A Report on a Deliberative Public Engagement Exercise concerning the use of Biotechnology in Non-food Agriculture for the Agriculture and Environment Biotechnology Commission

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1. Introduction

1. Background – original brief from AEBC

The Agriculture and Environment Biotechnology Commission (AEBC, hereafter referred to as 'the Commission') is looking at the role biotechnology could play in the development of Non-food agricultural products. It intends to explore public opinion about Non-food agriculture and the use of biotechnology.

Deliberative research is required to inform this process by canvassing public opinion on applications of modern biological science to Non-food agriculture and by facilitating deliberation on issues, aspirations and concerns arising from such potential applications.

Government policy towards sustainable agriculture is creating a momentum for a range of Non-food uses of crops. A number of benefits are cited, particularly in the potential of these crops to play a role in meeting significant societal needs such as:

- Renewable energy provision to reduce reliance on non-renewable fossil carbon sources
- Cleaner manufacturing to reduce greenhouse gas emissions
- Novel methods of production for therapeutics making cures for pernicious diseases more widely available at lower cost
- Support for the rejuvenation of the rural economy, and particularly the ability to create much needed "value added" opportunities for conventional farmers currently producing commodity crops
- Diversification of agriculture in the UK countryside.

However, for each potential application, alternative approaches may exist that could achieve the same or similar benefits. For example, reducing energy consumption and improving efficiency of use would also reduce fossil fuel consumption and greenhouse gas emissions. Furthermore, in creating these

benefits using Non-food agriculture, there is potential for a significant alteration in the pattern of land use in the UK. This could lead to issues of:

- Unknown effects on biodiversity (both positive and negative)
- Changes to the appearance of the UK countryside
- Judgements around when land should be preserved for maximising food production rather than addressing these alternative needs
- Necessity to consider both intermediate term and long term requirements made of agriculture.

In many of the examples of Non-food uses of crops, there is the possibility (and in some cases an existing reality) that the speed of delivering these products to market, and the efficiency of action of these products, could be enhanced by the application of biotechnology, defined in its broadest sense which includes genetic modification (GM) but also other genomic and molecular biological techniques.

2. Project objectives

The project had two sets of objectives, the first to produce qualitative research findings and the second to facilitate and report on deliberation.

Research Objectives

- To discover the social, political, ethical, economic, environmental, and health and safety criteria that people consider relevant to Non-food agriculture
- To discover which of the above criteria are considered relevant to potential future applications of biotechnology in this arena
- To explore whether the public holds different attitudes towards the application of biotechnology in food and in Non-food crops
- To explore whether the public's attitude to the application of biotechnology varies according to the stage of the production process at which it is utilised
- To explore public attitudes towards, and mechanisms of, balancing and assessing risks and benefits in the biotechnology arena.

Deliberative Objectives

- To facilitate a general discussion about attitudes to Non-food agriculture, so that participants identify the issues that they see arising from Non-food agriculture, the potential applications of biotechnology and their associated questions, aspirations and concerns
- To facilitate access by participants to information about Non-food agriculture and potential biotechnology applications, initially by means of examples provided by the Commission
- To facilitate access by participants to information about potential societal, economic, health, safety and environmental benefits and disadvantages of Non-food agriculture and associated biotechnology, and to information about potential alternatives that could be pursued by society to deliver similar outcomes, and the benefits and disadvantages of the latter
- To explore and discuss any conditionality that participants might place on their acceptance of particular applications of biotechnology
- To facilitate discussion and deliberation about societal, economic, health, safety and environmental concerns and aspirations concerning Non-food agriculture and associated biotechnology.

2. Methodology

1. Method

A four-phase process was employed to answer the project objectives.

Phase 1 followed recruitment of qualifying participants, and comprised benchmarking of current knowledge and attitudes of Non-food agriculture (NFA) via two open-ended and one closed question. Participants were then provided with three non-food agriculture case studies – Energy crops - Short Rotation Coppice Willow and Poplar, Dental Caries and Packaging Materials (bioplastics). Copies of all the case studies employed in this study will be found in appendix 4.

Phase 2 comprised four Workshops each lasting three hours. The first section of each workshop, approximately one hour in length, explored participants' pre-existing knowledge and responses to the initial three case studies. The second section lasting approximately two hours involved a facilitated meeting between participants and several stakeholders. Details of stakeholder participation will be found in appendix 6. The final section of each workshop entailed orienting participants toward their own self-directed deliberation. Participants were also given five further case studies (HIV microbicides, Building Materials, Bioethanol, Phytoremediation of Organic Pollutants and Dutch Elm Disease Resistant Trees).

The style of facilitation employed in the sessions was very similar to that employed in the Foundation Discussion Workshops conducted for the AEBC by Corr Willbourn in 2002. The philosophical underpinnings of this approach were discussed in the Foundation Discussion Workshops Report and the reader is directed to that source for a fuller discussion – see, for example, http://www.gmnation.co.uk

Importantly, although our approach is informed by the non-directive facilitation methods developed by Carl Rogers and others [see for example Rogers (1965/2002), Client-Centered Therapy, Constable, London], we also draw upon Process-Oriented Psychology as developed by Arnold Mindell [see for example Mindell (1985), River's Way, Arkana]. Thus, while participants are encouraged to meet and work with the material in their own way, and to draw upon their

own lived world frames of reference, there were many occasions during the workshops, and subsequent seminars in phase 4 (see below) where either the facilitators directly, or indirectly (by requesting input from stakeholders), challenged participants' pre-conceived notions or technically erroneous perceptions. This meant that participants were given the opportunity to revise their thinking in the light of further information or clarification of substantive points and not left to deliberate on erroneous notions. However, in line with non-directive facilitation theory participants were not coerced into accepting any particular reading of the information, simply given access to wider frames of reference.

Phase 3 took place over about two weeks and consisted of participants' independent research, discussion, reflection and deliberation on the issues. Each participant was provided with a folder for recording his or her deliberations.

Phase 4 consisted of each workshop being reconvened into two seminars. Thus eight seminars were conducted each lasting one and a half hours. The seminars focused on participants' deliberative activities and explored the conclusions, whether firm or tentative, they had come to. At the conclusion of phase 4 participants were invited to receive a copy of the draft report and comment on it if they so wished. The vast majority accepted the invitation to receive the report, although none did in fact respond with comments.

2. The Sample

The sample was required to be indicative of a broad cross-section of the mainstream of the UK population. To ensure that the sample was a good cross-section, despite its relatively small size, we recruited via four broad lifestages and two broad socio-economic groupings. This sample construction has been used successfully on many previous projects and has been shown to provide a good understanding of the public's views and levels of engagement with numerous complex issues. It is also important to note that the general public sample comprised people who had no direct allegiance with, or connection to, agriculture or biotechnology. Hence they genuinely represented the mainstream of public opinion. The sample was as follows:

	Scotland Urban, Edinburgh	Northern Ireland Rural Newtownards (and surrounding areas)	North of England Semi-rural York	South of England Urban/ Metropolitan Sutton, Surrey.
Phase 2 WORKSHOPS	Workshop 1 ABC1 Half - 18 – 24 Half - 40 – 59	Workshop 2 C2DE Half - 25 – 39 Half - 60 -74	Workshop 3 ABC1 Half - 25 – 39 Half - 60 -74	Workshop 4 C2DE Half - 18 – 24 Half - 40 – 59
Phase 4 SEMINARS	Seminar 5 ABC1, 18 – 24 Seminar 6 ABC1, 40 - 59	Seminar 7 C2DE, 25 - 39 Seminar 8 C2DE, 60 - 74	Seminar 9 ABC1, 25 - 39 Seminar 10 ABC1, 60 - 74	Seminar 11 C2DE, 18 – 24 Seminar 12 C2DE, 40 – 59

Workshops were recruited to have fourteen participants, and an equal number of men and women. In Workshop 2, one participant was unable to attend the first session and hence took no further part in the process. The total sample was therefore fifty-five participants.

3. Recruitment Criteria

- All Workshops were be an equal mix of men and women (although none were partners)
- Workshops will be recruited by broad lifestage:
- 18-24; the majority to have no dependent children
- 25-39; the majority to have dependent children
- 40-59; the majority to be parents of teenage families
- 60-74; the majority to be empty nesters.
- No participant worked directly in agriculture or in biotechnology
- Recruitment was inclusive of ethnic diversity
- No participant to be an active member of an organisation campaigning on either environmental or biotechnology issues.

The areas were chosen to provide as broad a coverage across the UK as is practical within a small sample. There is no location which is the epitome of urban or rural UK, hence representative coverage is provided by a diversity of localities.

4. Timing and personnel

The fieldwork took place between Tuesday 11th January and Tuesday 1st February 2005. The project was designed, conducted, analysed and reported by David Corr and Hugh Willbourn.

5. Research materials

Questionnaire

As part of the recruitment process participants were asked two open ended and one closed question relating to their knowledge of and attitudes toward non-food agriculture. These questions were part of the formal recruitment questionnaire a copy of which will be found in appendix 2. Analysis of the responses to the three questions will be found in Section IV.

Case studies

Eight case studies were employed in this study. Three were given to participants at recruitment prior to attending the workshops and the remaining five were provided at the end of each workshop. The case studies were developed by the AEBC and their secretariat and edited by Corr Willbourn. Copies will be found in appendix 4.

The case studies were developed and employed to provide both a context in which participants could meet non-food agriculture and the uses of biotechnology in NFA, and as specific examples of how NFA could be employed giving rise to the kind of issues that might be raised by such applications and NFA itself. However, the Deliberative Engagement exercise was not constructed to evaluate the case studies as such. Rather, the case studies were employed as stimulus material to raise awareness, to concretise the concept of NFA and

related biotechnology uses, to render the issues raised by NFA more accessible, and to provide a means of enabling participants to articulate their frames of reference and values sets. Moreover, the case studies provided concrete examples that encouraged participants to reveal how they make trade offs between benefits and attendant risks. Thus responses to the individual case studies are employed in this report to illustrate the findings rather than to instantiate them per se. Employing specific case studies inevitably introduces some distortion on the findings at the general level. However, without using specific examples, particularly in this technically complex arena of NFA, the public engagement would have been so ill-informed as to be vitiated. Hence the risk of inadvertently inviting too much focus on the specific case studies was significantly less than the risk of failing to engage and utilise the deliberative faculties of the participants - which would have been the result had the case studies not been employed. Of course, it is recognised that the number of case studies that could usefully be used was small compared to the number of potential NFA applications, yet it was believed that the case studies selected offered an appropriate and wide range of potential applications, and hence structurally the case studies taken as a whole provided a broad context of NFA for participants to engage with.

It was also evident in both the workshops and seminars that most, if not all of the case studies, begged as many questions as they provided answers. This was not a shortcoming of the case studies. On the contrary the consequent enquiries, their objects and referents form a substantive part of the findings below. The case studies were not intended to be definitive treatises (and nor could they have ever fulfilled this intention). They were intended to introduce NFA, to concretise the concept using specific and accessible examples, and provoke debate. This they did convincingly.

GM scenarios

A series of boards were prepared by Corr Willbourn describing various stages of production/consumption at which GM technology can be employed. Copies of these statements will be found in appendix 5.

Deliberative folders

Participants were supplied with a folder and each folder comprised a sheet listing a range of website addresses germane to the field of enquiry. They also comprised a set of sheets each headed with a key frame or category identified as important in relation to non food agriculture by our client viz:

Social: What considerations are there for society and communities

Environmental: What environmental issues are there?

Economic: What are the economic consequences?

Ethics: What is the right thing to do?

Health and Safety: What are the health and safety implications?

Politics: What are the political implications?

A further sheet was also appended entitled 'Other issues: What else needs to be taken into account?'

Participants were made aware that the categories were only one way of approaching the deliberation around non-food agriculture and should serve as a prompt to and not a limit on their thinking and deliberation.

Case study rating sheets and Participant recommendation sheets

Toward the end of the seminars participants were invited to rate the eight case studies in terms of how keen they were to see each application developed. They were also invited to write down the key recommendations that they wished to be passed on to Government on their behalf. The data from these exercises is integrated into the main findings in section IV.

3. Executive Summary

1. Summary of key findings

This project set out to explore the public's views on non-food agriculture (NFA), and the potential role of biotechnology within this.

The majority were previously unaware of NFA as such. In both rural and urban areas there were very strong opinions expressed that the countryside is under increasing threat from development and urban sprawl.

It was clearly demonstrated that the majority of the public possess little detailed knowledge about the structure and realities of modern agriculture, and relate to agriculture primarily in terms of it preserving and maintaining the familiar look of the countryside (the 'green and pleasant land'), and only secondarily to the actual outputs of agricultural production. In this context agriculture is framed by the public primarily as the guardian of the countryside – a role that all wish to see continue. The level of concern about increasing urban sprawl and concomitant loss of countryside is very strong among the public. Whilst many recognise that these attitudes are coloured by a romantic view of the countryside and agriculture's place within it they are both sincere and serious.

On further discussion it was widely recognised that the countryside had changed very much in the last few decades and mixed farming had all but disappeared. There was some nostalgia for such farms. For a sizeable minority, the farmers' market movement, and the growing emotional antipathy to supermarkets and their policies - which are believed to be both ruthless and environmentally damaging - lead them to believe that mixed farming and locally grown and sold produce should, and would, be actively encouraged. Against this backdrop many perceived, at least initially, that NFA might have a role to play in this mix.

Deeper exploration of NFA and potential applications however raised complex questions and issues. The role of biotechnology was especially salient and clearly presented the biggest barrier to public acceptance. For the vast majority biotechnology was synonymous with genetic modification. Even when non-biotechnology applications were introduced, many felt that NFA might represent an attempt to introduce genetic modification into the UK 'through the back door'. Importantly, the public met the concept of NFA and the attendant issues through their own frames of reference – frames that are grounded in the experiences of their everyday lived worlds, rather that through the technical frames of reference employed by those with a professional engagement.

The central frames of reference were:

- *Environmental safety and human health* - impact on the countryside, potential effect on, or entry into, the food chain of alien genetic material.
- *Waste and packaging* - primarily framed in terms of landfill, domestic rubbish and supermarket packaging.
- *Fuel/energy* - global warming, pollution, cost and dependence on middle-eastern / foreign oil.
- *Wariness of large corporations* – viewed as excessively concerned with profit and insufficiently concerned with externalities and environmental risks.
- *Wariness of politicians* – the Government was not trusted to protect the countryside, nor to adequately control multi-national corporations.
- *Human suffering* – the development of novel medicines for the cure or alleviation of serious diseases, such as cancer and HIV/AIDS.

This study was designed to encourage the public to engage with and deliberate on the issues raised by NFA. This deliberation was wide ranging and generated a broad range of responses and opinions. A number of clear themes emerged and there was broad consensus on a number of central issues.

Biotechnology

As already noted the terms 'biotechnology' and 'genetic modification' (GM) are virtually synonymous for many members of the public. While all of the case studies employed as stimulus to discussion featured the potential role of GM, it was also made clear that many of the applications could proceed without the use of GM. Nevertheless, the GM theme returned again and again throughout the discussions and deliberations. The majority were clearly very concerned about the use of GM in NFA. Some were willing to consider its use in controlled conditions if there were serious positive medical benefits.

Arguments that GM improved the economics or efficiency of a process were not considered sufficiently significant to prompt acceptance of GM. Participants felt that in spite of research to date the long-term risks of GM were still both unknown and potential irremediable.

The majority believed that research into genetic modification would nevertheless continue and therefore hoped that exemplary safety would be clearly established before any commercial exploitation of GM is attempted.

Hierarchy of acceptability

However participants did have a hierarchy of acceptability of GM – if to be used. Most acceptable were applications that utilised genetically modified micro-organisms employed solely within closed / factory / laboratory conditions to produce for example products such as alcohol from field grown non GM feedstock. Less acceptable were genetically modified crops grown in secure greenhouses – although many felt that even the most stringent safety procedures would not totally prevent accidental release of GM material. Still less acceptable was the field growing of GM non-food crops, and least acceptable was the field growing of GM food or fodder crops.

Risk – Benefit analysis

Generally people did not conduct, nor apparently have the means to conduct, sophisticated or finely balanced risk / benefit analyses. If a potential benefit was

considered overwhelmingly valuable (and not liable to be suborned by corporations or Government) e.g. a cure for cancer or HIV/AIDS it was, for many, sufficient to justify running the risk of authorising cultivation of a GM crop (although ideally under strictly controlled still conditions). However if the benefit was not considered overwhelming, they erred on the side of caution and tended to advocate more research.

If GM was removed from the frame, it was not felt necessary to conduct a risk/benefit analysis because no other risks were considered sufficiently significant to even call for such analysis. Thus in the absence of GM the evaluation process became more of a cost/benefit analysis i.e. 'is it a real benefit, and if so, to whom? . . . and what will the impact be on jobs, health, the countryside, and the environment *in toto* be?

While the public were invited to deliberate on the issues raised by NFA through the six key frames identified by the Commission (namely: social, political, ethical, economic, environmental, and health and safety criteria) participants were also invited not to be constrained by these given frames. The majority did, however, use the given frames as the primary organising structure for their deliberations. But beyond this, it was very clear that the public's criteria are grounded not in the technical categories of engaged actors but in lay understandings of science, technology and policy decisions. Moreover, the public tended not to assert their criteria as statements, bit express them in the form of questions. The public's key questions or criteria in relation to NFA and the potential role of biotechnology within this were:

- Is it safe?
- Will I benefit?
- Will someone benefit?
- By how much will I/they benefit?
- What's it going to cost?
- Is this really the best idea?
- What is the agenda of those promoting it?

- What would happen if we said 'no' and carried on as we are?
- Even if we do say 'no' will they do it anyway?

In conclusion the public believe that non-food agriculture could play an important role in the future of UK agriculture. The majority believe however that NFA should be progressed without GM, although they expect to see GM research going on in the background (but not commercially exploited) to establish categorically its long-term risks and benefits.

2. Brief outline of methodology

A four stage deliberative exercise concerning non-food agriculture (NFA) was been carried out among the general public. The stages were as follows:
Stage 1 – Recruitment of participants and collection of data on attitudes toward the countryside and knowledge of NFA. Dissemination of three NFA case studies: Packaging materials, Dental Caries and Short Rotation Coppicing.

Stage 2 – A series of Workshops among the public exploring attitudes toward NFA in depth, along with input from Stakeholders. Dissemination of a further five NFA case studies: Bioethanol, HIV Microbicides, Phytoremediation of organic pollutants, Building Materials and Dutch Elm Disease.

Stage 3 – Participants engaged in self-guided deliberation lasting approximately two weeks.

Stage 4 - A series of Seminars exploring participants' conclusions.

4. Analysis and Main Findings

1. Some comments on the sample

The general public sample for this project was constructed to provide a broad cross-section of the public by recruiting according to a few broad lifestage categories. The study did not, however, given the size of the sample, set out to provide an exhaustive analysis of how attitudes toward non food agriculture and potential applications of biotechnology within it vary across the various lifestages or other sample variables.

In comparing this sample to the many samples we have met in commercial and other non-commercial research projects, we conclude that the sample for this project was a good reflection of the general public.

In understanding the data presented in this report it is crucial to bear in mind that none of the participants who took part in this study were deeply knowledgeable about modern farming methods nor were they versed in the science underpinning biotechnology. Thus there were many areas highlighted in the case studies, or brought to light in participants' own research, that at a technical level were outside participants' understanding and knowledge bases. It could be argued that in the absence of detailed technical knowledge it is very difficult to appraise the merits or otherwise of some of the issues raised by non food agriculture. Indeed, a good number of participants argued this very case themselves. However, participants were neither asked nor required to provide a scientific assessment. They were asked to provide an assessment grounded in their lived experience and citizenship. They clearly succeeded in this task and the data presented in this report reflects that success.

