Report to
MINISTRY FOR THE ENVIRONMENT

APPENDIX 1
TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

Background Literature Review[1]

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Introduction

This review focuses on several key areas that inform survey and modelling activities in this project. While there is a lot of literature and media reporting on the issue of commercial use of genetically modified organisms (GMOs), in the last few years, some substantial publications have reported on the first round of sustained economic analysis of genetic modification (GM) products in agriculture. Such literature moves the discussion forward considerably from 2000, when the Royal Commission on Genetic Modification determined that there were a number of unanswered questions about the economic importance of GM to New Zealand. In broad terms the following review primarily examines consumer, production, and trade issues relating to biotechnology. It is specifically directed at GM technologies, but much of the relevant literature only addresses GM as a subset of the wider group of biotechnologies. The literature is very uneven with considerable material being available on consumer perceptions of agriculture, medicine and food uses of biotechnology, with associated material of relevance to tourism. However, the key issues for this report which link environmental uses to economic activity can be informed by only a small body of literature. While this review does not set out to document comprehensively every possible economic issue around GM, it does cover the key areas of literature that inform the survey and modelling activities of the Clean Green Image project.

1. The Clean Green Image in New Zealand

The origins of the concept of a 'clean green' image for New Zealand is actually comparatively recent. Claudia Bell (1996) argues that the conscious attempt to label New Zealand as 'clean and green' commenced in the mid-80s around the time of New Zealand's shifting global political relations surrounding the Rainbow Warrior incident (1985) and the passing of the New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act (1987). Bell notes that the term 'clean and green' originated as an alternative political slogan, but was adopted by mainstream political parties during this period in the mid-80s. Moving the slogan into commercial branding occurred soon after. The two key events typifying this commercial shift were the Brisbane Expo (1988) and the Seville Expo (1992) – the Expo Commissioner in 1992 using the slogan: 'We're clean and green. We produce food that doesn't glow in the dark' (Bell, 1996: 96-97).

It is not long after this that researchers began to investigate the CGI in terms of its marketing and consumer significance. The initial research into this issue was conducted by Gendall et al. (1993). This research clearly related the CGI to nuclear free and broader environmental issues – predating a later focus on GM. Their report showed that the CGI had become a widely recognised concept among New Zealanders, but that 42% thought it was a myth. Citing this report, later researchers (eg. Hughey et al. 2002) moved away from an examination of a generic CGI preferring to focus on specific resource sectors.

The first extensive attempt to evaluate the economic value of the CGI was commissioned by the Ministry for the Environment (MfE) in 1999. The resulting report: *Key Opportunities and Risks to New Zealand's Export Trade from Green Market Signals* (Woodward Clyde: Wellington), provided a very useful analysis of what might be involved in the generic concept of the CGI and how that might be unpacked in terms that would enable more concrete economic analysis. In particular, they moved beyond the term CGI and argued that for economic analytical purposes what was being considered was: 'green market signals'.

These market signals comprise:
• emerging trade pressures in terms of overseas government deployment of environmental criteria in trade access;
• the emergence of Environmental Management Systems;
• the development of eco-labelling schemes;
• buyer group pressure gatekeeping the market; and,
• consumer sentiments around food scares, risk, environmental criteria, and food safety.

The next stage after Woodward Clyde (1999) was to attempt some actual economic modelling of sector specific values and risks around loss of environmental image. A subsequent MfE funded study was undertaken by PA Consulting Group (*Valuing New Zealand's Clean Green Image*, PA Consulting Group, 2001). The three sectors modelled in the PA Consulting Group (2001) were:

- Dairy exports under the scenario of a worsening environmental image for New Zealand.

• Inbound Tourism under the scenario of a worsening environmental image for New Zealand.
• Organic agriculture under the scenario of uncontrolled release of GMOs into the environment.

While the results were instructive – clearly making a case that the CGI was important economically to New Zealand – the third of these scenarios was hampered by methodological difficulties in assessing the emergent organic agriculture sector and its market gatekeepers.[2] As a result, (and consequent on the GM versus organic scenario) some of the broader questions about the economic impact of GM on the New Zealand economy remained unanswered.

Alongside the MfE sponsored research, a body of university research undertook an analysis of the kinds of green market signals identified in Woodward Clyde (1999). Cook et al. (2001) and Hughey et al. (2002) undertook two surveys on the CGI and the New Zealand environment. They generally agreed with PA Consulting (2001) that the CGI was important economically for NZ. Their five key results were:

1. New Zealanders thought NZ was clean and green.
2. Respondents thought our environment was good, but emerging trends were not positive.
3. Farming is increasingly seen as a source of environmental problems.
4. Different ethnicities in NZ differed significantly on all views.
5. Pollution is the main concern. Biodiversity and GM are less compelling.

These papers and commissioned reports highlight an interesting set of issues for policy advisers and researchers. While this body of work does indicate an economic value for our CGI, this conclusion is based on relatively few analyses and raise more questions than they answer. In particular, Woodward Clyde (1999) suggested a range of issues that actually cluster together under the single concept of the CGI which include consumer sentiments, market gatekeepers, trade politics, emergent new management systems in primary production and new labelling schemes in key markets. Likewise, the PA Consulting Group (2001) report suggested some important emergent issues for the economic impact of GM in primary production, but was only able to conduct a partial review of one minor aspect of primary production in New Zealand.

In order to unpack this cluster of issues around the CGI and the economic impacts of GM, the following sections review literature relating to:

• The way in which consumers perceive GM, public opinion polls, surveys and qualitative analyses of changing consumer sentiment.

[2] Market gatekeepers involve a number of layers of entry to markets. These include regulators at the border, distributors, manufacturers who import raw ingredients, and, most importantly, retail chains who make decisions about what kinds of products they stock, and also what the composition of their 'own brand' products will be.

• Economic analyses of GM, including: evaluations of farm level performance of GM; levels of grower adoption of GM; trade performance of GM; and the macro-economic modelling of GM in New Zealand.
• Two country case studies: Canada and Switzerland. In both these countries, there are strong consumer perceptions of high environmental values and yet both are positioned within the development of GM technologies.

2. Consumer Perceptions of GM

The understanding of consumer perceptions as of the end of 2000 is summarised in Campbell (2000). That review considered 61 publications on consumer perceptions of biotechnology up until 2000. Since 2000 another 41 surveys and polls have been conducted and these have been reviewed and added to the findings of Campbell et al. (2000). In general, surveys and opinion polls since 2000 have found similar results to those reported in 2000. The most significant development since 2000 is the first body of publications from the Public Perceptions of Agricultural Biotechnologies in Europe (PABE) project. The PABE project used a large number of intensive focus groups in numerous EU countries to elicit understandings about people's concerns and hopes for biotechnology.

2.1 Public Opinion Surveys

There are a range of possible sources of information on consumer/public understandings and perceptions of biotechnology (for example, internet sites, academic journals, book chapters, technical reports, customer surveys, public opinion polls in newspapers and privately funded consultants' reports for large industry). There is a wide variance in quality of these sources.

There are three main kinds of literature:
• A large number of marketing style surveys and opinion polls. These sources are of extremely variable quality but can be useful as indications of drifts in public opinion without, however, being able to offer explanations as to why these may occur.
• Psychosocial and quantitative social science surveys. These have a more rigorous design but are very focused at the individual-level, thus missing broader social dynamics.
• Finally, there are the more speculative social science pieces which examine larger social trends in an effort to explain their effect on individual and group behaviour.[3]

This literature is restricted to only a few geographical regions: predominantly North America and Europe.

[3] This review will deal directly with this broader social science literature. While it is clear that there are broader social trends, interest groups, and media processes that act as key influences on consumers, the literature surrounding them is broad. A preliminary analysis of some of this literature is presented in Campbell et al. (2000). There are also important issues of risk. Green (2000) reviews case studies of different regimens and perceptions of risk around new technologies.

