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– ARTICLE –

SCIENCE VERSUS INDIGENOUS KNOWLEDGE?
TOWARD A DIALOGICAL APPROACH

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ABSTRACT

In November 2019, three academics from Auckland University published an opinion piece in which they examined the relationship between science and mātauranga Māori. They concluded that, 'Mātauranga Māori…subverts those aspects of science – namely objectivity, universality, and dedication to progress – that can further advance the understanding of nature and help find solutions to the major problems afflicting the planet.' Part One of this paper examines the assumptions behind that conclusion and the sources of information used by the authors to construct their argument. It uncovers a fabric of wilful distortion, fabrication, omission, false comparisons and hyperbole. Part Two then addresses one of the major problems currently affecting the planet – the loss of biodiversity – and finds that the above-mentioned authors' assumptions about science, indigenous knowledge and the planet's problems are contradicted by the current global scientific consensus.

Keywords: mātauranga Māori, science, planetary problems, biodiversity, human-nature relationships.

INDIGENOUS KNOWLEDGE AND SCIENCE

In recent years, a number of international science organisations have made recommendations for bridging the divide between indigenous knowledge and science. These organisations include the World Conference on Science in 1999, the US National Committee for the International Union of the History and Philosophy of Science (2001), the International Council for Science (2002), and the American Association for the Advancement of Science (Bala and Joseph 2007, 40). A number of United Nations' institutions and development agencies have also supplied recommendations, including the International Labour Organisation, the Food and Agriculture Organisation, the World Health

Organisation, the World Bank (2003), the Canadian International Development Agency (2002), the International Development Research Centre, and the Netherlands Organisation for International Cooperation in Higher Education (Bala and Joseph 2007). The United Nations Environmental Programme (1999), the International Panel on Climate Change (2014), and the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (2019) should also be mentioned.

The number of academic articles addressing this issue over the last decade has been extensive (for a review see Bohensky and Maru 2011). In New Zealand, Māori indigenous knowledge, or *mātauranga* Māori, has recently been incorporated into the country's science policy under the Ministry of Research, Science and Technology's policy *Vision Mātauranga,* a move that has been welcomed in some quarters, but criticised in others for its potential risks (Muru-Lanning 2012, 2018; Barber 2019; Corballis *et al.* 2019). In what follows, I will discuss two such risks: the effects of this policy on the integrity of *mātauranga* Māori and the Māori communities whose property it is (Barber 2019); and, as dicussed by Corballis *et al.* (2019), the effects of this policy upon the integrity of science and its ability to find solutions to major problems afflicting the planet. I will begin by describing the New Zealand Ministry of Research, Science and Technology's policy *Vision Matāuranga.*

Vision Mātauranga

Vision Mātauranga is the name given to a Ministry of Research, Science and Technology (MoRST) policy document. Its full title is *Vision Mātauranga: Unlocking the Innovation Potential of Māori Knowledge, Resources and People*. A key phrase in this title is 'innovation potential', which is defined in the document's glossary as 'the process by which marketable products are developed through R&D [research and development], commercialized and made available to the market place' (MoSRT 2007, 24). This makes the intent of the policy clear, and unambiguously supports the claim made by Muru-Manning (2018) that *Vision Mātauranga* has been created to commodify Māori knowledge (p. 139).

Another key word in the document is 'distinctive', which is used in combination with 'research themes', 'activities and products', 'issues, challenges and opportunities', 'products, processes, systems and services', and 'products that may be distinctive in the international marketplace'. The emphasis is on the distinctiveness of the contribution that Māori knowledge, resources and people might make 'in partnership with Vote RS&T [research, science and technology]…to the nation as a whole' (MoRST 2007, 8).

The policy goes on to define four research themes: economic growth; environmental sustainability; improving health and social wellbeing; and indigenous knowledge as a contribution to research, science and technology (RS&T). Under the theme of 'economic growth', we are told that 'iwi and hapu pools of knowledge and experience…could be used to fashion distinctive products, processes, systems and services' (MoRST 2007, 9) for the international market place, and that,

> Many iwi- and hapu-based entities own and manage a range of resources [that] might also be utilized to create distinctive products. These include mineral deposits, natural gas, geothermal fields, unique landscape features (micro-climate, soil types), lakes, rivers, coastlines and seabed, native flora and fauna, traditional knowledge, intellectual or cultural property, customary rights. (MoRST 2007, 10)

Again, the intent of the policy is unambiguous: it is to facilitate the commodification of Māori knowledge and Māori owned natural resources for the purpose of producing products for international markets. In a previous article, *Vision Mātauranga and its risks*, I have argued that the risk to Māori communities engaging in research conducted under the jurisdiction of the *Vision Mātauranga* policy lies in the reduction of *mātauranga* Māori (Māori knowledge) to its codified form, and severance from its organic connection to the Māori people (Barber 2019). This, firstly, diminishes Māori knowledge, and, secondly, undermines the capacity of Māori society to reproduce itself.