2. Knowledge about and attitudes toward non food agriculture at the beginning of the deliberation process

As noted earlier, at recruitment participants were asked three questions to gauge their prior knowledge about and attitudes toward non food agriculture. The responses to these questions were surveyed by the researchers prior to the workshop sessions and formed stimulus for the first section of each workshop.
In the following analysis we have therefore aggregated data from the initial questions and the first part of the workshop sessions.

The countryside

Participants were asked how they would wish to see the land and countryside of Britain used in the next twenty to thirty years.

The majority of comments in both rural and urban areas showed a very strong desire to maintain and conserve the amenity value of the UK landscape.

Preserve what we have/ Threat of development

"I would like to see our land look like it is today with no more land taken away from us and used for building new housing estates to accommodate open house entry into this country that the government is adopting."
[ABC1, 60 - 74, York]

"To stay the same and not to be built up. We should preserve what we have for future generations to enjoy."
[C2DE, 40 - 59, Sutton]

"Kept green and picturesque, no major housing or industrial developments. Probably used for crops because it still looks nice and is useful."
[ABC1, 18 - 24, Edinburgh]

"Green fields and rolling hills – much less building in rural areas and a limit to urban building."

[C2DE, 60 - 74, Newtownards]

Farming

Farming and agriculture emerged as the second most mentioned theme – although the number of mentions was about one quarter of the number of mentions for preserving the countryside. Moreover, as will be seen in some of the quotes below the desire to maintain the amenity value of the landscape was also part and parcel of the desire to see agriculture flourish:

"I would like it to be fully utilised for growing food products, but also our green belt maintained and preserved for leisure pursuits, hill walking etc. I wouldn't like to see our green areas of natural beauty disappear."

[ABC1, 18 - 24, Edinburgh]

"For farming and agriculture. No housing. We do not have enough [countryside] . . . . family picnics etc – not private or restricted – for people who wish to experience the beauty of the countryside."

[C2DE, 18 - 24, Sutton]

"To keep it rural – not too much building. Keep the country for the country - develop the farming aspect by more diversification."

[C2DE, 25 - 39, Newtownards]

Open access

Allied to the desire for maintaining the amenity value of the countryside were several calls to ensure that open access to the countryside is preserved, if not extended:

"I think it will look much the same and my hope is that there will be greater access for people who want to use it."

[ABC1, 40 - 59, Edinburgh]

Sustainability

A few framed their responses in terms that can be construed as congruent with the sustainability agenda. This was particularly noted in Scotland with a number expressing strong concern that traditional forms of land husbandry are under serious threat from modern agricultural and economic patterns:

"I'd like to see traditional ways of life not being eradicated. The small farms not being swallowed up by conglomerates and forestry – protection of what we have; hedgerows and protection of habitats of wildlife. I think sustainability and diversity is very important and it is vital to preserve what we have now have."

[ABC1, 40 - 59, Edinburgh]

The quotes above show that the public have very clear views on how they wish to see the countryside managed in the future. Fundamentally, the majority wish to see the development of housing estates, out of town shopping facilities and concomitant road building curtailed. As already noted these themes were explored in more depth in the first sections of the workshops, and it was very clear that there is a very real fear that indiscriminate development is felt to be the biggest threat to the countryside. All recognised the inherent tension between society's needs for housing and facilities (including a workable road system). In the rural areas, in particular, the issue of affordable homes for local people was also a particularly pertinent issue. However, all also recognised that the price of development is the continued loss of open and green spaces – which are considered core features of the UK countryside, and important for the well-being of society at large.

Some recognised that there are no easy answers to balancing the needs for housing and the need to preserve the countryside. However, the majority were adamant that current Government policy (as currently understood) poses a threat to the integrity of the countryside. Inevitably, such a discussion evoked comments about the population size of the UK and the perception (particularly in the workshops in England) that immigration into the UK is a major

contributor to the pressure on the land. Hence there were many calls for tighter controls on immigration and recognition by Government that the UK has finite resources which are already stretched.

Within this, it is interesting to note that farming/agriculture is seen to play a crucial role in preserving the current pattern of land use. Hence farming activity is seen to not only provide food and other agricultural products (although it must be said that many people's knowledge of modern UK agriculture – especially in the urban workshops – was sketchy to wholly uninformed), but also to provide a wealth of 'green and pleasant' environments that otherwise would become part of the built landscape. In the more rural areas participants were more acutely aware of the pressures faced by farmers:

"I have got a couple of friends who are farmers. One is a sheep farmer and he has to have three other jobs in order to finance life for his family. He has a small house, one child, and his wife works fulltime as well and he cannot make enough money out of farming."
[ABC1, Workshop, York]

Some were aware that many farmers have been forced, through economic circumstances, to sell off tracts of land to developers, and are very keen to see farmers being given assistance to slow down or even prevent this process.

Thus it could be said that the public's fundamental relationship to agriculture now is one of 'guardian of the countryside' with the desire that this guardianship limits development. Hence the outputs of agriculture are framed as a secondary and not its primary purpose.

The amenity value of the countryside has more salience for the public than agricultural production as such. Thus it seems that what people 'consume' from the countryside is a green and pleasant environment first and foremost – the production of food and other agricultural products is below the horizon. Of course, the public purchase and consume agricultural products, but this engagement is grounded in, and framed by, their everyday activities of

'shopping', or 'feeding the family' etc., and not grounded in a lived experience of agriculture itself. Thus while the public are of course aware of many agricultural outputs, and are aware of some of the issues farmers face in delivering these outputs, their experience of agriculture is not grounded here.

Some discussed the value of Farmers' markets and wished to see these better supported. These are seen to have many benefits including supporting local farmers and fresher, higher quality food. Beyond these obvious benefits there was also evidence of a wish for the emotional rewards of a closer re-connection to the actual production process and outputs of agriculture. This seemed to be a quite widespread latent need.

Non food agriculture

Participants' prior awareness of the term non food agriculture was gauged via a closed question at recruitment. The majority (around three quarters of the sample) claimed not to have heard the phrase before. Following this participants were asked to say what they though non-food agriculture might mean- whether they had heard of the term before or not.

Although about a quarter of the sample claimed that they had heard of the phrase non food agriculture, it was clear that the majority of these participants did not have any substantive knowledge about the topic. Many of them in fact defined non food agriculture in self-reflexive terms. Thus when asked to say what they understood by the term they replied with a statement such as 'Non food agriculture is the growing of things which aren't used for food.'
Perceptions of what non food agriculture might be fell into several clear categories and these are discussed below in descending order.

Materials/artefacts

The most frequent perceptions were that non food agriculture is associated with producing plant and animal products for the manufacture of materials and artefacts such as clothing and furniture etc:

"Things like flax for cotton, linen. Trees used for furniture and packaging."
[ABC1, 60 - 74, York]

"Growing plants and trees for use in manufacture and industry."
[C2DE, 60 - 74, Newtownards]

"Clothing, cotton, sheep's wool. Things in the countryside you don't eat."
[C2DE, 40 - 59, Sutton]

Self-reflexive definition

A good number – even of they believed they had heard the term before defined it essentially in self-reflexive terms. The term appears to be self-evident and people's inability to define it in concrete terms underlines the finding that many members of the public do not ordinarily think about the specifics of agricultural production:

"Obviously non food. Using what is found in the land to use for non food purposes or grown for non food purposes. For example, cotton, or clay or even maintaining what we have."
[C2DE, 40 - 59, Sutton]

"I think it means it should or could be used for uses other than human consumption. But that doesn't mean that it wouldn't be used for human consumption."
[ABC1, 40 - 59, Edinburgh]

Return land to nature/conservation/amenity

Some believed – or perhaps more accurately hoped – that non food agriculture would herald a return of much agricultural land to wholly amenity use:

"Land that is no longer used for farming left just to nature."
[ABC1, 25 - 39, York]

"Land clearing, planting, people making the land look better tending to trees attending to the land to produce beauty rather than food."

[C2DE, 18 - 24, Sutton]

"It would be about plants which grow in their natural habitat and also the wildlife."

[ABC1, 40 - 59, Edinburgh]

Medicine/health

A small number felt that the term referred to the growing of crops with pharmaceutical value:

"This to my understanding of non food agriculture is that farmers are growing crops for the benefit of health for human beings and other forms of life."

[ABC1, 60 - 74, York]

"I would think as a guess it may be to do with medical research – maybe growing crops which can be used for medical purposes."

[ABC1, 18 - 24, Edinburgh]

However, in the follow up discussions in the workshops it was clear that many more people were interested in the development of novel medicines from plant sources. None of these people expressed a definite desire that these products would be 'natural' or herbal. Rather, the underlying attitude was one of extracting medically valuable substances from plants as pre-cursors of standardised drugs.

Set aside/EU

A few thought that non food agriculture either described the current practice of set-aside, or was a formal extension of it:

"The leaving of land fallow to obtain EEC grants in return for not adding to the food mountain or growing trees for tax relief."

[ABC1, 60 - 74, York]

Forestry

A minority felt that non food agriculture referred to forestry or the re-establishment of Britain's hedgerows:

"Something maybe to do with forestry or maintaining the countryside for example hedges and bushes."

[C2DE, 40 - 59, Sutton]

Others (mentioned once only)

"Growing GM crops and bad things."

[C2DE, 40 - 59, Sutton]

It will be noted that many of the comments echoed the views participants articulated earlier, that is the desire to see agriculture playing a vital role in preserving the countryside and wildlife/habitats. However, the largest category of response related to the growing of agricultural products to be used in a wide variety of applications – broadly under the heading of manufacturing. It is fair to say, therefore, that in general many participants' perceptions as to what non food agriculture could mean were broadly in line with the case studies presented.
Having said this, while some were aware of specific current applications (such as the growing of coppice in Northern Ireland) none of the participants were aware of the very wide range of applications that are currently in development.

Moreover, none of the participants had formally thought about non food agriculture within the interlocking frames of e.g. social, environmental and economic considerations and consequences before. This is not altogether surprising. Members of the public generally meet the world in terms of their own interests and understandings and rarely meet concepts in the tightly delineated way that engaged actors do.

Within this it was clear that the case histories given to participants at recruitment (prior to the workshops) were valued for presenting a balanced case but equally criticised for being equivocal. We discuss this further in the following section.

3. Contextual issues raised by the case studies

Three case studies – Short Rotation Coppicing (SRC), Dental Caries and Packaging Materials - were given to participants at recruitment prior to their attendance at the workshops. Responses to these were discussed during the workshops. Five further case studies were given to participants at the completion of the workshops and formed part of their self-directed deliberations, the output of which was explored in the subsequent seminars.

In analysing these responses it became clear that rather than reporting on each case study individually, as if they were stand alone concepts, it would be more congruent with participants' deliberations to explore the general themes that the case studies evoked.

The contextual issues discussed below were provoked by the concept of NFA and the specific case studies employed. It is clear that these contextual issues form a normal and current part of public discourse, but generally these issues are latent for most people and only become a focus of attention by such things as news stories or the case studies used in this study. Hence in discussing the contextual issues we will also include illustrations of how each of the case studies contributed to the overall salience of the contextual issues. It would be inappropriate to separate the contextual issues and the case studies because the case studies were vary largely the stimulus that evoked discussions around these larger contextual issues.

1. Difficulty, balance and closure

A good number of participants claimed that they found the case studies difficult to engage with fully. Some claimed that this was because of the scientific and technical terms/concepts employed. It seems that this is not simply because the terms themselves are unfamiliar, but rather because many people seem to

respond to technically-sounding language by believing that they won't be able to understand it.

Notwithstanding these difficulties it was very clear in discussion that the vast majority of participants could grasp the essential 'offer' contained within each case study and could discern whether the concept in question appeared to be viable or not. It was also clear that the range of examples chosen provided broad enough coverage to enable participants to engage with the underlying concept of NFA – and the wider issues that NFA is part of (such as land use, environmental issues and so on).

For some, a significant difficulty posed by the case studies was the fact that for every potential benefit a potential negative was cited. Participants seemed to value the fact that the material presented to them was balanced and was not glossing over important problems. Yet that very balance did seem to make sustained engagement problematic.

Thus in the SRC example the concept of bioremediation is introduced which can be seen as an important benefit. However, immediately this potential benefit is qualified by the data that the ash resulting from burning coppiced wood grown on contaminated land would need to be disposed of safely. Similar potential benefits and potential problems featured in all of the other case studies. This was, of course, intended. None of the case studies were presented as trying to 'sell' or not the concept in question. They were designed to present a balanced introduction to the concept using as far as possible neutral language. Yet, many members of the public when presented with such data wish to also find closure – such that they can confidently make up their mind as to the value to ascribe to the proposal:

What is very clear is that the public – even if they find technical information difficult to engage with – have a very well honed ability to spot the unknowns in any data. In all of the case studies there are overtly referenced and implied unknowns which is to be expected given the stage of development of many of the case studies. Not surprisingly, when these unknowns are met, the public

typically respond by requesting that more research and/or testing is carried out until the questions begged by the unknowns can be answered. This theme of 'we need more research' surfaced throughout the entire process – yet despite this all were able to evaluate the overall concept of NFA and the individual case studies using their own criteria.

2. The effect of Genetic Modification

All of the eight case studies explored in this study discussed the potential applications of biotechnology in developing the applications. The decision to construct the case studies in this way was taken by the Commission because one of the primary objectives of the deliberative engagement process (congruent with the Commission's remit) was to explore whether the public holds different attitudes towards the application of biotechnology in food and in Non-food crops. Thus this study must be seen in context – as an exploration of NFA and the potential role of genetic modification (and other biotechnology applications) within this.

While it was made clear in each case study that Genetic Modification was only one of several potential biotechnology approaches, it was very clear that the vast majority, if not all, participants conflated the two terms and invariably read 'biotechnology' as meaning genetic modification (GM). This is not an altogether surprising finding. Most members of the general public have little awareness of biotechnology outside of GM, and the vast bulk of popular media attention in this area has focused on GM (largely in negative ways). Moreover, as we found in earlier work for the Commission (the Foundation Discussion Workshops and the Narrow but Deep studies *loc cit)* the term GM evokes considerable concern amongst large numbers of the public:

"Looking at some of the polls that have been conducted most people are against GM. So why is the government still pursuing it? It seems to me that the government isn't listening."

[ABC1, 40 - 59, Edinburgh]

All of the participants noted, many on numerous occasions, that they were aware that the public had already made clear its views on GM – i.e. that the majority were against the growing of GM crops in the UK. Hence there were a good number of participants who wondered if the entire non-food agriculture project was not in fact subterfuge - the real interest in it being a way to 'get GM in through the back door'. This viewpoint was expressed during some of the workshops and again surfaced in many of the seminars following the self-deliberation period:

"You begin to wonder if there is a hidden agenda behind the whole lot of it (non food agriculture*) because they were all such airy fairy ideas* (the case studies) *and I began to wonder whether since most people in this country are totally against GM foods, you know paranoid about them, whether if you tried to bring in GM non agriculture produce and say 'Oh, it's good, it's drugs, it's all this and that' then people would go with it."*

[ABC1, 60 - 74, York]

Importantly, not all participants met the GM issue with caution or suspicion. Indeed, a minority in response to the three questions asked at recruitment spontaneously mentioned GM in relation to how they imagine the countryside in twenty years and/or in relation to what they thought the term non food agriculture meant:

"I would like it (the countryside) *to be used for more agriculture and forestry which would help the environment and if that means GM crops that have been proven safe so be it."*

[ABC1, 60 - 74, York]

"Personally I hope there might be more protected land and I feel that the farming industry won't last as it is now. I think that in the sense of GM farming it will increase and I don't actually mind because I think in the long term it will benefit us. I think that people complain about the sides of GM farming but they forget that we already have harmful pesticides. They forget we wouldn't have our perfectly formed fruit and veg if science wasn't already involved in farming."

[ABC1, 18 - 24, Edinburgh]

However, overall it was clear that the majority were either 'against' GM until it becomes a proven technology, or at least extremely cautious about its development. Not surprisingly, therefore, GM featured as a recurring theme throughout the workshops, participants' self-directed deliberations and the subsequent seminars. Even when the facilitators or stakeholders (in the workshops) encouraged participants to consider the wider issues (for example, by re-iterating how many of the non food agriculture applications can be developed without GM technology) the topic of GM returned again and again and remained very potent. This raises a very crucial question, namely why did the topic of GM assume such importance during this deliberative process? It was clear that once the topic of GM was raised (as indeed it was in the case studies provided at recruitment) it continued to feature within the conversation simply because it is such an emotive subject. It is not our intention here to repeat the analysis of the public's views of GM that we presented in our earlier reports. However, there is one very important difference between the earlier work which focused on GM crops and this current study. In past studies we have noted how many members of the public claimed to be more supportive of the use of GM technology in medical applications (such as gene therapy and growing GM plants which yield important pharmacological substrates). Yet, this more open acceptance was always in relation to very strong rejection of, or caution toward, growing GM crops for human consumption. In this current study none of the applications featured a food crop, and hence this comparator was absent. In its absence it was clear that the majority were somewhat more cautious about the medical applications, for example. It is clear that the use of GM technology within non-food applications is also controversial and even if it were to gain

acceptance stringent safeguards similar to those that the public wanted to see in place for food applications are very likely to be required.

3. Global Warming and energy needs

Awareness of global warming was near universal across the sample – although detailed knowledge appeared to be low. It was widely believed that addressing the likely causes of global warming - such as reducing CO_2 emissions - is a 'good thing', and very possibly a very urgent task. However, many were aware that the United States has not agreed to honour the commitments of the Kyoto Agreement, and hence wonder if any reductions achieved by the UK would make any substantive difference. At present it is fair to say that many members of the public are aware that global warming is a potentially devastating phenomena, yet have little sense of how any changes they made to their energy needs and consumption would deliver any substantive benefit to the environment. It is also clear that many feel that they could not contemplate radical changes to their lifestyle – given the reliance not just of individuals but also society as a whole on the motor car, air travel and centrally heated homes for example. Against this backdrop it was very clear that any potential method of reducing CO_2 (whether via a non food agriculture application or any other method) would need to offer more than a theoretical benefit to be worthy of serious consideration. The short rotation coppicing case study provides a good illustration of how the public meet the issue of global warming/reducing CO_2 output.

Short rotation coppicing

During the workshops it was clear that many participants had assumed that Short rotation coppicing (SRC) was being promoted as a significant energy provider. When stakeholders or facilitators introduced the idea that
SRC would in all likelihood be developed as a 'local' resource – such as firing combined heat and power units in municipal buildings – many wondered if a significant reduction of CO_2 would in fact be realised. While few raised any objections to growing areas of coppice (in fact many felt that it could be an attractive feature) a good number questioned whether other forms of energy

generation – such as solar and wind power - might not be more economically viable. A few, however, believed that none of these other alternatives have yet delivered substantive benefits:

"When you actually look at the statistics of some of these things that certain activities are supposed to reduce carbon emissions and I am thinking of wind farms on the Isle of Lewis. If we look at the statistics on the surface it appears to be a wonderful thing, but when you discover that in order to build the wind farms they had to dig seventy miles of road through peat bogs which releases huge amounts of carbon dioxide. And it will take between eight months and eight years to come back to a position of zero carbon dioxide. So it's rather pointless the whole exercise."

[ABC1, Workshop, Edinburgh]

Thus, not surprisingly many felt unable to unequivocally support an application like SRC or not, without clear quantitative evidence of its benefits. In some of the workshops one or more stakeholders pointed out that decisions around applications like SRC cannot be made on the basis of some global formula, but rather the decisions need to be taken on a case by case basis. It was further explained that SRC is likely to be linked to a local biomass or CHP generator. This notion was considered more acceptable than very large-scale SRC, but its net contribution to the amelioration of global warming was still questioned.

