chapter

7.

Crops and other field uses

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Key issues:

- The effect of genetic modification on our unique environment and biodiversity
- Whether the risks associated with genetically modified crops can be minimised
- Can we provide a strategic framework that allows for organics, conventional farming, IPM horticulture and genetically modified crops?

Introduction

1. Much evidence was presented to the Commission on the use of genetic modification in food crops. Non-food applications of genetic modification were also discussed, including uses in forestry, pest and weed control, bioremediation and bioreactors.

2. This chapter discusses, among other things, the use of genetic modification in food crops in New Zealand. Food consumption and medicines are dealt with in separate chapters. Here we consider for the first time the release of genetically modified organisms and products into the environment.

Crops, fruit and vegetables

Applications and benefits

3. Genetic modification of crops is generally undertaken to:

- incorporate pest or viral resistance into plants
- incorporate herbicide tolerance
- increase yields or improve nutritional quality
- slow ripening in fruit and flowers by inhibiting the actions of certain genes
- change colours in fruit and flowers, again by inhibiting the actions of certain genes.

4. Genetic modification can lead to crop improvements more quickly than classical breeding, by efficiently identifying and transferring the desired trait. That characteristic alone is propagated.[1] Balanced with such benefits are the potential risks that genetic modification introduces, such as the ability to cross the species boundary and the uncertainty and potential for harm this introduces.[2]

5. Currently there are no genetically modified food or other crops approved for open field release in New Zealand. New Zealand's current crop production systems include traditional or conventional farming, IPM (Integrated Pest Management), and organic farming. IPM was defined by Dr Hugh Campbell, social geographer and witness for the Organic Products Exporters Group [IP53], as "an internationally recognised movement in which scientists attempt to create crop and livestock management systems that reduce reliance on broad spectrum chemical interventions and promote more ecologically integrated solutions to pest control".[3] IPM production systems are more environmentally friendly and are closer to the organic system of production than to conventional farming. They have been fostered in New Zealand by the pip fruit, kiwifruit and wine industries.

6. The fact that genetically modified crops are not commercially grown in New Zealand is not clearly understood, as the Commission's survey shows. The survey results showed that 680 of respondents believed genetic modification was currently being used in commercial crops in New Zealand, with 58% disapproving of such use. There is also confusion in the public understanding of the path between experimental work and commercial release. To date, genetic modification has only been used as a research tool in New Zealand's primary industries. Research is being undertaken to understand how plants, trees and animals grow, to develop new varieties of plants and animals, alter the production efficiency or quality of food, crops and fibre, and develop new products.[4]

7. The Ministry of Agriculture and Forestry (MAF) in its public submission told us that "genetically modified crops have been rapidly adopted by farmers in some overseas countries, but genetic modification is mainly used as a research tool in New Zealand".[5] MAF noted that China was the first country to grow genetically modified crops commercially in the early 1990s, with the United States establishing widespread commercial plantings of soybean and corn crops in 1996. MAF stated that genetically modified crops are grown in 12 countries and occupy close to 40 million hectares (approximately 1.5 times the area of New Zealand). Internationally, most genetically modified crops are grown in the United States (72%), Argentina (17%) and Canada (10%), with minor plantings in China, Australia, South Africa, Mexico, Spain, France, Portugal, Romania and the Ukraine.[6]

8. In New Zealand the first contained field trials of genetically modified organisms were conducted in 1988 and since that time more than 50 approvals

have been granted for further contained field trials.[7] Genetic modification field trials in New Zealand have taken the form of small-scale experiments with a range of organisms. MAF lists these as: pasture plants (clover), fruit (apple, kiwifruit and tamarillo), vegetables (asparagus, broccoli, potato), field grains and crops (barley, canola, forage brassica, maize, peas, sugar beet), ornamental crops (*Lisianthus*, *Petunia*), animals (goats, sheep, cattle), trees (*Pinus radiata*) and microorganisms (bacteria).[8] Trials have not been conducted on soy or wheat crops in New Zealand.

9. The modifications in these trials were described as resistance to herbicides, viral, bacterial and fungal diseases, insects, and improvements in crop performance. Some examples were:

- peas, to test for pea mosaic virus which decreases yields
- tamarillos, to test for resistance to a virus which causes black spotting of the skins, decreases yields and shortens tree life
- potatoes, to test for resistance to potato tuber moth and to herbicide, to confer bacterial and insect resistance, and to improve the nutritional and cooking qualities of harvested tubers
- petunias, to alter form or colour and assess field performance.

10. As discussed in chapter 4 (Environmental and health issues), a research trial to develop salmon with additional growth hormone genes, with the ultimate aim of full release, has also been conducted in New Zealand. Concern was expressed about the standard of containment of the transgenic fish. The Environmental Risk Management Authority (ERMA) [IP76], responsible for the project from part way through its term, imposed significant improvements in the containment of the research. However when deformities developed in the fish, the research was terminated.

Economic benefits

11. Evidence identified likely economic benefits from genetically modifying crops as building agricultural expertise by making commodity production more competitive; the development of niche markets; expanded opportunities in New Zealand's knowledge economy; and decreased chemical use. The National Farmers' Federation of Australia, in a report on the Australian Gene Technology Bill 2000, listed production benefits from crops derived from gene technology as:

- increased resistance to pests and diseases
- associated reductions in pesticide and herbicide use, input costs and adverse environmental impacts
- reduced labour and energy costs
- improved yields and quality

- adaptation to industry and consumer requirements
- better accommodation to environmental and climatic factors (such as water shortages, salty soils and drought)
- incorporation of nitrogen fixing ability into crops, thereby promoting soil nutrition and enhanced productivity
- accelerated breeding of plants with improved characteristics, leading to productivity gains, such as faster growing trees and higher quality grains.[9]

Pasture crops

12. Dr Derek Woodfield, a plant breeder and geneticist at AgResearch [IP13], described research to develop white clover resistance to porina moth larvae,[10] and also high-energy white clover and perennial ryegrass. He saw among the benefits of such applications:

- the need to use less chemical pesticide
- improved energy yields from pasture plants (in turn leading to higher milk production and longer lactation in cows, greater weight gain and wool growth in animals, and reduced ammonia and methane pollution)
- improved yield and quality of pasture plants
- new knowledge of biological processes.

13. Similarly, Warwick Green, President of the New Zealand Plant Breeding and Research Association and an executive of Wrightson [IP3], outlined benefits of the genetic modification of ryegrass, noting there was potential to modify ryegrass pollens to eliminate the allergic response in humans and to improve animal health by reducing the nitrate toxicity level of greenfeed crops.

14. Genetic modification might also have the potential, through modification of grasses such as ryegrass, to develop deeper root structures that could stabilise high country soils. Genetically modified crops with improved uptake of nutrients might also be developed, requiring less fertiliser and in turn reducing nutrient run-off into waterways and the subsequent over-production of weeds.

Seed production

15. New Zealand is internationally recognised as a producer of high quality seeds and has a national seed certification scheme. Neil Barton, a Canterbury seed farmer and chairman of the Grains Council of Federated Farmers a witness, for Federated Farmers of New Zealand [IP34], provided evidence about the counter-season seed production opportunities in New Zealand. He noted that the ability to adopt genetic modification technologies created further potential to develop a large-scale and profitable seed multiplication industry in this country. Mr Barton said that the production of seed crops here during the northern

hemisphere winter enabled plant breeders and seed multipliers to double their annual production volumes and increase the rate of genetic gain in plant varieties. Similarly, Aventis CropScience [IP14] stated locating seed production and evaluation trials in New Zealand allowed two seasons in a single year for field trials, and such benefits had been recognised here by major seed companies such as Pioneer, Pacific Seeds and Wrightson Research.

Horticulture

16. HortResearch [IP5] mentioned in its submission that in its research and development programmes, genetic modification technologies were used in relation to plant breeding, crop production and post-harvest handling. Dr Richard Newcombe, plant molecular biologist for HortResearch, said these included HortResearch's initiation of a genomics project to discover and determine the function of genes from New Zealand's key horticultural crops, including apples and kiwifruit.

17. New Zealand Vegetable and Potato Growers' Federation/New Zealand Fruitgrowers' Federation/New Zealand Berryfruit Growers' Federation (Vegfed, Fruitgrowers, Berryfed) [IP75] said in its submission it had previously supported a trial to produce potato plants with genetically modified resistance to the potato tuber moth, the major insect pest of potatoes in many parts of the world. A trial to produce genetically modified resistance to alfalfa mosaic virus (AMV) in peas had the potential to reduce the economic impact of the disease on growers.

18. Vegfed, Fruitgrowers, Berryfed also supported a HortResearch project to introduce resistance to tamarillo mosaic virus (TaMV) into tamarillo plants, which has the potential to increase tamarillo exports:

> Most tamarillo plants in New Zealand are infected with this virus. TaMV remains a barrier to tamarillo exports because infection is obvious and fruit quality is reduced.[11]

19. HortResearch's genomics programme has benefits for Vegfed, Fruitgrowers, Berryfed. The programme includes gene discovery efforts across a number of target areas, such as the genes involved in the synthesis of secondary metabolites, including antioxidants and vitamins, known to be present in abundance in apples, kiwifruit and berryfruit. The HortResearch project will generate a number of product opportunities using marker assisted selection. This method, referred to as 'smart breeding', uses genetic identification at the level of seeds or young plants to identify desired traits, rather than waiting years until the plant matures and has seeds or fruit of its own. The time taken for breeding is condensed. Dr Sue Gardiner of HortResearch, who uses smart breeding to develop new apple varieties, stressed the trees themselves were not genetically modified.

