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Article

Applying the Precautionary Principle to Hidden Collapse

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Abstract: There is growing evidence around the world of serious decline in biodiversity requiring urgent application of precautionary risk management. A better regulatory regime for precautionary management of long-term risk is now an urgent priority. This article addresses the prioritization of long-term risk management by examining risk management of ecosystems that may be experiencing hidden collapse. Hidden collapse refers to the existence of environmental indicators indicative of future collapse of forests, even though the forest appears intact and not at risk of ecosystem collapse. Professor David Lindenmayer and Dr Chloe Sato (Lindenmayer) first identified hidden collapse in 2018 in Mountain Ash forests of Victoria, Australia. The risk of hidden collapse represents a long-term environmental threat and is a potential trigger for application of the precautionary principle (principle). Implicit in hidden collapse are two preconditions for application of the principle; the risk of a serious or irreversible environmental threat, and the existence of scientific uncertainty about the nature of the risk. Despite hidden collapse satisfying these essential preconditions for applying the principle, decision makers did not apply it in respect hidden collapse of Mountain Ash forests in Victoria. This article considers the current status of the principle in regulation and how it can be adjusted to address long term environmental risk.

Keywords: precautionary principle; sustainability; risk management; long term criteria and indicators of sustainability

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1. The Principle and Hidden Collapse

The principle is used as a regulatory mechanism to apply precautionary measures where there is the threat of serious risk to the environment or human health, and scientific uncertainty about the extent of that risk [1]. Versions of the principle vary across jurisdictions; however this article adopts the following as applied to environmental risk: '. . .if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation [2]. This construction establishes two preconditions for application. The first is a threat of serious or irreversible environmental damage, and the second, a lack of full scientific certainty. Where these preconditions are met the decision maker should take precautionary measures to prevent environmental damage.

Whilst the principle has widespread use, this article argues for a fundamental change in how it is used in regulation to address long term environmental risk. The aim is to provide a more rigorous framework for the incorporation of science, particularly through the use of criteria and indicators (criteria) of sustainability in regulation. By incorporating criteria in this way, in conjunction with regulated methodologies addressing when and how to apply the principle, it is more likely that hidden collapse identified by Lindenmayer will be dealt with. Hidden collapse refers to an appearance of an extant forest ecosystem, but in reality is experiencing an extended period of decline, with a consequent projected failure to recover dominant ecosystem components. Given the urgent need to protect biodiversity around the world, it is essential that there is adequate regulatory response to the risk inherent in hidden collapse. This risk is not being properly dealt with by the current use of the principle in regulation. Accordingly, it is important to reconsider some of the difficulties presented by the principle from a regulatory perspective.

A motivation for this paper is the importance of research about identifying early warning indicators of future collapse as essential for monitoring the state of degraded ecosystems [3]. Regulation needs to address a response to the presence of early warning indicators detected in forests and other ecosystems. Lindenmayer's work on hidden collapse in Australia's mainland Mountain Ash forests raises complex issues about when and how to apply the principle when actual collapse has not yet occurred. In that respect there are many challenges in regulating the principle. These include definitional issues surrounding what amounts to a serious environmental risk, determining the extent of scientific uncertainty and identifying when to trigger application. There is also debate over how the principle affects the balance between development and ecological protection [4]. On one hand the principle is seen as stifling development and unscientific in its scope, whilst others argue it is an important protection for the environment and human health [5]. This divergence of view is fueled, in part, by different definitions, applications and interpretation of the principle between stakeholders and experts. These differences are also driven by the view that being overly cautious may result in more societal harm [6]. The divergence is also driven by debate over how to treat scientific uncertainty surrounding environmental risk.

Literature on the principle is diverse encompassing law and policy and different sectoral applications [7]. Whilst some of this literature covers practical challenges in knowing when and how to apply the principle, there is little to address how the principle applies to long term environmental risk. This places some focus on how administrative decision makers apply or do not apply the principle. Where the principle is included into legislation without regard to administrative decision-making processes, problems arise from different interpretations about the timing and nature of the precautionary management response. These application challenges are exacerbated by differences in defining what amounts to scientific uncertainty and serious environmental risk across different risk scenarios, the administrative environment in which decisions are made and the inherent gap between policy and practice. A mandatory requirement to apply the principle may not guarantee application even with clear evidence of a serious environmental threat and this has been highlighted in recent Australian case law [8].

A brief history of the principle does provide some context to the application challenges. The principle derives from West German law in the 1970s which required the 'early detection of dangers to health and [the] environment,' and taking actions to protect the environment despite scientific uncertainty about the nature of the risk [9]. During the 1980's the principle started to have a higher profile in international environmental law, especially after inclusion in various international agreements [10]. For example, the principle was included in the Rio Declaration on Environment and Development in 1992 [11]. These international developments gave the principle a high-level legitimacy, and also encouraged application of the principle into domestic law [12].

The principle was seen from the 1990s as the basis for a more sophisticated response to scientific uncertainty [13]. The principle started to be viewed as a response to an over reliance on 'sound science' as the basis of public policy [14]. Establishing scientific certainty may not be possible, so addressing scientific uncertainty is, at least, acknowledging the problem of uncertainty and not allowing it to derail precautionary responses. The 1990s also saw the principle discussed in the context of aligning public policy and law [15]. Often the inclusion in policy was in the context of using it as a guiding decision making, such as the Australian example in the National Strategy for Ecologically Sustainable Development [16].

The foregoing developments highlighted that use of the principle involves multiple stakeholders who may not agree as to when and how to apply the principle [17]. This has led to debate over the appropriate regulatory strategies in addressing the when and how of applying the principle in the presence of scientific uncertainty [18]. The complexity of this application challenge is reinforced by the context in which the principle may be used. Much of the literature, for example, analyses application of the principle across different context such as protection of the commons [19], transnational trade disputes [20] and international biosafety agreements [21]. These applications highlight the principle can be applied in diverse contexts, each having their own issues surrounding when and how to apply it.

Whilst use of the principle is now widespread, some critics identified practical issues surrounding both form and application. For example, some argue the principle has a no-risk and 'science-light' base which implies it does not do what it is meant to do, which is to address risk in the context of scientific uncertainty [22]. In practice, however, science is often a key focus, such as in the EU where science is seen an important factor in regulatory decision making [23]. Another criticism is the principal does not provide clear guidance to decision-makers [24] and lacks internal coherence which is referring to both definitional and structural issues with the actual words used in regulation [25]. Further, some argue the principle justifies arbitrary action allowing decision-makers not to rely on facts when making decisions [26]. The foregoing criticisms have a common theme relating to problems of when and how to apply the principle across diverse risk scenarios.

The inherent complexity of the principle focuses attention on institutional decision making, and its capacity to address this complexity [27]. Decision making can occur at different administrative levels, such as ministerial, elevated level departmental or at a lower level, such as a compliance and enforcement unit within a government department or operational staff undertaking extraction of a natural resource. Each administrative level may have different perceptions of risk, which increase the importance of having a regulatory framework for managing risk perception, whilst also taking account of scientific uncertainty. This framework requires balancing the degree of scientific uncertainty against the seriousness of the risk, within the context of administrative decision making [28]. Decision making that accounts for scientific uncertainty, by definition, must contain some methodology on processing scientific information at a departmental level [29]. Where there is no clarity over how science is used in departmental decision making, this increases the chance the principle is not properly applied [30].

