Witness Brief — Form 2

Royal Commission on Genetic Modification

(For Publication)

1. Name of Witness

Dr. E. Ann Clark

2. Name of "Interested Person" (on behalf of whom the Witness will appear)

Green Party

3. Witness Brief Executive Summary

Executive Summary

Provide an overarching summary of the evidence and recommendations made [in respect of items (1) and (2) of the Warrant]. The Executive Summary should be no more than **3** pages in length

Please note that individual section summaries will be required and therefore the Executive Summary should focus on summarising the issues addressed in the brief and provide cross references to the sections in which the issues are covered rather than summarising the substantive content

1. Genetically modified crops pose significant risks to the environment, and particularly to the unique environment of NZ. Risks identified in the refereed literature, from diverse disciplinary perspectives, are numerous and far-reaching. With the current rudimentary state of understanding of both gene function and physiology, these risks are largely unavoidable. If ever there was a time to invoke the precautionary principle, it is now.

2. With time and research effort, these risks may be ameliorated. However, research funding and infrastructure are finite. Allowing GM to dominate agricultural research endeavors, faculty positions, lab space, and growth rooms – as is undeniably happening around the globe - compromises research capacity in other areas of clear societal and environmental benefit. Indeed, it is entirely plausible that the longterm legacy of the current fascination with GM may well be the elimination of alternatives to GM in the future. Permitting continued expansion of the GM industry, especially in NZ, would be detrimental not just to NZ but to humanity as a whole.

Evidence by Section (as specified in the matters set out in the Warrant)

Evidence by Section

Witness briefs are to be structured in line with the matters specified in the Warrant and the sections numbered accordingly

Each section should stand alone, and include a section summary, identifying the issues addressed in the section

Witness briefs may address **all** or only **some** of the sections (as specified in the Warrant). However section numbers should be retained, for example, if a brief addresses matters (a), (c) and (e), the sections shall be numbered (a), (c), and (e), rather than a, b, and c

Witness briefs may, within each section, adopt a sub-section approach using different headings; however, each paragraph should be consecutively numbered

Section A Recommendations

The Warrant has set the Commission the task of receiving representations upon, inquiring into, investigating, and reporting on the items set out in Section A (1) and (2) below

Section A (1)

A (1) the strategic options available to enable New Zealand to address, now and in the future, genetic modification, genetically modified organisms, and products

Section A (1) Summary

3. A GMO-free NZ will have an enormous economic, environmental and societal advantage over North American and other competitors. This brief will focus on environmental advantages, but it should be clear that the range of potential impacts is broad.

A (1)

4. GM agriculture is being rejected globally, as people come to understand a) the risks to both the environment and to human health, and b) the lack of consumer benefit from first wave GM crops.

5. Environmental risks derive not simply from the intended traits, e.g herbicide tolerance (HT) or pesticidal plants (e.g. Bt), but also the unintended trait expression which so often accompanies transgene insertion (Meyer, 1996; Bergelson et al., 1998; Kumpatia et al., 1998; Demeke et al., 1999; De Neve et al., 1999).

6. Intended trait effects on the environment are have been identified from pesticidal plants – those fitted with genes coding for endotoxin production, to deter herbivory. Tritrophic effects have been documented for both Bt and lectin genes, indicating the potential for ramifying ecological impacts among trophic levels. Numerous other effects relate to soil organisms, trees, and horizontal gene flow.

7. The issues of gene silencing, unstable expression of the target trait, and unintended gene expression are well known and widely reported in the scientific literature. To a large extent, these problems are unavoidable because of the randomness of transgene insertion. The net effect is that contrary to the representations of industry, government, and academic proponents, GM is not precise, is not the same as plant breeding (Hansen, 1999), and does

engender a whole range of unpredictable and often adverse side-effects which can and will affect the environment.

Section A (2)

A (2) any changes considered desirable to the current legislative, regulatory, policy, or institutional arrangements for addressing, in New Zealand, genetic modification, genetically modified organisms, and products
Section A (2) Summary

8. NZ should capitalize on its isolation as an island, and its clean and green reputation, through a major push toward organic production systems. To allow production of GM crops in NZ would be to waste these inherent advantages.

