# The Economic Potential of Plants and Animals Not Currently Fully Exploited by the Welsh Agricultural Sector

**FINAL REPORT**

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## SUMMARY

A consortium led by the Central Science Laboratory, which included the School of Agricultural and Forest Sciences at the University of Wales, Bangor (UWB) and the Centre for Ecology and Hydrology based at UWB was commissioned by the Welsh Development Agency (WDA) to undertake a study of the economic potential of plants and animals not currently fully exploited by the Welsh agricultural sector. This work compliments concurrent work being done by other groups developing action plans for the WDA on alternative uses of forestry, biomass energy production, horticulture and aquaculture.

The overall aims of the work are to evaluate the agronomic and commercial potential of novel plant and animal products for Wales, taking into account the environmental conditions that exist and any potential environmental consequences that may occur as a result of implementation or expansion of new crops and animal enterprises. As alternative opportunities in the forestry, biomass energy crop, horticultural and aquaculture sectors are being covered in other projects they are not considered in this study. Traditional breeds of mainstream livestock enterprises were not considered as part of this study.

### Approach

An initial list was compiled of currently under-exploited plant and animal species as well as plant species and animal by-products which exhibit potential as new crops or raw materials for production of bio-renewable materials. This exercise identified 94 plant species and 20 animal species for further consideration. Of this preliminary list, 43 plant species were identified as currently growing in Wales and a further 11 were identified as native to Wales.

For each of the identified opportunities, information was sought on habitat requirements and basic agronomy or husbandry requirements to identify whether commercial production in Wales would be possible. Prospective species were examined against factors such as frost tolerance, pertaining agroclimatic zones, annual rainfall, soil requirements and effects of altitude and topography to assess likelihood of success in Wales. Based on GIS data sets covering these parameters maps were drawn for the most promising species to identify potential areas of production across Wales.

Based on analysis of current and potential yields and information on the current potential and developed markets for renewable raw materials or animal products, each species/enterprise was broadly ranked on the basis of market potential by drawing on the best available information regarding product value, potential market outlet, value of the market, size of the market and timescale required to achieve market potential.

At this stage, species which had potentially long lead times to establishment, *i.e.* tree and hedgerow species tended to be eliminated from the primary list.

On the basis of the above sifting, 27 plant species and 15 animal enterprises were prioritised for further research and assessment. Plant species were categorised on the basis of current state of agronomic knowledge, current level of commercial

development and current barriers to development to provide a priority matrix based on timescale to realisation of commercial production and scale of current barriers to development (Table 1).

Table 1. Preliminary prioritised list of plant species

| Time to fruition | Few or no limits to uptake or current development | Moderate limits to uptake or current development | Major limits to uptake or current development |
|---|---|---|---|
| 0-3 years | *Industrial:*<br>Crambe<br>High Erucic Acid Rape<br>Hemp | *Food/feed:*<br>Linola<br>*Industrial/textile:*<br>Flax<br>*Healthcare:*<br>St Johns Wort<br>Valerian<br>Borage<br>Evening Primrose<br>Echium<br>*Essential oil:*<br>Peppermint<br>*Pharmaceutical:*<br>Foxglove<br>Poppy | |
| 3-5 years | | *Industrial/textile:*<br>Meadow foam<br>Miscanthus (Fibre)<br>Calendula (Oils & food dye)<br>Woad (dye)<br>*Healthcare:*<br>Gold of pleasure<br>Oats<br>*Pharmaceutical:*<br>Mugwort | *Industrial:*<br>Yarrow (dye)<br>Madder (dye)<br>Native Grasses (Fibre)<br>*Novel:*<br>Bog Myrtle |
| 5-10 years | | *Industrial/textile:*<br>Spurge (oils/ polymer)<br>Nettle (Fibre) | *Industrial/textile:*<br>Giant Reed (fibre)<br>Reed Canary Grass (Fibre)<br>*Healthcare:*<br>Sea Buckthorn<br>*Pharmaceutical:*<br>Henbane |

All of the animal enterprises identified have been commercialised to some extent and therefore the majority are capable of being exploited in a relatively short timescale. However, in many cases there are current market, financial return or investment barriers which prevent greater exploitation. Based on these criteria a matrix of prioritisation for animal enterprises was derived (Table 2).

Table 2 Preliminary prioritised list of animal enterprises.

| Few or no limits to uptake | Some limits to uptake | Moderate limits to uptake | Major limits to uptake |
|---|---|---|---|
| Bees (Honey) | Goats (Dairy) | Ostrich | Quail |
| Venison (Finishing) | Goats (Mohair) | Camelids (Alpaca *etc.*) | Snail |
| | Sheep (Dairy) | Venison (Breeding (upland)) | Worm farming |
| | Water Buffalo (Dairy/Meat) | Sheep (wool*) | Goats (Cashmere) |
| | Wild Boar (Meat) | Rabbits (Meat) | |

* Refers to alternative uses for upland fleeces

For each of the plant and animal enterprises in Tables 1 and 2, an assessment of potential environmental impacts was made. Each enterprise was scored against anticipated impacts on soil quality, risk of water pollution, air quality, agrochemical and fertiliser inputs. In addition, potential effects on the landscape were evaluated as well as risks to the existing genetic resource base in Wales, *e.g.* through possible 'escapes'. Conversely, potential benefits to native biodiversity (*i.e.* invertebrates) were also evaluated. Environmental impacts were assessed as being positive or negative compared to the existing practice on the land (*i.e.* compared to wheat cropping on arable land, and sheep farming on grassland).

The majority of preliminary prioritised plant species were assessed as either causing little change in environmental impact compared to winter-sown conventional arable crops, or, as with spring sown crops such as oilseeds and perennial fibre and dye crops, were anticipated to provide environmental benefits as they require less agrochemical and fertiliser input than conventional crops. Perennial crops were also anticipated to improve soil structure and organic content over time. Exploitation of plant species such as bog myrtle, which is likely to be harvested in its natural habitat, will need to be carefully managed to minimise any environmental impacts. The introduction of improved strains of plants (*e.g.* nettles from Austrian breeding programmes) could potentially pose a risk to native species in Wales. These risks are difficult to quantify and would require further examination before wide-scale production.

While some animal species such as goats and camelids (alpaca *etc.*) can be complimentary to sheep grazing and therefore effect little change on most environmental parameters, other species such as boar and to a lesser extent rattites (ostrich and emu) can have a detrimental effect on existing ground flora. This

restricts suitable habitat to areas of low sensitivity, particularly where there is a risk of escape.

To assist with final prioritisation, a more detailed evaluation of commercial viability was undertaken. Where data were available, an analysis of the economic impact at the farm level and in the wider rural economy was evaluated or estimated. Labour inputs and returns for individual enterprises and the potential for added value processing beyond the farm gate were estimated to assess added value to the wider economy.

A final prioritisation was undertaken on the basis of scoring against the following criteria on a 1-10 scale -

1. Return to producer sector
Return to the farmer, size of market that could be captured and ease of access to market.

2. Return to the regional economy
Return from the total area of land that could support the enterprise, number of jobs created, potential for post-production processing (adding value) in Wales and number of potential jobs in post-production.

3. Cultural factors
Practicality of implementation given the current skill base, potential to enhance Welsh agriculture and potential to enhance other rural industries such as tourism.

The weighting given to scores in each of these criteria differs depending on the interests of the observer, however the key criterion is the financial return to the producer. The results of this exercise are shown in figures 1 and 2, and are based on flat profiled summation of scores without weightings. The higher the subjective score, the higher the return to the grower/farming sector, regional impact or cultural impact.

**Workshop**

An interactive workshop was held in Mold, North Wales to enable key influencers and other interested parties to discuss and provide feedback on interim findings.

**Crop enterprises**

Overall crop scores for returns to the grower sectors are similar across a wide range of crops. This score actually reflects on the scale of returns that the grower could expect compared to current enterprises, the potential demand for product and the ease of access to market. In many of the highlighted cases market demand is low compared to current arable crops so area of production will be very limited. However the actual returns that growers could receive vary from £400-450/ha for industrial oil and healthcare oils and fibre crops (*e.g.* High Erucic Acid Rape (HEAR), crambe, borage, hemp and miscanthus (for fibre)) which is typical of returns from current oilseed crops. In contrast specialist crops such as echium, peppermint, woad and poppy can realise returns of £500 – 700/ha, but areas of production are very limited (UK areas are of the order of only a few hundred hectares and are likely to remain low).

With many industrial oil crops, unless material can be retained in Wales for processing then there is little opportunity to add wider value, this is likely to affect crops such as borage, evening primrose, crambe, HEAR and poppy *etc.*, where crops are grown on contract and loads are shipped to a central processing facility. Unless local markets can be developed to add additional value to the basic oils. Fibre crops offer more potential for added processing and Wales suits the growth of crops such as hemp and miscanthus (which although being evaluated as an energy crop also shows potential for use in technical fibre production). As UK facilities for such crops are still being developed to meet growing EU demand there is opportunity to develop facilities in Wales building on developments at the Biocomposites Centre in Bangor. There would also be potential added benefits to the wider economy though production of natural textiles with outlets for tourism *etc.* In the longer term, novel crops such as nettle offer possibilities to add interest and value to this niche market and could help diversify the markets of fibre processing plants to protect against market volatility and competition *etc.*

With other 'niche' crops such as echium (healthcare), calendula (essential oil), woad (dye) and peppermint, there is potential to add value in the locality by developing small extraction facilities, and adding further value by developing products locally. In general the tonnages for processing are low but of high value. In some cases further development is required to develop crops commercially (*e.g.* woad). Ideally industrial extraction and processing plant could be utilised to cope with a range of plants *etc.* to diversify risks in the face of volatile markets. In many cases there would also be benefits to local tourism for example through the development of natural dyes and use of natural yarns and fibres *etc.*

**Animal enterprises**

A number of the most promising animal enterprises rely on adding value to produce (Figure 2). There is a growing interest in alternatives to cows milk and more importantly in processed products such as goats and sheep cheeses which can be locally branded. More novel enterprises such as mozzarella production from water buffalo also offer potentially high returns to the farmer. However, only those with the best grassland pasture are likely to be able to capitalise on such enterprises. These enterprises offer the opportunity to add significant value to the local economy and to raise the profile of Welsh produce but there would need to be significant investment to stimulate development of these enterprises.

There is increasing demand for novel meats such as venison and wild boar and there is potential for increasing production in Wales. Wild boar offers very high returns, but it is a licensed operation and requires careful management. Marketing has proven to be difficult to date. With venison, Wales has the capability to capitalise on venison production by developing breeding enterprises in the uplands and links to finishing enterprises in the lowlands which could be used to help increase returns for the less profitable upland breeding units.

There is potential to exploit the natural habitat for honey production. Cheap imports mean that the market price for mixed-flower honey is low. This is an enterprise which though limited in size, offers opportunities to add value locally and which could compliment other flowering novel crop developments.