20. Dr Adolf Stroombergen, economist, Infometrics Consulting Ltd, appearing for New Zealand Life Sciences Network [IP24], noted in his witness brief that genetic modification could be used to provide disease resistance to apples, "notably resistance to black spot and powdery mildew", and that, while there may be some output benefit in terms of higher quality apples, the main benefit was on the input side:

> The annual cost of spraying for black spot and powdery mildew is $43 million. World-wide the spraying programme is estimated to be worth $6 billion per annum. Thus a successful product would also generate income from intellectual property and gene patents, plus royalties and licence fees from new plant varieties.[12]

21. Peter Corish, a farmer and Chairman of the Australian Cotton Industry Council, who was called by Federated Farmers, told us about his experiences growing Bt cotton. On his farm Mr Corish had been growing Ingard cotton, a Monsanto product with a Bt gene fused into a conventional cotton variety. The Bt toxin used in Ingard cotton is target-specific to the heliothis caterpillar, a major pest in Australian cotton crops. The principal benefit that Bt cotton provides is the reduced use of pesticides. Mr Corish estimated where he has Ingard cotton plantings his usage of pesticide has been reduced by 50%:

> The use of Ingard cotton has allowed us to reduce our pesticide usage by 50% and in some cases more than 50% in the areas where Ingard cotton is grown. That means it's easier to manage in sensitive areas, for example, around houses, waterways, roads, where some of those public issues really come to the fore.[13]

22. Mr Corish said that Ingard cotton was introduced into Australia in 1996 and had been readily accepted by growers. He noted that consumer issues around Bt cotton had not generally arisen: "I would suggest that one major reason for that is that people wear cotton, they don't actually eat it."[14] In Australia, conditions had been imposed on the use of Ingard cotton, requiring that no more than 30% of a planted crop could be Ingard cotton, so that the chances of the heliothis caterpillar developing resistance were minimised.[15]

Managing risks

23. Many of the environmental risks that might be generated by genetically modified crops have been addressed on a general level in chapter 4 and chapter 6 (Research).

24. The Commission considers that more research is needed into the environmental risks that genetically modified crops and non-food uses might pose for the ecosystems into which they could be released.

Bt modified crops

25. *Bacillus thuringiensis* (Bt) is a bacterium that creates its own insecticide. Bt plants have been modified to produce this substance in their leaves and/or pollen all year round. Insects that eat the plant die, so the plant is protected. Molecular geneticists designed these crops to help farmers sustain better yields using fewer sprays. Overseas, Bt has been incorporated into many genetically modified plants to protect plants from insect pests.

26. The Department of Conservation in its public submission commented on the impact that Bt bacteria might have such as

- risks to native insects related to the pest being targeted
- Bt plants might hybridise and threaten the integrity of indigenous species
- adverse effects on ecological processes in indigenous ecosystems
- modified plants hybridising with weeds in the conservation estate.

27. The Commission heard from organic producers about their use of the Bt microorganism as an insecticidal spray and their fear that the continued presence of the toxin in Bt plants would increase the risk of Bt resistance developing in the local insect population, and ruining one of their defences against insect attack. Home gardeners also use Bt spray.

28. Bt-modified crops are usually restricted to a proportion of the total crop in order to provide "refugia" for beneficial insects. As noted, Peter Corish told us in Australia Bt-resistant cotton has a post-release condition limiting it to 30% of the total cotton crop planted. The Commission agrees that Bt resistance is to be avoided and considers that New Zealand needs to develop a strategy to manage the use of this insecticide whether incorporated in plants or used as a conventional spray. This is to delay the inevitable emergence of insect resistance.

Recommendation 7.1

that, prior to the release of any Bt-modified crops, the appropriate agencies develop a strategy for the use of the Bt toxin in sprays and genetically modified plants, taking into account:

- **the concept of refugia**
- **limitations on total planted area**
- **home gardener use.**

Increased weediness through outcrossing

29. A number of witnesses presented material to the Commission stating that genetically modified plants would take over and result in the development of super weeds. Whether or not a crop will develop as a weed depends on the

characteristics of the plant. Professor Klaus Ammann, a Swiss botanist called by the Life Sciences Network, provided a list of the characteristics of weeds in his witness brief. The Royal Forest and Bird Protection Society of New Zealand [IP79] also noted that some plant species become weeds more predictably than others. Plant species that exhibit easy cross-pollination traits are most prone to weediness, including floriculture plants and crops such as oats, barley, ryegrass, sunflowers, and oilseed rape (canola).

30. The problem of outcrossing was often raised by submitters. Outcrossing is the term given to cross-pollination with compatible relatives.

31. We heard evidence from various parties that some crops posed higher environmental risks than others. Professor Ammann provided the Commission with a risk assessment framework for genetically modified crops that identified whether the crop was invasive as a weed and whether it would hybridise with wild relatives. He used three indicators that determined the chances for successful gene flow: the dispersal of pollen, the dispersal of diaspores and the frequency of distribution of wild relatives. Using these codes Professor Ammann had developed five categories of risk probability for gene dispersal from transgenic crops to wild flora, ranging from no gene flow effect through to substantial and widespread effects. The Swiss analysis found that crops such as fescue, alfalfa and ryegrass would have substantial and widespread risk, but other crops such as potato, maize and tomato would have no effect as they had no wild relatives in Europe and had little risk of weediness.[16] Dr Cohen stated in his evidence that in New Zealand very few introduced plants were able to hybridise with native flora and very few crop plants had weedy relatives here, apart from weedy brassicas. These weeds were accidentally introduced with crop seeds and are not native to New Zealand.

32. Dr E. Ann Clark, a pasture-grass scientist from Canada called by the Green Party of Aoteoroa/New Zealand [IP83], reported in a research paper[17] that outcrossing with weedy ancestors is not a problem with genetically modified crops if there is no wild relative or weedy ancestor for the crop in the vicinity. Professor Ammann also provided evidence supporting this view, as did Dr Michael Berridge, the Acting Director of the Malaghan Institute and a witness called by the New Zealand Association of Scientists [IP92]. Dr Berridge stated, in relation to pollen drift from genetically modified plants, that "many plants used for food production purposes do not have weedy characteristics and have no wild relatives in New Zealand".[18] He commented that selective breeding for food purposes has essentially ring-fenced most crop plants by reducing fitness to survive in the wild and that "terminator technology" could be applied where there might be a threat to native flora or where weedy characteristics were present. Terminator technology is one of the sterility technologies discussed below.

33. The Commission heard no evidence that genetic modification increased invasiveness of weeds. Certainly canola can become a weed pest in certain environments, but genetic modification of this plant does not appear to increase its weediness.[19] Several witnesses provided examples of situations where canola had developed as a weed. Percy Schmeiser, a canola farmer from Saskatchewan, Canada called by Bio Dynamic Farming and Gardening Association in New Zealand [IP61], told the Commission that canola had become a major noxious weed in Canada and could be seen in towns and along roadways.[20] Nelson GE Free Awareness Group [IP100] also commented that crops of canola in the South Island had resulted in the appearance of canola weeds.[21]

34. Dr Beatrix Tappeser, Head of the Department of Risk Assessment of Genetic Engineering at the Institute for Applied Ecology at Freiburg, Germany, and a witness called by the Pacific Institute of Resource Management [IP84], said experience and data pointed to a high probability that canola populations would prevail outside cultivated areas, as well as to the possibility of gene flow to non-transgenic populations and to wild herbs. Dr Tappeser cited an example where under field conditions canola had proven capable of hybridising with wild turnip, wild radish, wild mustard and a variety of other mustard species.[22] Dr Anthony Connor, a plant geneticist with Crop and Food Research [IP4], said,

> In our recent extensive report on "Ecological risks and managerial consequences of Roundup Ready oilseed rape in New Zealand" it was concluded: Artificial and natural field hybridisation studies, and current geographical distributions of casual escape, naturalised, indigenous and endemic species in the large Brassicaceae family, reveal that field hybridisations between oilseed rape and most other Brassicaceae species are highly improbable. Hybridisation of oilseed rape with wild turnip (B. rapa ssp. silvestris) and B. juncea is, however, likely to occur, but the hybrids will be largely confined to the land growing the oilseed rape where they will readily succumb to the methods currently employed for controlling volunteer plants of conventional non-transgenic rape.[23]

35. A study undertaken in the United Kingdom aimed to find out whether transgenic plants would be likely to persist in the wild if they dispersed from their cultivated habitat. The study involved four transgenic crops (canola, potato, maize and sugar beet) grown in 12 different habitats over a 10-year period. The study results indicated that "in no case were the genetically modified plants found to be more invasive or more persistent than their conventional counterparts".[24] Virtually all transgenic plants had died out within two to four years.

Pollen dispersal

36. Dr Phillip Salisbury, Senior Plant Breeder and Researcher from the University of Melbourne, called by the Life Sciences Network, Monsanto New Zealand [IP6] and the New Zealand Feed Manufacturers Federation/Poultry

Industry Association of New Zealand/Egg Producers Federation of New Zealand [IP35], stated in his evidence that canola pollen is transferred by wind and insects, especially honeybees, and that pollen counts decline steeply with distance from the crop. He noted that the vast majority of canola pollen travels less than 10 metres, although in extreme cases it can disperse by wind up to 1.5 kilometres, and by insect transfer up to 4 kilometres. Dr Daniel Cohen, a plant scientist with HortResearch, said, when looking at pollen movement, factors needing to be considered included how far the pollen can travel, how long it remains viable, the receptivity that a plant stigma has to the pollen and the concentration of competing viable pollen. Dr Cohen told the Commission that wind-borne pollens from some plants such as pine trees were light and could be dispersed over large distances, whereas other pollens like those from maize were heavier and fell within a metre of the plant.

37. Robert MacDonald, a witness for Aventis CropScience, discussed the pollen dispersal of canola, saying that some pollen grains might be transported by wind over distances of 32 metres, but around 75% of the total pollen was captured within 6 metres of the parent plant. He also cited other pollen monitoring studies that showed pollen had dispersed up to 400 metres from large release areas of transgenic canola. Mr MacDonald is the Global Product Safety Manager for Oilseed Rape (Canola) from Saskatchewan, Canada, and provided evidence that seed loss and dispersal from harvesters and grain transport trucks represents the main mechanism for the long-range dispersal of canola, regardless of its transgenic nature.[25]

Herbicide use

38. Herbicide resistance in genetically modified crops has been promoted to farmers as a means of reducing the need to use herbicides to control weeds. The Forest and Bird Protection Society stated in its written submission that a range of issues arose with the development of herbicide-resistant crops, including the development of resistance to the herbicide, effects on non-target species and the possibility of the transgenic crop becoming a weed.

39. Although several witnesses claimed that planting herbicide-resistant crops would lead to reduced herbicide use, evidence was also presented that some herbicide-resistant plants were double or triple stacking resistance to a range of herbicides, resulting in the need for an alternative, and potentially more toxic, herbicide to control volunteer self-seeded plants. Dr Lin Roberts in her background paper prepared for the Commission on *The Environmental Aspects of Genetic Modification*, cited evidence[26] that the herbicide resistance modification increased the use of herbicides, giving examples of increases in glyphosate usage in the United States.