A (2)

9. Research and extension funding has become disproportionately biased toward proprietary technologies, and towards GM in particular – not just in NZ but globally. Efforts to privatize agricultural research have necessarily channeled publicly funded research into proprietary directions. This is founded upon two untested assumptions, namely, that what is good for industry is good for society, and that proprietary technologies are the best way to advance agriculture. Each of these assumptions may be sound for specific cases, but certainly not in all cases. The extravagant amount of publicly funded research that went to support the development and commercialization of rBST in the US and Canada – a product that is globally rejected apart from the US - is just one example. Given global rejection of GM at present, it does not seem imprudent to ask for whose benefit are hundreds of millions of dollars of taxpayers money being expended in support of GM?

10. The organic sector in NZ is small but growing, as it is in the rest of the world. Indeed, organic is the only growth sector in agriculture in many countries. Without belaboring the point, it is instructional to consider why societal demand is growing at 20% a year, year after year, actively seeking organic produce which is being produced in a near vacuum of institutional support. Even more confusing, demand for organic is growing in preference to the chemical- and biotech-based produce which are being heavily promoted by government, academia, and industry. Perhaps the outcome of these deliberations should be informing decision making priorities for future research and extension to serve the people of NZ.

Section B Relevant Matters

The Warrant has set the Commission the task of receiving representations upon, inquiring into, and investigating, the matters set out in Section B (a) – (n) below

Section B (a)

B (a) where, how, and for what purpose genetic modification, genetically modified organisms, and products are being used in New Zealand at present
Section B (a) Summary

No comment

B (a)

Response

Section B (b)

B (b) the evidence (including the scientific evidence), and the level of uncertainty, about the present and possible future use, in New Zealand, of genetic modification, genetically modified organisms, and products
Section B (b) Summary

No comment

B (b)

Response

Section B (c)

B (c) the risks of, and the benefits to be derived from, the use or avoidance of genetic modification, genetically modified organisms, and products in New Zealand, including: **(i)** the groups of persons who are likely to be advantaged by each of those benefits **(ii)** the groups of persons who are likely to be disadvantaged by each of those risks
Section B (c) Summary

11. Due to the unpredictable nature of GMOs in commercial production, the people of NZ will be subject to environmental risk and ecological disruption.

B (c)(i)

Response

B (c)(ii)

12. Potential adverse impacts of GMOs on Canadian biodiversity have been summarized by Clark (accepted). Risks to the unique biodiversity of NZ may be presumed to be at least as great as those pertaining in North America.

13. Disciplinary Isolation. Resource-intensive agriculture, as supported by conventional plant breeding, exposes both biodiversity and hence, human health to risk (Grifo and Rosenthal, 1997). However, GM crops pose unique, additional risks, because they were conceptualized and developed largely in isolation from applied scientists. While conventional plant breeders work closely with applied scientists and farmers to improve crops, molecular geneticists have worked independently, to maintain control over the technology (see Wright, 1994). Examples of the avoidable ecological and agronomic problems created by the disciplinary isolation of GM crops are shown in Table 1.

14. **Table 1. Examples of the ecological and agronomic risks caused by the narrow disciplinary focus which has guided the development of the GM industry**

Untested and Since Invalidated Assumptions	**Missing Disciplines**	**Relevant Research Challenges**
regarding the three assumptions of the high dose/refugia model, 1. that major resistance genes will be very rare, 2. that resistance will be a recessive trait, and 3. that the refuge will supply susceptible mates - all of which are critical for resistance management in Bt crops	entomology, agronomy, ecology	Tabashnik et al. (1997); Huang et al. (1999); and Liu et al. (1999) documented that resistance genes may not be rare, that resistance is not recessive for some pests, and that pests that consume Bt and survive experience delayed development, putting them out of synch with susceptible mates; Andow and Hutchison (1998) stated that "None of the essential assumptions of the high dose/refugia strategy have been verified for BT corn" NET EFFECT: the high dose/refugia model may not be an effective deterrent to resistance in target organisms, shortening the effective lifespan of a given Bt event, obliging a return to toxic biocides to control target pests
4. that transgenic DNA will rapidly and completely degrade in the gut, precluding DNA transfer within or across the gut (e.g. a form of containment)	physiology, biochemistry, nutrition	Schubbert et al. (1997); Doerfler and Schubbert (1998); and Schubbert et al. (1998) demonstrated that when fed to rats, transgenic DNA moved across the intestinal cell wall into the nuclei of various cell types, including across the placental barrier and into embryonic nuclei. An artificial gut study reported by MacKenzie (1999) determined that DNA from transgenic bacteria survived long enough to potentially transform many other gut-inhabiting bacteria NET EFFECT: the intestines may be a portal for entry and exchange of transgenic DNA into new hosts, including humans, livestock, wildlife, and gut microflora (for more depth, see Clark, 2000).
5. that transgenes would affect only the intended target trait, and would not meaningfully affect expression of other genes in the host genome	plant breeding	Bergelson et al. (1998); Coghlan, 1999; Demeke et al. (1999); De Neve et al. (1999); Di Giovanni et al. (1999); Donegan and Seidler (1999); Hansen, 1999; Ho et al. (1999); and Kaniewski and Thomas (1999) - presented evidence of inadvertant expression of unrelated genes, the CaMV 35S promoter, gene silencing, and/or unintended effects of transgenic crops on soil biota NET EFFECT: gene insertion unpredictably affects any number of other, unrelated traits; the risks posed by GMOs encompass more