In general, care should be taken in analysing trends from any *one* of the categories of data previously described and a more reliable picture is likely to emerge from careful consideration of all three categories.

As there have been so many opinion polls and surveys, the key items of literature reviewed here are those that summarise the findings of multiple surveys or polls.

Zechendorf (1994) reviewed 24 surveys and opinion polls from different countries over 10 years and observed (despite the disparity between methodologies) that acceptance of the technology was different for various applications and was moderated by the individual's level of knowledge of biotechnology, their perception of risk, and their areas of ethical concern (for example, applications for drug use were preferred over interference with food or animals). Zechendorf also noted that those individuals who increased their knowledge of biotechnology also tended to become more accepting of it.

In 1998, Norton reviewed sixteen surveys and opinion polls from Australia, New Zealand, Northern America and Europe over the preceding eight years and described similar trends, in particular, the tendency to differentiate between the acceptability of certain applications of biotechnology (e.g. there was more distaste for manipulation of human material than for animal material). There was also concern for the unintended consequences which may have been associated with the technology and a lack of confidence in the ability of regulatory bodies to manage these risks.

Kamaldeen and Powell (2000) have reviewed polls of quite varied sophistication and rigour to gather North American opinions on biotechnology in relation to recent international opinion polls. They illustrate that concerns over biotechnology and GM food in particular are not as significant for North Americans as they are for Europeans as around 61% of Canadians feel comfortable with biotechnology as a general concept while 39% do not. However, 59% of the Canadians polled also saw GM *food* as a negative application of the technology in contrast to the 39% cited as being not comfortable with the technology in *general* (Angus Reid 2000 cited in Kamaldeen and Powell 2000), suggesting a similar differential response to applications of the technology as has been noted in other western countries.

In the New Zealand context, Cook et al. (2000) completed a review of seven studies of New Zealand attitudes to GM in food production, including a four-study work by Gamble et al. (2000), which were carried out over the period 1990 –2000. These studies show that knowledge of GM has increased over time and that acceptance of the technology remained rather higher than in other areas of the world until 1998 when it began to diminish (Macer 1994; 1998 cited in Cook et al. 2000). The differential response to the various applications of the technology seen in other parts of the world are also evident here (plant applications being more acceptable than animal or human interventions). Concern for the technology is based on food safety issues, environmental effects and its "unnatural-ness". A recent report by Gamble and Gunson (2002) found that GM food safety was still moderately important, and that around one-third of consumers claimed to

have changed their purchasing behaviour because of GM. They also found the expected variation of consumer responses to different applications of the technology.

A specific body of work by the researcher Thomas Hoban has extensively examined consumer perceptions in various countries, especially the United States (US) (Hoban 1989, 1994, 1995, 1996, 1997, 1999a, 1999b, 2000). His general findings prior to 1997 indicate a lower level of concern over biotechnology in the US than in Europe with people prepared to try varieties of GM food which have been engineered with specific benefits. However, there is still a differential response to the acceptability of certain applications of the technology (medical and crop technology are more popular than animal, food and fish applications).

The situation regarding European perceptions of biotechnology is best understood from the useful Eurobarometer polls (http://www.europa.eu.int/comm/dg10/epo/eb.html). Eurobarometer 52.1 was carried out in 1999 and included around 16,000 people from member states of the European Union (EU) on the topic of biotechnology. Results show that consumers were concerned about their lack of knowledge of biotechnology and they exhibited a noticeably decreasing trust in all available sources of information on biotechnology although consumer groups (26%), and medical (24%) and environmental organisations (14%) were regarded as the most trustworthy. Differential acceptance of the applications of the technology was still apparent with food applications being least acceptable and disease detection the most acceptable while medical and pharmaceutical applications were also viewed positively.

Since the 1999 Eurobarometer Poll, there have been a very large number of polls conducted in a variety of countries – clearly reflecting the significance of GM as a public and political issue. Accordingly, this literature review evaluated 37 polls conducted since 1999 (see Bibliography).[4]

These 37 polls varied according to a number of factors, including country of origin, quality, methodology, and findings. Most are based in North America (the main producer of GM crops) or Europe (the main opponent of such crops) - the two sides of the GM transatlantic debate - and in developed rather than developing countries. Those surveys that do focus on developing countries, highlight a major difference on the importance placed on possible health risks, with developing countries placing much less importance on these. The comparisons of several developing countries also established that the political, cultural, and historical backgrounds of each individual country significantly influences the issues brought up in the national biotechnology debate.

One set of polls – the International Food Information Council (IFIC) Polls (no date) – suggest that opinions are not changing. These were conducted by the Wirthlin Group until January 2001 and latterly by Cogent Research and do indicate that acceptance of genetically modified food (GMF) remained fairly consistent from 1997 to the most recent survey in August 2002. While these polls are based on a relatively unrigorous methodology, they do show constant patterns of consumer resistance to GM food and

[4] 16 new polls were reviewed and the remaining 21 were summarised in articles.

differential acceptance of other biotechnologies – particularly in diagnostic medicine and pharmaceutical applications. These results are in accord with the broad trends in the Eurobarometer and in the surveys summarised above in Zechendorf (1994), Norton (1998) and Kamaldeen and Powell (2000).

2.2 Psychometric Evaluations of Consumer Behaviour

One more specific methodology for understanding consumer behaviour is that which involves the psychometric evaluation of consumer behaviour. In the study of consumers and GM, the main body of research has been conducted by Lyn Frewer and her associates.

Frewer et al. (1994a, 1994b, 1995, 1996, 1998, 1999) have used psychometric surveys of (mostly British) consumer understandings of risk and psychological models of communication in relation to this topic. Their work also confirms a differential response to the acceptability of GM technology based on its applications, with negative responses to work on human and animal DNA while work on plants and micro-organisms being seen more positively. The decision by their subjects to view certain applications as negative was sometimes mediated by the perception of the benefit or need associated with the application. They also note significant distrust by their subjects of the government and industry as sources of information on biotechnology and demonstrate that medical doctors and consumer groups are regarded by the public in the United Kingdom (UK) as more trustworthy sources (Frewer et al. 1999). They also describe some cultural differences in responses to their surveys on concern over biotechnology with the UK sample expressing concern over the risk associated with the technology while, for the Italian sample, ethics appeared to be the more problematic aspect of biotechnology (Frewer et al. 1999). This work on risk, confirms both the broad trend noted above (country variability, differential acceptance of different applications of biotechnology, persistent questions and trade-offs of risk and benefit), but it is also limited by the lack of engagement with broader social and economic processes.

2.3 Discussion: Consumer and Public Opinion Surveys and the PABE report.

While the surveys and opinion polls reviewed above do indicate some broad trends, as well as clearly showing the variability between different countries, their methodological approach necessitates a limited view of consumer and public perceptions and actions. More recently, however, the PABE report (Marris et al. 2001) has highlighted the way in which intensive qualitative research can generate insight into some of the complex ideas and processes that underpin consumer perceptions of biotechnology – including GM.

Due to its importance, the PABE report will be discussed in detail.

One central finding of the PABE report identified that stakeholders involved in the GM debate have misunderstood public responses to GM. This is given as a key cause of the ‘current impasse’ in that debate. The PABE report argues that public responses to GM are usually explained by ‘decision-makers’ in terms of the public having: ‘a lack of

knowledge' or 'ethical concerns'. This kind of explanation does not acknowledge the 'social, cultural, and institutional factors shaping these concerns' (Marris et al. 2001:7). Instead the PABE findings are complex and blur common distinctions (such as those made between 'real' and 'perceived' risk), illuminating societal concerns and then contrasting these with official views of public perceptions.

