, there is no perfect way to achieve this using the current methodology.[255] Instead, it may be possible to draw from a

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[250] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [55].

[251] At [61] and [72(4)].

[252] Ben R Newell and others "The Psychology of Environmental Decisions" (2014) 39(1) Annu Rev Environ Resour 443 at 446.

[253] Freek J Venter and others "The Evolution of Conservation Management Philosophy: Science, Environmental Change and Social Adjustments in Kruger National Park." (2008) 11(2) Ecosystems 173 at 173.

[254] Stephen Polasky and Seth Binder "Valuing the Environment for Decisionmaking" (2012) 28(4) Issues Sci Technol 53 at 53–61.

[255] Peter Clough and Michael Bealing *What's the use of non-use values? Non-Use Values and the Investment Statement* **(**New Zealand Institute of Economic research, Revised NZIER report to The Treasury, 1 February 2018) at 29.

central source that is representative of the general public or has been legitimized by society in a legally and politically acceptable manner to attain a representation of these values. This chapter aims to discuss whether or not the NZEnvC can attribute significance to the environment by reference to such guidance.

To achieve a thorough discussion on the best method for valuation of the environment in a resource management decision-making context, I will compare two propositions that have been made to clarify risk assessment. In doing so, I aim to demonstrate how crucial it is for any attribution of environmental significance to include broader policy objectives that are drawn from society; although science plays an important role in resource management, it must be remembered that policy and value judgements are also relevant.[256]

The first of the suggested improvements to risk assessment which I will analyse is the idea that environmental value should be quantified using a monetary figure to provide consistency to decision-makers and ensure that environmental services are not overlooked.[257] Although this suggestion may be useful to the NZEnvC if carried out in a standardized manner, the traditional methodology that is currently utilised to determine the non-market value of the environment tends to be inconsistent and does not appropriately account for public participation or nationally held values.[258] Thus, although a standardized method of attributing a fiscal value to the environment may be helpful, the NZEnvC must go beyond this to seek guidance on how the general public attributes value to the world surrounding them.

The second suggestion for guiding risk assessment (although made in a different context to this thesis), is the use of national policy statements or national environmental standards.[259] This suggestion has arisen from the recognised need for central guidance on

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[256] Somerville, above n 18, at 430.

[257] Peter Clough, Matt Hickman and John Stephenson *Valuing natural assets: Essential for decision making* (New Zealand Institute of Economic research, NZIER public discussion document, May 2013) at 25.

[258] Clough and Bealing, above n 255, at 29.

[259] Somerville, above n 18, at 450–492.

the issue of risk assessment to counter the episodic nature of decisions from local authorities or the NZEnvC.[260]

After analysing both of these suggested methodologies for improving risk assessment, I will explore the notion that the NZEnvC may be able to draw guidance from within the broader legal system of New Zealand (outside of the RMA) when assessing the significance of a consequence. These central sources have been legitimized (to varying degrees) in a legally and politically acceptable manner through the democratic process.[261] By referring to these sources, the NZEnvC may be able to incorporate broader centralised societal values when attributing significance to the environment.

Although the following discussion may initially appear to encapsulate the debate as to whether science or policy should be preeminent in the risk assessment realm,[262] this is not the intention of my analysis. Rather, I aim to assess how the NZEnvC can draw from a legally and politically legitimized framework as guidance for environmental valuation.

H   The Challenges of Valuing the Environment

Valuing the environment is complicated by the need to account for the intrinsic value of nature, considerations of intergenerational equity and society's evolving beliefs regarding the natural and physical world that we live in.[263] There is no obvious market for many aspects of the natural and physical world; where the price of a house may be easily

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[260] At 450 and 461.

[261] Wojciech Sadurski "Law's Legitimacy and 'Democracy-Plus'" (2006) 26(2) Oxf J of Leg Stud 377 at 377–380. Note that this source contains further detail about the requirements for law to be fully legitimate.

[262] Veerle Heyvaert "Risk Regulation and Administrative Constitutionalism by Elizabeth Fisher" (2009) 72(5) The Mod Law Rev 873. Elizabeth Fisher criticises the dichotomy between science and policy (or the democratic process).

