

Annual report of the Government Industry Forum on Non-Food Uses of Crops

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Acronyms used in this report

BPD	Biocidal Products Directive
BWMB	British Wool Marketing Board
CAP	Common Agricultural Policy
CIMNFC	Competitive Industrial Materials for Non-Food Crops
CIRIA	Construction Industry Research and Information Association
CNAP	Centre for Novel Agricultural Products
CO ₂	Carbon Dioxide
CSL	Central Science Laboratory
DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department for Environment, Transport and the Regions
DfT	Department for Transport
DTI	Department of Trade and Industry
EC	European Commission
EFRA	Environment Food and Rural Affairs
EINECS	European Inventory of Existing Commercial Chemical Substances
ELINCS	European List of Notified Chemical Substances
ELV	End-of-Life Vehicles Directive
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GM	Genetic Modification
GMO	Genetically Modified Organism
HGCA	Home Grown Cereals Authority
HSE	Health and Safety Executive
IGER	Institute for Grassland and Environmental Research
ISO	International Organisation for Standardisation
LCA	Life Cycle Assessment
NDPB	Non-Departmental Public Body
NGO	Non-Governmental Organisation
NNFCC	National Non-Food Crops Centre
OP	Organophosphate
OSR	Oilseed Rape
OST	Office of Science and Technology
PAO	Poly-Alpha Olefin
PEG	Poly-Ethylene Glycol
R&D	Research and Development
RD&D	Research, Development and Demonstration
RES	Rural Enterprise Scheme
RME	Rape Methyl Ester
SPG	Sustainable Procurement Group
SRC	Short Rotation Coppice
STI	Sustainable Technologies Initiative
t/ha	Tonnes per Hectare
UK	United Kingdom
VOC	Volatile Organic Compound
WIP	Waste Implementation Programme

Foreword by the Chairman, Rob Margetts CBE

In its second year the forum has made substantial further progress in the evaluation and exploration of the barriers that inhibit the widespread introduction of agriculturally derived materials that can make a significant contribution to sustainable development.

We are especially heartened by the support given on many fronts from government to our activities including its positive response to the recommendations in our first annual report, its establishment of the new National Centre for Non-Food Crops and the funding of several key initiatives. We are pleased to work in tandem as it develops a coherent UK strategy for the whole activity.

We continue to develop our case study portfolio of potential applications to their individual logical conclusions with excellent involvement from industry and commerce, government, academia and a wide range of other experts, all of whom I thank for their enthusiastic support. We are also now focusing on the generic issues - regulation, land use, bioscience, sustainability, incentives, demonstration *inter alia* - to establish sound mechanisms for judgement, decision and implementation.

I wish to thank my Forum colleagues, stakeholders and the secretariat for their tireless contribution to unlock this most complex and potentially very important set of opportunities.

A handwritten signature in black ink that reads "Rob Margetts". The signature is written in a cursive, flowing style.

Rob Margetts

Chairman, Government Industry Forum on Non-Food Uses of Crops

Executive summary

1. The Government Industry Forum on Non-Food Uses of Crops is an advisory non-departmental public body sponsored by Defra and supported by the DTI. It was set up in March 2001 with the remit to provide strategic advice to government and industry on how to promote development of non-food uses of crops in UK, in particular to promote development of sustainable opportunities that will add to UK economic activity. This is the forum's second annual report.
2. We are grateful for all the letters we have received from industry and government agencies in response to our first report and recommendations. We are also indebted to the many industry representatives who have given up their valuable time and resources to assist the forum in its investigations. In promoting non-food uses of crops we are trying to enable a more sustainable basis for industry in the 21st century, and it is vital that we have their support. We are also extremely grateful to the many academics and researchers who have taken the time to discuss their work and the key scientific issues with us.
3. The government has made financial and strategic commitments to extending the competitive non-food uses of crops in the year since our last report; their embryonic long-term strategy for non-food crops is pivotal to realising this and we look forward to advising government as it develops. In addition the government has committed to taking the UK towards a lower carbon economy. The recently agreed indicative targets for transport fuels under the EU Biofuels Directive put further pressure on the UK to move in this direction. There are also numerous potential commercial opportunities in the medium to long term arising from plant genetic research to provide industry with renewable raw materials with superior productivity, performance and functionality, and importantly, to contribute to the resolution of environmental problems. These opportunities also provide a sound scientific basis for further improvements in primary production and bio-processing. It is our view that, placed in the context of the government's overarching commitment to ensuring development is sustainable in the long term, these factors should combine to position a number of crops at an important juncture where they increasingly become the raw material of choice for industry.
4. In our first annual report we commented on the surprising diversity of opportunities for non-food uses of agricultural crops. As research has continued in our second year, we continue to be fascinated by the functionalities provided by crop-based raw materials. They can substitute for non-renewable resources in an enormously varied range of applications. Added to this is the potential for production of novel products of high utility through the bioscience route; this presents the forum with a challenging range of opportunities to assess. However since our first annual report we have undertaken fewer new case studies than in the first year; instead we have concentrated on consideration of the generic issues that impact upon many of these potential uses and the importance of these to the sector as a whole.

5. We have devoted considerable time to examining the sustainability of the use of crop derived products. It is beyond our resources to undertake life cycle assessments for each of the opportunities. We have subjected them to much closer scrutiny than previously in the context of the economic, environmental and social dimensions of sustainable development. The renewable resource does not always offer the most sustainable solution. In certain instances the non-renewable resource has been developed with such sophistication that the environmental impact is small and the economics almost impossible to match at this point in time; an example of this is large-scale use of synthetic dyes.
6. But there is still much to be done if progress is to be realised. We have advised Defra and DTI on plans for the new National Non-Food Crops Centre as it has developed and we think this will provide a valuable focal point for the sector. The government's proposed demonstration scheme will also give support to the market introduction of a range of crop-derived products, as will programmes such as the HGCA's Enterprise Award for non-food products, and the Sustainable Technologies Initiative.
7. Ultimately we believe that non-food uses of crops must be market led, but there are very important contributions that government can make to the development of this emerging industry. Sustainable procurement policies, featuring a requirement to use crop-derived raw materials where possible and practical would be a strong market driver. Emerging EU legislation is often designed to address problems created by materials already on the market and it is important this should not disadvantage the use of renewable raw materials; government departments should enter negotiations with the EU with this as the cornerstone of their position.
8. The government responded to our first annual report and recommendations in June this year and we were encouraged by the generally positive comments. The response document is available on our website. It is now for us to work with the government and with industry to see that, where our recommendations have been accepted, they are taken forward and implemented. We were particularly pleased to see the positive response to recommendations on biopackaging; this is an area where there is a clear, large-scale potential for use of a UK grown crop to contribute to one of the government's key priorities. We have committed a significant proportion of our meeting times and other resources to this issue. Individual comments are discussed in part 5 of this report.
9. Liquid biofuels for transport are often in the news these days and we too have spent considerable time on this complex issue. The Sheffield Hallam¹ report commissioned for the forum by Defra in 2001, was published in January this year. We engaged in lengthy discussions with the authors in September last year when the research was nearing completion; we have also received letters and taken advice from a number of potential

¹ N.D Mortimer, P. Cormack, M.A. Elsayed and R.E. Horne. Evaluation of the comparative energy, global warming and socio-economic costs and benefits of biodiesel. Resources Research Unit, Sheffield Hallam University.

stakeholders in a UK biofuels industry. We advised ministers on the potential benefits of biofuels in November 2002. Our key message was that the commitment to a biofuels industry should be considered in an holistic framework given the range of potential benefits, and that in our view a 20p per litre tax rebate would be insufficient to support development of a significant UK biofuels industry. We believe this is an area of evolving policy and we watch for further developments. In particular we retain a strong interest in the potential offered by lignocellulosic technologies for production of bioethanol and will commit further time and studies to track its development.

10. This report contains our conclusions and recommendations for three case studies - plant oil based lubricants for use in hydraulic fluids in total loss and potential loss applications, plant derived anti-microbial products, and adding value to wool. These three reports illustrate very well the breadth of the issues we have encountered in this sector. In particular adding value to wool has been a very complex area; we entered it thinking the opportunities may be rather limited, only to find the opposite, there are plenty of innovative uses for wool, but the incumbent regime provides a very inflexible framework for development of these new opportunities.
11. In our third year we will be keen to see the recommendations of our first report implemented, and we look forward to the government's response to recommendations in this report in due course. We are aware there are a number of areas that we have not yet addressed and we will be reviewing our case study portfolio to take on new work areas; the input of industry and stakeholders on this would be most welcome.
12. This report and all other reports that have been commissioned to support the forum's work, together with all forum meeting papers can be downloaded from our website at <http://www.defra.gov.uk/qifnfc>.

1. Progress in the year since the last report

The first year of the forum's work was heavily project based, focusing on specific opportunities for commercial development of non-food uses of crops; the key outputs of this approach were recommendations for furthering the opportunities for these applications. In the process of examining these specific applications the importance of generic issues was crystallised and earmarked for further discussion.

In our second year we have taken a broader approach. Whilst progressing a number of specific case studies, in particular biofuels and biopackaging, we have also been advising Defra and DTI on their plans for a new national centre for non-food crops and demonstration activities. As planned we have also spent time on the generic issues. Year one case studies are discussed in part 5 of this report. Three new case study reports and recommendations are also in part 5.

1.1 National Non-Food Crops Centre (NNFCC)

1.1.1 A new National centre for non-food crops sponsored by Defra and the DTI will shortly be opening as part of the government's commitment to promote the sustainable exploitation of crops for non-food use. Defra in particular is committed to extending the competitive non-food uses of crops as part of its strategy for sustainable farming and food and the non-food crops centre is a key part of this.

1.1.2 The initiative has developed from recommendations of the OST's Foresight Panel 'Food Chain & Crops for Industry Task Force: Unlocking the Potential of Industrial Crops' in April 2001, that a 'respected, independent centre of know-how should be created with a remit to bring together all the existing and potential players to facilitate developments in the non-food area'. The forum voiced its support for this recommendation in its first annual report. We have therefore taken great pleasure in seeing plans for the centre develop and advising Defra on certain issues.

1.1.3 Establishment of the centre is timely; sustainable development is a key priority for the government and there is increasing awareness of the benefits non-food crops can deliver in this area. We think the non-food crops centre will be key in helping to deliver these potential benefits by encouraging new industry effort and increased take-up of the outputs of ongoing investment into research, development and demonstration activities. There are currently a number of activities in the UK promoting development of non-food uses of crops but there is not a coordinated effort. We are optimistic that the centre will build critical mass and follow through existing activities to generate real outcomes.

1.1.4 We envisage the centre will stimulate interaction between users and suppliers, both for demonstration of the use of existing crops and by-products in existing markets, and for development of new opportunities for novel crops in existing or new markets. We think the centre has a key role to play in developing industry 'pull' for renewable raw materials to complement technology 'push' from RD&D efforts.

- 1.1.5 Our roles will be complementary. The forum has an essentially inward facing role providing strategic advice to ministers on the development of non-food uses of crops that stand to add to UK economic activity. By contrast the new centre will be outward facing and proactive in helping to progress developments identified by the forum and others. It will actively engage with stakeholders at all stages in the supply chain. We will look to the centre to provide technical input and to undertake discrete studies to underpin our work.
- 1.1.6 The chairman of the new centre will be invited to attend forum meetings, and we anticipate the forum will advise the centre on its strategic direction. It is possible that in the future the centre may assume the role of the forum, and this may offer a natural progression once the centre is well established. The National Non-Food Crops Centre is expected to open in Autumn 2003 and will be based in York. For more details contact the forum secretary.

1.2 Market introduction activity

- 1.2.1 Interest and investment in plant based materials for industrial use has not translated into uptake in the UK market place to the extent that was foreseen perhaps ten years ago, and renewable raw materials are not making the contribution to economic and sustainable development that was predicted. In a number of case studies the forum has identified the need for a project to demonstrate the capability of a crop based raw material in a specific application, but to date there has been no formal mechanism to fund this kind of work.
- 1.2.2 Defra and DTI sought our view on proposals to fund a new scheme to encourage industry uptake of renewable raw materials in September 2002. We welcomed this proposal; it is our view that a well structured programme focused on increasing industry awareness of plant based materials that are available, and demonstration of their suitability for use is a key first step in engaging with industry.
- 1.2.3 Defra commissioned a scoping study to advise on the key requirements of a market introduction scheme². The forum has discussed the resulting report and recommendations. Our key recommendation is that the new programme should go beyond the role of a traditional 'demonstrator' and support all aspects of bringing a product to market. The requirement for a sound business case which clearly identifies the barriers to market introduction and demonstrates how these can be overcome will be crucial. We have recommended that the programme should provide support to applicants to ensure development of good consortia, a strong business case and ongoing project management. Dissemination of the outputs of the programme will be essential to its success in the long term.
- 1.2.4 The forum is pleased that Defra has decided to fund a number of pilot projects in advance of a scheme being formally available, and that our recommendations for demonstration projects in the biosolvents and biolubricants areas will be funded.