The report presents two types of results about public perceptions:

- -Perceptions of GM among ordinary citizens were studied in focus groups held in five EU member states: France, Germany, Italy, Spain, and the UK (total of 55 sessions).
- -Perceptions of public responses to GM among stakeholders (actors engaged in the GMO controversy) were studied using interviews, participant observation and document analysis.

A comparison of these results identifies a 'gulf' between stakeholder views of the public and public views expressed in the focus groups. The main conclusion identifies the need for the development of a 'more constructive and satisfactory debate on agricultural biotechnology'; which would include recognition by policy makers that the behaviour of institutions involved in the management of GMOs, as well as public behaviour, are sources of the problem. While this finding is not of direct relevance to this project, within the PABE findings are a number of points of relevance to understanding consumers and GM.

An important finding was the overwhelming similarity of focus group findings across countries, groups, and time. Contrary to expectations, there was a broad similarity in the repertoire of arguments mobilised by focus group participants in all five countries. This result ran strongly counter to all the surrounding survey activity, which highlighted differences between countries – suggesting that some of those differences might be due to different methodologies rather than real differences. However, there still were inter-country differences, especially when the combined effect of public perception and regulatory process is taken into account. The PABE also only studied EU countries.

The project identified 10 key 'myths' which stakeholders held about public perceptions of biotechnology. Four of these are directly relevant to a consumer analysis:

Myth: People are either 'for' or 'against' GMOs.
Myth: Consumers accept medical GMOs but refuse GMOs used in food and agriculture.
Myth: Consumers want labelling in order to exercise their freedom of choice.
Myth: It's the fault of the BSE crisis. Since then, citizens no longer trust regulatory institutions.

The findings of the focus groups challenged these myths. The PABE research found that although ordinary citizens are largely ignorant of scientific facts concerning GMOs, this lack of knowledge does not explain their response to agricultural biotechnologies. While scientists and policy makers tend to assume that specialised scientific knowledge is

required for the public to have a rational opinion about GMOs, focus group participants utilised three types of knowledge in supporting their arguments about GMOs:
1) Non-specialist knowledge about the behaviour of insects plants and animals.
2) Knowledge about human fallibility from daily experience.
3) Knowledge about the past behaviour of institutions responsible for the development and regulation of technological innovations and risks (the most predominant type of knowledge used).

Overall, participants did not express opinions 'for' or 'against' GM but were ambivalent, identifying both positive and negative aspects of agricultural biotechnology. Participants did distinguish between medical and agricultural applications of GMOs. However issues such as access to information and regulation were important in influencing this distinction. Participants were sceptical about some benefits claimed for GMOs, (for example, claims that they could 'feed the world' were viewed as a marketing ploy). Participants wanted GM food labelled to allow consumers to 'send a message' through boycotts, and as a demonstration that the promoters have nothing to hide.

The presumption that people are either 'totally for' or 'totally against' GMOs is also challenged by some surveys being undertaken around the same time as the PABE exercise, especially those that employed focus groups. Rather, respondents often held ambivalent views of biotechnology as a whole, accepting some applications but rejecting others. Medical applications of biotechnology were generally more accepted than agricultural applications. In contrast, agricultural applications are seen to benefit large companies financially, whereas the public at large is put at risk.

In conclusion, the PABE report, when contrasted with the other surveys evaluated in this review, does challenge the degree to which behaviour varies by country within the EU. However, it does provide important substance to a number of other trends: the strength and durability of public concern, the variable acceptance of different uses of biotechnology, the agriculture/medical division, and the importance of regulatory contexts which build/undermine trust. Due to the methods used in the PABE project, the focus group participants focused almost entirely on medical/food uses of biotechnology.

2.4 Economic Measurements of Consumer Demand

Economists have tried to measure consumer demand with several tools. Their contingent valuation (CV) surveys do not indicate anything new about consumer sentiment but do serve to suggest the strength of demand for non-genetically-modified food (non-GMF). A CV survey of US and UK consumers assessed their willingness to avoid (WTA) GM breakfast cereal (Moon and Balasubramanian, 2001). Both countries had consumers who would pay to avoid GM cereal. However, the average WTA – the increase in price consumers were willing to pay in order to avoid GM cereal – was higher in the UK than in the US (56% versus 37%), which is consistent with opinion poll results.

Choice modelling is another tool for measuring WTA. A choice modelling survey of Western Australian consumers found that genetically modified food would need to sell at

an average discount of 20% to 47% in order to offset negative attitudes (James & Burton, 2002). UK consumers were even less disposed to buy GM (Burton 2001). Respondents were grouped into six categories according to gender (male or female) and how often they purchased organically grown food (Infrequent, Occasional, or Committed purchaser). All groups were willing to pay more for non-GM, from the lowest category at 26% to the highest at 468% (Burton et al. 2001).

The design of choice modelling surveys makes them useful for analysing trade-offs in a way that simple opinion polls cannot. However, they still do not indicate what respondents would do in a retail situation. To discover what consumers might actually do, economists have begun analysing market data. For example, Kiesel et al. (2002) analysed market data for milk and found that labels indicating the milk was produced without rBGH (recombinant bovine growth hormone) increased demand. They further found that the positive effect of labelling had likely increased over the period analysed, suggesting that resistance to the use of rBGH is not fading with time.

Because rBGH is a special case in which clearly labelled products with close substitutes have been widely available for years, economists have devised auction experiments to provide insights into responses to other GM foods. US Midwest consumers, given the chance to bid on GM and non-GM vegetable oil, corn chips, and potatoes, discounted the GM products by an average of 14% (Huffman et al. 2001). Another experiment with the same products indicated that tolerance for contamination by GM is non-linear: consumers discounted food containing up to 1% GMOs similarly to foods containing up to 5% GM (Rousu et al. 2002).

In a widely publicised report, Noussair et al. (2001) found that French consumers' willingness to pay for products labelled as containing GM ingredients fell by nearly 30% when such information was clearly shown to them in the experimental situation. However, they noted a strong tendency for the research participants to not read labels on food when such activity was not specifically directed by the experimental design. This was hypothesised to account for why consumer sentiment and consumer behaviour might be dissonant.

The effect of actual product experience was also assessed in a laboratory experiment (Grunert et al. 2002). Consumers were given cheese to taste (it had been earlier determined which cheese the subjects preferred, so that their tasting experiences would be positive). They were then told that the cheese was GM. The findings suggested that the positive experience with GM cheese made the subjects less negative about GM foods overall and reduced the importance of the issue of GM in their food consumption.

2.5 Consumers and Environmental Values

Environmental values are an important part of perceptions of GM food (Cook, 2000; Bredahl et al.1998). However, the relationship is not straightforward. Researchers found that favourable attitudes towards nature correlated with negative attitudes towards GM (Bredahl, 2001). More specifically, survey respondents did not agree that GM is

environmentally friendly (Small et al. 2002), and ecocentric respondents (those that value nature intrinsically) did not support GM (Siegrist, 1998). Likewise, those who felt that the costs of technological growth and energy consumption were too high tended to have negative attitudes towards GM (Sparks et al. 1994). In general, acceptance of GM was less likely when there is greater environmental risk (Small et al. 2001; Macer 1992). In fact, the Organisation for Economic Cooperation and Development (OECD) has attributed the lack of acceptance of rBGH outside the US to concern for animal welfare (OECD, 2000).

