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Is the Grass Always Greener?
Issues Affecting the Adoption of Genetically Modified Pasture Grasses in New Zealand

Prepared by
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Established by the
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to facilitate public policy dialogue
between New Zealand and
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Educated in New Zealand and England, Sir Ian held Professorships at Cornell University and the University of California, and was Vice-Chancellor of Victoria University of Wellington for three years. For many years, Sir Ian was director of the Max Planck Institute for Aeronomy in Germany, where he was involved in the planning of several space missions, including those of the Voyager planetary explorers, the Giotto space probe and the Ulysses galaxy explorer.

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During my interview, one of the panel members raised a somewhat sensitive issue by noting that I was “a bit past mid-career” (the target range for Axford participants) and wondered if I would be likely to use my experiences in Wellington when I go back, if I follow a predictable career path into senior management in my agency. I know that the information, relationships, and new perspectives I have gained during my fellowship will be invaluable when I return to USDA, wherever my career leads, and I hope I justified the selection committee’s faith in me. I am honoured and will always be grateful for the opportunity to live and work in New Zealand and to be a part of the Fulbright program.

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EXECUTIVE SUMMARY

Adoption of genetically modified (GM) crops has increased globally every year since the first large-scale plantings in North America in 1996. In 2009 134 million hectares of GM varieties (five times the total area of New Zealand) were planted in 25 countries, primarily cotton, corn, soybeans and canola modified to be resistant to insect pests or tolerant to certain herbicides. High food and fuel prices, concerns over climate change, and recognition of the importance of sustainable agriculture are resulting in increased consideration of biotechnology as a tool to address these global issues. However, the development and use of GM crops remains a contentious issue.

Ten years after the Royal Commission on Genetic Modification concluded that New Zealand should 'keep its options open' with respect to genetically modified organisms (GMOs), there are no GM crops in commercial production here. One key reason is that none of the products on the market elsewhere would provide sufficient benefits to New Zealand to warrant the expense of taking the product through the regulatory system and the risks of uncertain market acceptance.

New Zealand's economy is dependent on pasture-based farming, and the majority of this country's dairy and meat products are exported. The success of the farming industry in New Zealand is tied to the country's environmentally-conscious image as well as to the ability to produce high quality products at low costs. Farmers reliant on pasture-based farming are facing rising costs for fuel and fertiliser, loss of available land, increased pressure to mitigate pollution, and competition from low cost producers overseas. In order to remain competitive, they need to find ways to increase productivity and keep costs low.

For New Zealand, a basic question is whether there are risks in getting left behind in the use of GM technologies, or whether the country would lose a market advantage by planting GM crops and losing its GM-free status.

The New Zealand government, along with a number of industrial partners, has continued to support GM technologies as a research tool as well as a method to develop products with traits that could prove beneficial to New Zealand. Several varieties of GM forage grasses in development have the potential to provide benefits in terms of increased productivity, decreased greenhouse gas emissions from dairy and cattle farms, and the production of healthier meat and milk. This report looks at some of the issues that could influence a decision in New Zealand whether or not to adopt GMOs, with a focus on GM forage grasses.

To help understand these issues, I conducted interviews with researchers, industry representatives, government officials, farmers and stakeholders, attended a public hearing on an application for a GM research project, and read articles in the press as well as technical and popular publications. While my findings are not comprehensive, the messages I heard were consistent across many of the groups and in many respects remain consistent with the views documented in the Report of the Royal Commission ten years ago.

The dairy industry is generally pragmatic about the option of using GM forage grasses, not philosophically opposed to the technology but, concerned about impacts

on productivity, markets and profits. There continues to be general opposition in New Zealand to the use of GM technology in food and agriculture, however there are indications that consumers may be more accepting of products with environmental or health benefits or of 'cisgenic' varieties that do not contain foreign genes. Māori may also have fewer concerns about cisgenic varieties and of the use of GMOs for non-indigenous species like perennial ryegrass.

The strongest opposition to the adoption of GM pasture grass is likely to come from individuals or groups who believe that any use of GMOs is incompatible with New Zealand's perceived 'clean and green' image. For some, this is based on their world view and for others the concern is economic, as they believe tourism and exports would be negatively impacted by any adoption of GMOs. There is increasing interest in New Zealand in low input, sustainable agriculture and in moving away from pasture-based commodity production towards high-value products targeted to niche markets. Would these scenarios exclude the use of GMOs or could GMOs coexist with, or be part of, changes in New Zealand agriculture?

A key finding of this report is that there is not enough information at this time to determine whether GM pasture grass would be beneficial for New Zealand. Additional research is needed to demonstrate the safety, agronomic performance and efficacy of the new GM varieties. Economic analyses are needed to assess potential benefits and risks to farmers and to New Zealand. These analyses will be complex and will need consideration of externalities such as potential harm to tourism or export markets. There is also a need for data to gauge the economic value of the 'clean, green' image and whether adoption of GMOs would harm that image or whether certain GMO products such as GM ryegrass could be a positive part of 'clean and green'.

Could GMO and non-GM or organic farms coexist in New Zealand? Management practices exist for growing certified seed or specialty crop varieties and these could be adapted for separation of GM and non-GM varieties. However for GM grasses in particular, measures to minimise GM pollen or seed spread into non-GM fields may be difficult and expensive. Some unintended GM material in non-GM or organic pastures would be likely and coexistence would only be possible if there was an acceptance of some level of unintended GM material in non-GM products. This is currently not acceptable to the organics industry.

Irrespective of whether New Zealand chooses to adopt GM crops, there is a strong desire from some research organisations and industry groups to investigate the potential opportunities for GMOs in New Zealand. For GM pasture grasses, a range of laboratory and greenhouse studies are underway as well as a few offshore field tests. However, the regulatory system in New Zealand, together with the other factors mentioned above, presents a high hurdle for performing the research for development of the safety and efficacy data needed to inform any decision to adopt these new varieties. The last section of this report summarises the challenges faced by researchers in New Zealand, in comparison with the US and Australia, and provides some suggestions for a way forward to allow New Zealand to make informed decisions about the option of using GMOs.

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PREFACE

Genetic modification describes the use of modern biotechnology to move genes between organisms to introduce new traits for use in research, industry, medicine, or agriculture. Genetic modification and the organisms produced, referred to in this report as genetically modified organisms or GMOs, are considered by some to be a potential solution to world hunger and climate change and by others to be a pending ecological disaster. The ability to introduce new traits into plants can be compared to methods used in thousands of years of plant breeding. But the power of genetic modification is that it allows the transfer of *specific* genes between organisms and *between species*. This latter fact, the ability to move genes between species, is one aspect of this technology that causes consternation for many who believe genetic modification to be morally objectionable and scientifically unpredictable.

My personal views lie somewhere between the two extremes. I am a scientist by training and I now work in a regulatory agency that assesses new GM plants to make sure they can be used safely in agriculture and the environment. I see genetic modification as a useful and very powerful tool for introducing new traits into organisms that should be assessed case-by-case for safety and performance.

Farmers in the US have rapidly adopted genetically modified (GM) crops, and most of the animal feed and processed foods in the US are likely to contain some GM corn or soy products. However, 10 years after the Royal Commission on Genetic Modification left the door open for the use of GMOs, no GM crops have been planted in New Zealand. One reason is that the products currently in commercial production elsewhere in the world do not make sense in the context of New Zealand agriculture and would not be likely to provide economic or environmental benefits sufficient to overcome economic risks or public disapproval.

However, several research organisations have been developing GM varieties of grasses and clover that could provide major benefits for New Zealand farmers and consumers. While any decision within New Zealand regarding adoption of GM forage grasses is years away, publicity about these developments has generated some new interest in the topic of the potential use of GM organisms in New Zealand agriculture. This report focuses on issues that could impact a decision to adopt GMOs, and particularly GM pasture grasses in New Zealand.

The differences between the agricultural systems in the US and New Zealand are obvious to anyone who had driven through the American Midwest. US farmland is dominated by millions of acres of corn and soybeans, much of which goes to feeding livestock and much of which is genetically modified. In contrast, New Zealand agriculture is based on pasture-raised animals for meat and dairy. This topic was particularly interesting for me as it gave me the opportunity to think about the use of GMOs in the context of New Zealand's traditional farming systems, and to learn about pasture biology, pasture management and dairy farming, all very new topics for me.

In addition, this issue is very interesting from a scientific and regulatory viewpoint, as there are several varieties or GM grasses in the lab that scientists would like to move to the field for further research. While thousands of field trials of GM crops have been conducted in the US and internationally, there is little experience with GM grasses. Pasture grasses are wind-pollinated perennial species grown on very large acres under minimally managed conditions and a decision to release GM grasses would pose a number of unique and sensitive challenges.

This report is not intended to be a referendum on the use of genetic modification or the benefits or risks of the technology. It is meant to look at the issues that would need to be considered or resolved if New Zealand is faced with a decision to adopt GMOs, and in particular GM pasture grasses. This paper reflects what I learned from interviews with researchers, industry and stakeholders, as well as from the press, technical and popular publications, and attendance at a public hearing. Every interview opened new questions and avenues to explore, many of which I was unable to follow up due to time limitations. Any apparent bias in the extent of coverage of some of the issues reflects the limitations in the amount of material I had time to cover and interviews I was able to conduct.

I need to make two clarifications regarding terminology.

- Throughout this report I use the terms genetic modification, GM, and GMO. Other terms often used to discuss this technology are ‘genetic engineering’ or ‘GE’, recombinant DNA technology or modern biotechnology. The term ‘genetic modification’ is considered to be a more general term referring to any change in an organism’s DNA regardless of the technique. However, in New Zealand, ‘genetic modification’ was the term used by the Royal Commission and is also used in the Hazardous Substances and New Organisms (HSNO) Act that provides the authority for regulation of these organisms in New Zealand. So I will use ‘genetic modification’ and ‘GMO’ throughout this paper.
- I also need to make a clarification with respect to the use of the term *field test*. This term is used generally to refer to experimental or controlled environmental releases of regulated GMOs. The process for conducting field tests varies between countries and the process for conducting field tests in containment in New Zealand is quite different than in the US or Australia. The regulatory processes for New Zealand, the US and Australia are described in Section 5 and in Appendix 3 of this report. For simplicity, the term *field test* will be used to refer to environmental releases of regulated GMOs in the US under permit or in Australia under a license for a ‘dealing for intentional release.’ The term that will be used here for growth of GM plants within a secure outdoor location in New Zealand, is *field test under containment*. The distinction may seem trivial but it has significant implications for the ability to conduct GM research in the three countries.

One final note – GMOs are still a very sensitive topic in New Zealand and this is a very small community. Everyone I interviewed was very candid in their comments; in order to preserve confidentiality, in most cases I have presented comments from my interviews anonymously. Any direct quotations are from public presentations or documents, reflect presentations of facts or statistics, or have been approved by the individuals quoted.

INTRODUCTION

The fact that New Zealand's economy is based on agriculture and more specifically on pasture-based farming is obvious as soon as you get beyond the city boundaries of Auckland or Wellington. Iconic images of green hills dotted with sheep and cows dominate the landscape. Approximately 37 per cent of New Zealand's land area is covered in pasture grass dedicated to beef, sheep, dairy and deer farming.[1] A recent report estimated the value of New Zealand pasture products to the total GDP (Gross Domestic Product) to be NZ$20.5 billion, with the largest contribution coming from the dairy industry.[2]

In addition to the farm profits, the pastoral environment also contributes to the second largest industry. Tourism contributes NZ$21.7 billion to the economy each year, 9.1 per cent of New Zealand's gross domestic product.[3] In the 1990s, Tourism New Zealand instituted a campaign to attract tourists to the country using the slogan '100% Pure New Zealand', and the "tourism industry counts on tourism [to add] value to other export sectors by promoting the 100% Pure New Zealand brand internationally".[4]

However, a number of factors are increasing the cost of farming in New Zealand that may force changes in 'business as usual'.[5] Farmers are facing rising costs of inputs (e.g. fuel, fertiliser and water) and competition from low-cost producers overseas so they need to find ways to increase productivity and keep costs low. As the population increases there will be less land available for agriculture, which leads to intensification of farming practices, including higher stocking rates and increased inputs (including water for irrigation). This is turn puts additional pressures on farmers to mitigate negative environmental impacts from their farms, such as emissions of greenhouse gases and effluent run-off. There is increasing awareness internationally about the need to ensure farming practices are sustainable in the context of potential climate change, increasing populations, and reducing pollution.

A number of scientists in New Zealand are using genetic modification to develop new varieties of forage grasses that have the potential to increase productivity and moderate pollution from pasture-based farms. New Zealanders have opposed introduction of GMOs as inconsistent with the values and image of the 'clean and green,100% Pure' New Zealand brand. But some here believe the time is right to begin asking if this is still the best direction for the country.

Is New Zealand really 'clean and green' and what are the impacts of image vs reality for the country's economy? Would GMOs be incompatible with this image, or could they be part of the solution? Is it possible for New Zealand to support both low-cost, high-productivity agricultural systems that may include GMOs and agricultural systems that produce high quality, value-added products targeted to niche markets? Or does it make better economic sense for New Zealand to remain GMO-free and to focus on improving and expanding the adoption of 'biological' and organic farming

[1] *Environment New Zealand 2007*
[2] Sanderson and Webster (2009)
[3] *Key Tourism Statistics* (2010)
[4] *Tourism in New Zealand* (n.d.)
[5] Goldson (2010)

methods as the key to sustainable production?

For this report, I looked at the current and changing situation in New Zealand with respect to research and adoption of GMOs. I focused on changes since the Report of the Royal Commission on Genetic Modification in 2001 and on issues tied to GM pasture grasses – what products are in development and what are the issues that could affect a decision to adopt GM grasses in New Zealand? The last section deals with regulatory issues – do scientists and regulators have the tools they need to determine if GM forage grasses are safe and if they could provide benefits for New Zealand that would outweigh the social or economic risks?

1 GMOS IN 2010

The first transgenic plants – tobacco and petunia modified to express bacterial genes for antibiotic resistance – were reported in 1983. By 1994, the first GM food was available in the US market. The delayed-ripening Flav-Savr tomato was not a commercial success, but by 1996 farmers in the US and Canada began to devote large acreage to GM varieties of soybean, corn and canola. Adoption of GM crops in the US[6] and internationally has continued to grow every year, with an 80-fold increase in the number of hectares planted in GM crops from 1996 to 2009.[7] In 2009 134 million hectares were planted in 25 countries, with rapidly increasing adoption in India, China and South America (Fig. 1).[8]

Table 1. Global Area of Biotech Crops in 2009: by Country (Million Hectares)

Rank	Country	Area (million hectares)	Biotech Crops
1*	USA*	64.0	Soybean, maize, cotton, canola, squash, papaya, alfalfa, sugarbeet
2*	Brazil*	21.4	Soybean, maize, cotton
3*	Argentina*	21.3	Soybean, maize, cotton
4*	India*	8.4	Cotton
5*	Canada*	8.2	Canola, maize, soybean, sugarbeet
6*	China*	3.7	Cotton, tomato, poplar, papaya, sweet pepper
7*	Paraguay*	2.2	Soybean
8*	South Africa*	2.1	Maize, soybean, cotton
9*	Uruguay*	0.8	Soybean, maize
10*	Bolivia*	0.8	Soybean
11*	Philippines*	0.5	Maize
12*	Australia*	0.2	Cotton, canola
13*	Burkina Faso*	0.1	Cotton
14*	Spain*	0.1	Maize
15*	Mexico*	0.1	Cotton, soybean
16	Chile	<0.1	Maize, soybean, canola
17	Colombia	<0.1	Cotton
18	Honduras	<0.1	Maize
19	Czech Republic	<0.1	Maize
20	Portugal	<0.1	Maize
21	Romania	<0.1	Maize
22	Poland	<0.1	Maize
23	Costa Rica	<0.1	Cotton, soybean
24	Egypt	<0.1	Maize
25	Slovakia	<0.1	Maize

* 15 biotech mega-countries growing 50,000 hectares, or more, of biotech crops

Source: Clive James, 2009.

Figure 1.

However, the use of GM crops continues to be controversial and the subject of polarised debate. Many countries, including Japan and Korea and many in the European Union do not plant GM varieties. Environmental groups such as Greenpeace advocate internationally against any use of GMOs, citing an unproven safety record, economic risks to organic and conventional farmers due to 'contamination' from GM crops, and the potential negative impacts to small Third World farmers 'forced' to purchase seed from agricultural monopolies.

[6] *Adoption of genetically engineered crops in the US* (n.d.)
[7] James (2009)
[8] Ibid.

While far from resolved, the debate is shifting. After almost 15 years of large-scale production of GM crops with no documented harm to health or safety, the 'Frankenfood' label seems to have fallen from use. A number of recent studies have documented that the herbicide-tolerant and insect-resistant crops currently being grown in the US, Canada, and South America have produced significant economic and environmental benefits to producers as compared to non-GE crops.[9, 10, 11] Rising prices for food and fuel, and increasing concerns about global climate change and environmental degradation are also raising awareness that all possible tools to address these issues, including the use of GM crops for food and energy applications, should be considered[12] and that a progressive view of agricultural sustainability includes the use of new technologies.[13]

[9] National Research Council (2010)
[10] Carpenter (2010)
[11] Céleres (2010)
[12] Pinstrup-Andersen (2010); see also articles reproduced on www.agbioworld.org
[13] Aerni (2010)

2 GMOS IN NEW ZEALAND

Despite active research programs using genetic modification to study and develop new varieties of crops or animals to benefit New Zealand, there are no GM crops in production here, and there have been just a handful of field tests in containment over the past 10 years. When Nina Federoff, Science Advisor to US Secretary of State Hillary Clinton, visited New Zealand in January 2010, she encouraged New Zealand to consider genetic modification to increase food production and address climate change.[14] Andrew West, Chief Executive for AgResearch[15], agreed, saying, "If genetic modification can create more food from fewer inputs, I think we have a moral obligation to use it."[16]

Adoption of GMOs in New Zealand presents a number of special challenges, especially compared to the US. New Zealand is a small island nation with a large number of unique indigenous species. The country is sensitised to potential negative impacts to native flora and fauna due to economic and environmental damage caused by previous intentional (e.g. possums, gorse) and unintentional (e.g. mudsnails, didymo) introductions of invasive species. The economy is based on agricultural systems that could be harmed by introduction of a new species (GM or conventional) with unintended consequences. New Zealand trades on its 'clean and green' image, which some believe should not include GMOs. There is also an indigenous population with deep cultural ties to the environment. New Zealand has a strong moral and legal imperative to ensure consideration of the spiritual and cultural views of the Māori population.

In the late 1990s, increasing public concern over GMOs led to the government establishing a Royal Commission of Inquiry (the Royal Commission on Genetic Modification) to investigate the issue of genetic modification in New Zealand. The report documenting the findings of the Royal Commission was published in 2001.[17] The events leading up to the establishment of the Commission, a summary of the issues and outcomes, and an analysis of the public consultation process were the subject of a report by a previous Ian Axford fellow[18] and I will not discuss the report in detail here. In short, the Royal Commission recommended that New Zealand keep its options open to use all forms of agriculture but to proceed carefully while minimising and managing the risks.

However, despite this recommendation, and continued funding of research to develop GMOs in New Zealand, the issue continues to be controversial and progress has been slow. Today, the report of the Royal Commission seems surprisingly fresh; the issues and concerns are virtually the same ten years on.

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[14] Griffin (2010)

[15] Andrew West has since resigned as CE of AgResearch; the new CE is Tom Richardson, former head of the Forest Research Institute

[16] Griffin (2010)

[17] *Report of the Royal Commission on Genetic Modification* (2001)

[18] Pollack (2003), see also McGuinness et. al. (2008a,b) for a summary of the history of GM in New Zealand and the recommendations of the Royal Commission

The regulatory environment

GMOs in New Zealand are primarily regulated under the Hazardous Substances and New Organisms (HSNO) Act of 1996.[19] The Environmental Risk Management Authority (ERMA) was established to administer the new legislation. By definition, 'new organisms' includes any organism not present in New Zealand when the HSNO Act came into effect in July 1998, and, also by definition, all GMOs (unless given approval for an uncontrolled release).

Under the HSNO Act, applications must be submitted to ERMA New Zealand to conduct activities involving GMOs, including research in containment, importation into containment, field testing in containment, and (conditional or full) release into the environment. The only growth of GM plants outside of laboratories or greenhouses in New Zealand has been in field tests. Prior to the HSNO Act, field tests involving GMOs were approved by the Minister of Environment under the guidance of the Interim Assessment Group (IAG). Over 40 field test approvals were granted under this system between 1988 and 1998.[20, 21] HSNO Act approvals have been granted for field tests in containment of GM livestock, potatoes, petunia, sugar beet, maize, pine, *Brassica*, and onions, but as of June 2010, there are no GM plants in the field in New Zealand. The only application for a conditional release of a GMO, approved in November 2008, was for the release of two GM equine influenza vaccines intended for use in emergencies.[22]

A few well publicised incidents have raised public concern. Several reports of the presence of GM material in maize seeds imported into or grown in New Zealand[23, 24] prompted concerns about the ability of the government to protect the country from GM contamination in imported goods. Then, in December 2008, two flowering plants were detected during a field test of *Brassica* plants modified for insect resistance in violation of the conditions of the approval.[25] The breach resulted in an investigation and the experiment was halted. More recently two GM *Arabidopsis* plants were found outside of a greenhouse in Lincoln. This discovery prompted an investigation that consumed the lives of several people associated with the greenhouse facility for over six months.[26] The investigation "found no evidence of a failure to take reasonable care or of negligence".[27] These incidents highlight the sensitivity of the issue in New Zealand. In the US these incidents would have resulted only in minor compliance infractions. During my interviews several people cited these two infractions as evidence that all field tests 'cannot be contained'.