'The Defence of Science and the Status of Māori Knowledge'

In November 2019, a group of academics from Auckland University published an article entitled, *The Defence of Science and the Status of Māori Knowledge* (Corballis *et al*. 2019). In this article, the authors, Michael Corballis, Elizabeth Rata and Robert Nola, issue a warning that science is in danger of losing its authority as a system of knowledge. They claim that it is under attack from anti-vaccers, climate change deniers, footpath lichen eaters and 'alternative fact' claimants (p.1), and state that, 'On a larger scale, there have been the science deniers who adopt competing worldviews such as one of the various religions, a mystical worldview or one of the many different, often incompatible, ethnic traditions to be found in the world' (p.1). This is the context in which they consider recent efforts to incorporate *mātauranga* Māori into New Zealand science policy, asserting that an approach that 'subverts those aspects of science – namely objectivity, universality, and dedication to progress – that can help find solutions to the major problems afflicting the planet' (p.1). Their aim is to defend science from the weakening effects of 'indigenisation' (p.1) by defending science's methods.

The authors do see a role for *mātauranga* Māori in bringing elements of the rich traditions of Māori into science, but they insist that any form of knowledge so informed should be subject to the same rigorous standards and methods of science (Corballis *et al*. 2019, 6), i.e., its truth claims should be open to rational criticism, its theories open to falsification, and its methods accountable to scientific disciplinary authority of peer review. In this case, we could expect that those aspects of Māori knowledge that survive the torch of scientific scrutiny could then be held to be legitimate scientific knowledge.

Mātauranga Māori, however, is more than just discrete packages of appropriable knowledge. As Corballis *et al*. explain, *whakapapa*, the central ordering principle and cognitive framework of *mātauranga* Māori, creates ongoing links with the past. It provides stability to Māori society by linking the cultural knowledge, beliefs and practices of today to their history, thereby binding individuals to the group and the group to its ancestors (p.4). My concern is that reducing *mātauranga* Māori to appropriable items of empirical data will disempower it as a source of meaningful links to the past, thereby destabilising Māori society, culture and identity. This is an issue I raised in an earlier paper with regard to the commodification of *mātauranga* Māori for the purpose of generating products for international trade (Barber 2019). Corballis *et al*., however, are concerned about the disempowering effects of *mātauranga* Māori upon *science*: we have seemingly approached the issue from different perspectives.

In Part One of this article, I assess the integrity of Corballis *et al*.'s argument by conducting a 'forensic examination' of their logic and use of sources. In Part Two, I take their central claim that the incorporation of indigenous knowledge into science 'subverts those aspects of science that can help find solutions to the major problems afflicting the planet' and, by taking the example of one major problem afflicting the planet – the loss of biodiversity – contrast Corballis *et al*.'s view of the indigenous knowledge-science relationship with that of the prevailing scientific consensus.

PART ONE: A FORESIC EXAMINATION OF 'THE DEFENCE OF SCIENCE AND THE STATUS OF MĀORI KNOWLEDGE'

Corballis *et al*. centre their criticism of the integration of *mātauranga* Māori into New Zealand science policy upon the claim that *mātauranga* Māori and science 'should be considered 'equivalent'' (p.3). They argue that there is a lack of equivalence, and do so on two grounds: differences in methods and differences in standards of truth.

Differences in method

The authors accept the common translation of *mātauranga* Māori as 'Māori knowledge', and see it as a form of 'traditional knowledge', 'encompassing the traditional Māori way of viewing the world' that 'can include knowledge which has been scientifically established in order to solve problems' (Corbalis *et al.* 2019, 14). What they dispute is that there is an 'equivalence' of methods between *mātauranga* Māori and science. To illustrate this point, they use the argument that 'the Earth orbits the Sun':

> One may come to hold this [claim] on the basis of a séance, or a matter of faith, or because some Holy Book says so, or because it is society's traditional belief, and so on. But none of these provide the kind of evidence on the basis of which Copernicus and Galileo came to make this claim.
>
> What this illustrates is that two people might hold the same belief but quite different pathways have led to it; some scientific some not. Clearly this does not make for equivalence of belief systems. As illustrated, there is a lack of equivalence founded in the different method that was employed by Copernicus and others to arrive at his claim. In the light of this, science and Mātauranga Māori cannot in any good sense be regarded as equivalent as bodies of belief; the difference lies in the method and evidence used to justify the belief. (Corballis *et al.* 2019, 3)

Before considering the relevance of this illustration, we should ask who is claiming that *mātauranga* Māori and Science *are* equivalent? Corballis *et al.* state that Hikuroa (2017), an advocate for *mātauranga* Māori, 'builds on several decades of publications justifying an alleged 'equivalence' of traditional knowledge and science' (p. 3). However, we are left with no direction as to these 'several decades of publications', and Hikuroa himself makes no such claim. His concern is for *mātauranga* Māori to be seen as 'compatible' with science (p. 6). In addition, there is a difference between 'equivalent' and 'compatible': 'equivalent' means of equal value; 'compatible' means able to co-exist.