[263] Michael Hanemann "Valuing the environment through contingent valuation" (1994) 8(4) J Econ Perspect 19 at 19–20; and Polasky and Binder, above n 254, at 53–61.

quantified based on market value, most aspects of the broader "environment" have no directly attributable value because there is no set reference point to determine price from.[264]

Additionally, accounting for intergenerational equity poses a problem when deciding how to attribute significance to the environment.[265] Put simply, "[t]here is no market for inter-generational property rights"[266] so there will always be a question about how natural and physical resources should be valued in light of the requirement to distribute these over both space and time.[267]

Another difficulty faced when determining the significance of the environment is the fact that the value of the environment is, at least partially, determined by the significance that humans attribute to it (all philosophical debates aside).[268] This leads to the logical conclusion that decision-makers must also incorporate this societal value when determining the significance of the environment, which is no simple task.[269]

12 The problems associated with the inability to value the environment

The inability to clearly value the environment creates a problem for decision-makers when attempting to determine the significance of environmental consequences. As "many potential risks are hard to quantify, and involve subjective judgments of value",[270] it is

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[264] Hugh Ward "Citizens' juries and valuing the environment: A proposal" (1999) 8(2) Environ Politics 75 at 75.

[265] James Summers and Lisa Smith "The Role of Social and Intergenerational Equity in Making Changes in Human Well-Being Sustainable" (2014) 43(6) Ambio 718 at 718.

[266] Somerville, n 18, at 397.

[267] Summers and Smith, above n 265, at 718; and see generally Bruce Pardy *Environmental Law: A Guide to Concepts* (Butterworths Canada, Canada, 1996) at 64 for explanation on the economic process of "discounting."

[268] Murray G Patterson and Anthony O Cole "Total economic value" of New Zealand's land-based ecosystems and their services" in Dymond JR (ed) *Ecosystem services in New Zealand – conditions and trends* (Manaaki Whenua Press, Lincoln, New Zealand, 2013) 496 at 496.

[269] At 496.

[270] Gluckman, above n 1, at 5.

inevitable that a consent authority will not objectively assess the significance of environmental consequences.

At the later stage of the overall broad judgement, this inability to determine value is also problematic when the consent authority is faced with a choice between a quantified value (most often for economic benefits) and a potential adverse effect on the environment that cannot be expressed accurately in monetary terms.[271] The NZEnvC in *West Coast Environmental Network Inc v West Coast Regional Council and Buller District Council* acknowledged that the facts of the case before it were balanced between economic and ecological values, before noting that:[272]

> Ultimately, the issue for the Court to determine in the light of the relevant statutory instruments and the overarching purpose of the Resource Management Act, is which of the various competing elements amongst those favouring consent and those favouring refusal, merits the more significant influence in the final outcome.

This statement directly acknowledges the fact that the value attributed to environmental consequences may influence the final decision of whether or not a RC is granted. Thus, this decision as to the significance of a consequence may be determinative. When humans are faced with decisions such as these, there are a myriad of cognitive biases that may influence the outcome[273] and it is postulated that we may simply find a result that is 'good enough' when deciding a course of action.[274] By leaving the decision-maker to determine the significance of the environment, there is room for a high degree of subjectivity. Although this will never be eliminated, it may be moderated by external guidance.

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[271] Gluckman, above n 1, at 21–23.

[272] *West Coast Environmental Network Inc v West Coast Regional Council and Buller District Council* [2013] NZEnvC 47 at [3].

[273] Md Sayed Iftekhar and David J Pannell ""Biases' in Adaptive Natural Resource Management" (2015) 8(6) Conserv Lett 388 at 388–394; Gluckman, above n 1, at 8–11; and Christensen and Kirkpatrick, above n 97, at 112.

[274] Gustavo Barros "Herbert A. Simon and the concept of rationality: boundaries and procedures" (2010) 30 Brazilian Journal of Political Economy 455 at 455–457.

I   How does the Environment Court of New Zealand Determine Environmental Significance?

As with probability, evidence of environmental value may be given in quantitative or qualitative form and the NZEnvC then makes an overall qualitative judgement as to the significance of the consequence.[275] The NZEnvC in *Shirley Primary School* noted that determining the significance of the consequences is the "necessarily less objective assessment" in the process of risk analysis,[276] because it can require judgement on matters such as human health or life that are inherently difficult to attribute value to.