Procedures for reviewing science data on environmental risk should be included in regulation, and not be left solely to discretionary decision making. This requires some clarity over what a sufficient evidential threshold is to trigger application. This means sufficient evidence on the environmental risk and the threshold relating to scientific uncertainty. This article considers both evidential thresholds in the context of long-term environmental risk and the type of precautionary response proportionate to the level of risk within long term risk scenarios. Implicit is the need to specify who is responsible to make this decision, which, in the context of public forestry, must be the department and/or the producing authority, responsible for harvesting. These decisions must all be decided within a particular administrative context [31]. The administrative context will vary across jurisdictions and between different natural resource sectors. Whilst it is not possible to address diverse administrative context, this article does establish a generic administrative process for decision making that is likely to be adaptable to most resource sectors across jurisdictions.

The procedure for reviewing scientific data must be sufficiently adaptable to address long term risk scenarios [32]. The precautionary response might require an extended time frame in effectively managing the forest estate to account for gradual changes that need monitoring over time. Biodiversity management in the long-term risk scenario envisaged herein may require cross sector and departmental interaction, which means many practical complexities in gaining their alignment [33]. Addressing adaptive decision making in an administrative context, especially with the aim of ensuring transparent public discourse, will be complex when responding to a long-term risk scenario [34]. Consequently, reviewing scientific data on long term environmental risk requires a firmer legislative footing, with some prescription over the review process.

The foregoing suggest the need for a rethink how the principle is regulated as part of a new regulatory framework to prevent ecosystem collapse and provide rapid action to identify and reduce long term environmental risk [35]. This 'new framework' requires a change in regulating the principle to address risk of ecosystem 'hidden collapse' defined by Lindenmayer which is a category of long-term risk identified in Mountain Ash forests in Victoria, Australia. The impetus for this suggested change arises from their view on the absence of, further attempts to implement legislation or policy that appropriately protects trees, stabilizes the ecosystem or reverses the risk of ecosystem collapse. For this analysis, the main arguments supporting the identification of hidden collapse are summarized in succeeding paragraphs of this section. The aim is to provide context to suggested application and implementation methodologies for application of the principle, discussed in Section 6.

In respect to the identification of hidden collapse, many past accounts of forest collapse are mainly post hoc with limited empirical descriptions of ecosystems in the process of collapse [36]. A post hoc account, therefore, does not account for the processes leading up to collapse and may overlook factors identified in hidden collapse. Lindenmayer explains the hidden collapse trajectory as an ecosystem that superficially appears intact, but after a prolonged period of decline coupled with long lag times for recovery of dominant ecosystem components mean that collapse is almost inevitable. This view highlights hidden collapse as scientifically evident, although not readily apparent, requiring earlier intervention than the forest appearance suggests.

The identification of hidden collapse differs from other identified collapses, such as collapse in fish stocks. The latter has been postulated in one study, as an abrupt change after a prolonged depletion in stock [37]. In another, peer reviewed study, a fish stock was defined as collapsed if its minimum annual biomass fell below 20% of the biomass necessary to support maximum sustainable yield [38]. In both cases the collapse is not 'hidden' but readily apparent by either an abrupt change after a prolonged period of depletion, or a fall in biomass that prevented obtaining maximum sustainable yield. By contrast, hidden collapse is identified by a decrease in key environmental indicators in an otherwise extant forest. Thus, hidden collapse within an extant forest cannot be seen as similar to a collapse in fish stocks in terms of identifiable factors in the actual collapse scenario.

According to Lindenmayer, hidden collapse is marked by changes in ecosystem conditions, 'particularly the rapid decline in populations of keystone ecosystem structures,' which include organisms, nutrients, and physical features of the environment. This collapse scenario is characterised by a marked difference between the actual trajectory of the ecosystem, and political and forestry projections of the same system. The difference potentially results in a failure by regulators to recognise the problem and ensure adequate populations of old growth cavity-producing trees and cavity-dependent species. The precarious state of an ecosystem subject to hidden collapse is often exacerbated by an overcommitment of resources and a realisation that comes too late for preventative action.

Identification of hidden collapse by Lindenmayer is based on empirical findings on the status of Mountain Ash forests in Victoria, Australia. This includes data from multifaceted long-term empirical studies of Mountain Ash forests in south-eastern Australia conducted by Lindenmayer and his research team. Lindenmayer's empirical analysis included assessment of current and projected decline in populations of large old cavity trees, and their alignment with projected decline in cavity-dependent fauna. Changes in the number of old cavity trees is an indicator of biodiversity and ecosystem health, given their impact on tree germination and seedling recruitment, contribution to carbon storage, the water cycle, and fire dynamics. The findings highlighted a 50% decline in populations of large old cavity trees in affected regions between 1997 to 2011, and a projected decline of less than 10% of 1997 populations by 2067. Lindenmayer also noted declines in arboreal marsupial and bird biodiversity with a 50–65% decline in site occupancy for arboreal marsupial species dependent on large old cavity trees [39]. The projected hidden collapse of the Mountain Ash Forest ecosystem manifested (in part) through changes in key ecosystem structures, in particular old cavity trees that provide crucial habitat for cavity-dependent species. The predictions of decline are likely to be less than actual decline, due to not fully including all climate change effects. The predictions of decline highlight the adequacy of

Victorian protected regions for forest dependent fauna [40]. Three key drivers of these habitat changes are the interaction of fire, logging and climate change, which collectively push the Mountain Ash ecosystem toward hidden collapse. Lindenmayer emphasises the cumulative effects of the interaction of these drivers of collapse, and how the risk outcomes require targeted management intervention. Multiple interacting drivers of change, linked with long recovery times of key ecosystem components (like old cavity trees) is masking collapse and delaying management intervention, which together render collapse inevitable. Whilst acknowledging the complexity of averting the risk of collapse, Lindenmayer argues for limitations on logging and a corresponding reduction in sustainable timber yield, whilst at the same time increasing the extent of protected areas [41].

Lindenmayer acknowledges they were unable to determine, even with long term monitoring, the point in time when the Mountain Ash system began to collapse. This acknowledgement highlights a degree of scientific uncertainty, which is a precondition for applying the principle. Despite the inability to find the beginning point of collapse, Lindenmayer concludes the identified indicators show the Mountain Ash ecosystem as going through a process of collapse which is 'hidden' in the sense collapse is not yet identifiable as completed. Complete scientific certainty in this context is arguably unattainable [42]. Scientific method usually relies on empirical enquiry, which cannot necessarily guarantee a level of proof that accords with a legal standard, such as beyond reasonable doubt [43]. Hidden collapse, therefore, represents a challenge for decision makers given this type of scientific uncertainty. Dealing with this challenge requires decision makers to deal with long term collapse scenarios after taking account of indicators that identify a process of collapse. The proposals outlined later in this paper seek to address this process.

Can the proposed changes provide legal certainty in preventing hidden collapse? Whilst legal certainty cannot be guaranteed, this article argues it is possible for regulation to provide a greater level of certainty in preventing hidden collapse. Methodologies for triggering application of the principle and the precautionary response are recommended for inclusion into regulation. With this inclusion, a procedural process must take place that weighs up the level of risk to the environment, and the level of scientific uncertainty. These methodologies take account of both of these preconditions. With scientific uncertainty, for example, the methodology accounts for the differences in assessment of risk levels associated with hidden collapse. There is a current divide between leading forest ecologists about the true level of risk presented by hidden collapse. A leading forest ecologist criticised the hidden collapse findings, albeit not in a scientifically rigorous way [44]. Professor Rod Keenan, from the Melbourne University School of Forest Sciences, questioned the methodology used to identify hidden collapse [45]. His main argument is the hidden collapse hypothesis relies predominantly on the number of old trees in the forest. He argues government datasets show the Mountain Ash forests can recover and animal numbers have not fallen as much as claimed [46]. Lindenmayer, by contrast, presents empirical data identifying hidden collapse in Mountain Ash forests, and predicts the probability of collapse at approximately 90% in the next 50 years. These contrasting positions are examined under the proposed decision-making process, using the latest scientific evidence. Fundamental to increased certainty in preventing hidden collapse is regulation including a trigger for application. The principle is no longer subject to the vagaries of departmental decision making, and now requires a specific administrative process.