Untested and Since Invalidated Assumptions	Missing Disciplines	Relevant Research Challenges
		than simply the intended target traits; gene silencing compromises the utility of transgenic crops for industrial enzyme production and other traits
6. that horizontal gene transfer occurred in the lab but not in the harsher field environment	microbial ecology, virology, pathology	Hoffmann et al. (1994) and Ho (1998) discussed evidence of horizontal gene transfer; Ochman et al. (2000) reviewed evidence of horizontal gene movement via plasmids, transposons, and other mobile genetic elements, with emphasis on antibiotic resistance, virulence attributes, and metabolic properties NET EFFECT: lateral (horizontal) movement among unrelated organisms is another means by which transgenes can spread into the wider ecological community
7. that the possibility of, and implications of, sexual transfer of transgenic traits to a) same crop and b) wild relatives would be rare and manageable with current technology	plant breeding, evolutionary genetics	Desplanque et al. (1999); Ariolla and Ellstrand (1996 and 1997); Chevre et al. (1998); Ellstrand et al. (1999); and Traynor and Westwood (1999) provided evidence of actual or potential gene flow between crops and wild relatives NET EFFECT: transmission to same crop fields has already occurred, involuntarily affecting neighbors; sexual transmission of transgenes into wild and weedy crop ancestors will occur, most likely in crop centers of diversity in the Third World, potentially leading to loss of agronomically useful genes
8. that hybridisation and transformation events are so rare as to be inconsequential, disregarding the question of probabilities and scale of exposure	landscape ecology, statistics	Van Damme (1992) emphasized the lack of data available to assess risk of hybridisation, the difficulty of detecting hybrids, and the genetic variability within species for potential to hybridize NET EFFECT: it is not a question of ‘if’ but ‘when’; in his own words, van Damme (1992) asks where the threshold for concern should be placed - “in our own life, that of our children, or do we take an evolutionary point of view”?
9. that the unconstrained dispersal of both the products of pesticidal plants, and other GM transgenes into both neighboring fields and into nature is inconsequential	plant breeding, entomology, evolutionary genetics, wildlife biology	Hilbeck et al. (1998); Birch et al. (1999); Losey et al. (1999); Muir and Howard (1999); Tommeras and Hindar (1999) - documented actual or potential effects on beneficial insects, fish populations[1], and trees NET EFFECT: effects of pesticidal transgenes, and possibly the transgenes themselves, can radiate outward, exerting multi-trophic, potentially disruptive effects on both managed and natural ecosystems

[1]According to Reichhardt (2000), transgenic research is currently underway on 35 species of fish, including Pacific salmon, catfish, and tilapia. Most research involves growth hormones, creating concerns about extinction of native stocks, due to both inter-breeding and competition.

15. Imprecision. Genetic modification is premised on the idea that genes are unilateral controllers which will reliably perform the same functions in a new host as in the original host. In truth, gene-to-gene and gene-to-environment interactions affect gene expression in ways that are only vaguely understood (Brown, 2000; Facchini et al., 2000). It is implausible in the extreme to contemplate changing a specific metabolic, developmental, or compositional outcome without affecting other characteristics as well.

16. The process of inserting transgenes is anything but precise. Transgene packet insertion is random, both within and among chromosomes, and order matters not simply to the reliability and stability of transgene expression but also to inadvertent expression of unintended traits. Kumpatia et al. (1998) presented evidence of the ability to distinguish self from non-self at the nucleic acid level. They stated that: "The widespread occurrence of transgene inactivation in plants....suggests that all genomes contain defense systems that are capable of monitoring and manipulating intrusive DNA". They presented a detailed and lucid review of the methods by which genomic integrity is maintained against incursion and/or expression of foreign DNA (and RNA).