The assessment of environmental significance is demonstrated in *West Coast Environmental Network Inc.*[277] Here, the NZEnvC heard expert evidence on threatened or at risk plants that grew in the wetlands and how the proposed mining activity may impact this flora.[278] In the assessment of this future effect, the NZEnvC found that "[t]he loss of a number of rare wetland plants from the mine site is likely and constitutes an adverse ecological effect of some significance."[279] There was no explicit reference point as to why the loss was "of some significance" other than the expert evidence presented to the NZEnvC. Rather, the NZEnvC simply made this value judgement in a qualitive manner based on the facts before it.[280] This assessment of significance occurs in a broader context, as recognised in *Clifford Bay Marine Farms Ltd,* where it was suggested that potential effects must be assessed "in the light of the principles of the RMA, and the objectives and policies of the relevant instruments".[281]

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[275] Mark Christensen and Maree Baker-Galloway "Valuation of Natural Assets- What the Courts Have Said So Far" (August 2013) RMJ 9 at 16; and Jackson, above n 19, at 32–33.

[276] *Shirley Primary School v Christchurch City Council,* above n 15, at [131].

[277] *West Coast Environmental Network Inc v West Coast Regional Council and Buller District Council,* above n 272, at [150].

[278] At [150].

[279] At [150].

[280] *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [314].

[281] *Clifford Bay Marine Farms Ltd v Marlborough,* above n 17, at [68].

J   Valuing the Environment in Monetary Terms

Determining the significance of consequences in the NZEnvC is complicated by the inherent challenges of valuing the environment, as aforementioned.[282] There have been suggestions that quantifying these consequences in monetary terms could improve the process of assessing environmental significance by ascribing a set numerical figure that decision-makers can refer to.[283] Arguably, this non-market valuation is required so that the intrinsic value of the environment and the services that it provides are fully recognised by decision-makers.[284] However, the traditional methodologies that are commonly used to achieve this valuation tend to be inconsistent with one another, resource intensive or are centered on solely scientific methodology that is unable to properly account for public participation and broader policy.[285]

The inadequacy of these non-market valuation methods was an issue raised in *West Coast Environmental Network Inc:[286]*

> ...non-market valuation, that is the attribution of value to effects not observed in market prices, was fraught with difficulties such as the experimental nature of some of the methods used, and reliance on hypothetical questions which might give unrealistic answers. Mr Clough's evidence fairly acknowledged that the techniques used to arrive at non-market valuations were time-consuming and resource-intensive, and that the variable methodologies used in New Zealand do not provide a reliable set of indicative values.

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[282] Patterson and O Cole, above n 268, at 496–497.

[283] Clough, Hickman and Stephenson, above n 257, at 28–30.

[284] Patterson and O Cole, above n 268, at 496–497.

[285] Christensen and Baker-Galloway, above n 275; and *West Coast Environmental Network Inc v West Coast Regional Council and Buller District Council,* above n 277, at [110].

[286] *West Coast Environmental Network Inc v West Coast Regional Council and Buller District Council,* above n 277, at [110].

This effectively summarises the shortcomings of these valuation methods. Notably, the NZEnvC drew attention to the inability of these methodologies to provide indication of the value that society attributes to the environment. This problem has been echoed outside of the legal system as a general theme relating to non-market valuation research:[287]

> Studies tend to derive localised estimates that are not readily generalisable or scalable to a national level, and [i]t is hard to find studies that aim to establish national values

This presents a problem in the context of resource management because one of the core notions of "sustainable management" under the RMA is the management of natural and physical resources in a way that "enables people and communities to provide for their social, economic and cultural well-being".[288] Using non-market value methodologies that do not appropriately incorporate public participation or broader societal values when attributing significance to the environment runs counter to this overall purpose of the RMA.[289] It excludes those people and communities who should be represented or involved when decisions concerning the environment are being made.[290] Sustainable management requires more than 'balancing the books' in monetary terms. Even in scenarios where members of the public are questioned as to how much they would hypothetically pay for an aspect of the environment (contingent valuation),[291] this reduces the role of the public to that of consumer choice, rather than enabling their engagement in sustainable management though political choice as is appropriate.[292]

This lack of broader public participation or policy value does not exclude non-market valuation from being a useful tool. Indeed, if there is a standardized way to attribute

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287 Clough and Bealing, above n 255, at 29.

288 Resource Management Act, s 5.

289 Section 5.

290 Somerville, above n 18, at 397.

291 Hanemann, above n 263, at 19–21.

292 Somerville, n 18, at 403.

a monetary value to the environment this may prove useful to the NZEnvC.[293] However, because there is no effective way to establish central public values using this methodology, it cannot currently provide all of the information that a decision-maker needs.