New Zealand seems to face a 'Catch 22' with respect to regulation of GM crops. The rigorous regulatory system here makes it a challenge for scientists to do the research needed to demonstrate efficacy and safety of new GM plants. However, trust in the New Zealand regulatory system for GM crops is essential to gain public acceptance

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19 Hazardous Substances and New Organisms Act (1996)
20 *Completed Interim Assessment Group (IAG) Applications* (n.d.)
21 In 1998 ongoing approvals under IAG were transferred to become approvals under HSNO
22 *Equine influenza vaccines* (n.d.)
23 *Genetically modified organisms – Sweet corn and maize* (n.d.)
24 *Brief 02/50 – GM contamination in maize seed* (2002)
25 *Measures put in place in response to field trial at Plant & Food Research Lincoln* (2009)
26 Personal communication
27 *Investigation of possible GM plant containment breach finds no grounds for prosecution* (2010)

and maintain the confidence of export markets. One industry official told me that "given that New Zealand's major business is export of food to discerning markets, keeping a tight regulatory regime is in our interests".[28] Regulation of GM crops, and particularly mechanisms for conducting contained outdoor field tests, will be the subject of Section 5 of this report.

The political environment

There has not been significant public debate or changes in policy with respect to the use of GMOs in New Zealand since the publication of the Report of the Royal Commission in 2001. The recommendations from the Report still stand: New Zealand should "keep its options open" with respect to GMOs, "proceed carefully", and "encourage the coexistence of all forms of agriculture".[29]

The current government, led by the National Party, is very supportive of technology and innovation as emphasised in a February 2010 speech to Parliament by Prime Minister John Key[30] and as supported by the new Budget allocations for science. However, the issue of GMOs continues to be very political, with particularly strong opposition from the Green Party.[31] Several people expressed the view that the Mixed Member Proportional (MMP)[32] system of representation, which necessitates development of coalitions between the majority parties and the minor parties such as the Green and Māori Parties, makes it hard to get momentum for controversial changes.

One industry representative told me that he believes the government is keeping their "head in the sand" about the issue of the use of GMOs in food and agriculture and are just waiting for the situation to get to the point where GMOs have become so ubiquitous that the discussion becomes redundant.[33]

Funding and Research

There is significant support for science and innovation research in New Zealand, reflected in financial support for biotechnology research that accounts for about one fourth of the total government research and development (R&D) budget.[34] In 2008/09, the government committed NZ$480.7 million in Vote RS&T funds[35] for emerging technologies, of which 44 per cent, or NZ$209.2 million was targeted to biotechnology.[36]

[28] Author interview, 2 March 2010
[29] *Report of the Royal Commission on Genetic Modification* (2001), p.2
[30] Key (2010)
[31] Delahunty (2007)
[32] Mixed Member Proportional (MMP) is a form of representation adopted in New Zealand in 1994 where the overall total of party members in Parliament is intended to mirror the overall proportion of votes received.
[33] Author interview, 30 March 2010
[34] *Biotechnology Research Roadmap* (2007)
[35] Each year the government sets aside, or 'votes', a certain amount of money ($743 million in 2009/10) for research, science and technology in its budget. This money is called Vote RS&T. These funds are invested by the Foundation for Research, Science and Technology (FRST), the Royal Society of New Zealand (RSNZ) and the Health Research Council (HRC) in several hundred projects every year.
[36] *New Zealand RS&T Scorecard* (2009)

In May 2010, the Prime Minister announced a new strategy for science and innovation[37] as well as the science portion of the new budget that allocates NZ$321 million for new science and technology initiatives. Strategies are included to get New Zealand businesses more involved in research and development, such as technology development grants for business, and mechanisms to encourage technology transfer between the publicly funded research institutes and New Zealand businesses. This could encourage researchers to find mechanisms to move GMOs from the laboratory toward commercial application.

In New Zealand, the majority of genetic modification research to develop new agricultural products is conducted in the Crown Research Institutes (CRIs)[38] or universities supported by public funds. Of the more than 60[39] field tests/outdoor development applications that have been submitted for approval under the IAG or the HSNO Act to conduct field tests or outdoor development of GMOs, only a handful have been submitted by New Zealand or foreign businesses.

One comment I heard from several researchers was that is difficult to conduct GMO research under the current system. The CRI funding has been dependent on short-term, competitive contracts. Development and testing of GMOs can be resource intensive and long-term and researchers expressed concern that the three year election cycle can create an unpredictable political climate that could impact support for controversial projects. In October 2009, the government established a Crown Research Institute Taskforce to review the CRIs and their contribution to New Zealand development. The report, published in February 2010,[40, 41] recommended a number of changes that could impact the direction and financial support for publicly funded GMO research. These include a recommendation for a decreased emphasis on CRIs to make a profit, allowing a focus on research that will provide benefits to New Zealand, and granting of longer term funding to CRIs with increased responsibility for each organisation to accomplish their research goals.

The situation is different in the US. Developments in genetic modification have stimulated market-driven, privately-funded R&D in biotechnology over the past 20-30 years.[42] The website for the US-based Biotechnology Industry Organization (BIO) notes that US publicly traded biotech companies spent USD$27.1 billion on biotechnology R&D in 2006.[43] For agricultural biotechnology, several large agritech companies dominate the market, and most of the new GM seed varieties that have been commercialised are from these big players who also have the finances and expertise to navigate the US regulatory system. Decisions about research and product development can be based on market considerations and projected profits.

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[37] *Igniting Potential: New Zealand's Science and Innovation Strategy* (2010)

[38] The Crown Research Institutes (CRIs) were established in 1992 as Government-owned businesses charged with conducting scientific research for the benefit of New Zealand. Each of the eight institutes is based around a productive sector of the economy or a grouping of natural resources.

[39] ERMA New Zealand, Personal communication

[40] *Report of the Crown Research Institute Task Force* (2010)

[41] *CRI Taskforce Implementation* (n.d.)

[42] Caswell and Day-Rubenstein (2006)

[43] *Guide to Biotechnology* (2008)

What's in the lab?

Genetic modification is widely used as a research tool in New Zealand for a variety of medical, industrial, and agricultural applications.[44] Currently the research is almost exclusively in contained laboratories and under approvals granted by ERMA or under delegation from ERMA. The majority of the research uses GM techniques to understand cell function and gene expression. Research is also underway to develop modified plants and animals with improved traits to increase productivity, increase resistance to pests or disease, or introduce quality traits such as increased shelf life for vegetables or improved wood quality in trees.

Much of the research is being conducted by the CRIs with funding from the New Zealand government and the private sector. Plant & Food Research (which was formed in 2008 by the merger of Crop & Food Research and HortResearch) is developing crops such as potatoes and onions that are resistant to diseases or that have improved agronomic qualities. Products in development include potato plants engineered to produce a synthetic gene toxic to microbes that cause soft-rot disease;[45] a 'tearless' onion produced using gene-silencing to reduce production of volatile irritants;[46] and plants such as potato, pepper, tomato, and eggplant with increased levels of selenium, a chemical shown to be effective in prevention of some types of cancer.[47]

In addition to pasture-based industries and crops, New Zealand has a major exotic forest industry. In 2007 there were approximately 1.8 million hectares of trees in commercial production, mostly Radiata pine.[48] Scion, a CRI formerly known as the Forest Research Institute, has been working to improve trees used for commercial production in New Zealand, using both conventional and GM techniques. GM pine trees have been in development for almost 20 years and field tests in containment have been conducted on trees engineered to be herbicide resistance and containing marker genes to study stability of the trait over time under field conditions.[49, 50] Scion has also conducted environmental impact studies that have confirmed the absence of negative effects of genetically modified trees from their trials on invertebrates and soil microorganisms.[51]

The most publicly visible research involves the development of transgenic animals by AgResearch. In April 2010, ERMA approved an application from AgResearch to expand their programme to develop transgenic cows, sheep, and goats to produce therapeutic proteins for the treatment of human disease. In addition, AgResearch is requesting additional approvals for transgenic animal research on a wider set of organisms and applications for both basic and applied research, including the use of livestock as models for human gene function and enhancement of traits in livestock to improve productivity and animal health.[52]

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[44] *How genetic modification is being used in New Zealand research* (n.d.)
[45] Barrell and Conner (2009)
[46] Eady et al. (2008)
[47] McKenzie et al. (2008)
[48] *New Zealand forest industry facts & figures* 2008/2009 (n.d.)
[49] Author interview, 4 March 2010
[50] *Lay summary of the amendment* (n.d.)
[51] Schnitzler et al. (in press)
[52] *Transgenic livestock programme: Summary of proposed programme* (n.d.)

Public attitudes toward GMOs

While the number of countries and individual farmers growing GM crops has continued to increase worldwide,[53] discussions on the potential benefits and risks of GMOs continues to be a very polarised debate in New Zealand and elsewhere. Bruce Small from AgResearch provided a good summary of the issues.

> Proponents of GE technology claim that it is safe and will lead to many positive benefits as well as being essential for economic and scientific development...Some benefits these advocates claim include: new medical treatment technologies (e.g. gene therapy) and new drugs with cheaper methods of production that will help to cure the world's major diseases; the production of new plant species that will increase production yields, tolerate adverse environmental conditions, be pest and disease resistant, and help solve the world's food problems, and plants that will help alleviate the environmental problems caused by current agriculture practices by requiring less chemical pesticides and fertilisers.
>
> Opponents, on the other hand, claim that the technology is: intrinsically unethical (e.g. immoral, disrespectful to nature, usurps the role of God, is against their spiritual or cultural beliefs); is too risky with the benefits of adoption being uncertain; carries the possibility of unforeseen negative consequences which may be dangerous to the health and safety of humans, animals and the environment; that it is unnecessary – there are safer, less disturbing alternatives to achieve the same desired ends, and that it places farmers and consumers in the power of multi-national corporations whose principal motivations are profit – irrespective of public good or harm.[54]

The Royal Commission on Genetic Modification heard this wide spectrum of views in 2000 and the same range of opinion was expressed during my interviews and in the media during my research. Almost everyone had a position on whether New Zealand would or should accept GMOs and whether the views have changed since the Royal Commission. The opinions ranged from blanket assertions from opponents that 'New Zealanders do not want GMOs' to 'a few people care a lot and a lot of people don't care' from proponents. There was general agreement in my interviews that public knowledge of the issues is low and that education (including education of the media) and engagement with the public is critical to gaining trust and acceptance of GM technologies.

Survey data

There have been a number of surveys done to gauge public perceptions towards genetic modification both during and after the Royal Commission. The research by the Agribusiness and Economics Research Unit (AERU) at Lincoln University[55, 56, 57]

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53 James (2009)
54 Small (2009), the paper provides extensive references for the topics listed here
55 Cook et al. (2004)
56 Cook and Fairweather (2005)
57 Cook and Fairweather (2006)

showed that while more than half of those surveyed expressed concerns about genetic modification, they were less concerned about GM than issues such as crime prevention and health care.[58] One researcher summarised his impression as "a whole bunch of people don't want GE and a whole bunch of people don't mind".[59]

AERU found that for many people, their 'world view' and values affects their willingness to accept GMOs more than specific knowledge about the technology. The level of acceptance was higher for non-food applications (e.g. use of a GMO crop as a fuel source as opposed to food) and consumer acceptance could be influenced by demonstrated benefits for specific applications or by price. Respondents cited specific concerns over safety, compliance with regulations, and harm to New Zealand's 'clean and green' image.

I tried to get a feel for whether public attitudes have changed in New Zealand since the Royal Commission. One researcher said he believes views have not changed significantly and that "people feel GM is a settled issue; they can't continue to worry about it. They've staked out their positions….public acceptance has plateaued.[60]

AgResearch has also conducted surveys on public attitudes, values, and beliefs about new technologies[61, 62] and in general the results support those from AERU. By repeating identical surveys over a period of eight years, the researchers found only a small decrease in opposition over time. In addition to the issues noted above, consumers noted concerns about accountability by companies who produce GM products and labelling of GM products.

AERU also conducted surveys of farmers and growers in 2000 during the Royal Commission[63] and a follow-up survey in 2003.[64] They reported that during this period the farmers' views towards GM crops had become less polarised. In general, farmers were less supportive of New Zealand remaining GM-free and more likely to believe there could be potential economic benefits from the use of GMOs. However, they remained ambivalent about the use of GMOs, unsure about the benefits for New Zealand, and expressed concerns about the ability to control the spread of GMOs and the potential impact of GMOs on the organic industry.

There is one other oft-quoted study worth mentioning that looked to assess how consumers in countries with negative views on GM technology (including New Zealand) might react to GM food products with stated benefits and with different pricing structures.[65] At a roadside fruit stand, New Zealand consumers presented with the option of organic fruit, 'spray-free'-GM fruit, or conventional fruit preferred the organic fruit (46%) as compared to conventional or GM (27% each). However, when the organic fruit was priced at a 15% premium and the GM at a 15% discount, 60% of the consumers chose GM. While this is a very limited study, it does support the

[58] Cook et al. (2004)
[59] Author interview, 1 April 2010
[60] Ibid.
[61] Small (2005)
[62] Small (2009)
[63] Cook et al. (2000)
[64] Cook and Fairweather (2003)
[65] Knight et al. (2007)

premise that information and cost can influence purchasing decisions with respect to GMOs and that more research and public education are needed.

Māori and GMOs

New Zealand's population is made up of about 73 per cent European, 14 per cent Māori, 9 per cent Asian, and 7 per cent Pacific Islanders.[66] However, in many ways it is a 'bicultural' society, with special consideration given to preservation of the cultural heritage of the indigenous Māori as guaranteed in the Treaty of Waitangi, and to ensuring appropriate resolution of issues through legal channels such as the Waitangi Tribunal.

Māori views on GMOs are shaped by deeply held cultural values and beliefs (tikanga Māori) and traditional practices with respect to relationships "between the spiritual and physical, or the human and 'non-human' world".[67] The concepts of whakapapa, defined as genealogy but also described as the links between people and with nature, and kaitiakitanga (guardianship) obligate Māori to protect and respect nature in the same way they would family or tribal members.[68] However, the Māori population is made up of a number of tribes (iwi), and "each group (iwi or tribe) will have its own distinctive, although recognisably similar, perspective".[69] During the Royal Commission, Māori views were expressed during a number of regional hui (conferences), and the range of views can be found in the Commission's report.[70]

Mere Roberts, who has done extensive research on Māori views toward genetic modification, believes that most Māori are opposed to transgenic[71] organisms, as they believe that the transfer of genes (particularly human genes) from one species to another is in conflict with traditional beliefs and values, in particular the integrity of whakapapa. But she believes that cisgenic organisms might be more acceptable.[72] Māori also believe they have obligations of kaitiakitanga over native flora and fauna and will likely oppose any GM application that could harm indigenous species.[73, 74]

Roberts summarised Māori views on GMOs in an article that presented the results of surveys and focus groups with Māori from the North and South Islands.[75] She found that Māori are generally pragmatic, and that views on GMOs would be based on a consideration of the potential risks to cultural values and principles, weighed against the purpose of the proposed GMO application and potential benefits to people, environment and economy. Economic considerations may also take on additional weight as settlement of claims under the Treaty of Waitangi result in historical lands returning to Māori control that could provide income for agriculture or forestry.

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66 *QuickStats about culture and identity-2006 census* (n.d.)
67 Satterfield et al. (2010), p.5
68 Report of the Royal Commission on Genetic Modification, Appendix 2, Section 3
69 Roberts et al. (1995), p.8
70 Report of the Royal Commission on Genetic Modification, Appendix 3, Section 4
71 'Transgenics' refers to the use of genetic modification to transfer genes between species. 'Cisgenics' refers to the transfer of genes between closely related species. This will be discussed in more detail in Section 4 of this report
72 Mere Roberts, Author interview
73 Mead (2005) includes several "test cases" relating to GMOs
74 Comment made in ERMA New Organisms Standing Committee meeting, 1 July 2010
75 Roberts (2005)

There is a requirement under the HSNO Act to ensure consideration of Māori views with respect to introductions of new organisms, including GMOs (see Appendix 3 of this report). The difficulty in consideration of Māori views is that the cultural or spiritual risks are intangible, and it is difficult to understand how to weigh these concerns against scientific assessments of risks and benefits.[76] The basic conundrum was posed by the Māori advisory committee, Ngā Kaihautū Tikanga Taiao (NKTT) with respect to an application to conduct contained research on GM cows in 2000. They asked "...what, if any, are the circumstances in which Māori cultural values, particularly those of a spiritual or non tangible nature, might be considered of sufficient importance to necessitate the decline of an [otherwise scientifically acceptable] application?"[77]

Dr Roberts and her colleagues have recently proposed modifications to ERMA's decision-making protocol for GMO applications that can "take into account both the tangible and intangible 'effects' of biotechnologies on different human communities, their environment and culture".[78] ERMA is also working on a suite of programs to improve the Māori consultation process to provide more concrete information and clearer articulation of Maori concerns with respect to introductions of GMOs.[79]

Scion Case Study

In a paper prepared for a Food and Agriculture Organization (FAO) of the United Nations/International Atomic Energy Agency (IAEA) Symposium in 2003, Robin McFarlane described "the dilemma that that has arison [sic] between a western science and secular-based paradigm which emphasises quantitative risk assessment, versus a traditional belief system that is fundamental to an indigenous (Māori) culture".[80] In the presentation the authors noted that it is "difficult to find common ground in a secular, culture-free, rational society".[81] While I disagree with the characterisation of Pākehā (non-Māori) as being "culture-free", this statement does highlight the problem faced by scientists who do not fully understand the Māori cultural concerns and thus may be intimidated by ERMA's requirements to take these concerns into account in assessing the potential benefits and risks associated with new GMOs.

One organisation that has successfully conducted contained field tests of a GM plant (pine trees) for over 20 years is Scion. Christian Walter, a Senior Scientist at Scion and the Team Leader for the Future Forest Program, believes their early and ongoing engagement with the local Māori has been a key part of the process.[82] Scion has sought input from the local iwi on their GM research beginning in 1994, prior to a requirement for Māori consultation under the HSNO Act. The interactions have included conducting a number of local hui; seeking advice on conducting the trial from Māori; support of Māori students, including student involvement in development

[76] Satterfield et al. (2010)
[77] Ibid, p.6
[78] Ibid.
[79] ERMA New Zealand, Personal communication
[80] McFarlane (2003)
[81] McFarlane and Roberts (2003)
[82] Christian Walter, Author interviews

of a brochure on the field trials; and ongoing monitoring of the trial by mana whenua (local Māori authorities). Scion has used the trials as an opportunity to enable Māori to learn about the new technologies and the possible benefits of the GM pine trees for Māori who are becoming major owners of forest lands from settlement agreements under the Treaty of Waitangi. The discussions around the Scion trials also helped bring about the formation of Te Aroturuki, a national Māori advisory group to ERMA on science issues. As a result of this ongoing engagement, the field trials of GM pine trees at Scion continue to be supported by the local iwi.

What is the press saying?

While the topic of GMOs is of interest in the press in New Zealand, it does not appear currently to be a high profile issue. Stories crop up occasionally in response to a specific event (such as the Royal Society report on GM forage,[83] or the approval of the application from AgResearch to continue their project on transgenic animals). However, my impression was that stories in the mainstream press tend to be neutral reports that mention both the potential benefits and risks of GM technologies.[84]

This impression was supported by a recent qualitative survey of media coverage in 2008 and 2009 by an independent research organisation commissioned by Pastoral Genomics.[85] They found the overall coverage to be neutral, but with a prevalence of stories from a few vocal anti-GM campaigners.[86] GMOs also seem to be much lower on the New Zealand media 'radar screen' than during a similar period at the time of the Royal Commission. In 2003, Daniel Pollak found more than 550 press reports that mentioned genetic modification in just two Wellington newspapers between January 2000 and June 2002,[87] while this recent survey identified only 227 media reports throughout New Zealand from January 2008 through February 2010.

Agricultural industry

NZBIO is an industry organisation that represents the bioscience-based industries of New Zealand. Chief Executive Brownyn Dilley[88] believes the climate in New Zealand is changing with respect to GMOs. She told me that industry organisations kept a low profile during the Royal Commission but now have a policy of being more proactive and are promoting biotechnology as a key element of economic growth in New Zealand. NZBIO believes New Zealand's success lies in a bioeconomy that integrates biological innovation, including the use of renewable biomass for energy, use of bioprocesses for industrial applications, and applied biotechnology and GMOs.[89] I attended the 2010 NZBIO Annual Meeting and there was a sense of optimism about the potential for biotechnology in New Zealand for health, industry and primary production. NZBIO believes that adoption of GMOs in New Zealand is a public domain issue that will be won or lost based on the ability to communicate well with the public, particularly with respect to the economic benefits of the technology for

83 Goldson (2010)
84 For example, see several articles from *The Listener* 6 February 2010 'Morsel Combat'
85 Unpublished research, provided by authors (2010)
86 Personal communication, 6 May 2010
87 Pollak (2003)
88 Author interview, 16 April 2010
89 *Driving economic growth through bio-based industries* (2009)

New Zealand.[90]

The views of industry and farmers will be discussed in more detail later in this report, with a focus on adoption of GM pasture grasses in New Zealand. Very generally, and not unexpectedly, the willingness of farmers and the agricultural industry to adopt GM varieties is based on pragmatic concerns of efficacy of the product and, more importantly, potential impacts on the export markets for New Zealand's dairy and horticultural products. In my interviews, I heard very little ideological opposition to, and significant support for genetic modification as a tool in crop or animal improvement from farmers or seed producers. The exception to this was organic growers who are strongly opposed to any use of this technology. But there was also almost unanimous concern for the potential negative impact of the adoption of GM technologies on export markets in Japan, Europe and other regions opposed to the use of GMOs.