40. Lavern Affleck, a witness called by the Bio Dynamic Farming and Gardening Association in New Zealand [IP61], referred to problems arising from the use of genetically modified Roundup Ready canola. Mr Affleck, a cropping farmer from Saskatchewan in Canada, gave evidence by video link, telling us that he did not mind being indoors as the outside temperature was minus 20 degrees. He chose not to plant Roundup Ready canola as he was aware it could result in herbicide-resistant volunteers (self-seeded) establishing themselves as weeds. However, because of contamination from neighbouring fields of Roundup Ready canola, Roundup-resistant seeds had transferred to his land, with the result that he could no longer rely on Roundup alone as a weed control agent. Mr Affleck did not attribute this to carelessness on anyone's part: "There is just no practical way of keeping it out of our fields."[27] Mr Affleck acknowledged Monsanto's help in spraying with 2,4-D but said that once the Roundup Ready crop "escaped", despite best efforts it was impossible to control. He spoke of volunteer canola that was resistant to three herbicides, and that some suspected of resistance to 2,4-D was now showing up as well. He noted that in his experience crops and weeds were spread in many ways: by wind, waterways, and farm machinery and trucks. He commented that some degree of genetically modified crop contamination was now present across the entire Canadian prairie.

41. It appeared to the Commission that Mr Affleck raised some important concerns. We consider that there are potential risks involved in planting genetically modified crops on a large scale, and that sufficient consideration should be given to the dangers involved and the controls that ought to be put in place.

42. Roundup Ready crops on the market include many not currently important to the New Zealand agricultural economy, such as soya beans, canola for oil and hard maize for animal feeds. These commodity crops are profitable when grown in large quantities, for example on the plains of Canada. The Commission believes that the so-called first wave of genetically modified crops has little to

Percy Schmeiser and Monsanto

Percy Schmeiser and his litigation with Monsanto had become familiar to the Commission long before his appearance as a witness for the Bio Dynamic Farming and Gardening Association. Anti-genetic modification campaigners mentioned his case as exemplifying the perceived evils of genetically modified crops and multinationals in the genetic modification business. In the event the Canadian court held that Mr Schmeiser had knowingly used genetically modified seeds without authority, thus infringing Monsanto's patent. Although we mention the case because of the frequency with which it was brought to our attention, the Commission does not consider it helps solve any of the issues before it.

offer New Zealand, apart from small, specific applications such as counter-season seed multiplication (Wrightson) or specialised pure seed production (Aventis CropScience).

43. Having regard to the evidence on the use of herbicide resistance genes, including the resulting dependency on herbicides for weed control and the possibility of an increase in herbicide resistance in weed plants, we do not consider that these limited uses justify the environmental risk to New Zealand, until more is known about the size and management of that risk. We acknowledge production of pure unmodified seed might provide an economic opportunity.

44. While this is a matter for ERMA the Commission considers crops using herbicide resistance genes should not be approved for release (conditionally or otherwise) until (a) it is clear there is no trend indicating either increased use or increased toxicity of herbicides, and (b) research indicates there is no increase in the weedy outcrossing involving herbicide resistance genes.

Biosecurity and seed certification

45. MAF commented that New Zealand's isolation and border control activities had ensured that we had one of the highest levels of biosecurity protection in the world. However, our borders were not impenetrable, as recently evidenced by the illegal importation from Australia of the rabbit calicivirus (RCD), a viral haemorrhagic disease, in an attempt to control rabbits throughout the country. The Hazardous Substances and New Organisms Act 1996 (HSNO), covering the importation of new organisms, and the Biosecurity Act 1993, covering exclusion, eradication and effective management of pests and unwanted organisms, were in force at the time.

46. A difficult question arising for New Zealand's biosecurity is how to tell whether crops or products imported into New Zealand have been genetically modified. Government is aware some imported seeds may contain a small proportion of genetically modified contaminants and has therefore stepped up security measures to include testing of all imported seed. MAF stated in its written submission that even with the X-ray machines at our international airports some high-risk goods such as seeds are difficult to detect because of their size and shape. It noted seeds are often brought in with passengers or sent in the mail. MAF also commented there is no generic test to detect for genetically modified goods coming into the country and that it relies on importers obtaining the appropriate approvals from ERMA. We therefore acknowledge it is difficult to keep all genetically modified organisms out of the country.

47. Warwick Green, the President of the New Zealand Plant Breeders' Research Association and a witness called by the New Zealand Arable-Food Industry

Council [IP56], said that New Zealand had a voluntary seed quality assurance scheme, administered by MAF as the regulatory authority. Mr Green said “the seed certification scheme can provide an assurance of purity for GM cultivars just as it has done for conventionally bred cultivars for the last 80 years”.[28] The Arable-Food Industry Council believed an industry code of practice was required for management of genetically modified crops, similar to codes that operated in countries such as the United Kingdom. Neil Barton commented in his written evidence for the Council that

> the New Zealand MAF Seed Certification Scheme is recognised world-wide, and provides purchasers of New Zealand seed with an assurance of high quality product that is true to type, and free from disease and weed contamination.[29]

48. Mr Barton told the Commission that the grain and seed industry in New Zealand has “an industry recognised protocol for isolation distances for crops to ensure that we don’t have cross-contamination problems, particularly for vegetable seed brassica”.[30] Mr Barton said that the protocols were voluntary and to a large extent neighbours worked together, notifying each other of crop locations, to achieve the isolation distances. He commented that where farmers signed a contract to grow a variety of seed vegetables, they had to give an assurance that they could achieve the isolation distances.

49. Dr Morgan Williams, the Parliamentary Commissioner for the Environment [IP70], advised the Commission that to handle genetic modification issues such as pollen drift New Zealand would need more formal systems, and not rely on informal agreements between neighbouring farmers, particularly if it moved toward a more corporate system of farming.[31]

50. Later in this chapter we discuss and make recommendations on the use of buffer zones and separation distances to facilitate coexistence. As part of the Commission’s coexistence strategy, we also recommend in chapter 13 (Major conclusion) that communication networks be developed between different farming interests.

Ornamental and nursery plants

51. Research is currently being conducted to genetically modify petunia and lisianthus plants. An ERMA approval was granted to Crop and Food Research in 1999 for tests to assess the field performance of genetically modified petunias with altered form or pigmentation. When questioned by Greenpeace New Zealand [IP82] about the likelihood of pollen escaping from the petunia field trial, Dr Oliver Sutherland, Deputy Chair of ERMA, said that a requirement of the trial was that all flower buds be removed before they opened.

52. Flowers may be the first genetically modified organisms to be commercially released in this country, as they are not required to undergo evaluation for human health implications and will have a shorter pathway to approval.

53. The genetic modification of flowers and garden plants is likely to be directed towards novelty features or colourings and changes to growing cycles that will allow "out of season" flowering plants to obtain the best prices in high-value niche markets overseas.

Environmental impacts

54. Genetic modification of exotic rather than indigenous plant species reduces the likelihood of outcrossing problems with native species. However, in its written submission Federated Farmers stated that of the 240 naturalised invasive plants that were pests of the conservation estate, around 180 were brought into New Zealand as garden ornamentals. Examples of exotic garden plants that have escaped into the wild to become weeds include lupins, morning glory, Californian poppy and the ginger plant.

55. ERMA documentation[32] supplied to the Commission for the petunia field trial showed that the environmental assessment undertaken as part of the application involved investigation of gene transfer to other plants including natives, non-modified petunia plants and a species of wild petunia. The assessment also looked at whether the modified petunia might establish a self-sustaining population. Control mechanisms proposed for the petunia field trial included buffer zones of non-modified petunias and location of the trial site away from residential areas.

56. The risk of a plant becoming a weed could be reduced by the use of sterility technology. This would accelerate the approval of an application to genetically modify a flower or garden plant since potential problems of pollen transfer by bees and insects would be reduced.

Labelling

57. Labelling of propagative material in order for producers to exercise choice was an issue raised by Vegfed, Fruitgrowers, Berryfed:

> We believe that labelling of seeds, nursery stock and other propagative material with their GM status is required. This is key to ensuring that information is passed down the production chain and vital in terms of producers being able to exercise choice about whether or not they grow GM crops.[33]

58. The Commission is aware of the number of developments in progress in this area and considers that some system of identification needs to be established.

Recommendation 7.2

that the appropriate agencies develop a labelling regime to identify genetically modified seed, nursery stock and propagative material at point of sale.

Bees

59. The principal issues affecting bees and bee products raised in evidence before the Commission included the potential for bees to:

- pick up pollen from genetically modified crops, whether in field trials or grown for production, and cross-pollinate non-genetically modified crops
- produce bee products, such as honey, which could not be guaranteed to be 100%-free from genetic modification.

60. Honeybees, through their pollination activities, are important to agriculture and the environment. Bill Bracks, Board Chairman of Comvita New Zealand [IP74], noted that honeybees are especially vulnerable to any effects of genetic modification of crops, as they rely almost exclusively on pollen as a food source. He also said there was a lack of publicly available evaluations of the effects of genetically modified crops on honeybees.

61. Comvita stated it was New Zealand's largest manufacturer of therapeutic bee products, exporting to more than 20 countries, and last year became a totally genetic modification-free food and dietary supplements company.[34] Comvita was therefore opposed to growing genetically modified food crops in New Zealand, as the company would suffer market resistance if its products, particularly manuka honey, could not be guaranteed genetic modification-free. Supporting this view, Dr Doreen Stabinsky, Science Advisor on Genetic Engineering for Greenpeace, said consumers in Europe were increasingly demanding honey sourced from areas where genetically modified crops had not been grown.

62. Comvita referred to honeybees being "free range" as they "can never be excluded from obtaining honey, pollen and propolis resources from any commercially produced outdoor crop".[35] Dr Stabinsky also noted that honeybees were natural pollinators. She commented that bees liked the strong smell and the sweet nectar of canola and that the pollen grains from canola were sticky and could stay on a bee to fertilise plants with pollen on subsequent foraging trips. She cited evidence from the United Kingdom where six beehives located 0.5–4.5 kilometres from a farm-scale trial were found to contain genetically engineered canola pollen.[36] Dr Woodfield, a plant breeder and geneticist for AgResearch, spoke of experiments that looked at gene flow of white clover pollen from

transgenic to non-transgenic pastures. These experiments showed that 99% of pollen spread by bees was deposited within 24 metres of the pollen source and only a very small proportion (<1%) was transferred a greater distance.[37] Conversely, Jane Lorimer, Executive Member of the National Beekeepers Association of New Zealand, Poverty Bay Branch [IP62], said that bees flew distances of 6.5 kilometres to gather nectar and pollen and that bees would fly as far as 13.7 kilometres to a food source if no other sources were closer to the hive.[38] Dr Salisbury cited research by Ramsay and others (1999) that found most honey bee colonies foraged up to two kilometres from their hives, indicating potential to transfer pollen and fertilise crops up to four kilometres away.[39]

63. Other evidence suggested it was possible to provide control mechanisms for bees and genetically modified crops. Neil Barton said that, with bee-pollinated crops such as brassica, farmers tended to put hives beside the crop to keep away bees from further afield and avoid contaminating it. He noted that farmers employed isolation distances to prevent the bees from contaminating other farmers' crops.