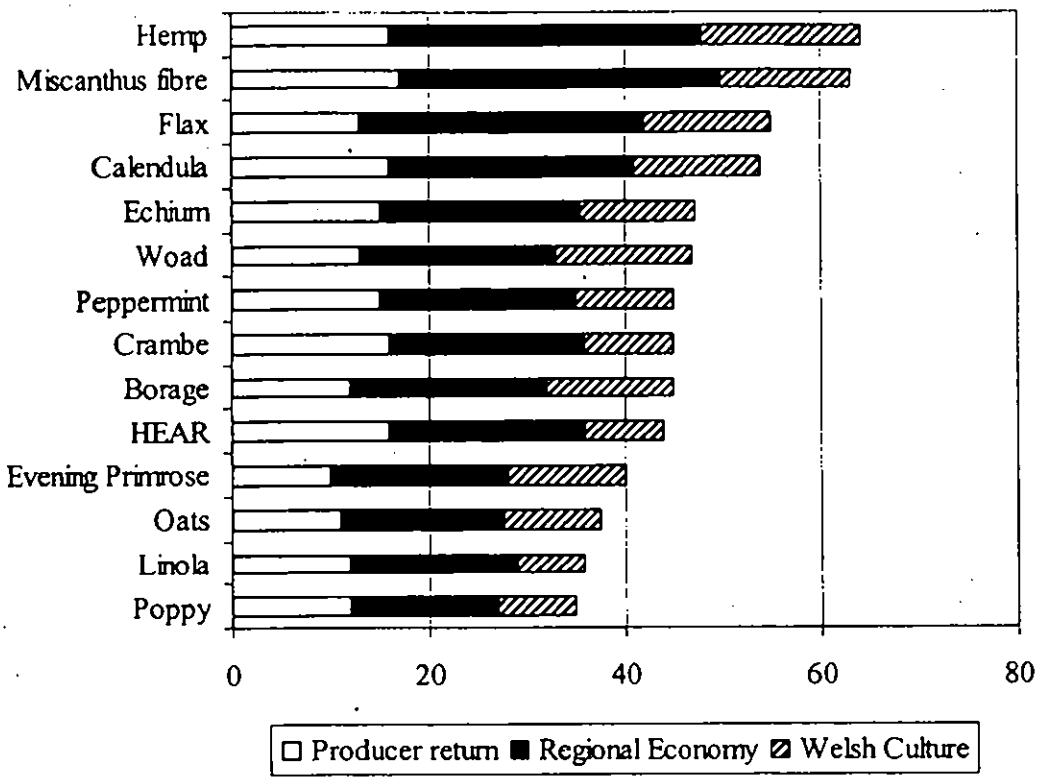


Figure 1. Results of scoring to assist with prioritisation of plant-based enterprises

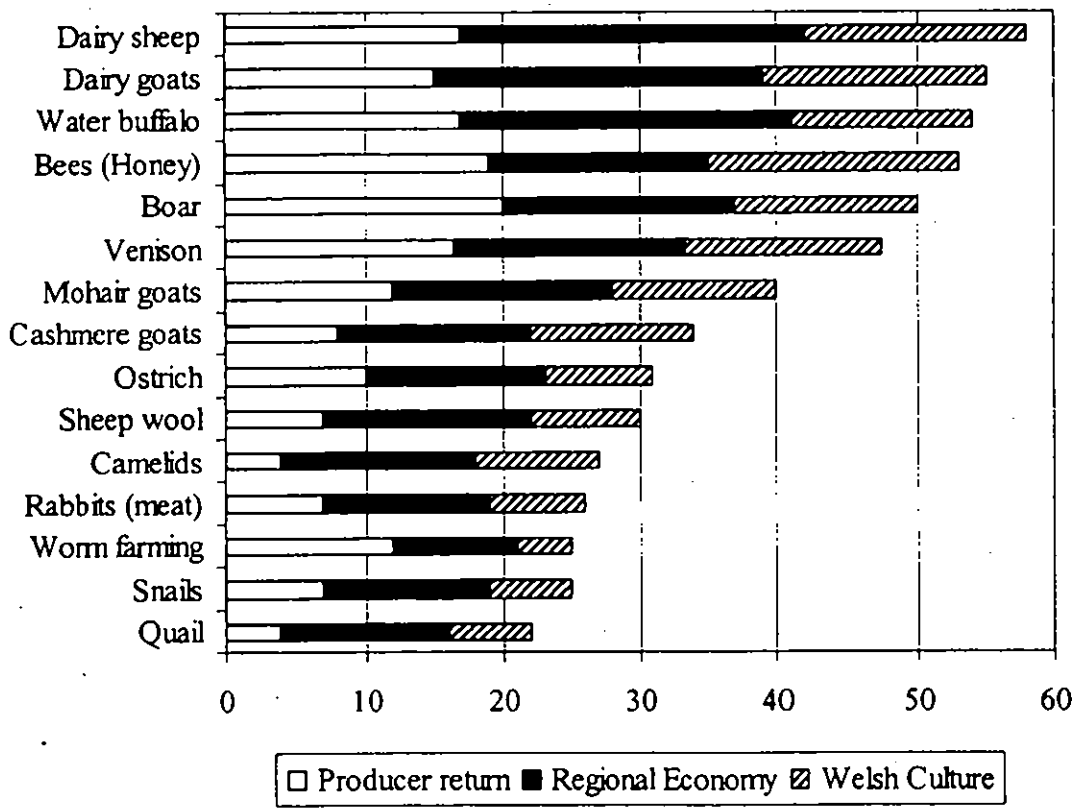


Figure 2. Results of scoring to assist with prioritisation of animal-based enterprises

The markets for ostrich and camelids appear to be saturated and limited by problems in selling by-products abroad (ostrich hides). Profitability is linked to breeding enterprises, but as the returns from fibre production (camelids) and meat (ostrich) are low, it is unlikely that breeding markets are sustainable long-term. Profitability of current ostrich enterprises relies increasingly on direct marketing of meat through farmers markets *etc.* to ensure the best returns.

In the longer term there is potential to add value to upland sheep fleeces which are currently virtually worthless in the face of high quality Australian and New Zealand imports. The use of processed fleeces for building insulation is being investigated, but current costs make the final product three times as expensive as current insulation materials, though insulation based on wool may have some benefits in terms of fire retardation *etc.* which could result in niche markets. While such developments are unlikely to result in an improvement in returns to farmers, it would have wider benefit to the rural economy.

**Processing facilities**

Wales already has facilities for processing flax fibre at Bangor. This provides an area of expertise in the North Wales area for processing fibre crops. The close links of this facility with the Biocomposites Centre at Bangor means that there is a cluster of key expertise in fibre extraction and down-stream processing of fibre crops. This expertise could be used to develop a number of alternative generic fibre crops, looking to crops which are currently well developed as well as those that may show potential in 3-5 or 5-10 year timescales.

There are no seed oil crushing or refining plants of any commercial size located in Wales. The nearest large scale crushing and refining plant is located in Liverpool (Cargill). This adds significantly to haulage costs and Wales is therefore generally at a disadvantage to the rest of the UK where commodity oilseeds are concerned. However, small scale processing of niche crops could still provide a useful income stream. There are no commercial facilities for small scale extraction and refining of oils in Wales, but there are facilities in Tamworth Staffordshire, which is within relatively easy reach of North, East and South East Wales. Other areas of Wales lack access to such facilities. Pembrokeshire, Carmarthenshire and Ceredigion need to invest in small scale crushing and refining plant to take advantage of their potential for novel oil crop production.

Processing of dairy products into cheese is currently carried out at three locations in North Wales. To take advantage of the significant areas identified as having potential for dairy sheep, goat or water buffalo production in South Wales there would need to be development of local processing facilities. Appropriate location of small scale processing facilities would make it easier to brand produce for small niche outlets interested in speciality cheeses *etc.* However, there is a significant amount of hygiene and other legislation which would have to be complied with, plus significant set-up costs, which means that piecemeal development is unlikely.

Based on its traditional livestock markets, Wales is relatively well supplied with abattoirs, though there are gaps in coverage in the northern half of mid-Wales in areas around Southern Gwynedd, Northern Powys and in some areas of South East Wales. A significant number of abattoirs are organic registered abattoirs, which suggest that

they are prepared to deal with small volume processing and the interruption to normal processing that this entails. They are also able to deal with issues of separation and maintenance of produce identity, which is key to assurance where branded products are concerned.

Steps are being taken to add value to wool fleeces. An old wood depot in Gwynedd is being renovated to develop a plant which will produce thermal insulation from low grade wool collected from North West Wales.

**Top 10 priorities**

On the basis of information and data gathered in this study, the 10 crops/enterprises deemed most likely to be successfully in Wales, and most likely to add value to the wide community in the short and medium term are listed in Table 3.

Table 3. Top 10 prioritised enterprises for Wales

| Timescale | Plants | Animals |
|---|---|---|
| 0-3 year | Hemp & or Flax* | Dairy Sheep |
| | Miscanthus | Dairy Goats |
| | | Wild Boar |
| | | Venison |
| 3-5 years | Nettle | Wool – added value |
| | Woad | |
| | Oats | |

* Depending on identified potential in different areas of Wales

These represent enterprises where there are currently least barriers to adoption and technical leads or developed processing facilities exist in Wales. It also includes a longer term speculative indication of enterprises that could have a significant impact on Welsh agriculture given sufficient investment and development in the interim.

These enterprises represent areas where further development and investigation should be focussed to provide the greatest returns for Welsh farmers and the wider Welsh economy. That is not to say that other enterprises discussed in this study should be dismissed but they are currently considered to be of lower priority than those listed above. Markets can change significantly and quickly and technical developments can overcome constraints affecting some enterprises. A watching brief should be kept on all the enterprises highlighted in the initial prioritised list as these are known to have potential for exploitation in Wales.

**Support**

To aid development, in many cases support for market development will be required. Marketing is a time consuming and costly process, closing of the gap between producer and purchaser is required to stimulate development. Support for the development of co-operatives for development or marketing could also assist the establishment of new enterprises.

With novel animal species, costs of fencing and measures to prevent escape can be considerable and may require assistance in the short term. Where further on-farm or centralised processing is required then assistance with costs of investment and business planning will be required.

Training will be required in areas such as animal handling for novel species and food hygiene regulations *etc.* for those involved in the food sector.

Support for development of small processing facilities for dairy enterprises, fibre or oil crops may be required to stimulate local development.

**Further development**

This study is not the end but a starting point in an exercise to identify novel crop and animal species for Wales. There are a number of technical, practical, logistical, market and support actions required to realise the potential of enterprises identified in this study. In some cases detailed information is lacking and further work will be required on a local basis to assess the feasibility of developing the above prioritised enterprises and to develop plans to site processing facilities. The GIS data used in the mapping exercise highlights potential (but not necessarily exclusive) areas of production of various enterprises and should provide a focus for attention at a local scale for development of demonstration facilities to encourage technology transfer.

## 1. INTRODUCTION

In July 2002, A consortium led by the Agricultural and Rural Strategy Group at the Central Science Laboratory, which included the School of Agricultural and Forest Sciences at the University of Wales, Bangor (UWB) and the Centre for Ecology and Hydrology based at UWB, was commissioned by the Welsh Development Agency (WDA) to undertake "a study of the economic potential of plants and animals not currently fully exploited by the Welsh agricultural sector". This work compliments concurrent work being done by other groups developing action plans for the WDA on alternative forest products, biomass energy production, horticulture, aquaculture and the potential markets for fibre production. So these areas are not covered in this study.

### *1.1 Aims*

The overall aims of the work are to evaluate the agronomic and commercial potential of novel plant and animal products for Wales, taking into account the environmental conditions that exist and any potential environmental consequences that may occur as a result of implementation.

## 2. METHODS

The project was designed to run as two linked phases of four parts as follows.

Phase I – Prioritisation of crops and animal species.

I.i – Compilation of a primary list of animal and plant species and evaluation of crop agronomy and animal husbandry requirements.

I.ii – Development and launch of a web site to host information generated by the project.

I.iii – Assessment of the availability of Geographical Information Service (GIS) databases and capabilities, within the limits of the project budget and timescale, to map potential areas of production.

I.iv – Initial prioritisation of enterprises on the basis of agronomy/husbandry and anticipated environmental impacts to derive a secondary list of enterprises with commercial potential.

Phase II – Evaluation of commercial opportunity.

II.i – Evaluation of economic, social and cultural impacts of the prioritised list of enterprises.

II.ii – Evaluation of the commercial potential of the prioritised enterprises.

II.iii – Further prioritisation on the basis of findings regarding commercial viability, feasibility, environmental sustainability and economic, social and cultural value.

II.iv – Recommendations for further evaluation and research

*2.1. Primary search for species of interest*

An initial extensive list of plants and animals with potential for use in a range of food, industrial and pharmaceutical market sectors was collated from a range of information sources including; IENICA, Plants for a Future Database, BioMat Net, other general web searches and from books, reports and literature searches. A list of the sources consulted is detailed in Appendix I. In addition, further crop and animal species were included based on the experiences of CSL in this subject area. The initial list comprised over 150 plant species and over twenty animal species.

The preliminary list of plants and animals was continually updated throughout the project as further information was obtained from each phase of the project. At this stage of the project, of the species showing some potential for development, 43 plant species were identified as currently growing in Wales and a further 11 were identified as native to Wales.

For some of the reviewed plant and animal species information regarding current and potential production is limited. Where this is the case it has been difficult to predict whether there is potential for successful production in Wales. In addition, where plants are not currently grown on a commercial scale there is only limited attention being paid to breeding programmes to improve the potential of the crop. In such situations the limitations to increased productivity are currently unknown.