The possibility that SRC could also be combined with bioremediation and/or fertilised with municipal sewerage met with approval, although evoked some concerns. Disposal of ash from SRC grown on bioremediated land was considered to be a significant issue – and perhaps an example of solving one problem whilst creating a different yet as serious problem elsewhere. Treating municipal sewerage by using it as an organic fertiliser for SRC led to many wondering if such land could be returned to food production if this was needed, or whether such land would no longer be suitable for growing food crops. Clearly, re-assurances about the ecological safety of such practices would be required to allay public concerns. It must also be said here that the vast majority did not evaluate the bioremediation potential of SRC strictly in terms of its

potential impact on the energy efficiency of the process. Rather, it was seen more as a holistic environmental issue.
This, along with many other findings from this research, suggests that NFA applications with multiple, interlocking benefits of different types are more likely to get a favourable reception. However it is also clear that unambiguous communication of such multiple benefits is a significant challenge.

Many were encouraged by the fact that when growing SRC crops absorb carbon dioxide, which was generally known to be a greenhouse gas implicated in global warming. However, there were some calls for quantitative data on the ratio of carbon fixed during the growing phase to how much is released by burning the harvested crop. Several of the stakeholders pointed out that such data could only be calculated within the context of a specific usage scenario. Participants generally accepted this, but for many the small scale implied that it would not be a serious contributor to the UK's energy needs and carbon balance – and as such will probably remain a fringe application. Having said this it was also clear that some found the SRC concept very appealing:

"I think the short rotation coppicing is a totally brilliant idea and why aren't we doing it already?"

[ABC1, Workshop, Edinburgh]

Having evoked the contextual issue of global warming it was clear that many wanted to see one or more substantive examples of how this can be tackled. Thus in many ways the context overshadowed not just the specific example of SRC, but to a large extent the potential role of NFA in addressing serious environmental issues. The general public typically do not employ the same strategic thinking as involved actors. Thus when some information (such as the potential of NFA to contribute toward a lowering of CO_2 emissions) is presented it tends to evoke a desire to see a *global solution* rather than an application that may, as part of a co-ordinated strategy, provide some substantive benefit. However, in marked contrast the bioethanol application for many appeared to offer enough potential benefit to be worthy of significant support.

Bioethanol

This was the most widely favoured application across the sample. In many ways it is the easiest concept to understand, and moreover, many felt that it was the most likely to succeed given that Brazil and the USA already produce significant quantities of bioethanol, and hence the application is *already proven to be viable in the broad sense.* Furthermore, the UK is considered to be well placed to exploit the application as it already successfully grows several sugar bearing crops. It was also clear that bioethanol is the only application that has immediate consumer relevance and demands no behavioural or attitudinal change by the consumer. This point perhaps is worthy of underlining. While the context evoked by SRC and bioethanol was 'global warming' it was clear that bioethanol, to some extent, allowed participants to feel that a solution had been identified which potentially provided *enough benefit* to enable them to feel they could make a meaningful contribution towards solving the global warming problem without serious inconvenience to their lifestyles. A good number were aware that the emissions from the private motor car contribute toward the increase in greenhouse gases released into the environment, however by and large the deliberations around bioethanol framed it as a contributor to *maintaining* usage of the car and *reducing* our dependence on Middle Eastern oil states. Thus bioethanol was seen to be a benefit in terms of its contribution to our energy and transport needs:

"We are dependent on fuel and we are dependent on the Arabs. If we could grow our own fuel that would be absolutely fantastic."

[ABC1, Workshop, York]

There was quite significant discussion around the core role that the motor car plays in modern life and no-one was seriously contemplating reducing their reliance on it. Public transport was discussed, with most feeling that it fails to offer a real alternative. Moreover, the tenor of the discussions indicated that few feel confident that public transport will improve to the point where it becomes an attractive alternative. Thus whilst the motor car is seen to be part of the problem (of global warming etc), it is also seen as a sine qua non of modern life. Even those who thought the issue through to a conclusion and realised that increasing

car use may offset all the gains achieved by using bioethanol still considered it to be a project worth progressing.

Many were puzzled as to why bioethanol and other similar alternate fuels have not been more strongly championed by Government – such that they become economically viable. Indeed, there were calls for Government action to make bioethanol competitive, either via tax breaks on bioethanol production, tax rises on the petrochemical industry, or a lowering of duty on bioethanol. Ideally, consumers would like to see bioethanol introduced without the need for any price rise at the petrol pump. A minority, however, believed that even if bioethanol remained more expensive it should be progressed as a matter of urgency.

Genetically modifying the plants for SRC or bioethanol was largely rejected on the grounds that the technology is as yet unproven (in terms of both risk and benefit) and thus it is too early to accept widespread field growing. Neither of these applications appeared to lend themselves to growing within contained environments. However, in the case of bioethanol genetically modifying the yeast used in fermentation to improve alcohol yields was supported by many – if and only if the modified yeast was used in a tightly regulated and contained environment, with no possibility of the organism escaping into the wider environment.

4. Waste

This topic was evoked almost exclusively by the Packaging materials case study, but proved to be a very robust issue that returned to the discussion numerous times. Across the sample the majority were concerned about the amount of packaging which accompanies many bought items (foods, toys and brown goods were felt to be particularly bad culprits), much of which is believed to be plastic of some kind. Many claimed quite vociferously that such packaging is excessive, wasteful, if not unnecessary. Retailers and manufacturers were frequently described as being irresponsible in this respect. Similarly, many wanted to see

central Government take a more proactive stance toward retailer and manufacturer behaviour by pressing for change or even legislating for it:

"Manufacturers should be fined or similar if they use environmentally harmful materials if there is a realistic alternative."

[C2DE, 40 - 59, Sutton]

A minority, however, recognised the impact of their own consumption choices in this area - openly admitting that they prefer fresh food produce to be packaged, as this makes the produce more attractive and less likely to be damaged by handling.

Many talked about re-cycling initiatives in their local areas and generally seemed very supportive of such schemes. A good number believed that the need to reduce waste taken to landfill was urgent, and the overwhelming majority supported the introduction of biodegradable plastics for packaging – indeed the packaging materials application was rated the second most appealing:

"The use of biodegradable plastics in heavily used products e.g. nappies and sanitary products should be introduced as soon as possible."

[ABC1, 25 - 39, York]

Many also wanted to see considerably more action by central and local government in promoting recycling. A good number also felt that such topics should be introduced into schools as part of the national curriculum.

No one researched this specific application in sufficient depth to look at the trade off between bio-degradable plastic and the release of CO_2 during its breakdown and the 'locking up' of carbon in non-degradable plastic. When the public are confronted with such huge contextual issues as 'waste' apparent solutions are readily supported in the absence of a thorough investigation of potential negatives in the overall scenario. However, this is not to level criticism at the public, nor to make light of the complexities involved. It is, however, an important meta-context to keep in mind when analysing public engagement in

any technically complex and challenging area. The public, in many ways quite rightly, expect specialists in the field in question to explore the minutiae and to engage the public on the broader themes in question. This remains, we believe, a considerable challenge in public engagement work: how can the public's frames of reference and ways of meeting the world be honoured whilst at the same time ensuring that 360^0 deliberations can take place.

The case study on Building Materials also mentioned the issue of waste ('currently the construction industry is one of the major producers of waste that goes to landfill'), but rarely was this case study mentioned in discussions about waste. These discussions were almost exclusively focused on domestic waste stemming from food and other consumer items. By and large the building materials case study was treated as a sub-set of packaging materials. If viable bioplastics can be developed then the public feel that they should be exploited in all areas where plastic is employed:

"It just seems to be something you could do comparatively easily without too much risk if you could get rid of plastic gutters and things and replace them with something a bit more environmentally friendly
[ABC1, 40 - 59, Edinburgh]

Overall, participants' views on the potential application of biotechnology (which as we have seen typically meant GM) in developing bioplastics was the same as for energy crops. The majority do not wish to see field grown GM source plants until the technology is proven to be safe. Again, however, there was significantly less concern expressed about using micro-organisms in the polymerisation stage as long as this is done under tightly controlled conditions.

5. The hegemony of major retailers

Within the discussions about packaging in all sessions participants raised strong concerns about the major food retailers' dominance of the UK food market. While many acknowledged the convenience of major supermarkets, and their own patronage of such stores, many were equally concerned that such stores

have led to the loss of many smaller stores – not just in rural areas, but also in many high streets on busy towns. Similarly, a number were very concerned at the power the major retailers play in both depressing the price farmers realise for their produce, due to their powerful buying power, and their role in procuring produce abroad which further undermines UK agriculture:

"The supermarkets are colossal now and they are dictating. They dictate to every single member of the public what you eat, how much it costs, what you can have, what you can't have."

[ABC1, Workshop, York]

"Tesco say they are on target this year for two billion pounds profit and so if the farmers aren't making money and the consumer is spending money, it is only the supermarkets making any money out of it."

[C2DE, Workshop, Newtownards]

Many also decried the lack of locally sourced produce, and felt that the buying decisions of the supermarket majors were responsible:

"We import beef that we would not be allowed to produce, but supermarkets flood the shelves from around the world with some substandard meat, and I think that it's absolutely scandalous. Every supermarket should hold its hand up."

[C2DE, Workshop, Newtownards]

Others were concerned about the cost and environmental impact of sourcing food from overseas:

"I think the concern is a lot of supermarket produce travels a long way which has effects on other life, you know other nation's livelihoods and also the environment, you know just the implications of all this stuff being air freighted in."

[ABC1, Workshop, Edinburgh]

While the above discussion may seem to have no direct relationship to the topic of non food agriculture these themes arose in every workshop to a greater or lesser extent and form an important contextual factor for the public. Some of the case studies (e.g. SRC) proposed that NFA could contribute to a reinvigoration of UK farming and rural communities. While few members of the public have access to detailed information about the economics of farming, they do believe that modern retailing methods and decisions play an important role in its viability. Hence it is no surprise that retailer power is part of the discussion evoked by non food agriculture, for the simple reason that many could see value in non food agriculture but did not want to see this developed to the further detriment of the UK's ability to produce its own food.

6. Medicine

It has already been noted that some when first meeting the term 'non food agriculture' thought that it might entail the production of pharmaceuticals from plants. It was also clear throughout the engagement process that the public have a very strong desire to see medical science continuing to develop viable treatments for the diseases and conditions that they perceive as representing the highest health burden (such as HIV/AIDS and cancer). Part of this desire is framed as the hope that novel therapeutics will be developed. Within this many feel that the plant world potentially offers therapeutic agents which could be exploited. Despite the strong desire for medical breakthroughs neither of the two medical application case studies drew sustained support.

Initially in all of the workshops there was significant support for the HIV microbicides application – as this was felt to be addressing one of the world's most devastating health issues. However, as we shall see many early supporters of the HIV microbicides application withdrew support when they understood that the application was not a cure or viable treatment but a topical prophylactic.

HIV microbicides

Across the sample support for viable treatments for HIV/AIDS were considered to be urgent and vital. Initially, therefore, many were drawn to the HIV

microbicide case study. On reflection (and for some this required a stakeholder or facilitator to point out that the case study referred to a prophylactic and not a treatment for HIV/AIDS) many felt that the application would fail to deliver a real benefit. While many could see the value of a barrier gel that prevented the transmission of the virus during sexual activity, for some two major obstacles were cited that undermined support for the concept. Firstly, it was believed that considerable education would be required on the ground to encourage use of the preparation – the very same education which it is believed has failed to encourage systematic usage of condoms. Within this, some believed that in areas of high HIV incidence women are generally dis-empowered and that lack of male support would result in minimal usage, thus rendering it ineffective in the fight against HIV/AIDS. Secondly, a number perceived the decision by the major drug companies not to pursue development of these microbicides to be evidence that they would not be particularly effective. Having said this, many were highly critical of the drug companies for not doing enough to assist sub-Saharan Africa in particular in combating and treating HIV/AIDS.

Moreover, despite the fact that the case study stated that the microbicides were being developed by a consortium of scientists funded by grant, and that the microbicides would be freely licensed, there was quite strong suspicion that the cost to the end-user would be prohibitive.

Many felt that research and development should be directed toward improving education re safe sex, distributing anti-retroviral drugs as cheaply as possible and developing a viable vaccine.

This case study also generated significant debate about the safety of growing large areas of genetically modified source crops. The potential benefits of a topically applied microbicide were seen to be outweighed by the risks to the environment, and possibly human health, of growing GM plants in the field. In contrast many conceded that they would be far more likely to support such growing if the pharmaceutical product in question offered a cure, or at least viable treatment, for HIV/AIDS.

Thus there was a huge mis-match between what the public want to see happening and what this particular case study appeared to be offering. Having said this the potential of NFA to provide applications of serious medical benefit

was not diminished – merely it remained an expectation that was not yet met. The other medical NFA application – Dental Caries – met with little support and was in many ways more an example of how NFA could be employed in ways that waste valuable resources rather than a serious medical application, and is thus discussed in the following section.

7. Wasting resources – Setting appropriate priorities

The remaining three case studies amplified a contextual theme that was usually lurking at the edge of participants' thinking. While not immediately salient for most people, the notion that a good deal of scientific and technical research is conducted 'because it can be done, rather than because it is useful', reveals a concern that the research and development agenda is a very long way from most people's lives, and that the decisions taken on what is researched and developed are done so without any consultation with the public. The dental caries application was, for many, a vivid example of how resources can be wasted attempting to achieve a certain technical result rather than focusing on a what was for our respondents a far more pressing issue at hand, such as the loss of many NHS dentists.

Dental caries

Overall, this was one of the weakest concepts for participants. Many dismissed it as a 'waste of money'. Most felt that the alternative strategy of promoting proper dental hygiene would be far cheaper, pose less risk and produce the same if not better results. The data that tooth decay costs the US approximately $50 billion annually was for some considered to reveal the seriousness of the problem. Yet, the vast majority believed that the problem was largely self-inflicted through poor dietary habits (such as the ingestion of excessive refined sugar) and poor oral hygiene.

A significant minority were very critical of the situation in the UK with the widespread difficulty of finding an NHS dentist. Some wondered whether the development of CaroRx ™ was in fact a cynical ploy by government to further downgrade the dental service:

"On the other side of the coin are they bringing this in because they can't provide us with enough dentists?"

[ABC1, Workshop, York]

It was very clear, however, as it was in previous research, that the public do believe that plant-based pharmaceuticals could play a very important role in medicine. However, their interest is confined largely to finding cures or viable treatments for very serious conditions, such as cancer and HIV/AIDS. In this context the development of a treatment for what is seen as a wholly avoidable condition such as tooth decay was felt to be trivial at best:

"Why not just get all the manufacturers to cut down on sugar and salt on all the foods?"

[C2DE, Workshop, Newtownards]

Phytoremediation of organic pollutants could be seen as falling within the Waste category above. However, responses to this case study were dominated by the specific example of remediating land poisoned by TNT and other high-explosives. This led many to get bogged down in the detail (such as will the plants pose a danger of exploding when incinerated etc) and unable to view this case study from a wider frame of developing ways of cleaning up various kinds of land pollution. In principle people supported the idea of restoring land spoiled by explosives to productive use, but a good number wondered if the benefit of restoring toxic land might be undone (or made worse) by the risks pursuant on the development of transgenic plants which obviously would have to be grown *in situ*:

"It's all very well in theory but when it comes down to practice I'm not so convinced."

[C2DE, 18 - 24, Sutton]

Thus many, on reflection, felt ambivalent about this application as they were unable satisfactorily to decide whether the risks arising from polluted land were greater than or less that the risks perceived to be attendant on using genetically modified plants to remediate the land.

The ***Dutch Elm Disease Resistant Trees*** case study also by led most participants to focus on the specifics of the case i.e. elm trees. Even after quite heavy prompting (for example that this was an example that could open up the possibility of creating effective treatment for many economically important tree species) very few supported this application:

"I couldn't understand why they are spending so much money on Dutch Elm disease. Does it (elm) *have any commercial use or is it any good to us?*
[ABC1, 60 - 74, York]

It was very clear that the elm tree does not engender very strong levels of emotional connection (possibly because most people have never heard about the elm as an economically important tree, and because very few people would recognise an elm tree, whereas a species such as the oak has widespread recognition).
This application also depends on the use of transgenic plants and the vast majority did not consider the elm important enough to offset the perceived risks of e.g. gene transfer into other species.
However, a minority were very keen to see this specific application progressed:

"I think if science can save Elm trees from such a serious disease then that's really beneficial."
[ABC1, 40 - 59, Edinburgh]

The majority were able on reflection to see that some benefits may accrue from such an application (such as maintaining the amenity value of certain areas), but nevertheless believed that the money and other resources that might be required to bring about this benefits could not be justified when there were far more pressing problems to address (such as global warming, poverty, cancer treatment etc).

The findings revealed by the case studies (from the workshops, participants' own self-directed deliberations and the seminars) show that the public relate very

strongly to sustainability issues. Importantly though few members of the public code their engagement in terms of 'sustainability'. When they are confronted with issues in this arena they use familiar categories such as waste, energy and supermarkets. It would thus seem timely that policy makers in this field begin using these categories drawn from the lived world rather than the more technical categories in current use.

The findings also make clear that concern about environmental values is widespread. This does not mean that the public are engaged to the extent that they are voluntarily making lifestyle choices that would deliver substantial environmental benefits – but a latent desire to act more sustainably is noticeable.

4. Deliberation around the six key frames

Following the workshops participants were engaged in a process of self-guided deliberation lasting approximately two weeks. Participants were provided with the six key frames identified by the Commission (and given a folder to record their deliberations). The six key frames were:

- Social
- Environmental
- Economic
- Ethics
- Health and Safety
- Politics.

A Further category "Other Issues" was also suggested to ensure that participants were not constrained by the given frames. Participants were also given a range of websites for further information, and invited to be creative in how they approached the process. They were also given a further five case studies to deliberate on.

Across the sample the following deliberative activities were reported:

- Written responses to the key frames recorded in their folders
- Visiting websites and printing off key pages

- Discussing the case studies and issues arising with friends, family and work colleagues
- Looking for and reading relevant articles in the media.

On reporting back many participants remarked how the topic was unknown amongst their friends and associates:

"I asked everyone at work about non food agriculture farming and no-one had a clue what I was talking about."

[C2DE, 40 - 59, Sutton]

It is also clear from all the conversations with the public in this current study that apart from the potential role of GM in non-food agriculture, the topic overall does not provoke a significantly intense emotional engagement.

As we have noted before many participants also found the case studies difficult to engage with:

"Yes. I had to read them a few times to understand it and then I thought well really I could do with a scientist's brain to sort this out."

[ABC1, 60 - 74, York]

"Some of the words you couldn't even read, like ethics and that."

[C2DE, 18 - 24, Sutton]

However, not all found the case studies difficult to engage with:

"I think the pros and cons in all the pieces were quite interesting and it was quite interesting to read something quite plain and simple. Well these are the pros and these are the cons. Because you can see the media if any of these ideas were developed they would grasp one of those cons and blow it all out of proportion. I feel it was quite an informed thing to read."

[ABC1, Workshop, Edinburgh]

It also became clear during the seminars and in reading participants' deliberative folders that many found the boundaries between the key frames to be very porous. Indeed, many noted how they found themselves writing the same comments under many, if not all of the frames.

There was considerable overlap between the outputs across the sample. In the following section we set out the core issues raised under each of the key frames.

5. The key issues

In the following analysis we set out the key themes reported in participants' deliberative folders and subsequently discussed in the seminars. We have aggregated the data and will only detail data from individual sample cohorts where germane. We have also added short commentary where appropriate. It must be noted that some of the themes have already been discussed in section 3 which explored responses to the case studies. We have attempted to minimise undue repetition – although some repetition is unavoidable as here we are looking more deeply at the outputs of the deliberation process. Those topics and themes that recur throughout the study (i.e. at recruitment, during the workshops, self-guided deliberation and the seminars) are clearly ones that engage and are important to the public.

Other issues

A number of participants wrote entries in their deliberative folders in the 'Other Issues' section. However, all of these other issues were also mentioned by other participants under one or more of the six given categories and hence we have subsumed them under the six core categories as appropriate.