However, surveys that attribute environmental benefits to GM in agriculture find positive reactions. In the IFSC/Wirthlin Group/Cogent Research surveys, respondents were asked whether they would buy biotechnologically derived food that required fewer pesticide applications and whether they would buy biotechnologically derived food engineered to taste better or stay fresher. Consistently, respondents express more support for the biotechnology application that has an environmental benefit (IFIC 2002). Canadian, New Zealand, and Australian research has revealed a similar pattern (Sheehy et al.1998; Macer, 1994). Choice modelling highlights this trade-off: research in Western Australia found that respondents would purchase GM food at a 20% to 47% discount, but would also pay 36% more to reduce agrochemical use by 30% (James & Burton, 2001).

Environmental values seem to cut both ways. To the extent that GM may represent a perceived threat to the environment, they are less valuable to some consumers. To the extent that they are perceived to reduce environmental damage, they become more valuable.

2.6 Key Conclusions

There are two broad conclusions that can be drawn from this work. First, since around 1995-96 a segment of the market in many Western countries has developed negative attitudes towards GM food, with more tolerance or open encouragement for GM medicines and diagnostic technologies. Levels of trust and perceptions of risk associated with GM technologies is increasingly related to broader concerns about ethics, food morality, regulation and food safety, and the perceived politics of food trading. The first conclusion is therefore that there is likely to be resistance to GM food as a potential export product from New Zealand. This resistance in key markets has become relatively stable and comprises a minority segment of some of our key markets.

The second conclusion, however, is that there is a great degree of variability within this broad trend. Levels of consumer concern vary by country and vary strongly by actual application of biotechnology. GM food is considered the most problematic, but other GM technologies like environmental remediation and medical uses have more ambiguous or, in some cases, positive consumer responses.

Apart from these two conclusions, it is also worth noting that there is a complete absence of literature directly targeting the key issue in this research project: does the presence of some GM exports influence consumer's *stated* buying behaviour for other non-GM

products? Although there is an absence of evidence showing that consumer preference for non-GM products has affected purchase behaviour in non-GM products from countries that grow GM, there is a clear gap in the existing knowledge around GM, justifying the survey and modelling work undertaken in this project.

3. Economic Issues for GM

This section covers some of the key issues in relation to economic issues and GM. Specifically reviewed are:

- the impacts of GM in primary production in the US is reviewed;
- the level of grower adoption of GM;
- studies of the trade performance of GM;
- the specific macro-economic modelling of GM in New Zealand; and
- the trade and market strategies of some of our key markets.

The following literature is heavily weighted towards the economic issues of GM in primary production. Very little work has been done on the economics of GM in medical and pharmaceutical contexts as the consumer and regulatory contexts for medical GM are quite similar to that for all pharmaceutical products. Thus, GM has not been isolated out for special economic evaluation.

Similarly, there has been no attempt to evaluate the potential economic value of environmental products derived from GM. There is some discussion of the environmental impacts of new GM products in agriculture, but none that tries to evaluate a GM technology specifically designed for an environmental purpose (eg. to control a pest in the wider environment).

3.1 Impacts of GM in primary production

The economic impact of the commercial release of GM depends upon the combined responses of both producers and consumers to GM in the international trading environment. Initially, this section assesses the impact of GM on producers in isolation and then turns to the trade impacts. As the commercial release of GM food crops has mainly been in the US, most of these studies relate to that country.

The following review examines the key GM food crops (meaning crops for human consumption). This is only one area where GM developments have occurred. Two others are GM cotton, and GM crops destined for animal feed. The main purpose of this literature review is to provide underpinning information for scenario development. The relevant scenario for this section involves human food consumption – not fibre or animal feed production.

The current commercial release of first generation GM food affects the production system. The main commercially released GM food crops are insect-repellent maize and herbicide-tolerant soybeans and canola. Thus, most of the current benefits of GM come from the supply side and relate to potential increases in yield and/or reductions in costs.

Given that GM field crops were well into production in 1996, it is not surprising that the first on-farm evaluations of crop performance commenced a few years later. The results from various early studies (1998-1999) show that the impact of GM production on yield varies according to the crop type. In the case of soybeans and canola there seems to be little change in yield, and in the case of soybeans there have actually been falls recorded in the yield of the GM crop compared with GM-free. This result is perhaps not surprising as these GM soybeans and canola are not targeted at the productivity of the plant but rather at changes in input use, so expected gains should be from savings in input costs. In the case of maize there are reported increases in yield which vary according to the level of insect infestation. These gains in yield have been estimated to range from 0.26 to 1.88 tonnes per hectare depending upon the degree of infestation and the study (CEC 2000; Gianessi and Carpenter, 1999; and Duffy and Ernst 1999).

There is a reduction in the cost of herbicides for GM production of soybeans and canola. The cost of seed is higher for all GM production products, as expected. Another benefit from GM production reported by producers is increased flexibility in production. For example, it was found that 12% of farmers surveyed cited increased flexibility as a reason for going GM (Duffy et al. 1999, cited in CEC 2000). This increased flexibility may lead to lower costs or increased revenues but these are difficult to quantify.

The impact of any changes in yield and costs on gross margins (assuming no impact on demand and therefore prices) has so far been indeterminate. For GM soybeans, the fall in herbicide costs was reported to be offset by rises in seed costs, with the net returns to land and labour being slightly more for conventional soybeans (Duffy et al. 1999, cited in CEC 2000). This is supported by a United States Department of Agriculture (USDA) study which reported that while there was some positive impact on yield and reductions in herbicide use from GM production, net returns did not change (USDA 2000).

It is more difficult to assess the impact on gross margins for GM corn given that it is highly dependent on the level of insect infestation and thus the potential losses in yield have to be set against the higher price for GM insect resistant seed. A study by Furman Seltz (1998) reported in CEC (2000) shows a gain in returns from using GM corn especially under heavy insect infestation. However, Gianessi and Carpenter (1999) found mixed results from using GM corn, with a gain in returns in 1997 but a loss in 1998, whereas Duffy et al. (1999, cited in CEC 2000) found a small gain. It may be that the use of GM corn reduces the variability of farmers' returns, operating as a kind of crop insurance. The value of this reduced variability is currently unknown but potentially calculable. In the case of canola, results are again mixed with Fulton and Keyowski (1999) reporting lower returns with GM canola, whereas the results from a study in Alberta in 1999 found that GM gave lower returns on one type of soil but a higher returns on another (CEC 2000).

The effects of GM crops on producer surplus are complex, as two articles dealing with this specific issue have shown. In the case of Bt cotton in 1996, US producers did gain and other countries' producers lost producer surplus (Falck-Zepeda et al. 2000). The

authors noted that the pricing strategy Monsanto followed probably affected the division of surplus between the innovator and producers. This *caveat* is important as concentration in the biotechnology industry has increased since 1996. A simple model of world soybean production and trade (Moschini et al. 2000) found that gains by producers were critically dependent on assumptions about yields and the spread of technology. US soybean farmers increased their producer surplus only when the technology did not affect productivity and the technology remained in the US. When yields increased or when other countries adopted the technology, prices decreased and producer returns fell.

This body of literature comprised the most reliable sources available to 2000. Since then, attempts have begun to draw together these findings and make broad conclusions about the relative successes and failures of GM in US agriculture. There have been four key reports which both review the prior material and introduce important new analyses:

- USDA May 2002
- National Center for Food and Agricultural Policy 2002
- UK Soil Association (Warwick & Meziani 2002)
- Commission of European Communities (CEC) Report 2000.

Two of these portray unambiguous findings. The NCFAP ((Gianessi et al.2002) reports significant benefits from GM crops in agriculture. From the results of 40 case studies this report argues that the widespread adoption of GM crops in the US has resulted in significant yield increases, savings for growers and pesticide use reduction. It predicts that successful development of 32 additional biotech cultivars, either not yet fully developed or not yet adopted, will extend similar impacts to other crops. The report predicts economic benefits for every state examined.

The strong claims made by this report regarding the economic performance of GM crops have been viewed with considerable caution after it was revealed that the study was par-financed by Monsanto and the Biotechnology Industry Organisation (BIO).