The other candidates for the claim of 'equivalence' between *mātauranga* Māori and science are New Zealand's universities and research institutes, among which Corballis *et al.* state that *Vision Mātauranga* has been operating for over a decade: 'a state of affairs justified by the perceived 'equivalence' between the two types of knowledge' (p. 6). No evidence is given, however, of the said universities and research institutes justifying their adoption of *Vision Mātauranga* on this basis. It is possible that, if a survey of these institutions was carried out, any number of alternative 'justifications' might be found. For example, it might be that adoption of the policy gives access to government funded research grants.

To return to the example of 'Earth orbiting the Sun', what, we might ask, is this illustration meant to prove? *Mātauranga* Māori is not devoid of knowledge of planetary movements, for how else did the ancestors of Māori navigate their way to Aotearoa and their descendants devise a calendar (*maramataka*) as 'a predictive tool for scheduling activities critical to the continued success of hapu and iwi such as fishing, gathering kai moana [sea food], and planting and harvesting food' (Hikuroa 2017, 7)? The point is, *mātauranga* Māori is oriented to a different set of practical concerns than the science of Copernicus and Galileo, and the question should therefore be whether or not their respective findings are based on careful observation and prediction: there is every reason to think that they are.

When it comes to theory, Corballis *et al.* put great stock in the Popperian principle of falsification for defining whether a theory is scientific or not. They attribute to this principle the relentless advance of science through its exercise of unceasing doubt and challenge to traditional authority. By contrast, they explain how traditional knowledge tends to uphold tradition and valorise the past. As an example of this, they refer to the following statement by Hikuroa (2017) regarding Māori cosmonogy:

> Whakapapa is the central principle that orders the universe, demonstrates an interconnectivity between everything, and is a cognitive genealogical framework connecting creation of the universe to everything that exists within it via descent from ancestors. In Māori cosmogony, because there is only one set of primal parents (Ranginui and Papatuanuku, from whom everything ultimately traces descent), all things are related. (Hikuroa 2017, 6)

Such a theory, Corballis *et al.* claim, 'provide[s] stability by *not* doubting – by linking the cultural knowledge, beliefs, and practices of today to their history… [binding] individuals to the group and the group to the ancestors. It gives traditional knowledge its mana and status', but is *highly unlikely to survive within science* (p. 4). The implication is that traditional knowledge is rigid and conservative, whereas scientific knowledge is dynamic and progressive.

The crux of their argument, however, is the comparative adequacy of methods, and, in a statement of *mātauranga* Māori methodology, Hikuroa writes:

> Mātauranga Māori is the pursuit and application of knowledge and understanding of Te Taiao [the Universe], following a systematic methodology based on evidence, incorporating culture, values and world view. Purukau [traditional stories] and maramataka [the Māori calendar] comprise codified knowledge and include a suite of techniques empirical in nature for investigating phenomena, acquiring new knowledge, and updating and integrating previous knowledge.… [T]hey incorporate critically verified knowledge, continually tested and updated through time. (Hikuroa 2017, 5)

Surprisingly, Corballis *et al*. overlook this statement of *mātauranga* Māori methodology, i.e., one that describes methods very similar to those of science, in favour of one on Māori cosmogony.

Different attitudes to truth

In their second effort to demonstrate the lack of 'equivalence' between *mātauranga* Māori and science, Corballis *et al.* compare their 'different attitudes to truth'. They take as an illustration the Moriori exhibition at New Zealand's National Museum (Te Papa) in 1999:

> Four History professors took Te Papa to task for the omission in its Moriori exhibition of all references to the 1835 conquest of the Chatham Island by 'mainland' Māori and massacre of a great portion of the traditional Melanesian-Moriori population who had been living there since, probably, the 1500s. The professors accused the museum of misrepresentation and suppressing the truth. (Corballis *et al*. 2019, 5)

As evidence of *mātauranga* Māori's different standard of truth, they present a defence of the museum's actions by 'an acknowledged Mātauranga Māori expert [Professor Mason Durie]', as follows:

> People who do not understand Mātauranga Māori may have difficulty in understanding there are many different standards of truth. Since relations between Māori Te Ati Awa and Moriori remain contentious

> more light is shed by the omission of certain events than by their inclusion. (Munz 2000 as cited in Corballis *et al*. 2019, 5)

What this 'quotation' is meant to show is that in *mātauranga* Māori, the suppression of truth is justified. However, the 'quotation' just given differs significantly from what Durie was actually reported to have said. Munz quotes Durie as saying,

> there are many different standards of *knowledge and each standard reflects the cultural situation of the historian*. Since relations between *some* Māori Te Ati Awa and Moriori remain contentious, 'more light is shed *on the Moriori story* by the omission of certain events than by their inclusion'. People who do not understand mātauranga Māori, he said, may have difficulty in understanding *this*. (Munz 2000, 14; italics added)

When we compare these two accounts of what Durie said, we see that Corballis *et al*. have removed certain words (those in italics), fragmented Durie's first and last sentences, and reassembled the parts differently. Durie's *last* sentence, with the word 'this' removed, has been added as the first part of Durie's *first* sentence, with the word 'knowledge' replaced by the word 'truth', and the words 'each standard reflects the cultural situation of the historian' have been removed altogether. The effect is to create an entirely new sentence with a different meaning. From Durie's second sentence, the words 'some' and 'on the Moriori story' have been removed.