Social

The key issues reported were:

Preserve open spaces

As already noted the issue of access to the countryside and the need to preserve open spaces was a very important issue for participants across the sample. While

continued development of the built environment is seen to be the biggest threat facing the countryside, there was also an undercurrent regarding NFA that it could lead to a more 'industrialised' countryside and hence negate the role agriculture plays in preserving the 'green and pleasant land:

"Need to preserve open spaces for children; for example to reverse the sell off of school playing fields."

[C2DE, 18 - 24, Sutton]

Recycling

Recycling was considered to be a very important issue across the sample. Many believe that bringing this and related issues into schools, perhaps as part of the National Curriculum, would be the most effective strategy. Within this, the development of bio-degradable plastics was seen to be an NFA application worth promoting:

"Manufactures should be more considerate re packaging."

[C2DE, 40 - 59, Sutton]

Danger of NFA applications solving one problem and causing another

Few of the case studies presented an application that was seen to be fully tested and evaluated to be effective. Thus there was some concern that applications might be adopted which created as many problems as they solve:

"NFA could lead to a loss of important wildlife habitats."

[C2DE, 40 - 59, Sutton]

GM and other risks

We have already noted in section 4 how GM loomed large throughout this study. It is interesting to note that for many participants the issues evoked by GM are as much social questions as they are questions about health and safety:

"There is no demand for GM in the UK – so why keep pushing?"
[ABC1, 60 - 74, York]

"If NFA GM plants are grown then non GM crops cannot be grown subsequently on that land."
[C2DE, 40 - 59, Sutton]

"It amounts to little more than back-door introduction of GM."
[ABC1, 25 - 39, York]

NFA and rural communities

Many could see the potential benefits to rural communities and rural economies of NFA. Few were aware of the recent changes to the Common Agriculture Policy, but when briefly explained were in favour of active land management versus passive set-aside. However, it was not at all clear to participants that real economic and hence social benefits would accrue to the UK farming sector and rural communities unless UK farmers have greater freedom to set their own agendas.

Some, however, perceived that NFA applications, such as short rotation coppicing might in fact require less labour leading to an overall negative impact on the rural economy.

In Northern Ireland there was particular concern that widespread development of NFA could have deleterious effects on the aesthetic quality of the Irish countryside. This was considered to pose a potentially serious threat to the Irish tourism industry. Within this, it was felt that possibly Northern Ireland's enviable countryside might be sacrificed in favour of NFA development:

"Is this exploitation?"
[C2DE, 25 - 39, Newtownards]

Potential solutions addressing the wrong problems

All across the sample, recognised the devastation that HIV/AIDS is wreaking in sub Saharan Africa and supported research into viable treatments. However, once the HIV microbicide application was understood most considered that it would be highly unlikely to provide adequate benefits. All wanted to see greater emphasis put on education into sexual health and considerable effort into finding reliable treatments rather than prophylactics:

"If people don't use condoms who on earth is going to use a high-priced barrier method like that?"

[ABC1, 60 - 74, York]

Robbing Peter to pay Paul

A significant minority wondered if the money and other resources being put into the development of NFA applications might not be draining resources from other areas of social importance (such as medical research or research into other alternative energy sources). There were many calls for greater integration of international research efforts to ensure that work was not being duplicated.

Many also wondered whether NFA would in fact provide any tangible economic benefits for society, particularly as hard data was not seen to be forthcoming on how long it would take for some of the applications to move from theoretical possibilities to actual practical application.

A few also wondered whether new products developed from NFA, such as bioplastics, in replacing current raw materials might not in turn bring about problems in disposing of those unwanted raw materials:

"Plastics are made form the parts of oil you don't need. So, would that leave us with another problem? Would we not be using all this waste that we are using at the moment?

[ABC1, 18 - 24, Edinburgh]

Need for quantification

Some were engaged by the wider issues raised by the case studies, such as the issue of global warming and felt that they needed hard data on how serious these issues are before being able to assess the likely benefit of NFA solutions.

Increasing industrialisation

A minority were very concerned that NFA, particularly as presented in the case studies could lead to further industrialisation of farming. Hence the potential benefits of more sustainable and environmentally sensitive agriculture would not be realised.

Food

A significant minority were generally in favour of developing NFA but were equally concerned that this did not threaten local food initiatives. Indeed, a good number were very supportive of UK food production becoming more locally focused.

It is readily apparent in the above analysis that the boundary of social concern was very porous – appropriating issues that involved actors might place under environmental or economic issues for example.

Environmental

Effects on food chain

This issue arose frequently in response to GM plants. It also arose in relation to using plants for phytoremediation – with concerns raised that wildlife may eat the contaminated plants and spread this contamination into the human food chain eventually. While many recognised the danger of contaminated land a good number were far from convinced that concentrating the toxins in growing plants was a sensible solution.

Land usage patterns

There was significant discussion about the amount of land that might be required for NFA applications. The short rotation coppicing case study noted that for to provide all of the UK's electricity requirements would demand around 99% of all agricultural land to be used for coppicing. While no-one took this as a serious possibility, it was clear that it did lead to considerations that large areas of agricultural land would be required to make investment in NFA viable. This led to strong concerns that the UK could jeopardise its food growing capability chasing NFA benefits that might not be forthcoming.

There were also a number who wondered if land used for NFA applications – whether GM or not – would be suitable for returning to food production should this be required.

Environmental benefits

A good number noted that some of the NFA applications, especially bioplastics and bioethanol appear to provide unequivocal environmental benefits and as such should be pursued vigorously (all other things being equal):

"Some of the NFA options give us the choice to reduce environmental damage."
[C2DE, 40 - 59, Sutton]

GM

Many posed questions regarding the possible environmental impact of growing GM plants. Overall, the majority were clearly against the release of GMO's into the environment until they have been adjudged wholly safe.

Many questions were posited regarding the fate of inserted genes:

"Naturally occurring transfer of the inserted gene into a wild related plant which might have unexpected ecological effects."
[ABC1, 25 - 39, York]

"New diseases and pests could be developed (as a result of GM)*"*
[C2DE, 25 - 39, Newtownards]

Within this, many wanted to know which scientists could be believed on the safety aspects of GM, as the public are well aware that there are very clear pro and anti voices in the GM debate.
The most serious consequence of releasing GMO's into the environment was seen to be the irreversibility of the decision – that is once released and they cannot be recalled.

The balance of benefits and risks
A good number found engaging in a risk-benefit analysis problematic for two main reasons. Firstly they felt they had insufficient data (on e.g. the safety of GM, whether the reported benefits of NFA applications would actually be realised) to make the analysis. Secondly, they felt that even in the presence of more detailed and comprehensive data that as non-specialists they would be unable to weigh the evidence in a way an expert could.

Wrong solution
While the great majority of participants believed that reducing CO_2 emissions was an appropriate goal, some felt that the SRC application was an example of a wrong solution and that better home insulation would deliver greater savings.

Economics

Recycle
Some participants believed – partly as a result of their deliberations and partly through pre-existing knowledge - that recycling was of paramount importance in preserving the scarce land resources we have in the UK.

Cost
A good number wished to know how much public money would be spent on developing NFA applications – and many revealed considerable scepticism that the taxpayer would unequivocally get a 'good deal'. Several wondered what the pay back period would be on the research and development costs. Allied to this some believed that even if the development costs were high, or if the economic

benefits were not great, then NFA applications may still be worth progressing if they genuinely delivered important social and environmental benefits. However, a good number became very sceptical about the applications presented – feeling that very few of them appeared to be economically viable.

As noted in the previous section some in Northern Ireland were very concerned that NFA might have negative impacts on tourism in the region.

Some also felt that because GM was almost a certain component of many NFA applications (to make them viable) that costs would increase due to the cost of implementing monitoring programmes.

Jobs

As noted in the previous section some participants came to the conclusion during their deliberations that NFA would not necessarily impact the rural economy positively. However, others also wondered whether NFA applications (such as developing bioplastics) might deleteriously affect employment in existing industries. While finding more environmentally sound solutions to some of the problems we face was applauded, participants did not want these gains offset by job losses in other industries:

"If these non food agricultural things are going to require less people then it's going to be a bigger change on the local communities and that would be a terrible shame. That is going to make an already bad situation much worse in my view."

[ABC1, 25 - 39, York]

In marked contrast some felt that NFA would improve the economic and social vitality of rural areas.

Economies of Scale

Many acknowledged that the cost of new applications is often higher at the beginning of their life cycles, and fully expected to see costs reduce as volume production increased. This was particularly felt to be true for bioethanol and bioplastics. However, many called on the Government to intervene – either

through tax breaks or tax penalties on current manufacturing methods – to more quickly make these applications economically viable.

More productive land use

Some felt that NFA could have a very positive impact on the viability of farming and the UK agriculture sector by allowing fallow (set aside) land to be returned to production (with e.g. short rotation coppicing), or by being able to productively use land which is only marginally viable for food production:

"Farmers get paid to set aside fields and so why not pay them to grow these trees?"
[ABC1, Workshop, York]

Benefiting the developing world

While many, as already noted felt that the HIV microbicides application was not as potentially valuable as education and developing curative drugs/vaccines, there was a widespread belief that helping the developing world help itself (e.g. by providing the know how to produce pharmaceuticals from locally grown plants) was a positive potential. However, all were clear that they would only support such development if the developing nations themselves benefited and the intended recipients of such applications were not prevented from benefiting through lack of money.

Some, however, were alarmed to discover that pharmaceutical companies had withdrawn from developing HIV microbicides, believing that this was not purely an economic decision, but one based on a realisation that the technology would not deliver substantive benefits. Within this some felt that because the large pharmaceutical companies possess the expertise they should be incentivised by Governments to develop drugs of low economic return but high social value.

Co-operatives

Some believed that the NFA applications considered would favour large scale farms – and indeed a good number wondered if biotech companies might not buy up vast tracts of farmland and create 'superfarms' where they could grow GM crops unhindered. Thus it was felt that small farmers might only be able to

compete by working together in co-operative ventures. The fear of biotech companies controlling UK agriculture was quite widespread – largely because the biotech companies are seen to be indifferent to potential long-term risks.

Education

Several participants put the need for education of the public on NFA and contiguous issues (such as waste management, global warming) within the economic category – feeling that if these issues are not dealt with appropriately the economic consequences would be catastrophic.

Some wanted to see this education remit expanded to include addressing retailers and manufacturers about their responsibilities:

"Raise public awareness of Non-food agriculture. This will allow reasonably informed public opinion, rather than leave opinion formation in the hands of the rabid popular media."

[C2DE, 25 - 39, Newtownards]

"More education in schools on this subject is needed so that our children are also aware and can do their bit to help and will grow up caring for the environment around them."

[C2DE, 40 - 59, Sutton]

Bioethanol

This case study was singled out in the economics category as being the most likely to succeed in the short term. Many felt that both farmers and consumers would benefit and moreover agreed that reducing reliance on Middle Eastern oil states would be economically and socially beneficial.

Some felt that the depletion of fossil fuel reserves was reason enough to pursue bioethanol even if it resulted in an increase in the price of petrol.

Ethics

Compulsion

A good number of participants felt that the urgent need to recycle more and produce less waste was sufficient grounds for central and local Government to compel citizens to behave more responsibly. No-one felt that this would violate civil liberties in any meaningful way.

Some did not go as far but nevertheless believed that consumers do need to be educated into more responsible behaviour:

"The government could encourage people to make more informed choices which would be of benefit to the environment, economy and society."

[ABC1, 18 - 24, Edinburgh]

Playing God

Many were concerned that GM pushes man's conquest of nature too far – and are fearful that this arrogation of responsibility is not matched by man's ability to know or control the consequences of such actions. Similarly, a good number felt that giving the green light to genetic modification in plants and animals would make it easier for other controversial processes – such as cloning human beings – to be officially sanctioned.

Research alternatives

Some believed as a result of their deliberations that there was an urgent ethical case for researching alternative solutions to the problems identified in the case studies that do not involve biotechnology. The reasoning behind this was that it seemed inconceivable that potentially grave global problems were being addressed with a technology whose consequences were not currently known and perhaps couldn't be known for many years/generations.

Change values

It was felt that the issues raised by NFA argued strongly for Government and policy makers to begin thinking and acting in terms of long term goals rather than the expedient short-termism that is seen to pervade modern politics.

Priorities

A significant number felt that the issues raised also called for serious consideration as to what society's priorities are. Thus many considered spending money on saving elm trees utterly frivolous compared to the urgent need to improve treatment of many serious human diseases – such as cancer and HIV/AIDS.

The case for GM

A minority either believed or conceded that GM and other biotechnology approaches could be justified if they demonstrably contributed to ameliorating serious issues such as reducing greenhouse gas production. Having said this it was very clear that the public feel that such technologies have yet to prove that they can indeed deliver such benefits. Extrapolating from these deliberative conclusions it is also important to note that the majority do not support the development of GM if its benefits are only marginal to low. A minority though felt that a more pragmatic attitude toward GM is required. They argued that the devastation that global warming for example could cause is a far greater risk than the possible escape of GM genes and the development of a few superweeds. Having said this it was also clear that the majority feel that the ethical case for continuing to research the value of GM can be made if such research is conducted in controlled conditions that prevent environmental release and that the developers (whether corporate or governmental) are scrupulously honest about the results:

The developing world

Many believed that there is an unquestioned ethical case for the developed world to assist the developing world combat its endemic problems of famine, disease and instability. Within this some wondered if developing certain applications,

such as disease resistant elm trees, could in any way be justified when the world still has so many people living below subsistence:

"What rights do we have and what safeguards are going to be put into place that this land isn't wasted when we could be feeding people that really, really need food and not oil for chainsaws. Not that I've got any objections to the oil for chainsaws but I just wonder where our priorities should be."

[ABC1, Workshop, York]

Democratic principles

Some saw an ethical dilemma posed by the bioethanol application. While it was acknowledged that finding a less polluting fuel than petrol would be highly beneficial, some argued that the motorist should not be the one to pay extra to make bioethanol viable, given that the motorist already pays considerable amounts of tax (road fund licence and fuel tax) only some of which is spent directly on projects which benefit the motorist.

Health and Safety

Human health/environment

Both of these issues figured large in participants' deliberations. Most were wholly unconvinced that GM has yet been demonstrated to pose no threat to human health or to the environment more widely. As such most are reluctant to see field grown GMO's.

The public are very aware of numerous developments which have been shown over time to have unfortunate consequences (the most commonly cited examples were thalidomide, BSE, hormone disrupters and CFC's). Thus the public have witnessed numerous unintended consequences that have had devastating effects. Thus, it comes as no surprise that many members of the public wish for a new technology such as GM to be treated with utmost caution. It is also true that many members of the public claim that GM plants should not be grown in the open until it has been proven to be absolutely safe. While some clearly intend

this request to be taken absolutely literally, others mean by this that any risks that may attend GM are known, quantifiable, controllable and small in relation to the benefits accruing to society.
Many feel that the commercial and political imperatives would lead to GM development racing ahead of knowledge about risks and risk management and feel that this could be even more foolhardy than doing nothing to address the current environmental problems.

Political

Responsibility
A significant minority explored the issue of responsibility regarding untoward consequences following the release of GMO's in to the environment. Most felt that the Government should shoulder such responsibility and ensure that appropriate compensation in the event of detrimental consequences. Within this, a number felt that the Government is pro GM and seems to be putting unfair pressure on farmers to adopt GM technology.

Leadership
Equally, a sizeable number of participants felt that Government has a duty to promote NFA – through financial support – given the potential benefits it could bring both to the agriculture sector and society at large. The vast majority were unaware of the support that schemes such as short rotation coppicing have already received. Again, when participants became aware of such facts it strengthened calls for more communication by Government as to what projects it does promote.
A number felt that NFA will only succeed if Government champions its development.

Lottery
Some gave consideration to how decisions will be made regarding what non food crops will be grown where – and wondered if the situation might be no better than a lottery – with significant lobbies (based on the NIMBY principle)

ensuring that their region is not blighted by large scale growing of non food crops.

International co-operation

Many felt that the issues that NFA is potentially addressing are so important that international co-operation will be required to maximise research budgets and sharing of findings.

Some also wanted the developed nations to work alongside the developing nations rather than imposing 'solutions' on them.

A small, yet trenchant minority wondered though whether the UK should eschew such global considerations and simply do what is best for the UK.

Legislation

There were some calls for international agreements on bringing about the required lifestyle changes in developed nations (such as more responsible consumption and waste management). To achieve such profound changes some were open to the idea of Government legislating to ensure compliance.

As we have seen earlier there were also some calls for retailers and manufacturers being held accountable for their actions, and being penalised for unsustainable activities (such as using non biodegradable plastics).

Grandstanding

A minority were concerned that Government might use NFA for political gain rather than focusing on genuine public benefit:

"For this to be dealt with properly in the context of politics it has got to be a cross party issue because whatever is decided in the life of a government has to be sustainable through to the life of the next."

[C2DE, 60 - 74, Newtownards]

6. The public's criteria

It was very clear in discussions with participants that they do not ordinarily approach issues such as NFA through a set of formal categories such as social, political etc. Even in the research environment participants did not draw out and consider thematically the criteria by which they evaluated NFA and the case studies. Our participants certainly had criteria of judgement which they used pre-reflectively, but as in everyday life such criteria, which shape and structure thinking, were rarely, if ever, elevated to become an overt part of the thinking process.

However, it is very clear from the previous section that the pubic employ a range of criteria in evaluating NFA. In the analysis that follows we list the criteria that were evident in participants' deliberations (from both their verbal and written responses). However, we have not placed these into a hierarchy of importance, as it is our view that in an arena such as this the public employ the full range of their criteria and attempt to **maximise** fulfilment of their criteria. That is they are generally not looking to satisfy their 'most important' criterion but to have as many of their criteria satisfied as fully as possible. This seems to be a common pattern when dealing with complex issues where there is uncertainty (whether that uncertainty is consensually agreed upon or not). These criteria and the maximising pattern also describe the process by which participants assessed the risks and benefits of NFA and the role of biotechnology within it.

The criteria the public employed within each domain were as follows:

Social

- Likely impact on land use and the amenity of the countryside
- Requirements for social responsibility
- Likely impact on direct beneficiaries (i.e. farmers, manufacturing industries)
- Likely impact on society in general
- Social priorities and institutional decision-making processes
- Likely impact on Britain's ability to be self-sufficient.

Environmental

- Likely impacts on the food chain and human health
- Likely impact land use
- Potential for amelioration of environmental problems
- Trust in information sources and trust in the positions such experts take.

Economics

- Cost and who pays?
- Likely impact on employment
- Likely impact on land use
- Likely impact on developing nations
- Likely impact on the hegemony of institutions and large corporates
- Potential strength of the public's voice in decision-making.

Ethics

- Role of legislation
- Desirability of increasing hegemony of mankind
- Social priorities and institutional decision-making processes
- Likely impact on developing nations
- Fairness of cost allocation.

Health and Safety

- Likely impacts on human health and the environment
- Degree of risk
- Degree of certainty in current knowledge and degree of uncertainty of extrapolated knowledge
- Using past catastrophes as the guide to current behaviour.

Political

- What is Government's position – and can I trust they are telling the 'whole truth'?
- How much responsibility is Government willing to take?
- What is the degree of leadership by Government?

- Maximising resources
- Potential role of legislation.

Of course, the above analysis is in terms of the Commission's frames and we have rendered participants' contributions into semi-technical language in order to fit the data into the frames. A closer expression of the public's criteria and their risk-benefit analysis protocol regarding NFA would be:

- Is it safe?
- Will I benefit?
- Will someone benefit?
- By how much will I/they benefit?
- What's it going to cost?
- Is this really the best idea?
- What is the agenda of those promoting it?
- What would happen if we said 'no' and carried on as we are?
- Even if we do say 'no' will they do it anyway?

Underpinning all of these questions (bar the last one) is a more fundamental question regarding trust in the integrity of the answers provided by, and motives of, experts on any side of the debate.

It is also clear from the findings that the public do not make judgements in this arena via a process of simply oscillating between benefits and risks, or positives and negatives. Rather, the process is more like having to clear a series of hurdles. The early hurdles (such as 'will someone benefit') being relatively small and the later hurdles (such as 'is it safe?') being very high indeed.