Recommendation 7.3

> **that the Ministry of Agriculture and Forestry develop a strategy to allow continued production of genetic modification-free honey and other bee products, and to avoid cross-pollination by bees between genetically modified and modification-free crops, that takes into account both geographical factors (in terms of crop separation strategies) and differences in crop flowering times.**

Forestry

64. No genetically modified trees have been commercially released into the environment in New Zealand to date. The forestry industry is important to our economy, with forestry products valued at $3.11 billion, or 13% of total exports, for the year to June 2000.[40]

65. ERMA's documentation showed that small-scale applications have been approved for genetic modification field trials to test for resistance to herbicide in *Pinus radiata* (Monterey pine) and *Picea abies* (Norway spruce) trees. These trials are likely to take seven to nine years to complete and will be conducted in containment, meaning in this instance that the experiments will be conducted in contained laboratories and glasshouses. In those rare situations where they are grown outside glasshouses, the reproductive structures will not be allowed to mature, or have pollen or seed develop.

Potential benefits

66. Forestry industry companies and a variety of other organisations provided information to the Commission on specific potential benefits of genetic modification in forestry. Such benefits included:

- the ability to produce faster growing trees so that increased productivity could be achieved from the same land area in a shorter time frame. (This may have implications for the use of marginal land and for the conservation of native forests.)
- the ability to make trees infertile so that they produced more wood and less pollen. (Evidence presented at the public meeting held in Rotorua indicated that an infertile tree could produce up to 30% extra wood compared with a tree that was fertile.)
- the ability to produce trees with specific characteristics, including trees for efficient paper production and reduced downstream environmental effects from wood pulp processing. At the national hui in Ngaruawahia, Grant Hawke (Ngati Whatua) graphically commented on current paper production pollution saying that "to get white paper you get black rivers".
- the potential to produce by-products from currently under-utilised parts of trees, for example pharmaceuticals from tree bark.

67. Carter Holt Harvey/Fletcher Challenge Forests [IP17] gave evidence about additional benefits of genetically modified trees including the potential for new forestry products (such as a tree that might reduce the amount of energy consumed in paper production), the ability to improve the environmental performance of forestry by using genetic modification in pest management, and the ability to create social benefits such as high technology jobs in the forestry sector.

68. Dr Patrick Moore, a former Director of Greenpeace, Canada and of Greenpeace International, who is now involved in promoting sustainable forestry options, spoke for Life Sciences Network. He said that genetic modification of trees could lead to species that were faster growing, disease resistant, had better wood quality and would allow for the expansion of both native and exotic forests. The faster growth of plantation tree species would, he believed, make the industry more profitable. Environmental benefits outlined by Dr Moore included faster carbon uptake by the trees leading to a "reduction in net greenhouse gas emissions, better protection of soils, clean air and water, and the provision of more renewable fuel and material for the economy".[41]

69. Genesis Research and Development Corporation [IP11] also commented on a range of benefits that genetic modification would provide for the forestry

industry in New Zealand. The main ones cited were to landowners, from increased growth rates of trees, wood quality and tolerance of stress conditions; and to the environment, from improved biodiversity, bioremediation uses, reduced pollution and an increase in conservation lands.[42]

Environmental impacts and concerns in forestry

70. Potential impacts of using genetic modification in forestry that were brought to our attention included:

- greater areas of monocultural land use
- further loss of biodiversity in pine forests because of reduced undergrowth and seed spread
- dominance of one species over others that could lead to weediness as has happened with wilding pines[43]
- the potential impacts on insect and bird life of sterile trees if no flowers or seeds are produced
- the potential effects on soil nutrients and the water table from faster growing pines
- the potential risk of horizontal gene transfer from modified tree roots to soil microflora with impacts on soil ecology.

71. Additional concerns raised about genetically modified forestry in cross-examination of Carter Holt Harvey/Fletcher Challenge Forests related to the potential for:

- cross-pollination of genetically modified forest trees into neighbouring plantations certified as non-genetically modified
- pleiotropic or unintended side effects of genetic modification of forest trees
- the risk that side effects of genetic modification of forest trees might not be discovered for many years.

72. In response to issues raised about outcrossing or gene flow by pollination, the New Zealand Forest Research Institute [IP2] submitted that pine trees, as well as other plantation forest species used in New Zealand, had no botanically close relatives among New Zealand's indigenous flora and as result there had been no hybridisation of exotic with indigenous plant species. The Institute also commented that, although pollen from pine trees is able to travel large distances by wind, insect or animal vector, it can only pollinate other *Pinus radiata* or *P. attenuata*.[44] This gene flow risk was reduced further in current field trials for genetically modified radiata pine by removing any reproductive structures as they formed. Dr Moore stated that using sterility technology such as a "terminator

gene" in order to make plantation trees sterile would avoid further encroachment of exotic tree species into native forests.[45]

73. Monocultures of pine trees exist now in New Zealand. Genetic modification technologies may affect the area of land planted with pine trees as silviculture becomes a more viable economic option for land use.

74. In its submission, Greenpeace discussed the economic risks of genetic modification in forestry. Greenpeace noted that more and more consumers were demanding wood products that were certified and labelled as coming from forests that were managed in an environmentally appropriate, socially responsible and economically viable manner. Such forests could obtain Forest Stewardship Council (FSC) certification, but not if genetically modified organisms were employed. In New Zealand, Fletcher Challenge had recently obtained FSC certification, hoping this would provide significant marketing opportunities. Greenpeace noted that if genetically modified pine trees established themselves in FSC certified forests through pollen spread or wild seeding this would breach FSC certification principles and could lead to decertification.

75. Dr Stabinsky provided evidence for Greenpeace on hazards specific to genetically modified trees in New Zealand. With respect to gene flow and wilding pines, she noted that wilding pines were an invasive exotic species in New Zealand that were widely distributed by wind and established easily. Dr Stabinsky commented that pine pollen could be transported by wind for distances of up to 1000 kilometres, which meant that pollen from genetically modified pine trees could pollinate pine trees in other plantations, as well as wilding pines, up to 1000 kilometres from the original tree. Dr Stabinsky also noted that the planting of some genetically modified trees with higher growth rates had resulted in unintended side effects and that fast growing trees tended to use up nutrients faster, so that chemical fertilisers might need to be applied, thereby disrupting soil fertility.[46]

Recommendation 7.4

> **that, in connection with any proposal to develop genetically modified forest trees, an ecological assessment be required to determine the effects of the modification on the soil and environmental ecology, including effects on soil microorganisms, weediness, insect and animal life, and biodiversity.**

76. The Commission regards sterility technology as one valuable tool in a genetic modification strategy for forestry, especially in the case of those genetically

modified trees more likely to cross-pollinate with non-genetically modified trees in the New Zealand context, such as pine trees. A recommendation on the use of sterility technology appears with others in chapter 13 (Major conclusion).

77. Use of genetic modification in forestry also raises cultural issues, for instance if particular trees were chosen to have their characteristics altered. This "cultural gate" to development would arise if there were a proposal to make native trees grow faster so that additional native wood supply could be provided or so that native timbers could be grown on a commercial basis. Te Runanga o Ngai Tahu [IP41] pointed out that the Ngai Tahu Act 1995 identified 53 taonga species of native plants, in addition to other birds, marine mammals, fish and shellfish species that are also taonga.[47] Te Runanga o Ngai Tahu submitted that to allow genetic modification into New Zealand that might affect taonga species was to ignore Article 2 provisions of the Treaty of Waitangi. (Issues relating to native species and genetic modification are also discussed in chapter 3: Cultural, ethical and spiritual issues, and chapter 10: Intellectual property.)

Bioremediation

78. Bioremediation is the use of plants or microorganisms to clean up or minimise the presence and effects of known pollutants. Bioremediation involves using the natural activity of living organisms or their products, such as enzymes, to help degrade environmental contaminants, either by breaking them down into non-toxic contaminants or by accumulating the chemicals. Bioremediation also includes the use of plants to improve the environment, such as plants that can grow in salty soil. Genetic modification can enhance plants' natural abilities or alter them in such a way that that they can grow in adverse conditions. Particular environmental problems that bioremediation is aimed at include the removal of toxic pollutants in soil, sludge, industrial waste-water and open water bodies. Specific transgenic trees and plants with the ability to accumulate heavy metals such as lead, nickel, gold and cadmium can also be used to remediate degraded or contaminated environments by taking up dioxins, PCBs and heavy metals.

79. However, it is likely to become an important application of the technology. It is probable that in future, commercial uses will develop where private companies are legally required to clean up contaminated sites or where governmental bodies cannot identify a solvent, liable polluter. In terms of the safety of using genetic modification technology for bioremediation, the use of genetically modified plants may be preferred over the use of genetically modified bacteria as the organisms are likely to be easier to contain.

80. Landcare Research [IP12] stated in its submission that bioremediation offers the potential for cost-effective clean up and that genetic modification would be a powerful tool in its development. For example, Landcare Research is undertaking research on the potential for genetically modifying free-living bacteria so that they could help remediate New Zealand soils from the effects of DDE contamination (a DDT degradation product).[48] Dr Andrew Shenk, a witness called by Genesis Research and Development, told us of the bioremediation of sites damaged by chemical hazards such as mercury by planting trees genetically engineered to accumulate the metal. Dr Shenk mentioned the potential for using genetic modification to develop forestry for environmental recovery applications, such as where soils have elevated salinity levels. He noted that rising salt levels in soils were an increasing agricultural problem worldwide, exacerbated by over-use of irrigation.[49]

81. Professor John Mattick, the Foundation Professor of Molecular Biology at the University of Queensland, Australia, a witness called by Auckland UniServices [IP23], stated that genetic modification had enormous potential for bioremediation and reclamation of polluted and degraded environments using genetically engineered microorganisms. For instance, he identified soil salinity as a significant problem in Australia and said that, by engineering trees to become salt tolerant, salt-affected lands could be reforested.