The extraordinary liberty that Corballis *et al*. have taken with what Durie is reported to have said has the effect of concealing what he was actually saying. To see this, we simply need to ask, what was Durie referring to in his last sentence by the word 'this'? It is reasonable to assume that he was referring to his immediately preceding statement, 'Since relations between *some* Māori Te Ati Awa and Moriori remain contentious, 'more light is shed *on the Moriori story* by the omission of certain events than by their inclusion' (italics added). Durie was thereby explaining what 'people who do not understand *mātauranga* Māori may have difficulty understanding'.

It is important, therefore, to examine what Corballis *et al*.'s removal of the words 'some' and 'on the Moriori story' conceal. The removal of the word 'some' conceals the knowledge that contentious relations between Moriori and Te Ati Awa remain, with only *some* (not all) Te Ati Awa. The significance of this lies in the fact that (as we learn from Munz) Moriori have a claim pending under the Treaty of Waitangi (Munz 2000, 14), and this would explain why Moriori would have chosen to omit mention of the 1835 massacre from their museum exhibition. Their desire was for good relations with *all* Te Ati Awa, and they would not have wanted to inflame relations with those Te Ati Awa with whom contention still existed by highlighting a historical massacre that put them in a bad light. This is understandable both in pragmatic terms and in terms of *mātauranga* Māori.

From a pragmatic point of view, with Moriori being a tiny minority within a minority, and struggling for recognition of their treaty claims, it is understandable that they might put their desire for good relations with Te Ati Awa ahead of reviving memories of past massacres. In pursuing their Treaty claim, Morori are looking to the future, and in that context, calling attention to past massacres, and insisting that *they* be the focus of their 'story', may not have been in their best interests. In terms of *mātauranga* Māori, an approach to knowledge that prioritises social relatedness, it is understandable that Moriori might prioritise good social relations over objective standards of historical truth, and this is what Durie means when he explains that those who do not understand *mātauranga* Māori would have difficulty understanding.

This interpretation of Moriori actions is accessible from the information made available by Munz (2000), but it appears to have eluded him: he even suggests that 'Moriori claims against Māori would be strengthened, not weakened, by the memory of the massacre' (p.14). This only shows that he does not understand *mātauranga* Māori, and how, being personally unaffected by Moriori/Te Ati Awa relations, could feel free to pursue his interest in the abstract idea of objective historical truth, regardless of how it might have affected those relations and the outcome of the Moriori Treaty claim.

There will be many people who feel the same way as Munz, but the staff of the Te Papa Museum were not among them, and they were subsequently castigated by Munz and Corballis *et al*. for violating academic standards in taking the position they did. Whether or not the museum staff fully understood why Moriori were telling *their story* as they did, they did have the decency and humility to support their right to do so. Munz and Corballis *et al*., on the other hand, think that the museum should have put Western academic values before the values of Moriori and censored the exhibition. Munz (2000) even saw the museum's failure not to do so as an act of 'political propaganda' (p.16). Corballis *et al*. go further: they see the museum's approach as 'no more justified than some German, French, Polish approaches to holocaust history. Or the Chinese Communist Party's approaches to Cultural Revolution or Tiananmen

Square history' (p.17). These comparisons, however, though exaggerated, are, in another important respect, inapt: in the Moriori case, it was the victims of the massacre who were choosing, for their own reasons and of their own volition, not to mention it. This cannot be said in the cases of the Holocaust, the Chinese Cultural Revolution and the Tiananmen Square incident. In this respect, Corballis *et al.*'s standards of comparison are seriously flawed.

What we learn from Durie is that the Te Papa Moriori exhibition was about *making* history, not recording it: this is what Durie meant by the omission of the massacre from the exhibition *shedding more light on the Moriori story than its inclusion*. The Moriori story is about looking to the future, and representing themselves in a light that best serves that future. This understanding of Moriori actions was made accessible by Munz to anyone who wished to read him, even though he himself did not articulate it. In the case of Corballis *et al.*, it is made *inaccessible* to their readers by their wilful distortion of what Durie is reported to have said. It is ironic that this wilful distortion perpetrated by Corballis *et al.*, and the hyperbole redolent in their flawed comparisons, were being made in defence of the scientific ideal of truth.

Other questions arising

The above points of discussion refer specifically to *mātauranga* Māori, but the Corballis *et al.* article also raised questions of a more general nature, which I have summarised below. The first concerns their efforts to differentiate scientific and indigenous knowledge as opposed and competing forms of knowledge.

Scientific and traditional knowledge

There is a long history of scholarly attempts to differentiate scientific and traditional or indigenous knowledge (the terms 'traditional knowledge' and 'indigenous knowledge' are often used synonymously). Some philosophers of science have argued for the special character of science based on its search for universal and objective truth; others on its formal methods. These arguments have relied, however, on idealised models of science that fail to capture the complex reality of actual scientific practice (Ellen 2004). Empirical investigations of scientific practice have shown how rooted science is within institutionalised cultural values, social hierarchies, and political and economic interests, and how these ideological entanglements generate a diversity of theoretical and methodological approaches. The same can be said of indigenous knowledge: indigenous knowledge is equally embedded in diverse institutional frameworks and its theories and practices vary accordingly. Any attempt, therefore, to categorically differentiate indigenous knowledge from science can only be made at the level of ideal models, and here the danger lies in mistaking these simplified idealised models for the complex reality of actual knowledge systems, and in using these ideal models to denigrate and marginalise alternative ways of knowing. In place of this idealised, oppositional, zero sum view of scientific versus traditional knowledge, some scientists are recommending a more dialogical approach.