The forgoing discussion on application of the principle to the hidden collapse scenario does not preclude a wider application across other types of environmental risk. Regulation that adopts a trigger for application and precautionary response methodologies encompasses both short term and long environmental risk, able to respond across temporal and spatial variation. A regulatory process to weigh up the level of environmental risk against the degree of scientific uncertainty is arguably more responsive to long term risk scenarios but does not preclude a response to short term or 'one off' environmental risks. The reason for widespread responsiveness across diverse risk scenarios is discussed in this paper and relates to a broader regulatory set of inclusions for both the trigger and precautionary response mechanisms. These inclusions mandate a high level of deliberative decision making. A generic model is proposed for both the trigger and precautionary response methodologies that is adaptable across jurisdictions and between both natural resource and conservation sectors. The initial focus on the Australian Mountain Ash Forest hidden collapse scenario is designed to look at long term environmental risk, the same weighing up of environmental risk with scientific uncertainty can apply to other risk scenarios. What is proposed is an adaptable model that ensures administrative decision-making across all environmental risk scenarios.

The need for a new way to deal with precautionary environmental risk management has never been greater. The work of Lindenmayer in identifying hidden collapse helps in constructing a new regulatory response to long term environmental risk. Lindenmayer's work identifies empirical findings of long-term identifiable ecosystem collapse, which can be the basis for a rethink in how the principle is regulated. Whilst Lindenmayer is not the first to identify collapse in natural ecosystems [47], they are the first to address a methodology for how to predict long term collapse in forest ecosystems. By highlighting how an extant ecosystem may still exhibit indicators of impending collapse, even though collapse is not obvious to non-scientific observers, Lindenmayer has sounded a warning about the massive loss of biodiversity taking place across the world. As a result of this body of literature, the author considers a review of the principle is necessary to address large-scale biodiversity losses and the risk of hidden collapse.

Section 2 discusses the conceptual underpinnings of the views advanced in this article. Section 3 examines issues associated with regulating risk perception. This has particular relevance to the hidden collapse scenario where there may be a failure to perceive any long-term risk. Section 4 examines how the principle is regulated in the Victorian jurisdiction where hidden collapse was first identified. The case study is designed to highlight problems in simply placing the principle into regulation without regulating on administrative decision making. Section 5 provides a comparative assessment of two methodologies where the principle is used in an administrative context, albeit with clear differences in how this is done. The aim here is to provide some context for later discussion of how administrative decision making could address the hidden collapse scenario. Section 6 details the regulation of methodologies designed to address long term risk perception and, in doing this, manage hidden collapse risk. Finally, Section 7 provides a brief conclusion designed to summarize the key issues considered in this article.

2. The Conceptual Framework

A conceptual framework is designed to map the study and guide how data is used and interpreted [48]. The conceptual framework allows the researcher to draw conclusions after taking account of variables in the study and the interplay between them. The aim is to define the approach taken in modelling of the precautionary principle to address hidden collapse. It is necessary to look at relationships and connections between various concepts and variables. Understanding causality in the relationships and connections from a regulatory perspective is a key consideration. Whilst this may involve consideration of theoretical underpinnings, it is not necessarily dependent on them. What is more important is the placement of science inputs into the regulatory mix, and this is not a theoretical construct. The conceptual emphasis is on the relationship between science-based indicators that are triggering a regulatory response. Scientific inputs are considered here as the main variables that must be addressed in regulation for application of the principle. Discretionary decision makers may not analyze scientific data in a way that produces consistent results. Data relating to hidden collapse may be particularly vulnerable here since a decision maker may not be able to address long term projections in a meaningful way. The chance of getting this type of decision maker to proactively address hidden collapse by applying the principle may be limited. The conceptual framework, therefore, is setting out how long-term projections can be addressed in applying the principle.

The foregoing discussion highlights the key variable are the environmental indicators indicative of hidden collapse, the science associated with these variables that demonstrate the environmental threat, existential risk such as fire and logging that may reduce the resource base and reinforce the hidden collapse outcome and the resources necessary to address the proportionate precautionary response. How these variables are addressed, particularly the environmental indicators of hidden collapse, become crucial in responding to long term risk. The overview of the literature in Section 1 and the problems of regulating risk perception discussed in Section 3 highlight the 'implementation challenge.' This challenge could be described as a problem of getting decision makers to think long term and, in the process, address the science around environmental risks in a more rigorous manner when making decisions. In order to address the factors implicit in the implementation challenge, this article argues it is necessary to legislate trigger and application methodologies that effectively 'force' decision makers to take account of these variables in a systematic and transparent way. The inclusion of trigger and precautionary response methodologies provides prescriptive guidance at an administrative level for applying the principle and determining the proportionate response to the level of environmental risk.

The conceptual framework uses environmental and sustainability criteria and indicators (criteria), relevant science and existential threats to the resource base, such as drought or fire, to examine the risk of long-term environmental risk, including hidden collapse. The combination of criteria and science represents a challenge for regulatory design. This article advances the proposition that it is no longer possible to leave decisions about long term environmental risk simply to the whim of discretionary decision makers. Conceptually, this means constructing a regulatory framework that guides the decision-making process to use data from available science proactively, within a defined administrative structure. Whilst the proposed regulatory framework cannot presume a particular administrative structure, it can still guide the decision-making process within such structures.

The use of criteria in conjunction with science presents some conceptual questions for regulation to address. What criteria and science data triggers application of the principle? When triggered, how is criteria and science used in constructing the precautionary response? Once identified, how should this appear in regulation in a way that guides decision makers to address long term environmental risk? These questions require greater levels of prescription than a simple mandatory rule to apply the principle. Yet too much prescription is not necessarily a good thing if it leads to greater regulatory cost and the risk of not aligning with particular administrative structures. Conceptually, a more nuanced approach is necessary that balances greater regulatory prescription with a decision-making process that can fit into most administrative structures, or at least be readily adaptable to these structures.

To answer the foregoing questions regulation must address how decision makers manage risk perception. Varying risk perception is problematic for applying the principle, since it creates inconsistent application, especially when looking at long term environmental risk. Managing risk perception is essential since decision makers will vary in how they perceive the level of risk, making it is necessary to ensure the assessment of risk accounts for science data on environmental risk based on relevant criteria. Where there is alignment of science around criteria the assessment of risk will be based on a common pool of information rather than ad hoc assessment based on incomplete or erroneous data.

Basing risk assessment around a prescriptive set of criteria provides some rigor in the decision-making process. Conceptually, this requires understanding how regulation can adopt use of criteria in a deliberative process for decision making on long term risk assessment that can apply to most administrative structures. Looking at a comparative assessment in Section 5 on two examples of use of the principle within administrative structures provides some context to the later recommendations in this article. It is essential, from a conceptual standpoint, to incorporate the use of criteria within regulated methodologies that address a trigger for applying the principle and also addressing the proportionate response to the level of risk. The use of criteria in this way provides a clear basis for incorporating science into precautionary decision making to address the hidden collapse scenario discussed in this article.