An information sheet was compiled for each plant and animal species considered. This was used to collate information on habitat requirements, potential uses, basic production and agronomy along with information on potential impacts of commercial exploitation on the environment, related species and sensitive habitats. The availability of information varied considerably between species and depends on the current degree of commercialisation achieved. The templates are available from the searchable web site developed as part of the project (section 2.5) and are provided as an annex to this report.

2.2. *Prioritisation of plant and animal species based on climate, soils, agronomy and suitability for production in Wales*

For each of the plant and animal species an information search was undertaken to determine whether it was suited to production under soil and climatic conditions found in Wales. Based on agronomic/husbandry, soil and climatic information for Wales it was possible to derive data on the following for all areas of Wales, against which prospective species could be screened.

i Frost tolerance of each species and dates of first and last frost (length of available growing season – and likelihood of problems with late harvesting).

ii Agroclimatic zones (length of growing and grazing season allowing assessment of likelihood of problems with late harvesting or poaching of ground by animals *etc.*).

iii Annual rainfall.

iv Soil type/suitability and period between the start and end of soil moisture deficit (period of soil workability).

v Altitude and topography.

GIS maps were obtained for all of the above criteria to highlight the range of situations pertaining to Wales. In addition, for analysis of animal enterprises, the extent of heather occurrence in Wales was also determined (for heather honey production) and the areas of improved and unimproved grassland were identified to assess suitability for grazing animal enterprises *etc.*

Analysis of current and potential yields, objectives of current breeding programmes for identified plant species and constraints to increased production facilitated further elimination of crops identified as having limited potential at present. Plant species showing agronomic or market potential were checked against records of natural occurrence in Wales using flora citations (*e.g.* Preston, Pearman and Dines, 2002), to identify species most suited to production in the locality.

*2.3 Prioritisation based on market development of the crop/animal or derived products.*

Based on information gained from the search highlighted in 2.1 above and other information on markets for renewable raw materials (see section 4.0), plant species were ranked for anticipated market potential based on the criteria of range of market outlets, size of market outlets and potential market value to give a 1-3 ranking assessment of market potential based on the best available market information, where 3 represents well developed market potential. The results of this are presented in the tables in Appendix II. For the animal species identified, market commercialisation is much better developed (Appendix IV), allowing a more detailed assessment of market potential and ranking of enterprises.

The actions in 2.1 to 2.3 above were used to draw up an initial prioritised list of 27 plant and 12 animal species for further evaluation of environmental and economic impacts to allow further prioritisation.

*2.4 Environmental impacts (actual or predicted)*

Once the preliminary list of species had been shortened to produce a secondary list, an assessment of the potential environmental impacts was undertaken to highlight any potential issues of concern.

A matrix was created to score the actual (or envisaged) impacts on soil quality (risk of erosion, loss of structure and impacts on organic matter status) flood risk, risk of water pollution, air quality (odour, $CO_2$ and Methane (animals) emissions), agrochemical and fertiliser inputs, and landscape. The impact on biodiversity was assessed in relation to;

1) Risks to existing genetic resource base (*i.e.* risk of contamination of the local genetic resource by native species from commercial strains or cultivars, or arising from potential to cross fertilise with non-native species).

2) Potential to impact on native diversity (*i.e.* in the case of plants, benefits for native invertebrates from flowering species, or in the case of animals the risk from escapees via grazing damage or competition with native populations).

3) Potential impacts on ecological value of wildlife or semi-natural habitats (*i.e.* potential to become a weed or pest species to the detriment of native habitats).

Most plant species were assessed as having no effect on habitats in the absence of information on characters such as invasiveness or competitive ability in local habitats.

Environmental impact assessment scores were allocated based on quantitative data where this was available. Where no quantitative data was available then decision were based on what is known of related species or by extrapolation from characteristics of the species. The matrices use slightly different criteria for crops and animals to reflect the different potential impacts. Short descriptions of the major environmental impacts for each species are presented in section 6.

In general, it is assumed that perennial crops will benefit soil structure and reduce the risk of erosion and flooding, although soil structure may be adversely affected by any winter harvesting of perennial crops (*e.g.* for biomass and fibre markets). Impacts on soil organic matter status were judged against known impacts associated with wheat cropping, assuming that wheat straw is removed in Wales. Therefore novel crops are anticipated to have a positive impact on soil organic matter content if plant residues are incorporated rather than removed.

Carbon dioxide emissions from energy consumption will be lower where fewer cultivations and agrochemical inputs are required. Perennial crops in particular are anticipated to have a positive impact relative to winter wheat.

Impacts on landscape are difficult to quantify and may depend on circumstances and scale of planting. Plants with brightly coloured flowers (depending on the colour – yellow being less distracting when OSR is also in flower), tall crops and biomass crops left standing over winter were assessed as having a relatively negative impact on the landscape.

Impacts were assessed as being +ve or –ve compared with a common control. In the case of crop species, anticipated environmental impacts were compared to those that might be expected from winter wheat cropping. For example spring sown oilseed crops require less nitrogen than winter wheat and so would attract a +ve ranking against fertiliser inputs. It is assumed that species such as Bog Myrtle would be exploited in their existing natural habitat. In such cases, the impacts were assessed against the same but unexploited habitat.

Impacts of outdoor animal enterprises were compared with those typically expected from sheep farming. Indoor animal enterprises (*e.g.* worm farming and rabbit farming are very limited in scale and are anticipated to have little significant impact as part of a larger farm enterprise where waste can be adequately and safely disposed of *etc.*

Impacts of individual species were ranked against the impacts of the above control enterprises as follows for each criteria (see Appendix V and VI)

0 no effect
-/0 could have a more detrimental impact in some circumstances
+ or - some positive or negative impact
++ or -- significant positive or negative impact
(+) or (-) extrapolation but no direct evidence
? Insufficient information on which to base a judgement

Impacts on biodiversity and habitat were assessed with respect to escapes (Appendix VI). Impact on the existing genetic resource base is assumed to be negative where the crop is related to Welsh native species or where there may be a potential for a non-native species to cross with a related Welsh native species. Crops which are beneficial for invertebrate species, as host plants or nectar sources, are considered to have a positive impact on biodiversity. Spring sown crops are likely to benefit a range of other species, particularly if they follow an overwinter stubble which provides a food source for higher trophic groups and where weed populations can be tolerated. Crops which could establish invasive populations are assessed as having a potentially negative impact on semi-natural habitats.

### *2.5 Socio-economic analysis*

An assessment of the socio-economic impact of existing or new commodities derived form agriculture is made by assessment of the economic output (gross or net) of the feedstock production system or processing plant and/or on resulting employment in the wider economy. Changes in feedstock prices or costs of processing have a significant impact on output and employment. Such changes are difficult to predict as they arise from a complex interaction of many variables. Changes in output and employment are assumed to be the result of a well-defined relationship, however the value of any production/function or 'rural multiplier' commonly used in such analyses will change over time.

*Direct, induced and indirect effects*
Impacts of farming enterprises on the rural economy are estimated by evaluating cash flows in the rural economy arising from cultivating a crop. This generates a direct income and attracts subsidies. After deduction of costs of production and fixed costs (money which usually fails to enter the rural economy to any significant degree), the remaining cash (net income which represents farmer and labourer income) can be spent locally and has a *direct effect* on the rural economy. At the same time, the growth in any particular sector of the rural economy is likely to have positive effects on related sectors. This is because of the interconnection in the production system. Such effects occur in terms of additional income and employment. These effects are assigned '*multipliers*' which provide an approximation of the total effects applicable to the primary production.

In the simple case of farm management costing, gross margins are used to indicate the economic impact of a crop. Such gross margins do not include elements for fixed costs (since such costs are not specific to a single crop but to the business as a whole) and therefore they overestimate farm income. Despite this, they can be used to provide an approximation of income flow into the local community for a particular crop enterprise.

'*Induced effects*' concern the effects associated with spending of the additional income generated (known as a 'Keynesian' multiplier).

Multipliers can be derived to assess the production relationship between different parts of the economy (*'indirect effects'*). For example, an increase in the production of a commodity (for example oilseed rape) will have an impact on related industries (fertilisers, pesticides, oilseed processing industries) boosting both output and employment in these related industries. The magnitude of these indirect effects depends on the level of interconnection and is reflected in the scale of the applied multiplier (known as a 'Type I' multiplier). Adding the effects of the Keynesian multiplier (induced effects) (representing subsequent expenditure) to that of the Type I multiplier produces a 'Type II' multiplier.

Multipliers have not been developed specifically for many crops, and some of the crops highlighted in this study are in some cases not well developed. However, it is possible to estimate multipliers for the above crops based on multipliers generated for enterprises such as cereal cropping, cash cropping or hill sheep production.

Table 2.1 illustrates the Type I and Type II multipliers applicable to cereal crops, other cash crops and upland sheep production.

Table 2.1 Economic multipliers for cereal crops, other cash crops and upland sheep Leat *et al.* (1989).

| | Cereals | | Other cash crops | | Sheep | |
|---|---|---|---|---|---|---|
| | Income | Employment | Income | Employment | Income | Employment |
| Type I | 2.22 | 1.56 | 1.68 | 1.21 | 2.14 | 1.73 |
| Type II | 2.67 | 1.75 | 1.78 | 1.34 | 2.57 | 1.92 |

*Comparative analysis at the farm level*

It is assumed that in most cases the introduction of new enterprises in Wales will be at the expenses of more traditional arable crops or livestock enterprises. For new crop enterprises, comparison with either Cereals or OSR enterprises will be made and for new or novel livestock enterprises with hill sheep farming.

*Arable cropping farm*

Winter wheat typically generates a gross margin of around £500/ha (based on average yields) (Nix, 2002). Considering the induced and indirect effects, applying the cereals income multipliers (Table 2.1), the total value added equates to between £1,110/ha and £1,335/ha respectively flowing into the rural and wider economy.

Management of winter wheat requires

Ploughing – 1.4 hours/ha
Cultivating – 1 hour/ha
Drilling/sowing – 1.3 hours/ha
Basal Fertiliser application – 0.4 hour/ha
Spraying –1.3 hours/ha
Fertiliser top dressing –1.2 hours/ha
Combining and crop store work – 3.4 hours/ha

Total input = 10 hours/ha.

The cultivation of 100 ha of winter wheat therefore requires approximately 1000 man-hours. Based on a working year of 1,963 hours (Nix, 2002), managing 100 ha requires 0.5 man years. If we consider the induced and indirect effects of this production in the wider farm enterprise and rural economy the employment potential increases to between 0.78 and 0.875 man years per 100 ha of cultivation.

Winter and spring OSR average gross margins are around £445/ha and £325/ha respectively. By taking into considerations the induced effects (indirect effects) the total value added to the rural economy equates to £988/ha (£1,188/ha) for WOSR and £721/ha (£868/ha) for SOSR

Management of winter OSR requires

Spraying – 0.6 hour/ha)
Fertiliser top dressing – 1 hour/ha
Windrowing and combining – 5.5 hours/ha
Cultivating, drilling and barn work (5.3 hour/ha)

A total of 12.4 hours/ha (10.8 hours/ha for spring OSR).

The cultivation of 100 ha of winter OSR requires 1,240 man hours, So, 0.63 man years are required to manage 100 ha of winter OSR. If we consider the induced and the indirect effects, the cultivation of 100 ha of WOSR will generate employment of 0.98 – 1.1 man/years.

The cultivation of 100 ha of spring OSR requires 1,080 man hours. So, 0.55 man years are required to manage 100 ha of spring. If we consider the induced and the indirect effects, the cultivation of 100 ha will generate employment of 0.86 – 0.96 man/years.

Livestock enterprises
Upland sheep typically generate a gross margin of £29.2/ewe. (Nix, 2002) Given a stocking rate of 9.5 ewes per forage hectare, this equates to a gross margin of £277/ha. If we consider the induced and indirect effects by applying the type II multiplier from Table 2.1, the equates to an induced effect of £712/ha (or £75/ewe).

Managing sheep requires approximately 4 hours/ewe (based on 1 full time shepherd managing 600 ewes with additional help at lambing time). Considering the induced and indirect effects (type II multiplier) this equates to 7.7 man hour per year per ewe.

The above examples of traditional enterprises in Wales will be used for comparison with the highlighted novel and new enterprises to identify whether they provide additional value to the Welsh farming and rural economy.