The possibilities of dialogue

Following the 2002 declaration by the 1999 World Conference on Science on the importance of traditional knowledge for science, and the US National Committee for the International Union of the History and Philosophy of Science's 2001 position paper urging scientists to learn from systems of indigenous knowledge, the International Council for Science (ICSU) set out to promote dialogue between science and indigenous knowledge (Bala and Joseph 2007, 40–41). At the time, there was concern among some scientists that such a dialogue would open the door to pseudo-scientific and anti-scientific claims (cf. Corballis *et al*.). This led the ICSU to set up a study group to identify ways of separating traditional/indigenous knowledge from pseudo- and anti-science. The study group began by differentiating science from pseudo-science. They reported that:

> Philosophers have failed to arrive at a satisfactory demarcation either by appeal to scientific method or other criteria. Moreover, some philosophers, such as Paul Feyerabend, have also contested the possibility and the desirability of making such a demarcation by appeal to a single method or set of criteria. (Bala and Joseph 2007, 43–44)

The study group proposed a combination of sociological and epistemological criteria for the demarcation. On the sociological front, they stated that 'from its inception, a pseudo-science is always more or less in explicit competition with a corresponding science' (p. 44), and on the epistemological front that, 'science has a higher degree of 'systematicity' [than pseudo-science]' in how it describes, explains, establishes knowledge claims, expands knowledge, represents the world, and pursues the ideal of completeness (p. 44). The group then proposed that indigenous knowledge could be distinguished from pseudo-science on the grounds that, unlike pseudo-science, indigenous knowledge is never concerned with subverting widely held scientific beliefs (p. 43), and that it should not therefore be seen as a threat to science. According to Bala and Joseph (2007), who recount these events, the problem facing the ICSU was 'a pervasive reservation within the discipline that dialogue with traditional knowledge would fling the gates open to multicultural barbarians who are out to destroy science and reason' (p. 56). They attribute this reservation to 'a multicultural science movement inspired by post-modern theory that set out to obliterate the distinction between knowledge and fiction' (p. 56). These comments could be used to better understand the position of Corballis *et al*.

The methods and purposes of science

The second question I have concerns the relationship between the methods of science and the purposes to which science is put. Knowing that science has sometimes been used to do harm to individuals, society and the planet, Corballis *et al*. ask that science's methods be seen as separate from the purposes for which they are used (p. 2). They claim that while the purposes are ethical, political and social and should be publicly debated, 'the methods of science belong to science' and are 'accountable to science itself' (p. 3). The suggestion seems to be that science's methods are not for public debate, yet this does not match their final plea that the relationship between science and *mātauranga* Māori be discussed publicly (p. 6). Finally, given that their defence of science's methods vis-a vis those of indigenous knowledge is premised on the greater efficacy of the former in helping find solutions to the major problems afflicting the planet, they themselves seem unable separate the evaluation of science's methods from the purpose to which they are put.

Indigenous knowledge and major problems afflicting the planet

The final question I have concerns the claim that the incorporation of indigenous knowledge into science policy subverts the efforts of science to find solutions to the major problems afflicting the planet. The major problems Corballis *et al*. appeal to are the measles outbreak of 2019 and climate change. They argue that the efforts of science to solve these problems are undermined by anti-vaccers and climate change deniers. This may well be so, but the main target of their critique is *mātauranga* Māori not anti-vaccism and climate change denial, and they give no evidence of how *mātauranga* Māori or any other ethnic tradition subverts efforts to find solutions to these or any other problem. They do assert that 'there have been science deniers who adopt competing worldviews such as one of the various religions, a mystical world view or one of the many different, often incompatible, ethnic traditions to be found in the world', and they give Mātauranga Māori as one example of this (p. 1). However, once again there is no evidence of anyone having adopted *mātauranga* Māori to support their anti-science views. It could even be argued that such an event would be unlikely: the dissident views in question are usually part of a larger package of populist sentiments, the proponents of which are usually dismissive of any tradition other than their own.

Given the seriousness of the problems afflicting the planet and the widespread search for solutions, it is disappointing to see a whole body of knowledge dismissed as counterproductive without giving any evidence of it being so, especially when there is a wealth of evidence to the contrary. In my own work, I have confronted one major problem afflicting the planet – the global loss of biodiversity – and in seeking solutions to this problem, I have encountered a growing body of opinions among scientists that a dialogical relationship between science and indigenous knowledge is necessary for any such solution to be found. In the second part of this paper, I will discuss this global problem, its causes and the proposed solutions, as well as the parts that science and indigenous knowledge can play within these.