In contrast, the UK Soil Association (2002) report documents failing markets, dubious on-farm performance and growing broad-based resistance. The report argues that there is major disruption at all levels of the agricultural industry, and estimates a potential cost of $90 million annually through lost sales or lower prices due to crop contamination in both organic and non-GM farms.

With regards to on-farm performance of GM crops, the report finds that:

- Contrary to industry data, GM crops have reduced average farm profitability.
- Herbicide-tolerant soya reduced average returns by about $8.8/acre compared to non-GM soya.
- Bt maize reduced average returns by about $1.3-$3.2/acre compared to non-Bt maize.
- GM seeds are significantly more expensive than non-GM seeds as farmers have to pay a technology fee which adds 25-40% to seed costs and prevents them saving seed.

- A significant fall in herbicide prices has offset the cost of greater use of herbicides for herbicide-tolerant crops.
- GM crops are receiving lower market prices than those available for non-GM crops; guaranteed GM-free crops are obtaining significant price premiums.

This report is cited widely by environmental groups, but the clear positioning of the Soil Association as an opponent to GM has been used to dismiss many of these claims.

Thus, both the NCFAP (Gianessi et al. 2002) and the Soil Association (2002) have had their credibility undermined by close association with key interest groups.

In contrast, the most important reports are those by the USDA and the EU.

The USDA (2000) reported on good progress and performance by GM crops in the US. It reported a positive outlook for GM crops and a range of benefits. In essence, the 2000 report tended towards the positive scenario later outlined by NCFAP (Gianessi et al. 2002).

However, a later USDA report (2002) by the same authors significantly moderated this positive outlook. While they reported positive trends in the uptake of GM crops and environmental performance, they considerably moderated their positive tone in relation to actual on-farm performance of GM crops. In a turnaround that received very wide coverage in the anti-GM media (but almost none in the mainstream US media), the 2002 report suggested that the evidence for beneficial outcomes from GM crops and positive net economic returns for farmers was ambiguous, at best, and that in many cases the evidence clearly demonstrated an absence of benefit. Specific results showed:

- The adoption of herbicide-resistant corn improved farm net returns among specialised corn farms. (However the authors note that the limited acreage on which this crop has been used is likely to be acreage with the greatest comparative advantage for this technology, and that positive financial impacts may also be due to seed companies setting low premiums for herbicide-tolerant corn relative to conventional varieties in an attempt to expand market share.)
- The adoption of herbicide-tolerant soybeans did not have a significant impact on net farm returns.
- The adoption of Bt cotton had a positive impact on net returns amongst cotton farms but adoption of Bt corn had a negative impact on farm returns among specialised corn farms.

In contrast to these on-farm performance evaluations, the USDA (2002) did create a more positive picture about the environmental impacts of GM technologies. USDA (2002) reports on the possible outcomes that occur due to changes in pesticide use and tillage practices – both key concerns for US agriculture. The use of pesticides has declined since the introduction of GM crops in 1996 by 19.1 million-acre treatments or 6.2% of total treatments. Further, whilst there is a reduction in the use of heavy pesticides, other chemicals are used in the treatment of GM crops. For example, glyphosate is substituted for previously used herbicides to treat herbicide-resistant soybeans. Glyphosate is nearly

three times less toxic than previously used herbicides and remains in the environment only half the time (USDA 2002:28). Herbicide tolerant crops also have the potential to facilitate the use of conservation tillage farming practices, as weeds can be controlled without tilling the soil. The benefits of conservation tillage include reduced chances of soil erosion and water and chemical run-off. However, USDA (2002) suggest that while early indications are good for the environmental impacts of GM technologies, there is little definitive empirical evidence thus far, as to what extent GM crops have influenced conservation tillage.

The CEC report on the economics of GM supports the more pessimistic tone of the latter USDA (2002) report, but adds in the poor market performance in Europe of US GM crops. This report gives a European-based perspective on trade issues for GM, with a particular emphasis on the powerful role of public opinion and market gatekeepers. The generally high level of concern among a large majority of Europeans is held to have a "cascading" effect back up the food chain in both domestic and foreign markets (CEC 2000). The GM-Free purchasing actions of the retail industry, such as many supermarket chains in the UK and Europe, are argued to have amplified perceived levels of consumer preference and concern and to have become a powerful shaping force in the market. The report outlines the problems of a bulk commodity trading system, in terms of the segregation, identity preservation and labelling of GM-derived foods.

The European Joint Research Centre report *Review of GMOs Under Research and Development and in the Pipeline in Europe* (2003), also demonstrates the caution in Europe with regard to GM. The authors assert that the 76% decrease in the annual number of GMO field trial notifications can be attributed the EU Council of Environment Minister's decision in 1999 to block any new commercial releases of GMOs, coupled with the general public mistrust of the technology. Furthermore, the survey conducted by the authors demonstrated that the key reasons for cancelling research and development projects within agricultural biotechnology were the unclear legal situation, low consumer acceptance and uncertain future markets.

It is worth noting that the primary difficulties experienced by export sectors deploying GM in the US have been in those sectors providing food crops for human consumption. The success of GM cotton crops is clear-cut in all these reports (although this is perhaps partly the result of the fact that many consumers are not aware that cotton seed oil is used as an industrial food input). Likewise, GM crops being sold into markets for animal feed have experienced different market dynamics to those being sold for human consumption.

3.2 Grower Adoption of GM Crops

The USDA (2002) is more positive about the level of uptake of GM crops across the US. It reports that the estimated global area of GM crops for 2001 is 52.6 million hectares, grown by 5.5 million farmers. The majority of GM crops are grown by four countries: the United States (with 68% of the world total), Argentina (22%), Canada (6%) and China (3%). The amount of GM crops grown in South Africa and Australia in 2001 increased by 33% and 37% respectively. Absolute growth was twice as high in industrial

countries as in developing countries. The main GM crops are in descending order; soybeans (63% of total area of GM crops), corn (19%), cotton (13%) and canola (5%) (James 2002). In the US, the most widely adopted GM crops have been either herbicide-resistant or insect-resistant. The rate of adoption differs depending on the particular crop. By 1997, herbicide-tolerant soybeans comprised 17% of the total soybean acreage in the US, increasing to 56% in 1999 and 68% in 2001. However, in contrast herbicide-tolerant corn has been much slower, remaining at around 8-9% in 1998-2001 (USDA 2002: 4).

An interesting point at issue now is why so many growers have adopted GM crops. One technology promoting organisation argued that "[t]his high adoption rate is a strong vote of confidence in biotech crops, reflecting farmers' need for and satisfaction with the technology" (James, 2001 cited at www.whybiotech.com/index.asp.id=1808). The USDA disagrees, posing the question in its report: "[p]erhaps the biggest issue raised by these results is how to explain the rapid adoption of GM crops when farm financial impacts appear to be mixed or even negative" (USDA 2002: 24). It goes on to answer that the farmers within the analysis commented that they found the new pest control systems easier to use than deploying conventional methods. They considered that the GM crops gave them greater flexibility. This is a useful outcome for farmers but was not the kind of benefit that would show up in the economic analysis of farm performance.

One Iowa State University study suggested an alternative answer: that GM crop uptake can be driven as much by how well farmers *believe* the crops deliver, as it is by factual data on their subsequent performance (Duffy & Ernst 1999). Duffy (2001:7) also comments on pressure from landlords and from advertising in seed planting decisions. The CEC report concurred, arguing that farmers had strong 'profitability expectations' when planting the crops (CEC 2000: 32). This report also noted that farmers had access to promotional material from companies suggesting high yields.