3. Problems in Regulating Risk Perception

The principle is concerned with managing environmental and other incidence of risk [49]. The regulatory response will depend, at least in part, on a decision maker's perception of risk. Different risk perceptions will impact the extent of precautionary risk control measures [50]. People have different perceptions of risk, for example, scientists may disagree on scientific findings [51]. Risk perception of an expert may vary significantly from the perception of a non-expert [52]. A risk to the environment may be perceived differently given variations in thinking about nature's resilience [53]. The last point involve two sub-categories of risk perception; one is the extent of the environmental risk itself, and the other is the extent of nature's resilience. Differences in risk perception arguably requires greater prescription in regulating the principle. The level of prescription could extend to a process of risk assessment limiting subjective, and potentially inaccurate risk perceptions by decision makers. This could avoid the problems arising in Environment East Gippsland v VicForests, for example, where decision makers believed there was no risk at all, even when presented with unambiguous evidence of the presence of endangered species in regions subject to timber harvesting, which, in the context of the Victorian jurisdiction, is a definite trigger for application of the principle.

Given different risk perceptions apply at a scientific level, it requires a regulatory framework to properly account for this difference [54]. However, it is probably not helpful to try to define what represents certainty from a regulatory perspective. Despite some arguing a threshold of 95% scientific certainty is sufficient to establish a standard of 'certainty' [55], this still allows for 5% uncertainty, which may not be a safe margin with some environmental risk [56]. The purpose of the principle is to manage a serious or irreversible risk to the environment in the presence of scientific uncertainty, which requires assessing the seriousness of the risk after taking into consideration the level of scientific uncertainty. Serious risk to the environment and scientific uncertainty are described as two preconditions for applying the principle [57]. A regulatory framework must account for the foregoing matters whilst addressing scientific risk perception at an administrative level. Whilst establishing the existence of scientific uncertainty is one of two preconditions for application of the principle, it should not mean trying to establish sufficient scientific certainty to preclude precautionary measures being taken.

Implicit with the foregoing considerations is an initial risk assessment based on scientific evaluation. How this is to take place is discussed later in this article, with some arguing risk assessment involves a focus on outcomes, since the aim is either a removal or mitigation of the risk, which is inherently outcomes focused [58]. A regulatory framework should facilitate the scientific evaluation process that accounts for likely outcomes of regulatory intervention. An outcomes-based evaluation in regulation could involve three stages; (1) the identification of potential outcomes, (2) estimation of the magnitude of these outcomes; and (3) probability of the realisation of the outcomes. Each of these stages involves some scientific assessment which may be time and resource intensive, thereby potentially increasing regulatory cost. In order to limit this burden, the regulatory framework must contain methodologies that includes guidance on how scientific data is interrogated. An absence of a scientific data review methodology in regulation would mean the data review is simply a discretionary exercise without any form or substance, or even any guarantee a decision is actually made.

The proposed methodologies on when to apply the principle, and the proportionate response to level of risk, require a cost-benefit assessment enabling a 'full accounting of the consequences of risk reduction, in both quantitative and qualitative terms' [59]. The cost-benefit assessment evaluates whether the expected benefits of risk control options outweigh the expected costs. This assessment could include non-economic values, including the benefit of environmental protection, since that is the primary focus of the principle. Where cost data is not readily available some estimates may have to be assigned to relevant costs and benefits. The proposed methodologies contain guidelines weighing up data inputs according to cost. Without a regulatory framework to weigh up the cost and benefits of options, decision making is at risk of being ad hoc, and potentially influenced by political and economic interests [60]. The objective is to avoid the risk of regulatory capture by these interests by ensuring an objective assessment of costs associated with a precautionary measure. There is an additional benefit of a cost benefit analysis, which is to ensure an objective assessment that helps address differing perceptions of risk.

Risk perceptions can also differ in respect to how well a particular precautionary measure will control the risk. Different precautionary options associated with a particular environmental risk, may create varying perceptions about their risk control efficacy. A risk control 'trade off' arises in ranking levels of risk control efficacy in order to determine which option maximizes benefit for the lowest cost. The key issue is to have a system for ranking different control options to ensure the most efficacious and cost-effective precautionary measure is used. Without a system for methodically assessing and ranking precautionary measures, there is no guarantee that the principle will be properly applied.

The foregoing highlights the importance of regulating risk perception [61]. Perceptions of risk will vary in relation to both the extent of environmental risk, and the effectiveness of protection provided by different precautionary options. A methodology that includes managing risk perception provides structure when making decisions in the presence of scientific uncertainty. This variation in risk perception should be managed in regulation, and not left solely to discretionary decision making. This is particularly necessary in assessing long term risk embodied in the hidden collapse scenario.

4. Use of the Principle in Legislation—A Victorian Case Study

The inclusion of the Victorian case study provides a specific analysis of why there was no regulatory response to identification of hidden collapse by Lindenmayer. Whilst this case study is illustrative of problems associated with managing long term risk scenarios, it is limited to issues unique to the Victorian jurisdiction. Despite this, the case study is an example of a regulatory inclusion of the principle without taking account of administrative decision making that weights up the level of environmental risk with the extent of scientific uncertainty. The adoption of the principle in regulation without a broader accounting for wider decision-making processes to address this weighing up may be part of other regulatory frameworks. To that extent, the Victorian example provides lessons on the limitations of a simple regulatory inclusion without clarity on the principle's application across diverse risk scenarios. Accordingly, this case study is designed to apply broadly as an argument against regulation that has no support methodology for administrative decision making.

The principle Is considered here in two contexts; the first is a comparison in Section 5 of two regulatory frameworks applying the principle. This comparative study examines how they address scientific uncertainty and manage the proportionate response to environmental risk. The second context relates to hidden collapse discussed in Section 1. This discussion draws attention to how the principle is regulated in Victoria by the Code of Practice for Timber Production [62], and the Sustainable Forests (Timber) Act (Vic) 2004. Addressing hidden collapse is vital given the alarming rate of biodiversity loss and the failure of regulators to consistently apply precautionary risk management to manage ecological risk. The lack of precautionary risk management to deal with widespread biodiversity loss increases focus on the way the principle is regulated. The importance of better regulation of the principle was recently highlighted in a submission from Environmental Justice Australia to the Australian Federal parliament [63]. Given these contexts, this section considers current use of the principle in the state of Victoria, where hidden collapse was first identified.

Case law in Australia confirms that application of the principle in Australia requires two preconditions. The first is a risk of serious or irreversible damage to the environment.

The second, a lack of scientific certainty as to the nature and extent of the risk [64]. Where these conditions are satisfied, then precautionary measures proportionate to the risk should be undertaken [65]. Where the risk is significant, then a greater degree of precautionary intervention is needed [66]. If precautionary measures are not sufficient to remove or contain the risk to acceptable levels, then it may be necessary for the proposed action not to proceed [67]. The foregoing highlight a series of responsive measures necessary to address various levels of risk. Despite this relatively clear agenda in using the principle when responding to different risk levels, regulation is generally silent on how this is done. In Victorian public forestry regulation, for example, there is no guidance on how to address long term environmental risk. Taking precautionary measures to address hidden collapse requires regulation that can provide a vehicle for decision makers to recognise and respond to long term risk.

Current applications of the principle in Australian jurisdictions contain simplistic mandatory obligations for applying the principle that do not account for long term environmental risk. The Victorian case study is a good example of a mandatory requirement to apply the principle, with no associated guidance on when to apply it and how to determine the extent of the proportionate response according to the level of environmental risk. This article argues that taking precautionary measures to address long term risk presents a challenge in regulatory design at both the trigger for application and taking precautionary response stages. Therefore regulatory methodologies are required for a trigger to apply the principle and for determining the appropriate proportionate response. The proposed changes incorporate use of scientific data at critical stages of precautionary decision making. These changes are designed to have the potential to address long term ecological risk implicit in hidden collapse.