7. Attitudes toward biotechnology

We have already noted that for many the terms genetic modification and biotechnology are virtually synonymous. Knowledge about other biotechnology techniques was virtually absent across the sample. Moreover, the term biotechnology seems to entail meaning founded in hi-tech genetic manipulation techniques, rather than being seen as a generic term embracing many approaches

to working with biological systems. In the following discussion we use the term genetic modification, as this was the term the public more or less exclusively used.

While some were adamant that they did not wish to see GM in any form a good number believed that genetic modification could have potential benefits and research into it should continue to quantify these benefits and as importantly to assess the risks to human health and the environment. However, they believe that this research should be tightly regulated and monitored, and should only take place in contained environments. The chief question, which the public want answered, is 'What are the long-term impacts of genetic modification?'. None across the sample believed that there is sufficient data at present to answer this question either way.

Thus in terms of developing NFA applications with genetic modification the majority believe:

- that it is too early to field grow genetically modified plants for food, animal fodder or any of the NFA applications discussed
- that using GMO's during the production process (such as enzymes extracted from genetically modified micro-organisms or genetically modified yeast to ferment sugar to make bioethanol) is supportable if and only if stringent measures are taken to ensure that the GMO's are kept within contained environments
- that the only circumstances in which field grown crops could be supported is if the benefit was so significant and the problem it addressed was urgent and/or devastating. Thus if a genetically modified crop plant provided an **cure** for HIV/AIDS or cancer then it could well receive widespread public support, even in the absence of some safety data. However, the benefit would need to be unequivocal – partial solutions attract considerably less support
- that growing field crops in contained conditions (such as sealed glasshouses) might be acceptable if there was no risk of soil contamination or transfer of animal vectors such as insects into or out of the contained area. Having said this most people are highly sceptical that such safety measures would work in

practice due to a belief that, whatever precautions are taken, accidents will happen

- that if the green light is given to researching GM or employing GMO's in strictly contained laboratory conditions, the developers should not take this as carte blanche to forge ahead with other more risky activities such as open field cultivation of genetically modified crops:

"Sustainability – if this is the key do not use high-risk or potentially lethal, mutated, unknown substances and sciences."

[ABC1, 40 - 59, Edinburgh]

"I would like to see GM going forward but it must be tried and tested. I am just afraid that we would contaminate the world with GM."

[ABC1, 60 - 74, York]

"When it comes to GM applications far more research is necessary into (i) unanticipated effects, (ii) possible transfer of GM to other plants etc., (iii) possible effects of GM on the food chain (human and non-human). The examples we were shown all have attractions but far more work is needed before we proceed."

[ABC1, 40 - 59, Edinburgh]

APPENDICES

Appendix 1 – Research Brief

SPECIFICATION FOR WORK ON DESIGN AND RUNNING OF A PUBLIC ENGAGEMENT EXERCISE FOR THE AGRICULTURE AND ENVIRONMENT BIOTECHNOLOGY COMMISSION

INTRODUCTION AND PROJECT PURPOSE

The Agriculture and Environment Biotechnology Commission (AEBC, hereafter referred to as 'the Commission') is an independent body that provides the Government with strategic advice on developments in biotechnology and their implications for agriculture and the environment. The full terms of reference of the Commission are available at Annex 2 and further information can be found at the website www.aebc.gov.uk

The Commission is undertaking a new piece of work looking at the role biotechnology could potentially play in the development of Non-food agricultural products. It intends to explore public opinion about Non-food agriculture and the use of biotechnology, and assess the degree to which existing legislation is appropriate for regulating biotechnology in this area.

The Commission's interest stems from the growing attention being paid to the contribution Non-food agriculture might make in seeking a solution to a wide range of social and environmental issues. These include the need for diversification of the rural economy post Common Agriculture Policy (CAP) reform, the use of biomass and biofuels in place of fossil fuels to reduce greenhouse gas emissions and dependence on oil, the development of sustainable and less polluting ways of producing industrial feed stocks and chemicals, and using transgenic plants in "molecular pharming" to produce pharmaceuticals economically and in bulk.

The Commission is keen to ensure that it is informed about, and can address, the issues that interest the public on Non-food agriculture. We feel a proactive approach is required in order to engage people and opinions that may not be captured through our normal stakeholder contacts

The Commission is therefore seeking a contractor with appropriate expertise to work with them to develop and undertake a deliberative public engagement exercise as part of its 'non food agriculture' project.

The Commission aims to present the results of this exercise to Government and to use them in forming its advice on Non-food agriculture, with the aim of informing policy-making in this area.

This specification sets out the expected outputs and parameters of the exercise, but does not stipulate a particular methodology in the belief that the potential contractors invited to tender are best placed to identify appropriate methods themselves.

FINANCE

We would expect proposals for the public engagement exercise to cost in the region of **£30,000**. Contractors are asked to detail in their proposal the specific methodology that

they feel will achieve the desired outputs as set out in this specification, and associated costs.

Bids should include all costs, including any expenses for remuneration of participants, should this be required.

TIMESCALE

The aim is to conduct the exercise as soon as is practicably possible after the contract has been awarded, with an expectation that the exercise be completed by the end of February 2005.

EVALUATION

Contractors should be aware that there may be an independent, peer-reviewed evaluation of this exercise and contractors will need to be available to participate in this and provide relevant documentation.

A note on the 'lessons learned' from the exercise would need to be produced by the contractors at the end of the exercise.

BACKGROUND TO THE WORK

Government policy towards sustainable agriculture is creating a momentum for a range of Non-food uses of crops. A number of benefits is cited, particularly in the potential of these crops to play a role in meeting significant societal needs such as:

- Renewable energy provision to reduce reliance on non-renewable fossil carbon sources
- Cleaner manufacturing to reduce greenhouse gas emissions
- Novel methods of production for therapeutics making cures for pernicious diseases more widely available at lower cost
- Support for the rejuvenation of the rural economy, and particularly the ability to create much needed "value added" opportunities for conventional farmers currently producing commodity crops.
- Diversification of agriculture in the UK countryside

However, for each potential application, alternative approaches may exist that could achieve the same or similar benefit. For example, reducing energy consumption and improving efficiency of use would also reduce fossil fuel consumption and green house gas emissions. Furthermore, in creating these benefits using Non-food agriculture, there is potential for a significant alteration in the pattern of land use in the UK. This could lead to issues of:

- Unknown effects on biodiversity (both positive and negative)
- Changes to the appearance of the UK countryside
- Judgements around when land should be preserved for maximising food production rather than addressing these alternative needs

- Necessity to consider both intermediate term and long term requirements made of agriculture. (i.e. although the current direction in crop production is away from food uses to non food uses what will be the long term effect with an increasing world population?)

In many of the examples of non food uses of crops, there is the possibility (and in some cases an existing reality) that the speed of delivering these products to market and the efficiency of action of these products could be enhanced by the application of biotechnology, defined in its broadest sense (the term biotechnology covers a multitude of modern biological science applications, including genetic modification (GM) but also other genomic and molecular biological techniques). Public attitudes could be influenced by the role of biotechnology. It may be that people differentiate between what they see as acceptable and unacceptable in this regard. Acceptability may or may not be clearly linked or balanced against the benefit to be derived.

By way of a range of examples of Non-food uses of crops involving biotechnology, the Commission intends to canvas public attitudes to these applications. The examples would be described by the Commission in short "case studies". This information would be made available to the contractor for use in a way that they considered appropriate best to explore public attitudes. See Annex 1 for a brief description of three possible applications of Non-food agriculture - the expectation is that the research would cover not fewer than 5 examples, and not more than 10.

THE PROPOSAL FOR PUBLIC ENGAGEMENT

The AEBC is commissioning a professional research company to design a method that will:

I. Provide information to a sample of the UK public (see PARTICIPANTS below), on:
   - The background to Non-food agriculture, using the example applications, and including the role that biotechnology could play in each.
   - The potential societal, economic, health, safety and environmental benefits and disadvantages
   - The potential alternatives that could be pursued by society to deliver the same or similar outcome, and the benefits and disadvantages of these.

II. Conduct a general discussion to examine participants' attitudes to Non-food agriculture, facilitating participants so that they themselves identify the issues that they see arising from the potential applications and the associated aspirations, opportunities and concerns. This would be expected to include any conditionality that participants might place on the acceptance of particular applications.

III. Specifically, conduct a process to:
   - Understand the social, political, ethical, economic, environmental, and health and safety criteria that people consider relevant to Non-food agriculture generally and the different applications to be discussed.
   - Probe to see how participants view the potential application of biotechnology to Non-food agriculture, taking into account how this might make the

application more useful; potential problems; and benefits and disadvantages of alternatives. Issues that may be raised by participants and that the Commission would be interested to explore include:
    - Differences in public attitudes towards biotechnology applied to Non-food opposed to food crops. Does involvement of a product in the food chain influence attitudes?
    - Differences in public attitudes towards uses of biotechnology in various stages or aspects of the production process (see Annex 1)
- Develop data and information on public attitudes towards balancing risks and benefits. How are these attitudes formed? Do participants "trade-off" benefits against risks in considering applications of Non-food agriculture? If so, how and, if not, why?

EXPECTED OUTPUTS

I. Qualitative data on public attitudes and how they are formed in relation to Non-food applications of agriculture compared to food applications, including potential uses of biotechnology.

II. Qualitative data on the criteria raised by participants in response to specific examples. If appropriate, a "continuum of acceptability" to rank the examples qualitatively.

III. An analysis of the criteria that participants cited as important to them when looking at Non-food agriculture and the judgements that are made in deciding upon the acceptability of a particular course of action. This should illuminate how social benefits are determined and weighed in relation to economic, social, environmental or other costs of the various options. For example, does the presence or absence of biotechnology, and the nature of the intervention, make a difference? Is there a difference in attitudes to different categories of benefits e.g. improved human health, fossil fuel use reduction, reduction of green house gas emissions? How important to participants is the rural economy and the appearance of the countryside?

IV. Where possible, data showing whether the attitudes of different demographic groups differ.

PARTICIPANTS

Participants should be selected randomly from representative demographic groups. While we would not expect a statistically representative sample, we would hope to recruit participants from a broad cross-section of the population, including across the UK (in line with the Biotechnology Commission's UK-wide remit), insofar as this is possible while creating an atmosphere for effective communication between group members. Care

should be taken to ensure participants are not actively involved either personally or as a member of a stakeholder group with an interest in an area of the Commission's work.

Potential contractors should also consider the option of involving experts on Non-food agriculture, from the Commission or otherwise, to inform discussion and engage in dialogue with participants.

Advice is sought on appropriate size, composition and recruitment methods for the engagement exercise.

PROJECT DELIVERABLES

- Project plan outlining activities, resources required, timings etc at start of project. This should include methods of recruitment, production of any stimulus material, description of how any meetings will be facilitated and reported on, and interaction with the Commission.

- Regular updates to the Commission on progress

- Preparation of appropriate means to inform participants' deliberation, using "case study" information provided by the Commission, among other things. Any stimulus materials prepared by the contractors must i) accurately reflect the Commission's input; ii) be presented in an easily understandable and accessible manner for the public group; and iii) be designed to stimulate discussion and encourage thought in areas that may be new to that audience. If appropriate, deliberation may also be informed by the presence of experts at events, from the Commission or otherwise.

- Report produced for the Commission from each event, containing summary of discussion, thorough analysis of findings and main conclusions.

- Final report of the entire exercise to be agreed by all public participants and submitted to the Commission.

DESCRIPTION OF QUALITIES AND EXPERIENCE REQUIRED

- Ability to design, facilitate and run dialogue events in order to stimulate debate and extract views from participants in a complex area to which many are unlikely to have given previous thought. This should include the capacity to facilitate participants towards generating their own questions, concepts, priorities and conclusions in their own vocabulary.

- The ability to undertake rigorous analysis, interpretation and reporting of the dialogue event(s) and present these in a manner that addresses the matters of interest to the Commission.

- Capability to quickly establish an understanding of the issues the Commission is working on, and communicate them to public participants in an easily understandable, accessible manner.

- Effective organisation and project management skills to oversee and manage the dialogue event(s) successfully.

- Demonstrable professional competence to ensure the Commission's public profile and long-standing reputation is maintained.

- Previous experience of working with public sector bodies in qualitative research projects is desirable, particularly, deliberative public engagement exercises.

- Knowledge or background in agricultural biotechnology issues and/or non food agriculture would be helpful but is not essential.

CRITERIA

Bids will be judged on the quality of proposals in providing evidence against the following criteria:

- Understanding of service requirement and quality of proposals in meeting the aims as set out in the specification.

- Ability to provide the key deliverables within the constraints outlined

- Demonstration of the 'qualities and experience' required

- Compliance with tendering procedures laid out in the invitation to tender letter and acceptance of DTI Terms and Conditions of Contract.

- Value for money

ANNEX 1:

POSSIBLE EXAMPLE CASE STUDIES

These examples are given as background to help bidders appreciate of the range of potential applications of Non-food agriculture. Applications will be explored in more depth in the exercise itself, including potential benefits and disadvantages, and a consideration of alternatives. The successful candidate will be provided with information on examples once the contact has been awarded.

The examples would be expected to cover at least the following potential applications:

- Biofuel [the use of crops to provide renewable fuel for energy generation];

- Biomaterials [the use of crop feedstocks in the production of materials including packaging, clothing and plastics];
- Biopharmaceuticals [the use of crops, altered by genetic modification, to produce pharmaceutical products in an alternative to conventional drug manufacturing processes].

Biotechnology can be involved in Non-food agriculture in a wide-variety of ways, which may provoke varying public attitudes. Some examples include:

- Use of genetically modified (GM) crops as a feedstock for a production process
- Use of a GM enzyme with to process a non-GM feedstock
- Use of non-GM techniques such as marker-assisted breeding to control crop traits.
- Use of a GM feedstock that is not integral to the process but is hard to avoid for practical reasons, for example because it comes from the USA, where it can be difficult and expensive to source non-GM crops.
- If GM is involved at some point in the production process, the final product may or may not be GM free.

Non-food uses of crops may also still have connections to the food chain, which may affect public attitudes. For example, biopackaging materials might be used to package food products and Non-food applications (such as biopharmaceuticals) might sometimes involve crops also used for food purposes, which raises food-safety issues and the need to ensure separation from the food-chain.

Example 1 (Biofuels) – Short Rotation Willow Coppicing .

Energy crops can be used as fuel in power stations and heating systems. In substitution for fossil fuels, they have the potential to reduce emissions of the greenhouse gas carbon dioxide. Energy crops will need to contribute if the UK is to meet its:

- obligation under the Kyoto Protocol to reduce greenhouse gas emissions by 12.5 per cent below 1990 levels by 2012;
- domestic goal to generate 10 per cent of the nation's electricity from renewable sources by 2010.

One of the major energy crops currently grown in the UK is short rotation coppice. This is primarily willow, although poplar has been used occasionally and may be planted more commonly in the future following the production of varieties more suited to coppicing.

There is also the capacity to undertake bio-remediation at the same time as energy production – for example if sewage sludge is spread on land where willow is being grown, the willow will remove pollutants and decontaminate the land. However, there are constraints on the use of energy crops because of the need for appropriate associated power generating systems

The use of willow or poplar is unlikely to involve GM technology in the immediate future as better yields and quality improvements can be achieved through conventional plant breeding and improvements in farming methods. However, genetic modification could be used in the more distant future to tailor the plants to even more specific uses.

Example 2 (Biomaterials) – Polylactic acid (PLA) plastics

Polylactic acid is an example of a bioplastic that can perform as well as a traditional plastic and have a reduced environmental impact in terms of energy consumption and green house gas emissions. It has the potential to be completely biodegradable.

PLA is produced from starch which is first fermented to obtain lactic acid and then polymerized into polylactic acid. The global market for such materials is currently 3,000 tonnes per annum. Most production is carried out in the US although growth in this sector could lead to production becoming more global.

PLA can have a wide variety of uses including packaging, apparel and textiles, and can be processed in many different ways to make it either biodegradable, compostable or long lasting. Starch can be derived from a wide range of crops and, although it has so far mainly been produced using US-grown maize, it would be possible to use starch produced from wheat, which can be easily produced in the UK.

Genetic modification can be involved at various stages in the production of PLA or not used at all. For example, GM maize can be used as the original biomass, although this use is incidental rather than necessary for production. A further step involves the use of GM micro organisms for processing in contained use (i.e. in a closed environment). In both cases, GM technology would be applied without any presence of GM in the final product. This example also gives the opportunity to explore the public's attitude to importing a GM product (US-produced maize) and different attitudes to the production of GM in the UK , to the use of GM in a food, or to the use of GM at any stage in the manufacture of a product.

Example 3 (biopharmaceuticals) – A topical treatment to prevent HIV transmission

There is potential to produce vaccines in plants by making use of their ability to put together complex proteins. One of the biggest advantages cited of producing vaccines in plants would be the scale at which they could be produced. Profitability depends, in part, on the yield that it is possible to get from the crop.

The use of biotechnology in this way would necessitate genetic modification of the crop. All pharmaceuticals produced in plants would have to under go the same stringent safety test as other pharmaceuticals, including human and animal testing.

It is unlikely that there will be a vaccine for HIV/AIDS in the foreseeable future but female-controlled prevention of viral transmission might be achieved through the use of topically applied gel containing antibodies that would destroy the HIV. A five year European Union sponsored programme is currently underway to develop strategies for the production of pharmaceutical proteins in plants, including putting HIV antibodies into a plant (probably maize as its genetics are well characterized and it can be grown all year round in some parts of the world) with the aim of eventually producing a marketable medicine (see http://www.pharma-planta.org/). This will inevitably raise questions of the safety of using a food crop for pharmaceutical production.

ANNEX 2:
Agriculture and Environment Biotechnology Commission

Terms of Reference

In 1999 the Government reviewed its advisory and regulatory framework on biotechnology. It concluded that a broader approach was needed for strategic issues. The Agriculture and Biotechnology Commission (AEBC) forms part of the new strategic framework.

The Commission will:

- offer strategic advice to Government* on biotechnology issues which impact on agriculture and the environment;

- liaise closely with, but not duplicate the work of the other two bodies which together with the AEBC form the new strategic advisory framework i.e.:
  - the Human Genetics Commission (HGC) which will advise on genetic technologies and their impact on humans; and
  - the Food Standards Agency (FSA) which will include within its responsibilities all aspects of the safety and use of genetically modified food and animal feed.

- keep under review current and possible future developments in biotechnology with actual or potential implications for agriculture and the environment;

- advise Government on the ethical and social implications arising from these developments and their public acceptability; and

- consider and advise on any specific issues relating to relevant aspects of biotechnology as requested by the Government.

As part of this process the Commission is expected to:

- identify any gaps in the regulatory and advisory framework;

- consider the wider implications of the lessons to be learned from individual cases requiring regulatory decision;

- advise on any changes which should be made to Government guidelines which regulatory bodies are required to follow;

- make recommendations as to changes in the current structure of regulatory and advisory bodies;

- co-ordinate and exchange information with the relevant regulatory and advisory bodies;
- seek to involve and consult stakeholders and the public on a regular basis on the issues which it is considering; and

- operate in accordance with best practice for public bodies with regard to openness, transparency, accessibility, timeliness and exchange of information.

The Commission will:

- in carrying out its work take into account European and global developments;

- nationally, adopt a UK perspective taking appropriate account of legal and other differences between England, Scotland, Wales and Northern Ireland; and

- draw up a work programme.

The Government may also ask the Commission for advice on a particular issue and, if necessary, direct it not to become involved in an area if this could be better handled elsewhere.

* In the context of the work of the Commission 'Government' comprises the UK Government and the devolved administrations.