² Application of demonstrator projects to the market introduction of crop derived products. Dr Richard M Miller, Miller-Klein Associates Ltd. February 2003. Executive summary and recommendations available at www.defra.gov.uk/gifnfc

1.3. Government strategy for non-food crops

1.3.1 The Policy Commission report on the Future of Farming and Food³ recommended in January 2002 that “England needs a long-term strategy for creating and exploiting opportunities for non-food crops, including starch and oils. This area should be a high priority for the research and technology transfer effort (we have) outlined”. The government responded in its Strategy for Sustainable Farming and Food⁴ (December 2002) with an undertaking to develop a long term overarching strategy for creating and exploiting opportunities in non-food crops. This will be a complex and difficult task due to the cross cutting nature of this sector. We will contribute to development of the strategy, which is in very early stages at present.

1.3.2 Bioscience will form an integral part of the strategy and the forum has undertaken to commission a study to analyse the UK’s strengths in this area and examine the potential contribution bioscience can make to sustainable development in the long term. The study will review areas of key interest worldwide for the future, analyse UK strengths in the field and identify areas that will build on the UK’s world class science base to strengthen the UK competitive position. These strengths will then be considered in the context of meeting the needs of sustainable development. The findings of the study will feed into the strategy development process.

1.4 Other activity in UK

1.4.1 The forum was pleased to endorse the Home Grown Cereal Authority's new Enterprise Award scheme for non-food crops⁵, introduced in October 2002. This will raise the profile of non-food uses of crops and provide a much needed mechanism to help producers commercialise emerging crop based products. Forum member Richard Miller is an expert evaluator for the HGCA's scheme, assessing and recommending on proposals received. A number of interesting projects have recently been funded and we will follow their progress with interest.

1.5 The future for non-food uses of crops in the UK

1.5.1 The government has made a clear commitment to the commercialisation of plant based products in the last two years and this is very welcome; in the near future support will be provided collectively by a long term strategy for non-food crops, the National Non-Food Crops Centre and a scheme for market introduction of non-food crop products. These combined with the Sustainable Technologies Initiative, Defra’s investment in its R&D programme for renewables, HGCA Enterprise Award (Non-Food) and the strategic guidance provided by the forum, together with the drive for sustainable development, should combine to ensure that non-food crops make significant progress towards achieving commercial success. It will be essential to monitor shifts in industry usage of raw materials and concomitant environmental and social effects over the coming years to judge the success of these measures.

³ Farming and Food – a sustainable future. Report of the Policy Commission on the Future of Farming and Food. Published by the Cabinet Office. January 2002.

⁴ The Strategy for Sustainable Farming and Food. Published by Defra. December 2002 (PB 7751A).

⁵ See www.hgca.com

2. Contribution to the government's objectives, including those of sustainable development

- 2.1 Achieving sustainable development is at the heart of the government's policy making. Four key objectives contribute to sustainable development: social progress which recognises the needs of everyone; effective protection of the environment; prudent use of natural resources; and maintenance of high and stable levels of economic growth and employment. It is Defra's role to promote sustainable development across government and the country as a whole.
- 2.2 The non-food use of agricultural crops will make a substantial contribution in supporting the government's objectives for sustainable development. The most immediately tangible benefits of non-food use of crops are effective protection of the environment and prudence in the use of natural resources. Renewable raw materials can provide industry and consumers with alternatives to sending waste to landfill and enable them to reduce their use of volatile organic compounds, reduce the use of environmentally damaging and non-renewable mineral oils and lubricants and reduce CO₂ emissions; of these reduction of greenhouse gas emissions and household waste are key parts to Defra's strategy⁶.
- 2.3 The government launched its Powering Future Vehicles strategy⁷ in July 2002, designed to move the UK to a low-carbon road transport system, minimising the environmental impacts and maximising the benefit to UK industry. Following this in February 2003 the Energy White Paper⁸ further asserts the government's commitment to shift the UK to a low carbon economy and to make renewable energy a part of that. Transport fuels derived from agricultural crops can make a significant contribution to reduction in carbon dioxide emissions and other gases that contribute to global warming; indeed the forum has said that biofuels provide one of the main routes for the next decade or so to a significant reduction in the net carbon dioxide emissions from transport.
- 2.4 The use by industry of crop derived raw materials offers important economic opportunities for inward agri-industrial investment in UK and new market potential for UK farmers. In turn this can strengthen the rural infrastructure and bring much needed jobs to rural areas, contributing to more sustainable rural communities. Ensuring development of sustainable farming and rural communities is also a central theme of Defra's strategy⁹.
- 2.5 Ensuring that the world-class science base in the agri-business sector is translated into innovation, jobs and prosperity for the UK is a key priority for the DTI and something to which Defra is also committed. Non-food use of crops creates clear opportunities to build on the UK's science and skills base as developments in bioscience and genomics will enable plants to be used as factories to provide industry with renewable raw materials with superior productivity, performance and functionality, and to contribute to the resolution of environmental problems.

⁶ Our Strategy 2003-06. Published by Defra. June 2003 (PB 7981).

⁷ Powering Future Vehicles Strategy. Published by the Department for Transport. July 2002.

⁸ Energy White Paper. Our energy future – creating a low carbon economy. Published by the DTI. February 2003 (Cm 5761).

⁹ Our Strategy 2003-06. Published by Defra. June 2003 (PB 7981).

3. Generic issues

The forum adopted a case study approach to its work at the outset. This has been an instructive process; the case studies have examined a broad range of topics and each has presented a unique set of barriers to commercial development and in turn recommendations have been unique to each case study. The generic issues that impact across the sector can present an additional, longer term barrier to commercial development and have broad implications for the development of industries based on non-food uses of crops. They are also more difficult to address than the case-specific barriers. Increasingly these wide-ranging and complex issues have been an important consideration in the forum's work on which views are discussed below.

3.1 Are renewable raw materials always environmentally sustainable?

3.1.1 We recognise that life cycle assessment is the only definitive way to establish a product's sustainability, but it is beyond the forum's resources to go back to first principles to establish this for each of its case studies. We have made the assumption that in general developments may be regarded as making a positive contribution to environmental sustainability where they involve substitutions that reduce carbon emissions from fossil fuels, or a shift from the use of toxic to non-toxic or non-biodegradable to biodegradable resources. We have also assumed that the crops are being produced in a way that is consistent with sustainable development. We believe that in most cases our assumptions have been upheld. All case studies undertaken are subject to ongoing, robust assessment against our own set of sustainable development indicators.

3.1.2 The forum's sustainable development indicators are tools by which the contribution that individual case studies can make to sustainable development are qualitatively assessed. These focus on the comparative economic, environmental and social performance in the use and disposal of non-food uses of crops and where relevant, as a substitute for a depletable resource. Case studies judged to make a poor or marginal contribution after initial investigations are discontinued. An example of this is the substitution of synthetic dyes with natural dyes in the textiles industry where some serious concerns on economic and environmental grounds became evident. Individual assessments are available on the forum's website (www.defra.gov.uk/gifnfc). Positive assessment against sustainable development indicators is not considered proof of sustainability.

3.1.3 A number of non-food uses of crops such as biolubricants, biosolvents and biodiesel require production of oilseed rape if UK produced raw materials are to be utilised. Yet questions are frequently raised about the sustainability of growing large acreages of this crop in terms of biodiversity and other issues of public concern. The forum hopes to bring some clarity to this with its assessment of land use implications. This is discussed in more detail in section 4.

3.1.4 The forum's view is that as a generality plant derived raw materials are more sustainable than non-renewable, but that claims on the sustainability of

individual products or processes must be substantiated by analysis over the product's whole life cycle on a case-by-case basis. Life cycle assessments are complex, expensive undertakings; they require data that relates to the production of the substitute material and we believe they should be done after the performance of the new materials has been demonstrated to match that of the conventional material and to be otherwise acceptable to the market. But it is clearly important that assessment of the sustainability of any new product is made from an early stage and is reviewed as the material is developed, in a way that is proportional to the cost of development of the material. We have recommended that formal life cycle assessment should be undertaken for biopackaging materials and for biosolvents as these products are entering the market.

3.2 Bioscience

- 3.2.1 Gene discovery is the foundation for the value generated by the biosciences. The human genome and the genomes of model organisms in the plant and animal kingdoms have been sequenced; these data and the associated technologies comprising "genomics"¹⁰ open up new opportunities to benefit both developed and developing countries of the world.
- 3.2.2 It is appropriate therefore that the Forum explores the contribution of the biosciences to UK competitiveness and the role that novel applications made possible by this new science can play in sustainable development. This will form an important strand of our work over the coming months, particularly with respect to the non-food crops strategy.
- 3.2.3 The Forum recognises that bioscience and genetic modification (GM) technology are not the same thing. In fact GM technology is only one route to application of the gene discovery process, and there are many other possible areas of research and development in the biosciences.
- 3.2.4 Together with the disciplines of chemistry, physics and engineering, an understanding of biology provides the foundation for determining novel non-food uses of plants, their tissues and cells, and their molecular components. This is true whether one is considering oils, lubricants, plant fibres, metabolites providing industrial feedstocks, dyes, or products involved in anti-microbial, antiviral or pest defence, and so on. Bioscience research therefore underpins many of the proposed applications discussed in the forum's case studies.
- 3.2.5 Plant molecules are made and transformed by plant catalysts (enzymes), which in turn are encoded by genes. The revolution in gene discovery and the use of genomics to define gene function, open the path to identifying hugely important enzymes. The enzymes, their substrates and the products they make are all potentially important novel non-food products from crops. Through bioscience we now have an opportunity to discover new functionalities which in turn open up new technologies, products and industries.

¹⁰ Genomics, the branch of genetics that studies organisms in terms of their full DNA sequences, or genomes.

- 3.2.6 It is essential that the government is conversant with the current potential offered by bioscience, and recognises that the timeframe for effective action to ensure UK competitiveness in this field is limited. Data are freely available from gene sequencing databanks and are being mined worldwide continuously to make commercial gain from the enabling technologies and their future products. It is our view that the UK should not miss this opportunity because of a lack of understanding of the potential of the biosciences.
- 3.2.7 The forum also considers it is important to explore the risks and benefits of novel non-food crops that are constructed using GM technologies. GM shares many commonalities with genetic variation brought about by traditional plant breeding¹¹ but one aspect that is unique to the new technology is the possibility of transferring genes more widely between organisms and species.
- 3.2.8 Examples of beneficial applications that could only be made possible by GM include the use of crop plants to manufacture vaccines for human and animal health, high value pharmaceuticals whose use is restricted by availability (e.g. interferon). Many of these applications do not require the extensive production of field-grown crops and could therefore be contained to minimise any possible risk to the environment. There appears to be no reason why use of glasshouse-grown high value GM non-food crops should not be maintained on the agenda of UK government. However, the Forum believes that field-grown applications, for example the production in plants of plastics that therefore do not depend on petrochemical availability for their synthesis, should also be explored to assess fully the use of GM in each different application, its potential benefits and the potential risks to the environment.
- 3.2.9 There will come a time when the decline in availability of fossil resources is such that alternative resources must be found. In the medium to long term it is likely that plant-based renewables will increasingly need to supplement fossil resources and, ultimately, replace them. In this context, there is every reason to expect that bioscience research will contribute to the sustainable development agenda through aiding: (1) alternative energy strategies, such as increased yields of biomass; (2) the chemical sector through provision of new large-scale feedstocks; (3) reduction in agricultural inputs through increased efficiency of the crops, raised natural protection against pests and pathogens, and increased ability to withstand temperature stress and water shortage; (4) economic development of the countryside through providing arable farmers with crops with new, high value functionalities for cultivation in the UK. A major consideration in the contribution of bioscience to the UK's strategy for non-food crops must therefore be its impact on sustainable development and we will be giving due consideration to this.