[90] Author interview, 16 April 2010

3 IMPROVING PASTURE-BASED AGRICULTURE – ARE GMOS AN OPTION?

This section of the report provides an overview of the use of genetic modification to produce new varieties of perennial ryegrass with potential benefits for New Zealand's pastoral-based farming system. I also look at some of the non-GM options to address the same need for increased productivity and reduced environmental impact.

A number of grass and other forage plants are used in New Zealand's pastures. Perennial ryegrass is probably the most prevalent, but other grass varieties such as tall fescue, brome grasses and clovers are also used and pastures are likely to contain a mixture of forage plants.[91] Ryegrass varieties may also contain specific endophytes,[92] symbiotic fungi that aid in pest management but that can be toxic to cattle or sheep.

For the purposes of this paper and because of time limitations, I focused on perennial ryegrass. There have been recent advances in development of GM perennial ryegrasses that make this a timely discussion. But work is underway using genetic modification to improve other GM forage species, including white clover, and to modify specific ryegrass endophytes to minimise negative side effects on grazing animals. Much of the discussion in this paper will apply to adoption of any GMO and/or any GM forage grass in New Zealand, but I will try to note any specific issues or distinctions as appropriate.

The current situation

Agriculture is the largest sector of the New Zealand economy, including farming animals for meat, dairy, and wool, growing crops for feed and food, and plantation forestry. New Zealand is very dependent on exports, and agricultural products make up 48 per cent of all export products.[93] In 2009, 21.1 per cent of the total exports were dairy products.[94] The farming systems in New Zealand are primarily pasture-based, with hay and silage, as well as some corn (silage and grain) and palm kernel extract (PKE) used as supplemental feed[95, 96] in winter and dry summers.

While some farmers on the South Island use indigenous grass species, the farming system in New Zealand is based on non-native pasture grass species such as perennial ryegrass and tall fescue.[97] Since World War II, there has also been an increasing dependence on chemical fertilisers to supply nitrogen and phosphorus, and more recently increasing use of grass varieties containing endophytes.[98]

There is increasing pressure on the pasture-grazing system in New Zealand due to increasing land costs, competition from low-cost markets overseas, and concern over negative environmental impacts from effluents, nitrate accumulation in the soil, and

[91] *Pastures: grasses, growth, renovation, hay, weeds* (n.d.)
[92] *What is endophyte*? (n.d.)
[93] Bryan (2009)
[94] *Global New Zealand* (2009)
[95] *Production and feeding* (n.d.)
[96] Hutjens (2001)
[97] Syd Easton, Author interview
[98] Ibid.

greenhouse gas emissions. Increasing the productivity per cow would work towards resolving some of these issues by requiring less land and producing less waste to produce the same volume of milk.

Dairy cattle in New Zealand produce an average of 307 kilograms (kg) of milk solids per cow per year, as compared to 730kg in North America.[99] The difference in production is primarily due to the lower energy content of pasture grasses as compared to corn, alfalfa, and hay used on feedlots in the US (which may also be supplemented with soy meal, fats, vitamins, and in some cases, injections of bovine growth hormone to increase milk production). Research has been underway for a number of years in New Zealand, funded both by government and by industry and using both conventional breeding and genetic modification, to introduce new quality traits into forage grasses that will lead to increases in productivity. The research has produced a number of promising GM varieties that are currently confined to the laboratory and glasshouse; these will be described in detail below.

The Royal Society

In March 2010, the Royal Society of New Zealand published a paper on issues related to GM forage grasses that provided an overview of the technologies and discussed implications and issues for New Zealand agriculture.[100] The paper was not intended to provide recommendations on adoption of GM forages, but simply to "inform discussion on the benefits, risks, and acceptability of the use of these technologies".[101]

The Royal Society paper touched on a number of topics, including:

- a discussion on consideration of the trait (as opposed to method of production) as the basis of a case by case evaluation of new GMOs
- the implications of the use of cisgenic organisms as opposed to transgenics with respect to acceptance and safety
- the potential benefits of GM forage grasses in development, noting that modelling or research to demonstrate economic impacts at the farm level have not been done
- the potential averse effects of GM forage, primarily related to the inability to control movement of genetic material
- the socioeconomic issues that would need to be addressed for adoption of GM forages in New Zealand.

The publication of the Royal Society paper precipitated a number of articles in the press[102, 103, 104] and negative responses from groups opposed to any use of GMOs in New Zealand.[105] In general, press response was neutral, noting both the potential environmental and economic benefits of GM pasture for New Zealand but also the

[99] Bryan (2009)
[100] Goldson (2010)
[101] Ibid.
[102] Gardner and NZPA (2010)
[103] *GE plants promoted as 'cisgenic'* (2010)
[104] Wallace (2010)
[105] *No seed is safe with GE pasture* (2010)

potential for public resistance and negative impacts on trade.

GM perennial ryegrass – in the pipeline

The primary grass used for forage in New Zealand is perennial ryegrass (*Lolium perenne)*. Perennial ryegrass is a very productive and competitive temperate pasture species that establishes well and stands up to treading and grazing by cows and sheep.[106] Biotechnology techniques including plant tissue culture, marker assisted selection, and genetic modification have been used to complement conventional plant breeding to improve the productivity, persistence and pest and disease resistance of pasture grasses for over 15 years.[107]

There are three main entities developing GM forage grasses in New Zealand, although all the players seem to work closely together and the research community on GM grasses was described to me by one industry representative as an "extended family".

AgResearch

AgResearch is one of the eight CRIs; their primary mission is to support the sustainability and profitability of New Zealand's pastoral sector. Research is underway in the Forage Biotechnology Section of the Applied Biotechnology Group in Palmerston North to develop pasture grasses with higher levels of metabolisable energy (to increase productivity per animal) with reduced environmental impact.[108, 109]

Altered lipid levels

Perennial ryegrass has lower energy content as compared to other feedstocks and a relatively high level of protein content as compared to the levels of sugars and fats. One goal for AgResearch is to increase the level of lipids in ryegrass, providing more energy for pasture-grazed cows and sheep. Genetic modification has been used to develop ryegrass that overproduces one of the key enzymes in the synthesis pathway for triacylglyerol (TAG), the main storage lipid in plants.

Plant lipids contain long chain unsaturated[110] fatty acids that have been shown to provide cardiovascular health benefits over animal fats. To prevent microbes in the cow's rumen from saturating these lipids, AgResearch has also developed a mechanism to coat the lipids in the ryegrass with a protein isolated from sesame. This capsulation technique protects the plant lipids from saturation by the rumen microbes, resulting in more release of TAGs in the cow's intestine. Supplemental feeding trials have indicated that modifying the amount and composition of ryegrass lipids could not only increase productivity per animal, but could also result in increased levels of healthier omega 3 lipids in the meat and milk for human consumption.[111]

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[106] *The biology of Lolium multiflorum Lam. (Italian ryegrass)…*, (2008)
[107] Van Heeswijck et. al. (1994)
[108] Gregory Bryan, Author interview
[109] Bryan (2009)
[110] Simply put, 'unsaturated' lipids contain kinks in the molecules that keep the molecules more fluid, while 'saturated' lipids are more rigid (e.g. vegetable oil as opposed to solid shortening).
[111] Cosgrove et al. (2004)

By the end of 2010, AgResearch hopes to have completed development of ryegrass lines with the level of TAG doubled from 3 to 4 per cent to 8 per cent using the encapsulation technology.[112] In order to test the plant's agronomic properties, researchers will need to move the plants into the field. It was reported in late 2009 that AgResearch was planning to apply to ERMA in 2010 to conduct research outdoors involving GM high lipid ryegrass,[113] but current plans are to perform the initial field trials overseas.[114]

Increased sugar content

Scientists at AgResearch working in collaboration with Pastoral Genomics (see below) are also developing GM ryegrass with increased levels of fructans, the main storage sugar in pasture grasses. Using a combination of marker assisted breeding (a molecular method used to speed up the selection of desired traits) and genetic modification, ryegrass plants have been developed that produce significantly higher levels of fructans, without the seasonal variations in sugar production that naturally occur. The new varieties could provide a 5 to 7 per cent increase in metabolisable energy for dairy cows.[115]

Environmental benefits

The high sugar and high lipid forage grasses in development at AgResearch could also result in significant environmental benefits. If more energy is available to the cows from sugar and lipids, there will be reduced degradation of excess protein by microbes in the cow's rumen. Excess protein is excreted as urea, which can be further broken down to form nitrates or converted to nitrogen dioxide (NO_2), a greenhouse gas. In addition, fermentation of protein in the rumen can produce methane.[116] Burping of methane gas from dairy cows has been identified as a significant source of greenhouse gas production.[117] Researchers believe that wide-scale adoption of high energy forage could result in significant reductions in both methane and nitrogen dioxide emissions from New Zealand's dairy farms.

Increased digestibility

The cell walls of plants are made up of cellulose, hemicellulose, and lignin. Unlike humans, cows can digest cellulose fairly easily with the help of the microbes in their rumen. However, lignin is much less digestible; AgResearch is working to develop grasses with better digestibility by altering the lignin content and making the cellulose more accessible to rumen microbes. Similar work has already been accomplished in alfalfa and tall fescue overseas, and AgResearch is adopting the technology and looking at the impacts for ryegrass in New Zealand.[118] This project is also tied to development of biofuels, as digestion of cellulose by rumen microbes may play a role in sugar production for ethanol fermentation.

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112 Jones (2010)
113 Gibson (2009)
114 Jones (2010)
115 Ibid.
116 Winichayakul et. al. (2008)
117 *Emissions from burping cows 'higher than family car'* (2008)
118 Jones (2010)

Pastoral Genomics

Pastoral Genomics (PG) is an industry-good research consortium. Funded by Fonterra, DairyNZ, Meat and Wool NZ, Deer Research, and AgResearch, with matched funding from FRST, it has the goal of using biotechnology for improvement of forage grasses to benefit New Zealand pastoral farmers. PG has adopted a research strategy based on enhancing conventional breeding through marker-assisted selection and the use of cisgenics, so that new traits will only be introduced by moving genes from ryegrass into ryegrass and clover genes into clover. This is in contrast to the transgenics approach taken by AgResearch, where the focus is on introducing the best trait and "the gene that gets the job done".[119] GMOs produced by cisgenics are still considered 'new organisms' under the HSNO Act, but PG believes products developed using cisgenics may be more acceptable to farmers and consumers.[120]

PG is working on a number of different approaches to improve productivity and reduce the environmental footprint of GM forages. These include increased year-round biomass, increased sugar content (described above), enhanced nutrient use efficiency and drought tolerance. The product farthest along in development is drought tolerant cisgenic ryegrass, which would likely be attractive to farmers in this region due to recent droughts in Australia and New Zealand. (It is estimated that the economic impacts of the drought to the dairy industry alone in Northland could be NZ$220 million this year.[121]) The drought tolerant variety has been modified so that a normally dormant gene is switched on during dry conditions, allowing the plants to continue growing well during early drought conditions. While not meant to provide protection during severe drought, the new variety could extend peak animal production by up to four weeks.

PG is now conducting a small field test of drought tolerant ryegrass in North America in order to gather the data needed for submission of an application to ERMA.[122] Assuming the regulators and public in New Zealand and customers in overseas markets accept this product, the earliest possible commercialisation would not take place here before 2017.

Gramina

PGG Wrightson Seeds, the largest forage seed producer in Australasia, is another company with ties to New Zealand that is actively developing GM forage grasses These GM grasses are being developed in Victoria, Australia by Gramina,[123] a joint venture between PGG Wrightson Seeds, subsidiary PGG Wrightson Genomics and the Australian Molecular Plant Breeding Cooperative Research Centre (MPBCRC). Gramina is developing three major products: perennial ryegrass with high levels of fructan, and tall fescue and subtropical grasses with improved digestibility through reduced lignin content.[124] Limited, controlled field tests of these GM perennial ryegrass and tall fescue plants, approved by the Australian Office of the Gene Technology Regulator (OGTR), have been conducted over the past two years in

119 Author interview, 17 Feb. 2010
120 Author interview, 24 March 2010
121 *Northland drought cost climbs* (2010)
122 Wallace (2010)
123 *Gramina grass innovation* (n.d.)
124 Personal communication

Victoria. Although Gramina has said they would like to have the product ready for commercialisation by 2013, PGG Wrightson Seeds has no immediate plans to commercialise GM forage varieties in New Zealand.[125]

Does it have to be a GMO?

In a number of my meetings, both with supporters of GMOs and with those opposed to the use of GMOs in New Zealand for economic or cultural/ethical reasons, the discussion included consideration of whether there are less controversial alternatives to the use of GM pasture grass to meet the goals of increased productivity and reduced environmental impact for New Zealand's pasture industry.

Classical breeding to improve pasture grass

New Zealand scientists in both the public and private sector are using classical breeding technologies as well as modern (non-GM) techniques such as marker-assisted breeding to improve forage and improve on-farm productivity.

The Applied Biotechnologies Programme[126] at AgResearch uses classical breeding and selection to produce high performance grass and clover cultivars for use in New Zealand and for international markets. They also perform basic research to better understand pest resistance, plant development, and endophyte interactions, as well as gene function and protein expression to aid in the development of new varieties.

There are a number of privately funded companies developing new forage varieties as well, often in partnership with the CRIs. PGG Wrightson Seeds,[127] New Zealand Agriseeds Ltd,[128] and ViaLactia Biosciences,[129] a subsidiary of Fonterra, all have plant breeding and research programmes to develop grass seed cultivars to optimise farm productivity and profits for temperate zones such as New Zealand. Traits in development include enhanced heat-stress tolerance, water efficiency, and resistance to pests.

However, progress in developing new varieties of pasture grass has been hampered by several factors. Ryegrasses are difficult to work with in the lab and have only recently been domesticated, so there is a short history of breeding and few well characterised varieties to work with (as compared, for example, to corn.) In addition, certain traits, such as sugar accumulation, are strongly influenced by environmental and management factors, so varieties bred elsewhere, such as the United Kingdom (UK), do not perform well in New Zealand.[130] Traditional breeding has only resulted in incremental improvements of about 1 per cent per year.[131]

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[125] Ashton (2010)
[126] *Applied biotechnologies section* (n.d.)
[127] *About us - PGG Wrightson Seeds* (n.d.)
[128] Gardner and NZPA (2010)
[129] *Taking the lead* (n.d.)
[130] Harrigan (2009)
[131] Ibid.

Improved management

In addition to improving the quality of the pasture, there is evidence that significant improvements in productivity can be gained from changes in management practice. One project at Lincoln University showed that by conducting simple 'farm walks' to assess the state of pasture growth and flowering, farmers could increase productivity merely by moving animals between fields to better manage grazing impacts, prevent flowering, and to optimise fertiliser applications, saving up to NZ$5000 per walk.[132]

Another option for increasing productivity is to increase the rate of pasture renewal. Actively managed pastures can remain productive for 20 to 30 years and in practice, only a small percentage of the pastures (3-5 per cent) in New Zealand are replanted every year. The Pasture Renewal Charitable Trust (PRCT) argues that pasture renewal is essential to maximise benefits, including increased dry matter production, better stock performance, improved animal health and greater management flexibility and resulting higher income.

In 2009, PRCT commissioned Business and Economics Research Ltd (BERL) to perform a study assessing the economics of increasing the rate of pasture renewal.[133] Based on a number of scenarios of increased rates of pasture renewal and estimated pasture responses (increased rates of dry matter production following renewal), BERL estimated that an increase in pasture renewal rates for dairy from 6.11 per cent (the rate of dairy pasture renewal in 2007) to 12 per cent could increase farmgate values by 8 to 27 per cent and direct GDP from dairy from NZ$5.2 billion to NZ$6.0 billion. In reality, improving the pasture renewal rate is difficult on intensively managed farms where taking a pasture out of production can be costly and possibly risky if the performance of the new seed is unclear. In addition much of the pasture in New Zealand is on hillsides that are too steep for ploughing, complicating introduction of new forage varieties.

The caveat to these scenarios is human nature, and whether farmers will adopt new practices that may be time or labour intensive. Farmers may prefer adoption of a 'magic bullet' such as a new seed variety that could result in significant increases in productivity without a major change in management practices. New Zealand farmers are quick to adopt new seed varieties that promise increased productivity or quality. One example is the rapid adoption of ryegrass varieties containing the AR1 endophyte. This fungal strain provides the benefits of pest protection but produces reduced levels of alkaloids toxic to sheep and cattle. The AR1 strain was introduced in 2001 and currently makes up 70 per cent of ryegrass seed sales.[134, 135]

It is obviously dangerous to generalise about the behaviour of the 11 600 farmers in New Zealand. The analysis is complicated by the fact that seed companies have a vested interest in promoting new seed varieties and increased rates of pasture renewal. There are few publicly funded mechanisms, such as university extension services, to provide information on new management techniques, such as the 'farm walk' program from Lincoln.

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[132] Murray Willocks, Author interview
[133] Sanderson and Webster (2009)
[134] Charton (2006)
[135] *Economic costs of pests to New Zealand* (2009)

More research is needed

Developers of GM pasture grasses realise that there is a need for additional research to inform decision-making about the costs and benefits of adopting GM pasture grass as opposed to, or combined with, other mechanisms to benefit the dairy industry. To this end, a team at AgResearch is preparing detailed analyses of the economic impacts of a variety of approaches to improve productivity and reduce greenhouse gas emissions of the dairy system in New Zealand. These approaches include the use of supplemental feed or alternative forages, or improvements in fertilisation or cropping practices, and increased frequency of pasture renovation.[136] Preliminary results indicate that while changes to farming practices can result in improved productivity and environmental benefits, none of these methods are likely to provide the 'step change' that could result from adoption of certain new GM varieties such as the high lipid ryegrass,[137] in particular if combined with traditional breeding and improved management.

What is the status of GM forage grasses in other countries?

Although there has been research underway in the US and elsewhere for many years using genetic modification to improve grasses or legumes,[138] there are currently no GM varieties of any forage species in large-scale production. However, it is useful to note that of the 134 million hectares of GM crops currently in production worldwide, much of this is used for animal feed, either directly (corn), in processed products such as soy meal or corn gluten feed, or in allowing animals to graze on residues of harvested fields. Despite the vocal opposition to GMOs in Europe, Japan, and elsewhere, significant amounts of GM products from the US, Canada, Argentina and Brazil are used in the production of meat and dairy products from these countries.

Roundup Ready® alfalfa

There is only one GM forage crop that has received regulatory approval for environmental release. Roundup Ready® (RR) alfalfa was modified to be resistant to the broad spectrum herbicide glyphosate,[139] which is sold under trade name Roundup. In 2005, RR alfalfa completed regulatory reviews for food and feed safety and environmental release in the US and was rapidly adopted by farmers with an estimated 300 000 acres of forage planted within two years.[140] However, the decision by USDA to deregulate RR alfalfa was the subject of a lawsuit in 2007 and as a result it is currently only being grown on limited acreage under conditions imposed by USDA Administrative Order or under permit.[141]

RR alfalfa has also been approved for environmental release, as well as for food and

[136] Author interview, 17 February 2010
[137] Ibid.
[138] Information on field testing of GM forage grasses will be provided in Section 5 below
[139] Glyphosate is a broad-spectrum systemic herbicide used to kill weeds, especially perennials. It was initially patented and sold by Monsanto Company under the tradename Roundup®; the US patent expired in 2000. Glyphosate-tolerant GM plants have been marketed under the name 'Roundup Ready'
[140] Reisen et.al. (2009)
[141] *Roundup Ready® alfalfa* (n.d.)

feed safety, in Canada and Japan.[142] There is no commercial production of any GM varieties in Japan at this time. Canada does produce significant amounts of GM canola, soybeans, and corn, but RR alfalfa has not been registered in Canada for commercial production. A recent report[143] has indicated that RR alfalfa may be cleared for production in Canada in 2010, and some Canadian forage seed producers are expressing concerns about potential harm to their EU markets if this happens. The report also notes that the developer, Forage Genetics, has said it has no immediate plans to release GM alfalfa in Canada.

Roundup Ready® creeping bentgrass

Despite the fact that over 300 field trials of GM grasses have been conducted in the US[144] no GM forage grasses have been deregulated. In 2003, USDA received a petition from Monsanto Company and the Scotts Company for a determination of non-regulated status for glyphosate tolerant creeping bentgrass (*Agrostis stolonifera*), known by the trade name Roundup Ready® creeping bentgrass (RR CBG). CBG is a fast-growing perennial widely used for golf courses. The GM variety would be used to facilitate general weed control.

Following a preliminary risk assessment, USDA determined that because CBG is a wind-pollinated perennial that can establish without cultivation and can form hybrids with other grass species in the US, further information would be needed before a decision could be made regarding deregulation. Due to the complexity of the issue, a decision regarding deregulation of this organism is still pending. USDA is preparing an environmental impact statement (EIS)[145] that will be published in the Federal Register for public comment. The comments will be considered by USDA in their decision whether to grant non-regulated status to RR CBG.