To assist with final prioritisation, based on the above assessments a detailed evaluation of commercial viability was undertaken. Where data was available, an analysis of the economic impact at the farm level and in the wider rural economy was evaluated or estimated. Based on the methodology outlined above and assessment of the potential for added value processing beyond the farm gate a final prioritisation was undertaken on the basis of scoring against the following criteria on a 1-10 scale.

1. Return to producer sector
Return to the farmer, size of market that could be captured and ease of access to market.

2. Return to the regional economy
Return from the total area of land that could support the enterprise, number of jobs created, potential for post-production processing (adding value) in Wales and number of potential jobs in post-production.

3. Cultural factors
Practicality of implementation given the current skill base, potential to enhance Welsh agriculture and potential to enhance other rural industries such as tourism.

The weighting given to scores in each of these criteria differs depending on the interests of the observer, however the key criterion is the return to the producer. The higher the subjective score, the higher the return to the grower/farming sector, regional impact or cultural impact.

*2.6 Web site*

As part of the project an interactive website was established to display information on all aspects of work carried out. The website is currently hosted by CSL and can be found at http://safs.csl.gov.uk. It describes the scope of the study and hosts project reports.

A full information sheet is available on the website for 94 of the initial selected plant species capable of growing in the UK and for 20 animal species. These sheets provide details on agronomy, husbandry and potential impacts of each species. The full list of plant and animal species can be searched by English/Welsh/Latin name or potential uses. A simple e-mail link was established to allow feedback from individuals or organisations using the site.

The site also hosts GIS maps (see 2.6) for the prioritised species to allow viewers to identify potential areas of production.

*2.7 GIS Mapping*

The key aim of the mapping phase of the project was to use GIS techniques to highlight areas of potential optimal production in Wales. A GIS is a computing environment that allows users to handle geographically referenced data. Data can be captured, processed, analysed and then output in the form of maps. Two GIS systems were used, ARC/INFO and ArcGIS. ARC/INFO was used to carry out the processes to define areas of potential optimal production and ArcGIS to produce the final maps.

Geographical data can be held in two ways on a GIS, as vector data or raster data. With vector data, information is stored as a series of co-ordinates. Data can be stored as discrete points, lines or closed polygons. With raster data, the information is stored as a series of discrete cells held in rows and columns to form a grid. Each cell has a value, for example the amount of rainfall or soil classification. In ARC/INFO a raster dataset is referred to as a grid coverage. The GIS work used grid coverage for two main reasons. Firstly a number of the data sets were already held or were readily available as grid coverages. Secondly, overlaying grid coverages is far more convenient than vector coverages.

Data sets were sourced that would help define soil, land use, vegetation, length of growing season and other climatic factors for Wales, against which the known requirements of plant and animal enterprises could be judged.

The following data sets and resources were used. The resolution at which the data are held is also given:-

Simplified soil map (from the National Soils Resources Institute) – 5km$^2$ resolution

Met Office Rainfall from GISevices - 5km$^2$ resolution

Number of days between first and last frost (from horticultural website) – 5km$^2$ resolution

Slope and altitude from digital elevation model (held by CEH) – 50m$^2$ resolution

Relief regions (from Brown 1960) – 100 m$^2$ resolution

Urban areas (held by CEH) – 100 m$^2$ resolution

All woodland (held by CEH) – 100m$^2$ resolution

Woodland greater than 300ha$^2$ (held by CEH) – 100m resolution

National Park Boundaries (held by CEH) - 100m resolution

Sites of Scientific Special Interest (held by CEH) – 100m$^2$ resolution

Areas of heather, to map the potential for heather honey production. (held by CEH) - 100m$^2$ resolution

- The following information from Phase 1 maps from Countryside Council for Wales (CCW) – all at 100m$^2$ resolution (from UWB):-

    Arable land

    Improved grassland

    Semi-improved grassland

    Unimproved grassland

Where required, the sourced data sets were converted from vector coverages and geo-referenced images to grid coverages.

It is possible to combine large and small resolution grid coverages without losing the detail of the smaller resolution grid coverages. When the overlaying process takes place the large resolution grids are resampled so that they are the same resolution as smaller resolution grids.

A routine was written for each potential crop and animal enterprise. The routine overlays the relevant grid coverages to define the areas of potential optimal production. ArcGIS was used to produce the final maps. In a few cases, for example, Oilseed Rape and Madder, the requirements were the same. In such cases only one map has been produced.

Final mapping has been carried out at 100m$^2$ resolution. The blocky appearance of the final maps relates to the large resolution of the soils classification and rainfall data (i.e. 5km square). Potential areas of production were defined and mapped for 28 novel crops and 8 novel animal enterprises identified as having potential for Wales via the primary screening process.

*2.8 Feedback workshop*

An interactive workshop was held in Mold, North Wales on 24 Feb 2003 to enable key influencers and other interested parties to provide feedback on the interim findings and to respond to presentations on the results of the project by the project team.

As part of the workshop three interactive seminars provided an opportunity to discuss issues directly with the project team and to raise points for consideration. In addition the content of the established web site and method of GIS mapping used in the project was displayed in informal sessions prior to the meeting and during breaks in proceedings *etc*. Feedback from the event, from informal and formal sessions was recorded and key relevant points are documented in Appendix IX. The comments received, where relevant, were used to amend the content of information sheets developed by the project and were taken account of in drafting of the final report.

## 3.0 AGRICULTURE IN WALES

*Agricultural land use and enterprises*

Of the 2.1 million hectares of land in Wales, 81% is devoted to agricultural use and 12% to forestry and woodland. The majority of the agricultural land is represented by permanent grass and rough grazing (Fig 3.1). In 2000, permanent grazing accounted for 57% of the agricultural area (933,000 ha), rough grazing 27% (442,000 ha (of which 180,000 ha is estimated to be common grazing land)), arable land (classed as capable of being used for arable cropping) 12% (200,000 ha) and the remaining 4% (58,000 ha) on-farm woodland and/or set-aside (Fig 3.1). The area classed as 'arable land' is actually dominated by rotational grass (133,000 ha) production (<5 years old). The area of arable crops stands at around 67,000 ha, of which approximately 12,000 ha are devoted to production of fodder crops. A breakdown of crop area statistics and number of holdings by main farming enterprise is given in Tables 3.1 and 3.2.

Wales currently has a livestock population of around 82,000 pigs, 12 million sheep and lambs, 1.3 million cattle and calves and 10 million poultry birds. Agriculture in Wales is dominated by livestock farming and this has impacts on arable land use for supply of feed grains, animal bedding and protein crops as well as provision of supplementary forage for overwintering or finishing of animals. There are regional variations in the distribution of arable land. Almost half of the current area under arable and forage crops is located in South Wales and Pembrokeshire. This will have a significant influence on the location of any processing plant used to add value to, or process, arable crops where costs of raw material transport can add significantly to costs of production. Similarly, the highest concentrations of sheep and lambs are found in North East Wales and Powys, dairy cows in Pembrokeshire and Camarthenshire and beef cattle in Powys.

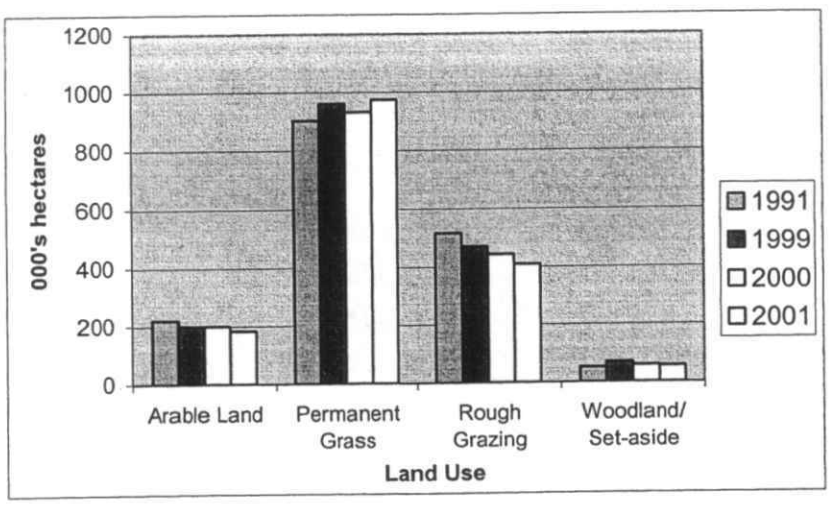


Figure 3.1. Agricultural land use and on-farm woodland in Wales, 1991-2001

Table 3.1 Welsh agricultural land and crop areas in 2000

| | Area (ha) |
|---|---|
| Wheat | 15,361 |
| Barley – Winter | 11,085 |
| Spring | 15,083 |
| Oats | 3,722 |
| Mixed corn | 168 |
| Rye | 51 |
| Triticale | 592 |
| Total cereals | 46,062 |
| Oilseeds | 1,695 |
| Potatoes | 2,677 |
| Vegetables | 627 |
| Other horticultural crops (fruit/flowers/glasshouse) | 1,117 |
| Other arable crops (*e.g.* linseed/s.beet) | 1,906 |
| Total forage crops (maize, swedes, beet, kale, beans) | 12,019 |
| Bare fallow | 3,538 |
| Grass < 5 years old | 133,253 |
| Permanent grass | 933,009 |
| Total arable (excluding rotational grassland) | 67,152 |
| Total arable and grassland area | 1,133,414 |
| Total all woodland | 288,000* |

Source: Derived from Welsh Agricultural Statistics 2001 except * Forestry Commission 2002

Table 3.2 Holding by farm type (2001)

| Holding class by main activity | No's |
|---|---|
| Cereals | 253 |
| General cropping | 162 |
| Horticulture | 370 |
| Pigs and poultry | 401 |
| Dairy | 3,364 |
| Cattle and Sheep (LFA) | 12,143 |
| Cattle and Sheep (Lowland) | 3,218 |
| Mixed | 625 |
| Other types | 8,244 |

*Less Favoured Areas (Tir Mynydd)*

As a result of the lower than average returns achieved from agricultural production in Wales compared to the UK average, almost 74% of the agricultural area is granted Less Favoured Area Status under the Tir Mynydd scheme (the area aid scheme designed to replace the Hill Livestock Compensatory Allowance Scheme with effect from 2001). Therefore, a significant area of agricultural production in Wales attracts special measures to assist farming; 21% of the cropping area lies within an area designated as 'disadvantaged' and 12% within an area designated as 'severely disadvantaged'. This particularly affects land used for fodder crops where 29% of the permanent grassland area is classed as 'disadvantaged' and 48% as 'severely disadvantaged'.

Two thirds of the Welsh cattle herd is present in LFA's, half in the most severely disadvantaged areas. 89% of the Welsh sheep flock is situated in LFA's, with 69% in areas classed as 'severely disadvantaged'.

Support to hill livestock farms ranges from £7-£23/ha in disadvantaged areas and £10.50-£35/ha in severely disadvantaged areas, depending on the size of holding. Additional enhancements to payments are available for maintaining stocking rates at 1.2 livestock units/ha or below which 69% of claimants have accessed. The mid-term review of the CAP may affect the benefits of the scheme from the end of 2003, and it appears there will no longer be provision of a 'safety net' to underpin farm incomes which was established to facilitate the transition from HLCA payments to the Tir Mynydd scheme (by comparison to farm receipts under the HLCA Scheme for 2000). This current uncertainty could affect longer-term business planning.

*Farming income and employment in agriculture*

Total income from farming in the UK has declined by as much as 25% in recent years (Agriculture in the United Kingdom, 2000) Net farm incomes in Wales are currently only between 22 % (Cattle and sheep farms in LFA's) and 51% (Dairy non LFA's) of those in the peak years of 95/96. Cattle and sheep enterprises in the lowlands are almost wholly dependant on subsidy payments. It is reported (Farmers Weekly, Welsh Focus) that in 2000, 15% of agricultural producers in Wales made a loss, the average loss being around £5,500 although in some cases losses were as high as £20,000. Extensive Livestock farms are also very dependant on direct subsidies and environmental scheme payments, in 2000/2001, subsidies accounted for 52% of output on hill sheep farms, and 41% of output on hill cattle and sheep farms (Farm Business Survey in Wales, 2002).

The workforce employed by agriculture continues to decline. Currently there are around 56,000 people employed in agriculture in Wales, this figure is almost ten thousand less than it was over ten years ago. Agriculture supports over 10% of full time employees, if the industry continues to decline, unemployment rates in Wales are likely to be significantly affected.