¹¹ GM Science Review: First Report. An open review of the science relevant to GM crops and food based on the interests and concerns of the public. Prepared by the GM Science Review Panel (July 2003). Published by Defra.

3.3 Impact of legislation

EU legislation is often introduced to address problems associated with materials already on the market. In our first report we identified a number of cases where this has placed seemingly unfair restrictions on plant-derived products, presenting significant barriers to their potential for commercial development. We mentioned the EINECS and ELINCS regulations for chemical substances, also the Plant Protection Directive. Two areas that have concerned us particularly over the last year are the EU's focus on recycling, and the recently introduced Biocidal Products Directive.

3.3.1 Recycling

a) The forum has concerns over the current EU drive towards recycling which is often at odds with use of renewable materials. Renewable raw materials are not always suitable for recycling; composting or recovery of energy through combustion at the end of their useful life may be more sustainable options. In both the biopackaging and natural fibre case studies the current drive to meet recycling targets conflicts with increased use of renewable materials, as the use of renewable materials does not contribute to recycling targets, and this carries a financial cost. In these cases assessment of sustainability of the use of renewables is difficult to resolve when placed in the context of the legislative pressure to recycle.

b) If the use of renewable raw materials is not to be disadvantaged, government departments with responsibility for emerging legislation on management of wastes should ensure that the current drive to recycle does not disadvantage renewable raw materials which have the same or reduced environmental impact over their life cycle.

3.3.2 Biocidal products

a) A further piece of EU legislation with potential to limit development of plant derived products is the Biocidal Products Directive¹² (98/8/EC), discussed in section 5.2.2 of this report. The Directive and UK Regulations require the authorisation of a wide range of biocidal products that currently do not require authorisation. This requires submission of an extensive product dossier together with a system of data protection, estimated to cost £2-£3 million per case and which can take up to four years to prepare.

b) The worldwide market for biocides is estimated at £2.7 billion per annum and is growing at four per cent per annum. However in Europe the biocides industry is undergoing a dramatic transformation as a result of the BPD, because regulations are tougher than any other in the world. It is estimated that it will cost the biocides industry £340 million to meet the new requirements. The costs are too high to maintain the existing wide range of products and it is predicted that many small and medium sized businesses will not survive.

c) The Directive has potentially serious implications for the introduction of new plant derived anti-microbials. Even if a new plant extract or molecule can be demonstrated to have exceptional efficacy, it is unlikely to be supported for approval under the BPD unless the molecule or product can be protected under patent. This is rarely the

¹² The formal definition of a biocidal product is: "active substances and preparations containing one or more active substances, put up in the form in which they are supplied to the user, intended to destroy, deter, render harmless, prevent the action of, or otherwise exert a controlling effect on any harmful organism by chemical or biological means."

case as there is often prior publication on the plant species, its composition and biocidal activity. This leaves only the specific application that can be protected and this may not generate sufficient revenue to support an application under the Directive.

d) We do not believe that it can be assumed as a general principle that because a product is derived from a plant it is *a priori* safer than a synthetically derived product. However in the case of anti-microbials, unlike synthetics, naturals generally have very low concentration in use and have a well understood degradation pathway. The Biocidal Products Directive has a legal framework for data waivers, which may provide an opportunity to relax the requirements for the plant derived products. These must be presented to the competent authority in the applicant country in the first instance and are considered on a case-by-case basis. The forum is currently engaging with the Health and Safety Executive to gain their view on the potential for data waivers to ease the burden for plant-derived anti-microbials under the Directive.

3.4 Impact of the Common Agricultural Policy

3.4.1 The CAP operates a system of market support for some agricultural crops. The current round of reform has created a more market oriented basis for European agriculture, which we welcome, but there is still an element of market intervention. The UK government is strongly supportive of market led production in Europe and future talks on CAP reform will probably take us closer towards that position. In the meantime, for industry, which prefers to buy materials which are not subject to price fluctuations caused by government intervention, the lack of a single support structure for a reasonable period of time undermines confidence. However we are of the view that as the European Union moves away from an interventionist approach to agricultural production and pressure to address environmental issues increases, the negative effects of the CAP will be reduced over time.

3.5 Government procurement

3.5.1 The potential for government procurement to better support sustainable development is vast. In 1999 UK central government procurement was estimated at almost £13bn per annum, around 1.3% of UK GDP. The government has said it recognises that a clear strategy on sustainable procurement would be a tangible expression of the level of government commitment to sustainable development. Inertia in purchasing practice and activities that restrict market innovation are perceived to be two of the main barriers to sustainable procurement.

3.5.2 The government has established an inter-departmental Sustainable Procurement Group (SPG) to look at the scope to improve the way in which sustainable development considerations are incorporated into purchasing. The group is considering how government bodies can carry out the procurement of goods and services in a manner that supports the government's policy and objectives for sustainable development. Outcomes from the group's recommendations will inform the Framework for Sustainable Development on the Government Estate. The forum has established contact with the SPG and is working with them to encourage the positioning of

renewable raw materials as a key feature of the government procurement strategy where possible and practical.

3.6 Awareness raising

3.6.1 Even when the principle and benefits of use of a renewable raw material are proven, and the infrastructure is in place to support its wider use by industry, a lack of awareness within industry means that uptake more often than not does not meet the predicted potential. This is not always because economic constraints prevent change; industry often does not know what is available and what could potentially be provided to meet their needs.

3.6.2 To ensure that the investment currently being channelled into developing commercial non-food uses of crops translates into use by industry, we believe it is essential that the availability of new products or types of product is accompanied by focused awareness raising, outreach and education activities. These should be directed particularly at the end user industries but also at all other elements in the supply chain that may have a part in delivering the product/s. This is where we think the National Non-Food Crops Centre will play a vital new role. It will also be an essential feature of the new demonstration activities. Sound precedents are already set in this area by the DTI's Bio-Wise programme, and the Envirowise programme run jointly by Defra and DTI.

4. Land use and resource implications

- 4.1 The forum has devoted a lot of time to consideration of specific commercial opportunities for non-food uses of UK grown crops and recommendations have been made to support further development of these opportunities. We acknowledge that thus far we have not made a detailed assessment of the implications for land use if these uses were to be taken up by industry to meet the estimated UK markets.
- 4.2 In its response to our first report and recommendations the government has signalled its commitment to supporting wider use by industry of renewable raw materials. Reform of the Common Agricultural Policy has recently been agreed for the next few years. Defra and DTI's market introduction programme for non-food crops is under development, and with the government developing its first long term strategy for non-food crops, we feel the UK is at an important juncture and the time is right for potential changes in land use to be audited and the implications assessed.
- 4.3 Preliminary assessment of first year case studies has been undertaken and is discussed below and summarised in table 1 and we will consider the implications of these. However we recommend that in depth assessment of changes in land use and the associated impacts should become a substantial element of the long-term strategy for non-food crops that is being developed.
- 4.4 Any assessment should distinguish between the substitution of a food use by a non-food use of the same crop, shifts between different arable crops, and more substantial changes of land use, for example to the production of perennial crops for energy production or small-scale contained production of plants. Advice should be taken on the likely impact of the wider context, including CAP reform, extension of the EU and land use and planning policy. The assessment will be complicated by the fact that renewable raw materials are a traded commodity and will not necessarily be grown in the country in which they are used.
- 4.5 In our consideration of non-food uses of crops to date we have assumed that agricultural crops are produced in a manner that is consistent with sustainable development - it has been beyond our resources to do otherwise. Where estimated land use is assessed to be potentially significantly greater than the current arable area, or where there is a significant shift in patterns of use, we recommend that sustainability of the agricultural practices employed in the production of the crops should be assessed as part of the non-food crops strategy. Issues such as growing large acreages of oilseed rape for industrial products are regularly criticised for being unsustainable in the long term, but this has not been formally assessed - the strategy should also aim to bring clarity to these discussions.

Table 1: Summary of potential land use in 2005 for applications of non-food crops¹

<i>Application</i>	<i>Source crop</i>	<i>Level of substitution for a non-crop based product</i>	<i>Market for plant-based products in 2005 (tonnes)</i>	<i>Area of crop required in 2005 (hectares)</i>	<i>Proportion of current area of source crop (%)</i>
Starch-based biodegradable packaging materials	Wheat	0.1% ²	1,600	195	0.009
		2%	32,000	3,900	0.195
Natural fibres in composite materials (automotive industry) ³	Hemp	100%	22,400	18,000	600
Plant oil derived solvents in the printing industry	Oilseed rape	2%	720	497	0.115
Plant oil based lubricants for chainsaws, outboard motors and hydraulic fluids	Oilseed rape	2%	1,500	1,127	0.260
		5%	5,500	4,132	0.956
Biofuels	Oilseed rape	2% (diesel only)	295,000	203,448 ⁴	47
		2% (all fuels)	706,000	486,897 ⁴	113

¹Figures provided by Central Science Laboratory.

²Bastioli C., (2000). Global status of the production of biobased packaging materials. Proceedings of the Food Biopack Conference, Copenhagen, 27-28 August 2000.

³Estimate to 2010.

⁴Allows for 100,000 tonnes from waste vegetable oils & animal fats.

Biopackaging

a) The UK plastic packaging market is currently estimated at 1,520,000 tonnes per annum, of which only 0.1% (1,520 tonnes) is estimated to be biodegradable and starch based. The market is predicted to grow to 1,600,000 tonnes by 2005. At the present market penetration of 0.1% this represents a potential market of 1,600 tonnes of starch-based packaging materials by 2005. A (optimistic) 2% market penetration for biopackaging by 2005 would create a market of 32,000 tonnes.

b) Wheat contains between 62-70% starch. Assuming an 80:20 starch:other polymer blend and assuming wheat starch market penetration of 85-90% for the biopackaging sector¹³, 1,000 tonnes of wheat starch per annum would be required to meet the UK market needs in 2005 at the present market penetration rate of 0.1%. With average wheat yields at 8 tonnes per hectare, this equates to 195 hectares of wheat, less than 0.01% of the 2 million hectares of wheat currently grown in the UK. Making the same assumptions, 2% penetration of the plastic packaging market would require 21,000 tonnes of wheat starch per annum to meet UK demand by 2005, this would occupy 3,900 hectares of wheat which is less than 0.2% of the wheat currently grown in UK.

Biocomposites (for the automotive industry)

d) It has been estimated that by 2010 the European automotive industry could require more than 100,000 tonnes of natural fibres per year for compression moulded composites; if injection moulded composites are included, the market for natural fibres in the EU automotive industry could be as large as 160,000 tonnes per annum. The UK industry's requirement for these fibres is currently 4,000 tonnes for compression moulding only. This could rise to 22,400 tonnes in 2010, split between 14,000 tonnes for compression moulded composites and 8,400 tonnes for injection moulding.

e) Flax and hemp supply the bast fibres needed for these applications. Economics of production in the UK indicate that hemp is most likely to be the crop of choice. If the total market requirement for UK produced fibre reaches 22,400 tonnes per annum by 2010, assuming a 5t/ha yield of hemp with 25% bast fibre content, 18,000 hectares would be required. This would represent an increase in the cropped area of hemp from 3,000 to 18,000 hectares by 2010.

Biosolvents

f) The UK printing industry is estimated to use 40,000 tonnes of organic solvents per year for cleaning machinery. Markets are currently declining at the rate of 1-2% per year due to pressure to reduce the use of volatile organic compounds. Industry estimates predict that 36,000 tonnes of solvents will be required to clean machinery in 2005.

g) In 2005 if a 2% substitution rate is achieved, the market will require approximately 720 tonnes of plant based solvent. Rape methyl ester (RME) derived from oilseed rape could be used in this application. The technology to produce RME is proven and current best practice yields 0.415 tonnes (472 litres) of RME per tonne of oilseed

¹³ This is to take into account the fact that other natural polymers (mainly PLA) are currently used to produce bioplastic and that blending with non-natural polymers could occur.

rape. Based on an average seed yield of 3.5 t/ha, RME production potential is up to 1.45 tonnes per hectare of oilseed rape in the UK. On this basis, 497 hectares of oilseed rape would be required. This represents less than 0.12% of UK's current oilseed rape production.

Essential oils

h) In 2003 a maximum of 450 hectares was used for the production of peppermint, spearmint, lavender and lavandin oils in the UK. Production of speciality crops is an expanding area in the UK. However markets for these products are sensitive to overproduction and this will limit the impact on land use relative to the total UK arable area. For this reason, essential oils have not been included in table 1.