[142] *Center for Environmental Risk Assessment* (n.d.)
[143] Friesen (2010)
[144] *Information systems for biotechnology* (n.d.)
[145] *Environmental Impact Statement: Petition for deregulation of genetically engineered glyphosate-tolerant creeping bentgrass* (2004)

4 KEY ISSUES FOR ENVIRONMENTAL RELEASE OF GM PASTURE GRASS

In this section I discuss the key issues that would need to be addressed in a decision about whether to adopt GM grasses in New Zealand. Much of what I heard would relate to adoption of any GMO and, as noted above, many issues raised during my interviews were discussed during the Royal Commission. I tried to focus this section on issues that relate more specifically to adoption of GM pasture grasses.

Readers familiar with the issues around adoption of GMOs will realise that I have chosen to largely ignore the question of safety; that is whether GM forage will cause harm to the environment (by becoming weedy or invasive or negatively impacting indigenous species), or whether the forage is safe for consumption either by its intended consumer (grazing cows, sheep, deer), or unintended, or downstream consumers (insects who feed on pollen, fish who eat the insects or reside in water downstream from GM pasture, people or animals who consume meat or dairy products.) These are all very real issues of legitimate concern and continued debate that would need to be addressed on a case-by-case basis prior to any decision to allow a conditional or full release of GM forage.

Prior to approval for release, a new GM variety would be subject to extensive evaluation for safety and efficacy, based on the crop and the trait introduced into that organism. To date, no GM forage grasses have progressed past the stage of small scale field tests in any country, so the data has yet to be produced to document safety or efficacy for any of the applications in development. Therefore, for this section of this report, I have assumed that the GM forage varieties under consideration for adoption (or other GMOs discussed in this context) would be subjected to full assessments for environmental safety as well as human and animal health as part of the regulatory process (as described in Section 5 of this report) seeking approval by ERMA for either a conditional or full release in New Zealand.

Clean and green and 100% pure

The recommendation from the Royal Commission in 2001 was for New Zealand to 'keep its options open' with respect to GM technologies, and to 'encourage the coexistence of all forms of agriculture.[146] However, almost 10 years later the debate continues as to whether GMOs should play any role in the future of New Zealand agriculture. Much of the discussion centres on New Zealand's image as 'clean and green' and whether GMOs could, or should, fit into this picture.

Is New Zealand 'clean and green', and does it matter?

A number of the people I spoke with expressed doubts about the reality of New Zealand as clean, green and pure, providing evidence that the perception is not the reality with examples of polluted rivers and high-emission vehicles. This was also documented in the press, with frequent articles highlighting environmental issues,[147]

[146] *Report of the Royal Commission on Genetic Modification* (2001)
[147] Easton (2010)

including a proposal to allow mining on protected lands,[148, 149] pollution of rivers from dairy effluent,[150, 151] and a proposal to allow 'factory' farming in the MacKenzie Basin on the South Island.[152]

However, while 'clean, green and 100% pure' may not be the reality, it is how New Zealand perceives itself and the image that New Zealand presents to the world. Many believe strongly that damage to this image will harm tourism and exports. A 2001 study by the Ministry for the Environment (MfE) provided some evidence to support this, finding that New Zealand's 'clean and green' image "is worth at least hundreds of millions, possibly billions, of dollars – aggregating value elements from dairy, tourism, and organic produce, and extrapolating to other sectors such as meat".[153]

Whatever the current reality, there is growing consumer and industry interest in low input, sustainable farming practices to help alleviate negative environmental impacts from agriculture. The question is whether GMOs, and GM pasture grass in particular, could or should be part of a 'clean and green' New Zealand.

Does 'clean and green' mean no GMOs?

Opponents to adoption of GM technology in New Zealand believe that GMOs are fundamentally incompatible with the image of '100% pure'. This view was exemplified in a recent press release from the Soil and Health Association in response to AgResearch's announcement about a genetic breakthrough that could allow the development of white clover with potential for improved animal health and waste reduction:[154]

> With a continued effort towards genetically engineering New Zealand pasture plants and developing herds of genetically engineered (GE) animals, AgResearch appears to miss the meaning of clean green 100% Pure…AgResearch in developing GE ryegrass and GE clover as a means of altering farming's greenhouse gas emissions, misses the point that the aware consumers who value 'clean and green' and are concerned at greenhouse emissions, are also aghast at genetic engineering. GE rye, clover, and animals cannot coexist with a clean green New Zealand.[155]

Others I spoke to argued against adoption of GMOs in New Zealand based on economics, i.e. that 'clean and green 100% Pure New Zealand' is equated with 'Brand' New Zealand, that GMOs are inconsistent with this brand, and that any introduction of GMOs, including contained field tests, would harm exports and tourism.[156] There is also a growing movement in New Zealand to promote dynamic/biological/organic farming methods, focusing on reduced inputs and more holistic farming approaches. Proponents of these methods believe them to be better

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[148] NZPA (2010)
[149] Chug (2010a)
[150] Watt (2010)
[151] Chug (2010b)
[152] *Factory dairy farming arrives in New Zealand* (2009)
[153] *Valuing New Zealand's clean green image* (2001)
[154] *World-first science GE discovery that could lead to more productive farms and reduced greenhouse gases* (2010)
[155] *GE plants and animals do not belong in clean green 100% pure NZ* (2010)
[156] Author interviews, 3 March 2010, 23 March 2010

for the environment and more sustainable, and also believe that exporters who can establish their 'sustainability credentials' will have access to high-value speciality markets.[157]

Could GMOs be part of 'clean and green'?

The contrasting viewpoint, supported by some members of the research community and representatives from pasture-based industries, is that New Zealand should pursue new technologies as a tool in maintaining sustainable agriculture and in mediating negative environmental impacts that result from pastoral farming practices. This was supported by a very recent report that compared views of stakeholders from Switzerland and New Zealand towards sustainable agriculture. The surveys found that compared to the Swiss, New Zealand stakeholders consider "precision agriculture and agricultural biotechnology…[to be]…essential components of the future of sustainable agriculture".[158]

The GM grasses in development have the potential to reduce greenhouse gas emissions and nitrate pollution, which the researchers believe should be touted as positively contributing to the 'clean and green' image. Several recent studies have documented the significant environmental benefits (such as reduced chemical inputs and decreased erosion) from adoption of GM row crops in the US, Canada, and Brazil.[159, 160, 161] While the specific crops and traits grown elsewhere may not make sense for New Zealand, farmers here have expressed interest in having access to appropriate new technologies, including GMOs, particularly when they can contribute to reduction in chemical inputs or deliver other environmental benefits.

Another view expressed was that New Zealand, recognised as a world leader in pasture grass research, needs to take advantage of the available technologies that are being adopted by the rest of the world or get left behind. Tied to this was a view that New Zealand should capitalise on its reputation for high quality research and safety as part of the 'clean and green' image – if GMOs are destined to be part of world agriculture, would New Zealanders want them developed here or in countries such as China with less reliable food safety standards?

This issue of whether GMOs could contribute to the 'clean, green' image was highlighted following the recent announcement by AgResearch about the breakthroughs that could lead to cisgenic white clover with potentially significant environmental benefits for New Zealand. Both the Green Party[162] and the Soil and Health Association[163] put out press statements following the announcement opposing the research and any potential use of GMOs, including cisgenics, in New Zealand. This precipitated some interesting discussions in the 'blogosphere' about the priorities of the environmental groups in blanket opposition to any GM technologies, including applications like this clover variety that could have compelling environmental benefits.[164]

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[157] OANZ, Personal communication
[158] Aerni (2010)
[159] Carpenter (2010)
[160] National Research Council (2010)
[161] Céleres (2010)
[162] Norman (2010)
[163] *GE plants and animals do not belong in clean green 100% pure NZ* (2010)
[164] Brown (2010)

Commodities or specialty crops?

Overriding both sides of this debate is a more fundamental discussion of the best direction for New Zealand's agricultural future. On one side is the view expressed by Minister of Agriculture David Carter in a speech to the DairyNZ Farmers Forum:

> [a recent report from KPMG][165] said New Zealand can no longer compete as a food exporter on the basis of low-cost pricing. I agree. This mantle of being a low cost producer has now firmly passed to developing countries, primarily in South America. Our future here in New Zealand is as a producer of high-quality, value-added goods.[166]

Opponents to GMOs in New Zealand argue that GM crops are targeted at reducing costs for production of low-value commodities, and that New Zealand should focus on providing high quality, value-added, and exclusively non-GM products to middle-class niche markets overseas. They fear that any adoption of GMOs here would compromise New Zealand's ability to capitalise on its reputation for purity and high quality products.

But Minister Carter's speech did not address GMOs. Proponents would say that genetic modification could be a valuable tool for adding value to agricultural products, such as tearless onions or healthier meat and milk that could result from animals grazing on high lipid grasses.

On the other side is the belief that New Zealand should stick with its strength as a low cost producer of quality, pasture-based primary products (meat, dairy and wool). Proponents of genetic modification believe GMOs can provide the 'step-change' needed to increase the productivity of pasture grasses that would allow New Zealand to remain cost competitive with low-cost producers overseas.[167] According to one industry representative, if New Zealand were to remain GM free:

> …it has the potential to lose the single most important differentiation we have as a country. It's not being 'clean and green', it's being a low-cost producer of commodity products. And it's a low cost producer because we grow grass so well here and so cheaply.[168]

He also questioned the premise that New Zealand should focus on value-added products. He believes that New Zealand's markets do not want value-added products, but look to New Zealand for high-quality, low-cost raw materials (milk powder, not cheese, and lumber, not paper), and that the value for this country continues to be in keeping costs down for high primary productivity. He also questioned whether the markets would pay a premium for non-GM (conventional) products.[169]

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[165] Minister Carter was referring to a recent report on the future of New Zealand agribusiness from KPMG available at http://www.kpmg.com/NZ/en/IssuesAndInsights/ArticlesPublications/Press-releases/Pages/NZ-Agribusiness-sector-under-threat.aspx

[166] Carter (2010)

[167] Jones (2010)

[168] Author interview, 31 March 2010

[169] Ibid.

Does New Zealand want, or will it accept, GM pasture grass?

Public acceptance of GM pasture

The New Zealand public continues to be sceptical of genetic modification. The images of cows and sheep grazing on pristine pasture are iconic in New Zealand, and it is likely arguments for or against the use of GM pasture will be measured against these bucolic scenes. Those opposed to genetic modification insist "GE rye, clover, and animals cannot co-exist with a 'clean and green' New Zealand",[170] while proponents believe the potential environmental benefits such as reduced greenhouse gas emissions from GM grasses are completely compatible with 'clean and green'.

The views of the public with respect to genetic modification and GM plants and animals in general were discussed above. At least two studies have indicated that these attitudes are likely to apply to GM forage grasses as well.[171, 172] Both studies also indicated that cisgenics forage crops may be more acceptable to the public than transgenic varieties. However, GM pasture grass presents some unique issues. Corn, soy, and canola are processed into oils and other products found in foods directly consumed by people, while forage grasses would only become part of the food supply as feed for sheep, cattle, and deer. Consumers more inclined to accept GMOs with direct health benefits may find it hard to make a connection between ryegrass with altered lipids and healthier meat and milk. People concerned about unintended environmental consequences will likely be uncomfortable with (uncontrolled) release of a GM grass into New Zealand's pasture-based landscape.

New Zealand law requires that any food containing GM DNA or protein, or having altered characteristics (e.g. soybeans with high oleic acid content) must contain this information on the label.[173, 174] However, products such as meat or milk from animals fed GM feed do not have to be labelled. New Zealand currently imports corn and soy as supplemental feed from countries such as the US that produce GM crops. Meat and dairy products from animals that consume these feeds are not labelled. I have not seen any evidence that sales of these products have been affected, although it is not clear if consumers are aware of this issue or if this would become a concern if GM pasture was adopted in New Zealand.

There was one well publicised incident recently that may foreshadow the debate about the acceptance of GM grasses and of products from animals fed on GM forage. In November 2009, the Commerce Commission gave New Zealand poultry producer Inghams Enterprises a warning for false advertising for claiming that their chicken contains 'no GM content and are not genetically modified', although the chicken were eating feed containing GM soy.[175] Although animals fed GM grain do not meet any definition of 'genetically modified,' Jack Heinemann from Canterbury University argued the GM DNA could be 'transferred' to the animals.[176] DNA is present in all

[170] *GE plants and animals do not belong in clean green 100% pure NZ* (2010)
[171] Small (2004)
[172] Independent research commissioned by Pastoral Genomics, Provided to author (2010)
[173] *Genetically modified foods: labelling and safety* (n.d.)
[174] There is an allowance for an unintentional presence of 1 per cent GM content before an ingredient must be labelled.
[175] Gregor (2009)
[176] Ibid.

food and feed and is digested along with the food; there is little evidence to suggest that DNA from any food becomes functionally incorporated into the DNA of the animal or person consuming the food.[177] It is likely this argument will resurface in the context of any application to grow GM forage in New Zealand.

Māori acceptance of GM pasture grass

The views of Māori with respect to adoption of GM pasture grass are likely to mirror those of non-Māori in many respects. Because perennial ryegrass is not indigenous to New Zealand, nor are cows, sheep, or deer that would be grazing on GM pastures, GM ryegrass may be more acceptable to Māori than other GM applications.

Do farmers want GM pasture grass?

There are approximately 63 000 farms in New Zealand,[178] so it would be difficult to generalise the reaction of 'farmers' to adoption of GM pasture grasses. Agriculture is the largest sector of the New Zealand economy; farmers are not subsidised and 91 per cent of what they produce is exported. The drivers for adoption of new technologies by the farmers include potential for increased production, sustainability of farming practices, and acceptance of products within New Zealand and by their major markets.

Nick Pyke from the Foundation for Arable Research (FAR) believes that farmers in New Zealand would use GMOs, but only if there are significant financial and environmental benefits.[179] None of the GM crops on the market now would provide sufficient value for New Zealand farmers to offset potential risks of adopting the technology. He noted that pest pressures are different in New Zealand than the US and management practices such crop rotation, herbicides, and using animals to clean up weeds in fields, work well for farmers here. Any new variety would have to provide a major step change in productivity or production efficiency beyond what can be achieved using methods such as pasture renewal and management for farmers to adopt GMO varieties.

Dairy farmers and potential impact on dairy exports

My impression from discussions with farmers and industry representatives is that dairy farmers would be open to adoption of GM forage. Jaqueline Rowath, Head of Agriculture at Massey University, told me that New Zealand farmers "feel way behind"[180] with respect to the use of GM crops. New Zealand dairy farmers seem to be neutral about genetic modification per se, but need to be convinced that the technology makes economic sense. Bruce Thorrold from DairyNZ summarised views of dairy farmers following a workshop on GM forage grasses at the DairyNZ Farmers Forum in May 2010:

> Some farmers are keen to adopt GM pasture grasses, but others are hesitant due to concerns that the higher yields might result in a loss of persistency or

[177] Ibid.
[178] *A snapshot of New Zealand agriculture* (n.d.)
[179] FAR receives funding from a levy collected from arable growers as well as other sources to invest in research and education to benefit these producers. Projects include training in integrated pest management, weed control, soil sampling, and water management (www.far.org.nz)
[180] J. Rowath, Author interview

> produce other changes that reduce the overall performance of the grass. Farmers are very cautious about consumer acceptance and would need to be convinced the technology's really going to deliver.[181]

Any individual decisions by farmers for adoption of GM forage grasses are overshadowed by the fact that most of the dairy industry is controlled by Fonterra, a multinational dairy cooperative owned by over 10 500 farmers in New Zealand.[182] Fonterra is New Zealand’s largest company, with revenues of more than NZ$16 billion. Fonterra exports 95 per cent of its product and has a market share of approximately 30 per cent of the world’s dairy exports,[183] selling a range of dairy ingredients and consumer products in up to 140 countries.

Fonterra is pragmatic about GMOs and GM pasture grass in particular, driven by the market considerations. They are members of the Pastoral Genomics consortium and support responsible GM research and the potential use of GM products if they can be demonstrated to be safe and beneficial for agriculture and the environment. However, Fonterra would not support commercialisation of GMOs until there is certainty in their market acceptability. Support of adoption of GM forage in New Zealand would have to be consumer driven and in the context of global acceptance of GM products.[184] They believe their strength in the market comes from quality and consistency of the products, low costs, and a tie to New Zealand’s ‘clean, green’ image.

I asked whether Fonterra is engaging their foreign markets about their likely response if New Zealand were to adopt GM pasture grass. There had been some engagement (some buyers would be strongly opposed, some would not care), but since this is not a near-term issue, the industry is hesitant to raise the issue to avoid unnecessary concern in the market. Fonterra is also keeping an eye on the situation with respect to GMOs in Australia, and whether consumer acceptance will be influenced by positive environmental impacts of GM technologies.

Bruce Thorrold told me that the industry was investing in GM technologies but were not ‘precious’ about their right to use GMOs, and would do whatever makes economic sense.[185] He believes this view differs from that of developers who stand to make a direct profit from intellectual property resulting from the research (although non-adoption in New Zealand would not preclude profits from business overseas). He raised several scenarios.

- If New Zealand *does not* adopt GM forage grass:
    - competitors in North or South America could adopt the more productive grass varieties first and out compete New Zealand on price for commodities, but
    - New Zealand could gain a competitive advantage in specialty markets by not using GMOs.

[181] B. Thorrold, Author interview
[182] Fonterra also collects milk from farmers overseas, including farms in Australia, Chile, and China
[183] Author interview, 17 February 2010
[184] Ibid.
[185] B. Thorrold, Author interview

- Alternatively, if New Zealand *does* adopt GM forage grass:
  - farmers could gain a productivity advantage to maintain their low cost market share, but
  - New Zealand could lose key markets due an association with GMOs.

He acknowledged that the industry is in a difficult position and they continue to move forward cautiously by supporting the research to determine safety and efficacy, while waiting to see where the market will go.

There is little direct evidence that the use of GM feed will negatively impact a country's ability to export milk or meat products. According to the USDA Global Agricultural Trade System (GATS) database,[186] US exports of dairy, poultry, eggs and meat continue to increase worldwide, even in GM sensitive markets like the EU. In January 2009, the Australian Bureau of Agricultural and Resource Economics (ABARE) published a study analysing the issues related to the use of GM material in animal feed. The report concluded:

> No evidence of import restrictions on meat, egg and dairy products derived from animals fed with stockfeed containing GM material was found in any of Australia's major livestock product export markets considered in this study. There is also no evidence of regulation in any of Australia's major export markets for mandatory labelling of products from animals which have been fed GM stockfeed.[187]

New Zealand exports dairy products to over 140 countries worldwide; the top markets are China, the US, Japan, Philippines and Australia. Major markets for New Zealand beef are North America, Korea and Japan, and approximately half of New Zealand's sheep meat exports go to Europe, along with North America, North Asia and the Pacific. While consumers in markets like Japan, Korea, and Europe are opposed to GM food, none of these countries have labelling requirements for animal products fed GM feed, nor (to my knowledge) explicit requirements that GM feed used in the exporting country must have domestic approval. On 7 July 2010 the plenary of the European Parliament rejected a proposed amendment to the EU Novel Food Regulations that would have required labelling of foods produced from animals fed GM.[188, 189]

Could GM pasture grass impact other agricultural sectors in New Zealand?

While farming systems based on pasture dominate in New Zealand, there is also significant production of fruit (kiwi, apples, pears, grapes), vegetables (potatoes, onion, carrots, squash, sweet corn), grains (wheat, barley, and maize), and seeds for both domestic use and export.[190, 191, 192] Federated Farmers is an industry organisation that represents the interests of members including meat and fibre, dairy, goats, rural

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[186] *GATS* (n.d.)
[187] Ansell and McGinn (2009)
[188] *Chance to get labels on foods from animals fed GM* (2010)
[189] *MEPs call for ban on food from cloned animals* (2010)
[190] *Agricultural Production Statistics* June 2009
[191] *Who & what is NZGSTA*? (n.d.)
[192] *Fruit and vegetable industry in New Zealand* (2007)

butchers, high country, grain and seed, and bees. They support the use of genetic modification as a tool in improving the characteristics and yields of plants and animals. However, they want assurance that appropriate controls are in place and that risks and benefits are assessed on a case-by-case basis to ensure their industry will not be subjected to unacceptable risks.[193] I met with several representatives from Federated Farmers who told me they believe that some grain and crop farmers are opposed to introduction of GMOs due to concerns that changes in cropping patterns (introduction of new crops or dominance of one crop) or entry of new farmers in their markets could impact profits.[194]

ZESPRI International, a cooperative of over 2700 kiwifruit farmers in New Zealand and elsewhere, has taken a strong position opposed to genetic modification for their product, as seen by this statement from their web site.

> ZESPRI will not fund research, market or have in its inventory any genetically modified kiwifruit. ZESPRI supports Research and Development as a key component of the New Zealand kiwifruit industry's future success but chooses not to pursue genetically modified kiwifruit as a new fruit product.[195]

It is ZESPRI's view that consumer opinion and perceptions will limit the acceptability of GMOs in New Zealand in the foreseeable future and that robust consumer research needs to be undertaken before the adoption of any GM products here.[196] ZESPRI believes that their market for premium kiwifruit is enhanced by the association with 'clean, green, GMO-free New Zealand'.[197] A decision on whether to adopt any GM product such as pasture grasses in New Zealand would need to consider the wider implications for New Zealand markets beyond the immediate market segment for that product.

Organics

During my interviews, I often heard the term 'Brand New Zealand' as a marketing term tied to the perception of New Zealand as 'clean and green, 100% pure', and also associated with production practices such as free-range, biodynamic farming, and organic. Proponents of organic farming in New Zealand, as elsewhere, are among the strongest opponents to any use of GMOs. I will touch briefly on the organics industry here, but will cover this in more detail below in the context of the potential for coexistence of GM pasture with organic and conventional farming methods.