K   Attributing Value to the Environment using Central Policy Documents

Another method that has been suggested to provide clarity in the area of risk assessment is clear direction from national policy statements or national environmental standards.[294] These are both instruments that are created by central government and can influence the regional and district levels of the RMA hierarchy.[295] In his PhD thesis, Dr. Royden Somerville QC assessed the use of these centralised mechanisms for setting guidance in regards to the level of risk that is acceptable to society.[296]

Whilst doing this, Dr. Royden Somerville QC also provided underlying reasoning as to why consistent centralised guidance is needed. It is this reasoning that will be analysed to highlight why an alternative method for providing guidance to the NZEnvC on the assessment of environmental significance is required.

Firstly, it was highlighted that there needs to be some safeguard against arbitrary decision-making so that there is consistency in the outcomes of resource management decisions.[297] In the context of valuing the environment, this would be achieved by having some central objective set of guidelines so that significance is attributed to the environment following a standardized process.

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[293] Christensen and Baker-Galloway, above n 275, at 16.

[294] Somerville, above n 18, at 450–492.

[295] Warnock, above n 22, at 509; and Environment Foundation "National Environmental Standards: What are national environmental standards?" (Environment Guide, 15 February 2019) <http://www.environmentguide.org.nz/rma/planning-documents-and-processes/national-environmental-standards/ >.

[296] Somerville, above n 18, at 450–492.

[297] At 450.

Secondly, Dr. Royden Somerville QC raised the issue that there is need for consistency across boundaries; environmental effects are not limited to the region that a decision is made in.[298] This issue of regional level assessment causes problems when assessing environmental significance, although in a different manner. Regions of New Zealand may have some of the more inherently valuable ecosystems within them.[299] The question then arises as to whether these areas are valued by the decision-maker in the context of the region, or at a national level. Arguably, there should be both national and regional values incorporated so that there is a broader national context to compare significance against, but also localised knowledge.[300]

Lastly, it is postulated that the NZEnvC determines cases mostly on a factual basis and in an episodic manner.[301] There is a need to indicate which values are driving these decisions; similarly, there is a need to specify how value-judgements concerning the significance of environmental consequences are made.[302]

These observations as to the faults in the resource management decision-making process highlight the need for some form of guidance to be provided so that there is consistency and clarity in the way that significance is attributed to the environment.

L   Suggestions for Valuing the Environment within the Broader Legal Framework

The NZEnvC operates within a polycentric governance system that is guided by a hierarchy of legislation and other relevant documents.[303] However, when determining the

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[298] At 489.

[299] Nicholas Singers and Geoffrey Rogers *A classification of New Zealand's terrestrial ecosystems* (Department of Conservation, May 2014).

[300] Somerville, above n 18, at 490(14).

[301] At 490(11).

[302] At 490(11).

[303] Bret Birdsong "Adjudicating Sustainability: New Zealand's Environment Court and the Resource Management Act" (2002) 29 Ecol Law Q 1 at 12.

significance of value it may be appropriate to draw guidance regarding the nationally held value of the environment from sources outside of this, namely from within the broader legal framework of the New Zealand legal system. The benefits to this potential approach will be weighed, before assessing what level the NZEnvC can be expected to draw guidance from and how this may be done for each relevant instrument.

Reference to this legal framework is not intended to provide a determinative value for the environment, but simply adds another source that a decision-maker can assess before making their final judgement. The aim of this additional consideration is to encourage consent authorities to infer environmental value from a central source that has been politically and legally validated before making a final decision.[304]

13 *Using the wider legal framework to establish significance*

It is postulated that if legislation outside of the RMA has a clear purpose of protecting an aspect of the environment or preventing an effect from occurring, the NZEnvC should refer to this when valuing the environment to help determine the final significance that is attributed to the consequence. As legislation has been created via the democratic process it is, to an extent, politically and legally legitimised.[305]

(a) Examples of using primary legislation to find significance

In *Aquamarine Ltd* the NZEnvC considered the issue that potential discharge of ballast water may pose to the environment.[306] Notably, there was a risk that invasive species (or foreign organisms) could be released into the fiord[307] and lead to subsequent ecological damage.[308] Here, the significance of this environmental consequence can be calibrated against the purpose of other legislation within the wider legal framework of New Zealand

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[304] Sadurski, above n 261, at 377–380.