*Benefits of new and novel enterprises*

The development and establishment of novel crop and animal species and associated industries in Wales could potentially improve many aspects of the rural economy. In addition, local processing and manufacturing plants could create jobs in a range of areas, from marketing to processing and transport.

Wales has an advantage in being able to trade on its regional status and tourism trade. Welsh regional produce has always helped trade in commodities such as lamb, and initiatives such as the marketing of specialist Welsh salt-marsh lamb are good examples of this. Wales is also being recognised for regional production of beef by recently gaining 'Place of Geographical Origin' status. There is therefore an opportunity to add value to certain non-industrial commodities and to take advantage of the tourist trade, though in the case of the latter the seasonality of demand has to be considered.

*3.1 Reform of Common Agricultural Policy and potential impacts on novel crop production*

It is worth noting the possible changes that may occur to the Common Agricultural Policy (CAP) as it is structured today and the implications this may have for future novel crop enterprises on land eligible for arable area payments.

Most minor crops, including many industrial crops, do not receive direct support from the CAP. These crops have traditionally been dependant on area aid payments received when grown under contract on set-aside. The European Commission is currently undergoing a mid-term review as a prelude to reform of the CAP with the aim of reducing expenditure on agriculture. Under current Commission proposals, there would be no financial support for crops other than cereals, oilseeds, protein crops, flax, hemp, linseed and starch potato crops. Set-aside will be non-rotational and the exemption allowing production of industrial crops on set-aside will be removed. Under these circumstances most minor crop might not receive any form of direct subsidy. These proposals have yet to be agreed and there is likely to be considerable debate and lobbying before rules are finalised.

## 4.0 THE MARKETS FOR PLANT DERIVED MATERIALS

The aim of this section is to provide some background information on the present status of the markets for crop derived products and to outline the drivers for future changes. Information on the market is essential. The greatest return on efforts to diversify agriculture will be achieved in those sectors where relevant markets exist.

*4.1 Oils/Lubricants*

*4.1.1 Oils for human consumption*

The UK is a net importer of sunflower and rape oil for human consumption. Linola is an 'edible' variety of linseed which has a high linoleic acid content and low linolenic acid content which makes it suitable as a substitute for sunflower oil (*i.e.* margarine

production), but it also can be used in the nutritional supplement market (see section on Pharmaceuticals). The meal (35% protein content) is also suitable for animal feeding. However, Canada and Argentina are the world's largest producers of linseed (both linseed and linola) and an increase in production could have a destabilising effect on price.

*4.1.2 Industrial oils*

Industrial uses of oil crops include lubricants, surface coatings, polymers and solvents. Total size of the lubricants market for the EU has been estimated at 4.3-4.9 million t/annum (806 kt/annum in the UK). The potential for surface coatings (printing ink industry) has been estimated at 70,000 t/annum in the EU. Erucamide derived from High Erucic Acid (HEA) Rape is used as a 'slip agent' in plastic production. Vegetable oil derived HEA oils have significant potential in all the above markets. Consumption of HEA in the EU was 40,000 t/annum in 2000 and is predicted to increase to 55,000 t by 2005. In addition to HEAR, erucic acid can also be derived from crops such as Crambe in commercially significant volumes.

The use of vegetable oils in the lubricant sector is mainly restricted to hydraulic fluids and chainsaw lubricants, stimulated by environmental considerations. The use of Environmental Acceptable Hydraulic Fluids (EAHF) is facilitated by several international standards (*i.e.* Swedish Standard SS 15 54 34, International Standard 150 1539 and other eco-labels like Blue Angel or White Swan). Similar legislation in other sectors could stimulate growth in the use of renewable oils.

HEAR and crambe oils have a high degree of lubricity and they are used either directly as lubricants or in the manufacturing of lubricants formulations. In the future metal working fluids and motor and gear oils could represent important markets.

Table 4.1 Current EU markets for renewable oils in the lubricant sector

| | *Total EU use (1000 t)* | *Current use of renewable oils (1000 t)* |
|---|---|---|
| Hydraulic fluids | 750 | 34 - 51 |
| Greases | 138 - 400 | 1 |
| Chainsaw lubricants | 40 - 125 | 11 - 29 |
| Mould release agents | 82 - 125 | 4 - 10.5 |
| Motor and Gear oils | 2,400 | 4.5 - 48 |
| Metal working fluids | 338 - 1000 | 2 - 4.5 |

Source: SAC, (2002) unpublished report
(data from EU DG Enterprise) and Oliver (2001).

*4.2 Plastics*

At present the commonly used constituents of plastic are hydrocarbons derived from oil. Such hydrocarbons are not soluble in water, therefore they do not biodegrade. However plastic can be made by rearranging other "natural" polymers like starches, cellulose and proteins. Such polymers are water-soluble and therefore biodegrade. Natural polymers are usually blended with synthetic ones to obtain desirable functional properties. Total plastic consumption in Europe amounted to 32 million

tonnes in 2000, 4 million tonnes in the UK. Packaging accounts for 37% of total plastic consumption. Plant derived biodegradable plastic are principally made from starches (corn and wheat).

*4.3 Natural Dyes*

Existing markets for natural dyes are predominantly in the textile sector and include niche markets for use on natural fabrics. Worldwide it is estimated that 800,000 t/yr of dye is used to colour textiles (Shewry *et al*, 1997). Natural dyes could account for 5% of this market (40,000 tonne/yr). The UK imported 567 t (value € 7 m) of natural dyes in 1997, of which vegetable dye imports (excluding black clutch) were 485 t (value €5 m). The average import value for (plant) natural dyes is € 10-11,000/t. However retail price is much higher (Table 4.3). Prices fluctuate widely across years and between suppliers depending on the quantity and quality of the batch.

Table 4.2 Plant derived dyes

| *Colour* | *Chemical Classifications* | *Common names* |
|---|---|---|
| Yellow and brown | Flavanoids Dyes | Weld, Quercitron, Fustic, Osage, Chamomile, Tesum Dolu, Marigold/Calendula, Cutch |
| Yellow | Iso-quinoline Dyes | Barberry |
| Orange-yellow | Chromene Dyes | Kamala |
| Brown and purple-grey | Naphthoquinone Dyes | Henna, Walnut, Alkanet, Pitti |
| Red, purple and brown | Anthraquinone Dyes | Lac, Cochineal, Madder |
| Purple and black | Benzophyrone Dyes | Logwood |
| Blue and purple | Indigoid Dyes | Indigo, tyrian purple |
| Neutrals and browns | Vegetable Tannins: gallotannins, ellagitannins, and catechol tannins | Wattle, Myrobalan, Pomegranate, Sumach, Chestnut, Eucalyptus |

*Source: RAISE, 1999*

Table 4.3: Natural dyes retail price

| *Natural dye* | *1000 €/t* |
|---|---|
| Cochineal | 95 |
| Indigo | 50-60 |
| Madder root | 55 |
| Osage orange | 40 |
| Logwood powder | 40 |
| Liquid fustic | 30 |
| Kamala powder | 18 |

Source: RAISE, 1999

Use of natural dyes in large industrial markets has been investigated and they could have potential in the printing inks sector (Researchers at Bristol Uni, Dr S. Hill, *et al.*). However others in the industry (M. Clayton, Sunchemical Ltd.) are more sceptical. At present indigo has significant potential (on the basis of colour yield, solubility, strength, fastness, operator safety and ease of application) for industrial use (denim). Natural and synthetic derived indigo are identical. Indigo is used the largest volumes of any natural dye based on consistency of supply and price.

From the primary list of plants identified, the plant species listed in table 4.4 have potential use as dyes.

Table 4.4 Plant species in the preliminary sift with reported potential for use in dye production

| *Natural dye* | *Market* | *Functionality* | *Price* |
|---|---|---|---|
| Artichoke/Cardoon | * | - | - |
| Bog-myrtle | * | - | - |
| Chicory | * | - | - |
| Common Snapdragon | * | - | - |
| Dyers Bugloss | * | - | - |
| Heather | * | - | - |
| Madder | ** | ** | ** |
| Marigold/Calendula | ** | ** | ** |
| Safflower | * | - | - |
| Sea Buckthorn | * | - | - |
| Sunflower | * | - | - |
| Weld | ** | ** | ** |
| Woad | *** | ** | ** |

Each species is scored with respect to market potential [*= no market potential; **= niche market potential (usually textiles); ***= niche and extended market potential (*i.e.* indigo can be used in niche textile markets and in large denim production)]; functionality [*= poor; **= good for niche markets; ***= good for niche and large markets]; price [*= not competitive; **= not competitive with synthetic, but competitive on the niche market; ***= competitive in both niche and extended markets].

## *4.4 Fibres*

### *4.4.1 Textile industry*

World demand for textile fibre is forecasted to reach 61 million tonnes in 2003. Natural fibres account for 40% of this market. Use of synthetic fibre continues to expand at the expense of natural fibres (mainly cotton and wool) due to expanding use in household, technical and carpet sectors. Cotton will remain the dominant fibre in high-quality apparel markets. In the carpet sector initiatives have been launched to develop products that make better use of low value darker fleeces from upland sheep breeds such as the Herdwick, which are then specifically marketed as Lakeland Herdwick carpets.

*4.4.2 Technical markets*

The potential for use of natural fibres in technical applications is significant. Flax and Hemp have seen increasing use in recent years in biocomposite construction *etc.* and have been taken up for use by the automotive industry in significant quantities (Table 4.5).

Table 4.5 Use of natural fibres in the EU automotive industry (tonnes)

| *Fibre* | *1996* | *1999* | *2000* |
|---|---|---|---|
| Flax | 2,100 | 15,900 | 20,000 |
| Hemp | 0 | 1,700 | 3,500 |
| Jute | 1,100 | 2,100 | 1,700 |
| Sisal | 1,100 | 500 | 100 |
| Kenaf | 0 | 1,100 | 2,000 |
| Coconut | 0 | 0 | 1,000 |
| Total | 4,300 | 21,300 | 28,300 |

Source: Karus and Karup, 2002

The use of fibres in the automotive industry is forecast to increase as they have some significant technical advantages over synthetic fibre-based composites. Environmental drivers may also influence uptake. It is estimated that each kg of natural fibre that substitutes fibreglass in bio composites saves 1.4 kg of $CO_2$ in a whole life cycle analysis (Karus and Karup, 2002). In addition, the "End of life Directive" (EC Directive 53/2000) requires manufacturers to engineer vehicles that are capable of being 95% recyclable from 2015. This could have a significant impact on the use of natural fibres in the automotive industry.

It is also anticipated that there is potential for increased use of fibres in the production of speciality papers. The EU reported a trade deficit in natural fibres for pulp of 50 million tonnes.

By-products from fibre processing have potential for use in animal bedding the potential market is over 40,000 tonne per year (considers only the core fibre). This has a high value in the context of Wales where straw prices are high relative to the rest of the UK.

From the primary list of plants identified, the plant species in Table 4.6 were identified as having potential for use in the fibre sector.

Giant reed: has been studied for use in biomass energy generation and for paper production (FAIR project CT96-2028, Duke *et al*, 2000). However giant reed has not been commercially evaluated so far, so there is no available information on price.

Hemp has the potential to be used in both large markets (automotive industry) and in small niche markets (animal bedding and high quality graphic paper). In order to increase the competitiveness of hemp in the automotive industry, cost saving techniques (*i.e.* blending with polypropylene) are required.

Table 4.6 Plant species in the preliminary sift with reported potential for use in fibre production

| *Fibre* | *Market* | *Functionality* | *Price* |
|---|---|---|---|
| Giant reed | *** | - | - |
| Hemp | **_*** | **_*** | **_*** |
| Linseed/flax | *** | **_*** | *_** |
| Nettle | ** | ** | - |
| Miscanthus | ** | **_*** | *_** |

Each species is scored with respect to market potential [*= no market potential; **= niche market potential; ***= niche and extended market potential]; functionality [*= not good; **= good for niche markets; ***= good for niche and large markets]; price [*= not competitive; **= not competitive with synthetic, but competitive on the niche market; ***= competitive on the niche market and on the extended market with synthetics].

Flax has significant potential in the automotive industry. However UK production has rapidly declined as a result of changing EU support measures. Most flax is currently cultivated in Russia and the Ukraine with small quantities in France and Belgium.

Nettle has potential in the niche apparel market. No data on prices are currently available since it has not yet been cropped commercially on anything other than a test scale. However, articles of clothing have been produced for demonstration of its potential by leading Italian fashion houses, and there is now interest in commercialising sales.