Appendix 2 – Recruitment questionnaire

CORR WILLBOURN

R E S E A R C H & D E V E L O P M E N T

Tel: 020 7633 9957• Fax: 020 7633 9816 • I50 Waterloo Road SE1 8SB

Job No: 887 Job Name: Carroll

RECRUITMENT QUESTIONNAIRE

RESPONDENT DETAILS

Name:_____ Tel: _____

Address:_____

_____

_____

Date and time of Workshop: _____

Workshop number: _____

(If being held other than in recruiter's home please give respondents full directions and telephone no. of venue)

RECRUITER: PLEASE SIGN AND DATE EACH QUESTIONNAIRE

I certify that I have carried out this interview according to your instructions and that the interview was conducted face to face with the respondent who is not a relative or friend of mine

SIGNED: _____ DATE: _____

QUESTIONNAIRE SCRIPT

Good morning/afternoon. I am carrying out a market research survey and would like to ask you a few questions.

Q.1 Have you ever taken part in a market research depth interview or group discussion before?

Yes ..... V **ASK Q2** No .....X **ASK Q4**

Q.2(a) Have you knowingly taken part in a market research discussion in the last 6 months? - **CLOSE IF YES. IF NO, ASK Q2 (b)**

Q.2(b) What subjects have you been interviewed on before? **(LIST ALL)**

_____

_____

IF ON A SIMILAR SUBJECT AS THIS SURVEY, CLOSE INTERVIEW

Q.3 ASK ALL: READ OUT

We are conducting a survey into people's attitudes and therefore need to ensure that we talk to a representative sample of the general public. Could you please tell me **if you or any of your immediate family work now or have worked in the past five years, or are full or part-time active volunteers, in any of the following forms of employment:**

Advertising/Market Research/Journalism/Public Relations	**V**
Biotechnology Industry	**X**
Scientific research into gene technology	**0**
Agriculture (directly involved in farming)	**1**
Campaigning organisation/group concerned with bio-technology /gene technology	**2**
None of these	**3**

ALL MUST CODE AT 3.

Q.4(a) May I ask what is the occupation of the chief income earner in your household

Write in occupation and all relevant qualifying criteria _____

_____

Q.4(b) Code Social Class:

A	V
B	X
C1	0
C2	1
D	2
E	3

For Seminars 5, 6, 9, and 10 – All must code at V, X or 0

For Seminars 7, 8, 11 and 12 – All must code at 1, 2 or 3.

PLEASE ENSURE A GOOD SPREAD OF SOCIAL CLASSES.

Q.5 PLEASE NOTE GENDER OF RESPONDENT

Male ☐ Female ☐

THE GENDER SPLIT IN EACH SEMINAR SHOULD BE THREE OF ONE GENDER AND FOUR OF THE OTHER.
PLEASE ENSURE THAT YOU HAVE NO MORE THAN SEVEN MEN OVERALL.

Q.6 ASK ALL **Please may I ask your age:**

Write in _____

For Seminar 5 all must be aged between 18 and 24, and for Seminar 6 all must be aged 40 – 59. These seminars make up Workshop 1.

For Seminar 7 all must be aged between 25 and 39 and for Seminar 8 all must be aged between 60 and 74. These seminars make up Workshop 2.

For Seminar 9 all must be aged between 25 and 39 and for Seminar 10 all must be aged between 60 and 74. These seminars make up Workshop 3.

For Seminar 11 all must be aged between 18 and 24, and for Seminar 12 all must be aged 40 – 59. These seminars make up Workshop 4.

PLEASE ENSURE THAT YOU RECRUIT A GOOD SPREAD OF AGE WITHIN THE SPECIFIED AGE BREAK WITHIN EACH SEMINAR.

Q.7(a) Please can you tell me do you have any children

Yes	V
No	X

Seminars 5 and 11: no more than two, if any, per seminar to code V. Go to Q.8
Seminars 6 and 12: majority to code V. Go to Q.8
Seminars 7 and 9: around half to code at V. Go to Q.8
Seminars 8 and 10: majority to code V. Go to Q. 7(b)

Q.7(b) Do any of your children live with you in your house

Yes	V
No	X

Majority to code X. Go to Q.8

Now ask the following questions.

N. B. Questions 8 to 10 are not qualifying criteria. Please record full answers in respondent's own words.

Q.8 Thinking about the land and the countryside of Britain, what is your preference for what it will look like and how it will be used in the next twenty to thirty years?

*Write in verbatim*_____

Continue overleaf if necessary.

Q.9 Have you heard of the phrase "Non-food agriculture"?

Yes	V
No	X

Q.10 Whether you have heard it before or not, please could you tell me what you understand by the phrase 'Non-food agriculture'?

*Write in verbatim*_____

CHECK DEMOGRAPHICS AND AVAILABILITY AND RECRUIT.

Appendix 3 – Discussion Guides

Non Food Agriculture (NFA)

Workshop Process Guide

CWR&D Job No 887

Draft 24/12/04

Research Objectives

- To discover the social, political, ethical, economic, environmental, and health and safety criteria that people consider relevant to non-food agriculture (NFA)
- To discover which of the above criteria are considered relevant to potential future applications of biotechnology in this arena
- To explore whether the public holds different attitudes towards the application of biotechnology in food and in non-food crops
- To explore whether the public's attitude to the application of biotechnology varies according to the stage of the production process at which it is utilized
- To explore public attitudes towards, and mechanisms of, balancing and assessing risks and benefits in the biotechnology arena.

Deliberative Objectives

- To facilitate a general discussion about attitudes to NFA, so that participants identify the issues that they see arising from NFA, the potential applications of biotechnology and their associated questions, aspirations and concerns
- To facilitate access by participants to information about NFA and potential biotechnology applications
- To facilitate access by participants to information about potential societal, economic, health, safety and environmental benefits and disadvantages of NFA and associated biotechnology, and to information about potential alternatives that could be pursued by society to deliver similar outcomes, and the benefits and disadvantages of the latter
- To explore and discuss any conditionality that participants might place on their acceptance of particular applications of biotechnology
- To facilitate discussion and deliberation about societal, economic, health, safety and environmental concerns and aspirations concerning NFA and associated biotechnology.

Each workshop will have two facilitators and last three hours.

[This guide will be adapted to fit the social style of each group and to make use of the energy that evolves during the workshop. Whilst all the key question areas will be addressed, in each group the order and mechanism of discussion will be adapted to suit best the disposition of the participants.]

Introduction

Explain protocol – 2 facilitators, deliberative exercise and research element, ongoing engagement.

- Participants introduce themselves – work / family situation.

Pre-existent opinions

- Thinking back to before this project – what ideas and attitudes did participants have about the countryside today
- What is their knowledge of, and attitudes towards, agriculture in general
- In groups of 2/3 – Brainstorm what their "Ideal" pattern of land use locally and more widely on the UK would be in 10-20 years time. After sufficient time facilitators to 'feed in' further probes e.g. what would be the balance of food vs. Non-food agriculture? What would be the balance between agriculture and related activities (e.g. forestry) vs. housing, roads, shopping centres, recreational land etc? Each group to feedback to plenary session. Pick up hot topics and especially any areas that participants were reluctant to address – explore reasons for this (and note these for use in the later part of the session with stakeholders if relevant)
- What is their knowledge of, and attitudes towards the use of (modern) technology in farming/food production and agriculture more widely – explore indirectly how they code 'biotechnology' – is this a subset modern farming practice or a set apart?

Responses to the Case Studies

- What was their first impression of the topic?

- Was anything not understood, if so what (to be noted, do not explore in depth at this stage)?
- What was the most surprising thing they read – what reaction did they have to that?
- Which case study seemed most interesting – why?
- What relationship – if any – do they see between all the case studies?
- (Using post it notes) -Thinking now more broadly about NFA what are the key questions/issues that need to be considered -from **your** perspective – by:
    - the public
    - the agricultural community
    - the biotechnology developers
    - the regulators/government
    - any other group(s) you think are an important part of the decision-making process.

Collect up questions for each category and ask participants to reflect on the similarities and differences – which group(s) do they see as being:

- the most in tune with public needs and desires
- the least in tune, and why.

Lay out the three case studies already seen (SRC, dental caries, bioplastics) in separate areas of the room. Ask each participant to go and stand by the one concept that they would feel most comfortable supporting development of

- Explore reasons why each person chose their particular concept
- What do they see as the major benefits – and why?
- What do they see as the disbenefits – and why?
- Why did they not choose the other 2 concepts – were they rejected, were they simply not motivating enough, not clear enough etc?

[Short break]

Meeting the Stakeholders

Moderators introduce the stakeholders – people with professional knowledge and interest in a range of areas concerned with Non-food agriculture who have volunteered to take part in the project in order to stimulate debate and raise public engagement with the issues

- Stakeholders introduce themselves briefly
- Participants introduce themselves to stakeholders

Question Time in the Round

All participants and stakeholders sit in a large circle with the moderators and all are invited to share questions for comment and discussion by the whole group. A very small / simple question is used to start in order to give permission to all sorts and styles of question

- Moderator ensures that opinions of stakeholders are accessed and all voices are recognised
- As questions and opinions are voiced the moderator issues are probed as necessary to meet research objectives
- Debate with or between stakeholders is facilitated within the context of participants' engagement
- As discussion evolves initial attitudes and question areas and areas of volatility, high energy, curiosity or low levels of awareness or understanding all to be noted.

Further Exercises

To further exploration of particular areas, any or all of the following techniques will be deployed:

Snakes and Ladders – e.g. to explore complex ethical or political issues

Small Group Discussions – e.g. if participants wish to explore specific detail of an area or proposition

Questions as Platforms – e.g. to explore reasons for, and relationships between different attitudes to a specific issue.

Widening the Debate

Whether or not consensus is reached on any topic, after an hour or so two or more new case studies will be introduced.

Layout headline statements for each of the 5 new concepts (e.g. Bioethanol from plants as a fuel for cars, Developing microbicides from plants to control the spread of HIV/AIDS). Ask each participant and stakeholder to go and stand by the concept that they feel has most potential/that they would most like to know more about.

- Briefly explore why participants have chosen the concept they have – paying particular attention to the criteria and values underpinning the choice. Allow participants to move to a new concept if they hear a compelling argument. Explore reasons for movement.
- Each group to then explore the full concept behind the headline:
    - Explore the strengths, weaknesses, caveats and reframes needed (i.e. what would need to change about this concept or people's expectations etc to make it work?)
- Each group in turn will present to the whole workshop the case study and the issues they have identified
- Other participants will be invited to nominate other aspects of the case study for exploration or discussion

The topics arising will be explored using appropriate techniques as above.

Taking Stock

Towards the end of the workshop stakeholders will be invited to ask their questions of the group that have been evoked by the process – and to explain to the group why they are asking these questions (i.e. what are the criteria and values underpinning these questions)

Following this participants will be able to ask in the same way the questions they have of the stakeholders.

- Further discussion will be facilitated

Spatial Mapping

- Participants will be invited to show their positions on the main dimensions of the deliberation that have emerged so far.

Orientation towards Phase 3

Participants will be given

- copies of further case studies
- notes of further sources of information (URLs etc) and
- a deliberation folder and explanation of the key frames (e.g. ethical, economic etc)

Participants will be invited to suggest different ways in which they can continue their deliberation and offered further ideas by the moderators

Stakeholders will be thanked

Participants will be thanked and reminded of date of Seminars in approximately two weeks. END.

Non Food Agriculture (NFA)

Seminar Discussion Guide

CWR&D Job No 887

24/1/05

Research Objectives

- To discover the social, political, ethical, economic, environmental, and health and safety criteria that people consider relevant to non-food agriculture (NFA)
- To discover which of the above criteria are considered relevant to potential future applications of biotechnology in this arena
- To explore whether the public holds different attitudes towards the application of biotechnology in food and in non-food crops
- To explore whether the public's attitude to the application of biotechnology varies according to the stage of the production process at which it is utilized
- To explore public attitudes towards, and mechanisms of, balancing and assessing risks and benefits in the biotechnology arena.

Deliberative Objectives

- To facilitate a general discussion about attitudes to NFA, so that participants identify the issues that they see arising from NFA, the potential applications of biotechnology and their associated questions, aspirations and concerns
- To facilitate access by participants to information about NFA and potential biotechnology applications
- To facilitate access by participants to information about potential societal, economic, health, safety and environmental benefits and disadvantages of NFA and associated biotechnology, and to information about potential alternatives that could be pursued by society to deliver similar outcomes, and the benefits and disadvantages of the latter
- To explore and discuss any conditionality that participants might place on their acceptance of particular applications of biotechnology
- To facilitate discussion and deliberation about societal, economic, health, safety and environmental concerns and aspirations concerning NFA and associated biotechnology.

[This guide will be adapted to fit the social style of each group and to make use of the energy that evolves during the workshop. Whilst all the key question areas will be addressed, in each group the order and mechanism of discussion will be adapted to suit best the disposition of the participants.]

Introduction

- Welcome back – what were the highlights and the lowlights of the deliberative process. What really caught and held your attention and what didn't? Explore underlying reasons why.

Deliberative findings

- Thinking about each of the categories of deliberation (e.g. social, political etc) invite participants to nominate in which order they would wish to discuss their deliberative findings:
- Commencing with the first category explore:
    - how important the category was for participants
    - what they produced in their folders within this category
    - the extent to which it overlapped with other categories
    - the firm conclusions that they have already drawn in relation to this category
    - the tentative conclusions they have drawn
    - their views now in response to the wider debate
    - the group's formal conclusions that can be reached at this point and the group's remaining questions and issues that they wish to be recorded.

THROUGHOUT THE ABOVE DISCUSSION PAY PARTICULAR ATTENTION TO EXPLORING THE ROLE OF GM AND BIOTECHNOLOGY AND SEEK TO UNDERSTAND THE DIFFERENCES IN ATTITUDES TO 'CONVENTIONAL' NFA APPLICATIONS VERSUS 'BIOTECH' APPLICATIONS.

Responses to the further Case Studies

[This section may already have been covered above}

- What was their first impression of the 5 new case studies
- Was anything not understood, if so what
- What was the most surprising thing they read – what reaction did they have to that?
- Which case study seemed most interesting – why?
- What relationship – if any – do they see between all the case studies, including the first 3 case studies
- Did you come across any other applications in your own research that you found interesting – explore in detail
- Invite participants to complete Case Study ranking sheet

Action points

- Invite participants to complete Participants' Recommendations sheet.

Taking Stock

- Does anyone have any outstanding comments/issues/questions
- Discuss participant feedback on draft report and note any participant who expressly conveys that they do not wish any further contact. Moderator to now check all participants' addresses and note e-mail addresses if relevant.

THANK PARTICIPANTS FOR THEIR PARTICIPATION

END.

Appendix 4 – The Case Studies

BUILDING MATERIALS

INTRODUCTION

Many agricultural materials have for centuries been used in construction: in the UK one of the oldest uses is in thatch roofs, while earth (with fibre) has been used in a number of ways since prehistoric times, including sod, rammed earth, straw-clay and wattle and daub. Timber has always been an essential part of building construction. In addition, natural products such as wool have been used for insulation.

Today, through the application of modern technology, new bio-based products are reaching the building materials market. Bio-based structural composite materials (commonly called plastics or polymers) will play a significant role in the next generation of housing applications. Plastics (polymers) have an enormous range of uses in construction, from light switches and fittings through decorative mouldings to many water applications such as pipes and gutters. In recent times almost all these polymers have been made from petroleum based materials frequently combined with reinforcing fibres such as glass or carbon. Attention is now being directed to substituting these products with sustainable bio-plastics where the bio-plastic is formed from cellulose, starch, polylactic acid, polyhydroxyalkanoate or derived from a variety of plant oils such as sunflower oil and oil seed rape. Reinforcing fibres are then derived from materials such as hemp, sisal, flax, wood and coir.

Natural fibres combined with synthetic fibres (e.g. glass) in a totally bio-based polymer matrix or a hybrid blend of bio-based and petrochemical based polymer matrix have the potential to dramatically change the nature of structural materials and emerge as realistic alternatives to glass reinforced petrochemical based

composites. They can deliver the same performance for lower weight and can be 25 – 30% stronger for the same weight.

Two products already commercially available are **Thermafleece** which is a wool-derived insulation material that is used in the construction industry for roof, wall and floor insulating purposes, and **Natilin**, also a natural fibre product, which is manufactured from the short fibre flax by-product from the linen industry and French hemp. In terms of performance both of these products are competitive with the more commonly used products such rock wool and glass fibre, but because of their low production levels they are significantly more expensive at present.

WHY IS THERE INTEREST IN THESE PRODUCTS AND WHAT ISSUES DO THEY RAISE?

There is potential for crops and by-products of animal husbandry to help reduce the environmental impact of construction and so make it more sustainable (which means in part using more renewable resources and creating less waste - currently the construction industry is one of the major producers of waste that goes to landfill – where waste materials instead of being recycled are buried in deep pits). At the same time, this could help to bring tangible benefits to the UK agricultural sector by adding value to existing crops by using crop by-products that are currently not used. or by developing new crops.

Within the USA the manufacture, use and replacement of conventional building materials such as petrochemical-based plastics and glass fibres are becoming priorities because of growing environmental consciousness. Similar moves can be identified in several EU member states and the UK is starting to follow suit.

In the future, it is likely that an ever-increasing proportion of the products used by the construction industry will be produced in the most sustainable way possible, that is as products or by-products of agriculture. However, there are issues associated with the additional use of agricultural products for construction materials:

Many products are in the early stages of development and research needs to be done, particularly in the field of biocomposite production. They will not progress without the mainstream construction industry being prepared to take up proven new technologies, this they are traditionally loathe to do.

Standardised **life-cycle analyses** need to be developed and carried out to ensure that any new product being brought to the market is no less sustainable than the one it is intended to replace, in terms of overall energy use throughout the product's lifetime, and the absence of toxic by-products etc.

Although food production in the developed world is considered to be in surplus, in the longer term this may not be the case and land suitable for food production that has been turned over to growing Non-food crops may be required again for the production of food to feed a growing world population.

The use of modern biotechnology in the production of building materials, such as bio-plastics, raises issues around the possible use of genetically modified organisms in the production of the materials, and could impose regulatory hurdles, and questions related to possible environmental effects and problems of consumer acceptability.

POTENTIAL OR ACTUAL ROLE OF BIOTECHNOLOGY

The above applications could all be considered to use biotechnology to the extent that they involve the application of modern technology in the production of

biologically derived products. However, the potential applications of what is more commonly considered biotechnology – using modern methods of molecular and cell biology, including genetic modification – lie primarily with the use of bio-plastics. These were described in the bio-packaging case study. Briefly, some bioplastics involve the contained use of genetically modified micro-organisms to convert the plant-derived feedstock into the polymer. Others do not involve genetic modification in the processing phase but could potentially use feedstocks derived from genetically modified plants.

POTENTIAL ALTERNATIVES

Conventional building materials could continue to be used. However, these may be less sustainable than bio-based materials as they consume non-renewable resources such as petrochemicals, earth and clay and other minerals, or consume large amounts of energy in production.

Bio-based materials whose production involves the use of genetic modification could be avoided in construction to steer clear of potential issues of consumer acceptability and fears of unanticipated effects of modification. However avoiding this use of technology might compromise the economic competitiveness or beneficial properties of the materials.

The development of building materials from biological sources raises a number of important questions. Two general questions to get you started might be: -

1. How do you think decisions should be taken about whether and how to pursue this application of Non-food agriculture?

2. Does it seem to you appropriate to use GM and other biotechnology approaches to develop this application, taking into account the potential benefits and risks, and the other possible ways to achieve the same aims?

DENTAL CARIES AND NON-FOOD AGRICULTURE

INTRODUCTION

Dental plaque is a major cause of dental caries (tooth decay) and dental caries is one of the most common diseases worldwide.
One of the major plaque causing bacteria is *Streptococcus mutans* which has the ability to stick to the surface of teeth where it lives on the sugars from the foods we eat and produces acids that attack the teeth and cause decay.
A technique has been developed that uses plants to produce an antibody that can be applied to the teeth. This treatment prevents the *Stretococcus mutans* bacteria from sticking to the teeth and hence stops tooth decay. Studies have shown that this treatment can eliminate the bacteria for up to two years.