PART 2: THE PROBLEM OF BIODIVERSITY LOSS

Biodiversity is the variety of forms of life – plants, animals and microbes – within an ecosystem, and the interactions between them. The more diverse an ecosystem, the more sustainable it is. When ecosystems are diverse, there are many pathways for ecological processes, so if one is damaged or destroyed, an alternative pathway can be used. Biodiversity also applies to farming systems where it is called 'agro-biodiversity'. Where there is high agro-biodiversity, such as in poly-cropping systems, there is more effective natural pest control, more effective pollination and nutrient cycling, and the system as a whole is more stable and resilient. There is a growing consensus among scientists today that the loss of biodiversity is *the* major problem facing the earth, and that a major cause of this has been the industrialisation of agriculture.

Industrial agriculture

All forms of agriculture imply the simplification of nature's diversity by replacing it with a small number of cultivated plants and domesticated animals (Altieri 2003, 1), but industrial agriculture simplifies nature in the extreme. With the adoption of large-scale monocrop plantations of uniform high-yield crop varieties, industrial agriculture has created genetically homogeneous landscapes in which genetic diversity has been severely eroded. This has led to serious environmental problems. Biological diversity plays a key role in pest control and nutrient cycling, and the lack of biodiversity makes industrial monocultures extremely vulnerable to pests and diseases (Third World Network and SOCLA (TWN) 2015, 1). To protect these monocultures, copious amounts of pesticides are used at considerable environmental and human cost (Altieri 2003, 3). Plants and animals, however, quickly develop genetic resistance to pesticides, and this, compounded with the destruction of natural control mechanisms through the loss of beneficial wild plants, insects and birds, has led to rapid pest recovery, calling for the application of newer and stronger pesticides (Altieri 2003, 9), a process that has been labelled the 'pesticide treadmill' (Perfecto, Vandermeer and Wright 2009, 54). High-yield industrial crop varieties also require heavy applications of chemical fertiliser, leading to soil erosion, loss of soil fertility, depletion of nutrient reserves, soil salinization and alkalinisation, and the pollution of water systems (Altieri 2003, 9). In addition to these environmental problems, industrial agriculture brings with it a variety of economic and social problems: negative impacts on public health and food quality, the disruption of traditional rural livelihoods, and accelerating indebtedness for thousands of farmers (Altieri 2009, 102; Shiva 1991).

Solutions to these environmental and socioeconomic problems cannot be simply technological, because they are deeply rooted in an economic and political system that promotes a rural development agenda dominated by a small group of multinational corporations that control what is produced, what technologies are used, what food consumers eat, the quality and quantity of that food, and the price they pay for it (Third World Network and SOCLA (TWN) 2015, 3). This agenda is followed in pursuit of profits at the expense of everything else, including the health of consumers and farm workers, the viability of small family farms, wildlife, the environment and rural communities (Altieri 2003, 11). Meanwhile, the environmental and social costs of industrial agriculture – chemical pollution, greenhouse gas emissions, water contamination, loss of biodiversity, soil losses and public health impacts – are treated as 'externalities' to be paid for by the public and future generations (Third World Network and SOCLA (TWN) 2015, 4). A growing number of scientists are now stating that, to solve these problems, a transition from industrial agriculture to agroecology – 'the application of the science of ecology to agricultural systems' (Third World Network and SOCLA (TWN) 2015, 4) – is required, and that one of the main sources of knowledge for guiding such a transition is *the traditional knowledge of indigenous farmers.*

Agroecology

Altieri describes agroecology as a 'highly knowledge-intensive' (Altieri and Toledo 2011, 589) form of agriculture founded on 'the systems that traditional farmers have developed and/or inherited throughout the centuries' (Altieri 2002, 3). Such systems are said to exhibit high levels of biodiversity, indigenous systems of resource management, diversified agriculture, and resilience to environmental disturbance, and to be nurtured by traditional knowledge systems and traditional socio-cultural institutions (Altieri and Toledo 2011, 591).

Vandermeer and Perfecto (2013, 76–77) endorse the agroecological focus on traditional knowledge, arguing that traditional small-scale farmers have a knowledge base that is similar to the growing scientific understanding of ecological complexity. Norgard and Sikor (1995) argue that the required transition to agroecology would require a change to the methodology of conventional agricultural science, and in comparing the methodology of conventional agricultural science with that of agroecology, they comment that,

> Conventional agricultural scientists follow the dominant premises of science. For example, they assume that farm production can be understood objectively, apart from farmers, how farmers think, and apart from social systems and from the surrounding agroecosystem. Accordingly, they conduct controlled experiments in laboratories and on the plots of experimental field stations. Furthermore, they assume that farming can be understood atomistically, or in small parts. Hence, they divide themselves into disciplines and sub-disciplines and study the physical properties of soil apart from its biological properties and apart from the life the soil supports. They examine the toxicity to insects of different chemicals without considering how diverse insects interact with each other and with plants, and the separate understandings are developed and transferred to farmers in the form of new technologies. Needless to say, farmers have not always found that the new technologies fit their farming system. Furthermore, the separately and individually derived technologies frequently have unexpected effects when used on the farm, especially when used in combination. And the cumulative effects of conventional agricultural technologies when used by all farmers together sometimes have devastating ecological and economic impacts.
>
> Conventional agricultural scientists have long realized that their agricultural technologies have problems…[and have] begun to pay more attention to farmers' needs, tried to listen to the farmers, and begun to conduct on-farm research.…[These efforts] however, have only been moderately successful in overcoming the problems of their technologies, because they have yet to realize that the problems are inherent to the philosophical premises of their methods and practices.…[T]hey have not really been able to listen to what farmers have