Miscanthus could have potential for use in fibre production in the future. At present the crop is being developed for biomass energy generation. The crop could have use in the building industry and is reported to be suitable for the production of MDF particle board (Hague, 1997). However the MDF market is quite volatile due to large investments in MDF production plants in SE Asia. There may therefore be potential for dual marketing as an energy and fibre crop.

### *4.5 Pharmaceuticals/nutraceuticals/cosmetics/essential oils*

#### *4.5.1 Pharmaceuticals market*

The existing market for medical/pharmaceutical plants is large. In 2001 the UK pharmaceutical manufacturers sales volume was £ 8 bn. The market is conventionally divided into medicines and food supplements (including essential oils). In the pharmaceuticals sector, price is of secondary importance to functionality.

From the primary list of plants identified, the following plant species have some potential for use in this sector (Table 4.7).

Table 4.7 Plant species in the preliminary sift with reported potential for use in the pharmaceuticals sector.

| *Crop* | *Market* | *Functionality* |
|---|---|---|
| Yew | ** | *** |
| Poppy | ** | *** |
| Mugwort | ** | *** |
| Echinacea | ** | ** |

Market: **= niche market; ***= large market; Functionality: **= functional for niche markets; ***= good for niche and large market.

Originally Taxol (for cancer treatment) was extracted from Yew bark, traditionally 900 kg of bark was required to produce 1 kg of Taxol. Today a compound from Yew clippings is synthetised into a Taxol-like substance (Taxotere) by a French company (Aventis Pharma). By this method 3 kg of clippings produce 1 kg of Taxol/Taxotere. Yew clippings Ltd is the only UK company authorised to supply Yew clippings to Aventis. The price offered for clippings range from 35p/kg to over 50p/kg (in 1996). The market is very small and is currently saturated.

Medicinal Poppy is grown for the production of morphine. Total legitimate cultivation is thought to be 247,000 ha (2002). In 2002, 400 ha was grown in the UK. Major competitors are Tasmania and also other EU Countries. The seeds can be harvested and sold for culinary uses.

Recently artemisinin (an anti-malarial agent) was derived from Annual Mugwort. Other potential crops with medicinal applications include Echinacea.

The pharmaceutical market is highly regulated and registration of medicines is time consuming and expensive which inhibits the development of naturally derived medicines. No medicinal product may be placed on the market unless a marketing authorisation has been obtained through the European Agency for the evaluation of Medicinal Products (EAEMP), which will assess safety and efficacy of the medicinal product.

*4.5.2 Nutritional supplement and essential oils markets*

The UK nutritional (retail) market is significant (Table 4.8); a growth of 5% p.a. is forecasted until 2005.

Among the plant essential oils, EPO/starflower oil is the most commonly bought oil. There has been an increasing interest in the use of herbal products, especially St John's Wort.

Table 4.8 UK nutritional supplement market for natural plant oils and herbal remedies

| | *1996 (£m)* | *1998 (£m)* |
|---|---|---|
| *Essential oils* | | |
| Cod liver oil | 97.2 | 92.0 |
| EPO/starflower oil | 53.3 | 38.7 |
| *Herbal products* | | |
| St. John's Wort | 10.4 | 11.5 |
| Garlic | 32.4 | 17.8 |
| Ginseng | 7.3 | 10.5 |
| Other herbals | 11.6 | 12.5 |
| *Other natural products* | | |
| Royal jelly | 7.3 | 7.3 |

Source: Slater, 2000

Table 4.8 Plant species in the preliminary sift which contain oil seeds or essential oils which are reported to have potential in the nutrient supplement sector, or in other novel areas

| *Crop* | *Market* | *Functionality* |
|---|---|---|
| Bog-myrtle | ** | ** |
| St John's wort | **-*** | **-*** |
| Borage | *** | *** |
| Linola oil | ** | *** |
| Evening primrose | *** | *** |
| Echium | *** | *** |
| Valerian | **-*** | **-*** |
| Yarrow | ** | ** |
| Thyme | ** | ** |

Market: *= no potential market; **= niche market; ***= large market; Functionality: *= not functional; **= functional for niche markets; ***= good for niche and large market.
Notice that in the pharmaceuticals sector price is of secondary importance compared to functionality.

Bog-myrtle has been used in Scotland to produce an essential oil that acts as midge repellent. At present the market is not well developed and there are technical problems in commercialising the crop.

Sales of St John's Wort represent around 3% of the UK nutritional supplements market. In Germany it is the most popular prescription drug for the treatment of depression.

Borage, Evening primrose and Echium spp are popular sources of Gamma Linoleic Acid. The market for this is well established but highly volatile.

Linola cultivars of linseed oil are very rich in polyunsaturated linoleic acid (71% of oil content) which is effective in lowering blood pressures and reducing blood clotting. The market for this product is established in UK. The high street price ranges between £ 5.27-18/kg.

Valerian has a niche market for insomnia treatment.

Yarrow has a niche market for use in tea infusions.

Thyme has a niche market as an essential oil used for treatment of degenerative diseases of old age.

A consequence of the increasing acceptance of 'herbal remedies' is likely to be an increasing requirement for standardisation and monitoring, such that herbal remedies may become subject to some of the same level of regulation as conventional drugs, increasing the cost of production. The current production of herbs within the UK is a relatively small area (1,400 ha) and UK herb companies still import large quantities of herbs which could be grown in the UK, though it is difficult to compete on price.

*4.5.3 Cosmetics*

The UK cosmetics market was worth over £6 billion in 2000. Plant derived oils and essential oils are used in cosmetics production but it is very difficult to obtain data on the volumes used by industry.

From the primary list of plants identified, the following plant species have some potential for use in this sector (Table 4.9).

Table 4.9 Plant species in the preliminary sift with reported potential for use in the cosmetics sector.

| Crop | Market | Functionality |
|---|---|---|
| Bugloss/v. bugloss (Echium) | ** | ** |
| Thyme | ** | ** |
| Oats | * | * |

Market: * Limited or unproven market potential **= niche market; Functionality: * limited or unproven potential **= functional for niche markets;

Oil from Bugloss/vipers bugloss (Echium) is the most promising source of stearidonic acid (SdA), which is an important intermediate in the production of a number of important compounds in the body. It also has 'anti skin wrinkle' and 'anti-inflammatory properties. Bugloss/vipers bugloss also contains high levels of Gamma Linoleic Acid (GLA). The oil is currently used in cosmetics.

Thyme provides and essential oil is used for many different purposes - cosmetics, perfumes, and aromatherapy.

Oats have been evaluated for use in the cosmetics sector. Oat flour is a natural emulsifier, and oat protein has potential as an animal protein replacement in shampoos and conditioners. Oat oil and oat beta-glucan also show promising potential for use in sun cream and body lotions. Oats also contain anti-oxidants with potential in the cosmetic and food sector.

*4.6 Animal enterprises*

The markets for animal enterprises are much better documented than those of plant species. A description of the current markets and potential for a wide range of novel and exotic animal enterprises is detailed in Appendix IV.

## 5.0 INITIAL PRIORITISATION

On the basis of assessments and considerations outlined in sections 2.2 to 2.4 a preliminary list of prioritised species was drawn up. As the identified novel animal enterprises tended to be better developed than some of the novel crop enterprises (some of which have not been commercialised at all) separate priority lists were drawn up for the animal and plant–based enterprises. The majority of animal species could be taken up relatively quickly and predominantly problems with market returns, market security, or market outlets currently limit further development (Table 5.2).

In the case of plant species, some have seen considerable development and uptake, but where little commercialisation has taken place there are significant barriers to development related to agronomy or technology or costs of production compared to traditional non-renewable raw materials. In this case it will take some time before commercial development can be realised by the plant species. In this case plant species were provisionally ranked in terms of envisaged limits to uptake and anticipated timescale to fruition (Table 5.1).

This list of species and crop enterprises was used as a basis for further economic analysis, feasibility assessment and analysis of market size *etc.* to further refine and identify the most promising lists of species and enterprises for development in Wales.

On the basis of the results of this first phase of the project, recommendations for further development were be made based an the results of socio-economic analysis, further examination of market potential and identified limitations to development.

Table 5.1 Preliminary prioritised list of plant species

| Time to fruition | Few or no limits to uptake or current development | Moderate limits to uptake or current development | Major limits to uptake or current development |
|---|---|---|---|
| 0-3 years | *Industrial/textile*<br>Crambe<br>H.E.A.Rape<br>Hemp | *Food/feed*<br>Linola<br>*Industrial/textile*<br>Flax<br>*Healthcare*<br>St Johns Wort<br>Valerian<br>Borage<br>Evening Primrose<br>Echium<br>*Food/essential oil*<br>Peppermint<br>*Pharmaceutical*<br>Foxglove<br>Poppy | |
| 3-5 years | | *Industrial/textile*<br>Meadow foam<br>Miscanthus (Fibre)<br>Calendula (Oils & food dye)<br>Woad (dye)<br>*Healthcare*<br>Gold of pleasure<br>Oats<br>*Pharmaceutical*<br>Mugwort | *Industrial/textile*<br>Yarrow (dye)<br>Madder (dye)<br>Native Grasses (Fibre)<br>*Novel*<br>Bog Myrtle |
| 5-10 years | | *Industrial/textile*<br>Spurge (oils/ polymer)<br>Nettle (Fibre) | *Industrial/textile*<br>Giant Reed (fibre)<br>Reed Canary Grass (Fibre)<br>*Healthcare*<br>Sea Buckthorn<br>*Pharmaceutical*<br>Henbane |

Table 5.2 Preliminary prioritised list of animal enterprises.

| Few or no limits to uptake | Some limits to uptake | Moderate limits to uptake | Major limits to uptake |
|---|---|---|---|
| Bees (Honey)<br>Venison (Finishing) | Goats (Dairy)<br>Goats (Mohair)<br>Sheep (Dairy)<br>Water Buffalo (Dairy/Meat)<br>Wild Boar (Meat) | Ostrich<br>Camelids (Alpaca *etc.*)<br>Venison (Breeding (upland))<br>Sheep (wool)<br>Rabbits (Meat) | Quail<br>Snail<br>Worm farming<br>Goats (Cashmere) |

## 6.0 PRIORITISED CROP AND ANIMAL ENTEPRISES

### *6.1 Enterprises with few or no limits to current uptake and realisation of market potential*

#### 6.1.1 Crambe

Crambe produces an oil with a high Erucic Acid content (60%). Its potential applications are very similar to those of High Erucic Acid Rape (HEAR). Isolation distances between crops (required for HEAR production) are not required.

In addition, crambe is a low input crop, requiring few pesticides. The uses of HEA are detailed in section 4.1. Erucyl alcohol from HEA is used mainly in cosmetics market. However, the production of cationic surfactants as active ingredients (various fatty nitrogen derivatives) in the healthcare and laundry softeners markets is well established. Crambe meal can also be used in ruminant feed as a finishing meal, however, due to the high glucosinolate content it is not recommended for feeding single-stomach animals (poultry or swine).

*Socio-economics*

The table below illustrates the potential induced and indirect effects associated with crambe production, based on a yield of 2 t/ha, and a seed value of £150/tonne.

Table 6.1.Induced and indirect effects on cash flow associated with crambe production.

| *Crop* | *Gross margin (£/ha)* | *Type II multiplier* | *Total Value Added (£/ha)* |
|---|---|---|---|
| Crambe | 340 | 2.67 | 908 |

This is a lower return than that associated with HEAR, but the yield potential of crambe is improving with experience. Raising this to 3t/ha, which is achievable in the north east of England, could return £490/ha.

Contracts for up to 12,000 ha of crambe are currently being put out to tender. Wales has the potential to capitalise on up to 2000 ha of this to realise up to 5000 tonnes of production, 1000 ha is perhaps a more realistic target in the short term. Costs of transport to crushing plants may limit uptake.

With respect to employment, it is assumed the cultivation of crambe requires roughly the same effort as spring OSR. With the above anticipated production area, crambe is unlikely to result in significant employment or added value outside the farm gate, except in the transport sector.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Crambe is spring sown and slow to establish so erosion risk will be high in susceptible situations. Crambe is likely to have little impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Crambe is visible in the landscape, it is 2m tall and has white or yellow flowers. There are unlikely to be any impacts on the existing genetic resource base, there are limited benefits for native invertebrate species during the flowering period. Spring sowing following an overwinter stubble may provides a food source for higher trophic groups, particularly bird species. Crambe is related to mustard and therefore seed may persist in the environment for long periods due to long period of enforced dormancy. However, it is not anticipated that it would pose a weed threat to native habitats.