[305] At 377–378.

[306] *Aquamarine Ltd v Southland Regional Council,* above n 42, at 15.

[307] At 37.

[308] At 72.

(if my hypothetical guidance were to being used). Notably, the Biosecurity Act 1993, Hazardous Substances and New Organisms Act 1996 and Wild Animal Control Act 1977 are all associated with either the prevention or control of invasive species. The former two pieces of legislation appear to be concerned primarily with preventing foreign (or invasive) species from entering the country.[309] If the NZEnvC were to draw value from these broad purposes, then the significance that would be attributed to the consequences associated with invasive species in a fiord would be high. There is a central aim to prevent foreign organisms entering New Zealand (albeit, not in a marine centric context) in these statutes. Thus, it would seem consistent with this to place a high significant on the effect that invasive organisms in the fiord may have on the environment.

(b) Limitations to using primary legislation for guidance

Of course, the use of legislation cannot always provide a clear framework because there is still an element of statutory interpretation that could vary between decision-makers. However, as a simple reference point this may be enough to require decision-makers to consider broader national values.

14 Using secondary legislation (with a focus on regulations) to guide significance

Some regulation may be appropriate for the NZEnvC to reference if it is made by the Governor-General and overseen by the House of Representatives.[310] However, the use of secondary legislation (more broadly) as guidance for valuing environmental significance presents a practical problem; until the process under pt 5 of the Legislation Act 2019 has been completed (which will clearly identify all secondary legislation and where it is located), there may be difficulty in ensuring that secondary legislation is referred to

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[309] Biosecurity Act 1993, s 28A, 28A and 29; and Hazardous Substances and New Organisms Act 1996, s 39–253.

[310] Parliamentary Counsel Office "Secondary Legislation Bill: About the Bill" <http://www.pco.govt.nz/secondary-legislation-bill/ >; and Sadurski, above n 261, at 377–380.

consistently because it is not easily located.[311] Additionally, instruments that are made outside of government may not be legitimised by the democratic process.[312]

M Conclusion:

There is a clear need for guidance when attributing a value to the environment. This chapter has suggested that this guidance may be drawn from the wider legal framework. However, whether or not this suggestion would work in practice due to the wide interpretation that can be given to legislative purpose is unclear.

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[311] At 1.

[312] Sadurski, above n 261, at 377–380; and Parliamentary Counsel Office, above n 310, at 1.

V Conclusion

Predicting the future will never have a certain outcome, nor will it ever be 'risk free.'[313] The NZEnvC is required to traverse the polycentric realm of resource management law to make predictions as to potential effects of activities.[314] This task is carried out against the inherent complexities of the natural environment and often conflicting societal values.[315] Under these conditions, it would be impossible to create a theoretical framework in which the consideration of future effects is entirely standardised to produce 'certain' results when determining the level of risk. However, this is an area which could benefit from improvement so that there is more calculability in decision-making for interested parties and greater consistency in the outcomes of RC applications. This could be achieved by creating a standardised method, or guidelines, for assessing future effects so that the consent authority determines risk within a bounded framework or by using consistent methodology.

This thesis has aimed to analyse how the RC decision-making process can be carried out in a clearer and more calculable manner. By focussing on the requirement for the NZEnvC to "have regard' to potential future effects under s 104(1)(a), it has become apparent that the law requires an analysis of risk when assessing future effects.[316] Importantly, this analysis must be split into the two components of "probability" and "consequence" (impact on the environment).[317] Within the assessment of both of these components, there is room for further clarity and calculability.

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[313] *Shirley Primary School v Christchurch City Council,* above n 15, at [106].

[314] Resource Management Act, s 104.

[315] Charlotte Aspin "There is No Plan B**:** The Necessity of Public Participation in the Plan Making Process" (LLB (Hons) Dissertation, University of Otago, 2017) at 8.

[316] *Clifford Bay Marine Farms Ltd v Marlborough District Council,* above n 17, at [55].

[317] At [55].

Probability is "simply a statement of our uncertainty when making a prediction".[318] The NZEnvC currently determines the probability that a future effect will occur by carrying out a qualitative assessment based on the evidence before them.[319] However, this thesis has postulated (by drawing heavily on case law) that the use of Bayesian statistics to quantify probability may provide a more objective and calculable outcome. It is acknowledged that there are limitations to this: Bayesian statistics is often misunderstood in a wider sense,[320] and the presentation of probability in a numerical form is also contested because it may portray a false sense of accuracy.[321] These limitations may mean that in a practical sense Bayesian statistics will not successfully be established in the NZEnvC. However, given the theoretical advantages that it offers it should be encouraged as a method to increase objectivity in probabilistic assessment.