> to say because the philosophical premises of conventional science do not give farmers' ways of learning and knowing any legitimacy. (Norgard and Sikor 1995, 21–22)

The views expressed above are not those of just a few dissident agronomists: support can be found in a number of recent international publications. In 2009, after six years of consultation involving more than 400 scientists from all continents, the World Bank and United Nations sponsored International Assessment of Agricultural Knowledge, Science and Technology (IAASTD) concluded that, for industrial agriculture, '[b]usiness as usual is no longer an option' (IAASTD 2009, 3), and '[a] thorough and radical overhaul of present international and national agricultural policies is necessary to meet the enormous challenges of the 21st century' (Beck, Haerlin and Richter 2016). The same conclusion was reached by the United Nations General Assembly in 2010, and the International Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in 2019.

Proposed solutions to the agricultural crisis

The industrialisation of agriculture has been based on three assumptions: that there would always be abundant and cheap energy (namely oil), that climates would remain stable, and that there would always be plenty of available water. Today, none of these assumptions is valid (Third World Network and SOCLA (TWN) 2015, 2), and the world is faced with an agricultural challenge to increase food production on the same land base, *while using less petroleum, less nitrogen, less water, less herbicide and less pesticide* (Third World Network and SOCLA (TWN) 2015, 4). Currently, there are two solutions being advocated for this problem: biotechnology, i.e., the production of genetically modified (GM) crops that will be more productive with less water, less dependent on herbicides and insecticides, and more amenable to changes in the climate; and agroecology, i.e., the application of the science of ecology to agricultural systems in order to increase biodiversity and allow interactions among species to work effectively to reduce the need for artificial fertilisers, pesticides and herbicides (Altieri and Rosset 1999).

Biotechnology and genetically modified organisms

There are two main types of GM crops being sold today: those that are herbicide tolerant, allowing the crop to be sprayed with herbicide to kill the weeds while leaving the food crop undamaged; and those that are pest resistant, i.e., able to produce their own natural insecticide *bacillus thuringiensis* (*Bt*), so that there is no need to spray them at all (Altieri and Rosset 1999). It might be expected that these innovations would lead to less herbicide and pesticide use, but this is not the case: if you can spray herbicide over the whole crop without it affecting the crop itself, then this leads to more herbicide use, and, with regard to pest resistant crops, after a few seasons, the pests develop resistance to the insecticide and farmers have to buy new and more powerful pesticides. Such outcomes should come as no surprise given that these technologies are being produced and marketed by herbicide and pesticide manufacturers (e.g., Monsanto/Bayer).

A multitude of other problems arises from the use of GM technologies. GM crops are designed for mono-cropping, and this destroys biodiversity, leading to greater vulnerability to pests and disease. Genes for herbicide resistance can be transferred through gene flow from cropping plants to wild plants, and this can create herbicide resistant 'super-weeds' that cannot be controlled. As pests rapidly develop resistance to the natural *Bt* insecticide that GM crops are engineered to produce, this natural pesticide is becoming useless, forcing organic farmers who use this natural insecticide to give up organic farming and return to buying chemical pesticides. Meanwhile, the large-scale use of pest resistant *Bt* crops is killing beneficial insects and soil organisms that play important ecological roles in controlling pests and fertilising the soil. All this leads to greater dependence upon chemical fertilisers, herbicides and pesticides (Altieri and Rosset 1999).

The socio-economic and cultural effects are also disturbing: nobody yet knows what the long-term health effects are of eating GM foods, but the herbicide use that they encourage threatens the health of millions of farmers. Farmers who use GM crops become dependent on the supplier of GM seeds: they need to borrow money to buy both the seeds and the herbicides, and this leads to indebtedness, loss of control over what a farmer plants, and eventual loss of land. The introduction of GM crops also leads to the loss of ritual and ceremonies associated with native plant species, and long-standing practices of seed saving and sharing. (Altieri 2000, 13–23; Altieri and Rosset 1999, 155–162).

Even the argument that GM crops are necessary to feed the world's growing population do not stand up. It has been shown that GM seeds do not increase crop yield (Altieri and Rosset 1999). Furthermore, GM crops are designed for animal feed or biofuel production, and, as a result, food production has actually declined. The aim of the chemical companies that produce GM seeds is not to feed the world: it is to control the production process by making farmers dependent on them for their seeds, and, as the farmers fall under the control of such corporations, they have to plant whatever the corporations tells them to plant. Agrochemical corporations are in business to make profits, not to help the farmers or the consumers. Solutions to the problems facing agriculture do not, therefore, lie in buying more agrochemicals and GM seeds. The only real solution is a transition toward an ecological, non-chemical-based form of agriculture, such as agroecology.