Another issue in regulating the principle is who carries the burden of proof of a serious threat to the environment. Carriage of burden of proof is especially problematic when it comes to establishing long term environmental threats. The placement of the burden of proof has been described as a 'genuine political question as exists' [68]. This placement ideally should be informed by equity and fairness, as an expression of social justice. Shifting burden of proof according to changing circumstances has been described as a positive for democratic deliberation on risk. The issue in relation to long term environmental risk, is the possibility of some initial report or investigation that highlights the potential risk such as hidden collapse. This identification of risk may not arise from any particular development activity and could relate to long term extraction of the natural resource. At issue is the process behind moving the identification of environmental risk into a decision-making process of precautionary risk management. Stakeholders must have some form of compulsion to engage in deliberation about appropriate policy responses to long term environmental risk, and even where a decision not to act is made, be compelled to justify their decisions in both formal and informal arenas. Simply leaving such an issue to departmental discretion assumes that the identification will result in some form of decision-making process. Understanding how new methodologies deal with the initial identification of risk and who has carriage of the burden of proof is examined further in Section 6.

In the interim and as a precursor to outlining these methodologies, it is instructive to examine in more detail the current use of the principle in Victorian forestry regulation. This examination provides context to why a mandatory application of the principle without further regulatory guidance is not adequate to address long term risk. The Victorian Sustainable Forests (Timber) Act 2004 (Act) s5 imposes a mandatory application of the principle. Before discussing how this simple mandatory application of the principle is ineffective to deal with long term risk, it is necessary to understand the purpose of this Act. The Act's purpose set out in in s1 (a) is to provide a framework for sustainable forest management and timber harvesting in State forests. The management and harvesting is meant to be in conjunction with other purposes including granting of long-term access to timber resources in State forests (s1 (ab), and foster investment in, and return from, timber resources in State forests (s1 (ac)). Whilst sustainable forest management and harvesting is the main objective, the other objectives suggest an economic emphasis. An economic focus might influence how the principle is used, especially if use of the principle had a limiting or restricting effect on economic activity. Thus, decisions about when to use the principle and the nature of the precautionary response may be subject to the risk of regulatory capture from interests associated with wood production [69]. In order to avoid regulatory capture it may be preferable to have an arm's length process for activating the principle.

The mandatory application of the principle in the Victorian jurisdiction arises under the Code of Practice for Timber Production (Code). The entire Code has mandatory application under the Sustainable Forests (Timber) Act. Thus, where there is a threat of serious or irreversible harm to the environment, the principle must be applied. A failure to apply the principle arose when there was unmistakable evidence of the presence of endangered species at Brown Mountain, which should have been enough VicForests, the Victorian government producing authority, to halt logging. This failure to apply the principle raises serious issues including, the efficacy of a mandatory application of the principle without further application guidelines, and the enforceability of the principle in the Code. The way the principle appears in the Code, was shown by the Brown Mountain example, to have a number of ambiguities in regard to who is responsible for its application, and whether failure to apply the principle creates an actionable right to enforce its application.

The foregoing problems stem from the way the principle is set out in the *Code.* The principle definition appears in the 'Glossary' as:

> "*precautionary principle' means that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation... In the application of the precautionary principle, decisions by managing authorities, harvesting entities and operators must be guided by: (i) careful evaluation to avoid, wherever practicable, serious, or irreversible damage to the environment, and (ii) an assessment of the risk-weighted consequences of various options.'*

This definition has two instructions: (1) managing authorities and harvesting entities and staff must provide 'careful evaluation' of risk to the environment, and (2) decision makers must make 'assessment' of risk-weighted consequences of options. The first guideline refers to extent of the risk, and the second refers to evaluation of risk management options. These provisions must be read in conjunction with clause 2.2.2.2 to in the *Code* which states:

> '*The precautionary principle must be applied to the conservation of biodiversity values. The application of the precautionary principle will be consistent with relevant monitoring and research that has improved the understanding of the effects of forest management on forest ecology and conservation values... Note: It is intended by the definition of the precautionary principle and section 2.2.2.2 that the precautionary principle and its application in section 2.2.2.2 be understood as it was by Osborn J. in Environment East Gippsland Inc v VicForests [2010] VSC 335 (in relation to the precautionary principle as it appeared in the Code of Practice for Timber Production 2007).'*

The guidelines in the definition and clause 2.2.2.2 of the *Code* provide generalised direction rather than prescriptive guidance for decision making. For example, there is no guidance on what methodology is used to assess various options when making precautionary decisions. The reference to what is 'understood' as set out by Justice Osborn's judgement in *Environment East Gippsland v VicForests*, does not clarify what is necessary to consider in the judgement, which is problematic given the judgement is long and says many things about the principle [70]. To reference a judgement in this manner is an abrogation of drafting responsibility, and places far too much reliance on discretionary decisions correctly interpreting Justice Osborn's judgement. Some guidance in what the judgement says about applying the principle is necessary. In its current form, the *Code* example leaves a wide discretion that ambiguously references a judgement about when and how to apply the principle.

It is not surprising that hidden collapse identified by Lindenmayer did not induce application of the principle in Victorian Mountain Ash forests. The mandatory application in the *Code* has no trigger for application, provides limited guidance on when the principle is activated and nothing on working out the proportionate response to the extent of the risk. The Victorian case study provides an example of how current use of the principle does not address the risk of hidden collapse. Its inclusion is designed to provide context for more prescriptive guidance for administrative decision making to respond to this risk. The Victorian case study, in identifying regulatory gaps and failure in responding to long term risk, highlights the need to provide guidance in regulation to administrative decision making. What follows in Section 5 is a comparative study that reviews two application methodologies that address administrative context to decision making in applying the principle. This discussion is designed to provide context for the later focus on regulatory methodologies that provide guidance on when and how to apply the principle to address the hidden collapse risk.

5. A Comparative Review of Two Application Methodologies

Section 5 contains two examples of application of the principle using prescriptive methodologies. The first example, constructed from a theoretical research base, has a number of implications for regulatory practices, requiring a sequential four step process for specific inputs from decision makers in relation to managing scientific uncertainties and risk associated with environmental problems. The second example is contained in regulation, with a framework consisting of multilevel problem solvers and some emphasis on a deliberative process in decision making. The aim of this comparative study is to provide examples of prescription that could apply to the Victorian and other jurisdictions to ensure better response capability for long term environmental risk.

5.1. The Deville and Harding Framework

Deville and Harding developed the first example [71]. This involves a decision-making framework containing four sequential steps. Step 1 requires decision makers to apply the principle by ranking the extent of the risk to the environment and certainty of that risk. This means assessing whether there are threats of serious and irreversible environmental damage, and then determining where the threat lies on a scale of seriousness and irreversibility. The assessment includes criteria such as, magnitude, longevity, manageability, degree of public concern and spatial aspects of the threat. A second question asks how certain the threats are to the environment. Decision makers must rank the adequacy of the evidence the level of uncertainty and how it may be reduced. If a serious and irreversible risk exists and the risk is 'certain,' then the principle must be applied. If the seriousness of the risk and certainty is at issue then a review process may be necessary. Alternately, decision makers may still proceed with the next three steps. The foregoing process involves a ranking mechanism which could result in a lower ranking in terms of seriousness and certainty, resulting in a possible review process or a decision not to apply the principle.

Step 2 asks, 'how precautionary should we be'? The answer requires evaluating the significance of the threat and the extent of scientific uncertainty. The latter requires consideration of likely cause of the threat and its practical effect. This stage requires a practical assessment of precautionary intervention to either remove or at least limit the threat. Since this assessment requires expert analysis, and because input from the broader community is required for both steps 1 and 2, it is arguable a more formal decision-making process is necessary than simply leaving this to departmental discretion.