82. Biomining, which is similar to bioremediation, is another non-food application of genetic modification. Biomining involves using genetically modified or unmodified plants and concentrating the metal so that it can be harvested. The Commission did not receive any evidence on biomining but is aware that it is being researched at Massey University and overseas and might have potential for uses in New Zealand among gold tailings or in soils rich in heavy metals.

Environmental impacts of bioremediation

83. Several submitters, such as the Royal Forest and Bird Protection Society, Nelson/Tasman Branch [IP43] raised the issue of sites in New Zealand that require bioremediation, such as the Mapua chemical site where organochlorine pesticides (eg, dieldrin, DDT, lindane and PCBs) were used. In its oral evidence, the Forest and Bird Protection Society expressed concern that if genetic modification applications, mainly genetically modified bacteria, were used to clean up sites of this kind, such "experimental" applications might have unforeseen outcomes leaving the taxpayer or ratepayer to meet even more expense. They questioned the ultimate fate of products metabolised by the genetically modified organism in bioremediation and whether any transfer of

recombinant DNA would occur from the genetically modified organism into the food chain. The Forest and Bird Protection Society also stressed the need for a contingency plan to allow for unexpected events such as flooding if genetically modified organisms were to be used for bioremediation.

84. Dr Stabinsky was sceptical about many of the claims made for genetic modification's potential in bioremediation. She commented on problems with microorganisms not persisting long enough to perform the clean-up task, potential risks such as the inability to stop the spread of the microorganisms in open water situations and the possibility that bacteria could escape into the water system when used in sludge and waste treatment.

85. Maanu Paul of the New Zealand Maori Council [IP105] spoke about the health problems people had experienced from the use of dioxins in processing timber at the former Whakatane sawmill. He highlighted concerns about long-term and unintended effects that genetic modification might have, likening it to the effects of 2,4,5-T and 2,4-D, and of sawmill processing, which were not understood at the time of early use.[50]

86. Bioremediation is likely to become a more urgent matter in the future, and the Commission considers that as genetic modification technology develops it may become viable.

87. However, consideration of alternatives to using genetically modified plants or organisms would appear to be important in assessing applications for genetically modified organisms for bioremediation. Plants and trees that are not genetically modified, such as willows, also have the capacity to bioremediate.

Bioreactors

88. The term "bioreactor" can encompass the use of genetically modified microorganisms, plants or animals to produce medicines or specific proteins, including vaccines. Bioreactors are part of a larger process known as biomanufacturing.

Plant bioreactors

89. The Commission received little evidence that research on plant bioreactors was in progress in New Zealand. However Dr Jeremy Levin, a witness for Auckland UniServices, stated:

> We are using plant cell culture to produce naturally occurring compounds that have therapeutic value, such as the chemotherapeutic agent taxol,[51] a compound found in yew trees.[52]

90. Professor Mattick said that crops such as canola can be genetically modified to produce oils with an altered bond structure that make them suitable as raw materials for plastics production. Fergie Sumich, the Manager of DuPont New Zealand [IP1], noted that new processes such as genetic modification could produce textiles and plastics from renewable resources like corn. Similarly, HortResearch stated in evidence that, in future, plants might be used as "factories" to produce large quantities of biopolymers such as bioplastics.

Cell bioreactors

91. Many of the protein products we use every day, from the enzymes in our washing powder to the chymosin enzyme used in the manufacture of some cheeses, are produced from genetically modified bacterial or yeast strains which are grown in large fermenters containing a nutrient broth. An increasing number of medicines, such as recombinant human insulin, are also produced in this way (see chapter 9: Medicine). The microorganisms are modified to produce large quantities of specific proteins, which are secreted into the broth or medium and which can then be purified for use. The resulting proteins do not contain DNA.

92. Many of the human proteins needed for the treatment of disease cannot be produced in a biologically active form by microorganisms. These proteins need to be made in mammalian cells, which can shape and modify the protein correctly. In this case large, industrial-scale cultures of genetically modified animal or human cells produce the product required, in a similar manner to the example described above for the production of taxol. In order to coerce the cells to grow and divide continuously, the cells are often transformed to free them from the normal constraints on replication.

93. The Green Party made it clear to the Commission that the production of genetically modified products from mammalian cell cultures in containment was ethically and environmentally more acceptable to them than the use of transgenic animals such as cows.[53]

94. However, use of large-scale fermenters in an industrial setting can lead to the production of small quantities of very toxic contaminants, as happened with the production of L-tryptophan (see chapter 4). In addition, large-scale fermenters have major waste management and disposal issues. Associate Professor Michael Eccles, a biomedical researcher called by Lysosomal Diseases New Zealand [IP99], spoke of mounting evidence that the use of bioreactor transgenic farm animals or transgenic plants would be cleaner and more environmentally friendly than the large fermenters of microorganisms or cell cultures (cell bioreactors). He said that the broth from the cell bioreactors had to be treated with either disinfectants or other noxious substances before disposal.

Animal bioreactors

95. The use of animals as bioreactors is currently a highly capital-intensive undertaking. We cannot see our current farming being supplemented by large, unconstrained herds of pharmaceutical-producing goats, sheep and cattle in the near or medium future. However, bioreactor animals may form a small, high-value niche market in our mixed, diversified economy.

96. Dr Robert Welch, a witness called by the New Zealand Cooperative Dairy Company [IP88], provided evidence on a range of commercial applications around the world where transgenic animals such as mice, sheep, cattle, goats and rabbits had been used to produce proteins in milk.[54] He stated that the proteins so derived had been used only to a limited extent in clinical trials and that there was not yet any conclusive evidence of adverse effects of the proteins on human health.[55]

97. PPL Therapeutics Plc, one of the world's leading transgenic technology companies, is currently using genetic modification technology to breed transgenic sheep that can produce very high levels of a human protein (alpha-1 anti-trypsin) in their milk. New Zealand was chosen as a site for this experiment because of its skilled animal husbandry workforce, equitable climate and freedom from bovine spongiform encephalopathy (BSE) and sheep diseases such as scrapie. This protein is used in the treatments of emphysema and cystic fibrosis. Yields produced from using the transgenic sheep are estimated to be one thousand times higher than those achieved using animal cell culture techniques.[56] We heard from Basil Wakelin, Regional Manager (Industrial) of Sinclair Knight Merz, giving evidence for Biotenz [IP25], that currently the milk from bioreactive sheep in New Zealand is shipped to Scotland for extraction of the active proteins.[57]

98. ERMA has also approved the development of a field trial for 200 transgenic cows. This field trial involves inserting a basic human protein into cattle embryos to produce a protein for researching treatments of multiple sclerosis. ERMA's decision was challenged in a High Court appeal on numerous grounds (the *Bleakley* case),[58] but the High Court set the approval aside solely for the reason that ERMA did not follow the prescribed methodology in coming to its decision. At the time this report was being completed, the field trial was continuing.

99. As mentioned in the research chapter, the use of animals as bioreactors gives rise to animal welfare issues. In its submission New Zealand's national animal rights/welfare organisation SAFE (Save Animals From Exploitation) [IP85] raised concerns about using animals as "machines" to produce products.[59] SAFE expressed the opinion that current animal welfare legislation and regulations did not adequately protect animals that might be subjected to genetic

modification applications.[60] It noted that such animals would require protection from bacteria, parasites and the elements, and as a result intensive indoor farming might develop.[61] SAFE was opposed to genetic modification of animals on ethical grounds. However, when asked if animals could be bred to produce more animals all containing the same modification (so that they produced the same protein in their milk) but without cloning or undergoing the original genetic manipulation, Dr Michael Morris, Senior Lecturer, Shibaura Institute of Technology in Japan, for SAFE, indicated he would not see a problem with that.

100. Many submitters who noted the use of animals as bioreactors had great concern that these animals should be prevented from entering the food chain. If possible it would seem preferable to give priority to using animals not usually used for food as bioreactors in order to lessen the possibility of human health impacts and the associated anxiety over the potential for affecting food sources. For example, goats rather than sheep could be used for human protein production as less goat meat is eaten in New Zealand.

101. Care has to be exercised to prevent animals that have been modified as bioreactors from entering the food chain, for two reasons. First, these animals are likely to contain human genetic material and their consumption as food would therefore be unacceptable to many. Second, the meat from bioreactor animals would not have been certified as safe to eat by the Australia and New Zealand Food Authority (ANZFA).

102. To assist with biosecurity and help prevent them from entering the food chain, bioreactor animals should be electronically tagged for identification. Other methods of stopping these animals entering the food chain should also be explored. The Commission does not foresee open release of bioreactor flocks in New Zealand, as these animals are likely to be subject to conditional release.

103. The Green Party contended there would be no need to use animals as bioreactors, since all genetically modified products could be synthesised by microorganisms.[62] However, as mentioned previously, Lysosomal Diseases called evidence in rebuttal that microorganisms were not effective producers of the complex enzymes found in mammals. For example lysosomal enzymes were found only in animal cells and many animal proteins could not be modified correctly by microorganisms. Transgenic animals were therefore more likely to produce medically useful proteins. We accept Lysosomal Diseases' rebuttal evidence and are satisfied that it will not always be possible to use vats to produce the pharmaceuticals required.

Recommendation 7.5

that, wherever possible, non-food animals, or animals less likely to find their way into the food chain, be used as bioreactors rather than animals that are a common source of food.

Recommendation 7.6

that, wherever possible, synthetic genes or mammalian homologues of human genes be used in transgenic animals to avoid the use of genes derived directly from humans.

Pest control

104. Genetic modification has potential applications for pest control and consequent protection of New Zealand's unique environment and biodiversity. In terms of public acceptability of the use of genetic modification for crops and non-food uses, the Commission's public opinion survey showed 54% of respondents approved of the use of genetic modification for pest control; 65% thought that genetic modification was currently being used for this purpose.

105. Evidence was provided by Landcare Research that genetic modification offered more precise and better targeted ways of addressing pest problems than the current methods employed.[63] Applications of genetic modification technology being considered by Landcare Research were possum fertility control, stoat and wasp control, biosensors and bioremediation. The public submission from the Possum and Bovine Tuberculosis National Science Strategy Committee noted that similar research was being conducted in Australia for control of Australia's three major mammal pests – the mouse, the fox and the rabbit.[64] In particular, Landcare stressed the desire to reduce New Zealand's current reliance on large scale use of broad-spectrum poisons for pest control that left New Zealand exposed to substantial health, environmental and trade risks.