Biolubricants (including hydraulic fluids)

i) UK consumption of chainsaw oils is estimated at 500-600 tonnes per annum, at present 75% of the oil used for these applications are biodegradable. Detailed figures for oil usage in the outboard motors sector are not available, but the overall 2-stroke oil usage in UK amounts to only 2,000 tonnes per annum or 0.25% of total UK oil consumption, outboard motors are likely to represent a small percentage of this total. No data on use of biolubricants in the 2-stroke sector were available. In UK the total hydraulic fluids market amounts to 120,000 tonnes per annum, biolubricants currently account for less than 1% of this market, or less than 1,000 tonnes per annum. The greatest potential for expansion of biolubricants markets is thought to lie with hydraulic fluids.

j) Table 2 below gives predicted markets for plant based lubricants in the UK to 2005. Some industry estimates predict that introduction of eco-labelling and incentives for use of biolubricants could increase uptake by 5%.

Table 2: Potential UK biolubricants markets to 2005

<i>Market Sector</i>	<i>UK 2003 (tonnes)</i>	<i>Biolubricants 2003 (tonnes)</i>	<i>Biolubricants 2005¹ (tonnes)</i>	<i>Biolubricants 2005² (tonnes)</i>
Hydraulic Oils	120,000	1,000	1,000	5,000
Chainsaw Oils	600	450	500	500
Outboard Motors ³	n.a.	n.a.	n.a.	n.a.
Total⁴	120,600	1,450	1,500	5,500

¹Projection of biolubricants market in absence of specific initiatives.

²Projection of biolubricants market with further supporting initiatives.

³Outboard motor oil consumption represents a very small fraction of total oil consumption in UK.

⁴This does not include outboard motors oils.

k) Oilseed rape would be the main feedstock for producing biolubricants in UK. The crop oil content is approximately 35% and current estimates suggest that 2.63 tonnes of seed are required to produce 1 tonne of oil. On this basis, assuming an average yield of 3.5 tonnes per hectare, for the two scenarios presented in table 2 between 1,127 and 4,132 hectares of oilseed rape would be required to meet UK market needs by 2005. At the most this represents 0.96% of the 2002 UK oilseed rape area.

Biofuels

l) The EU Biofuels Directive has set indicative targets for renewable transport fuels. Targets are set at 2% replacement of mineral fuels by 2005 (in blends or as a total replacement fuel) rising by 0.75% per annum to a target of 5.75% replacement by 2010. Table 3 presents what this means for the UK if the targets are to be met.

Table 3: Scale of production of biofuels needed in UK to meet EU indicative targets

	<i>Total predicted fuel use (million tonnes)</i>	<i>Indicative target for substitution (million tonnes)</i>
2005 (2% substitution)		
All fuels	40.3	0.806
Diesel only	19.8	0.395
2010 (5.75% substitution)		
All fuels	44.5	2.56
Petrol Only	19.6	1.13
Diesel Only	24.9	1.43

m) In the short term it is likely that only biodiesel production will be sufficiently well developed commercially in the UK to contribute significantly to meeting the targets for 2005. Estimates by the waste oil industry indicate that around 0.1 million tonnes of fatty acid methyl ester (biodiesel) could be produced from waste vegetable oil and animal fat sources. This figure takes into consideration the ban from October 2004 on the feeding of catering waste, including cooking oil, to farm animals (Animal By-Products Regulation). The remaining requirement would have to be met from biodiesel derived from rape seed oil (rape methyl ester, RME).

n) Current best practice yields 0.415 tonnes (472 litres) of RME per tonne of oilseed rape, based on an average yield of 3.5 t/ha, RME production potential is up to 1.45 tonnes per hectare of oilseed rape in the UK. On these assumptions, 0.2 million hectares of oilseed rape would be required to meet targets for substitution of road diesel alone, or just under 0.5 million hectares to substitute for 2% of all transport fuel requirement in 2005. This represents 47% and 113% of the current oilseed rape crop area respectively.

o) Meeting the target for 5.75% substitution in 2010 will require a much broader range of biofuel feedstocks, including production of bioethanol. While bioethanol can be derived from traditional fermentation routes utilising crops such as wheat and sugar beet, to meet these indicative targets would also require derivation of bioethanol from lignocellulosic materials. However efficient conversion of biomass to bioethanol via the lignocellulosic route is still some way (3 – 5 years) from large-scale commercial availability and further research and investment is needed.

5. Forum case studies

The forum addresses its terms of reference through 'case studies'. Current technological developments and market opportunities for a range of applications are assessed as an ongoing exercise, those that offer the most immediate and sustainable potential to create economic value in the UK are adopted as case studies. Forum members facilitate identification of the basic issues; key industrial and other expert stakeholders are then engaged in discussion of technical, economic, policy and other barriers which stand in the way of commercial development. A qualitative assessment of the impact on sustainable development is made once initial investigations are complete. Strategic recommendations designed to underpin progress in the area are made to government and industry for case study areas which have potential to contribute to UK economic activity and which are judged to contribute positively to sustainable development.

5.1 Year 1 case studies review

The government response to the forum's first annual report and recommendations was sent to us on 18 June 2003. The document is available on the forum website. The response is positive and affirms the government's wish for the UK to be at the forefront of the development of non-food crops. The government acknowledges the important contribution the forum is making in helping to increase the use of non-food crops by industry and maximise the contribution to UK economic activity.

The additional funding allocated for non-food crops and the initiatives being undertaken are warmly welcomed. Comments specific to case studies are discussed below.

5.1.1 Biopackaging

a) The forum welcomes the government's positive response to its work in this area and recognition of the potential contribution that biopackaging can make to sustainable development. We support the government's approach to CAP reform in supporting market led development of opportunities for non-food uses of crops.

b) The forum's report and recommendations recognise that biodegradable (compostable) packaging can make a significant impact in replacing a non-renewable rapidly depleting resource with a renewable raw material. A major driver to the widespread use of bioplastics will be provision of the necessary waste disposal mechanisms to ensure that the compostable plastics are actually composted. Compliance with EU regulation requires a major reduction in the amount of waste consigned to landfill sites and the use of compostable plastics can contribute to this. We have noted the government's response in February 2003 to the Strategy Unit's Waste Not Want Not report (November 2002) and welcome the establishment of the new Waste Implementation Programme (WIP) team at Defra to take forward some the Strategy Unit's recommendations, including those to encourage composting. We will be seeking discussions with the WIP team focusing on whether National standards or guidance on best practice are going to be developed for disposal of biodegradable waste, and how consumer awareness is going to be raised.

c) All local authorities are expected to have composting facilities in place by 2005/6; the forum would be very supportive of consumer education activities such as the German Kassel project¹⁴ to be included in Defra and DTI's demonstration programme to support non-food uses of crops. The forum is funding research aimed at developing an understanding of what might drive consumers to opt for products utilising biodegradable packaging materials. This work is being undertaken in close association with supermarkets and we expect it to provide useful insight to this area that will be valuable to both the retailers and the forum. The study will also enable the forum to understand the issues that prevent industry from using biopackaging materials and how to address these.

d) The Environment Agency's intention to fund comparative life cycle assessment studies of starch based versus conventional plastics is very timely. We are also aware of the life cycle assessment study being undertaken for (potato) starch based packaging under the DTI's Sustainable Technologies Initiative. It is important that a consistent approach to life cycle assessment for renewable raw materials is undertaken to enable some degree of comparison to be made across applications. The forum believes there may be a role for the new non-food crops centre to bring consistency to the approach taken to these studies.

e) The forum is also very encouraged to note that an HGCA Enterprise Award has just been given to develop the Green Light[®] wheat starch based alternative to polystyrene packaging. In addition the STI LINK programme has funded a number of projects aimed at developing sustainable packaging materials.

f) The forum accepts that practical difficulties will be encountered in use of colour separation for biodegradable plastics and we agree that use of a logo and proactive encouragement of consumer separation should be the first step forward. Separation technology is becoming increasingly sophisticated and able to distinguish and separate different products in an automated waste stream. There may be scope in the future for a more subtle approach which takes advantage of these developments.

g) Alongside Defra's key role in putting provisions in place to manage compostable waste, there is also a clear need to ensure the supply chain develops to support production of the compostable plastics on a larger scale; the forum sees this as a key undertaking for the government's new National Non-Food Crops Centre.

h) Based on a qualitative assessment, the use of wheat starch for biopackaging materials has a positive contribution to make to sustainable development, particularly when economies of scale improve the economics for use of starch. While it will not provide any opportunity for agricultural diversification, the scale of the opportunity has potential to provide a significant new market for farmers. There are also the obvious environmental benefits of reducing waste entering landfill - provided the waste management infrastructure is in place.

¹⁴ Pilot project for marketing and recycling of compostable packaging made from biodegradable polymers, in Kassel, Germany. Funded jointly by industry and the German Federal Ministry of Consumer Protection Food and Agriculture. http://www.modellprojekt-kassel.de/eng/downloads/kassel-project_brochure.pdf

i) The forum will continue to take an active interest in this area but it will not be making any further recommendations. We would like to see Defra take this work forward as part of its strategic commitment to waste management.

5.1.2 Natural fibres in composite materials (automotive industry)

a) This area of the forum's investigations raises important issues about the potential for incoming legislation to discourage development of a commercial opportunity for the UK in an area where UK R&D and innovation is strong, and where use by industry of these materials could have significant economic benefits. The sustainable development impacts of this opportunity are judged to be positive for the UK with clear contributions to economic, environmental and social issues. Weakness lies in the need for varieties better suited to production in UK and the need to reduce risks at the retting stage. The environmental benefits of natural fibre composites would also be enhanced considerably if biodegradable resins were to be used. The government's response to the forum's recommendations is encouraging, we are very pleased that Defra will fund the reviews of flax and hemp varieties and retting that were recommended in our recommendation 6. Changes introduced in 2002 to the EU restriction on harvest date for hemp have improved the prospects for successful retting of the UK crop and together with the output from the two reviews this will underpin more competitive production of flax and particularly hemp crops in UK.

b) The End-of-Life Vehicles Directive is the linchpin to continued development of fibre crops for composite materials for the (valuable) automotive industry market in UK, and in Europe. The forum is concerned with the emphasis on recycling. It is generally uneconomic to recycle renewable materials and the industry view is that unless targets for recycling versus energy recovery with burning are addressed, the use of renewable raw materials in the automotive industry could be adversely affected. The forum will continue to work with DTI to encourage a more flexible approach to the ELV Directive's targets for recycling versus energy recovery.

c) The forum has not assessed fully the wider markets for composite materials; this will be addressed to some extent in the case study evaluating the use of agricultural materials in the construction industry (see section 5.3.5 of this report). We will continue to monitor the development of composites for other applications such as in trains and aeroplanes. In particular we will look in more detail at biodegradable resins for composites, in suitable applications.

5.1.3 Wheat secondary uses

a) The government's positive approach in this area is welcomed. Encouraged by the response, the forum has decided to take a more holistic approach to the contribution that renewable raw materials, beyond just wheat straw, can make to a sustainable construction industry. This is discussed in more detail in section 5.3.5 of this report.

b) Our view is that the use of straw bales in construction can make a positive contribution to sustainable development, with some important contributions across the economic, environmental and social areas. This will be explored further in the sustainable construction case study described above. The case study on secondary uses for wheat is considered closed; use of wheat starch and straw continue to be considered under other case studies.

5.1.4 **Biosolvents in the printing industry**

a) The forum agrees with the government that life cycle analysis is an essential task before use of plant based cleaning fluids is widely promoted and is pleased to see that this will be undertaken together with the demonstration activities outlined in our recommendation 11. Qualitative assessment against our sustainable development indicators judges this to yield clear economic and environmental benefits and we hope the LCA studies will confirm this. We will work with Defra to develop the project, we are keen to involve the HSE and the British Printing Industries Federation in this work, and to build on what has already been achieved through the Envirowise programme.

b) We do not envisage any further new work being undertaken in this case study although we recognise the need to consider the potential for use of biosolvents in other applications.