17. Commercialized transgenic crops may be unstable in expression across a range of environments representative of that in which it will be grown (e.g. a genotype by environment (G x E) interaction). Coghlan (1999) reported a study conducted by Bill Vencill of the University of Georgia, where farmers had reported unusual behavior in Roundup Ready (RR)(glyphosate tolerant) soybeans. In two successive springs, soils were particularly hot, causing RR soybeans - but not the original parental cultivar or other transgenic soybeans - to be stunted. Stem splitting occurred, exposing the plants to pathogen infection. In a normal year, this didn't happen. RR cotton has also exhibited a range of adverse side effects and instability problems relating to floral abortion and pod retention (Edmisten and Stewart, 2000).

18. Examples of unintended side effects would include:

19. *Klebsiella planticola* , a common soil bacteria, was genetically modified to transform plant residues into ethanol. However, it not only competed well with parental strains, but also with a beneficial soil fungus (mycorrhizae) and actually killed the test wheat plants (Holmes et al., 1998). Unmodified parental strains did not have these effects..

20. Doyle et al. (1995) reported that *Pseudomonas putida* which was genetically engineered to break down 2,4-D not only broke down the herbicide but also killed soil fungi which are an essential component of both soil fertility and plant disease protection.

21. Donegan et al. (1997) studied the post-harvest effects of *proteinase inhibitor I* - an insecticidal protein - in buried GM tobacco residues. Compared to unmodified (parent plant) tobacco residues, transgenic residues altered the species composition of the soil biota responsible for organic matter decomposition and nutrient cycling. For a review of GM effects on soil biota, see Donegan and Seidler (1999).

22. Di Giovanni et al. (1999) compared soil rhizospheric communities from two sets of parental and transgenic alfalfa cultivars. The transgenic cultivars were genetically modified to express

industrial enzymes - either a) bacterial genes of alpha-amylase or b) fungal genes for lignin peroxidase. Although isogenic for all but the target enzymes, the rhizosphere bacterial communities of the transgenic cultivars were different from those of their parents. Thus, traits other than industrial enzyme production had been affected by transgene insertion.

23. In Scotland, Birch et al. (1999) demonstrated tri-trophic effects of pesticidal GM plants on beneficial insects. They reported that ladybugs (*Adalia bipunctata)* which fed on peach potato aphids ((*Myzus persicae*) which had in turn fed on GM potatoes[1], produced up to 30% fewer progeny and lived only half as long as ladybugs feeding on aphids which had fed on conventional potatoes.

24. Foliar sprays made from a soil microbe, *Bacillus thuringiensis* or Bt, have long been used to control specific pests in organic and IPM systems. The endotoxin in Bt crops consists of a crystal protein toxin ('Cry' toxin) coded for by genes which have been isolated from the Bt organism. According to Andow and Hutchison (1998), over 100 Bt Cry toxin genes may have been patented, of which some are active against moths and butterflies (lepidopteran species), such as the European cornborer. Others target beetles (coleopteran species), as the Colorado potato beetle, or flies and mosquitoes (dipteran species).

25. The selectivity of foliar-applied Bt arises from at least two critical steps which are bypassed entirely in Bt-crops. The Bt in soil microbes exists as a *protoxin*, a precursor which is not insecticidal. It becomes activated (and insecticidal) only when a) ingested by an insect with the proper, alkaline intestinal pH, and b) specific enzymes are present to cleave the precursor into the active form, which then c) binds with receptor sites in the gut, leading to the death of the insect. In GMO applications, it is *active endotoxin* - not the precursor molecule - which is synthesized in the plant cells. Thus, the first two screening steps are absent, and the potential for non-target effects is increased. Crecchio and Stotzky (1998) emphasized the risk that transgenic Bt crop residues may be much less selective than the original Bt sprays.

26. In another tritrophic study, Hilbeck et al. (1998) demonstrated adverse effects of the Bt endotoxin (fed as GM corn) on non-lepidopteran prey and predator species. Their study challenges the claim that Bt crops retain the highly desirable selectivity of foliar Bt. If validated over a wider range of organisms and conditions, these findings suggest a loss of selectivity in transgenic vs. natural Bt applications.