In New Zealand, the organics industry is represented by Organics Aotearoa New Zealand (OANZ). OANZ is composed of 14 national organic groups including farmers, Māori community groups, processors, retailers, wholesalers, certifiers, exporters and consumers. OANZ is opposed to any introductions of GMOs in New Zealand. Their opposition to GM technologies are based on concerns about the safety and ethics of GM technologies,[198] on the belief that GMOs are incompatible with

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[193] *Submission to Environmental Risk Management Authority on Application GMF06001* (2006)
[194] Author interview, 10 May 2010
[195] *Frequently asked questions* (n.d.)
[196] Author interview, 3 March 2010
[197] I note that ZESPRI has licensed growers in several countries, including France and Australia, where GM crops or seeds have been, or are, being grown.
[198] *AgResearch's cruel experiments cover a wide range* of animals (2010)

‘clean, green 100% Pure New Zealand’[199] and on concerns that GM organisms will negatively impact New Zealand’s ability to market organic agricultural products.[200]

Cisgenics vs transgenic

One question that came up many times during my interviews was whether the use of cisgenics or intragenics (as opposed to transgenics) could influence the public debate. The majority of GMOs in commercial production today are ‘transgenic’, meaning DNA has been transferred between species in order to introduce the novel trait. For example, Roundup Ready® soybeans have been engineered to be tolerant to the herbicide glyphosate by insertion of a gene from a bacterium, as well as regulatory sequences from a virus and petunia. The ability to move DNA and traits between species is one reason the technology is so powerful. But it is also one reason many people are opposed, as they believe transgenics is unnatural or ‘playing God’, and that these methods will lead to unintended negative consequences for human or environmental health.

In response to this opposition, researchers have been exploring alternative techniques that do not result in foreign DNA in the modified organism. Using ‘cisgenics,’ novel traits are introduced into an organism using genes from that same species (‘corn into corn’). Tony Conner from Plant & Food Research, has taken this a step farther promoting the use of ‘intragenics’ for genetic modification of plants. Using intragenics, all genes and regulatory sequences are derived from the same species as the organism to be modified, including the use of plant-derived sequences (as opposed to bacterial sequences) to mediate transfer of the DNA.[201] Conner and others, including researchers at Pastoral Genomics as discussed above, believe that using methods that produce results more directly analogous to classical breeding will reduce the risk profile and be more acceptable to the public as well as to foreign markets.

Developers in New Zealand are working on both cisgenic and transgenic approaches to develop GM pasture grasses (as described in Section 3 above.) Pastoral Genomics is currently conducting trials of drought tolerant cisgenic perennial ryegrass, and they believe this approach will be more palatable for New Zealand, particularly during the early years of adoption of GM technologies. In addition, in June 2010, AgResearch announced their intention to pursue a technology that would use cisgenics to increase concentrations of condensed tannins in white clover to improve protein uptake by grazing animals and reduce nitrogen waste and methane emissions.[202]

Another research group at AgResearch believes that the key is developing organisms with the best traits, regardless of the source of the DNA.[203] These researchers are using genes from rice, sesame, and *Arabidopsis* to improve increase sugar and lipids levels in grasses.

It is unclear whether the use of cisgenics as opposed to transgenics will have a

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[199] *GE plants and animals do not belong in clean green 100% Pure NZ* (2010)
[200] Author interview, 23 March 2010
[201] Barrell et al. (2010)
[202] *World-first science GE discovery that could lead to more productive farms and reduced greenhouse gases* (2010)
[203] Author interview, 17 February 2010

significant impact on acceptance of GMOs by the public or by foreign markets. Surveys have shown that people are more comfortable with GMOs developed using cisgenics as opposed to transgenics when the concepts are clearly explained and compared to traditional breeding techniques.[204] One study by an independent market research organisation commissioned by Pastoral Genomics found that consumers who understood the difference between cisgenics and transgenics also tended to associate cisgenics with 'hybrids' (including the eco-friendly cars) and as being more natural.[205] And, as discussed above, cisgenics are more likely to be acceptable to Māori, as transgenic techniques that move genes across species raise concerns with respect to whakapapa.

However, views varied among the industry representatives I interviewed as to the potential impacts of cisgenics or transgenics on domestic and foreign markets. One representative from the dairy industry said that he does not believe farmers will care whether new ryegrass varieties are cisgenics or transgenic, as long as the seed provides added value. He did acknowledge, however, that consumers may be more accepting if they see the technology as another form of hybridisation. But he was also concerned that promotion of cisgenics could undermine consumer confidence in transgenics, which could be problematic if it turns out that the best traits ("all the good stuff") can only be identified from foreign DNA sources.[206]

Another dairy industry official also stated that he is not sure cisgenics will make a difference. He believes the public is struggling to understand 'GMOs', and that the cisgenics/transgenic debate is a subtlety that will be lost on most consumers and the buyers for New Zealand products.[207] The dairy industry is supportive of both cisgenics and transgenic research on forage grasses as they look to future industry needs, with the logical caveat of the need for consumer-driven market acceptance of any new technologies that could affect industry profits.

One complicating factor is that the HSNO Act definition of *genetically modified organisms* includes "any organism in which any of the genes or other genetic material have been modified by in vitro techniques".[208] This would encompass both cisgenic and transgenic GMOs. This is supported explicitly by the definition of *genetic modification* by the Royal Commission, that includes "the deletion, multiplication, modification, or moving of genes within a living organism", as well as "the transfer of genes from one organism to another".[209] While cisgenic technologies have potential to facilitate public acceptance of GMOs in New Zealand, these organisms for the time being are still subject to the same regulatory burden, and associated public scrutiny, as transgenic organisms.

These new methods blur the distinctions between classical breeding and genetic modification, and the argument could be made for exempting cisgenic or transgenic GMOs from regulation as new organisms. Supporters of cisgenic or intragenic technologies argue that minor DNA arrangements that could arise from these

[204] Small (2004)
[205] Unpublished survey (February 2009)
[206] Author interview, 2 March 2010
[207] Author interview 17 February 2010
[208] *Hazardous Substances and New Organisms Act (1996)*, Part 1 (2)
[209] *Report of the Royal Commission on Genetic Modification* p.366

techniques could also occur naturally and are likely to be less significant than DNA rearrangements that could result from chemical or irradiation mutagenesis used routinely in plant breeding.[210]

As experience with GMOs grows, and regulatory burdens for governments and researchers increase, regulators are considering options for regulatory relief and changes that more closely align regulatory oversight to actual risk. Exemption of cisgenic or intragenic organisms from some level of oversight would be one option. However, to my knowledge, no countries have yet specifically exempted cisgenic GMOs from regulatory oversight and continue to do risk-based evaluations on a case-by-case basis.

Does GM ryegrass make economic sense for New Zealand?

The potential economic benefits and risks of GM pasture grass for New Zealand are the topic of much discussion, but are basically theoretical at this point. As noted above, there is disagreement as to whether New Zealand will fare better economically if its agricultural sector focuses on low-cost primary production of high-value raw materials, or on value-added non-GM products for niche markets.

Any regulatory approval to conduct an environmental release of GM grasses in New Zealand must be accompanied by an assessment that demonstrates that the social and economic benefits outweigh the risks (discussed in Section 5 of this report.). There have been no applications submitted to ERMA for GM grass field tests in containment to date, and field tests in the US and Australia do not have to demonstrate economic benefit for approval. The economic analysis is likely to be complex as it may need to include, among other issues, benefits to the pasture industry from productivity gains and environmental mediation; profits from sale of modified seed varieties; impacts to domestic and international markets for conventional and organic dairy and meat products; potential indirect impacts to other exports (such as kiwifruit, apples or honey); impacts on tourism; research and technology gains to New Zealand; and opportunity costs due to funding of GM research.

Benefits to farmers and New Zealand

Several people mentioned that a 'step-change' in needed to increase the productivity of pasture grasses in order to remain cost competitive with dairy producers in South America and elsewhere, and that this can only be achieved by genetic modification.[211]

The economic analyses that have been done in this regard thus far are inconclusive. In 2003, the Ministry for the Environment and the Treasury commissioned a report[212] from BERL and AERU to examine the economic risks and opportunities associated with the release of GMOs in New Zealand. The authors looked at several scenarios including adoption of a GM technology that improved the productivity of New Zealand's pasture systems. The economic models showed a complex relationship between productivity gains, potential reductions in demand and discounted pricing for dairy products, and the impacts of adoption of GMOs and increasing productivity in

[210] Batista et al. (2008)
[211] Jones (2010)
[212] Sanderson et al. (2003)

competitor countries. The general conclusion was that:

> ….while the impact of single influences (either world market demand effects or New Zealand production opportunities) are potentially large, together many of the influences counter each other. Because of the counter-balancing influences, the actual effect on New Zealand's annual GDP ten years hence is thus not very great under any of the scenarios.[213]

In contrast, an economic model prepared for Pastoral Genomics in 2009 predicted significantly higher productivity gains as well as increases in the GDP between $75 million and NZ$1.5 billion plus significant increases in household income and employment in the dairy sector.[214] The economic advantage was predicated on first adoption of the new GMO grasses by New Zealand, with major losses to New Zealand if the new grass varieties are adopted first by competing producers. However, there could be an economic advantage to developers and the seed industry from sale of the intellectual property or of GM seeds, even if GM pasture was not adopted here.

Any discussion of economic benefit is complicated by the fact that, as with most new technologies, it may take a number of years before the economic winners and losers are clear, and this is likely to be influenced by unanticipated factors. This would be particularly true for GMOs, where so much depends on changing political and public priorities and perceptions. For example, in the US, New Leaf™ potatoes, engineered to be insect-and virus-resistant, were introduced by Monsanto in 1995. The GM variety was rapidly adopted by farmers who were able to reduce pesticide costs and improve tuber quality. However, in 2001 Monsanto decided to discontinue this product due to decisions by some large potato processors to avoid the use of GM varieties.[215]

On the other hand, most of the GM varieties currently in large scale production in North and South America are commodity crops modified for insect resistance and herbicide tolerance. Farmers rapidly adopted these varieties because they increased profits and facilitated pest management. But 15 years later, studies are also documenting significant environmental benefits from these varieties.[216]

Economic impacts from harm to the 'clean, green' image

I heard repeatedly that any adoption of GMOs in New Zealand would harm the 'clean, green' image and negatively impact both tourism and exports. However, there was also general agreement among the people I interviewed that there is little evidence to either support or refute this statement and that research on the potential economic impacts of GMO adoption on New Zealand exports and tourist industry is essential to inform the debate. Several people pointed out that contained research on GMOs, both in laboratories and in field tests, has been conducted in New Zealand for over 20 years, with no documented negative impacts on exports or tourism.

The 2001 study from MfE mentioned above did provide some preliminary support for

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[213] Ibid.
[214] Hanley (2010)
[215] Thornton (2003)
[216] National Research Council (2010)

negative impacts of GMO adoption for New Zealand's organic industry.[217] The researchers interviewed two wholesalers of organic fresh produce in the UK about their likely response to field tests in containment of GMOs in New Zealand as well as large scale release. The buyers indicated that in even in the advent of contained GM field tests for research purposes, they might begin looking for alternative sources of organic produce. And in the event of commercial release, they would likely stop or severely reduce imports from New Zealand.[218]

Is there a better use of research funds?

Another aspect for consideration is the level of public investment in the research programmes underway to develop GM forage grasses. The majority of the funding for GM research in New Zealand comes from public funds, under a mandate to fund research for the benefit of New Zealand. In contrast, the majority of the biotechnology research in the US is funded by private companies who can develop products based on anticipated market value. A quick search of the FRST website shows approximately NZ$4 million per year allocated to projects using genetic modification to develop new organisms for improved pasture in New Zealand (ryegrass, clover, endophytes).[219]

Opponents to GM technologies question whether the government should be using public money to fund controversial research with unproven benefits, and question why, after 10 years of research, there are no products available with tangible benefits for New Zealand (with no obvious recognition that opposition impedes research). Supporters argue that in addition to the potential to develop products of value for New Zealand, support for GM research is essential to keep world-class scientists in New Zealand and for New Zealand to remain a key player in the international research community.

I also heard that funding for GM research should instead be targeted to research on improving conventional or organic farming methods that could provide the productivity gains anticipated by GMO without the controversy or potential for unanticipated risks. The government does support this research as well – the Sustainable Farming Fund (SSF) at MAF provides up to NZ$9 million a year to support applied research and extension projects in rural communities on projects such as soil management, organic systems, irrigation efficiency and alternative land-use options.[220]

Co-existence: Is GMO ryegrass compatible with conventional or organic agriculture in New Zealand?

The recommendations of the Royal Commission were clear in not excluding the use of GMOs as an option for New Zealand, and the theme of preserving opportunities encouraged: "…the coexistence of all forms of agriculture. The different production systems [genetic modification, conventional farming, organics, and integrated pest management] should not be seen as being in opposition to each other, but rather as

[217] *Valuing New Zealand's clean green image* (2001)
[218] The report did not specify if the scenario presented during the interview was about any release of GMOs in New Zealand, or release of the specific commodity, i.e., apples or kiwifruit, to be imported
[219] *Research reports* (n.d.)
[220] *Sustainable Farming Fund* (n.d.)

contributing in their own ways to the overall benefit of New Zealand".[221] In a Cabinet Paper prepared in response to the Royal Commission, MAF elaborated saying that coexistence means that different productions systems can operate "while ensuring that their operations are managed so that they affect each other as little as possible".[222]

In 2004, Graham Brookes provided a similar definition for coexistence, saying:

> Co-existence generally refers to the economic consequences of adventitious presence[223] of material from one crop into another and is related to the principle that farmers should be able to cultivate freely the crops of their choice using any production system they prefer (GM, conventional or organic). It is NOT therefore a product/crop safety issue but relates solely to the production and marketing of crops approved for use.[224]

Opponents to GMOs will argue with this presumption of safety, citing uncertainty about the impacts of GMOs on human health or the environment. However, safety of GM crops must be demonstrated to regulatory agencies before the crops would be allowed in commercial production. Any unwanted material, such as GM grain in conventional corn, becomes an issue of marketing or consumer choice.

The forms of agriculture identified by the Royal Commission are based on different production methods and values that can be incompatible. In the US, GM crops in commercial production have undergone assessments by Federal regulatory agencies to ensure they are safe for use in the environment and in food and feed, but any decision to sell or plant GM seeds is left to the market. The agriculture system has adjusted to accommodate GMOs, and farmers and the food/feed production industry in the US have developed mechanisms to manage coexistence between GM, conventional and organic production. Coexistence is facilitated by allowing comingling of GMOs with conventional crops, or by farmer-to-farmer cooperation, implementation of segregation or identity preservation systems, and contractual agreements to meet the demands of domestic and foreign markets for non-GM commodities. Premium prices for organic or non-GM products can compensate for production practices needed to support these production methods.

New Zealand does not have any GM crops in production so there is no direct experience here with managing coexistence of GM crops with other agricultural production methods. However, there is significant experience with the coexistence of certified organic produce with conventional agriculture, as well as the production of certified seeds or crop varieties with specific traits, which could be applied to managing coexistence of GM varieties. The situation with GMOs is complicated by the biologically unrealistic expectation that coexistence necessitates a system that can guarantee 100 per cent non-GM content in other forms of agriculture. In a recent article, Ramessar and colleagues discuss GM/non-GM coexistence issues in Europe in an attempt to encourage rational debate:[225]

> What often gets forgotten in the heat of the GM/non-GM coexistence debate is

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[221] *Report of the Royal Commission on Genetic Modification* (2001), p.2
[222] MAF Cabinet Policy Committee (2003a)
[223] In the context of the GM discussions, 'adventitious presence' or AP refers to the presence of unintentional, low level GM material in non-GM commodities or seeds
[224] Brookes (2004)
[225] Ramessar et al. (2010)

> that the different varieties of the same crop species have coexisted for generations and that adventitious presence is recognized as an inevitable consequence of coexistence that can be minimized but not entirely eliminated. Therefore, almost all traded agricultural commodities anticipate some degree of inadvertent mixing, and thresholds exist that are recognized in laws, regulation, and/or voluntary standards.[226]

It is unlikely that New Zealand will be faced with any decisions about commercial planting of GM grasses or other crops for several years. However, as I heard from one seed industry official, the fact that the government continues to fund GM research suggests there is intent to commercialise GMOs at some point. If so, developers would need a mechanism to take these products to market that allows coexistence of all forms of agriculture.[227] As I discuss below, getting all sectors in New Zealand to first agree to this premise and to working out management solutions to implement coexistence, would be a formidable challenge.

Integrated pest management and GMOs

Although the Royal Commission acknowledges integrated pest management (IPM) as one of the four production methods in use in New Zealand, it is difficult to know how this fits into discussions on coexistence. The Royal Commission referred to the Consultative Group on International Agricultural Research (CGIAR) definition of IPM as

> ….ecologically-based pest management that promotes the health of crops and animals, and makes full use of natural and cultural control processes and methods, including host resistance and biological control. It uses chemical pesticides only where and when the above measures fail to keep pests below damaging levels. All interventions are need-based and are applied in ways that minimize undesirable side-effects.[228]

Unfortunately, I did not have time to speak to farmers or organisations who advocate IPM farming methods. Representatives from the organics industry that I spoke to indicated that an increasing number of New Zealand farmers are turning to IPM and a continuum of 'biological' farming methods that support low input sustainable practices. Published guidelines[229] do not indicate that GM technologies are excluded from IPM practices and it has been argued that GM and IPM are compatible technologies.[230] Farmers who practice IPM and other low-impact farming techniques are likely to express a range of views with respect to the use of GMOs; and consultation with these farmers will be a necessary aspect of any decision to adopt this technology in New Zealand.

Organic agriculture and GMOs

New Zealand has a small but rapidly growing organic sector, with 1145 certified organic farmers producing on more than 124 000 hectares. According to a recent

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[226] Ibid.
[227] Author interview, 30 March 2010
[228] *CGIAR policy statement on integrated pest management* (1997)
[229] *Generic IPM plan tool* (n.d.)
[230] Kennedy (2008)

report,[231] the value of New Zealand's organic sector has more than tripled since 2005, increasing from NZ$140 million to a total value of NZ$485 million in 2009. Exports of certified organic products from New Zealand have increased from NZ$70 million in 2005 to NZ$170 million in 2009, much of that growth coming from increases in sales of organic dairy and beverage products.

As discussed earlier in this report, the organics industry in New Zealand is adamantly opposed to any use of GM crops, both on philosophical grounds and for pragmatic economic reasons. OANZ supports the use of organic and 'biological' farming methods as better for the environment and more sustainable for New Zealand. They believe New Zealand's future lies in greater use of low input farming methods and production of high-value products for niche markets. I met with several representatives from OANZ who expressed concerns about the safety of GMOs but who also believe that any use of GMOs will threaten the ability of New Zealand to market non-GM or organic products. The concerns are not only of 'contamination' of organic or non-GM crops with GM material, but also that any use of GMOs in the country would be incompatible with New Zealand's pure image and could harm exports by association.

The actual economic impact of the adoption of GMOs on the organics industry in New Zealand is difficult to predict and would likely be dependent on the crop, trait, marketing strategy, and specific export markets for the crop in question. Organic farmers in the US have identified contamination by GM crops as a significant economic risk,[232, 233] and US organic farmers responding to a 2003 survey indicated they were taking additional measures and bearing new costs to protect their farms from GMO contamination.[234] However, according to USDA's Economic Research Service, there is currently very little data on the economic impacts of GM contamination of organic crops.[235] Despite the rapid adoption of GM crops in the US, the organics industry continues to grow there as well, with sales increasing 5.1 per cent from 2008 to 2009 and total sales of almost US$25 billion.[236]

The information I found in an internet search on economic impacts of GMOs on the organic industry was largely anecdotal[237] and time constraints did not allow me to pursue this issue farther. Documentation of negative economic impacts of GMOs on the organics industry, and implementation of measures to mediate those impacts in countries that have adopted GMOs, will be important to inform discussions in New Zealand.

Impacts of GMO forage on organic meat and dairy

In response to the article on GM forages published by the Royal Society in March 2010,[238] OANZ expressed specific concerns about the possible adoption of GM

[231] Cooper et al. (2010)
[232] Hanson et al. (2004)
[233] *OFRF releases partial results of 4th National Organic Farmers Survey: First impacts of GMOs on organic farmers are now documented* (2003)
[234] Ibid.
[235] Greene (USDA/ERS), Personal communication.
[236] *Industry statistics and projected growth* (2010)
[237] Hewlett and Azeez (2008)
[238] Goldson (2010)

pasture grass in New Zealand, stating that:

> …..all farms – but particularly those certified organic – would be put at serious risk by a release of genetically engineered pasture grasses…Contamination of non-GE products by genetically engineered pollen, or with GE products during harvesting, transport or processing, shows that no seed is safe once GE is unleashed.[239]

The potential impacts of adoption of GM forage grasses on the organics sector in New Zealand, including impacts on exports of organic dairy products or organic meats (from pasture-fed animals) and peripheral impacts on other industries such as organic fruits and vegetables is complicated and once again largely speculative. To help clarify these issues, the Ministry of Agriculture and Forestry (MAF) has commissioned a study on the economic consequences of low levels of GM material (adventitious presence or AP) that may unintentionally end up in conventional or organic grass seed or pasture. This study, due out later this year, will include impacts on the organics industry, the bee industry, and export markets.