WHY IS THERE INTEREST IN THESE PRODUCTS?

Dental caries can be prevented by avoidance of refined sugars and regular oral hygiene (brushing, flossing etc). Furthermore, the introduction of fluoride, either into drinking water or toothpastes, has had a significant impact in developed countries in reducing tooth decay. However, caries is still a disease that affects 50% of 5-year-old children and 96% of adults. Some areas are now starting to see a rise in caries incidence, probably as result of people relying on the presence of fluoride alone and neglecting simple oral hygiene measures. Approximately 115 million people in the US and Europe currently have clinically treatable tooth decay. It has been estimated that tooth decay costs the U.S. approximately $50 billion annually.
In Developing World countries caries is also a significant problem and is widely regarded as an important target for public health.

HOW HAS THIS TREATMENT BEEN DEVELOPED AND HOW DOES IT WORK?

The antibody treatment which prevents tooth decay (called CaroRx™) has been developed by genetically modifying tobacco plants. A gene is inserted into the genetic material of the tobacco plant and this gene causes the tobacco plant to produce the desired antibody. The antibody is then extracted for use.
The antibody sticks selectively to the *Streptococcus* bacterium (a process called binding) and this prevents the bacterium from adhering to the teeth.
The use of agricultural plants to produce pharmaceuticals in this way is sometimes called "pharming".

WHAT ISSUES DOES THIS RAISE?

The use of GM plants to produce pharmaceutical products in the broad sense raises a number of technical, legal and environmental issues:

- GM plants do not produce human antibody protein in the same way as humans. Testing will be needed to ensure that the plant product is as effective as that made in mammalian cells. There may be problems in the purification of the antibody or in maintaining consistent production. Other species of plants modified to produce antibodies have shown reduced production with successive generations.

- Some questions about possible environmental impacts of have been raised by some people :
    - the inserted gene might alter the behaviour of the plant in unexpected ways, for example causing it to become a weed;
    - naturally occurring transfer of the inserted gene into a wild, related plant which might then have unexpected ecological effects

- the drug itself being toxic in soil or to animals that consume it;
- the antibody gene being transferred to microorganisms in the soil.

Containment can be used to avoid these impacts. Biological containment, such as growing only sterile plants that produce no pollen, prevents gene transfer. Physical containment, such as growing the plants on isolated plots far away from any related species can also be used. The most precautionary method of containment is growth in "closed environments" such as green houses, but this is likely to increase production cost and decrease capacity significantly.

- In addition to these pitfalls, the development of pharma plants could be hampered by negative public perceptions that have surrounded the field of genetic engineering.

- The product will require clinical trials in the same way as any other pharmaceutical product. Patent costs may mean that it will be so expensive that it will only be available to consumers in the developed world.

- Pharming may not have much to offer to UK farmers. Small areas under tightly controlled conditions will inevitably be required and thus only a few farmers or landowners will be able to participate should the technology be used commercially, even if the returns from individual crops are good.

POTENTIAL ALTERNATIVES

One alternative is to synthesise drugs in animal cell cultures (Chinese hamster ovary cells are commonly used) grown in sophisticated fermentation vats or "bioreactors" in laboratories under carefully managed conditions. Plant cell culture systems are also being explored but are not yet commercially feasible.

This conventional system avoids some of the issues with the use of "pharming" discussed above, including potential environmental impacts. In addition, there is a lower risk of contaminating the product with toxins, herbicides and pesticides and performance is not subject to climate, soil quality and other agricultural variables. Isolation and purification of the product tends to be simpler. However, conventional production has two major limitations over the use of plants:

- Production of high-quality biological material via mammalian cells is very expensive
- There are not enough of these bioreactors available to meet existing, much less future, demand for drug production (within this it is important to note that developing an antibody to stop tooth decay is only one example of the possible treatments that could be developed by pharming).

Particularly because the product is unlikely to be affordable for all, and it has to be used under supervision, it might be argued that putting greater efforts into promoting oral hygiene and better diet would have a more significant effect on dental caries worldwide.

The development of pharming raises a number of important questions. Three broad questions to get you started might be: -

- To what extent should pharming be developed to help provide medicines for a wide variety of human diseases?
- Could the use of GM and other biotechnology techniques be justified if they contribute to new, effective treatments for human diseases?
- Should agricultural land be used to grow plants used in pharming, or should they be grown under very strict containment procedures (which would make the process more expensive)?

ENERGY CROPS - SHORT ROTATION COPPICE WILLOW AND POPLAR

INTRODUCTION

Some trees can be planted closely together and regularly cut back to provide wood. This process is called coppicing. By careful management coppiced trees can be continually productive for many years. Willow and Poplar trees are particularly suited to coppicing using a style of coppicing called short rotation coppicing (SRC). The wood when harvested can be used as a source of energy. For example, the wood can be burnt directly to produce heat and electricity. Or, using certain technological processes, the wood can be converted into solid, liquid or gaseous fuels which can be stored for later use.

WHY IS THERE INTEREST IN THESE PRODUCTS?

At present a large proportion of our energy needs are supplied by burning fossil fuels (gas, oil and coal) in power stations. While reserves of fossil fuels are nowhere near exhausted they are not a renewable source of energy.

In contrast, coppiced fuel is a renewable source. When the trees are cut back they re-grow and hence supply a fresh supply of wood.

It is also now known that burning fossil fuels releases carbon dioxide gas into the atmosphere. An increased level of carbon dioxide in the atmosphere is a significant cause of global warming (hence why carbon dioxide is often called a greenhouse gas).

When coppiced wood is burnt to provide energy carbon dioxide gas is also released. However, when trees grow they absorb an equivalent amount of carbon dioxide from the atmosphere. Hence energy crops, such as coppiced willow and poplar, can provide a more balanced way of meeting our energy

needs without increasing the overall levels of carbon dioxide released into the atmosphere.
A further potential advantage of energy crops compared to other renewable energy sources (such as wind, solar and hydroelectric power) is that they can be readily stored and hence used only when needed.
SRC is also seen as an opportunity for UK farmers, many of whom are finding farming uneconomic, to diversify into new products and markets.

BARRIERS TO USING SHORT ROTATION COPPICING

A major barrier to using SRC willow and poplar is that at present it is not an economically viable alternative to conventional energy sources (such as gas and oil).
To make SRC economically viable the yields of coppiced wood will need to be maximised.
Some ways of increasing yields would be in developing crops:
that are resistant to pests and diseases
that are tolerant to herbicides
that have less water content so that they burn more efficiently
that have more cellulose content and less lignin content (cellulose is a major component of the cell walls of plants. Lignin is a substance laid down in the cell walls that gives the plant rigidity and strength. It is harder to extract energy from lignin than cellulose).

If SRC willow and poplar can be developed into economically viable sources of energy other issues will also need to be considered:
For example, quite large areas would need to be planted with coppiced trees. This would obviously change the appearance of the landscape.
It has also been estimated that to produce all the electricity we currently use from coppiced trees we would need to devote around 99% of all agricultural land to

coppiced woods. Non one is suggesting that this proportion of agricultural land is used in this way, but it raises important questions as to how much land should be used in this way.

Growing large areas of coppiced woodland could potentially bring changes to the diversity of plant and animal species that live in those areas.

When wood is burnt it leaves behind ash which would need to be disposed of somehow.

Growing any crop is subject to the weather, and naturally there would always be the risk that extreme weather conditions could seriously affect yields and hence energy production.

Transporting large quantities of wood to power stations would incur significant costs. To reduce these costs power stations could be sited near areas of large-scale production (say within 25 – 30 miles). Consideration would need to be given to the impact of such power stations in rural areas – particularly in relation to their visual impact on the landscape and the emission of smoke from the burning of wood.

THE POTENTIAL ROLE OF GENETIC MODIFICATION

To achieve the required yield of wood to make SRC economically viable genetic modification and allied techniques could be used.

For example, to develop trees that are more pest resistant, or trees that are more tolerant of herbicides.

There are questions as to whether GM trees would have effects on the diversity of plant, insect and bird species on farmland.

There are also questions as to whether GM trees developed to be resistant to herbicides might pose a risk of being invasive (i.e. by becoming 'superweeds' outside areas where they were originally planted).

BIOREMEDIATION

One further potential advantage of willow and poplar is that they can be grown on soil contaminated with large quantities of pollutants such as heavy metals such as Zinc and Cadmium. The trees take up these pollutants from the soil through their roots. Land contaminated with such pollutants cannot be used for growing food crops and often cannot be built on until it is cleaned. Thus willow and poplar could be used to do two jobs in one; to clean up contaminated land (bioremediation) and provide a renewable energy source.

The trees could also be fertilised with municipal sewage or sewage sludge. This provides the trees with organic nutrients whilst at the same time treats the sewage.

However, the ash resulting form burning willow and poplar grown on contaminated land, or when treated with sewage would need to be disposed of safely.

POTENTIAL ALTERNATIVES

- Using less energy overall is the surest way to reduce fossil fuel use and emissions of greenhouse gases. Even small changes in industrial processes along with greater awareness by domestic consumers could significantly enhance energy efficiency. However this would require lifestyle changes for some individuals (for example, using cars less) and relies upon good alternatives being available at a reasonable cost. Investment in energy-efficiency measures such as double-glazing and insulation in the home could reduce energy use.

- Other renewable resources such as wind and solar could also reduce the use of fossil fuels and therefore greenhouse gas emissions. However, these too

have drawbacks, they cannot be stored and used on demand and the mechanisms involved can be an eyesore (e.g. wind farms).

- Instead of using genetic modification to improve the energy yield from short rotation coppice, conventional breeding of willow or poplar could have the desired effects. However, conventional breeding is likely to take longer.

- A combination of approaches including Short Rotation Coppice and other alternatives could be used to reduce greenhouse gas emissions.

The development of SRC clearly raises a number of important questions. Three broad questions to get you started might be: -

- To what extent should energy crops such as SRC willow and poplar be pursued to meet our energy needs?
- What role should GM and other biotechnology approaches play in developing economically viable SRC plants?
- Could the use of GM and other biotechnology techniques be justified if they contribute to a reduction in the amount of greenhouse gas emissions?

PACKAGING MATERIALS

INTRODUCTION

Nearly all the plastic we use is made from oil. However plastics can also be made from plants which, unlike oil, are a renewable resource. Many plastics made from plants (bioplastics) are biodegradable.

Several plastics derived from crops are already in or near production.

PLA (or polylactic acid) is a biodegradable plastic made mainly in the US from maize (corn), but it can also be produced from wheat starch. Its main uses are in food packaging and clothes, but it could have many other uses including medical implants and sutures and drug delivery systems. Toyota have announced plans to produce PLA plastics from sweet potatoes, sugar cane and maize, for use in a wide range of applications from household items to motor vehicle components.

PLA is completely biodegradable, and uses easily available raw materials. Its major drawbacks are that it is more expensive than conventional plastics and that, at present, its properties limit the uses to which it can be put.

Potatopak is a UK Company producing packaging material made from potato starch. Most of the potato starch used by Potatopak is imported from the EU. The only use to date is in food packaging. Its advantages are that it is completely biodegradable, indeed edible. Its major drawbacks are that, as with PLA, its applications are limited and it is higher priced (though the price would fall if output increased).

Ecobloc, produced by Green Light Products Ltd UK is a polystyrene-like product manufactured from wheat starch, used for electronic goods packaging. It is fully biodegradable.

Sorona is a U.S. produced product in which GM micro-organisms are used, in contained facilities, to turn sugar from plants into a type of plastic. It is bio-derived, but not biodegradable, and it is not yet in full production. Its main uses would be in clothing.

WHY IS THERE INTEREST IN THESE PRODUCTS AND WHAT ISSUES DO THEY RAISE?

We generate around 100 million tonnes of municipal waste in the UK each year – almost 2 tonnes per head. This amount is increasing at around 3% per year. Around 10% of municipal waste is estimated to be packaging materials, and nearly half of this goes to landfill.

Plastic is a particular problem for both recycling and landfill. It is expensive to collect and there are many different types of plastic which must be separated to be recycled properly. When it does get to landfill it degrades very slowly. On the other hand, to use paper (which can be recycled and does degrade) is not necessarily a better option. Thus the search is on for new kinds of plastic materials that:

- will degrade easily, avoiding the need to collect it for recycling
- come from 'renewable' sources – i.e. plants rather than oil (although only a small proportion – less than 10% - of oil is used to make plastics).

The extent to which these products offer a big environmental improvement over their conventional plastic counterparts will depend on a number of factors, for example:

how many petrochemical-based plastic products can be replaced

- whether consumers and companies compost them properly, rather than sending them to landfill

- whether they will also be recyclable, if composting is not practical

- whether they genuinely save energy across their whole life cycle from manufacture, to application and finally at disposal
- whether chemicals which could be harmful when released into the environment are needed in the manufacturing process to make the plastic viable
- whether they are derived from waste products, or whether from crops grown specially – if the latter, they are taking up land that might otherwise be used for food or wildlife.
- whether any biotechnology or GM features to their production might themselves have environmental disbenefits – for example, potatoes grown in open fields that are GM may raise issues if they are herbicide tolerant or pest resistant.

POTENTIAL OR ACTUAL ROLE OF BIOTECHNOLOGY

PLA can be produced from non-genetically modified maize and the production process does not need to involve biotechnology. However, the maize feedstock used currently might have some GM content, just by virtue of the fact that 40% of the maize grown in the U.S. is GM. But even if GM maize is used no intact maize genetic material (the DNA) would be present in the finished packaging material.

There is work in progress to make potatoes more pest or disease resistant through genetic techniques. Potatoes could also be modified with GM to optimise the type of starch they produce. Hence for PotatoPak biotechnology could be involved if, in future, the potatoes from which the waste starch is obtained were to be genetically modified.

There is also a possibility that Ecobloc could be produced from a GM wheat source that might become available in the distant future. As with PLA, once processed, the starch-based packaging would contain no intact DNA.

However, these uses of biotechnology in bio-plastics are unlikely in the present policy climate, as they would mean that GM potatoes and/or wheat would have to be widely grown in Europe.

The production of bio-derived Sorona is dependent on biotechnology as genetically modified micro-organisms are needed to produce the raw materials.

POTENTIAL ALTERNATIVES

Bio-plastics are one of a number of ways in which to minimise waste and the depletion of natural resources. Alternatives that could be used instead of, or in conjunction with, bio-plastics include:

- reducing the use of packaging materials for food and other products, but this may not meet consumer approval if it increases the chance of products getting damaging
- more recycling or re-use of ordinary plastics, but recycling is itself an energy consuming process
- more use of natural products such as paper and cardboard instead of plastic for packaging and natural fibres in place of artificial ones for clothing; however, natural products are not always good alternatives – for example paper bags are heavier and bulkier than plastic ones (so cost more to transport) and are more expensive to manufacture

In all these cases, financial or other measures could be imposed by Government to encourage the reduction of waste and conservation of natural resources. Examples include the UK landfill tax and the tax imposed on plastic bags in Ireland. However, these have been criticised as unfairly affecting certain business sectors and the plastic bag tax has been claimed to have a minimal effect on overall levels of waste.

The development of bioplastics raises a number of important questions. Three broad questions to get you started might be: -

- To what extent should bioplastics be developed to help reduce the amount of waste plastic going to landfill?
- What role should GM and other biotechnology approaches play in developing economically viable bioplastics?

How much of our agricultural land should be given over to growing crops to produce bioplastics (whether using GM or conventional plant breeding techniques)?

BIOETHANOL

INTRODUCTION

Ethanol (commonly known as alcohol) has been used as a fuel for transport for about 30 years, as both neat ethanol and as a blending agent in petrol. A 10% ethanol blend in petrol contains about 97% of the energy of pure petrol, although this 3% loss of energy is compensated by the fact that a petrol/ethanol mix burns more efficiently than pure petrol.

All modern car engines can run on blends of 10% ethanol interchangeably with ordinary petrol. In the USA about 18% of petrol is already blended with ethanol to some degree. Blends of up 85% ethanol with petrol are also available and can be used in cars called flexible fuel vehicles, of which there are already more than 3 million in the USA.

Ethanol can be produced from a variety of agricultural crops. In the US, it is produced mainly from maize, and in Brazil, from sugar cane.

Possible crops (or feedstocks as they are usually called) for ethanol production in the UK are sugar beet, wheat, grain, straw, wood (including short rotation coppice willow and poplar) and grasses such as *Miscanthus*.

Ethanol production is easiest from crops that produce abundant sugar (such as sugar cane and sugar beet), where the sugar is simply fermented with yeast to produce ethanol. In the case of maize, a starch crop, the kernel is first milled to release starch. The starch is then broken down into the sugar building blocks from which it is made by adding enzymes to digest it. This sugar is then fermented. More complex feedstocks, such as wood, straw, and grasses (known as lignocellulosic feedstocks) can be broken down into sugar, but a number of extra initial steps are needed to do this.

Ethanol production from sugar beet, maize and wheat grain can also potentially lead to a number of valuable co-products such as animal feed, electricity and heat, essential oils and other compounds for the cosmetics and health industries. In the case of ethanol from lignocellulosic feedstocks, possible co-products include heat and electricity.
The value of these co-products makes the economics of bioethanol production more favourable.

WHY IS THERE INTEREST IN THESE PRODUCTS AND WHAT ISSUES DO THEY RAISE?

If the world is to continue to use cars as it does today, a solution is needed both to the pollution that they cause and the fact that the world's oil reserves (from which petrol is produced) will one day be used up.
Bioethanol is seen as an increasingly attractive option, particularly as the price of oil rises. Furthermore, bioethanol is a renewable resource, and its production is limited only by the amount of land available to grow its feedstock crops (such as sugar beet etc).
Moreover, some bioethanol feedstocks (such as sugar beet, *Miscanthus* and wheat grain*)* can be grown in the UK, reducing our dependence on oil from politically unstable regions of the world.
Bioethanol is also a greener fuel than petrol. The crops grown to make bioethanol absorb carbon dioxide when they are growing, and therefore using bioethanol reduces overall emissions of greenhouses gases. It is also cleaner, producing fewer pollutants such as complex hydrocarbons, sulphur, nitrogen dioxide, and carbon monoxide, which can cause smog and endanger human health.
Bioethanol is also a high-performance fuel, and hence the performance of cars will not be reduced.

Growing bioethanol crops is also seen as a good opportunity for farmers, creating additional markets. Moreover, if farmers also invest in ethanol production facilities, they could increase incomes further, benefiting deprived rural areas.

For these reasons, Governments are promoting the use of biofuels including bioethanol. The British Government has reduced the tax on biofuels to encourage their uptake and, under the recently reformed Common Agriculture Policy, extra EU subsidies are available for farmers growing crops for biofuels.

However, there are several issues raised by the use of bioethanol as a substitute for petrol:

- Increasing the land used for bioethanol production would reduce the amount of land available for food production. Although food production in the developed world is considered to be in surplus, in the longer term this may not be the case and land suitable for food production that has been turned over to growing Non-food crops may be required again for the production of food to feed a growing world population.
- To avoid reducing the amount of land available for food production, non-agricultural land could be converted for bioethanol production. However, this might destroy diverse habitats, such as forests, and have unanticipated environmental effects. It is also possible that agricultural land which is set aside (under the terms of the EU's Common Agricultural Policy) and hence not currently used for agricultural production could be used for bioethanol production.
- Production of biofuels, like food crops, will require fertilisers and pesticides, water for irrigation, and will also incur transportation costs. These could cause environmental damage if energy crops are grown intensively and on a large scale. Of course, land that is already used for food production also requires these same resources.
- Production costs vary according to the feedstock used and the conversion technology required. Mid range projections suggest advanced production

technologies could produce bioethanol for around three times the current production costs of petrol and diesel. This however ignores the potential economic value of co-products of bioethanol production (see above) or the fact that the actual production costs of petrol and diesel are a very small proportion of the prices we pay at the pump, as by far the largest proportion of the pump price is tax.