One of the principal obstacles standing in the way of such a transition, however, is the massive pouring of scientific resources into the continued development of industrial agricultural technologies, while the much-needed development of agroecology is ignored. Vanloqueren and Baret (2009) argue in their article, *How Agricultural Research Systems Shape a Technological Regime that Develops Genetic Engineering but Locks Out Agroecological Innovations*, that this bias can be accounted for by the single-minded focus of government policy on economic growth and international competitiveness.

Bias in agricultural science research

Under the influence of state policies focused on economic growth and international competitiveness, 'public good' research has become defined as research that leads to the creation of commercialised products likely to support economic growth. Typical examples of this are technological discoveries that can be protected by patents and intellectual property rights. While genetic engineering (GE) technologies fit this description, agroecological technologies do not. Agroecological research is aimed toward environmental protection, democratic control of the food system, social equity and food security. While these are all public goods, they cannot be patented or privately owned. Therefore, regardless of how relevant they are to the public good of long-term social, political, economic and ecological sustainability, they are not seen to be contributing to economic growth and international competitiveness, and subsequently do not receive financial and policy support.

Government priorities of economic growth and international competitiveness also influence the prevailing research culture of the sciences. Most scientists frame their research around government priorities and, again, GE research fits neatly into these trends. Agroecology, on the other hand, challenges the dominant political and economic trends: it calls for a fundamental change to current food and agricultural systems, but scientists shy away from this type of research as unlikely to receive political and financial support.

The bias of the agricultural sciences toward research into GE technologies is also affected by the career interests of scientists. Research scientists operate under a regime of 'publish or perish', and are interested in quick publishable results. GE research, with its stress on easily measurable variables–such as increases in gross yield, plays into the personal career interests of research scientists. Agroecology research, on the other hand, with its focus on much more complex measures, such as sustainability, requires long-term, on-farm experimentation, and so does not match the timeframe for research grants and publishing demands. Agroecology is about complexity at the ecosystem level, and its systems approach does not fit the reductionist approach of laboratory research (Vanloqueren and Baret 2009).

CONCLUSION

With regard to the relative merits of scientific and indigenous knowledge as a source of solutions to the major problems afflicting the planet, I have argued that a dialogical rather than oppositional approach is needed. The barriers to such an approach, however, are formidable: they are partly epistemological and partly economic and political. Idealised epistemological models set up a false dichotomy between indigenous and scientific knowledge, and the claim that science has a monopoly on truth functions to delegitimise indigenous knowledge. As such, it undermines dialogical efforts to find solutions to the major problems afflicting the planet and supports the 'business as usual' approach.

We need to question the idea that science has a monopoly on truth. Although it is based on a claim of objectivity and universality, the major problems afflicting the planet have at their root human-nature relationships that are neither solely objective nor solely universal. Human-nature relationships are systems of meaning that have a subjective as well as objective dimension. Their subjective dimension includes aesthetic values, emotional attachments to place, beliefs in local spirits, and the use of metaphors of human-nature reciprocity. It is attention to these aspects, and their local contextualisation, that characterises indigenous knowledge and makes it so conducive to wise environmental management. The strict application of scientific methods, in its search for objective de-contextualised knowledge for universal application, strips human-nature relationships of their subjective and localised aspects (Hornborg 1996, 1998, 2006). Capitalist markets are equally objectifying, de-contextualising and universalising in their search for internationally marketable commodities. In this sense, there is a *homology of spirit* between science and capitalism: both reduce natural and human phenomena to one dimension, and it is the corrosive effects of this one-dimensionality of thought upon our understanding of environmental and economic relations that is preventing us from finding solutions to the major problems afflicting the planet.

It is exactly this form of one-dimensionality of thought that Corballis *et al*. are arguing for in the belief that it will somehow hasten the search for solutions to the major problems afflicting the planet. However, what the above discussion demonstrates is that they are completely out of step with the scientific consensus on these matters. They are also completely out of step with the norms and values of the scientific objectivity they espouse. In their efforts to demonstrate the superiority of science over *mātauranga* Māori in terms of their respective methods and standards of truth, they have resorted to deliberate fabrication, misrepresentation, wilful omission, false comparison and hyperbole.

As a final consideration, we might want to ask whether science, by itself, could ever solve the world's problems. Solutions to the world's problems are not just a matter of good scientific evidence, but of persuading people to act upon that evidence in a coordinated fashion. For this, people need a sense of common identity, social solidarity, shared responsibility and political cohesion. Without this, as we have seen during the current COVID-19 pandemic, the measures proposed by scientists for mitigating or overcoming the challenges we face will not be enacted to the degree required. A new perspective on nature may also be needed. Indigenous knowledge systems offer complex and versatile arrays of knowledge, know-how, practices and representations that have been developed locally via close everyday interactions between humans and nature, and are anchored in worldviews enhancing the values of respect, sharing, reciprocity and humility toward nature (Nakashima and Roué 2002; Berkes, Colding and Folke 2000). This is a perspective much needed today. Setting up false dichotomies and dismissing indigenous knowledge as inferior compared to the abstract ideals of science is not the way forward.

NOTES

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