As mentioned previously, no countries currently have requirements for labelling meat or dairy products from animals fed GM feed. It is not possible to test meat or dairy products from these animals for GM content as the transgenic DNA and protein will not be present in the meat or milk. No GM inputs are allowed in certified organic farming systems, so certification of an organic dairy or cattle farm should be sufficient to ensure meat or milk from that farm also meets export standards. Concerns would focus on whether New Zealand organic farms could maintain their GM-free organic status if GM pasture was adopted in New Zealand (is coexistence possible?), and whether the mere presence of GM pasture grass in New Zealand (even in field trials) would raise international concerns about the organic status of New Zealand's export products and negatively impact sales.

Unfortunately, there is little international experience for New Zealand to learn from on this issue. There are no GM forage grasses approved for commercial production. As discussed above, one GM forage variety, RR alfalfa, is currently being grown on limited acreage in the US. In November 2009 USDA published a draft Environmental Impact Statement (EIS)[240] in response to a court decision that USDA did not adequately address the potential environmental impacts of RR alfalfa, including impacts to producers of organic alfalfa, in their decision to deregulate this product.[241] The draft EIS includes an analysis of the potential impacts of the deregulation of RR alfalfa on the organic alfalfa industry, and while USDA acknowledges there could be impacts the preliminary conclusion is that the negative impacts would not be significant.[242] USDA is currently considering the public comments received on the EIS prior to a decision on whether to grant non-regulated status.

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[239] *No seed is safe with GE pasture* (2010)

[240] *Glyphosate-tolerant alfalfa events J101 and J163: Request for nonregulated status. Draft Environmental Impact Statement* (2009).

[241] *Roundup Ready alfalfa* (n.d.) http://www.aphis.usda.gov/biotechnology/alfalfa.shtml

[242] *Glyphosate-tolerant alfalfa events J101 and J163: Request for nonregulated status. Draft Environmental Impact Statement* (2009).

Tolerances

Products marketed as “certified organic” must meet strict production standards and growers must be certified by accredited agencies to market their products as organic. There are four agencies that certify organic producers in New Zealand, and producers can be certified for supplying organic products for the domestic market or for international markets.[243] Organic certification, consistent with international standards developed by the International Foundation of Organic Agriculture Movements (IFOAM) is processed-based and prohibits any intentional use of GM inputs. According to IFOAM:

> The use of GMOs within organic systems is not permitted during any stage of organic food production, processing or handling…..The organic label therefore provides an assurance that GMOs have not been used intentionally in the production and processing of the organic products.[244]

Most countries do not have specific thresholds for allowable levels of unintended GM material in organic seed or food. The presence of small amounts of GM material from pollen drift would not disqualify a producer from receiving organic certification as long as he/she can demonstrate no GM inputs were used. The EU, where consumers are generally opposed to GMOs in food, specifically allows 0.9 per cent GMO content in both organic and conventional products, as long as the GMO content is accidental or technically unavoidable.[245]

In practice, however, most organic producers and buyers consider any level of GM presence to be ‘contamination’, and contrary to the principles of organic production. European organic certification organisations actually use a threshold of 0.1 per cent[246] and virtually any detectable presence of GM material in organic crops could negatively impact sales and export of these products.[247] For buyers and consumers of organic products, ‘GM-free’ is considered to mean 100% pure with no detectable GM content. Producers of organic products in New Zealand believe they have a market advantage over organic producers in countries that also grow GM crops as they can guarantee ‘GM-free means GM-free’.

In a report presented at the 16th IFOAM (International Foundation for Organic Agriculture) World Congress in 2008,[248] a number of examples are cited to demonstrate how GM contamination of organic crops has resulted in loss of income or loss of organic certification for organic growers. But in most cases, the level of ‘contamination’ was less than 0.9 per cent, or it was just noted that a sample ‘tested positive’, or ‘contained GM material resulting from cross-pollination’. While economic losses did occur, they were the result of marketing preferences for 100 per cent GM-free (promulgated by the organics industry and those opposed to GMOs), not from violations of organic certification standards or legal thresholds.

Several of the people I interviewed (who would support the adoption of GM ryegrass

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243 *Certification* (n.d.)
244 *Organics standards and certification* (n.d.)
245 Crossfield (2006)
246 Ibid.
247 Hewlett and Azeez (2008)
248 Ibid.

in New Zealand) mentioned that coexistence is probably not possible as long as the organics industry maintains their stance on zero tolerance for any GM presence in organic agriculture. The issue of tolerances for GM in organic and conventional agriculture is not just an issue for New Zealand. In the recent report on the impact of GM crops on farm sustainability in the US, the National Research Council noted that:

> Gene flow of approved GE traits into non-GE varieties of the same crops (known as adventitious presence) remains a serious concern for farmers whose market access depends on adhering to strict non-GE presence standards. Resolving this issue will require the establishment of thresholds for the presence of GE material in non-GE crops, including organic crops that do not impose excessive costs on growers and the marketing system.[249]

I asked the representatives from OANZ about the possible benefits of establishing a marketing threshold (not only in New Zealand but internationally) to minimise market loss due to adventitious presence of GM material, should New Zealand choose to adopt GMOs. They were adamant that any level of GM was unacceptable to their consumers and markets and did not agree that consideration of thresholds as a 'back up plan' to a GE-free New Zealand' would make sense. When I asked whether their stance was unfair in not allowing other farmers to choose GM technology, the response was that any adoption of GMOs would remove their choice to farm organically.

The Royal Commission's recommendation for New Zealand agriculture was to keep options open to allow coexistence of GMOs with other production methods such as conventional and organic. From my short time here, I believe that addressing the concerns of conventional farmers who wish to keep their products GM-free and finding a mechanism to ensure that organic agriculture remains economically viable will be one of the biggest challenges for supporters of GM technologies in New Zealand. For this to happen, the conventional and organic industries would need to accept that all forms of agricultural production methods should be able to coexist in New Zealand and to work with the GM industry to find workable solutions.

Management options for coexistence of GM, conventional and organic forage grasses

Would it be physically possible to manage the growth of GM pasture grass in New Zealand to allow coexistence of GM, conventional, and organic production, with minimal negative economic impact to all sectors?

In many ways, the issues associated with managing coexistence for ryegrass are more difficult than for the GM crops (corn, cotton and soybeans) currently in production in the US and elsewhere. Perennial ryegrass is a self-incompatible, wind-pollinated crop that is grown on large acreages, often in minimally managed pastures and likely in combination with other grasses and forage species such as clover or forage beets. Seeds and pollen can be transferred between fields by animals and in hay that may be transported long distances. And while bees are not the primary pollinator, they can visit ryegrass and will pollinate clover in ryegrass fields, providing another mechanism for pollen dispersal and also raising concerns for the conventional and

[249] National Research Council (2010)

organic honey industry.[250]

Seed production

The general consensus from my discussions with seed industry representatives was that production of GM perennial ryegrass seed could be manageable using the same techniques used for production of certified non-GM seed.[251] New Zealand seed growers have extensive experience in production of certified grass seed with specific traits or endogenous endophytes. The same methods could be used to produce certified GM seed varieties and also to minimise spread of GM pollen and seed to non-GM seed stocks or pasture. These methods include use of appropriate isolation distances and border rows, or border species such as *Triticale* to minimise pollen drift, adequate weed control, thorough cleaning of equipment and cooperation with neighbours to plant non-compatible varieties or to stagger flowering times.

New technologies are being developed to ensure seed purity that could be adapted to GM seed production. The AsureQuality seed lab near Christchurch administers SCID, the Seed Crop Isolation Distance System.[252] SCID is a web-based mapping system that can alert growers of seed production of sexually compatible species on neighbouring pastures that could compromise seed purity. The information allows farmers and seed merchants to work together to maximise production and value. The system is currently being used primarily for Brassica species, but according to AsureQuality, could easily be adapted for other species or for GM varieties.

The caveat to this discussion is that production protocols for certified seed are designed to ensure the purity of the seed itself, and are not specifically designed to prevent all pollen or gene escape from the certified seed production field. Seed production also allows for a percentage of off-types, generally 1 to 2 per cent. Guarantees of absolute purity of GM seed or absolute containment of GM pollen would be difficult, although pollen drift could be minimised by larger isolation distances, increased border rows or even restriction of GM seed production to certain districts or water catchments. Practically, acceptance of some degree of gene flow would be needed.

Pasture

For the reasons discussed above, coexistence of GM pasture with conventional or organic production would be very difficult, and likely impossible if there is no accepted tolerance of AP levels of GM material. One official told me that “if the regulators decide that coexistence means no pollen flow then they have effectively killed the industry”.[253] Management conditions could be imposed on GM grass approvals that could minimise gene flow, such as increased isolation distances and management of grazing to prevent flowering and seed production. But the added value of the pasture would have to be high enough to warrant the extra costs of

[250] The issue of potential negative impacts of GM crops and forage on honeybees and potential economic impacts on conventional or organic honey producers would also need to be addressed in any decision to adopt GMOs in New Zealand. I did not have time to address this issue in this report
[251] Author interviews, 30 March 2010
[252] Evan Johnston, Interview, 30 March 2010; http://www.seedlab.co.nz/
[253] Seed industry official, Personal communication

management, and according to one industry official, grass farmers are not used to the 'fine management' that would be needed to manage gene flow from GM pastures.[254]

Commercialisation of GM pasture would then likely result in an onus on non-GM or organic farmers to prevent GM material from entering their production systems, with resulting higher costs that would need to be passed along to consumers. There is also the issue of liability for lost markets; would GM producers be responsible for lost sales for organic farmers? But again, particularly with GM pasture grass, there would need to be an acceptance of some level of pollen drift by organic and conventional farmers for this technology to be workable in New Zealand, which OANZ strongly believes is unworkable:

> New Zealand's pasture-based primary industry uses its open pasture scenario as part of its market differentiation. That scenario, part of the 'clean, green' 100% Pure New Zealand branding, cannot persist with the use of GE forages, flowering or otherwise. The fact that GE forages are used and widespread in the New Zealand environment will be as negative for pasture based products as a genetically engineered kiwifruit would be for Zespri's producers.[255]

One interesting option would be development of ryegrass varieties that did not transmit the transgene in pollen. Well-managed ryegrass pastures are not allowed to flower so the available energy can be used for growth of the edible leaves. According to one seed developer, if a perennial ryegrass variety was developed that did not flower, but that could be induced to flower for seed production, it would "take the market".[256] But gene use restriction technologies (GURTS) are very controversial, particularly with respect to implications for third world farmers who save seeds, so the use of these technologies could create additional image problems for GMOs.

Is there a role for government?

In the US and Australia, regulatory decisions prior to commercial release of GMOs are based on whether the organism could pose a risk to the environment or to human or animal health. In the US, products granted non-regulated status are considered as safe as their conventional counterparts and are not subject to permitting or other requirements for regulated GMOs. Any decisions to commercialise or export these products are up to the market and subject to market demands and relevant legal requirements in importing countries. In Australia, most GM crops commercialised to date have occurred under DIR[257] licences (see below) that may impose conditions to minimise potential biophysical risks, but as in the US, the government does not mandate market practices. Management of coexistence in both the US and Australia is primarily the responsibility of the farmers and driven by market demands.

At a recent conference on coexistence of GM crops in Melbourne, Preston and Baker[258] described the formation of the Gene Technology Grains Committee, an industry-led group of farmers and industry representatives that developed a set of principles and protocols for coexistence of GM and non-GM canola in Australia. This

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[254] Ibid.
[255] OANZ, Personal communication
[256] Industry official, Author interview
[257] *What are dealings involving an intentional release (DIR) of a GMO into the environment*? (n.d.)
[258] Preston and Baker (2009)

group was able to develop mechanisms that allowed production of non-GM canola (with 0.9 per cent allowable AP of GM material), and coexistence of GM and non-GM supply chains based on market forces and without government intervention.[259]

The Royal Commission made a number of recommendations for actions that could facilitate coexistence of GM and non-GM crops in New Zealand.[260] In 2003, MAF prepared two Cabinet papers in response to these recommendations that provided an overview of the issues of coexistence in the context of New Zealand agriculture and discussed the way forward for New Zealand.[261] I will not repeat the discussion here, but many of the issues have not changed and these documents are excellent resources in continued consideration of this issue.

Probably the most significant outcome was the amendment in 2003 of the HSNO Act to include a provision for conditional release. Under this provision, approvals for the release of a new organism (including GMOs) would be subject to controls to manage or mitigate risks. As will be discussed below, this mechanism has not yet been tested for release of GM crops. ERMA's regulatory authority covers socioeconomic as well as biophysical risks, so conceivably a conditional release approval could be granted mandating conditions to manage economic risks, which could help facilitate coexistence.

Ministry of Agriculture and Forestry

"The Ministry of Agriculture and Forestry's (MAF's) purpose is to lead the protection and sustainable development of [New Zealand's] biological resources…MAF's role includes providing policy advice and programmes that support the sustainable development of New Zealand's land-based industries."[262] With respect to GM crops, MAF's policy group focuses on providing advice on the coexistence of different forms of agricultural production, including GM and non-GM production systems.

MAF Policy is leading strategic work to identify the risks and opportunities for New Zealand related to GM forage. To this end, MAF is currently considering a number of issues focusing on the socioeconomic impacts of adoption of GM pasture grass; this work includes the study on the economic consequences of low levels of GM material that may unintentionally end up in conventional or organic grass seed or pasture mentioned above.

Industry looks to the future

What is the future for GM pasture grass in New Zealand? The developers remain convinced of the potential for GM forages to provide significant economic benefits in terms of increased productivity from reduced inputs, as well as environmental benefits in the form of reduced nitrogen and greenhouse gas emissions from cows that graze on modified pasture. The seed and dairy industries remain pragmatic – they support adoption of the technology as long as it makes economic sense for New Zealand, which would include acceptance by domestic and foreign markets, demonstration that

[259] Single Vision Grains Australia (2007)
[260] *The Royal Commission on Genetic Modification* pp.338-340
[261] MAF Cabinet Policy Committee (2003 a,b)…
[262] *Statement of Intent* (2010)

the products perform as intended and that the benefits outweigh potential market risks. Plans have been abandoned for now to apply for contained field tests in New Zealand, and Pastoral Genomics, AgResearch, and PGG Wrightson (Gramina) will be conducting field tests in the US and Australia to demonstrate proof of concept for their GM varieties. Even if all goes according to plan, it is not likely that New Zealand will be faced with a decision on commercial levels of planting of GM ryegrass here before 2017.

In anticipation, the developers and industry have decided to work together to develop a pathway to commercialisation of GM pasture grass.[263] An industry evaluation group has been set up that includes Pastoral Genomics, AgResearch, Grasslanz,[264] Agriseeds, and PGG Wrightson. There is active competition between some of these players, but all agree that significant analysis and up-front work needs to be done to ascertain the benefits and value of the new products, and they believe there is a better chance of success for everyone if they work together.

They plan to evaluate the technology for efficacy and agronomic performance, to perform economic analyses of the benefits and risks of GM forages, and to assess the changing international and domestic climate for GMOs. The result will be a determination of whether the benefits and value for these products warrant a decision to commercialise these products within New Zealand, with an understanding that the answer might be ‘no’.

[263] Information supplied by partnership members, May 2010
[264] Grasslanz is a subsidiary of AgResearch specialising in plant technology

5 WHAT NEEDS TO HAPPEN FIRST?

Although several of the opponents of GMOs implied that 'one blade of grass or one grain of pollen' from a GMO would compromise New Zealand's 'clean, green' image, most of my research and conversations about GMO pasture grasses were in the context of a decision by New Zealand to allow large scale planting of GM forage grasses as part of the agricultural system. But even if all goes perfectly, it is unlikely that ERMA will see an application for release of GM pasture grass for several years. What would need to happen first?

The database that tracks field test release applications in the US[265] shows over 16 400 applications have been approved since 1987. The majority of these trials included multiple crop/trait combinations and may have taken place at multiple locations under one permit, so the actual number of organisms tested is much higher. But despite the very large number of organisms in development, only a very small percentage have been taken through the full process to deregulation and even fewer are in commercial production in the US. As of June 2010, only 80 petitions for non-regulated status have been granted by USDA[266] and many of these products were never commercialised.[267]

Development of new crop varieties using genetic modification is touted as being more precise and efficient than classical breeding, but it still involves years of testing of individual varieties in the laboratory, greenhouse, and field to characterise trait expression, stability, efficacy and safety. Taking a new GM variety through field trials and full deregulation is a lengthy and expensive process. Developers must be confident of the safety and performance of the new variety to ensure regulatory approval and as a prerequisite to commercial success. The regulatory system in the US provides a fairly straightforward process that allows developers to do the field scale experiments needed to decide if a new GMO is worth pursuing.

The earliest estimate from Pastoral Genomics for consideration of commercial release of GM pasture grass in New Zealand is 2017. The current plans are to conduct field tests of the modified varieties in the US or Australia, before submitting an application in New Zealand. It is not clear that the information obtained from overseas tests will be sufficient to allow appropriate assessment by ERMA for release in New Zealand. But I heard from several researchers that the regulatory system here makes it extremely difficult to do the experiments needed to obtain proof of concept, efficacy, or safety of a new GM plant.

Biotechnology Regulatory Workshop

MoRST offered to host a workshop to bring in researchers and key stakeholders for a discussion of GMO regulation under the HSNO Act, to document the experiences of

[265] *Information systems for biotechnology* (n.d.)
[266] *Petitions for nonregulated status granted or pending by APHIS* (July 2010)
[267] While USDA does not formally track commercial status of GM crops, the Biotechnology Industry Organization (BIO) does provide information on the commercial status of agricultural biotechnology products developed by their member organisations (www.biotradestatus.org). Note that this list includes GMOs that contain 'stacked' traits. The USDA does not consider GMOs containing multiple transgenes to be regulated articles if they are produced by breeding two or more deregulated GMO varieties.

the regulated community and identify some aspects of the HSNO Act that could be improved. We focused on research needed to move new GMOs out of the laboratory or greenhouse and into the field, and eventually, to commercialisation. We began with the premise that GMOs are an option that should be considered for New Zealand as per the conclusions of the Royal Commission. The workshop was not intended to be a referendum on the pros and cons of the technology; we wanted to provide a forum for researchers to speak openly. To this end, participation was limited to researchers and key stakeholders who have had experience with the regulatory system and who have an interest in assuring appropriate oversight and potential adoption of GMOs in New Zealand.

A secondary goal of the workshop was to feed into a project underway in MoRST to identify outcomes from New Zealand's biotechnology regulatory system, including, but not limited to the HSNO Act. This project is in response to the New Zealand Biotechnology Strategy that calls for "…periodic independently contracted system audits to assess whether the regulatory regime and its operation are achieving an appropriate balance between assurance and innovation".[268] MoRST is currently refining the methodology to address these issues, including development of a survey/questionnaire for relevant stakeholders, and focusing initially on regulation of contained research in laboratories and greenhouses.

A summary of the workshop, including the agenda and participants list, is included in Appendix 2 of this report.[269] Much of the discussion reflected issues raised during my interviews and discussed elsewhere in this report. The workshop produced a set of suggestions to improve the regulatory process (from the perspective of the regulated community) and some potential 'next steps' that I will discuss in the conclusions for this report.

Field testing of GM pasture grass

This final section of the report will focus on field testing of GM grasses to help address the question of whether the tests needed to move this technology forward could be conducted under New Zealand's regulatory system. I will review the experience in the US and Australia with field tests of GM grasses. Summaries of the regulatory policies for field testing and releases of GMOs for New Zealand, Australia and the US have been included in Appendix 3 and the main differences are summarised below.

Field testing of GMOs - what is different in New Zealand?

During the regulatory workshop described in detail in Appendix 3, speakers presented overviews of the regulatory processes in New Zealand, Australia, and the US as background for a discussion on how the system in New Zealand could be improved. A number of key differences were noted between the three countries (Table 1).

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268 *New Zealand Biotechnology Strategy* (2003) p.32

269 This summary is essentially the report of the workshop presented to the ERMA New Organisms Standing Committee on 1 July 2010

	New Zealand (ERMA)	United States (USDA)[a]	Australia (OGTR)
Fees	There is a fee for applications submitted to ERMA for activities involving new organisms, including GMOs.	There is no fee to apply to USDA to conduct field tests.[b]	There is no fee to apply to OGTR for a 'dealing for intentional release' (DIR) license.
Risk/benefit analysis	Assessment of effects on health and environment, as well as social and economic impacts; benefits must outweigh risks.	USDA assessment based on potential for a GMO to pose a risk as a plant pest.	Assessment of potential health and environmental risks and the ability to manage those risks.
Public Consultation	Mandatory on any application for release and for field tests in containment. Discretionary for some other activities. Public hearing required if requested by any submitter.	For field tests: at discretion of USDA, but only if significant new issues or high risk. Deregulation: mandatory consultation on draft assessment. Public meetings are not required but may be held for issues of high interest or public concern.	Mandatory consultation on Risk Assessment and Risk Management Plan (RARMP) prior to final decision to a issue DIR license.[c] Public hearing may be held at discretion of the Gene Technology Regulator.
Field tests	ERMA issues approvals for *field tests in containment.* Approvals may be granted for multiple GMOs, and may be for multiyear periods. Conditions are mandated so that all heritable material must be removed or destroyed at the end of the field test.[d] ERMA may also approve 'conditional releases'. (This option has not been used for any GM plant).	The US issues permits (or acknowledges notifications) for field tests. Generally issued for one year. Conditions imposed to minimise the risk of establishment or spread of a regulated GMO.	Field tests are conducted under a DIR license. Must be an experimental, limited release with controls designed to restrict dissemination or persistence of GMOs outside the controlled area.
Full release	ERMA can approve a full release of a GMO. If approved the GMO would no longer be considered a 'new organism' and would not be under regulatory oversight.	The USDA can grant deregulated status for a GMO in response to a petition that demonstrates the GMO is not likely to present a risk as a plant pest. Deregulated organisms would not be	OGTR can issue DIRs that allow for large scale commercial release/license of GMOs with some conditions or controls. OGTR may also place a GMO on a register if satisfied that there is no

[a] This table only includes information relating to USDA regulation of GMOs that may pose a risk as plant pests, including microbes, insects, and plants.
[b] Developers of new GMOs that produce pesticidal substances must register the pesticides for use in the US with the US EPA prior to commercialisation; EPA does charge a fee for registration of new pesticides.
[c] For commercial releases, two rounds of consultation are required, one to seek advice prior to preparation of the RARMP, and a second on the RARMP prior to a decision by OGTR.
[d] This requirement is generally interpreted as precluding any flowering or pollen formation. However, ERMA has approved a field test in containment for onion that would allow limited flowering. All flowering plants would be contained in cages and the plants pollinated by laboratory-bred fly pupae introduced into the cages. Onions are insect-pollinated and these controls would prevent transport of pollen to other plants. As of July 2010, this approval has not been activated. (Source: http://www.ermanz.govt.nz/news-events/archives/media-releases/2008/mr-20081127.html)

	This mechanism has been used for biocontrol organisms but not for GMOs	under regulatory oversight.	risk to health or the environment. The only GMOs on the register are four GM carnations.