Step 3 (assessed in conjunction with Step 2) ask what precautionary measures can be applied. This framework requires broad based thinking on available precautionary measures which cover direct and indirect forms. A diagrammatic assessment on a four-quadrant graph (see Figure 1) is made with the significance of the threat on a vertical axis, against the degree of scientific uncertainty about the threat and its effects on a horizontal axis. Placement on the graph is guided by rules, with the more significant threat requiring greater precautionary measures, and more uncertain the threat also requiring greater precaution. Where the vertical and horizontal points intersect a threshold is reached for 'serious and irreversible' environmental damage and sufficient scientific uncertainty to warrant application of the principle. The top left-hand quadrant is the most important for application of the principle.

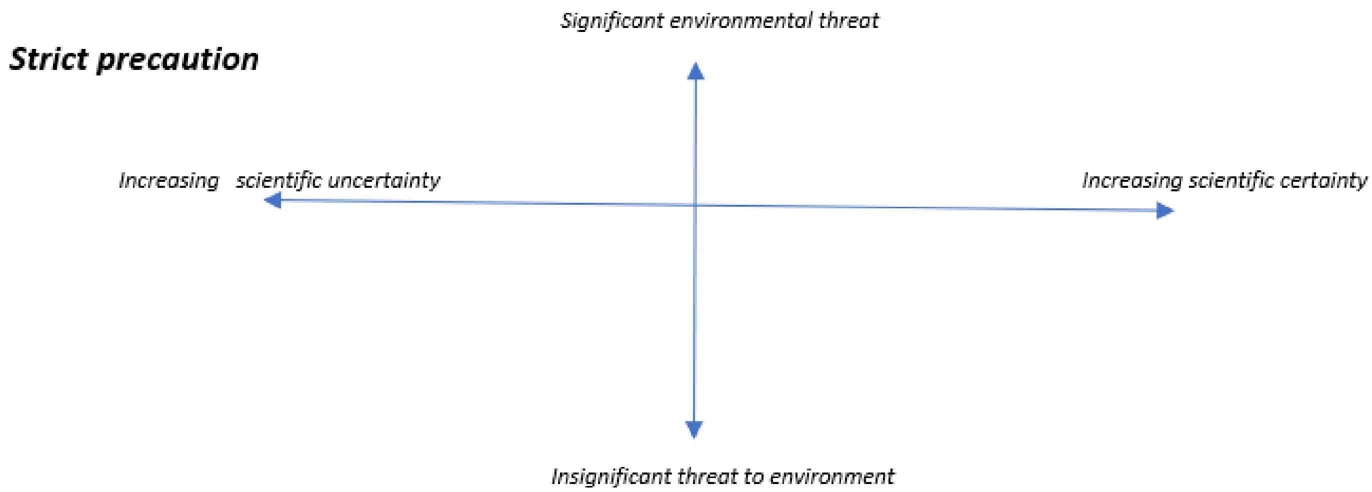

Figure 1. Assessing degrees of precaution under the Deville and Harding model.

Step 4 of the framework requires decision-makers to consider what precautionary measures should be applied. This is distinguishable from Step 2 and Step 3, as it is asking decision-makers to consider the range of options after taking account of economic and social costs and other relevant principles. This step takes the level of precaution identified in Step 2 and range of options considered in Step 3 and determines what should be applied from that context.

The Deville and Harding framework requires decision makers to identify and characterise scientific uncertainties within a deliberative process of cross disciplinary problem solving and adaptive capability that addresses risk whilst still accounting for new scientific developments. This framework has been described as a 'deliberative constitutive theory of administrative constitutionalism'. Its significance arises from its evaluative process rather than from any inherent innovation and requires an administrative body with powers to make adaptive decision making. These measures, involve deliberative decision making, where threat is defined broadly and who is included in the decision-making process is adjusted according to the type of threat. Decision makers must take care in defining and characterising the threat, something highly relevant to identification of hidden collapse. The process of defining and characterising the threat involves deliberative processes that could consist of collaborative or adversarial assessment.

5.2. The European Union Framework

The European Commission's Communication on the Precautionary Principle (Communication) [72], uses a multi-level problem solving capability based on the idea that administrative level decision makers are 'instruments' of the legislature conducting tasks that have limits on administrative power [73]. Any discretion exercised is regulated by rational science-based methodologies and seeks to control administrative action based on rational processes. Decision makers undertake a three-step process involving a science-based risk assessment, a political process of risk management and risk communication. The risk management and communication steps relate to public accountability in decision making, especially in circumstances where there is division between science and politics and is designed to ensure decision makers do not usurp power. The Communication states the principle only applies when a 'potential risk' and uncertainties surrounding it, are identified. The assessment requires reliable scientific data used to assess the likelihood of risk occurrence and how severe the impact on the environment. The risk assessment is defined in strict procedural terms covering hazard identification, hazard characterization, appraisal of exposure and risk characterization.

The Communication has limited guidance on how scientific uncertainty is identified and communicated in the risk assessment process. The Communication makes clear that a careful assessment of scientific uncertainty is a separate process from the application stage. The separation of the assessment of scientific uncertainty and the proportionate response stages is acknowledged in the discussion in Section 6, as the preferred approach, given that whilst they may impact and relate to each other, they must be assessed separately in the decision-making process. To combine them in one stage creates a risk of the response stage being muted by concerns over scientific uncertainty.

The Communication can be described as a prescriptive framework for decision making in applying the principle. Discretionary decision making is therefore constrained by methodologies that must be applied and which legitimises the decision made. The methodologies deal with risk assessment and regulatory impact assessment. The legitimisation arises through the use of methodologies and a decision has increased 'validity' because the decision maker has followed a prescriptive process within their power to make. This decision-making process, of course, assumes those methodologies will make the decisions legitimate.

5.3. Comparing the Two Models

The Deville and Harding model and the Communication have some common features. The first is both involve a prescriptive process of administrative decision making. Second, each have a transparent process and inclusive process. The frameworks require decision makers to use all relevant information, including scientific data and normative values. Each framework can potentially result in a range of different precautionary measures. The processes established by each framework is designed to legitimize decision making and provide accountability in public administration. These frameworks run counter to those who argue application of the principle is too arbitrary and does not properly include science.

The Deville and Harding Framework and the Communication differ in how they conceptualize environmental problems. The Deville and Harding Framework conceptualizes complex and potentially intractable environmental problems as requiring an institutional structure adaptable to individual circumstances. The Communication conceptualizes environmental problems as inherently manageable by use of methodologies in an institutional framework that requires decision makers to conduct pre-ordained tasks. The Communication, therefore, appears more prescriptive in using methodologies with defined tasks for decision makers.

The Deville and Harding Framework and the Communication also differ in how they characterize the decision-making process. The former does not separate political and scientific processes because it sees the complexity of these processes, especially in the context of scientific uncertainty, require a unified approach. By comparison, the Communication divides scientific and political processes to ensure decision makers conduct clearly defined and separate tasks. The Communication, therefore, adds a layer of prescription by the division between scientific and political processes.

The third difference between the Deville and Harding Framework and the Communication relates to the reasons for requiring inclusive and transparent decision making. The former requires broader participatory decision making and transparency, where participants enter into an informed process of deliberation that allows for a fuller evaluation. The Communication requires transparency primarily to demonstrate that decision makers have conducted assigned methodological tasks. Participant involvement appears more focused on registering their preferences for risk management than participating in a deliberative and evaluative process.

The fourth difference between the Deville and Harding Framework and the Communication relates to how each regulates various aspects of the decision-making process, resulting in different explanations for decisions. The former requires decision makers to examine the scientific uncertainties in any environmental problem and then carefully identify and evaluate options that can be applied. Decision makers have a responsibility to show how they have evaluated the environmental problem and then justify what methodologies and measures are used to address the problem. This focuses on substantive reasons for the decision and how they relate to the process of deliberation to address the problem. In contrast, the Communication presumes a decision is valid if the decision maker has adhered to a risk assessment methodology applying standards such as proportionality and non-discrimination. A decision is justified and valid if it accords with a set methodology and standards. The Deville and Harding Framework is more likely to evaluate a wider range of options, whilst the Communication may risk a decision that is relatable to the methodology.