POTENTIAL OR ACTUAL ROLE OF BIOTECHNOLOGY

Ethanol can be produced from crops without the aid of any modern biotechnology or genetic modification. However, the production of bioethanol is only marginally economically viable at present, and its competitiveness is highly dependent on fluctuating oil prices and favourable tax reductions. Production from complex lignocellulosic biomass is still at the demonstration stage and is not economically viable. Biotechnology might be used in a number of ways to improve the economics of bioethanol production.

Genetic modification could be employed to develop feedstock crops that are resistant to pests and diseases or tolerant of herbicides, thus making them easier and cheaper to grow for farmers. This has already happened with maize in the USA – 40% of the maize crop is genetically modified and therefore bioethanol is produced from GM maize, although this is not necessary for ethanol production. (If feedstock crops for ethanol production were genetically modified, no intact GM DNA would be present in the final ethanol product.)

- Genetic modification of feedstock crops to improve their properties, for example optimising the starch or sugar composition; altering the crops' water and/or carbon content; or increasing the proportion of cellulose to lignin to increase efficiency of ethanol production.
- Improving the efficiency of the digestion and fermentation process using biotechnology. Yeast or other microorganisms could be genetically modified

to improve the efficiency of the enzymes they produce, for example by allowing them to operate at lower temperatures.

There are however concerns about the use of certain biotechnology procedures. For example, it is possible that feedstock crops engineered for pest or herbicide resistance may have effects on the biodiversity of plant, insect and bird species on farmland. Any genetically modified microorganisms (such as yeasts) used in ethanol production from feedstocks would also have to be kept in strict containment to prevent their release into the environment and possible transfer of GM DNA to naturally occurring microorganisms. However, in the case of microorganisms the issue of containment is relatively straightforward when compared to GM crop plants which would need to be contained in large greenhouses.

POTENTIAL ALTERNATIVES

The use of bioethanol in cars reduces greenhouse gas production, but not to zero. When ethanol is blended with petrol, CO_2 emissions are only reduced by 10-20%. However, car use is growing very rapidly throughout the world, and even with increasing use of bioethanol it is likely that greenhouse gas emissions will continue to rise, potentially exacerbating global warming. An alternative way to reduce the greenhouse effect, or one to be used in conjunction with bioethanol, is to encourage the reduction of car use, for example through targeted taxation or improved public transport. However, such measures are likely to be unpopular and politically difficult. There are other ways in which emissions from cars could be reduced, including improving engine and vehicle design and the use of alternative fuels such as renewably generated hydrogen and electricity.

Bioethanol could be used in combination with some or all of these alternatives to reduce greenhouse gas emissions.

As an alternative to the use of genetic modification to improve the efficiency of feedstocks for bioethanol production, conventional plant breeding could be used. Conventionally-bred high starch varieties of maize are already available.

If side-products from food production, such as straw, could be used for bioethanol production, issues of conflict with food production disappear and environmental efficiency is increased because otherwise discarded parts of plant are used. Because of the more complex digestion required, bioethanol production from side-products is not economically viable at present, but efforts are being made to improve the efficiency of the process.

The development of bioethanol raises a number of important questions. Two general questions to get you started might be: -

1. How do you think decisions should be taken about whether and how to pursue this application of Non-food agriculture?

2. Does it seem to you appropriate to use GM and other biotechnology approaches to develop this application, taking into account the potential benefits and risks, and the other possible ways to achieve the same aims?

DUTCH ELM DISEASE RESISTANT TREES

INTRODUCTION

Dutch elm disease (DED) first appeared in north-west Europe around 1910. It is one of the most serious tree diseases in the world. It is caused by two related species of fungi which are spread by various elm bark beetles. The disease affects all species of elms including the so-called English elm. A recent study has suggested that all English elms could be descended from a single tree brought here by the Romans. This species of elm - the Italian Atinian elm - reproduces asexually, creating clones of itself (which would mean that all English elms in the UK are genetically identical and therefore susceptible to the same fungi and diseases).

Forestry Commission research showed that the outbreak of DED in the 1970s was caused by an entirely different, far more aggressive DED fungus than that responsible for the epidemic of the 1920s—40s, and that the new fungus had been imported into Britain on infested elm logs. Within a decade about 20 million elms out of an estimated UK elm population of 30 million were dead.
By the 1990s probably well over 25 million elm trees had been killed by the fungus. Studies on the new DED fungus showed that it differed from the original fungus in almost all its important biological properties. The two pathogens were later described as separate species, *Ophiostoma ulmi* being the original and *O. novo-ulmi* the new highly aggressive pathogen.

Southern England, with the exception of Brighton, has almost no mature elms left due to the fungal disease. The fight to save these trees has been going on in the UK since the early 70s and those remaining are heavily protected. The English

elm (*U. procera*), the smooth-leaved elm (*U. carpinifolia* or *U. minor*) and the wych elm (*U. glabra*) are all susceptible to *O. novo-ulmi*. In 1982 Forestry Commission studies suggested that the disease would not die down as had the first epidemic caused by *O. ulmi*, but instead, that the new DED pathogen *O. novo-ulmi* would return, in a continuing cycle, to attack the following generation of small elms once they were large enough to support beetle breeding. This is what is now happening in southern Britain. With these losses, DED remains by far our most destructive tree disease. Different parts of the country support different species of Elm and the progress of the disease varies across these areas. Some are still caught in the initial "wave" of the 1970s epidemic.

POTENTIAL OR ACTUAL ROLE OF BIOTECHNOLOGY

Genetically modified elm trees resistant to Dutch elm disease have been grown by scientists at a Scottish university. Researchers from Dundee's University of Abertay transferred anti-fungal genes into the elm's genetic material using minute DNA-coated ball bearings. They believe their work could lead to elm trees being reintroduced into their native habitat - although at present the transformed plants are not yet mature enough to be challenged by the fungus and therefore it is not yet clear if the strategy works.

WHY IS THERE INTEREST IN THIS AND WHAT ISSUES DOES IT RAISE?

Diseases of trees are of major economic importance. Therefore the work on Dutch elm disease could help in the fight against diseases in many other commercially and aesthetically important trees across the world.
This use of science has been referred to by some as "an example of environmentally friendly biotechnology".

There is a theoretical possibility that the modified genes inserted into the genetic material (or genome) of elms could pass into other species of microorganisms and plants. This risk is thought to be minimised by the fact that under normal conditions in Britain, the English elm does not produce seeds, but reproduces itself by means of suckers which emerge from the tree's roots.

Under the EU Directive 2001/18, any genetically modified tree would have to undergo the same application for release into the environment as any other genetically modified organism, which may make the whole process far more costly and restricting.

The impact of the loss of heritage trees can be measured in many ways: monetary loss from devastation of economic species, biodiversity loss and its eco-impacts, and loss of aesthetic value. However, the loss of opportunity for future generations is unquantifiable. Biotechnology research offers the potential for restoring species and damaged landscapes.

POTENTIAL ALTERNATIVES

Traditional plant breeding techniques have had limited success in tackling Dutch elm disease and even in the United States where trees have been injected with some protective chemicals every year at huge cost only some survive - (and this technique does not offer a cure). DED is currently managed by interrupting the disease cycle. The most effective means of breaking the cycle is early and thorough sanitation to limit the population of the insects that transmit the fungus from tree to tree. Other useful means of affecting the disease cycle include using insecticides to kill the insect vector i.e. the beetles. However, the chemicals for this are extremely toxic and very hazardous to humans. Other preventative techniques include breaking root grafts between trees (this is where roots from adjacent trees touch and eventually graft onto one another. This effectively connects the trees to each other making spread of the disease more likely),

injecting individual trees with fungicides to prevent or halt the fungus, pruning out early infections, and planting DED tolerant or resistant elm cultivars or indeed planting other tree species entirely.

The development of Dutch Elm resistant trees raises a number of important questions. Two general questions to get you started might be: -

1. How do you think decisions should be taken about whether and how to pursue this application of Non-food agriculture?

2. Does it seem to you appropriate to use GM and other biotechnology approaches to develop this application, taking into account the potential benefits and risks, and the other possible ways to achieve the same aims?

HIV MICROBICIDES

INTRODUCTION

The word microbicide refers to a range of different products that share one common characteristic: the ability to prevent the transmission of HIV and other sexually transmitted diseases (STDs) when applied directly to the surface of the human body (usually called topical application). A microbicide could be produced in many forms, including gels, creams, suppositories, films, or as a sponge or ring that releases the active ingredient over time.

A consortium of European plant scientists has recently been awarded a 12million Euro grant for a project to develop the production of pharmaceuticals in plants, including the production of HIV microbicides to prevent HIV infection primarily. The project aims to focus on treatments that would be of greatest benefit to the developing world, and any successful developments will be freely licensed in those countries.

WHY IS THERE INTEREST IN THESE PRODUCTS AND WHAT ISSUES DO THEY RAISE?

AIDS now accounts for more deaths worldwide than any other infectious disease and more than 40 million people are infected with HIV. It has been estimated that 2.5 million HIV infections could be prevented (over three years in 73 low-income countries) even if the microbicide used is only 60% effective. This would save billions in healthcare costs and productivity gains. However, commercial

pharmaceutical companies have in general withdrawn from development of these treatments because of the low economic returns expected.

But even if a candidate microbicide is shown to be safe and effective in clinical trials it must also be acceptable and accessible to end users: women wanting to protect themselves and their partners from HIV and other STDs. For a microbicide to be used consistently, women must understand the benefits, the elements of correct use, the potential side effects, and have the co-operation of their partners.

POTENTIAL OR ACTUAL ROLE OF BIOTECHNOLOGY

The consortium aims to genetically modify plants to produce antibodies against HIV to be used in a microbicide. The plants would be cultivated and processed locally, in the countries of use. A variety of genetically modified plants are being developed to produce the antibodies, including maize, tobacco, potato, alfalfa, rice, tomatoes and wheat. It has not yet been decided which crop will be used for the HIV antibodies, though maize and tobacco are the two primary candidates. The preference is likely to be for a crop where the antibodies would be produced in large quantities in the seeds, and therefore easily harvestable.

Plants are inexpensive to grow and could in theory produce large quantities of the microbicide antibody required through genetic modification. The possible advantages of using plants to produce antibodies include:

- cheaper production than other systems– it is difficult to predict how much cheaper but the EU consortium suggests between 10 and 100 times;
- large scale growing, harvesting and processing are technically feasible;
- plants offer natural, stable storage systems for proteins such as in seeds;
- reduced potential for contamination with human or animal pathogens compared to extraction of proteins from animal or human sources.

However, the use of GM plants to produce pharmaceutical products raises a number of technical, legal and environmental issues:

The way that plants produce the antibody protein is not exactly the same as when produced in humans. Thorough testing will be needed to ensure that the product produced in plants is as effective as that made in mammalian cells. There may also be unanticipated problems in purification of the antibody from the crop. In addition, maintaining consistent production of the antibody gene could be a problem – other species of plants modified to produce antibodies have shown reduced production with successive generations. All these issues will affect the economic viability of the process. Having said this, these are essentially technical problems which may be solved by further development work.

- Possible environmental impacts that some observers are concerned about include:
    - the inserted gene altering the behaviour of the plant in unexpected ways, for example causing it to become a weed;
    - naturally occurring "horizontal gene transfer" to a wild, related plant which might then have similar unexpected ecological effects or be toxic to animals consuming it;
    - the drug itself being toxic in soil or to animals that consume it;
    - the antibody gene being transferred to microorganisms in the field.

A food crop such as maize may be chosen to develop the required antibody. However, this raises the possibility of impacts on human health. Precautions would be needed to prevent the genetically modified food from getting into the food chain, and exposing people to inadvertent consumption of a biologically active compound which could prove dangerous, especially for infants, people who have an illness, and the elderly. Concerns have also been expressed that, if

the genetically modified plant were eaten, the inserted genes might be transferred to microorganisms in the intestine.

Containment can be used to avoid these environmental and health impacts. Biological containment, such as growing only sterile plants that produce no pollen, prevents gene transfer. Physical containment, such as growing the plants on isolated plots far away from any related species can also be used. The most precautionary method of containment is growth in "closed environments" such as green houses, but this is likely to increase production costs and decrease capacity significantly.

- In addition to these pitfalls, the development of pharma plants could be hampered by legal or regulatory barriers. Typically it takes about 10 years for a product approved for use in the developed world to reach developing countries. Marketing issues related to negative public perceptions that have surrounded the entire field of genetic engineering in Europe could also slow development. Initial field trials for the HIV antibody plants are likely to be carried out in South Africa, and there has already been some opposition to this.

- Even if they were grown in the UK, the production of pharmaceuticals in crops may not offer a great opportunity to UK farming. Small areas under tightly controlled conditions will inevitably be required and thus only a few farmers or landowners will be able to participate should the technology be used commercially.

An effective microbicide needs to interrupt the complex sequence of events between exposure to HIV (or other STD pathogen) in sexual intercourse and the establishment of infection. Many of the microbicides currently awaiting further development offer partial protection against HIV and a number of STDs. Full

protection against HIV and other STDs is likely to be achieved only through the combined use of several microbicides.

POTENTIAL ALTERNATIVES

One alternative to using genetically engineered plants to produce drugs is to synthesise them in animal cell cultures (Chinese hamster ovary cells are commonly used) grown in sophisticated fermentation vats or "bioreactors" in laboratories under carefully managed conditions. Plant cell culture systems are also being explored but are not yet commercially feasible.

This conventional system avoids some of the issues with the use of "pharming" discussed above, including potential environmental impacts. In addition, there is a lower risk of contaminating the product with toxins, herbicides and pesticides and performance is not subject to climate, soil quality and other agricultural factors. Isolation and purification of the product tends to be simpler. However, conventional production has two major limitations over the use of plants:

- Production of high-quality biological material via mammalian cells is very expensive and results in drugs that may be too costly for patients to afford
- There are not enough of these bioreactors available to meet existing, much less future, demand for drug production.

Alternatives to or measures to use alongside HIV microbicides to prevent HIV infection in the developing world include investment in education to change behaviours that lead to infection. In addition, a great deal of research is being carried out into HIV vaccines and other drugs which might be more effective at preventing infection than microbicides and provide longer-term protection. Finally, efforts are being made to license anti-retroviral drugs to treat those already infected for cheap distribution in the developing world.

The development of microbicides to prevent HIV infection raises a number of important questions. Two general questions to get you started might be: -

1. How do you think decisions should be taken about whether and how to pursue this application of Non-food agriculture?

2. Does it seem to you appropriate to use GM and other biotechnology approaches to develop this application, taking into account the potential benefits and risks, and the other possible ways to achieve the same aims?

PHYTOREMEDIATION OF ORGANIC POLLUTANTS

INTRODUCTION

Plants have a remarkable ability to extract and detoxify pollutants from soil, water and air – in a process known as phytoremediation.

WHY IS THERE INTEREST IN THIS?

The potential economic benefits of using plants for the treatment and containment of pollutants are impressive. Importantly, phytoremediation offers perhaps a more environmentally friendly alternative to conventional remediation methods for removing pollutants from contaminated sites.

These studies open the exciting prospect that large areas of land, particularly in third world countries, currently rendered uninhabitable by contamination with explosives may be returned to profitable use in an environmentally friendly way. Nevertheless it must be recognized that considerable research and development in this area remains to be completed.

POTENTIAL OR ACTUAL ROLE OF BIOTECHNOLOGY AND ISSUES RAISED

While it has become apparent over the last five years that conventional plants have some potential for the treatment of pollutants, it is also clear that phytoremediation of certain organic pollutants is hampered by the fact that many

of these pollutants are just too toxic for the plants used in phytoremediation. However, it is also known that many species of bacteria and fungi are capable of dealing with such organic pollutants. Yet using bacteria and fungi to clean up large areas of polluted land poses considerable practical problems.

Recently, though, it has been demonstrated that these limitations can be overcome by inserting genes from bacteria into plants. In one example, genes have been transferred into plants from bacteria that can safely detoxify the very toxic explosive TNT. If specific genes from the bacterium *Enterobacter cloacae* are inserted into plants it makes them able to remove appreciably more TNT from soil than ordinary plants.

Further work is being undertaken to engineer plants for all of the major classes of explosives. Related to this work a significant number of bacteria have been isolated from explosives-contaminated land that are capable of utilizing the organic pollutant RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) as their sole source of nitrogen (nitrogen being essential for their growth). The gene responsible for breaking down RDX has now been identified and inserted into plants. These transgenic plants have been shown to rapidly degrade RDX to safe end products.

However, this new technology does pose some important questions:

- It is possible that the inserted genes involved in the degradation of toxic pollutants could transfer from the modified plants to other plants or bacteria, by the naturally occurring process of “horizontal gene transfer”. It is often not clear what the likelihood of this is for a particular transgenic plant, and what the consequences would be of the unintended presence of the gene in other species. These transgenes could cause unanticipated ecological or other effects, and the potential for this to happen will have to be established.

- Confirmation would be needed that the end products of degradation of pollutants would not have any potential toxic effects themselves. Although the end products of degradation of the explosives mentioned above have been reported to be benign, other examples of phytoremediation are not so simple. For example, trees have been genetically modified to take up ionic mercury or organic mercury from polluted soil, convert it to less toxic elemental mercury, and expel it into the atmosphere, but this has been criticised as transferring a local, soil-based pollutant to a global, atmospheric one.
- There are also questions as to whether the plants can be left in the ground, or if any special procedures are needed to remove and dispose of them.

POTENTIAL ALTERNATIVES

Conventional plants have the ability to remediate some types of soil pollution. However, as discussed above, the use of genetic modification offers the potential to significantly improve plants' remediative ability.

Conventional methods of removing pollutants can be used – these include the excavation and burial of soil in landfill sites and soil incineration. However, these methods can cause serious environmental damage and are likely to be more expensive than phytoremediation especially when large areas are considered.

The development of phytoremediation raises a number of important questions. Two general questions to get you started might be: -

1. How do you think decisions should be taken about whether and how to pursue this application of Non-food agriculture?

2. Does it seem to you appropriate to use GM and other biotechnology approaches to develop this application, taking into account the potential benefits and risks, and the other possible ways to achieve the same aims?

Appendix 5 – The Research Materials

1. GM Scenarios

Eating a GM plant such as corn on the cob (maize)

Taking a medicine extracted from a GM plant

Using a plastic bag which has been made from GM plants

Growing trees which have improved pest resistance through GM

Using a cosmetic which contains an ingredient extracted from a GM plant

Filling up your car with an alcohol based fuel where the alcohol has been fermented using GM yeast

Using thermal insulation material in your loft made from constituents made in GM plants

2. Case Studies Rating Scale

The Case Studies

Please rate each of the eight potential Non-food agriculture applications that you have read about in the case studies.

Please rate each one on a scale of 0 – 10, where 0 = I would **definitely not** want to see this application as described in the case study progressed in the UK, and 10 = I would **definitely** want to see this application as described in the case study progressed in the UK.

SEMINAR NUMBER:

Application	Rating from 0 - 10
Short rotation coppicing	
Antibody to treat dental caries	
Bioplastics for packaging materials	
Using plants to clean up polluted land (phytoremediation)	
HIV microbicide	
Dutch Elm resistant trees	
Bioethanol	
Bioplastics for construction and DIY markets	

3. Participants' Recommendations Sheet

Considering all the deliberation you have done about non food agriculture and associated issues what recommendations do you want Government to be given on your behalf – please try to be as specific as possible.

Appendix 6 – Stakeholder Participation

Stakeholder Participation

York

Maggie Smallwood – NNFCC

Sue Mayer – AEBC

Sutton

Nick Starkey – Defra

Julie Hill – AEBC

Edinburgh

Rosi Waterhouse – Scottish Executive: Agriculture and Biological Research Group

Jeff Maxwell – AEBC

Dave Carmichael – AEBC

Ian Forshaw – Forestry Commission

Newtownards

Dave Carmichael – AEBC

Mike Camlin – Northern Ireland Department of Agriculture.