Table 1. Key differences in regulatory process for environmental releases of GMO between New Zealand, US, and Australia

Experience with field testing of GM grasses

Following development and testing of a new GMO variety in the laboratory or glass house, the next step would be to move the organism outdoors to test its agronomic performance under conditions it would experience under full release, and to produce sufficient material for further testing. The developers of the GM grasses described in Section 3 have decided to do these initial field tests overseas. However, if the developers decide to pursue commercialisation in New Zealand at some point, they will begin by seeking approval for field tests in containment or a controlled release from ERMA. This section looks at the experiences to date in conducting field tests of GM grasses that could inform ERMA's decision-making process.

Field tests for GM grasses in New Zealand

All of the research on GM grasses in New Zealand to date has been confined to the laboratory or greenhouse. Researchers from Pastoral Genomics, Gramina, and AgResearch are conducting, or planning to conduct, field tests of GM forage grasses in Australia or the US.

Field tests for GM grasses in Australia

According to the OGTR website,[270] only one DIR licence[271] has been approved to conduct a field test (described as a limited and controlled release) of GM pasture grass in Australia. The field test, underway now in Victoria, will test up to 500 lines of perennial ryegrass and tall fescue modified with genes intended to alter fructan content and lignin metabolism. As described above, these altered traits are expected to improve the quality of the forage by altering carbohydrate levels and improving digestibility. The purpose of the field test is to assess the agronomic performance of the GM varieties under field conditions and to produce plant material and seed for further study.

The risk assessment conducted by OGTR determined that the risk from the proposed activity was negligible considering the organisms, traits, and measures imposed on the test to restrict the dissemination and persistence of the GMOs. Conditions include location of the 800m^2 test site within an area surrounded by a fence and locked gate and away from waterways. The field test site is also surrounded by a cleared monitoring zone to identify volunteers and a 250m border of *Triticale sp.*[272] The plants will also be removed from the field to a glasshouse before flowering, and the

[270] *List of applications and licences for Dealings involving Intentional Release (DIR) of GMOs into the environment* (n.d.)
[271] *DIR 082/2007 - Limited and controlled release of perennial ryegrass and tall fescue genetically modified for improved forage qualities* (n.d.)
[272] *Triticale* borders are often used in the production of commercial grass seeds as a barrier to pollen dispersal and to prevent weeds, including compatible pasture grasses

fields will be sprayed with herbicide and monitored for at least 12 months following completion of the experiment to prevent volunteers. There is also a prohibition on using any of the GM material as animal feed.

Field tests for GM grasses in the US

According to the field test database for USDA's Biotechnology Regulatory Service (BRS) that is maintained by Virginia Tech,[273] approvals have been granted for approximately 300 field tests of GM grasses, including creeping bentgrass, switchgrass, tall fescue, Kentucky bluegrass, Bahia grass, Bermuda grass, St. Augustine grass, and several varieties of ryegrass. The first GM grass field tests were for creeping bentgrass modified to express a variety of new traits; these experiments were conducted from 1993 to 1997 under the permit system. In 1997 the regulations were amended to broaden the set of organisms eligible for notification and most of the grass field tests between 1997 and 2005 were conducted under notification.

The specific conditions of each field test are not publicly available. However, as with all field tests, the applicants must agree to conduct the release under conditions designed to minimise the likelihood of establishment and spread of the regulated organism, and in general, the conditions (such as planting distances) were based on conditions used for production of certified seed. In many cases, the grasses were allowed to flower, and some tests were conducted over multiple years, although the applicants had to reapply each year.

Beginning in 2005, field tests of perennial grasses were conducted under permit[274] (except in cases where the plants were sterile or grown under conditions that do not allow flowering.) This policy was formalised in 2008.[275] Permits are more restrictive than notifications and require developers to provide detailed (legally binding) descriptions of how their field test will be performed.[276]

Environmental assessments (EAs)[277] are available for field tests of GM Bahia grass and another for GM tall fescue and Italian ryegrass.[278] The Bahia grass test was a small experiment with 48 GM plants modified to contain marker genes and designed to investigate gene flow to non-transgenic Bahia grass. Controls designed to prevent escape of GM seed included construction of wooden cages covered with mosquito netting over the entire plot to prevent entry by insects, birds, or animals; bagging of seeds for transport back to the greenhouse; situation of the small test plot within a 20 acre field site without sexually compatible relatives; and three years of post-trial monitoring.

The other GM grass test for which an EA is available was designed to assess pollen dispersal, agronomic properties and out-crossing for tall fescue modified to express marker genes, and Italian ryegrass with markers and a gene for down-regulation of a

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[273] *Information systems for biotechnology* (n.d.)
[274] Ibid.
[275] *Policy statement regarding releases of perennials under notification* (n.d.)
[276] *APHIS Biotechnology: Permitting progress into tomorrow* (n.d.)
[277] EAs are generally not required for confined field tests of GM species under permits, but USDA determined it was appropriate to prepare EAs for these grass trials due to the demonstration by Watrud et al. (2004) that pollen from creeping bentgrass could travel over large distances
[278] *Permits with environmental assessments as of 12 May 2010* (2010)

pollen allergen. The test was conducted on 0.25 acres in Oklahoma in 2006. Controls were similar to those imposed on the Bahia grass trial and designed to confine GM seed and prevent dissemination of GM plants beyond the controlled site. In addition, the location of the trial meant that any wind mediated pollen movement beyond the 170 acre field site was unlikely to find a receptive compatible plant or to produce viable offspring due to the cold climate unfriendly to these grasses.

These EAs are publicly available and along with the Risk Assessment and Risk Management Plans (RARMPs) prepared by OGTR for grass trails in Australia, may be useful resources for ERMA if approvals are sought here for field testing of GM ryegrass or other perennial forages.

Perennial ryegrass trials in the US

Only four approvals for field tests have been granted for perennial ryegrass in the US, all under notification, so the conditions imposed on the tests are not publicly available. Three of these were conducted at research institutions between 1999 and 2004. The plants tested included varieties modified for increased salt and drought tolerance and reduced pollen allergens.

Between 2004 and 2007 there were also three approvals granted for field tests of GM endophytes in non-GM ryegrass. The EA is available for an endophyte field test conducted at the University of Kentucky in 2005-06,[279] however the conditions focused on control of the modified endophyte rather than prevention of spread of the non-regulated ryegrass host.

No other GM ryegrass tests were conducted in the US until 2009. The only trial currently underway is for drought tolerant GM ryegrasses developed by New Zealand’s Pastoral Genomics, conducted under notification at the University of Florida. These plants should not produce flowers or set seed as the temperature in Florida is too warm to trigger this process in the ryegrass varieties used.

Lessons learned

A large number of field tests of GM grasses have been conducted in the US, although much of the information about how the tests were conducted or information obtained by the researchers is not publicly available. The primary concern with a release of a wind-pollinated grass would be to minimise spread of the transgenes and establishment of the regulated organism outside of the containment area. The experience in the US with GM creeping bentgrass demonstrated that grass pollen can travel long distances, so extra controls may be needed to minimise pollen flow, particularly in environmentally sensitive areas.

A number of methods are available to minimise gene flow from pollen or seed dispersal, including selecting test sites in regions that are not conducive to flowering or seed set or that are not home to sexually compatible relatives of the GM variety; isolation of the test plot within a larger contained area; use of border plantings to trap pollen; movement of plants prior to flowering to an enclosed greenhouse; monitoring for volunteers; and the use of physical barriers such as cages or netting.

[279] Ibid.

For the two ryegrass trials underway overseas, conditions have been imposed on the releases designed to prevent flowering outdoors. The US requires field tests to be conducted so as to “prevent escape and dissemination”[280] of the regulated organism. In Australia, the Regulator can impose conditions to “restrict dissemination or persistence of the GMO or its genetic material”.[281] The requirement in New Zealand is more strict, in that the “organism, or any heritable material arising from it, [must] be retrieved or destroyed at the end of [the field test]”.[282] This level of containment required, and the potential penalties for non-compliance, would make it very difficult in New Zealand to conduct a field test in containment for plants that are wind-pollinated (such as ryegrass).

New Zealand does not have indigenous grasses that are sexually compatible with perennial ryegrass, but in order to conduct a field test in containment here, controls would be needed to prevent any gene flow into non-GM seed or pasture. Additional data may be needed on pollen drift and control mechanisms that could be used in New Zealand for containment. Regulators from the US, Australia and New Zealand should work closely together and with the developers to share information on management of these tests.

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[280] 7 CFR 340 (n.d.)
[281] OGTR, Personal communication
[282] *Biotech regulatory wayfinder* (n.d.)

CONCLUSIONS

The debate in New Zealand regarding the use of genetically modified organisms has not progressed significantly since the Royal Commission released its report in 2001. The reasons are complex but a few factors stand out.

There continues to be public and industry sentiment opposed to the use of genetic modification for philosophical or economic reasons. While some believe any use of GMOs is incompatible with New Zealand's 'clean, green' image, others are waiting for a clear indication of market acceptance and economic benefit before they would support adoption of GMOs. The general public, depending on how you ask the question, seems sceptical but willing to consider products on a case- by-case basis.

The issues that would impact a decision to adopt GMOs in New Zealand are unique and challenging – New Zealand's economy is based on pastoral farming and exports that are marketed with a tie to the 'clean and green' image. Major export markets like the EU are averse to GMOs. The country is also a small island nation concerned about negative impacts from new organisms and has an indigenous population with strong cultural ties to the environment and nature. The GM products currently in production overseas would not provide the economic incentive for New Zealand needed to overcome potential economic risks and social concerns that would be tied to introduction of GMOs. Thus, there has been little incentive for proponents to push the debate forward.

There is also the overarching debate about whether New Zealand's economic future lies in staying the current course that relies on low-cost production of commodities or focuses instead on providing value-added products to niche markets. Some believe that adoption of GMOs would be incompatible with the latter scenario and that markets for high-value specialty products will be dependent on remaining GM-free. Others believe genetic modification technologies can and should be a tool to produce value-added products.

Several people I spoke with feel very strongly that New Zealand is at a crossroads and that the government should provide clear direction. But the scenarios were the same during the Royal Commission and the government decided at that time to keep its options open. I do not see that things have changed enough since then to force the issue now.

Does there have to be a choice, or could GMOs coexist with conventional or organic agriculture in New Zealand? Looking just at the biology, the answer seems to be a qualified yes. But it would depend on the crop, a willingness of farmers to work together, and most importantly, a willingness for the different agricultural sectors and farmers growing non-GM crops (and their markets) to accept that gene flow will occur and some level of adventitious presence (AP) is acceptable. Promoting this idea within New Zealand, (and internationally), would reduce negative market impacts of very low levels of unintentional GM presence in non-GM or organic products. But the economic incentive for now is to keep New Zealand GM-free and not raise the spectre of GM contamination.

One industry official that I spoke with believes that, "It's not a case of organics allowing AP, but the government needs to step in and say 'this is what will happen'".[283] Should the government step in and set a threshold? In theory New Zealand could set a threshold as part of an approval for conditional release but this has not been tested and I do not know how much discussion ERMA has had around this option.

With respect to GM pasture grass, coexistence would not be possible without a tolerance for gene flow into organic pastures or non-GM pastures, and even then the management issues could be difficult and costly. Introduction of GM pasture grass in New Zealand would have to be supported by strong scientific evidence of the efficacy of the product, and economic analysis to support the financial benefits and minimum risks to adopters and to others who would be impacted by adoption of the technology.

Both supporters and opponents of genetic modification agree on the need for a sustainable agricultural system with decreased inputs, lower costs, and fewer negative environmental impacts. But there is fervent disagreement as to whether GMOs could be part of the solution. There is growing international recognition that no technologies should be excluded as potential tools to address problems of climate change and food security. While GM pasture grass poses some significant challenges, it is also a product that has the potential to provide economic and environmental benefits for New Zealand's unique agriculture-based economy. Maybe this is the common ground needed to bring the two sides together and is another reason New Zealand should keep its options open.

There is clearly a need for additional information and additional discussion in advance of regulatory or commercial decisions about adoption of GM grasses or any other GMOs. There is a clear need for documentation of the economic impact of New Zealand's 'clean and green' image. Are export markets and tourism dependent on this image of New Zealand, and if so, what would be the impact of adoption of GMO pasture, or other types of GM crops? Is there data on the negative economic impacts of GMOs on organic or conventional markets? Would there be indirect impacts, i.e. would adoption of GM pasture grass harm exports of non-GM kiwifruit? What are the benefits to New Zealand of proposed GM products? This information will be needed to inform discussions needed between the government, researchers, and potentially affected agricultural sectors. One industry official I spoke to said he thought there was a need for the government and industry to "socialise the idea that GMOs are not all bad and risks are manageable".[284]

In addition, New Zealand has a rigorous regulatory environment that presents a significant hurdle for scientists here to conduct research that is needed to move products toward commercialisation. The regulations need to be strict to ensure public confidence, but if too onerous it becomes very difficult for researchers to do the research to prove a GMO is safe and effective, and can also reinforce public perceptions that the organisms pose significant risks.

However, as I discussed in Section 5 of this report, this is all somewhat premature. New Zealand is unlikely to face a decision regarding commercial release of a GM plant for a number of years. In the near term, the question is whether New Zealand researchers who have been, and continue to develop GMOs with public funding have

[283] Author interview, 31 March 2010
[284] Author interview, 9 April 2010

the mechanisms they need to do their jobs. Outdoor growth of GM grass varieties is needed to scale up research material, and to evaluate the efficacy and safety of GMOs developed in the lab. As documented in the workshop, the current mechanism for field tests in containment has been found to be difficult, resource intensive, and stressful. Researchers also say they need a mechanism that would make it easier to allow flowering in order to obtain enough material for feeding studies and additional analysis.

In 2003, the HSNO Act was amended to include a provision for 'conditional release', which was seen as a mechanism to facilitate coexistence, for example by allowing exclusion of GMOs from regions that might suffer obvious economic harm (the example used at the time was excluding GM kiwifruit from growing regions near the Bay of Plenty). ERMA New Zealand believes the 'conditional release' option might be used to conduct research in the field; conditions could be tightly controlled but researchers would have more options without the mandate to ensure that all viable material is retrieved or destroyed. This approach has not been tested.

One contact at ERMA told me that there had been a proposal for funding to develop a 'virtual' application for conditional release of a GMO that was not funded. It would seem this would be an excellent opportunity to revisit this option, possibly with a virtual application for a conditional release of GM ryegrass prepared by the consortium mentioned in Section 4 above. The study could be used to identify needed research and issues of concern for stakeholders from various sectors in advance of an actual submission. One question would be whether the controls on the activity that lower the risk would also lower the bar for demonstration of benefits to make it easier to conduct this type of activity in New Zealand

However, the option to use the conditional release mechanism for field trials does not address the other concerns expressed by many researchers who see a need for a mechanism to conduct field tests in containment for very early stage research without the onerous requirements of public consultation or a need to demonstrate that the benefits of the application will be greater than risks. They argue that if containment is mandatory, the outdoor field tests should be considered in the same way as contained low risk laboratory research. This would mean elimination of a requirement for consultation, or as in Australia, the public consultation could take place following preparation of a risk assessment and management plan (the Evaluation and Review Report in New Zealand). There is not currently a mechanism under the HSNO Act to allow for this. It would also be very controversial, as New Zealand values participation and shared decision-making as core values, and any changes would need to recognise the sensitivities of Māori even to contained research, particularly if it occurs on Māori land or involves indigenous species.

RECOMMENDATIONS

New Zealand is not likely to be faced with a decision about adoption of GM pasture grasses, or other GM plants for several years. In anticipation, and in keeping with the recommendation to keep options open, emphasis should be placed on conducting the research and public outreach that will facilitate decision-making. Specific suggestions include:

- Economic analysis of the value of the 'clean and green' image for New Zealand's exports and tourism, and the impact of adoption of GMOs on the various sectors
- Documentation of economic impacts of GMOs on the organic industry
- International benchmarking of regulatory regimes for GMOs, including mechanisms for conducting research in the field and mechanisms and timing of public consultation (industry-led?)[285]
- Preparation of a 'virtual' application for a conditional release of GM perennial ryegrass to test if this mechanism could work for research in the field involving these GMOs (industry/ERMA collaboration?)[286]
- Development of an options paper for changing the HSNO Act to facilitate discussions on what changes might facilitate research while preserving safety and public participation (industry led?)[287]
- Continued public engagement, particularly with respect to specific applications and (for contained releases) with Māori and the public in the region of the release
- Facilitated discussions between stakeholders with opposing viewpoints to fully understand each viewpoint and to look for any middle ground. This should include exploring views on the possibility of using GMOs as tools in sustainable agriculture

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[285] Recommendation from regulatory workshop; see Appendix 2
[286] Ibid.
[287] Ibid.

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APPENDIX 1: ACRONYMS AND ABBREVIATIONS

AERU	Agribusiness and Economics Research Unit
AP	Adventitious Presence
APHIS	Animal and Plant Health Inspection Service (US)
BERL	Business and Economics Research Ltd
BRS	Biotechnology Regulatory Services (US)
Bt toxin	Bacillus thuringiensis toxin
CBG	Creeping Bentgrass
CGIAR	Consultative Group on International Agricultural Research
CRIs	Crown Research Institutes
DIR	Dealings Involving an Intentional Release (Australia)
EPA	Environmental Protection Agency (US)
EIS	Environmental Impact Statement
ERMA	Environmental Risk Management Authority, New Zealand
EU	European Union
FAO	Food and Agriculture Organisation (of the United Nations)
FAR	Foundation for Arable Research
FDA	Food and Drug Administration (US)
FRST	Foundation for Research, Science, and Technology
GATS	Global Agricultural Trade System
GDP	Gross Domestic Product
GM	Genetic Modification
GMOs	Genetically Modified Organisms
GURTs	Gene Use Restriction Technologies
HRC	Health Research Council (New Zealand)
HSNO	Hazardous Substances and New Organisms (Act)
IAEA	International Atomic Energy Agency
IAG	Interim Assessment Group
IBSC	Institutional Biological Safety Committee
IFOAM	International Foundation of Organic Agriculture Movements
IPM	Integrated Pest Management
MAF	Ministry of Agriculture and Forestry
MAFBNZ	Ministry of Agriculture and Forestry, Biosecurity New Zealand

MfE	Ministry for the Environment
MoRST	Ministry of Research, Science and Technology
MMP	Mixed Member Proportional Representation
NKTT	Ngā Kaihautū Tikanga Taiao
NZBIO	New Zealand Biotechnology Industry Organisation
NZFSA	New Zealand Food Safety Authority
NZPA	New Zealand Press Association
OANZ	Organics Aotearoa New Zealand
OGTR	Office of the Gene Technology Regulator (Australia)
PG	Pastoral Genomics
PKE	Palm Kernel Extract
PPA	Plant Protection Act (US)
PRCT	Pasture Renewal Charitable Trust
R&D	Research and Development
RARMP	Risk Assessment and Risk Management Plan (Australia)
RR	Roundup Ready®
RSNZ	Royal Society of New Zealand
SCID	Seed Crop Isolation Distance System
SSF	Sustainable Farming Fund
TAG	Triacylglyerol
US	United States
USDA	United States Department of Agriculture

APPENDIX 2: BIOTECHNOLOGY REGULATORY WORKSHOP

Workshop – Regulation of Outdoor Containment or Releases of Genetically Modified Organisms under the HSNO Act - 13 May 2010

Purpose: On 13 May 2010, MoRST hosted a one day facilitated workshop on regulation of genetically modified organisms under the HSNO Act. The focus was on outdoor containment approvals (field tests and outdoor developments) and environmental releases. The purpose of the workshop was to gain clarity on the views of the biotech research community and key stakeholders about the issues and challenges associated with the outdoor containment or release of GM organisms.

Methodology: Workshop participants included researchers, key industry stakeholders, government officials, and consultants with experience or significant interest in field testing and outdoor development of GM plants and animals, as well the releases of equine influenza vaccines and non-GM biological control organisms. The focus of the workshop was to discuss what is working, and what isn't working under the HSNO Act and why, and to brainstorm about what could be changed to make it work better. The workshop agenda and participants list are included at the end of this summary.