The final difference between the Deville and Harding Framework and the Communication relates to the inherent purpose of each framework. The former is seeking to address the best approach to dealing with uncertain and complex environmental problems across different legal and institutional context in Australian local, state, and Federal governments. Step 4 of the Deville and Harding Framework requires a reconciliation of this difference between these levels of government. The Communication is primarily concerned with addressing accountability of European Union institutions [74], and WTO rulings, keeping in mind the principle has a health focus in Europe [75]. This means the decision maker must demonstrate compliance with legal obligations under European Union and WTO law and does not demonstrate unconstrained power. These differences arguably highlight a different application of administrative law and theory to public administration. However, both frameworks appear to recognise the importance of science and inclusive participatory processes, whilst defining their use differently. The difference relates to how each characterizes public administration and the nature of environmental and health problems. The foregoing comparative assessment is illustrated in Table 1 which summarises the difference in approach.

Table 1. Comparative farmwork for models under review.

	Deville and Harding	**European Union**
Type of administrative theory	Deliberative constitutional framework	Rational instrument based
Reason for framework development	Use of the principle in diverse institutional settings	Use of the principle to accord with pre-existing legal obligations
Type of administrative process	Deliberation with scientific analysis	Some distinction between scientific and political processes
Characterization of risk regulation	Complex socio-political assessment	Use of methodologies
Decision making process	Adaptable use of broad deliberative powers	Rational methodology with a limited set of tasks
Public participation	Contribution to deliberative problem solving	Assist accountability and identification of preferences
Justification of decision making	Deliberation with reasons	Decision making adhering to methodologies and standards

What can we take from this comparative review? First, the two frameworks demonstrate how the principle can operate within a complex administrative environment which influences how it is interpreted and applied. However, the comparison also highlights it is important for regulation to be flexible enough to make allowances for differences in the administrative context for precautionary decision making. In this context the Deville and

Harding Framework allows for broad deliberative adaptive powers to address the problem at hand. The Communication conducts set tasks based on a rational methodology, which are predetermined and containing set standards. The Deville and Harding Framework may be better suited to implementing the principle into any institutional setting. The Communication shows action under the principle is accountable and consistent with pre-existing legal obligations.

Section 6 provides methodologies that adapt some of the best features of the frameworks discussed in Section 5, and also addresses the issues raised in Sections 1–4 in addressing long term environmental risk. The aim is to establish a framework for using the principle in regulation to address risk inherent in hidden collapse and other long term environmental risk scenarios.

6. Applying the Principle to Hidden Collapse

Section 6 discusses changes in how the principle is regulated to manage long term environmental risk. Whilst the focus is on managing long term environmental risk, the decision-making processes outlined in this section has a broader application to diverse risk scenarios. The tools and decision-making procedures outlined herein are designed to apply to hidden collapse risk which is the main focus of this article. However, the importance of a process to weigh up environmental risk against the extent of scientific uncertainty applies to both short- and long-term risk across both natural resource management and conservation sectors. The aim of this section, whilst addressing long term environmental risk implicit in the hidden collapse scenario, it is to highlight a generic framework adaptable across diverse jurisdictions, particularly those who rely on a simple regulatory inclusion of the principle without a broader framework for administrative decision making.

A key component is use of criteria and indicators of forest sustainability and evidentiary thresholds to determine the existence of a serious and irreversible threat to the environment and levels of scientific uncertainty. During the summer of 2019/20 in Australia, catastrophic bush fires caused massive damage to forests [76]. The scale of this loss would easily have triggered a threshold to apply the principle under what is proposed in this section. However, under the existing regulatory framework in Victoria, there was no immediate adaptive response to the vastly reduced forest estate. Although old growth forest harvesting has subsequently been banned in Victoria, this has not guaranteed the ecological viability of some old growth forests [77]. Hidden collapse requires adaptive measures to address long term risk in a more proactive way. The proactive response must manage the risk identified by reference to criteria and indicators of forest sustainability. It is the alignment of criteria and indicators of forest sustainability with precautionary risk management that sets what is proposed in this section apart from current applications of the principle.

Criteria and indicators of forest sustainability are the key reference point for decision making on triggers to apply the principle. Regulation of data collection around key indicators like sustainable timber yield, can proactively address long term environmental risk based on key thresholds [78]. For example, a change in sustainable yield may be a trigger for application of the principle. On that basis regulation will address a precautionary response when a level of harvesting is in excess of the ecologically sustainable yield [79]. A minimum threshold for application of the principle could be based, in part, on key data for sustainable yields and ratios of productive forest to overall forest coverage. The use of criteria and indicators of forest sustainability also provides a reference point for cost benefit assessment of options in precautionary management of an environmental risk. For example, the absence of large old cavity trees in a forest is an ecological indicator aligned with hidden collapse. When an indicator is specific and definable, a cost benefit analysis around that indicator is likely to have greater accuracy and definition. This level of specificity around an indicator, provides clarity over what options are available and at what cost to either remove or manage the risk.

The literature on the principle is often specific to a particular sector or industry and most do not account for long term environmental risk. The discussion in part 5 did address one model using methodologies to support decision making, whilst both models required a more structured deliberative process around analysis of science and evaluating options. What these examples made clear is regulating the principle without regard to a deliberative decision-making process, limits use of the principle and may even impede its application. The following set of recommendations are designed to address the requirement of a deliberative decision-making process and implement key recommendations from this paper.

6.1. Recommendation 1: Use of Methodologies in Applying the Principle

Sections 1–4 highlighted difficulties in regulating the principle requiring a different approach. The Victorian case study in Section 4 provided an example of a regulatory application without methodologies to guide decision making which lead to regulatory failure. Use of two methodologies can help overcome these problems; one methodology to trigger application and the other to address a proportionate response to environmental risk. This paper argues that use of methodologies are necessary to manage risk compliance [80]. Since the aim of the principle is to manage potential problems before they occur, a methodological process is necessary to address different risk perceptions (Section 3) as part of the trigger methodology, and to assess inputs into working out the proportionate response based on risk extents. Precedents exist for regulatory methodologies being contained in supporting regulation separate from the parent legislation [81]. Since the extent of long-term environmental risk is increasing; it is not sufficient to rely on simplistic mandatory applications of the principle without a more rigorous methodological approach in regulation. A simple command approach to regulating the principle fails to address the complexities of long-term environmental risk.

6.2. Recommendation 2: Use of Scientific Evidence Must Be Properly Regulated

Regulating the use of science has been undertaken in diverse areas including biomedical research [82], and animal welfare [83], but environmental regulation has been playing 'catch up' with these and other regulatory categories [84]. Most regulatory applications of the principle have no process for assessing scientific uncertainty. Applying the principle requires an assessment of scientific evidence as a precursor to application, and in formulation of the precautionary response [85]. A mandatory scientific evaluation of scientifically tenable information relating to the environmental risk could include a risk assessment consisting of four parts; risk identification, risk characterization, extent of risk, and the precautionary response based on level of risk. This assessment is designed to address perceptions of risk discussed in Section 3.