The question now arises as to whether farmers think they can abandon GM varieties if they do not perform. The Canadian case reviewed in the next section seems to indicate that there is a differential response to market difficulties for established GM crops and the potential future market difficulties of as yet unreleased varieties like GM wheat. While this differential response has never been researched, it is possible that extant GM crops are considered a *fait accompli* while choices are still much more open in regard to future GM crops.

3.3 Trade performance of GM crops

Preferences for non-GM crops have affected trade. For example, GM-sensitive European and Asian markets have increased their purchasing of non-GM Brazilian soyabeans and soymeal (Agra Europe 2001). As GM maize production has expanded, EU importers have turned to non-GM countries for their supplies (Agra Europe 2000), and the European Commission (EC) has effectively blocked bulk shipments of US corn to Europe (USDA 2002). USDA figures also show that the amount of US soybeans shipped to Europe fell from 1996 to 2000, as did prices. This was the same period in which US GM production expanded. As noted in a European Joint Research Centre paper (2003:5), the

US is still the main exporter of soybeans to the EU, but import levels have recently decreased and stabilised at 1994 levels after relatively high increases during the 1990s up to 1998. The report says that while there has been a shift from the US and Argentina in soybean imports towards Brazil which might be due to the GM situation, soybean meal imports 'are shared equally between Argentina and Brazil, thus indicating that the GM factor has little or no influence on the purchase decision of this type of commodity'. This market situation, however, is unstable, and could change significantly relative to the uptake of GM animal feed labelling.

An additional problem for trade has been the difference in specific GM crops authorised for production or import. Canada moved quickly into approval of GM canolas for export. This caused a disjuncture with emerging import regimes in different countries. For example, the EU lagged behind Canada in approving specific GM canolas, harming Canada's canola exports to the EU. Similarly, China's rapid introduction of rules on GM food similarly hurt Canada's canola industry (Agra Europe 2001).

The fallout from co-mingling StarLink maize (which was not approved for human consumption) with food-grade maize illustrates what can happen with GM commodities. While Starlink created problems due to an unapproved product entering human consumption chains – thus not relating directly to consumer sentiments regarding genetic modification – the market reactions outlined by Lin et al. (2001-2002) do exemplify trade effects (alongside the more direct and obvious regulatory sanctions against an unapproved product):

- Premiums: StarLink-free maize generally had a premium of 7 to 12 cents per bushel.
- Separation and diversion: By diverting co-mingled maize to approved (non-food) uses, grain handlers moved the appropriate maize to the appropriate market. In the process, they reduced the premium on StarLink-free maize.
- Government involvement: The U.S. and Japanese governments negotiated testing protocols that calmed Japanese buyers and, in turn, US sellers.

An additional trade issue is the intellectual property rights from GM innovations. Several researchers have commented on the importance of property rights for innovators to be able to capture returns to their technologies. Patent protection for biotechnology is not guaranteed internationally and will continue to be an issue in trade negotiations.

3.4 The Economic Analysis of GM in Primary Production in New Zealand

Since the emergence of adverse economic events for GM around 1998-99, a small body of economic analysis has begun to be undertaken in New Zealand around the potential impact of GM. In particular, most of this research comments on the fact that New Zealand has remained one of the few agricultural exporters that did not produce the already available GM crops – thus making New Zealand somewhat unique as a potential GM-free exporter. This literature differs somewhat from the international literature on the economics of GM crops production as New Zealand is not a producer of the key new GM commodities - canola, cotton, soy – and has only a minor corn export sector.

The first analysis to outline these issues was prepared under the auspices of the Independent Biotechnology Advisory Council (IBAC). They issued a discussion paper in 1999: *Economic Implications of a First Release of Genetically Modified Organisms in New Zealand* and solicited comments from the public and various stakeholders. The results of this process strongly informed the Background Briefing Paper: *The Economics of Genetic Modification* prepared by Jan Wright (a member of IBAC) for the Royal Commission on Genetic Modification. This paper clearly showed that there were important issues pertaining to the economic implications of the 'first release' of GM into commercial production in New Zealand, and called for a significant economic debate to be part of the Royal Commission's activities in 2000-2001.

In retrospect, the Royal Commission was characterised by a lack of broad debate on economic issues relating to GM and suffered from a lack of independent advice in the economic area. While a number of economic stakeholders (ranging from Crown Research Institutes, exporters, to anti-GM sectors like the organic agriculture sector) made their case to the Commission, few actually presented economic research in support of their claims. Two exceptions were the Life Sciences Network and the organic agriculture industries.

The Life Sciences Network commissioned Infometrics to provide a series of Computable General Equilibrium (CGE) model runs on a range of scenarios relating to deployment or restriction on GM in the New Zealand economy (Stroombergen 2000). The results were generally positive for GM (although this finding was contested in Nana 2000). As a first attempt at modelling the economic outcomes of GM, the Infometrics work highlighted both the importance of providing robust assumptions under modelling activities, and the need to clearly define and defend the scenarios used to initiate modelling activities. It also highlighted the problematic issue of attempting to compare a future possible sector (GM) with a small minority sector like organic agriculture.

The Royal Commission was also the venue for the first presentation of results from the Lincoln Trade and Environment Model (LTEM) with results being mobilised in presentations by the organic agriculture sector. In a later discussion paper, Saunders and Cagatay (2002) outlined their findings as being generally negative for the adoption of GM in primary production sectors. They also argued that such model runs were preliminary, and needed further elaboration of assumptions and scenarios.

Modelling activities rely on access to solid data on farm production, environmental outcomes, profitability, consumer sentiment, elasticities of demand and consistent data on the future productivity gains that novel farming systems might involve. In the time since the Royal Commission on Genetic Modification, new data has become available to assist in modelling, although there are still important areas of weakness in the data supporting some assumptions.

There have also been some modelling activities in the Australian context, although modelling assumptions used in the Australian research differed significantly from those used in this research. A Productivity Commission Report (Stone et al 2002) applied the

global general equilibrium modelling framework GTAP (Global Trade Analysis Project) to examine potential impacts of GM technology on Australia's trade in 'non-wheat grains' and 'oilseeds'. The results of the three scenarios considered demonstrated that very small 'absolute changes' would occur in Australia's import and export flows. Rather, regions with currently significant GM sectors (such as North America) received the most substantial impacts to trade and income. However, the results did imply that a longer-term expansion of GM technology could influence significant negative impacts on Australia's trade position.

3.5 Export Markets: Trade and Regulatory Strategies

For the demands of different market segments to be relevant, consumers must be able to distinguish between the products they do and do not want. One way for consumers to do this is through product labelling. The concentration of New Zealand exports makes it possible to discuss labelling regimes in its trading partners.

Regulatory strategies address several issues. Firstly, food labelling regulations generally fall into one of two types: mandatory labels on foods produced with GM; and voluntary labels, especially, but not necessarily, on non-GM foods. Secondly, regulations set tolerance levels to indicate the maximum allowable amount of adventitious presence or co-mingling of GM material with non-GM material. Thirdly, the products to be labelled are defined.

The following table sets out the basic labelling regulations in New Zealand's major trading partners:

Country	Mandatory or Voluntary	Tolerance level	Products to be labelled	Notes
Australia	M	1%	Food with novel proteins or DNA	Governed by same rules as NZ
European Union	M	1%	Foods from GMOs GM feed GM additives	Current rules. New more stringent rules are being adopted.
Japan	M	1% - "May contain" 5% - "GM"	Top three ingredients of a product, if greater than 5% of product's weight	
South Korea	M	3%	Top 5 ingredients in a product	
United Kingdom	M	1%	Also requires that restaurant meals with GM foods be labelled	Also under EU rules
United States	V			

Sources: ANZFA (2001); CEC (2000) and Phillips & McNeill, (2000).