106. Dr Phil Cowan, programme leader for research into mitigating the impacts of mammalian pests at Landcare Research, noted that the biotechnological approach to pest management by fertility control was equally applicable to other pests, such as stoats and wasps.

107. As a result of concerns about the continued use of poisons and the potential effect on New Zealand's trade, increased research is under way looking at biological control options for possums. The public submission from the Possum and Bovine Tuberculosis National Science Strategy Committee reported that,

The potential of genetic modification applications for possum control[65]

The Australian brushtail possum *(Trichosurus vulpecula)* was introduced to New Zealand in the 1850s from Australia to establish a fur trade. Since that time possums have become New Zealand's number one vertebrate pest in economic and ecological terms because of the damaging effects they are having on New Zealand's biodiversity, bird life, forestry, horticulture and primary production sector. In addition, possums also spread tuberculosis to cattle and deer, and carry diseases that have human health risks. Currently the principal control methods for possums are leg hold traps and poison baits.

New Zealand Crown Research Institutes, such as AgResearch and Landcare Research, are investigating new methods of possum control employing genetic modification. Landcare Research is looking at genetically modified fertility control, which acts by immunising female possums against proteins from sperm and eggs so that fertilisation is blocked and no young are born. Delivery of the immuno-contraceptive may involve the use of transgenic carrots or potatoes expressing possum proteins or may be by a transgenic possum-specific parasite such as an intestinal worm, being developed by Dr David Heath of AgResearch, Wallaceville. Dr Heath, who presented for the New Zealand Association of Scientists [IP92], stated his belief that biological control was the only method that offered effective control of possums in New Zealand. Roger Wilkinson, a social scientist employed by Landcare Research, told us that the public was frequently sceptical that any form of biological control could provide a complete solution to the possum problem.

Dr Phil Cowan of Landcare Research said there were now around 70–90 million possums in New Zealand spread over 95% of our land area. However, he noted that with the increase in controls over the last five years possum numbers might have reduced by 10–15 million. Dr Cowan told us that $50 million was spent each year controlling them, with the total cost of both possum control and damage estimated at between $80 and $100 million per year. He said that the main poison used in New Zealand for possum control was 1080 (sodium monofluoroacetate) and that each year New Zealand released about two and a half tonnes of this poison into its environment, comprising 90% of the world's use. Concerns had been expressed over the dangers of poisons used for possum control, such as environmental contamination and risks to non-target species, particularly native birds, and that the massive expenditure on possum control was unsustainable. The reliance on 1080 poison could also have trade implications if New Zealand's major trading partners were to find the continued use of this poison unacceptable.

during the year 1999–2000, $5 million was spent on research into new control technologies for possums.

108. Dr Williams, the Parliamentary Commissioner for the Environment, said there was a need for knowledge about the effects that possum biocontrols might

have on New Zealand's unique biodiversity, on non-target species or the broader environment, and on physical taonga. Dr Williams said his research report "Caught in the Headlights: New Zealanders' reflections on Possums, Control Options and Genetic Engineering" (October 2000) stated most possum control methods currently being researched involved identifying a biological control agent suitable for genetic modification to be a delivery system for possum control. Dr Williams said this "significantly increases the levels of public unease and perceptions of the potential risks of these technologies".[66] The report noted that, although genetically modified possum control technologies showed promise, they were still some years away from being ready for application in New Zealand.

109. In its public submission the Department of Conservation also expressed support for research into the potential for genetically modified organisms to be used for biological control of possums, but took a cautious approach to the introduction of new organisms. The Forest and Bird Protection Society did not support the spread of any genetically modified organism for possum control.[67] Principal concerns raised by the Society included the potential for the biocontrol to invade Australia where possums are protected as an indigenous species, the lack of testing of the carrot bait proteins on other animals, and the propensity for resistant possum populations to multiply if sterilising controls were not 100% efficient.

110. We heard evidence about the range of benefits of fertility control of possums. Those listed by the Possum and Bovine Tuberculosis National Science Strategy Committee in its public submission included:

- a reduction in the threat to non-target species
- a reduction in the amount of toxins used for possum control
- fewer problems with bait and poison shyness
- vaccines that were expected to be humane
- assistance from vaccines in helping reduce dependence on toxin
- greater public acceptance of a contraceptive rather than an exterminatory approach.[68]

111. The research report referred to by the Parliamentary Commissioner for the Environment identified fundamental criteria for acceptability of biocontrol technologies, including:

- specificity to possums as the target species
- effectiveness
- humaneness
- rigorous long-term testing of adverse effects on the environment
- consistency with the principles of the Treaty

- the development of the technology through a process fully transparent to the public.[69]

112. Similarly, the public attitude research undertaken by Roger Wilkinson found the two most important criteria for acceptability of genetic modification-based fertility control were that it was specific to possums and that it was humane.[70] The Parliamentary Commissioner for the Environment's research showed that, of the potential biocontrol methodologies, non-genetic modification methods such as hormonal control were most favoured, immunocontraception was regarded as generally acceptable, immunosterilisation of adult animals was considered a higher-risk option than contraception, and reducing possums numbers through infant mortality (such as through interfering with possum lactation) was considered inhumane.[71]

113. Mr Wilkinson's research found that some participants were wary of supporting genetic modification in possum biocontrol applications, considering it "a Trojan horse or thin end of the wedge", with one respondent stating "GE for possum control is about getting the foot in the door for GE for food, to reassure us it's safe". Another respondent in this research commented:

> When you allow GE for possum control, that says to the New Zealand public, "Look at this wonderful tool for controlling possums," they think perhaps it's not so bad if we have it in our food, or crops grown in the environment.[72]

114. The benefits of controlling possums by either genetically modified immunocontraception using carrots or possum-specific parasites would be negated, if even some dairy cows showed decreased fertility. In summary, we consider that genetic modification technology offers significant potential for the control of possums in New Zealand and understand that it is likely to form part of a management strategy that might integrate genetic modification techniques with conventional controls.

Biofuels

115. Given the finite and decreasing reserves of fossil fuels, there is great commercial interest in growing replacement fuels. However, we are not aware of any research into genetically modified biofuel products in New Zealand.

116. Biofuels may be synthesised from conventional, unmodified crops, but genetic modification may increase the likelihood of commercial yields of fuel from plants. Biofuel products are likely to become highly valuable and may raise issues of security or industrial espionage. Gary Goldberg, Chief Executive Officer of the American Corn Growers Association, a witness called by BIO-GRO

New Zealand [IP58], said that most genetically modified maize was being used in the United States for ethanol production as well as livestock feed.[73]

117. The use of genetically modified microorganisms such as *Klebsiella planticola*, a lactose-fermenting bacterium that converts agricultural waste into alcohol from crop residues, was described by Dr Roberts in her background paper prepared for the Commission on the Environmental Aspects of Genetic Modification. She quoted a study which found that crops grown in soil containing genetically modified *Klebsiella planticola* died. Dr Elaine Ingham, a Canadian soil scientist and author of that study, and a witness called by the Green Party, referred to a potential catastrophe from this use, claiming that the level of alcohol per gram of soil produced by the engineered bacterium could kill all terrestrial plants.[74] However, soon after this evidence was presented, the Green Party withdrew the essential parts, accepting that Dr Ingham's assertions went beyond the published literature. We do not give any credence to Dr Ingham's evidence.

Bioprospecting

118. Another application of genetic modification technology brought to the attention of the Commission was bioprospecting. Submitters claimed New Zealand's biodiversity represents a pool of untapped opportunity, with scientists estimating that only 30,000 out of an estimated potential 80,000 indigenous species have been identified so far.[75] In its public submission the Department of Conservation defined bioprospecting, or biodiversity prospecting, as "the exploration of biological material in order to provide chemical components, genes and their products for potential use and development in pharmaceutical, agrochemical, biotechnology, cosmetic and other applications".[76] The Department noted that using genetic resources of indigenous species for bioprospecting would raise ecological, commercial, cultural and ethical issues. They also noted there is no statutory management framework for bioprospecting in New Zealand at present. Genetic modification of indigenous plants or resources, such as modification of flax or manuka products, raises cultural risk issues for Maori. In particular, issues arise relating to ownership of indigenous resources and the as yet unresolved WAI 262 claim. This matter is discussed in greater detail in chapter 10 (Intellectual property).

Biodiversity issues

119. Biodiversity relates to the variety of all biological life; to plants, animals, fungi, and microorganisms, the genes they contain and the ecosystems they live

in, whether on land or in water.[77] Concerns about reducing biodiversity levels include concerns about the maintenance of the diversity of ecosystems and species in New Zealand and the retention of a resource of genes that may be important in the future.

120. New Zealand has a unique physical environment. The Department of Conservation, in its public submission, noted that New Zealand was isolated from other land masses for 80 million years, resulting in the evolution of unique biota. The Department stated that pre-settlement New Zealand lacked mammals, excluding bats, and as a result animals and plants had developed traits making them vulnerable to predation and browsing by introduced mammals such as rats, stoats, possums and goats. New Zealand's unique environment is also a product of recent settlement, the introduction of exotic species (including pests and weeds) and landscape changes for farming, forestry and settlement. In addition, on an international scale New Zealand has a remarkably high level of indigenous species.[78] We have a range of distinctive ecosystems and New Zealand's biological world has provided inspiration for our national icons: the kiwi, the silver fern and the koru.[79]

121. The decline in New Zealand's biological diversity was noted as New Zealand's most pervasive environmental issue in a *State of the New Zealand Environment* report prepared by the Ministry for the Environment in 1997. In particular, the pressures on biodiversity included insufficient habitat in lowland areas, declining quality of land and fresh water habitats, impacts of pests and weeds, and impacts on some marine species and ecosystems. The *New Zealand Biodiversity Strategy* (February 2000) says exotic species have had a dramatic impact on New Zealand's indigenous biodiversity and that invasive pests are recognised as the greatest single threat to our remaining natural ecosystems, habitats and threatened native species. It was estimated that about 1000 of New Zealand's known animal, plant and fungi species were now considered threatened, including three-quarters of our bird species.[80] The *New Zealand Biodiversity Strategy* says that, in the last 700–800 years in New Zealand, humans and pests have made extinct:

- 32% of indigenous land and freshwater birds
- 18% of all sea birds
- three of seven frogs
- at least 12 invertebrates, such as snails and insects
- one fish, one bat and perhaps three reptiles
- possibly 11 plants.