6.3. Recommendation 3: A Process for Dealing with Disputes over Application of the Principle

Most regulatory applications of the principle lack a regulated procedure for an initial assessment of environmental risk. In Australia there is the possibility of judicial [86] or merit reviews of departmental decision making post hoc [87]. However, there is a real issue about how justiciable the principle is, especially in respect to decisions to apply it or not [88]. This places a question mark over the possibility of judicial or merit reviews of decision relating to the initial assessment of decisions relating to applying the principle. This issue goes to the heart of decision making for long term environmental risk. There are some examples of Australian cases that consider the justiciability of the principle in this context, but the issue is not clear in respect to the initial decision-making stages regarding application [89]. In merit appeals, someone seeks an order from a court, such as the Environment Resources and Development Court in South Australia, to reverse a decision in a development application [90]. Courts have been prepared to apply the principle to either refuse a development application or add conditions for consent for the development. The issue here is whether a court should have authority to address application of the principle in the hidden collapse situation as detailed in Section 1. The issue relates to decisions about precautionary actions against long term risk at the initial stages of decision making relating to a particular extractive or other process, and its likely impact on the environment. The question is the possibility of giving legal standing to bring a merit review of a departmental decision to not apply the principle where there is evidence of long-term environmental risk. A merit review in this context could reconsider evidence relating to scientific evaluation of risk, including risk characterization and extent of risk exposure (discussed in recommendation 6.2).

Assuming regulation contained procedures for initial assessment of applying the principle, the possibility of successful merit reviews at initial stages is strengthened. However, it may be difficult for a merit review to know who is making the decision and what information is relied on which is subject to review. To address this problem, this paper proposes the creation of an 'authorised person,' to ensure procedures for undertaking a scientific assessment of environmental risk have been taken. The authorised person exists in Australian local government law, for example, and their role is primarily to ensure members of the public comply with relevant obligations under Local Government Acts [91]. This precedent could be usefully adapted into environmental law, to enable a point of reference for possible merits reviews of decisions about the principle. In order for this to have functionality, it requires the authorised person to have the power to address whether a scientific review has been undertaken within the department responsible for the extractive or other process and that a decision has been made on the merits of applying the principle. Standing could be given to range of stakeholders to undertake a merit review under defined circumstances. For example, standing for members of the public would not be unrestricted, but could accord to a similar position of standing for 'interested persons' under Australian federal environmental legislation [92]. This regulatory regime provides some context for initial assessment and potential merit reviews of matters pertaining to long term environmental risk.

6.4. Recommendation 4: Regulating the Use of Key Evidentiary Thresholds and Burdens of Proof

Key evidentiary thresholds relating to 'serious threats' and 'irreversible change' are potential triggers for implementing the principle. The nature of the trigger must address causal connections to triggering events and environmental risk. The problem for causality in this context is identifying critical thresholds that trigger a precautionary response before a long-term risk occurs. Regulations should be more prescriptive on evidentiary thresholds on what represents a serious environmental threat. For example, evidentiary thresholds with forestry pertaining to total allowable cut addressing the risk of excessive cutting rates and in the context of total logging take. Allowable cut indicators are important and could function as triggers for precautionary action.

Use of evidentiary thresholds requires clarity over who carries the burden of proof. The burden of proof generally falls on an applicant or plaintiff in a legal matter. In a merit review a challenger to a departmental authorisation would normally carry the burden of proof. In relation to decision making on evidentiary thresholds in respect to the principle, an objector to a decision about whether the threshold has been crossed or not would be required to bring forward relevant scientific evidence. The decision maker would then be required to disprove the objection beyond reasonable doubt or else otherwise indicate how the threat can be managed when not applying the principle. Who has the burden of proof on whether scientific thresholds have been crossed is not regulated in Australia. This regulatory gap means it is left to the courts to decide on who carries this burden. The level of scientific uncertainty on a matter should be subject to greater precision on evidentiary thresholds, thereby allowing a firmer base for precautionary decision making.

6.5. Recommendation 5: Use of Criteria in Regulation in Applying the Principle

Criteria and indicators of sustainable natural resource management by sector represent an essential element of precautionary risk management. In the context of sustainable forest management criteria and indicators can be used to improve monitoring of forest stands within the forest life cycle. For example, Criteria and Indicators of Sustainable Forest Management in Victoria contain reference points for all aspects of the forest life cycle and its management and care. For example, Criterion 1 relates to conservation of forest biodiversity, Criterion 2 covers maintenance of the productive capacity of forest ecosystems, and Criterion 3 covers maintenance of ecosystem health and vitality. They all provide benchmarking reference points for potential activation of the principle. Criterion 2.3, for example, covers annual production of wood products in Victorian state forests compared to sustainable harvest levels, providing an application threshold based on a fundamental standards for ecologically sustainable forest management. The rationale for Criterion 2.3 is to measure the take of wood compared to the sustainable level of production, which differentiates the commercial take of wood from ecologically sustainable levels of production. Use of Criterion 2.3 connects data collected with sustainable harvest levels and can be a potential precautionary trigger when applying the principle. The principle can be potentially applied when sustainable take is exceeded, giving rise to a proportionate adaptive management response to adjust the take.

6.6. Recommendation 6: An Administrative Framework for Decision Making Addressed in Regulation

Methodologies for application of the principle and the adaptive management response align data collection with criteria and indicators relevant to each stage of decision making. Regulation could provide a sequence of steps in administrative decision making consisting of: (1) identification of the responsible party for applying or determining the sustainability outcome, (2) data collection based on specific criteria and indicators, (3) reviewing the data against relevant criteria and indicators, (4) determining whether the status of the data activates a trigger, and (5) a process for determining and applying a proportionate response to the degree of risk. Stage1 - 5 is with the relevant department, subject to a review process by the independent authorised person, discussed in recommendation 6.3. In such a model, third parties, including environmental non-government organisations have authority to supply data to these entities. The authorised person has final authority over application of the principle based on supplied data.

7. Conclusions

This article identifies serious regulatory gaps and failure in how some jurisdictions apply the precautionary principle to long term environmental risk. Hidden collapse was identified in Victorian Mountain Ash forests in 2018, but this did not evoke a precautionary response at the time. Victorian government auditors have identified poor regulatory application of the principle for sustainable forest management, which suggests the need for reform. This article argues for a change in administrative processes for decision making in respect to the principle. It also proposes the use of prescriptive methodologies for application of the principle to address risk assessment, scientific evaluation, and available options to manage long term environmental risk. Use of prescriptive methodologies provide operational guidelines to trigger application of the principle and when administering a proportionate precautionary response. Such guidelines are strongly dependent on using data aligned with criteria and indicators of sustainable forest management. Methodologies must characterise the threat and help assess the risk uncertainties surrounding scientific and other data. Such methodologies must account for scientific uncertainty on long-term projections, such as those implicit in hidden collapse. It is essential these methodologies are contained in regulation with sufficient detail to support decision making on fundamental obligations such as a mandatory application of the principle in the face of evidence of the threat of serious or irreversible environmental damage.

This article discussed hidden collapse in the context of applying the principle. The principle is inherently problematic for regulation, and this was shown to be especially so in respect to identifying and responding to long term environmental risk. The conceptual framework advanced in this article is designed to address long-term risk after taking account of scientific uncertainty and the administrative context in which decisions are made. This context must provide a more rigorous process for scientific evaluation in order to address different levels of risk perception. The administrative context must account for inconsistency in decision making thereby requiring, in the view of the author, regulated methodologies as guidelines for the scientific evaluation process, and for consideration of available options in precautionary decision making for a particular matter. The latter requiring great care in determining the proportionate response to the level of environmental risk. In Section 5, a consideration of two regulatory frameworks was designed to highlight the need to address the administrative environment for decisions making. The discussion in Sections 1–5 is designed to make clear that a simple mandatory application of the principle, such as in the Victorian jurisdiction, simply will not work in addressing long term environmental risk. Indeed, such mandatory applications even run the risk of non-application of the principle because of a lack clarity over who and what triggers application and a process for scientific evaluation. The final list of recommendations provide guidance on addressing long term environmental risk, and a means to use the principle in a proactive, and not reactive way, to address serious decline in biodiversity across the globe.

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