5.1.5 **Speciality chemicals: essential oils**

a) The government responded positively to the forum's recommendation (number 14) for formation of an industry led initiative integrating producer and processor organisations, but commented that there may be limited industry support for the establishment of a British Essential Oils Producers Organisation. The forum has subsequently confirmed that this is the case and we will not be pursuing this further.

b) The government indicated support for variety trials, where this will contribute to sustainable development. This is welcomed where basic research into yield, disease resistance and other aspects of crop performance can be funded. We hope that the National Non-Food Crops Centre will play a key role in advising on government research in this area, in discussion with the essential oils industry.

c) Contrary to the assessment that lavender production would struggle to be competitive in the UK, a project to support lavender oil production funded by Defra's Rural Enterprise Scheme has been extremely successful. The success of this particular venture has in part been based on developing the recreational opportunity offered by production of the lavender crop and sale of the products at point of production. The producer is very positive about the support that has been received from RES in setting up the venture, which has extended beyond financial input. This is an excellent example of diversification into non-food crops that has benefited from support by the government. The Rural Enterprise Scheme has in fact supported a total of six projects to support production of speciality crops.

d) We consider these high value speciality crops make a positive contribution to sustainable development in the UK, particularly at the local level - there are few negative aspects to their production. However we fully endorse the government's view *vis à vis* unsustainable expansion of production for niche markets and we recognise that their production, and that of other speciality crops, must be essentially market led. We now consider this essential oils case study closed, although we retain an interest. Speciality crops are discussed further in the anti-microbial products case study in section 5.2.2 of this report.

5.1.6 **Biolubricants for chainsaw and outboard motor applications**

a) Plant based oils are technically suitable for use in chainsaw and outboard motor applications; the environmental benefits of biodegradability plus low ecotoxicity are the key drivers and selling points. Markets for this particular use of biolubricants are relatively small and the sustainable development benefits have not been fully assessed. Although we have found no evidence that LCA has been undertaken, qualitative assessment clearly points to positive impacts on sustainable development.

b) We are pleased to report that Defra is developing a project in consultation with the Environment Agency, Forestry Commission and British Waterways to build on initiatives that are already in place to support increased use of the plant based oils. The use of plant based oils in hydraulic fluids is discussed separately in section 5.2.1 of this report; the conclusions there are similar to those already drawn, that demonstration of suitability for use and requirements on procurement are the key levers government should be using to achieve increased use by industry.

c) The forum believes that government and EU procurement can have a key role in supporting increased use of plant based lubricants in environmentally sensitive applications. Their use in chainsaws and outboard motors represents a small market which is unlikely to impact significantly on agricultural production, nevertheless it is a good flagship for the more significant markets in hydraulic fluids and wider industrial use of lubricants. A number of the major landowners in UK were consulted for their view on this, a limited response has been received to date but we will pursue this. We are addressing the role for government procurement as a generic issue and discussions with the government's Sustainable Procurement Group are ongoing. This is discussed further in section 3.5 of this report.

5.2 Year 2 case study reports and recommendations

5.2.1 **Plant oil based lubricants for total loss and potential loss applications: hydraulic fluids**

Rationale

1. The forum's work to date investigating the use of plant-based oils in chainsaw, outboard motor and offshore drilling applications is discussed in 5.1.6 of this report. Subsequent work has focussed on the more significant market opportunity for use of plant based oils in hydraulic systems. This report presents the forum's thoughts and recommendations for this area.
2. We have already established that plant based oils are inherently highly effective lubricants but their thermal and hydrolytic stabilities limit the use of unmodified oils in hydraulic fluids. In this study the forum has focused on establishing whether the superior biodegradability and low ecotoxicity of plant based hydraulic fluids is a sufficient driver to support their development, notwithstanding technical limitations to their use, and their increased cost.

3. Work was commissioned¹⁵ to answer the many technical questions and issues surrounding biodegradability and ecotoxicity. The report and all other papers relating to this case study are available on the forum website.

Background

4. At present 50% of all lubricants sold worldwide end up in the environment via total loss applications, evaporation, spills or major accidents. More than 95% of these materials are at present mineral oil based with low biodegradability and high ecotoxicity and they pose a considerable potential threat to the environment.
5. In Europe out of a total lubricants market of approximately 5 million tonnes, hydraulic fluids make up 750,000 tonnes, this is valued at approximately £700 million. The UK market for hydraulic fluids is 120,000 tonnes per annum, valued at £107-£120 million (ca. 0.01% of UK GDP) - currently less than 1% of these are plant based.
6. Hydraulic fluids are essential to the operation of machinery in a broad range of applications such as earth moving machinery, water and underground pumps, lock operation machinery, wind turbines and agricultural machinery. They are needed for lubrication, protection against corrosion, attrition and heat removal. They are required to perform under conditions of high heat and pressure and when a hydraulic hose breaks, fluid is lost directly to the environment (typically 100 litres from a tractor, 150 litres from an excavator). Such large-scale loss of fluid to the environment creates localised environmental pollution, often in sensitive areas such as waterways, forests and other rural environments. In addition to the ecological impact, the financial costs of cleaning up a major spillage are significant.
7. For use in total loss applications lubricants and hydraulic fluids should be 'environmentally friendly', meaning highly biodegradable and with low ecotoxicity. Biodegradability is independent of the source of material, but as a generality, the higher the content of natural products the higher the biodegradability. While mineral oil based fluids meet most of the technical requirements required for a good hydraulic fluid they are generally low in biodegradability and high in ecotoxicity. Their relatively low flash points also make them more easily flammable.
8. The plant based oils are inherently good lubricants but their poor thermal and hydrolytic stabilities limit their use in hydraulic fluids and at present unmodified vegetable oils can only be used in total loss applications with very low thermal stress or in time limited high temperature/pressure applications. Chemical modification and use of additives can correct many of the inherent properties of plant based oils and make their performance comparable to mineral oils.
9. Lubricants are formulated from a broad range of feedstocks, from unmodified plant oils through to mineral oil, with a variety of compositions in between.

¹⁵ M. Schneider and P. Smith. Plant oils as base fluids – lubricants and hydraulic fluids. Green Chemistry Network. University of York.

There are also synthetic lubricant formulations in which the base fluid is made by chemical conversion of low molecular-weight components into compounds of controlled molecular structure with predictable properties. These may be bio-based and/or biodegradable and because their properties can be tailored to the intended application, synthetic lubricants typically have superior application performance when compared with mineral oil.

10. Assessment of the relative merits of the different types of lubricants requires proper definition of their composition. Lubricant nomenclature is currently inconsistent and confusing, phrases such as synthetic bio-based, synthetic ester biodegradable, bio-based synthetic esters, biogenic lubricants, bio-lubricants, biodegradable lubricants of mineral oil origin are frequently encountered. An agreed European-wide system of nomenclature would bring clarity. The forum has used the classification below:
 - bio-based natural esters: esters from unmodified plant oils;
 - bio-based synthetic esters: for the most part, comprise one component (acid or alcohol) of plant or animal origin and the other of mineral origin; typical examples are TMP oleates which are the most widely used bio-based synthetic esters as hydraulic fluids. A smaller category of bio-based synthetic esters is where both components are directly or indirectly derived from plant sources such as isostearic acid or azelaic acid;
 - mineral oil-based synthetic esters: both acid and alcohol components are of mineral oil (petrochemical) origin;
 - mineral oils: widely varying fractions of mineral oils (petrochemicals);
 - polyalpha olefins (PAOs): fully synthetic oils based on petrochemicals;
 - polyethylene glycols (PEGs): mineral oil based.
11. All lubricants are composed of base fluids and additives and with very few exceptions lubricants are supplemented with additives to improve stability and performance. Hydraulic fluids usually contain one to two per cent additives. The base fluid largely determines quality and a poor base fluid can never be transformed into a good lubricant by inclusion of an additive. The plant based oils require additives to protect against oxidative attack (although the need for this is reduced if the native oil is chemically modified) and to protect against hydrolysis.
12. None of the additives that are used in hydraulic fluids are based on plant oils and all display some degree of toxicity. A number of antioxidants are available which display relatively low or tolerable toxicities (some are used as food additives). Additive producers are also trying to develop increasingly environmentally friendly additive packages, in particular for biolubricants. Nevertheless there is a need for research and development into non-toxic novel antioxidants.
13. The volume of additives is so small that biodegradability is largely unaffected, but additives can reduce biodegradability indirectly by poisoning microorganisms. This should be put in the context that mineral oils are inherently ecotoxic and polluting, and they too require additives to improve

different properties. On the basis of biodegradability and ecotoxicity, the mineral oil based fluids will never match the plant based oils.

14. The switch from mineral oil based to plant based products is not without cost. The plant based hydraulic fluids are presently on average two to three times more expensive than those based on mineral oils; the need for machinery adaptation is an additional cost. Even those users concerned with adverse environmental impact are unlikely to be persuaded if claims of biodegradability are not substantiated. Lubricants are currently classified within EU according to ISO 15380¹⁶ which relies on application characteristics and a minimum biodegradability of sixty per cent to be deemed biodegradable. This is frequently met by petrochemical-based fluids and takes no account of the adverse environmental effects of degradation products or of the source of the hydraulic fluid itself. This obviously prejudices the potential market share of bio-based products, emphasising the need for a labelling system which clearly states the derivation of lubricant products with a statement on their biodegradability and ecotoxicity.

Recommendations

15. The forum considers the environmental and economic value of this application to be sufficient to justify the investment that is required to develop plant based oils for use in hydraulic fluids in total loss and potential loss applications. When judged against the forum's indicators for sustainable development, this use is considered to be sustainable in the long term whereas use of mineral oils is not. The application has potential to directly substitute for use of a mineral resource. The base oil would be provided by oilseed rape and the land requirement to fully meet the UK share of the market is thought to be in the region of 90,000ha (ca. 20% of current production).
16. Use of plant based hydraulic oils currently requires (costly) machinery modifications. The German 'Biolubricants Market Introduction Programme', sponsored by the German government, provides financial support for the conversion of machinery used in environmentally sensitive areas from mineral to plant based lubricant products. In UK the changeover is unlikely to take place without encouragement (fiscal incentives, public procurement), compulsion (regulation, landowner requirement), promotion (publicity campaigns) and/or clarification (stricter use of terminology). The possibility of introducing fiscal incentives or compulsory measures is thought to be remote; recommendations therefore focus on support through procurement, demonstration and labelling.

¹⁶ ISO 15380 "Lubricants, industrial oils & related products (Class L) - Family H (Hydraulic systems) - Specifications for categories HETG, HEPG, HEES & HEPR" (Eco-friendly fluids).

GIFNFC Recommendation 20

The forum reiterates its previous recommendation that government should require public procurement units, national parks and large landowners to lead by example and require all contractors to use plant oil based hydraulic fluids wherever possible or practical, in the medium- to long-term. This should apply to all contractors operating hydraulic machinery such as earth moving equipment, water and underground pumps, lock operation machinery, wind turbines and agricultural and forestry machinery, in particular those operating in environmentally sensitive environments. This measure is intended to develop market demand and increased cost competitiveness of plant oil based lubricants.

GIFNFC Recommendation 21

The current lack of a coherent system of nomenclature is confusing and does not enable clear distinction of the derivation of a lubricant; this is unhelpful when trying to encourage increased use of environmentally friendly products. It is suggested that an all-inclusive system of nomenclature is needed which clearly states the derivation of the lubricant products and includes a biodegradability and ecotoxicity statement. This should be agreed and adopted by the industry in UK and promoted Europe-wide.

GIFNFC Recommendation 22

The forum has welcomed Defra and DTI's plans for a programme of demonstration to support the market introduction of crop derived products. We recommend that a project demonstrating plant based hydraulic fluids is invited under this programme; the project should seek to support use of plant based hydraulic fluids in equipment used for example in high profile new building and/or amenity projects (public or private). It should be accompanied by a programme of knowledge transfer and awareness raising for end users, equipment manufacturers and the wider public. The programme should make clear the environmental and sustainable development benefits.

GIFNFC Recommendation 23

Additives are used to improve the performance of all lubricants. Currently none of the additives that are used in hydraulic fluids are based on plant oils and all display degrees of toxicity. We recommend priority is given to funding increased research and development into non-toxic novel additives that improve the performance of plant based oils yet do not compromise their low biodegradability and ecotoxicity.

5.2.2 High value speciality chemicals: plant derived anti-microbial products

Rationale

1. The forum has reviewed plant derived anti-microbial products as part of its wider consideration of the contribution that speciality crops can make to UK economic activity. This is a developing area and less mature than the essential oils industry considered previously (section 5.1.5 of this report). Nevertheless the market potential is significant and increasing legislative pressure covering the use of chemicals in food and the growing problem of anti-microbial resistance are driving industry interest. All papers relating to this case study are available on the forum website.