### 6.1.2 High Erucic Acid Rape

Oil from HEAR contains 50% Erucic Acid which has a number of industrial applications as described earlier. In 2000, 20,000 ha of HEAR were grown in UK on set-aside land for industrial uses. The meal is rich in glucosinolates and therefore is not suitable for feeding to swine and poultry, however it could be suitable for ruminants (except lactating animals, since glucosinolates are thought to affect iodine metabolism in dairy cattle) as a finishing meal (Glaser, 1996).

*Socio-economics*

The table below illustrates the magnitudes of the induced and indirect effects associated with HEAR production, based on a yield potential of 2.7 t/ha, and a crop value of £170/tonne.

Table 6.2 Induced and indirect effects on cash flow associated with HEAR production.

| *Crop* | *Gross margin (£/ha)* | *Type II multiplier* | *Total Value Added (£/ha)* |
|---|---|---|---|
| HEAR | 450 | 2.67 | 1,201 |

The labour input for HEAR would be the same as that for spring-sown oilseed rape. It is likely that up to 2000 ha of HEAR could be grown in Wales, based on current payment regimes.

*Processing activities*

HEAR is grown on buy-back contracts for central processing. With the above anticipated production area, HEAR is unlikely to result in significant employment or add value outside the farm gate in Wales, except in the transport sector.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. HEAR rape is predominantly winter sown and generates a crop canopy rapidly, so erosion risk is diminished in susceptible situations. The fibrous deep rooting of oilseed rape is beneficial for soil structure. Where straw is ploughed in, OSR may have a small beneficial impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be similar to those for wheat production. Oilseed rape is visible in the landscape though flowers are only present for a relatively short period in summer. The crop is also already widely grown in the agricultural landscape. There are unlikely to be any impacts on the existing genetic resource base, but benefits for invertebrate species may be observed during the short flowering period. Spring sowing following an overwinter stubble may provides a food source for higher trophic groups, particularly bird species. OSR is a persistent weed species in wasteland habitats where seed is spilled or shed and has very long dormancy, but it is unlikely to pose a threat to native habitats where soil fertility is low.

### 6.1.3 Hemp

Hemp has the potential in both large markets (automotive industry, speciality paper) and in small niche markets (animal bedding and high quality graphic paper), through production of four different non-food materials; long bast fibre, medium fibre, short core fibre, and seed oil. Though the crop has to be managed differently to optimise the fraction of interest. For example, fibre quality declines if the crop is left until seed fully matures, but mature seed is required to optimise oil yield and quality *etc.* However, current EU production rules insist that the crop cannot be cut until seed has been set. Hemp by-products are competitive in the quality animal bedding market. For hemp to increase its competitiveness in the automotive industry cost saving techniques (*i.e.* blending with polypropylene) are required. Hemp is reported to be the longest and strongest of the natural fibres, having a number of advantages over other fabrics. Compared to cotton, as well as being stronger and longer, hemp fibres are more lustrous and absorbent and more mildew resistant. Seed can be used in the cosmetics industry for moisturisers.

Hemp fibres have a number of advantages over flax, it can match or surpass flax in terms of performance potential and promises to be cheaper. There is currently potential for producing 2000 ha per year, which is likely to double in the near future. Contracts are currently available.

*Socio-economics*

The table below illustrates the gross margin for hemp, assuming average yields of 5 t DM/ha and a return of 110/tonne DM (which yields 65% fibre). This represents a medium price. On farm storage to maintain continuity to processors attracts higher prices. To account for induced and indirect effects, the cereals type II income multiplier was used.

Table 6.3 Induced and indirect effects on cash flow associated with hemp production.

| *Crop* | *Gross margin (£/ha)* | *Type II multiplier* | *Total Value Added (£/ha)* |
|---|---|---|---|
| Hemp | 405 | 2.67 | 1081 |

Cutting the tops early can produce a tonne of seed, providing an additional return of around £200/ha.

Wales could accommodate significant areas of hemp. Up to 3000 ha could be accommodated within current arable rotations (assuming substitution for or complimentarity with the oilseed rape and linseed area). This give an initial potential for 15,000 tonnes of production assuming average yields, though this is likely to rise with experience. Some improvement in margin are possible through increased yield or better returns through sale of by-products.

*Labour requirement*

Cultivation of hemp requires:
Ploughing - 1.4 hours/ha
Drilling - 1.3 hours/ha
Fertilising - 0.4 hours/ha
Spraying - 0.2 hours/ha
Head stripping - 1 hour/ha
Swathing - 0.8 hours/ha
Baling - 1.25 hours/ha

Total labour requirement is 635 man hours per 100 ha. 0.32 Man years are required to manage 100 ha of hemp. If we consider the induced effects (multiplier of 1.75) the added employment effect is 0.5 men per year/ha.

3000 ha of hemp would directly employ 10 people on farm and a further 7 in associated industries.

*Processing activities*

The crop was previously grown in the east of England near to processing facilities, and more recently in the south west, where yields are better, but transport costs are greater. Local processing facilities could improve returns. Clearly small volumes have so far justified establishment of processing facilities.

After harvest natural fibres have to be decorticated and the bast fibres baled (first processors[1]). The core fibres are sold as animal bedding. In the case of the composite industry, substrate suppliers (such as Biofibre in UK) further process the natural fibre to produce non-woven materials. These materials are then shipped to the composite manufacturers. In the case of paper production, fibre bales are delivered to pulping mills[2]. For processing.

Hemp stems contain 20-25% bast fibres and 60-65% core fibres. The composite industry and the speciality paper industry only use the bast fibre. Bast and core fibres could be pulped to produce graphic paper (Capelle, 1996 and van Roekel jr, 1994). Currently the only UK processor for hemp is Hemcore who also control licensing of the crop. In the past, bast fibre was mainly sold to France for speciality paper production. At present the bast fibre is all sold to Germany for the car composite industry. The whole crop is currently utilised.

The farm gate price for hemp ranges from £95-125/tonne, depending on date of delivery. Each tonne of hemp produces 65% of core fibre, sold as bedding at £325-350/t, and 25% of bast fibre sold at £240-350/t (the lower price is for paper pulp). First processors receive a subsidy of £57 per tonne of fibre. Even if processing costs are not available, it is evident that the activity is highly profitable. The table below shows the results of the sensitivity analysis (low and high prices).

Table 6.4 Economic analysis of hemp processing
(for 1 tonne of purchased dry matter)

| | *'Low' prices* | *'High 'prices* |
|---|---|---|
| Core fibre content (% of dm) | 65 | 65 |
| Price of core fibre (£/t) | 325 | 350 |
| Core fibre output (£/t of purchased dm) | 211 | 227 |
| Bast fibre content (% of dm) | 25 | 25 |
| Bast fibre price (£/t) | 240 | 350 |
| Bast fibre output (£/t of purchased dm) | 60 | 87 |
| Total output (£/t of dm) *(1)* | 271 | 315 |
| Farm gate price (£/t of dm) | 110 | 110 |
| Subsidy to processor (£/t of dm) | 14 | 14 |
| Total costs (£/t of dm) *(2)* | 76 | 76 |
| *(1) – (2)* | 195 | 239 |

Each tonne of purchased dry matter (dm) returns £195-239 from processing. 15,000 tons of crop would potentially inject up to £2.9 –3.5 million into the Welsh economy.

[1] In UK Hemcore is the only first processors of fibre hemp.
[2] At present there are no specialised mills in UK for hemp pulping. There are only three of such mills left in Europe (one in France). The majority of UK hemp production goes to Germany for the automotive industry.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Hemp is spring sown and quick to establish so erosion risk will be reduced in susceptible situations. As most of the crop is removed for processing it is likely to have little impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. The crop can be up to 3m tall and so is visible in the landscape. There are unlikely to be any impacts on the existing genetic resource base. Hemp is reported to be beneficial to a number bird species. Spring sowing following an overwinter stubble may provides a food source for higher trophic groups, particularly bird species. Hemp is unlikely to pose a weed threat to native habitats.

### 6.1.4 Bees/honey

There are 30,000 beekeepers in UK, most with less than 40 hives (the EU regards a professional beekeeper as one who operates at least 150 hives). Bees forage in a 2-3 miles radius of the hive and the honey production takes on the flavour of the main nectar sources available in this zone over the season. Where nectar, pollen and propolis are plentiful, foraging may be limited to 1 mile radius of the hive. EU is a net importer of honey, and in recent years prices have been declining. Current problems with contamination of Chinese honey provide an opportunity to stimulate home production. An EU regulation on honey is expected by August 2003.

Managing hives requires some skills in controlling swarms and there is the current risk of varroa mite infestation. Additional income could also be obtained through selling of native queens and hive nuclei

Native bees would be favoured in Wales as they survive the winter with smaller numbers than non-native bees and do not need additional sugar syrup to survive the winter. As native bees use less stored reserves overwinter they are better able to survive prolonged wet or cold winters commonly encountered in Wales.

There is a strong community-based system of beekeeping in Wales. Bees are mainly bought from local or neighbouring beekeepers and are traded at association sales. Most beekeepers raise their own queens and nuclei.

The GIS map in the appendix highlights areas where heather is found, however heather has performed poorly in Wales in most recent year, so potential for heather honey production may be more limited than the resource area suggests. The red areas on the map represent arable areas, but again appear limited. Bees would be able to use all of the arable area available (highlighted in other maps) and in many cases may compliment the numerous other flowering non-food crops such as borage which are rich in nectar.

*Socio-economics*

Typically a hive produces 40-80 lbs/yr of honey, with a return of £1.5-2.5/lb (returns of £60-200/yr/hive and material running costs of £ 20-30/yr/hive). Specialist producers are currently looking to boost their income by producing value added hive products such as wax, propolis, pollen and venom.

The table below illustrates a typical gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated in the methods section; this is because most the enterprise is relatively small and the knock-on effects are likely to be limited.

Table 6.5 Induced and indirect effects on cash flow associated with honey production.

| *Species* | *Gross margin* (£/hive) | *Type II multiplier* | *Total value added* (£/hive) |
|---|---|---|---|
| Honey bee | 30-180 | 1.5 | 45-270 |

Honey production requires 25 man hours/yr/hive. One man year invested in honey production (74 hives) is likely to return a profit (excluding labour costs) of between £6K and £26K. This is a relatively small return and is most likely to be viewed as an additional business venture. Additional value could be added by local marketing and by exploiting Welsh heather.

Initial costs of establishment of a large enterprise may prevent uptake and development.

*Processing activities*

Honey is a readily saleable product providing it is well presented. The introduction of some processing facilities could contribute to the creation of employment and value added in the region. However, the impact on farm employment and processing activities exerted by this enterprise is likely to be small as a consequence of the small scale of the enterprise. It is very difficult to predict the processing costs and value added for such an enterprise where the product is sold raw without processing. However, the small-scale nature of such projects would contribute to diversification of local industry and might help to improve farmers and producers incomes and attract further investment.

*Environmental impact*

Importation of non-native strains of bees could have detrimental effect on native bees managed for honey production and Welsh beekeepers are concerned to maintain native populations. Bees have a positive impact on biodiversity through pollination. No impact on genetic integrity of wild populations would occur because there has already been significant mixing of genetic material in the UK bee population. It has been suggested that increases in honey bee populations may have an adverse effect on wild bee populations because of greater competition, however there is no evidence to support this. There is an issue associated with safe disposal of chemical strips used to

control the varroa parasite, though the volume of material involved is extremely small in volume terms compared to broad-acre crop treatments.

### 6.1.5 Venison

There are 36,000 farmed red deer in UK (mainly in England). Lowland units rear and fatten calves and breed some replacements, while upland units usually sell calves at weaning for fattening on lowland units. Demand is slowly increasing because of food scares and due to the low fat content of the meat. Two market co-operatives have been established (one in Scotland and one in the Midlands) which have stabilised prices and the supply chain. There is also an established British Deer Farmers Quality Assurance Scheme. However, the market is threatened by imports from New Zealand.

*Socio-economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated initially; this is because most of the enterprises identified are relatively small and the knock-on effects are likely to be limited.