122. New Zealand is a party to, and has ratified, the Convention on Biological Diversity, which requires New Zealand's legislation and international actions to be consistent with the Convention's principles. In order to meet obligations under this Convention, the Biodiversity Strategy was developed by the Department of Conservation, the Ministry for the Environment and other government departments and was released in March 2000. In New Zealand, responsibility for the protection of biodiversity rests principally with the Department of Conservation. The Biodiversity Strategy is aimed at halting the decline in New Zealand's indigenous biodiversity as well as conserving the genetic resources of important introduced species. The Strategy also acknowledges the special holistic view that Maori have of the environment and biodiversity that arises from their belief system that all components of ecosystems are linked and possess the spiritual qualities of tapu, mauri, mana and wairua. The Biodiversity Strategy is now Government policy.

123. The Department of Conservation noted that in June 2000 Government announced a funding package of $187 million over five years to implement the key actions of the Biodiversity Strategy. This included $57 million for pest and weed control on public conservation lands. However, the Department commented that, despite this funding, the proposed expenditure would be insufficient to maintain indigenous biodiversity across all public conservation lands. As a result pest control would be restricted to priority areas until new techniques for pest control could be developed.

124. As discussed above, genetic modification may be used to benefit biodiversity, as it could assist in controlling pests, help with biodiversity restoration projects or reduce toxic chemical use. Landcare Research stated that, through the Biodiversity Strategy, Government had identified pest management as the principal means of protecting New Zealand's biodiversity. Landcare noted that protecting New Zealand's biodiversity was a national imperative and an international obligation that would call for a "full management toolbox"[81] including genetic modification technology.

125. We also heard evidence about the possibility of using genetic modification for conservation genetics, for example to characterise species, to possibly recreate extinct species such as huia, to grow genetically modified native plants to protect the conservation estate. However, these proposals generate significant cultural issues.

126. The development of seed-saving groups for heritage seeds forms an important part of improving our biodiversity. The Koanga Gardens Trust [IP72], a heritage seed-saving group from Northland, outlined how they were establishing and maintaining a collection of New Zealand heirloom plants. This was done to

ensure their survival for future generations as a resource for cultivation and genetic diversity, and as taonga for the public of New Zealand. Other seed-saving groups operate on a regional basis around New Zealand.

127. Information about potential long-term effects of genetically modified organisms on the environment and on biodiversity is still sparse. The Department of Conservation said there is no consensus as to the seriousness, or even the existence, of any potential harm from genetic modification technology.[82] As there is limited knowledge of the long-term effects of genetic modification, the Department asked whether decisions relating to releasing genetically modified organisms into the environment should be postponed until there is more information on their effects on New Zealand's environment and biodiversity.

128. The threat of genetic modification to biodiversity was a strong theme that emerged in the analysis of public submissions. Key issues raised by submitters included the potential that genetic modification would result in: the extinction of some species; the creation of new and dangerous organisms such as super weeds; the contamination of the environment from genetic modification activities (for example where organisms escaped from field trials or laboratories); and the irreversibility of genetic modification releases.[83]

Development of monocultures

129. The Commission heard that genetic modification technologies encouraged the development of monocultures, leading to a reduction in biodiversity, both in the gene pool within species and in the variety of species planted. Questions arose whether genetic modification actually exacerbated the development of monocultures or whether the loss of biodiversity occurring now was more a result of increasing agricultural intensification. There is evidence of this happening in New Zealand with the increased areas of *Pinus radiata* planted, and overseas with extensive plantings of wheat, rice and maize. It would appear that arguments over reduction in biodiversity tend to be more against increased agricultural intensification rather than against genetic modification technology itself. The Commission considers that, with regard to monocultures, genetic modification in crops and other field uses brings no new issues, other than of scale.

130. Dr Vandana Shiva, a theoretical physicist and philosopher of science, and a witness called by the Pacific Institute of Resource Management, wrote in her witness brief that genetic engineering was narrowing the genetic base of agriculture to only a few crops and accelerating the expansion of monocultures. This in turn led to the destruction of on-farm biodiversity through the use of broad-spectrum herbicides like Roundup and threatened survival of species

through the use of crops which have had bacterial toxins (such as Bt) added to allow them to produce their own pesticides. She said:

> Genetic engineering maintains and deepens the monoculture paradigm of the Green Revolution and industrial agriculture that focuses on single functions of single species, and fails to take yields of diverse species and diverse function into account.[84]

131. Anuradha Mittal, Co-director of the Institute for Food and Development Policy in Oakland, California, appearing by telephone link for Greenpeace, said that genetic engineering was based on the same principles as industrial agriculture: those of monoculture, technology and corporate control. She believed problems were likely to be exacerbated in countries that lacked stringent procedures for dealing with environmental problems caused by the release of genetically modified plants into the environment. She said that under "Green Revolution technology, farmers were encouraged to produce massive monocultures of the same high yielding crop" and that although high yields could be achieved the seeds were vulnerable and required heavy input of chemical fertilisers and pesticides.[85]

132. Ms Mittal said the Green Revolution caused short-term rises in production in many Asian and Latin American countries, followed by ecological collapse, farmer debt and increased hunger. The "miracle yielding" crops of the Green Revolution had also led to erosion of the genetic base of most crops. She said that "according to the FAO, 75% of genetic diversity in agriculture has been lost in the last century".[86] She also noted that monocultures had increased pest attacks on crops, as planting the same varieties year after year encouraged pests to build up and made plants vulnerable to attack by new viruses.

133. A range of witnesses told the Commission that the development of monocultures should not be encouraged because of the heavy input of chemical fertilisers and pesticides needed by hybrid seeds and the increased vulnerability of crops to disease and pest attacks. However, most of the evidence presented related to overseas experience. The Commission is more concerned with the need to pursue a strategy for New Zealand that will preserve the variety of land uses and the range of agricultural practices currently employed here, as well as providing for flexibility in future developments.

Compatibility with other production systems

134. The principal environmental risk in releasing genetically modified food and other crops into the environment is the physical contamination of other production systems.

135. The Commission heard evidence from a range of farming organisations on the perceived risks of establishing genetically modified crops near to organic, conventional or IPM-based horticultural crops and the potential for outcrossing. Organic farmers expressed concern about the potential for loss of organic certification if their farms were to be "contaminated" by genetically modified crops. They did not feel confident buffer zones of specified distances would ensure protection. The international organics movement sees no place for genetic modification in organic agriculture.

136. The Green Party stated that "the release of genetically modified crops and organisms into the New Zealand environment would represent a major and very serious threat to the organics industry in this country".[87] Similarly, Noel Josephson, the Managing Director of Ceres Enterprises Limited (a distribution company for biodynamic and organic food) called by the Bio Dynamic Farming and Gardening Association, said "the release into the environment of genetically modified organisms is to the disadvantage of those people associated with the industry that has built up around biodynamic and organic farming". Mr Josephson pointed out that cross-pollination could not be controlled once a genetically modified crop was commercially released into the environment. He said:

> A biodynamic or organic farmer in the area is then susceptible to cross-pollination of the same crop. Biodynamic and organic standards specifically exclude genetically modified material and therefore any cross-pollination would render a biodynamic or organic farmer's crop unsaleable as biodynamic or organic. As their farm is set up to perform to these standards the investment is lost and their livelihood under threat.[88]

137. The Green Party cited an opinion poll commissioned by the meat company AFFCO (dated May 2000) which found that "70 percent of farmers and commercial growers believed the future of New Zealand agriculture was with organic production". The same survey found that 15% of farmers and commercial growers believed the future was with genetically modified production and only a small proportion (4%) saw the future involving a combination of the two systems.[89]

138. The Commission asked MAF to prepare information[90] on the compatibility of genetic modification and organic agriculture. MAF stated that "if organics standards allow the possibility of accidental contamination, then coexistence is possible. If standards demand zero tolerance for accidental GM contamination, then coexistence may not be possible".[91] MAF was unaware of any study that had looked at compatibility between farming systems in any country, but knew of studies of separation distances between crops to manage cross-pollination.[92] MAF added this was an issue of importance to plant breeders prior to the introduction of transgenic crops. MAF mentioned the countries with the largest

areas of transgenic crops (United States, Argentina and Canada) had commercially successful organic production sectors.

139. The New Zealand Dairy Board [IP67] in its written submission commented that determining whether organics and genetic modification were compatible depended on how the term "organic" was defined. The Board noted that some definitions (such as the Codex Alimentarius Committee definition) did not necessarily prevent aspects of genetic modification becoming part of organic farming systems in the future. It expressed the opinion that compatibility might be possible if certification of organic produce allowed for some tolerance of genetic modification and if isolation distances from genetically modified crops permitted organic production to continue.[93]

Effects on organic certification

140. Governments or growers' organisations set a variety of standards for organic certification internationally. New Zealand has several. The principal standard used here is BIO-GRO. The Demeter standard is stricter and meets the BIO-GRO standard, in addition, the Agri-Quality standard has been developed in consultation with growers. These three standards do not allow for any genetic modification contamination of organic crops. Both BIO-GRO and Agri-Quality standards are accepted internationally.

141. At present there is no one accepted international standard for organic production, but there is a move to harmonise standards. Dr Salisbury, stated in his evidence that:

> … to ensure successful coexistence of organic and GMO canola crops, all growers need to accept similar standards of purity to those currently used for canola seed production worldwide, allowing, for example, a threshold of up to 1% off-types (Moyes and Dale, 1999). Such thresholds are currently being considered by organic growers in Europe.[94]

First release issues

142. Dr Campbell gave evidence relating to research on the potential first release of genetically modified organisms in New Zealand food production. He saw the three principal industries that might be affected by physical contamination from genetically modified crops production as honey (both conventional and organic production methods), organic farming and IPM-based horticulture. Dr Campbell provided a quantitative analysis of New Zealand's production options and advocated a position that would keep our options open. He noted that despite growth in organic exports the total volume was still small compared with IPM-based horticultural exports. Recent research estimates that IPM-based exports from New Zealand were valued at between NZ$900 million and

NZ$1 billion in the year 2000. He also cited figures showing the international growth in the market for organic products, saying that average growth rates were 30–35% in new markets and 20–25% in mature markets. According to Dr Campbell there were three important drivers in global markets for organics and IPM produce, each affecting the demand for or access to genetically modified food:

- trade/regulatory barriers such as "green protectionism"
- retailer strategies, with some retailers avoiding genetically modified foods
- consumer responses, with wealthy consumers tending to show a demand for organic foods and a rejection of genetically modified foods.