It is clear that national governments do not agree over the particulars of labelling. This disagreement has been traced to a fundamental difference in perception of GM (Caswell 2000; Paarlberg 2002). The US and Canada maintain that if GM food is "substantially equivalent" to non-GM, it is therefore subject to the same regulations but nothing additional. However, if the effect of the GM trait is not substantially equivalent, then the product must be labelled. The European Commission, on the other hand, maintains that the "precautionary principle" should prevail, because GMOs are novel organisms and the effects of their introduction into the environment and food system are unknown. This position was adopted after some novel GMOs were approved. Thus the EU has a moratorium on some GMOs but not all. These positions seem to be irreconcilable, but both are defensible and legal under international agreements (Caswell 2000). However, at least one researcher believes that the European Commission position will probably prevail, because importers tend to set international food standards: "[t]he customer is always right, and in world food markets the biggest customers are the Europeans and the Japanese, not the Americans" (Paarlberg 2002: 34).

Within the broader regulatory and trade context, internal gatekeeping effects have emerged due to the actions of some retailers in excluding GM products. The most obvious market where such actions have taken place is the UK, although such actions in the EU and Japan have also been common. Having conducted a review in 1999, *GMfoodnews* conducted a follow-up survey in 2003 and suggested that all the surveyed supermarket chains in the UK were still maintaining a ban on GM ingredients in their own brand products (gmfoodnews.com: 6 Jan 2003). They also noted an increasing trend since 1999 for some supermarkets in the UK to specific GM-free animal feeds.

In the Australasian market Robertson (2002) recorded similar activities as some manufacturers moved to GM-free ingredients to meet the requirements of some supermarkets to avoid the Food Standards Australia New Zealand (FSANZ) GM label on their own-brand products. In both the Australasian and the UK/EU cases, both retailers and some major manufacturers were moving to ensure GM-free product in their brands.[5]

Institutional preferences, retailer strategy and trade barriers are still strongly operating against GM food products in a number of countries. While the industry has been hoping for a quick reduction in these, there is an ongoing dispute between the EU and US over the moratorium on approving new GMOs and the extent and nature of the new regulatory regime for GMOs in the EU.[6]

[5] Thehighest profile manufacturer in New Zealand to go GM free in animal feed is Tegel ('Tegel vows no GM feed for its chooks'. New Zealand Herald, Aug 29 2001).

[6] White House trade advisers have recently advocated against the US pushing ahead with its intended action of taking the EU to the WTO over barriers against GM products (*New York Times* 2003). Such advice was given in the context of a public disagreement between Robert Zoellick (US Trade Representative) and Poul Neilson (EU Development Commissioner) over the legality of EU actions over GM food (*NZ Herald* 2003). This is one possible explanation of why long-promised US action at the WTO is being delayed.

It is arguable that the ongoing difficulties in all three areas – institutional preferences, retailer strategy and trade barriers ─have led to the key political dynamic within North American agriculture evident over the last two years, namely, a broadening of anti-GM sentiment out from the niche groups of environmentalists and organic producers. Instead, opposition to new GM crops in both Canada and Switzerland shows a broad coalition of mainstream agricultural organisations and companies opposed on purely economic grounds to the introduction of new crops. Likewise, some farm groups representing mainstream agriculturalists have begun to mobilise in opposition to GM in agriculture over the last 3 years.

The most intriguing aspect of this dynamic is the difference between farmer politics in commodities where GM crops are already present (corn, canola, soybeans) and in potential new crops (wheat). While activism against GM in the established crops is present, in general, growers are steadily adopting the technology. However, the reception of GM wheat shows a completely different political dynamic. Broad groupings are opposed, including such influential organisations as the Canadian Wheat Board. The key difference appears to be that farm groups and industry organisations consider that once GM is released in a sector, it is a *fait accompli*, and the chances of successful segregation or reversion to non-GM are small. In contrast, in sectors where GM is not present, hard questions are being asked as to the economic merits of the technology.

4. Country Case Studies: Switzerland and Canada

It is interesting to note whether other countries that trade on an environmental image have also raised questions about the uses of GM technologies. The two key comparisons are Switzerland and Canada. The consumer and in-bound tourism surveys reported elsewhere in this report clearly showed that New Zealand, Canada and Switzerland trade to some extent on a positive environmental image. This section reviews the current state of policy and concerns about market image in the light of biotechnologies (including GM).

4.1 Switzerland

A comprehensive review of Swiss biotechnology developments is provided by Bonfadelli et al. (2001). The Swiss government has been faced with conflict between two important political constituencies. In general, the Swiss public have been described as strongly anti-GM. However, there is also a substantial Swiss biotechnology industry. The Swiss government's attempts to regulate a path between the two has involved two initiatives: the Gen-Shutz and the Gene Lex initiative:

- In 1993 a Swiss 'popular initiative' - the Gen-Shutz Initiative (GSI) - was submitted for parliamentary debate. The initiative called for the prohibition of
    1. the production and sales of GM animals;
    2. the release of GM plants and animals, and
    3. the issuing of patents on GM plants and animals.

- By 1997 the Swiss parliament had developed an indirect counterproposal to the GSI with a specific gene law. Similarly Swiss industrialists decided to follow the strategy of not directly opposing the GSI, but rather pushing for additional legislation. In March 1997 the first draft of the proposed Gene Law was issued by the Swiss government, specifically addressing the regulation of gene technology. In addition they took some time to develop the 'Gene Lex package' which involved modifications to various other laws, mainly within environmental legislation, but also those concerning areas such as agriculture.
- In April 1998, a unique event occurred when several hundred genetics researchers and sympathisers gathered to march in demonstration against the GSI.
- The vote on the GSI was eventually rejected by a majority of Swiss voters (66.6%).
- In January 2000 new drafts of the Gene Law and the Gene Lex Package were published for further debate. The Gene Lex package was supported by most organisations, including the pharmaceutical industry and farmers, but criticised by some branches of the agricultural industry and by environmental organisations (Bonfadelli et al. 2001).

In October 2002, after lengthy debate, parliamentary representatives narrowly rejected the proposed five-year moratorium. However, they approved fairly strict regulations on the planting and labelling of GMOs. The debate was the subject of intense lobbying, from both environmental groups on one side and agrochemical companies such as Syngenta on the other (Reuters News Service 2002).

There has been some reporting of political debates inside Switzerland as to whether GM is compatible with their natural image. In 1999, Switzerland's federal environmental office (BUWAL) turned down a request to trial T25 maize, citing health and environmental concerns. The BUWAL statement said the ruling also sought to protect the image of Swiss products: "Swiss agriculture lives on our products' reputation for being pure and close to nature. Such gene technology experiments affect this image. This can have a far reaching impact on our agricultural sector" (cited in ProMED Mail Communication 1999). The statement also referred to the position of 'Switzerland as a unique GM-free island within Europe'.

In October 2002, however, the Swiss parliament voted not to impose a moratorium on GM testing. In response, a coalition of Swiss farmers and retailers announced a voluntary boycott on producing and selling genetically modified food. The Swiss companies/organizations declared they would not use GMOs now or at any time in the future, and would do all they could to maintain the GM-free status of the whole production chain, including the providers of their raw materials. The group included the Swiss Farmers Organisation (90% of Swiss farmers), Organic Farmers Organization (10% of farmers), Swiss Milk Producers (100%), Swiss Bakers Federation, Migros, Coop (retailers controlling 70% of the market) and Carrefour (Swiss Info Organic Newsline 2002). Additional to the boycott, the Swiss farmers' union announced an initiative of marketing food with a 'Made in Switzerland, without GMO' label (Thuburn 2002).

Currently, the Swiss government is trying to make space for this initiative to occur without disabling the activities of the large Swiss-based biotechnology companies. Their solution is the proposed Gene Lex package and many parties are watching closely to see whether the Swiss can form the Gene Lex package into a workable regulatory framework.