Participants included 10 representatives from CRIs (AgResearch, Plant and Food, Scion, Landcare Research), five representatives from stakeholder industries, and two consultants who have developed regulatory submissions to ERMA for approvals. In addition, there were 18 participants from New Zealand government agencies, including MoRST, ERMA, The Treasury, MfE, FRST, MAF, and NZFSA, and one participant from the Australian Office of the Gene Technology Regulator.

Participants were seated in groups of six to seven, and their notes and summaries of their discussions were recorded on flip charts and reported to the group. The summary presented here is not intended to represent a consensus or formal recommendation from the workshop, but rather to provide an overview of the discussions and main themes. However, it is worth noting that there was general agreement about the trends influencing discussions of GMOS, the need to consider revision of the HSNO Act (and why), and suggestions for a way forward.

Summary of discussions

The workshop was designed to consider how GMO issues are currently addressed in New Zealand under the HSNO Act and how the Act could be improved to allow a more enabling environment to advance the technology while maintaining the same level of safety. The workshop included a discussion of current trends affecting GMO research and adoption; an overview of regulatory policies and practices in New Zealand, Australia, and the US; and presentations and discussions highlighting what has and has not worked for field testing and releases of GMOs and biocontrol organisms in New Zealand (and why). Finally, participants provided suggestions for changes to the HSNO Act and a strategy to move forward.

Trends

There was general agreement that the international environment with respect to GMOs has changed significantly since the Royal Commission report was published in 2001. Adoption of GMOs is increasing every year, including rapid adoption in countries that are key trading partners and/or competitors with New Zealand such as China, Australia and Argentina. Data is accumulating about the positive environmental and economic impacts of the current generation of GM crops. While these products (insect-resistant and herbicide-tolerant crops such as corn, soybeans, and cotton) do not make agronomic sense for New Zealand, there is recognition that genetic modification could be used to develop products with positive impacts for food security, environmental mitigation, response to climate change, and production of high value products such as pharmaceuticals.

Another factor that has not changed since the Royal Commission is the impact of New Zealand's self image as 'clean and green, 100% pure'. The arguments against the use of GMOs suggest that a 'clean, green' New Zealand must be GM free, and that any use of GMOs would negatively impact tourism and trade. There was significant discussion of the image as opposed to the reality, whether others see New Zealand in this same light, and what trading on this image actually means, for example, could GMOs that provide environmental benefits be incorporated into the 'clean, green' image? The conclusion was that this is a topic that could benefit from additional analysis, with the recognition that it may be difficult to obtain an accurate assessment by conducting surveys or economic impact analyses on this topic.

Another key trend noted was that New Zealand has yet to 'make up its mind' if it wants to be a commodity producer (low cost, high output) or to produce products targeted to high-value niche markets. The implication was that there needed to be a choice between industrial farming, including GMOs, and agrarian farming (no GMOs, organic).

Finally, there is a perception that the media is a roadblock to providing a balanced view of GM technology. Several factors were identified, including increasing use of social media that allows the simplification of messages and perpetuation of stories by opponents of GM technology, often in small numbers but with extreme views. The science community must stick to facts and has a tendency to keep below the radar when possible, so there is not a trusted science 'personality' to talk about the benefits of biotechnology.

Regulation

Short talks were given by regulatory officials from ERMA New Zealand; the Office of the Gene Technology Regulatory (OGTR), Australia; and the US Animal and Plant Health Inspection Service (APHIS) describing regulation of GMOs in these countries, with an emphasis on field trials and environmental release. The key features of each system, as well as differences between the systems that might be relevant for this workshop, are noted in Table 1 above. However, participants highlighted a few aspects of the New Zealand regulatory process that make it more difficult to conduct GM research here as compared to the US or Australia:

- New Zealand is the only country of the three that charges fees for applications.

- New Zealand is the only country with a requirement that the benefits must be considered alongside (and outweigh) the risks, including assessment of cultural and socioeconomic impacts; US and Australia base decisions only on potential biophysical risks and the ability to manage those risks.
- For field tests, New Zealand's requirement for absolute containment is difficult to meet and consequences of non-compliance can be severe.
- The need for public consultation for field tests in containment early in the research process is costly and stressful.

What is working, and why

Presentations by CRI scientists highlighted that it is possible to obtain approval from ERMA to conduct GMO field trials under containment, but it is not easy to get through the system under the HSNO Act. However, another speaker indicated that the Act does not seem to be providing similar obstacles for release of non-GM biocontrol organisms.

Some of the factors that facilitated approval for applications for contained field tests of GMOs include:

- Lots of planning, including pre-application consultation with ERMA (it was noted repeatedly during the workshop that ERMA staff are consistently helpful and knowledgeable, and 'not part of the problem'.
- Early consultation with key stakeholders, and early, proactive engagement with Māori were also helpful and provided ongoing benefits.
- Need to manage the media through proactive engagement, positive press releases and limiting engagement to providing factual information.
- Applicants found it helpful to target applications and design experiment to address specific recommendations from the Royal Commission (e.g. looking at impacts on soil quality), and to see ERMA decision makers as the target audience for information provided in an application.
- Applications for release of biocontrol organisms did not face the same problems experienced by applicants for GMO field tests. Twelve approvals have been granted for release of biocontrol organisms. This is likely due to familiarity with the use of biocontrol to combat foreign pests, the lack of a doctrinally-driven opposition and a history of safe introductions of these organisms overseas.

However, similar strategies were noted to facilitate approvals for GMOs and biocontrol organisms, including frequent consultation with ERMA, relationship-building with key stakeholders, and transparency.

What isn't working, and why

Workshop participants noted both what some see as overarching problems with the HSNO Act that are stifling GM research and innovation in New Zealand, as well as the difficulty of the process for applying to conduct contained field tests of GMOs.

Many of the participants expressed the view that the HSNO Act is not achieving what it was intended to do, which is to allow research while minimising risks. The Act is seen primarily as a mechanism to avoid any risk, including risks to health and the environment, but also any social or economic risks, which are difficult to define or quantify. The need to provide evidence that the benefits, including socioeconomic benefits, outweigh any potential risks is seen as a very high, and perhaps unnecessary bar. This is especially true for conducting field tests that are small-scale, contained, and necessary to demonstrate proof of concept and to collect the data needed to demonstrate efficacy, safety, and benefits. There was general agreement that consideration of approvals for contained field tests for GMOs should focus on assessment and management of biophysical (health and environmental) risks, and that consideration of benefits may not be necessary until there is a consideration of release of the GMO.

One speaker noted that their group had conducted a small field test under the IAG (Interim Assessment Group) before the HSNO Act came into existence in 1998. The process was straightforward with a simple application of around 10 pages, no public submissions, no public hearing, no costs and no pain. The approval was granted without much problem, controls were limited and focused on the risk of spread of genetic material.

In contrast, the current application process was described as costly and resource intensive. Some specific concerns noted by participants were:

- The paperwork, engagement with ERMA, public hearings, and Māori engagement require substantial resources.
- The application fees and the complexity of the process result in submission of more generic applications, to preclude the need for new applications when researchers want to include new organisms or genes. If the process was simpler and cheaper, researchers would be likely to file more specific applications.[288]
- Mandatory public hearings are difficult and stressful, and open applicants up to personal attacks, negative media, and the possibility of having to reveal confidential details of the science.
- There should be a clearer focus on regulation of the risk of the activity rather than the organism. There is a perception that the regulatory system is 'one size fits all', where insufficient attention is given to who or what is at risk from different types of applications.

A mechanism is needed to allow flowering in field tests[289] – it was noted that the mechanism of 'conditional release', which was added to the Act in 1993, has not been tried for GMO plants.

- The response to compliance infractions is not proportional to the risks posed by the non-compliance, and failures in compliance can have significant

[288] One of the concerns expressed about the AgResearch application for extension of their transgenic animal research was that the application was too general and did not provide enough information to allow adequate assessment of the risks.

[289] See Footnote (d) in Table 1

consequences for individual researchers.

What should be changed?

There was general agreement among the participants that consideration should be given to revision of the HSNO Act, in particular with respect to regulation of GMOs (possibly by splitting the Act into separate pieces for New Organisms and GMOs). Suggestions for changes included development of a mechanism for conducting field tests that focuses on assessment and management of risks rather than a need to measure risks against benefits; simplification of the application process with a focus on information needed for assessment of risks rather than unnecessary details; and removal of the requirement for public hearings for field tests in containment.

It was acknowledged that revision of HSNO with respect to GMOs would require a political appetite for change, with clear policy goals and a recognition that consideration of socioeconomic issues will continue to be very important. Some felt that 10 years after the Royal Commission, there is a need for a new national conversation about the potential for the use of new technologies in New Zealand, including GMOs, but also nanotechnology and other applications. This should be a more structured conversation that would include information about the new drivers for the technology, and a discussion of where the New Zealand economy (and particularly the agricultural sector) is going, and what technologies and regulations are needed to get there. (It was also noted that this process could be highjacked by those opposed to the technology and backfire.)

Suggestions for a way forward

- The development of an options paper for changing the Act (the recommendation would be for industry to drive this).
- Research is needed on the potential economic implications of New Zealand's 'clean and green' image on tourism and trade, and on whether GMOs could be included in a 'clean and green' New Zealand.
- The need for 'international benchmarking' – how does the HSNO Act and the regulatory system in New Zealand compare with the regulatory process for GMOs in other countries and with guidance provided by OECD and elsewhere?

Meeting Agenda

9:00 AM	Coffee, registration
9:30 AM	Welcome and Housekeeping – Ian Gear, Facilitator Introductions (name, organisation, interests in workshop)
9:50 AM	Futurewatch concept; setting the context – Robert Hickson, MoRST
10:00 AM	Exercise – Panoptic – Discussion on issues and interactions between science and technology/economic/social/environmental issues affecting field testing or release of genetically modified organisms
10:30 AM	Report back/discussion
11:00 AM	Coffee break

11:20 AM	Overview of New Zealand (ERMA New Zealand), Australian (OGTR) and US (APHIS) regulatory polices and processes for field tests and/or releases of genetically modified organisms. • New Zealand – Kirsty Allen, ERMA New Zealand • Australia – Kylie Tattersall, OGTR • United States – Terri Dunahay, USDA/APHIS
12:00 PM	Panel discussion, Q&A
12:30 PM	Lunch (provided on site)
1:00 PM	Overview of the key issues, questions for discussion - Geoff Ridley, ERMA New Zealand
1:20 PM	"What works – and why" – Short presentations by participants who have obtained HSNO Act approvals • Glenda Hughes – equine influenza vaccine – release *Note – unable to attend; Jimmy Suttie discussed the experiences of AgResearch* • Christian Walter – Scion, pine tree - field tests *Note – unable to attend; Elspeth MacRae presented C.W.'s talk* • Richard Hill - biocontrol organisms - releases
2:00 PM	Panel discussion with presenters
2:15 PM	"What doesn't work – and why?" Round table discussions
2:45 PM	Report back to group
3:00 PM	Afternoon tea/coffee
3:15 PM	"What should be changed to make it work better?" Round table discussions
4:00 PM	Report back
4:15 PM	Meeting summary – Louise Malone, Plant and Food
4:30 PM	End

Participants:

Ian Gear – Facilitator
Terri Dunahay – Ian Axford Fellow
Robert Hickson – MoRST
George Slim – MoRST
Libby Harrison – ERMA New Zealand
Geoff Ridley – ERMA New Zealand
Kirsty Allen – ERMA New Zealand
Asela Attapatu – ERMA New Zealand
Linda Faulkner – ERMA New Zealand
Sharon Adamson – MAF
Kathryn Hurr – MAFBNZ
Barry Wards – MAFBNZ
Sue Ruston – MfE
Sarah Adams-Linton – MfE
Kylie Tattersall – OGTR

Tom Hall – The Treasury
Simon Duncan – The Treasury
Max Kennedy – FRST
Natasha Abram – NZFSA
Jimmy Suttie – AgResearch
Gregory Bryan – AgResearch
Vish Vishwanath – AgResearch
Barbara Barratt – AgResearch
Maureen O'Callaghan – AgResearch
Zulfi Jahufer – AgResearch
Louise Malone – Plant and Food Research
Libby Burgess – Plant and Food Research
Elspeth MacRae – Scion
Linda Newstrom-Lloyd – Landcare Research
Michael Dunbier – Pastoral Genomics
Anne Couper – Fonterra
Roger Hall – Fonterra
Marc Lubbers – NZBIO
William Rolleston – South Pacific Sera
Jerome Demmer – Consultant
Richard Hill - Consultant

APPENDIX 3: REGULATION OF GM ORGANISMS

The overviews of the regulation of GMO plants in New Zealand, Australia and the US provided here focus on oversight for field tests. 'Field test' is a term used generally for controlled or confined growth of GM organisms outdoors, but there are differences in the terminology, policies and procedures for conducting 'field tests' between the three countries that will be outlined here. Prior to commercialisation, new GMO plants might also be subject to food safety approval (if intended for consumption by animals or humans) and possibly oversight by other Federal regulatory agencies depending on the product or intended use. Additional information on the regulation of GMOs in the three countries can be found at the following websites:

- New Zealand: http://www.ermanz.govt.nz; see also http://www.morst.govt.nz/wayfinder
- Australia: http://www.ogtr.gov.au
- New Zealand and Australia: Approval of genetically modified food: http://www.foodstandards.gov.au/consumerinformation/gmfoods/
- United States: http://usbiotechreg.nbii.gov

Regulation of GMOs in New Zealand

GMOs in New Zealand are regulated under the Hazardous Substances and New Organisms (HSNO) Act. Applications must be submitted to ERMA New Zealand to conduct activities involving GMOs, including research in containment, importation into containment field testing in containment, and (conditional or full) environmental release. Activities considered 'low risk GMO research in containment' are subject to a rapid assessment process and may be approved by delegated bodies such as the Institutional Biosafety Committee (IBSC) at the research institution where the work will take place.[290] Low-risk contained research applications, as well as applications for importation of GMOs into containment, are not notified for public comment.[291]

Environmental release

Any application for the field test in containment of a GMO must be notified and is subject to mandatory consultation with Māori. In addition, a public hearing may be required if one or more of the submitters (or the applicant) asks to be heard, or if the decision makers think it is necessary. Following development of an Evaluation and Review Report, ERMA New Zealand provides a recommendation to the decision-makers on whether or not to approve the application. The decision-makers take the application, the Evaluation and Review Report, and the results of the public submission process into account when they make their decision.

The HSNO Act requires that any heritable material arising from the field test must be retrieved or destroyed at the end of the field test, which would make it difficult to obtain approvals that involve flowering and pollen production. In addition, unlike the

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[290] There are four IBSCs in New Zealand, at the University of Auckland, Massy University in Palmerston North, Lincoln University in Christchurch, and the University of Otago in Dunedin, which also oversees GMO research at AgResearch in Invermay.

[291] Research in containment that is not considered low risk may be notified at the discretion of the Authority

situation in the US or Australia, all field tests in containment of GMOs must be notified for public submissions, may be subject to a public hearing, and applicants must demonstrate that the benefits of their application outweigh any risk, including consideration of social, cultural, and economic impacts. Approvals for field tests in containment in New Zealand have generally been granted for multiyear periods, as opposed to the US where permits are generally granted for one year for specific experiments.

Conditional release
In 2003, in response to a recommendation from the Royal Commission, the HSNO Act was amended to include a provision for 'conditional release of new organisms.' This change was intended to facilitate coexistence by providing a mechanism for imposing controls or conditions on a release of a GMO, such as regional restrictions, where the presence of the GMO might pose a threat to an established industry.[292]

ERMA believes this mechanism could be used for conducting research in the field that would be difficult to do under conditions that require full containment, e.g. where the organisms would be allowed to flower or set seed. However, under the HSNO Act, conditional releases must meet the same minimum standards as for full releases laid out in Section 36, and must demonstrate that the positive effects outweigh adverse effects. ERMA has not received an application for conditional releases of GMO plants, so this approach has yet to be tested.

Māori consultation
New Zealand is different from the US and Australia, and probably unique internationally, with respect to special considerations put in place to ensure appropriate representation of Māori, the indigenous New Zealand population who make up 14 per cent of the population. Under Part 2, Section 6 of the HSNO Act, there is a mandate to consider the impacts that the introduction of a new organism (including a GMO) would have on "The relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, valued flora and fauna, and other taonga".[293] There is also a requirement to consider the principles of the Treaty of Waitangi.[294] This may involve consultation at a local or national level. A statutory committee, Ngā Kaihautū Tikanga Taiao (NKTT) provides advice and assistance to ERMA with respect to Māori matters, and with a focus on ensuring that Māori views receive appropriate representation during the consultation process. The NKTT may also provide written reports on specific applications.

Regulation of GMOs in the United States

The US policy for regulation of GMOs was published in 1986 as the Coordinated Framework for the Regulation of Biotechnology.[295] The policy described how existing agencies and legislation would be used to ensure that new products of biotechnology are safe for the environment and for human and animal health. The Food and Drug Administration (FDA) has oversight for the safety of GMOs in food and feed; the

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[292] *Report of the Royal Commission on Genetic Modification* (2001) p.337
[293] Hazardous Substances and New Organisms Act (1996), Part 2 Section 6; 'waahi tapu' are Māori sacred sites; 'taonga' refers to treasured possessions that can be tangible or intangible
[294] Ibid. Part 2, Section 8
[295] *Coordinated framework for the regulation of biotechnology* (1986)

USDA[296] ensures safe use in agriculture and the environment; and the US Environmental Protection Agency (USEPA) has authority over pesticidal substances produced by GMOs such as the Bt toxin[297] produced in a number of insect-resistant species.[298]

USDA regulates GMOs under the authority of the Plant Protection Act (2000).[299] Under the regulation, 7 CFR 340[300] USDA does not regulate research on GMOs in containment (i.e. in laboratories or greenhouses). USDA does regulate 'the introduction of organisms and products altered or produced through genetic modification that are plant pests or are believed to be plant pests';[301] these organisms are considered 'regulated articles.' Permits are required from USDA for any introduction (importation, interstate movement or environmental release) of GMOs that meet the definition of a regulated article, including field trials.

Field tests

Field tests of GMOs in the US must be conducted under permit, under conditions agreed to by USDA and the applicant that are designed to prevent escape and dissemination of the regulated article. There is also an administratively simplified permit procedure referred to as a *notification* that can be used for GMOs that meet eligibility criteria for lower risk introductions. Applicants must meet performance standards for the field test that prevent persistence of the regulated article in the environment.

Applications to conduct field tests in the US can be submitted electronically. While all applications are reviewed by USDA scientists, environmental assessments are only performed for tests with new organisms or new conditions that may pose new risks. Permits are generally issued for one year and can cover multiple GMO 'events' (varieties) in multiple locations. USDA currently issues between 750 and 900 permits or notifications for field tests every year.[302]

Deregulation (full release)

Developers of GMOs can petition USDA for a determination of non-regulated status for a new organism based on their ability to demonstrate that the regulated article is unlikely to pose a greater plant pest risk than the unmodified organism from which it was derived. USDA scientists review data submitted by the applicant and a decision is based on a Pest Risk Assessment (PRA) prepared by USDA. An Environmental Assessment (EA) is also required to assess the potential impacts of deregulation on the environment, including natural, social and economic aspects. The completed petitions, PRAs and EAs are published for public comment. If the initial review indicates there may be significant environmental impacts, USDA may decide to

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296 Within USDA, GMO regulatory activities are performed by Biotechnology Regulatory Services (BRS), a program within the Animal and Plant Health Inspection Service (APHIS)

297 Bt refers to *Bacillus thuringiensis,* a soil bacterium that produces proteins that are toxic to certain insects. A number of crops have been engineered to be resistant to insects by insertion of the gene for a Bt toxin

298 An overview of US regulatory policies and approvals for biotech products can be found at http://usbiotechreg.nbii.gov/

299 *Title IV-Plant Protection Act* (2000)

300 7 CFR 340

301 Ibid.

302 *Information systems for biotechnology* (n.d.)

prepare an environmental impact statement (EIS) to inform the decision.[303] Based on the findings and the comments received, USDA will either approve or deny the petition.

Regulation of GMOs in Australia

GMOs in Australia are regulated under the authority of the Gene Technology Act (2000)[304] and administered by the Gene Technology Regulator, who is supported by the Office of the Gene Technology Regulator (OGTR) in the Commonwealth Department of Health and Ageing. The Australian legislation regulates the research, manufacture and production, growing, breeding, transport, disposal and importation of GMOs in Australia.

Researchers who want to conduct a field trial of a GMO in Australia must apply to OGTR for a licence to conduct a ‘dealing involving intentional release’, known as a DIR. DIRs allow for limited and controlled releases of GMOs into the Australian environment. Upon receipt of an application for a DIR approval, OGTR prepares a risk assessment and risk management plan (RARMP) to consider and manage any risks to people and the environment that are posed by the GMO. The RARMP is published for public comment, and a decision can be made to grant the licence, including conditions to manage any potential risks.

Most commercial releases of GMOs in Australia are also done under a DIR licence, with conditions placed on the release if there are any risks to be managed. Australia also has a mechanism similar to the US process for ‘deregulation’, in that GMOs determined to pose minimal risk can be included on a GMO Register and are no longer subject to DIR licensing requirements. To date, the only GM plants included on the Register are four GM carnations with modified flower colour.

[303] The procedural requirements for preparing EAs or EISs to document the environmental effects of proposed federal agency actions are set out in the National Environmental Policy Act (NEPA)
[304] *The regulatory scheme for genetically modified organisms* (n.d.)