Future systems of production

143. Federated Farmers said "conventional production is likely to continue to be the dominant production system in New Zealand".[95] It noted that production systems needed to become more transparent, with a need for trace-back mechanisms and farm-to-plate assurance systems to compete in world markets. Farmers would have to weigh up the opportunities that genetic modification technology might offer, against potential losses in market share. Although there was disagreement as to where New Zealand's competitive advantage lay, mixed strategies were preferable "as they spread risk from cycles in market demands and consumer preferences".[96] Witness Neil Barton expressed the opinion that the various production systems could exist alongside genetic modification in New Zealand. He stated:

> The ability to continue production of organic or specialist non-GM crops, can continue without threat, should novel genetically modified plant varieties be grown in our cropping districts. This would occur in exactly the same way as different crops co-exist now.[97]

144. Dr Campbell looked at the issue of whether genetic modification could be used in the organics industry and cited research that suggested "an involvement of GM in organic production is unlikely".[98] He put forward reasons such as a strong market association between organic produce and being genetic modification-free and considered that the importation of genetic modification technology into the organics industry could seriously threaten the market niche it currently held. In addition, Dr Campbell noted that international organic agriculture movements were opposed to using genetic modification technologies in production. However, he said there had been no comprehensive research conducted in New Zealand to calculate the negative economic impact of genetic modification on organic production.

145. The Life Sciences Network argued that "coexistence of GM, conventional and organic agriculture is possible through appropriate use of management (stewardship) protocols (eg separation distances)".[99] Life Sciences also argued "coexistence is a farmer responsibility".[100] Tom Lambie, an organic dairy farmer and a witness called by the Dairy Board, spelled this out:

> As much as it is possible we seek to keep the effects of our activities within our own boundary. The farming community will accept a degree of external effect but these are tolerated only within "normal" standards. Should I demand a higher standard, I expect to internalise the cost of paying for that standard. For instance, if I don't like the colour of my neighbours shed I can plant a hedge or construct a fence to block the vision. If my neighbour traditionally uses conventional sprays I can plant hedges to act as a barrier and maintain a buffer zone to satisfy myself that there is no risk from any unintentional spray drift. Equally, I expect my neighbour to internalise the costs of his preferred production regime by taking action to prevent spray drifting across my property. The steps the neighbour can take include the maintenance of a buffer zone.[101]

146. While we agree and encourage this type of cooperation and self-reliance the Commission considers there also has to be an element of government regulation to develop and maintain coexistence.

Managing the risks and preserving the opportunities

147. The key impacts likely to result from genetic modification in crops and non-food uses associated with the release stage are the control of environmental effects such as cross-pollination, horizontal gene transfer and seed dispersal.

148. The United Kingdom Advisory Committee on Releases to the Environment (ACRE) has produced guidance notes[102] on best practice in the design of genetically modified crops to be released into the environment, including a wide range of techniques to reduce environmental risks. The guidance notes put forward three ways to reduce the exposure and therefore the risk from transgenes and their products: avoiding the inclusion of superfluous transgenic sequences, minimising the expression of the transgene, and minimising the dispersal of the transgenes into the environment. Examples of methods to minimise transgene dispersal in the ACRE guidance notes include:

- considering whether plants actually need to be released into the environment. (Some crops such as high value bioreactors might be grown effectively in containment.)

- choosing plant species that are appropriate recipients for the transgene. Since expression of pharmaceutical genes in food crop plants or plants with wild relatives might not be desirable
- exploiting differences in flowering times between plants, and using or breeding varieties that have flowers which are unattractive to insects, by altering flower colour, shape, scent or the production of pollen
- producing transgenic plants that either cannot produce pollen or produce sterile seed.

149. Some possible control mechanisms to which ERMA could give consideration are outlined in the following subsections.

Choosing which plants to modify

150. One method of managing risk related to genetically modified crops is to identify those posing the greatest risk in terms of outcrossing, ban them and allow less risky crops to be grown. The use of a risk assessment framework, such as the one provided by Professor Ammann, referred to earlier in this chapter, would help identify which crops would carry substantial and widespread risk.

151. No native species in New Zealand outcross with the major crops grown in this country. The risk assessment approach is obviously being considered by ERMA, as demonstrated in the assessment of wild relatives undertaken for the petunia trial application. A table for New Zealand similar to Professor Ammann's could be formulated that would help researchers identify high risk plants early and institute an appropriate methodology. Such an approach would enable those crops most at risk of outcrossing in the New Zealand environment to be identified. The Commission notes that Professor Ammann's analysis identified ryegrass as particularly prone to gene transfer through outcrossing.

Risk management for high-risk plants

152. Evidence was presented on a range of management options for growing both genetically modified and non-genetically modified crops that could help reduce the risks associated with genetic modification. A number of such methods are outlined below.

Physical barriers

- spatial barriers – where plants grow in different areas or where there is no common pollinator
- temporal barriers – which occur when plants flower at different times of the year

- biological barriers – which reduce the chance of cross-fertilisation between species by preventing fertilisation or seed development.[103]

153. Barriers of time as well as space could be used, for example crop rotation where certain crops were not planted for a specified time after harvest, or where different crop species rotate on the same parcel of land. Time barriers already apply to some crops where purity is an issue. For example, a minimum of four harvest seasons is required between growing different white clover cultivars in the same field.[104]

154. A United Kingdom Ministry of Agriculture, Fisheries and Food (MAFF) report[105] provided examples of other types of barriers that can affect the transmission of pollen to a receptor crop including:

- woods and hedges – which can act as a barrier to both wind-borne pollen and flying insects
- topography – wind velocity and airflow are affected by topography and this can influence the amount of pollen delivered to the receptor
- barrier crops of the same species as the crop – either planted around the crop emitting the pollen or around the receptor crop. Both of these systems mean that the pollen has a greater distance to travel and that insects might be more likely to visit the barrier plant.

Buffer zones and separation distances

155. MAF provided information[106] to the Commission on buffer zones in countries where genetically modified crops are grown. It noted buffer zones to mitigate the dangers of cross pollination were a requirement for seed production and that the OECD standard for maize seed was a buffer zone of 200 metres, adhered to in both the United States and the European Union. MAF noted this zone was imposed for reasons of seed purity rather than because of genetic modification or organics. MAF commented there did not appear to be specific rules, as distinct from standards, relating to buffer zones, apart from in the United Kingdom.

156. The Arable-Food Industry Council noted that an industry group in the United Kingdom, the Supply Chain Initiative on Modified Agricultural Crops (SCIMAC), had produced an industry code of practice for genetically modified crops. The Arable-Food Industry Council submitted that an industry code of practice for genetically modified crops, similar to the United Kingdom model, should be developed for New Zealand. The Council believed that such a code should be developed by cross-industry agreement and operated along similar lines to the seed certification production scheme.

157. MAF cited the MAFF (UK) report[107] noted above, which looked at separation distances used in agriculture that are intended "to secure desired levels of crop purity by limiting cross pollination between different varieties or types of the same crop". The guidelines seek to avoid pollen contamination between genetically modified and other crops. The main crops to which these guidelines relate are maize and sweetcorn, canola (*Brassica napus*) and turnip rape (*Brassica rapa* ssp. *silvestris*). The separation distances for each crop are set in relation to threshold levels of contamination from cross-pollination, for example for canola the separation distance for 1% contamination is 1.5 metres; for 0.5% contamination the distance is 10 metres; and for 0.1% contamination the separation distance is 100 metres.

158. Mr Barton gave evidence of isolation distances varying from 100 metres for ryegrass to 700 metres for kale,[108] and Dr Salisbury said "isolation distances of 100 to 500 metres were generally considered sufficient to prevent outcrossing and maintain seed purity for basic and certified seed".[109] Dr Salisbury noted further the isolation distances were not intended to prevent outcrossing entirely but to reduce outcrossing to an acceptable level. Dr Salisbury cited Hoyes and Dale (1999) who found that when appropriate isolation distances were used no contamination above the allowable thresholds was reported.

Recommendation 7.7

that the Ministry of Agriculture and Forestry develop an industry code of practice to ensure effective separation distances between genetically modified and unmodified crops (including those grown for seed production), such a code:

- **to be established on a crop-by-crop basis**
- **to take into account**
  - **existing separation distances for seed certification in New Zealand**
  - **developments in international certification standards for organic farming**
  - **emerging strategies for coexistence between genetically modified and unmodified crops in other countries**
- **to identify how the costs of establishment and maintenance of buffer zones are to be borne.**

Sterilising technology

159. Various techniques make crops infertile and allow the harvesting of the crop but prevent reproduction. The ACRE report[110] provides an excellent summary of the current research status of sterilising techniques. The technologies incorporate genes into the plants that stop the seeds germinating or the female flowers being fertilised. Some such genes have been called "terminator" genes and encode enzymes or similar products that confer sterility.[111] Professor Martina McGloughlin, Director of the Biotechnology and Life Sciences Informatics Programmes at UC Davis University in California and a witness called by the Life Sciences Network, commented on more recent ways to limit gene flow:

> There are strategies to reduce the … risk of gene flow from transgenic crops. One possibility is the use of male sterility plants, which works well but is limited to a few species. For many crops in which chloroplasts are strictly maternally inherited, which is to say not transmitted through pollen, transformation of the chloroplast genome should provide an effective way to contain foreign genes. Henry Daniell and colleagues at Auburn University introduced a gene for herbicide resistance into tobacco, showed that it was stably integrated into the chloroplast genome, and demonstrated that transgenic plants contained only transformed chloroplasts. This result advances the potential for chloroplast transformation to be an effective strategy to manage the risk of gene flow.[112]

160. Objections to "terminator" or "traitor" technology have been expressed by many organisations, such as the Pacific Institute of Resource Management, which noted that "over 30 patents have been issued for Terminator and Traitor technology, which is designed to make farmers chemically dependent and prevent them from saving their own seed".[113] Traitor technology requires the use of a proprietary spray, usually involving hormones, to turn on the genes of interest. Dr Stabinsky expressed concern in her evidence regarding the use of sterility technology in pine trees in New Zealand, noting that it could have a negative impact on organisms that rely on pine pollen as a food supply. The Commission considers the use of sterility technology in commercial forestry trees should be investigated, as it has the potential to reduce pollen production with its associated allergenicity problems and prevent wild pine escape. However, a full assessment, based on field trials, of the effects of genetically modified sterility on the ecology of the forest would be required.

161. The Commission considers an increasing variety of techniques is available to limit the effects of genetically modified crops on the environment and to control the escape of the modified genes.