27. The target of the Bt corn hybrids currently on the market is European cornborer. Losey et al. (1999), Hansen and Obrycki (1999), and Wraight et al. (2000) have studied the effects of Bt-corn pollen on non-target lepidopteran species. Losey et al. (1999) documented the toxicity of Bt pollen from a particular hybrid - N4640-Bt - to Monarch butterflies. Hansen and Obrycki (1999) quantified the natural density of corn pollen on milkweed located 0, 1, and 3 m from a Bt-corn field in Iowa. At levels of Bt corn pollen found within and at the edge of the field, mortality of first instar Monarch butterflies was 19% vs. 0% on non-Bt corn pollen exposed plants. Both studies are consistent with an adverse effect of Bt-pollen on a non-target lepidopteran species - Monarch butterfly.

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[1]Engineered to contain lectin from snowdrops, which is known to interfere with insect digestion

28. Vulnerability to the endotoxin in Bt-corn is known to vary among lepidopteran species, just as the concentration and type of Bt endotoxin varies among corn hybrids (Andow and Hutchison, 1998). Wraight et al. (2000) studied the effect of Bt pollen on another non-target lepidopteran species - the black swallowtail butterfly. The title of their paper, 'Absence of toxicity of *Bacillus thuringiensis* pollen to black swallowtails....' is somewhat misleading. Of the two GM corn hybrids examined (Max 454 and Pioneer 34R07), pollen from Max 454 was, in fact, shown to be quite toxic to black swallowtail butterflies. The remainder of the study - which dealt only with Pioneer 34R07 - failed to include a non Bt-corn control. All inferences of lack of pollen effect were based on mortality with varying Bt-corn pollen density as occurred at varying distances from the corn field. The very high mortality of the target instars observed at *all* field positions, reportedly due to predation, may have obscured pollen effects - if any. A corollary lab study was run for only 3 days, which may have been too brief to determine larval susceptibility. The evidence presented does not warrant the conclusion of an 'absence' of effect on another non-target lepidopteran species.

29. Tapp and Stotzky (1998) showed that the insecticidal activity of the Bt endotoxin persists for at least 234 days in the soil, bound to soil clay particles. Thus, the potential for a cumulative effect of GM-Bt in future years cannot be discounted. Saxena et al. (1999) demonstrated that Bt crops exude active Bt endotoxin from their roots during growth, which would mean that active endotoxin is exerting insecticidal effects throughout the growing season - not just after harvest in the fall.

30. Some studies have emphasized the short travel distance of most corn pollen, and inferred that impact - if any - on Monarchs or other lepidopteran species will therefore be limited. Consider, however, the enormous volumes and travel distances of *tree* pollen, including those of species modified to express 'low lignin' in pulp plantation trees or Bt for pest control. Approximately 24 trees species, including European and quaking aspen, black and Norway spruce, Monterey pine, and Easter cottonwood, have already been genetically modified and exposed to the environment through field trials (Owusu, 1999). The effect of the 'low lignin' GM trait on the wind and pest resistance of wild species, or of GM plant pesticides on non-target forest insects is, as yet, a matter of conjecture.

31. Early studies had concluded that GM rhizospheric organisms, such as the rhizobia which inoculate legumes and enable nitrogen fixation, had a the very limited dispersal ability in the soil. As such, they were essentially 'contained' at the site of application. Lamb et al. (1996) determined that **rhizospheric** organisms can move from the roots via the plant vascular system (phloem) to the leaves, where they are then available for redistribution to other organisms via insects and other means. Snyder et al. (1994) demonstrated the ability of southern corn rootworm (*Diabrotica undecimpunctata*) and red-legged grasshopper (*Melanoplus femurrubrum*) to acquire GM-*P. aureofaciens* by feeding on infected plants. Snyder et al. (1999) confirmed that grasshoppers ingesting GM-*P. chlororaphis* (formerly *aureofaciens*) were able to infect other plants through subsequent feeding. These newer studies clearly challenge the physical possibility of containment of GM organisms to the managed ecosystem where they are applied. The authors emphasized the implications of their findings to the risks associated with large scale release of GM rhizospheric organisms.

32. Impacts Enabled by GM Crops. Other adverse impacts - independent of the GM crop itself – arise from the increased use of practices or products enabled by the GM crop. An example

would be the use of glyphosate, which is enabled by the introduction of RR genes into crop plants. For example, Sanogo et al. (2000) cited producer concerns about the apparent vulnerability of RR soybeans to 'sudden death syndrome' (SDS) caused by a pathogenic fungus, *Fusarium solani*. Experimentally spraying glyphosate increased the severity of both foliar and root disease symptoms and decreased shoot dry weight. The effects of herbicide spraying were similar on RR and unmodified soybeans, suggesting a direct effect of the herbicide per se, rather than the RR genes.