4.2 Canada

Canada also trades on an environmental image – but unlike Switzerland is strongly centred in bulk commodity trading. Media reporting suggests that there has been some widespread discontent in those sectors (corn, canola) where European bans have hurt export returns.

The Canadian government has played a pro-active role in the development and promotion of biotechnology:

- The Canadian government identified biotechnology as a strategic technology in 1980 and announced a National Biotechnology Strategy in 1983. The focus of the strategy was on promoting biotechnology research in a few targeted areas including agriculture, forestry, aquaculture and pharmaceuticals (Einsiedel & Medlock 2001). The Canadian Biotechnology Strategy (CBS) vision is: "to enhance the quality of life of Canadians in terms of health, safety, the environment and social and economic development by positioning Canada as a responsible world leader in biotechnology" (CBS 1998: 8).
- The Canadian regulatory system for products of biotechnology is based on the assessment of 'novel traits', in a product rather than process-based philosophy. Canada has chosen to amend existing legislation and regulatory departments to accommodate these new products (Flint et al. 2000).
- Seven ministries share responsibilities in biotechnology regulation: Agriculture, Health, Environment, Fisheries, Mining, Industry and Foreign Affairs and Trade.
- For products of food biotechnology, the Food and Drugs Act was supplemented by the Novel Foods Regulations in 1999 (Einsiedel & Medlock 2001).

Canadian agriculture is highly dependent on world markets, with 70% of the country's total agricultural production being exported. Value-added or new crops have been held to play an important role in meeting Canada's domestic and international agricultural needs. Such products have been approved and trialed in Canada at a rapid rate, second only to the US. Approved biotechnology crops in Canada are sugar beet, argentine canola, polish canola, squash, soybeans, cotton, tomato, potato and corn (Einsiedel & Medlock 2001). However, canola is the main commercial GM crop, grown predominantly on the prairies. Approximately 60% of the canola there is genetically modified. Maize and soya are primarily grown in Ontario. In 2001, the total area of transgenic crops in Canada was estimated at 3.2 million hectares (Warrick and Meziani 2002).

Canada has a strong environmental image. However, the relationship between this image and commodity trading are not clear – especially the experience of GM commodity exports from Canada which, have suffered significant declines in export volumes to Europe due to moratoria on some GM products. Currently, Canadian farmers grow GM

canola, soybeans and corn, including varieties which are not approved by the EU. There is an effective ban on canola due to the problems of the bulk-handling system, where GM and non-GM canola are mixed together. The proposed European rule of 0.5% GM thresholds for unauthorised grain have Canadian exporters concerned that guaranteeing non-GM shipments to Europe will be virtually impossible (Rampton 2002).

EU moratoria and regulations on GM also hold implications for the debate over whether GM wheat should be commercialised in Canada. Canadian food exporters and the wider public have voiced great concern over the potential introduction of GM wheat into Canada. The extent of this concern was demonstrated in July 2001,when an unprecedented coalition of 210 major agricultural, environmental and citizens groups in Canada (including the Canadian Wheat Board and the National Farmer's Union) wrote to Prime Minister Jean Chretien asking: "[that] you act immediately to prevent the introduction of GM wheat into Canadian food and fields unless the concerns of Canadian farmers, industry, and consumers are addressed adequately" (cited in Phillipson 2001).

Perhaps the most revealing participant in this anti-GM wheat coalition is the Canadian Wheat Board (CWB). The CWB is solely responsible for the sale and marketing of Western Canadian wheat and barley and is one of the world's largest grain marketing companies. Of particular concern to the CWB was the potential loss of major export markets if the conventionally grown Canadian wheat supply became contaminated by GM wheat (Phillipson 2001).

Within this debate, Canadian producers have repeatedly cited the case of Australia stealing Canadian markets – something Australian farmers also seem to be aware of. A canola farmer from Victoria argued that Australia's 'clean green image' in regard to GM gave an advantage over many competitors and has even helped gain markets in the European Union that were previously supplied by Canada (Jackson 2002).

4.3 Summary

The case study countries show that for Switzerland, the compatibility between GM and an environmental image is an ongoing political issue for local producers and companies. The government has not yet provided a solution in either Canada or Switzerland. For Canada, even as a commodity trader, the major coalition against GM wheat is important. However, this coalition is based more on direct market access crises rather than impacts on Canada's environmental image.

In both cases, there has been a major transition over the last 18 months from opposition to GM being centred in the organic agriculture (and environmental groups) sector to a more broad-based concern (on purely economic grounds) from other producers, companies and producer boards.

5. Discussion

The effect of an adoption of GM in agriculture on New Zealand's CGI is tied up in the larger issue of the economic performance of GM agriculture generally. There are three areas of critical interest in the economic performance of GM in agriculture and food:

- market demand reflecting consumer sentiment towards the products;
- institutional preference, retailer strategy, trade barriers and the politics of market protection against GM; and
- on-farm evaluations of GM applications outlining tangible benefits or productivity gains.

While the results vary for different types of GM, the overall picture is sobering for the use of GM in food crops, while considerably more positive for GM in pharmaceutical and other medical uses.

In the current circumstances, market demand still remains poor for food derived from GMOs; with most GM products experiencing lower demand than their non-GM counterparts. One exception for agricultural producers is cotton – a non-food product. Similarly, medical products derived from GM ingredients or processes are not subject to the same broad negative market sentiments.

Finally, while the two previous factors – market demand and access issues – have been constant since 2000, the third issue – actual economic performance of GM crops in US agriculture – is only now becoming clear. Data from more years, more crops, and more regions has become available. While GM cotton remains positive, corn and soybean production has been re-evaluated by the USDA since 2000, and this evaluation suggests that these crops have actually under-performed on the farm.

While these conclusions can be drawn from the available literature, this review has served to indicate where there is very little knowledge about GM products, consumers and markets. The following section outlines these key issues which remain unresolved or cannot be informed by existing data.

5.1. Issues Outstanding

Clearly, there are no final answers as to the extent and nature of the risks and opportunities presented by GM in commercial production. There are, however, much clearer indications in the prior literature as to what the key issues are:

• To what extent is New Zealand's trade image influenced by consumer perceptions of New Zealand as having a good environmental image?

• What share of our overseas market might be influenced by shifts in this environmental image?

• What is the strength of the association between GM and broader environmental image in New Zealand?

• Does New Zealand export to consumers who hold a generic vision of New Zealand as a 'clean green' country, no matter what products they are purchasing?

• How will consumer sentiment be influenced by the presence of commercial GM activities in New Zealand even if such activities are not directly related to the kinds of products from New Zealand that are being purchased?

• What is the possible consumer reaction to non-GM animal products in which the animals were fed GM animal feed?

• What are the risks and opportunities presented to mainstream New Zealand agriculture (rather than to the small organic sector) by GM?

• What are the economic risks and opportunities of deploying GM technologies in environmental remediation?

• What are the risks and opportunities of deploying GM technologies in medicine?

• If New Zealand experiences adverse market effects from adopting GM products, what level of productivity gains would be required to ensure profitability for GM products?

• How likely is it that consumer purchasing behaviour will be influenced by price changes?

• Given that current consumer sentiment is negative for some segments of our markets, what are the characteristics of these segments (especially purchasing power)?

• What is the degree to which stated consumer preferences are actually expressed in purchasing behaviour?

• What is the likely duration of negative consumer sentiment in some market segments?

• What is the likely duration of institutional lock-out of GM products in markets by the likes of supermarket chains?

• What is the GM-free premium that markets are prepared to sustain in the long term?

• What is the likely lead-time in the development of novel GM products that will have strong commercial relevance to New Zealand?

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