Background

2. Anti-microbials are agents that are designed to reduce or mitigate the growth or development of microbial organisms. This is achieved by a variety of mechanisms, dependent upon the mode of action, composition, degree of activity and application. Their use leads to either death or arrested growth of the target microorganism. Since their discovery in the early 1900s, anti-microbial agents have transformed the prevention and treatment of infectious diseases and are now used across a very broad spectrum of markets.
3. In 2000, the global market for all anti-microbial compounds was estimated to be almost \$40 billion and a high growth rate is forecast. The US dominates the market with a 41% share. The most prominent sector is the pharmaceutical market, which will drive growth over the next ten years, doubling itself to \$69 billion. There are four main sectors, reflecting the largest market opportunities for existing and novel agents:
 - hygiene (both industrial and domestic);
 - food and personal care;
 - pharmaceutical and animal health; and
 - plant health.
4. These are complemented by a broad spectrum of other industries including drinking and industrial water treatment, textiles, leather and plastics, paints, coatings and adhesives, pulp and paper production, petroleum, metalworking fluids and wood preservatives.
5. Anti-microbials can also be categorised by their function, reflecting mode of action, target organisms and areas of application. Specifically:
 - strong and broad based, or
 - active against human pathogens or spoilage organisms that damage consumer goods, or
 - active against plant or animal pathogens.
6. Despite such classifications of sectors and function there are a large number of agents and applications leading to a very complex market. Equally complex are prices where accurate predictions are scarce with wide variations observed across geographic regions.
7. The majority of industries predominately use synthetic anti-microbial agents. These have been designed and developed to fulfill specific roles in each application.

8. Naturally occurring anti-microbial agents are abundant in the environment and are produced by plants, animals and microorganisms. Edible plants biosynthesise thousands of chemically diverse molecules with anti-microbial properties as part of their natural defence against microbial pathogens. Their activity has been demonstrated and some naturally occurring anti-microbials have found commercial applications (tea tree oil and neem oil are successful examples), such that the scientific study of natural pesticides is becoming recognized as a very practical endeavour.
9. There is a range of market drivers for the development of new anti-microbials including:
 - consumer demand for minimal processing and limited use of synthetic chemicals in food, hygiene and personal care products;
 - regulatory pressure to reduce the volumes of toxic chemicals used in industry;
 - the growing problem of anti-microbial resistance;
 - legislation to cover all of the above.
10. Economists estimate that research and development for a new product requires at least a 10 year investment and that investment can only be recovered if the product has a market value in excess of \$100 million. Investment into plant derived compounds is limited as only a small number of plant derived products fall into this category.
11. The forum commissioned the Centre for Novel Agricultural Products (University of York) to carry out a survey of key industrial and academic contacts with expertise in anti-microbial technology¹⁷. The report has provided a valuable insight into the market. In all cases the development of new anti-microbial agents was considered to be a very topical and valuable opportunity and several respondents expressed an interest in being involved in a workshop directed at plant based anti-microbials. The CNAP report is available on the forum website.
12. Plants offer a valuable source of new anti-microbial compounds. However, the process of developing and identifying such compounds is difficult because:
 - methods of purification have not been developed;
 - many actives may work synergistically with other compounds or only under certain conditions;
 - elucidation of the structure of natural compounds can be very complex;
 - patentability of natural compounds may be difficult especially if the plant has been previously identified as producing anti-microbial compounds;
 - many natural products can be toxic to animals and so may fail on safety grounds;
 - the cost of developing natural products can be prohibitive when balanced with the likely return and, for many manufacturers, the cost of developing a new anti-microbial agent is more important than the environmental issues.

¹⁷ Centre for Novel Agricultural Products. Anti-microbial scoping study. University of York.

13. A general lack of understanding of function and mode of action prevents full exploitation of currently used plant derived anti-microbials.

Impact of legislation

14. A key issue with potential to limit development of plant-derived anti-microbials is the EU's Biocidal Products Directive¹⁸ (98/8/EC) (BPD) of 1998 aimed at establishing a single European market in biocides by introducing a harmonised authorisation system based on assessment of risks to people and the environment, together with consideration of efficacy. The Directive was implemented in Great Britain under the Biocidal Products Regulations 2001.
15. The Directive and UK Regulations require the authorisation of a wide range of biocidal products that currently do not require authorisation, including disinfectants, preservatives and a number of other specialist products, as well as non-agricultural pesticides currently approved under the Control of Pesticides Regulations 1986 (wood preservatives, public hygiene insecticides, rodenticides, surface biocides and antifouling paints). The Directive will not apply to products already subject to European legislation including plant protection products, human medicines, veterinary medicines, medical devices or cosmetics.
16. If plant derived products with biocidal claims are to be approved under the BPD, approval for use in the EU must be obtained. This is an extremely costly process and it is predicted that many small and medium sized businesses will not survive. There is a legal framework under which the requirement for data can be waived but consideration is on a case-by-case basis and each must be presented to the competent authority in the applicant country. The Health and Safety Executive is the Competent Authority for the BPD in UK and the forum is engaged in discussions with them on this issue.
17. Despite these barriers, there are vast opportunities to be exploited for the use of anti-microbials from plants, especially as legislation becomes stricter and consumer demand for natural products increases. Within the hygiene industry it may be more difficult to identify strong broad-spectrum anti-microbials from plants, due to the nature of the compounds. However, in pharmaceutical and animal health, there are many opportunities for the development of alternatives to the currently used synthetic drugs.

Recommendations

18. Plant based anti-microbials appear to have a have a positive contribution to make towards sustainable development. However there are a number of potentially significant barriers to be overcome. The following recommendations are designed to support their further development.

¹⁸ The formal definition of a biocidal product is: "active substances and preparations containing one or more active substances, put up in the form in which they are supplied to the user, intended to destroy, deter, render harmless, prevent the action of, or otherwise exert a controlling effect on any harmful organism by chemical or biological means."

GIFNFC Recommendation 24

Consideration should be given to public funding of research to investigate mode of action and synergism of known plant anti-microbials. Identification of new molecules is thought most likely to remain in the private sector.

GIFNFC Recommendation 25

The Biocidal Products Directive has potential to inhibit completely commercialisation of new plant derived anti-microbials. To prevent this we recommend that a 'fast track' approval system should be investigated for those molecules that are Generally Regarded As Safe (GRAS) or derived from foodstuffs where the use rate is equal or less than the Acceptable Daily Intake (ADI).

GIFNFC Recommendation 26

A seminar should be organised to raise the profile of plant derived anti-microbials and to explore the barriers to their development with a view to identifying the action required to overcome those barriers. The seminar should cover the main areas of concern raised from interviews in the scoping study with experts from industry and academia, and should include legislation and the Biocidal Products Directive, patent law, anti-microbial resistance, activity/structure relationships and example case studies.

GIFNFC Recommendation 27

To supplement the general review of this area already undertaken by the forum, a detailed review of pharmaceutical applications for therapeutic and prophylactic anti-microbials for human and animal health should be funded. This is a very significant but as yet largely unexploited market and the review would identify key areas of opportunity for plant based anti-microbials in this market.

5.2.3 Adding value to wool

Rationale

1. The Forum has investigated the current status and future opportunities for use of sheep's wool as a natural fibre, non-food product in the UK. The research process necessarily involved exploring wool production by sheep breeds farmed in the UK, present uses, market demand and the processes for sale of wool by producers through the supply chain to applications developed globally.
2. Meetings were organised for all the stakeholders involved as well as relevant Government departments. The following summarises the findings and conclusions reached by these activities and investigations.

Background

3. Wool is a global commodity and is sold on a worldwide market. In consequence, market demand is set globally and can have an adverse or beneficial impact on wool prices, irrespective of the UK activities. Annually, the UK produces 38 million kg of wool of various qualities.
4. The principal products developed for wool are carpets and apparel. The bulk of the UK wool ("clip") goes into carpeting. In all markets, wool is at threat from synthetic fibres or alternative technologies. There are opportunities for developing new uses for wool but these require research investment and have not been priorities for the UK Government, unlike those in New Zealand and Australia, the two major wool producers worldwide.
5. Since the 1950s, the major commercial interest of the UK sheep industry has been meat, with wool being regarded very much as a by-product. Sheep breeding has therefore focused very tightly on developing and optimising animals for meat production. Some 80 sheep breeds are farmed in the UK. Many of the hill breeds, environmentally adapted, traditionally farmed and playing an integral role in the geographically tiered sheep production system of the UK, produce coloured and/or coarse fleece, which typically does not gain a high price in the marketplace.
6. The UK now remains unique amongst wool producers globally in continuing to maintain a centralised monopoly on handling wool from point of production to point of sale. The British Wool Marketing Board (BWMB) was set up in 1950 for "regulating the marketing of wool produced in the United Kingdom". The legislation is such that any producer with more than 4 sheep must supply fleece ("the clip") to BWMB. There are certain exceptions for rare breeds and for producers who directly export their clip. Producers who wish to develop entrepreneurial businesses involving wool that their own sheep have produced nevertheless must supply BWMB with the clip and buy it back at open market rates.
7. The prices paid to producers by BWMB reflect the open market rates minus BWMB's costs, since the organisation receives no core funding from UK Government. There is very little pressure or desire for change amongst the majority of wool producers, who see value in BWMB taking responsibility for

moving the by-product on and providing the producers with some returns. The problem arises with the low value wool; this affects only a relatively small proportion of UK producers, but the returns from the BWMB for these farmers often do not even cover the cost of shearing the sheep.

Recommendations

8. The Forum considers there are the following three critical issues:

GIFNFC Recommendation 28

When the BWMB was set up in 1950, it was an entirely appropriate vehicle to respond to the needs of the day. Given the changes there have been in society, in industry and in the market place, the Forum recommends a strategic review, which addresses the following 3 questions:

- Is the concept of a UK Marketing Board for wool, with its existing terms of reference, still valid?
- If the justification for such an organisation still remains, should its terms of reference be adapted to present day needs?
- Is there a more appropriate structure than a Marketing Board?

The Forum is aware that reviews of this nature have been conducted in the past, nonetheless we recommend that the sector would benefit from a strategic review carried out by an authoritative group wholly independent of the sector.

9. There are two problems that require immediate action:

GIFNFC Recommendation 29

Entrepreneurial development is currently stifled. The Sustainable Food and Farming Strategy strongly encouraged entrepreneurial activities as a means of sustaining economic development in the countryside.

One of the strengths of UK agriculture is its diversity and this is reflected in sheep farming where each region of the UK has distinct native breeds. In the context of sheep, the foundation is therefore in place for regional initiatives, building on regionally branded products such as could be developed for local wool and traceable even to individual farms.

The current legal requirement for producers to supply a centralised BWMB with the wool from their sheep blocks individual and regional initiatives and stifles the development of creative alternatives for the farmers' own products.

Producers who wish to pursue their own ventures should be allowed to do so, without losing the option to sell their wool through BWMB at any time. There is a derogation clause in existing legislation (Article 70¹⁹). In line with the principle of the Sustainable Farming and Food Strategy and recognising the need to re-connect wool producers

¹⁹ Article 70 (1) Exemptions: The Board may from time to time prescribe that any description of producers, wool or sales of wool, shall be exempt from such if the provisions of this Scheme as may be specified in the prescription.

with the market place, the Forum recommends the BWMB makes use of this exemption possibility in Article 70. Using this exemption, the Board should undertake a new entrepreneurial scheme for individuals and groups of producers to develop regional initiatives and regional boards. This will require BWMB to exempt producers on this entrepreneurial scheme for as long as they wish.

GIFNFC Recommendation 30

There is no research investment earmarked for exploring the unique qualities of wool as a natural fibre, industrial feedstock and non-food crop. The forum has highlighted the opportunities in developing new fibre crops for the UK. However this debate has taken place entirely from the perspective of plant crops such as hemp and flax. Wool fibres are proteins, unlike the polysaccharide nature of the plant fibres, and therefore form the basis of a different range of materials and applications. There are well recognised non-woven applications for wool, such as insulation, felting, replacements for imported coir matting for large-scale planting, and duvet fillings. All of these applications would readily supply markets for the UK's low value wool that cannot compete in other markets. Similarly, the amino acid composition of the wool proteins and the possibility of their chemical modification offer new opportunities for large-scale feedstocks for the chemical industry.

The Forum recommends that the Government earmarks open competition funding for new research into the design and development of advanced technologies to maximise wool utility, such as, for example, exploring multi-polymeric applications, intelligent fabrics and chemical modifications. The view of the Forum is that funding in this area of novel fibre development will be, at the very least, as cost effective as the proposed initiatives involving expansion of new plant based fibre crops.