33. Tate et al. (2000) associated the increase in free amino acids caused by glyphosate with increased abundance of *Pseudosuccinea columella*, a snail host for *Fasciola hepatica*, or sheep liver fluke. Liver fluke is a parasite causing millions of dollars of loss annually in the US.

34. Overuse of glyphosate has already generated *resistance* in two weed species (rigid ryegrass and goosegrass), and is shifting arable fields toward *tolerant* species (waterhemp species, velvetleaf, and smartweed)(Benbrook, 1999). Whereas the rigid ryegrass biotypes have not spread and remain isolated on particular fields, RR-resistant goosegrass has now spread to cover 12,500 acres in Malaysia. Goosegrass is among the 20 worst weeds in the world, with a proven ability to evolve resistance to other herbicides in other areas (Doll, 1999).

35. In addition to the above effects on fungal, mollusc, and plant species, glyphosate is also a known mutagen (Kale et al., 1995). In this regard, it is noteworthy that the allowable level of glyphosate residue on soybeans was increased by 200X (from 0.1 to 20 ppm) in several countries coincident with the approval of RR crops.

36. Risk of Invasiveness It is not possible to predict potential weediness of a GM crop from a few simple measurements. Mack et al. (2000) reviewed the 'enormous challenge' of identifying the attributes of either future invaders or of environments susceptible to invasion. They commented on the uselessness of relying on lists of traits purported to be predictive of invasive ability (e.g. Baker's List; Rissler and Mellon, 1996), due to the large number of exceptions. Giddings (1999) cited evidence of the difficulty of relating invasiveness to biological, genetic and/or environmental traits. In terms of colonising ability "...differences between plants which succeed and fail are often apparently trivial....and may be determined by just a few genes".

37. Further compounding the difficulty of predicting invasiveness is the timeframe over which invasion occurs. Mack et al. (2000) cited evidence of a lag phase which can last for decades or even centuries before an immigrant becomes an invasive species. Marvier et al. (1999) calculated a median interval of 30 to 50 years between first record of a weed and the onset of widespread infestation. Giddings (1999) cited an analysis of 90 invasive weeds in the northwestern US, where the initial extent and rate of increase of invaders were not predictive of the eventual distribution of the weeds. She emphasized the importance of environmental stochasticity in the evolution of feral populations, noting that if genes can be maintained in a wild population, then sooner or later, chance occurrences of favourable circumstances could transform the host to invasive status. Predictive modelling is only successful if situations are predominantly deterministic, but occasions abound where stochastic processes can override deterministic ones, particularly in the longer term.

38. At present, a largely assumptions-based process is used to infer that GM offerings will not be invasive in both the US (Purrington and Bergelson, 1995) and Canadian risk assessment processes (Clark, 1998). Remarkably little empirical information is requested or provided with GM submissions, and much of what is provided has little apparent relevance to actual risk of invasiveness. Particularly with increasing evidence of unintended side-effects attributable to transgene insertion per se, some of which could influence invasiveness, the evidence is not compelling that GM crops or crop:weed hybrids, or recipients of genes via horizontal transfer, will not be invasive.

39. Novel GMO Applications: Although HT and Bt crops dominate current GMO offerings, a huge range of applications is in varying degrees of readiness for commercialization. Thus, while much of what is currently in the market may seem unlikely to directly affect natural biodiversity, much more than herbicide tolerance is pending.

40. Consider, for example, what could happen when GM chitinase is inserted to protect commercial crops against insects or pathogens, as has already been done experimentally for control of tobacco budworm (*Heliothis virescens* F.) and brown spot fungus (*Alternaria alternata)* in tobacco (Shi et al., 2000). Chitin is present in significant quantities in many organisms. Chitinases occur naturally in many species, where they serve such functions as defense against fungal pathogens. In GM crops, genes coding for chitinase activity is stimulated to overproduce at very high levels (hyperexpress), typically using the CaMV S35 promoter[2]. The result is the presence of very high level of chitinase not normally seen in nature. What will happen to non-target fungi, including mycorrhizae, when residues of a GM crop designed to hyperexpress chitinase activity is soil-incorporated.