The more helpful component of risk to have guidance on is the assessment of environmental significance, which has been recognised as the "less objective assessment" in the process of risk analysis.[322] This thesis has stressed the need to ensure that environmental significance is not restricted to a purely scientific assessment because this would not be reflective of the broad requirement of "sustainable management" under s 5 of the RMA, which requires public involvement. This is not encouraging a dichotomy between science and the democratic process;[323] rather, it is simply acknowledging that environmental value is a broad concept. Within this thesis, I have proposed that it may be possible to draw guidance on the significance of the environment from the wider legal framework. This proposal is flawed due to the uncertainty that it would involve in practicality. However, given the inherent uncertainty in the process of risk analysis, this extra stage in the assessment of environmental significance may be appropriate in certain circumstances (especially if there is legislation that is clearly applicable in the context).

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[318] *Long Bay-Okura Great Park Society v North Shore City Council*, above n 16, at [314].

[319] At [314].

[320] Fenton, above n 140, at 36.

[321] Christensen and Kirkpatrick, above n 97, at 112.

[322] *Shirley Primary School v Christchurch City Council,* above n 15, at [131].

[323] Heyvaert, above n 262.

Although this discussion does not provide any clear answers on how the NZEnvC should predict the future, hopefully it elicits some of the more contentious points regarding risk analysis.

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VII Appendix 1

TABLE 3 *Comparison of the 'legal', 'scientific', 'Bayesian' and 'IPCC' scales of scientific uncertainty*

Level	Legal standards of proof	Informal scientific levels of certainty	Bayesian probability	Level in IPCC scale	IPCC assertions (2001)
10	'Beyond any doubt'	Fundamental theory that explains a wide range of observations	100%	(absent)	(none)
9	'Beyond a reasonable doubt'	Rigorously proven; critical experiment(s) give(s) a clear result	>99%	'Virtually certain'	CO_2 emissions from fossil fuel burning will be the dominant influence on trends in atomospheric concentrations of CO_2 in the 21st Century.
8	'Clear and convincing evidence'	Substantially proven; a few details remain to be worked out 'Reasonably certain'. (see main text)	90–99%	'Very likely'	The projected rate of global warming has no precedent in the last 10 000 years; globally, the 1990s were the warmest decade since 1861; forests took up more CO_2 in the 1990s than was lost to deforestation.
7	'Clear showing'	Very probable	80–90%	'Likely'	1998 was the warmest year, and 1990 was the warmest decade in the Northern Hemisphere in the last 1000 years; The present atmospheric CO_2 concentration has not been exceeded in the past 10 000 years; there is increased future risk of drying and drought in mid-latitude continental interiors; the Greenland Antarctic ice sheet will lose mass and the Antarctic ice sheet will gain mass.
6	'Substantial and Credible Evidence'	Probable; evidence points in this direction, but not fully proven	67–80%		
5	'Preponderance of the Evidence'	If I have to choose, this seems more likely true than untrue	50–67%	'Medium Likelihood'	(None)
4	'Clear Indication'	Attractive but unproven; evidence is beginning to accumulate in this direction	33–50%		
3	'Probable cause: reasonable Grounds for Belief'	Plausible hypothesis, supported by some evidence	10–33%	'Unlikely'	Warming over the past 1000 years is entirely of natural origin, according to reconstructions of climatic data; changes in natural forcing [i.e. causes that are not human-induced] are sufficient to explain global warming during the last 50 years.
2	'Reasonable, articulable grounds for suspicion'	Possible	1–10%	'Very unlikely'	Warming over the past 100 years is due to internal variability, as estimated by current models. The loss of grounded ice will lead to a substantial rise in sea level during the 21st century.
1	'No reasonable grounds for suspicion'	Unlikely: available evidence is against it, or violates existing paradigms, but not entirely ruled out	<1%	'Exceptionally unlikely'	(None)
0	'Impossible'	Against the known laws of physics or other science	0%		(None)

Charles Weiss Table 3 in "Expressing scientific uncertainty" (2003) 2 Law Probab Risk 25 at 30.