5.3 Other case study areas

5.3.1 Biofuels

a) The forum has studied liquid biofuels (biodiesel and bioethanol) for the transport industry and their potential to contribute to sustainable development in UK. Advice was submitted to Ministers in October 2002 (available on the forum website) and evidence was submitted to the EFRA Select Committee inquiry into alternative uses for crops (biofuels) in April 2003. This subject continues to be an area of key interest for the forum and a watching brief is maintained.

b) Biofuels are liquids derived from biomass, predominantly from agriculture, and used as a component within a transport fuel blend. Biodiesel and bioethanol are well developed and are being incorporated within diesel and petrol respectively in many countries and in a few EU countries near pure blend biofuels are sold. The addition of a 5% biodiesel or bioethanol blend can be fully accommodated with no technical or other performance impact on the UK's existing car fleets. One of the main advantages is the substitution of fossil fuels by a renewable source with the resulting contribution to the reduction of carbon dioxide emissions.

c) Biodiesel is produced in Europe from the extraction and esterification of oilseed rape and bioethanol from the fermentation and subsequent distillation of starches and sugars, derived in Northern Europe, principally, from sugar beet, potato and wheat. In the future, bioethanol may be produced from lignocellulosic materials, such as straw and wood, but this technology is probably at least three to five years from proof at scale. The forum was pleased to see the Chancellor earmarked lignocellulosic technology for consideration of further development in his 2003 budget.

d) The principal environmental argument for biofuels is based on the reduction in greenhouse gas emissions; as an approximation, every tonne of biodiesel produced would reduce the crude oil equivalent required by two-thirds of a tonne, and similar ratios are achieved for bioethanol. The proponents for biodiesel and bioethanol also argue that vehicle particulate emissions are reduced although evidence on this, at least for biodiesel, is inconclusive.

e) The Defra-commissioned review undertaken by Sheffield Hallam University (see footnote 1, page 4) was published in January 2003. The review concluded that there are more cost-effective methods than biodiesel elsewhere in the total economy to reduce carbon dioxide emissions - thermal insulation, building design, wood and solar based power all offer lower unit cost routes to the reduction of carbon dioxide emissions. However none of these alternative measures are relevant to the transport sector, and the emission savings from some of them are uncertain. Hence transport biofuels may have an important role in contributing to the UK's emission reduction targets.

f) The Energy White Paper published in February 2003 states the government's commitment to a low carbon economy. In June 2003 the EU Directive on the promotion of the use of biofuels for transport set indicative targets for the proportion of energy that should be sourced from fuels derived from renewable resources (2 per cent road transport fuels to be derived from biofuels by 2005, 5.75 per cent by 2010).

The DfT will consult early in 2004 on targets to set for UK. However on current performance it seems unlikely that the UK will meet the indicative targets. The forum believes that biofuels provide the major route for the next decade or so to a significant reduction in the net carbon dioxide emissions from transport; hydrogen sourced from electricity based on nuclear or renewables is still on or over the horizon. The government has granted 20p per litre reduction in the rated duty to both biodiesel (in 2001) and bioethanol (in 2003, effective from 2005); the forum does not believe this is sufficient to support the development of a UK biofuels industry that will enable the EU's indicative targets for biofuels to be met.

g) In addition to a reduction in CO₂ emissions from the transport sector, the forum believes that biofuels can deliver wider ranging benefits. Establishment of a UK industry presents an opportunity for major industrial investment coupled with the presence in the UK of key agri-industrial leaders. Biofuels may create potentially significant new markets and opportunities for UK arable agriculture and forestry with concomitant benefits on the rural economy; they also have potential to contribute to energy security.

h) We have considered the sustainable development impacts of biodiesel and bioethanol individually. Assessments are available on the forum website (www.defra.gov.uk/gifnfc). The forum's view is that both biodiesel and bioethanol present an overall positive contribution to sustainable development. If the economic conditions are right, development of a biodiesel industry offers considerable potential for agri-industrial investment together with innovation opportunities and good security of supply. Substitution and subsequent saving of fossil fuels are very positive environmental benefits although there is still some uncertainty over particulate emissions. Potential impacts on biodiversity through increased production of oilseed rape should be assessed but will depend on a complex mix of factors, including the current use of land on which oilseed rape might be grown. There is also the potential for competition with other uses for oilseed rape.

i) Of the two, we consider that bioethanol has potential in the long term to make a more positive contribute to sustainable development than biodiesel. This is largely because of the broader range of crops which can be utilised as feedstocks for its production, and the possibility of utilising by-products such as straw, processing wastes and other biomass as the lignocellulosic technologies become economically feasible. This has potential to support development of a more secure rural infrastructure than biodiesel, which in turn would have additional benefits for the rural economy. The environmental and economic benefits seen with biodiesel production also apply.

j) The forum's advice to ministers was that in a cross-sectoral review, biodiesel and bioethanol are relatively inefficient in economic and environmental terms. In the transport sector they are two of the few medium term options available to contribute towards meeting targets for renewable energy, and offer a good first step to prove and develop the supply chain for renewable transport fuels. This view has been strengthened following publication of the EU Biofuels Directive in June this year.

5.3.2 Substitution of synthetic dyes with natural dyes in the textile industry

a) In our last annual report, the forum reported that there appeared to be limited large-scale potential for development of a UK natural dyes industry but that there was a clear market for niche production for a low volume yet valuable sector of the fashion market. The forum has subsequently confirmed its view on this; for substitution on a larger scale there are environmental and technical issues to be overcome before commercial development will be seen. There are pockets of activity in UK where small industries serving niche markets have established but the markets and growth opportunities are unclear and difficult to predict. It is doubtful that the forum can enable activity in this field.

b) The potential contribution to sustainable development is mixed, with environmental and economic issues being the main areas of concern. The forum recognises that on a local scale natural dyes could present a limited number of potentially profitable opportunities which may benefit rural communities, for example by creation of local processing facilities and associated tourist attractions. For development on a larger scale there is a need to overcome the problem of heavy metal mordants required for use with natural dyes and this is an example where the use of synthetic petrochemical derived dyes presents an environmentally more acceptable and economic product than renewable raw materials. The forum will take no further action in this area but will monitor developments.

5.3.3 Forestry products: harnessing the under-exploited and growing availability of UK forest products (excluding fuel and construction)

a) Timber prices in the UK have fallen by about 50% in the last seven years and although prices have now stabilised, there is little prospect of a substantial rise in the near to medium term future. The use of biomass for heat and electricity generation is well understood, and there is a reasonable understanding of the use of forest products for biocomposites and bioethanol production. In addition the potential of other forest products, such as mushrooms, game and berries are being investigated. To add value to the UK's forest industry there is a need to identify alternative products from wood, in particular for the lower grades of timber that cannot attract the higher construction timber price, and for fractions of the tree that are not used at present such as foliage.

b) To address this the Forestry Commission and the forum jointly commissioned a review of potential products that could be extracted from woody biomass including an assessment of processing technologies, barriers to development and market demand. The review was specifically to identify primary and secondary chemicals, while not overlooking innovative uses of the raw material. Species to be assessed included Sitka spruce, Scots pine, Corsican pine, Douglas fir, the larches, oak, ash, beech, birch, cherry, poplar, aspen, and alder.

c) The research team was asked to describe what is known of the chemical composition of the species in the review, to translate this into potential end uses and to estimate the economic potential of various end uses taking account of yields, volume of raw material, extraction costs, product demand and market price, also any potential detrimental environmental effects.

d) The project team compiled an extensive database of primary and secondary compounds according to species. Traditional and emerging markets for tree products were identified. Industries exploiting tree metabolites as raw material are experiencing a 'renaissance' in existing, and a surge in the development of new, tree derivatives with many different applications. Inadequate extraction techniques were identified as one of the main reasons for the failure of many past wood-extractives ventures. Newly developed techniques such as super critical gas extraction promise to provide efficient, specific, environmentally friendly methods of obtaining value-added products at competitive cost. The review also identifies new opportunities to transform tree metabolites into value-added products but R&D support is required to fully evaluate the generic potential of these materials and thereby accelerate their adoption. Successful exploitation of the review's information will require collaboration of experts from a wide range of disciplines.

e) The forum will assess the report and make its recommendations in due course. The report will be available on the forum website.

5.3.4 Forage grasses and miscanthus

a) The UK potential for production of forage grasses is second to none, except perhaps New Zealand, but is currently under exploited. The forum has separately considered the commercial potential of this source of biomass for production of bioethanol.

b) Forage grasses are defined as those grasses that have traditionally been used as fodder or silage for livestock production. In UK and Europe, the rye grasses, *Lolium perenne* (perennial ryegrass) and *Lolium multiflorum* (Italian ryegrass) occupy about 70 per cent of the cultivated agricultural grassland areas with *Festuca arundinacea* (tall fescue), *Festuca pratensis* (meadow fescue) and *Dactylis glomerata* (cocksfoot) making up the remainder.

c) Forage grasses partition into a liquid phase and a fibre phase. The liquid phase is high in nutrient content and key interests are in production of lactic acid which is a feedstock for a wide range of chemical processes, and xylitol, a sweetener which is not metabolised by cariogenic bacteria and so is of great value in helping to prevent dental caries. The fibre phase of forage grasses produces long fibres which may have applications in biodegradable paper and board, or can be utilised as biomass.

d) Miscanthus is a perennial grass with an estimated productive lifetime of at least 10–15 years, and both the stems and leaves of the crop can be harvested annually. It has been the focus of considerable attention in the UK over the last 10–15 years for use both as biomass for energy and more recently as a source of short fibres in the matrix of plastics and composite materials. It is characterised by relatively high yields, low moisture content at harvest, high water and nitrogen use efficiencies and appears to have low susceptibility to pests and diseases. It is outside of the forum's scope to consider the value of miscanthus as a source of biomass for energy.

e) A study was commissioned²⁰ to scope the potential industrial uses of forage grasses and miscanthus. This included a review of R&D work ongoing in UK and across Europe. There appears to be a wide range of interest in this area across Europe in the cool, wet, more northerly parts of Europe such as the Scandinavian countries, Germany and the Netherlands, where biomass production rates are high. Here the concept of the 'biomass refinery' is well developed; in the Netherlands a pilot plant facility has been established to extract and evaluate the fibre, protein and high value chemicals portions.

f) The Institute of Grassland and Environmental Research (IGER) in Aberystwyth carries out most of the forage grass research in the UK. The bulk of its work is focused on the improvement of grasses for forage and amenity uses, but there is some research into increasing the levels of fermentable carbohydrate content and reducing the levels of phenolic acids within forage grasses to provide larger quantities of more easily accessible raw materials as feedstock for the production of fermentation products such as industrial lactic acid.

g) The report is available on the forum's website. Further work will now be commissioned to evaluate the commercial potential and economic viability of the key applications cited in the report.

5.3.5 Renewable raw materials in the construction industry

a) Developing from the earlier case study on wheat secondary uses (see section 5.1.3 of this report) and the emerging potential for use of straw bales in construction, the forum has widened the remit of this work to assess the potential for use of agricultural crops across the construction industry as a whole, and the potential contribution to a more sustainable construction industry.

b) Defra and DTI have recently part-funded, with industry, a small project entitled 'The use of agricultural crops (plant and animal) in construction'. The Construction Industry Research and Information Association (CIRIA) is leading the work. The output will be a resource guide for architects and building engineers detailing the materials that are available at present/in the near future for use in the construction industry with ease and (potentially) in volume. Products available for immediate use are likely to be panel products incorporating natural fibres, and insulation products. Wall and floor coverings, geotextiles, a range of composite board materials, fibre reinforced plaster and plastics, paints, glues and sealants are likely to follow.

c) Penetrating the building industry with new materials is notoriously difficult and the project will look at the barriers to use of these materials, particularly in the commercial building sector, and try to develop an understanding of the steps that must be overcome. The forum will also concentrate its own efforts in this area and on possible measures for overcoming these barriers.

d) It is thought there is likely to be a key role for government in supporting the use of more sustainable building materials – government is responsible for approximately 60 per cent of all building in UK (includes schools, hospitals, administrative buildings

²⁰ P.A. Fowler, A.R. McLauchlin & L.M. Hall. The potential industrial uses of forage grasses and miscanthus. BioComposites Centre, University of Wales.

etc), and procurement requirements for use of renewable raw materials could be very influential.

e) This work is in its early stages; the forum will be reviewing current building regulations and engage with the Buildings Research Establishment to gain an understanding of current environmental guidelines for new buildings. Defra views this as a potential area for demonstration activities in association with a high profile new building project.