41. GM technology has been released prematurely into the marketplace, based on an understanding of gene action and plant physiology which is rudimentary at best (Brown, 2000). Regarding the use of GM to modify plant metabolism to achieve industrial ends, Facchini et al. (2000) stated:

42. "...these efforts to alter plant metabolic pathways....have often produced unpredictable results, primarily due to our limited understanding of the network architecture of metabolic pathways...most current models of metabolic regulation in plants are still based on individual reactions, and do not consider the integration of several pathways sharing common branch points....."

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[2]Ho et al. (1999) and others have identified unique risks associated with the 35S promoter itself, as distinct from the transgene

43. Couple this with the at least equal level of uncertainty about how biodiversity actually *functions* in natural systems, and you have a situation conducive to invasion, displacement, destabilization, and dysfunction. The closest analogy for the unpredictable and potentially disruptive power of GMOs is that of exotic invaders, a phenomenon which has yet to be understood in any predictive sense, despite considerably greater effort than has yet been expended on GMO risk assessment. However, GMOs differ fundamentally from actual exotic invaders - whether intentional or accidental - because of the temporal and spatial scale of 'introduction': the annual sowing of millions of hectares of land. The potential for a suitable combination of stochastically varying environmental and biological factors to produce a genuinely 'invasive' species is incalculably greater with GMOs.

44. Will further research alleviate these concerns. What, in fact, would one study, when so many of the effects are completely unpredictable? How could research be priorized, when so little is known about most of the key elements in the question? The potential for harm is demonstrably large. Benefits, if any, have yet to be demonstrated. If ever there were a case for invoking the precautionary principle, this must be it.

Section B (d)

B (d) the international legal obligations of New Zealand in relation to genetic modification, genetically modified organisms, and products
Section B (d) Summary

Response

B (d)

Response

Section B (e)

B (e) the liability issues involved, or likely to be involved, now or in the future, in relation to the use, in New Zealand, of genetic modification, genetically modified organisms, and products
Section B (e) Summary

Response

B (e)

Response

Section B (f)

B (f) the intellectual property issues involved, or likely to be involved, now or in the future, in relation to the use in New Zealand of genetic modification, genetically modified organisms, and products

Section B (f) Summary

Response

B (f)

Response

Section B (g)

B (g) the Crown's responsibilities under the Treaty of Waitangi in relation to genetic modification, genetically modified organisms, and products
Section B (g) Summary

Response

B (g)

Response

Section B (h)

B (h) the global developments and issues that may influence the manner in which New Zealand may use, or limit the use of, genetic modification, genetically modified organisms, and products
Section B (h) Summary

Response

B (h)

Response

Section B (i)

B (i) the opportunities that may be open to New Zealand from the use or avoidance of genetic modification, genetically modified organisms, and products
Section B (i) Summary

Response

B (i)

Response

Section B (j)

B (j) the main areas of public interest in genetic modification, genetically modified organisms, and products, including those related to: **(i)** human health (including biomedical, food safety, and consumer choice) **(ii)** environmental matters (including biodiversity, biosecurity issues, and the health of

	ecosystems)
(iii)	economic matters (including research and innovation, business development, primary production, and exports)
(iv)	cultural and ethical concerns
Section B (j) Summary	

Response

B (j)(i)

Response

B (j)(ii)

Response

B (j)(iii)

Response

B (j)(iv)

Response

Section B (k)

B (k) the key strategic issues drawing on ethical, cultural, environmental, social, and economic risks and benefits arising from the use of genetic modification, genetically modified organisms, and products

Section B (k) Summary

Response

B (k)

Response

Section B (l)

B (l) the international implications, in relation to both New Zealand's binding international obligations and New Zealand's foreign and trade policy, of any measures that New Zealand might take with regard to genetic modification, genetically modified organisms, and products, including the costs and risks associated with particular options

Section B (l) Summary

Response

B (l)

Response

Section B (m)

B (m) the range of strategic outcomes for the future application or avoidance of genetic modification, genetically modified organisms, and products in New Zealand
Section B (m) Summary

Response

B (m)

Response

Section B (n)

B (n) whether the statutory and regulatory processes controlling genetic modification, genetically modified organisms, and products in New Zealand are adequate to address the strategic outcomes that, in your opinion, are desirable, and whether any legislative, regulatory, policy, or other changes are needed to enable New Zealand to achieve these outcomes
Section B (n) Summary

Response

B (n)

Response

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