5.3.6 Commercialisation of secondary products of oats

a) The OATEC project that was reported on previously and which formed the basis of the forum's interest in this area was published in November 2002. The project identified an opportunity for a high quality oat oil to be marketed to the cosmetic and nutraceutical sectors, based on the properties of the antioxidants and a good fatty acid profile. The technical challenge lies in reliable production of a homogenous highly specified product from heterogeneous raw material, at a sustainable commercial scale. Two projects have been funded under the CIMNFC LINK programme supporting technical development of high value fractions from oats - 'ABIPO' (Antioxidant Based Industrial Products of Oats) and 'Lubestarch' (cereal starches as dry lubricants). Boots plc is involved in these projects which may lead to innovative, marketable products.

b) The OATEC project has identified the need for UK to invest in a plant with the flexibility to deal with extracts from a range of plant material. A plant such as this could facilitate market entry for a number of innovative products, but it would require major investment, possibly on a European scale, and with a large share sponsored by government. Independent assessment of the value of the commercial markets for oats has suggested that current markets do not justify building such a plant.

c) The project has promoted UK interest and activity in secondary products for high value applications and has identified a potential commercial application; it has also led to further research projects which may generate commercial activity. The forum view is that these applications will be developed commercially if the market justifies it. The forum has not made recommendations to support further development of this opportunity.

6. Future work

1. The forum plays a key role in contributing to the government's long-term strategy for non-food crops and we will continue to give priority to advising government on this. The cross cutting nature of non-food uses of crops makes this a complex and difficult strategy to develop, but it will be fundamental to realising their full value. The potential of bioscience to contribute to the UK competitive position will be an integral part of the strategy and the work we have commissioned will be one of the forum's key inputs.
2. We will continue to work with government to see the implementation of our case study recommendations over the coming months. We will assist with development of the demonstration projects that are being taken forward as a result of these recommendations.
3. We have three ongoing case studies at the moment and we will continue to work on these, commissioning research where necessary. The case study reviewing the potential of non-food crops for the construction industry is likely to be a major piece of work for the forum. Our case study work is now at a manageable level and we will be reviewing our present case study portfolio and identifying new areas.
4. Of the generic issues identified, we intend to examine in depth the role that government procurement can play in developing the markets for crop-derived products.
5. In the coming months the forum will align with the new National Non-Food Crops Centre, and a working relationship will evolve as the centre establishes itself. From an early stage we will be looking to the centre to commission the technical studies essential to our case study work.

Acknowledgments

We are very grateful to the people listed below who have attended forum meetings, at our invitation, to provide expert advice for discussion of specific issues.

- Professor Nigel Mortimer and Dr Ralph Horne, Sheffield Hallam University
- Garth Entwistle and Dr Kerr Walker, Scottish Agricultural College and Bruce Knight, Innovation Management Ltd
- Professor Peter Lillford, Chair, National Non-Food Crops Centre
- Terry Robbins, Packaging Innovations Manager, Sainsbury Supermarkets Ltd
- Dr Richard Murphy, Imperial College, London
- Arna Peric-Matthews, CIRIA and Bill Addis, Buro Happold Ltd

We are also grateful to representatives from the DTI, DfT and from Defra who are not members of the forum secretariat but have attended forum meetings and contributed to discussions.

Contact point

The forum secretariat is based at Defra. All enquiries to the forum should be addressed to the GIFNFC Secretary in the first instance.

Sarah Hugo
GIFNFC Secretary
Area 5A, Ergon House
Horseferry Road
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Annex 1

Background to the forum

The Government-Industry Forum on Non-Food Uses of Crops is an advisory non-departmental public body sponsored by Defra, set up in March 2001. It has a steering group of eight external members and seven government members. Defra provides the forum secretariat. The forum meets four times each year. This is the forum's second annual report.

The forum was set up in response to a House of Lords Select Committee on Science and Technology report on non-food crops in November 1999, and the government response of April 2000 to provide strategic advice to government and industry on how to promote development of non-food uses of crops in the UK, in particular to promote development of sustainable opportunities that stand to add value to UK economic activity.

Terms of reference

To provide strategic advice to government and industry on the development of non-food uses of crops. In particular to:

- keep under review technological developments and market opportunities for non-food uses of crops;
- make recommendations on policy affecting non-food uses of crops and on R&D priorities; and
- publish an annual report.

Scope

A key guiding principle for the forum is that the areas it considers must involve crops grown or capable of being grown in the UK, and/or which stand to contribute to UK value creation through their subsequent processing or use.

The priority for the forum is to look at crop-derived raw materials and products. It is free to consider any areas relevant to its terms of reference although for practical purposes it operates a hierarchy in its work programme.

Solid biofuel crops have recently seen significant development in terms of both policy and support initiatives and are excluded from the work of the forum.

Forum membership

The forum has a chairman and seven members drawn from industry, appointed for their ability to think laterally and strategically. Forum membership is drawn from the following backgrounds: consumer-oriented end manufacturer, intermediate manufacturer, scientist, primary producer, environmental and sustainability experts. The current term of membership commenced in March 2001 and is for three years in the first instance.

The forum secretariat comprises representatives from Defra (2), DTI (3) and Forestry Commission (1). Defra is the sponsoring government department and also provides technical advisers (2) and a secretary.

The forum is open to consultation with a much wider audience and has a dedicated interactive website at <http://www.defra.gov.uk/gifnfc>. All forum papers are available on the website.

Remuneration

Members who are not civil servants are paid an attendance fee in line with those for other Defra advisory bodies. Currently these rates, before deductions for tax and National Insurance, are £199 per meeting for the Chairman and £156 per meeting for other members. Members are able to claim back reasonable travelling and subsistence expenses.

Frequency of meetings

The forum meets quarterly. The report of the forum meetings and all papers tabled at the meeting are made available on the forum website two weeks after the meeting has taken place.

Publication policy

The forum publishes a report annually with an overview of its activities and output throughout the preceding year. Specific recommendations to government and industry are published on an ad hoc basis as they are developed. All reports commissioned in support of the forum's work are made available on the website. Under the Freedom of Information Act the forum will formally develop a publication policy by February 2004.

Forum Membership

External members

Chairman: Rob Margetts CBE

Chairman of Legal and General Group Plc; Chairman - Europe, Huntsman Corporation; Chairman of BOC Group Plc.

Professor Dianna Bowles OBE

Director of CNAP, Weston Chair of Biochemistry, Department of Biology, University of York.

Dr David Carmichael

Director of Battle and Pears Ltd and Arable farmer in Lincolnshire.

Pamela Castle

Chair of Environmental Law Foundation.

Professor Paul Ekins (resigned August 2003)

Head of Environment Group at Policy Studies Institute and Professor at the University of Westminster.

Dr Ray Marriott

Chief Executive of Botanix Ltd.

Dr Richard Miller

Miller-Klein Associates.

Andy Taylor
Director of Corporate Citizenship, Ford Motor Company Ltd.

Full details of forum members' professional interests are given Annex 2

Government members

Andrew Perrins
Defra. Head of Organic Farming and Industrial Crops Division.

David Clayton
Defra. Head of Agri-Industrial Materials Branch, Organic Farming and Industrial Crops Division.

Dr Sue Armfield
DTI. Head of Agri-business, plant and marine bioscience, Bioscience Unit.

Peter Millman
DTI. Manager, International Trade and Investment, Chemicals Unit.

April Vesey
DTI. Head of Sustainable Technologies, Technological Innovation and Sustainable Development Directorate.

Dr Helen McKay (co-opted October 2001 for duration of forestry study)
Forestry Commission. Senior Policy Advisor, Forestry Group.

Secretariat

Technical advisers

Dr Donal Murphy-Bokern
Defra. Head of Arable Sciences Unit, Acting coordinator of Sustainable Farming, Food & Fisheries Science Division

Melvyn Askew
Central Science Laboratory. Head of Agricultural and Rural Strategy Group. Coordinator of the Interactive European Network for Industrial Crops and their Applications (IENICA) project.

Secretary

Sarah Hugo
Defra. Organic Farming and Industrial Crops Division.

Annex 2

Register of forum members' professional interests

Chairman: Rob Margetts CBE

Chairman of Legal and General Group Plc; Chairman – Europe of Huntsman Corporation; Chairman of BOC Group Plc

Also, Director of Anglo American Plc; Chairman of Natural Environment Research Council; Governor and Fellow of Imperial College of Science, Technology and Medicine; Member of Council for Science and Technology; Director of Foundation for Science and Technology Council; Member of Advisory Committee on Business and the Environment (until 30 July 2001); Director and Trustee of Council for Industry and Higher Education (from 1 July 2001); Member of Council of Chemical Industries Association; Member of Goodison Group; Fellow of Royal Academy of Engineering; Fellow of Institution of Chemical Engineers.

Professor Dianna Bowles OBE

Director of CNAP, Weston Chair of Biochemistry, Department of Biology, University of York.

Also, Independent member of Defra Central Science Laboratory Ownership Board (until 2001); Member of Foresight Panel Task Force on "Unlocking the potential of industrial crops" (until 2001); Member of National Co-ordination Committee on the protection of biodiversity of the UK farm animal genetic resources (until 2002); Member of DTI "high level strategy group" to design a new agri-business strategy for the UK (2002); Member of European Molecular Biology Organisation; Founder and Editor-in-Chief of *The Plant Journal* (until 2002); Member of EU DGXII Life Sciences and Technologies External Advisory Group on Cell Factories (until 2003); Member of the Yorkshire Agricultural Society Grants and Education Sub-Committee; Member of the Yorkshire Agricultural Society Council; Member of BBC Rural Affairs Advisory Committee (from 2002); Member of DTI GM Science Review Panel (from 2002); Co-Founder and Director of the National Non-Food Crops Centre (from 2003); Founder of Heritage GeneBank (2001) and Director and Chair of The Sheep Trust (from 2002).

Dr David Carmichael

Director of Battle and Pears Ltd, Arable farmer in Lincolnshire.

Also, Commissioner, Agriculture and Environment Biotechnology Commission; Member, National Farmers Union.

Pamela Castle

Chairman of Environmental Law Foundation.

Also, co-Chairman of the London Sustainable Development Commission; Chairman of Thames Region Environmental Protection Advisory Committee of Environment Agency; Chairman of Fire Safety Advisory Board; Fellow of Institute of Wastes

Management; Member of Natural Environment Research Council; Member of National Radiological Protection Board; Member of Port of London Authority Board; Member of Royal Society of Chemistry; Member of Law Society; Former Trustee of World Wide Fund for Nature (UK).

Professor Paul Ekins (resigned August 2003)

Head of Environment Group at the Policy Studies Institute and Professor at the University of Westminster.

Also, Member of the Environmental Advisory Group of Ofgem; Member of the Royal Commission on Environmental Pollution; Specialist Adviser to House of Commons Environmental Audit Committee; Co-Founder, and now Associate Director, of Forum for the Future; Senior consultant, Cambridge Econometrics; Member of National Consumer Council (to October 2002); Special adviser, Right Livelihood Awards Foundation; Recent research contracts from ESRC, EPSRC, European Commission, DETR/Defra, OECD and Joseph Rowntree Foundation.

Dr Ray Marriott

Chief Executive of Botanix Ltd.

Also, Director of Elixarome Ltd, Phytech Ltd and H.G Hesseberger Ltd (all companies involved in growing and processing of hops and other non-food crops); Director of the British Essential Oils Association Ltd. (BEOA); Member of Foresight Panel Task Force on "Unlocking the potential of industrial crops".

Dr Richard Miller

Miller-Klein Associates.

Also, Director of Knowledge and Sustainability and employee of Uniqema (a member of the ICI group) which uses industrial crops (until 30 July 2001); ICI Senior Research Fellow and Technology Board member (until 30 July 2001); Member of Foresight Panel Task Force on "Unlocking the potential of industrial crops"; (30 July 2001); founder of Miller-Klein associates (a business strategy consultancy); Chairman of Magic Mathworks Travelling Circus (a charity dealing with mathematics education); Fellow of the Royal Society of Chemistry and Chartered Chemist; founder and Director of Vigorat (a knowledge management consultancy).

Andy Taylor

Director of Corporate Citizenship, Ford Motor Company Ltd.

Also, Board member of Faraday Plastics; business advisor to Baby Lifeline (UK Charity); member of Business in the Community East of England Regional Leadership Team.