Table 6.6 Induced and indirect effects on cash flow associated with venison production.

| *Species* | *Gross margin (£/ha)* | *Type II multiplier* | *Total Value Added (£/ha)* |
|---|---|---|---|
| Venison | 125-740 | 1.5 | 187-1,110 |

The gross margin varies according main activities. Breeding and finishing (lowland) units yield up to £370/ha, upland breeding units yields £125-250/ha and lowland stag finishing yields £740/ha (Nix, 2002). The lower return associated with upland breeding units may jeopardise the lowland activities, by increasing costs of replacements. The initial set-up costs are high (in the range of £50,000 for 100 hinds breeding stock), specialised fencing and handling facilities are required as well as a covered yard if calves are to be overwintered. Most stags are available in autumn, causing oversupply and low prices at this time of the year. In terms of labour, an experienced stockman can manage over 400 head with some help when yarding. Training will be required to ensure handlers comply with pertinent regulations and welfare legislation.

*Processing activities*

The associated processing activities of this enterprise are likely to be small and related to the production of local speciality food. It is very difficult to predict the value added. However the small-scale nature of such projects would contribute to diversification of local industry and might help to improve farmers and producers incomes and attract further investment in the region.

*Environmental impacts*

Grazing of deer will have little impact on intensively managed swards, although their relatively low clover consumption may result in an increase in the availability of clover to other grazers. Escaped animals would have little impact on the wild genetic resource base if red or fallow deer were farmed, although hybrid European Fallow/Mesopotamian Fallow deer could alter the genetics of local or UK populations. However, wild deer are both scarce (around 1% of British population) and are locally distributed in Wales, therefore feral populations could have a significant impact on habitats. Because deer are browsers, farm woodland and forestry will be particularly sensitive to feral deer populations. High fencing associated with deer farming could have an impact on the landscape.

## *6.2 Enterprises with potential limits to current uptake and realisation of market potential*

### 6.2.1 Linola

Linola is a variety of linseed with low linolenic acid content and high linoleic acid content. The seeds are crushed for oil (which is comparable to sunflower oil) or, in small quantities, sold for use in the baking industry. Linola is very rich in $\alpha$-linoleic acid (55-58%) which is effective in lowering blood pressures and reducing blood clotting. The market for this product is established in the UK. The high street price ranges between £5.27-18/kg. The meal by-product contains 35% protein and can be used as animal feed.

*Socio-economics*

The table below illustrates the gross margin and the associated induced and indirect effects associated with linola production.

Table 6.7 Induced and indirect effects on cash flow associated with linola production.

| *Crop* | *Typical gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Linola | 340 | 1.78 | 605 |

The current uptake of linola is poor due to its poor on-farm returns. Linola is currently not financially attractive to growers. Yields are similar to those of linseed 1.4-1.8 t/ha), but seed values match those of oilseed rape (around £170/tonne (despite its lower yield potential)). As a result it cannot compete with returns from oilseed rape production.

Up to 12,000 ha of linola were grown in the UK in 1998, representing 12% of the UK linseed area, however areas of linseed and linola have subsequently slumped. The current area of linseed in Wales is below 1000 ha, but at the peak of production reached 1903ha in 1999. 2000 ha probably represents a realistic maximum area of linola production in Wales given an upturn in financial incentives for linseed/linola production.

Given the relatively small area involved, impacts on farm employment will be very small.

*Processing activities*

Linola is traditionally grown on buy-back contracts which means that production in Wales is likely to be affected by transport distances to crushing and oil extraction plant. To add benefit to the production of oilseed crops it will be necessary to invest in crushing facilities and in marketing. Only around 3000 tonnes of production is likely in Wales which does not to justify investment in crushing plant on its own. The impact on added employment is likely to be very low, and limited to jobs in the transport sector.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Linola is spring sown and slow to establish so erosion risk will be high in susceptible situations. The fibrous rooting of linola is beneficial for soil structure. Linola is likely to have little impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Linseed is visible in the landscape with its small blue flowers, but these are only present for a short period in summer. There are unlikely to be any impacts on the existing genetic resource base, but benefits for invertebrate species may be observed during the short flowering period. Spring sowing following an overwinter stubble may provides a food source for higher trophic groups, particularly bird species. Linola is unlikely to pose a weed threat to native habitats.

### 6.2.2 Goats (Cashmere)

Fibre is produced from Angora and Cashmere goats. Cashmere is the valuable fine undercoat found to varying degrees on all goats (except the angora), which is harvested by combing. It grows as a winter down which is shed in early spring when it is harvested either by shearing or combing. More than 3,000 tonnes of cashmere is produced worldwide, the majority coming from Mongolia with smaller amounts from Iran, Afghanistan, Australia, China and New Zealand from where Scottish cashmere processors traditionally import. There are currently around 50 producers in the UK with a herd of around 2,500 goats. The UK requires a breeding herd of around 2 million breeding females to be self sufficient in cashmere. Feral goats produce a small quantity (50g) of high quality cashmere (less than 16 microns). Through a specialised breeding programme cashmere stock now produce more than 300g. Fibre prices are in the region of £ 70-90/kg and gross margins (from fibre production) are around £10-30/doe.

*Socio-economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated in the

methodology because the enterprise is relatively small and knock-on effects are likely to be limited.

Table 6.8 Induced and indirect effects on cash flow associated with cashmere goat production.

| *Species* | *Gross margin (£/head)* | *Type II multiplier* | *Total value added (£/head)* |
|---|---|---|---|
| Cashmere (fibre goat) (£/head) | 10-30 | 1.5 | 15-45 |

*Processing activities*

The introduction of processing facilities could contribute to the creation of employment and value added in the region. However, the impact on farm employment and processing activities exerted by this enterprise is likely to be small as a consequence of the small scale of the enterprise. It is very difficult to predict the processing costs and value added for such an enterprise. However, the small-scale nature of such projects would contribute to diversification of local industry and might help to improve farmers and producers incomes and attract further investment in the region.

*Environmental impacts*

Goats have a more varied diet than sheep with a lower intake of clover and grazing can be complimentary to sheep, 10-20 goats/100 ewes can compliment each other on rough grazing without the need to change the stocking rates due to their different grazing behaviour. However, goats are browsers and have a very varied diet and feral populations have the potential to cause significant impact, particularly to woody vegetation such as scrub and farm woodlands. Goats are more agile than sheep and feral populations may have an impact on some plant species which are susceptible to grazing, particularly in upland areas where refuge populations exist on rocky outcrops which are inaccessible to sheep. There may be small scale impacts on landscape because goats require some in-field shelter and overwinter housing and higher fencing is required (1.2 m) than for sheep.

### 6.2.3 Goats (Dairy)

Dairy goat numbers in England have remained constant at around 33,000 over the past two years. Sixty per cent are kept in small herds for local milk production. The main breeds are British Saanen, British Toggenburg, British Alpine and Anglo Nubian. British Saanen goats produce higher milk yields and are most commonly used commercially. Anglo Nubians produce a higher fat content. Average lactation length is 280 days with average yields of 500 - 1,200 litres (depending on intensity of inputs). At peak this represents 4 litres/day. Main outputs are fresh, UHT & frozen milk, ice cream, yoghurt, cheese, goat meat and breeding stock. Average commercial herd size for milk production is 200 goats or for cheese production 100 goats. The largest herd is around 3,000 goats and there is an element of polarisation in the industry because many smaller producers got out of the industry when the Diary

Products (Hygiene) Regulations came into force in 1995. Goats' milk is perceived as a healthy product and provides an alternative for those who are allergic to cows' milk. It has been reported to alleviate symptoms of asthma and eczema.

There is a well established market for dairy goat products, with marketing handled by the farmers' co-operative Goat Farmers UK. About 75% of British production goes for cheese making, much of which is sold through supermarkets and specialist food outlets. Milk value ranges between £0.35-0.55/litre. Value is added through selling kids for breeding and through culling. Initial set-up costs are high due to requirements for a parlour and pasteurising/packaging facilities

*Socio-economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated in the methods; this is because the enterprises is relatively small and the knock-on effects are likely to be limited.

Table 6.9 Induced and indirect effects on cash flow associated with dairy goat production.

| *Species* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Goats (dairy) (£/ha) | 825 | 1.5 | 1,237 |

Average gross margins, assuming a stock density of 8 goats/ha, are £825/ha (Nix, 2002). There is a labour requirement of one person per 100 goats.

*Processing activities*

The associated processing activities of this enterprise are likely to be small and related to the production of local speciality food in the dairy and meat processing industry. It is very difficult to predict the processing costs and value added. However the small-scale nature of such projects would contribute to diversification of local industry and might help to improve farmers and producers incomes and attract further investment in the region.

*Environmental impacts*

See Cashmere goats above

### 6.2.4 Dairy Sheep

There are approximately 200 flocks of dairy sheep in the UK (12,000 ewes). Over a 210 day lactation, yields of 150 litres (cross-bred) to 600 litres (pure-breds) are possible. The main outputs are milk, cheese, yoghurt, wool and lamb. Cheese is the major processed output. There is a market to supply people allergic to cows milk and room for import substitution. The British Sheep Dairying Association (BDSA)

recommend a minimum economic herd size of 250 - 300 ewes, but advise that milk units should operate with 400 - 500 ewes with a lactation average of 250 litres. Initial set-up costs will be high for the milking parlour, equipment and stock. Hygiene and Food Safety legislation may also be an issue when setting up such an enterprise.

*Socio-economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated in the methods section; this is because most of the enterprises identified are relatively small and the knock-on effects are likely to be limited.

Table 6.10 Induced and indirect effects on cash flow associated with dairy sheep production.

| *Species* | *Gross margin (£/ewe)* | *Type II multiplier* | *Total value added (£/ewe)* |
|---|---|---|---|
| Dairy Sheep (£/ewe) | 97 | 1.5 | 145 |

Based on 250 litre production unit, a margin of £97/ewe is possible. At a stocking rate of 9 ewes/ha, this equates to £873/ha (excluding labour and machinery maintenance costs)

*Processing activities*

The associated processing activities of this enterprise are likely to be small and related to the production of local speciality food in the dairy sector. It is very difficult to predict the processing costs and value added. However the small-scale nature of such projects would contribute to diversification of local industry and might help to improve farmers and producers incomes and attract further investment in the region.

*Environmental impacts*

Dairy sheep require a higher intensity production system than breeding flocks. The nitrogen content of feed will be higher and they may need housing over winter. Nitrate pollution of watercourses is therefore potentially a greater risk in dairy sheep production systems.

### 6.2.5 Water Buffalo

Water buffalo are suited to milk and meat production. Demand for buffalo milk is strong because of its high calcium content and low cholesterol. It can be used to make cheese (including mozzarella), yoghurt and ice cream. The UK market is currently estimated to be around 2-3 million litres/annum and is not limited by EU quota. There is potential for this to be increased to 25 million litres/annum. There are currently only 2,500 buffalos in the UK on 16 farms (only 8 farms produce milk), however, there seems to be scope for UK herd of around 100,000 lactating buffaloes. The suckler cows qualify for the SCPS payments, all animals need to be registered

with the British Cattle Movement Service. Average milk production is generally no higher than 2,000 l/annum. Typical gross margins have been estimated around £1,012/head (excluding transport and forage costs). Milk is not collected by tankers and currently has to be delivered by the producer so transport costs are likely to be high.

Water Buffalo are also suitable for meat production. The meat has very low levels of fat. Bulls and steers qualify for BSPS payments. The animal is killed at 420-520kg (24-39 months); meat prices are typically £3/kg and gross margins are estimated at £475/head (excluding transport and forage costs).

If breeding stock, problems often occur in heat detection and timing of AI, hormones are therefore required to synchronise the oestrus cycle. Breeding success rates can be low, especially through the summer months.

*Socio-economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated in the methods section; this is because the enterprises is likely to be relatively small and the knock-on effects are likely to be limited.

Table 6.11 Induced and indirect effects on cash flow associated with water buffalo production.

| *Species* | *Gross margin (£/head)* | *Type II multiplier* | *Total value added (£/head* |
|---|---|---|---|
| Water buffalo (milk) (£/head) | 1,012 | 1.5 | 1,518 |
| Water buffalo (meat) (£/head) | 475 | 1.5 | 712 |

*Processing activities*

The associated processing activities of this enterprise are likely to be small in size and related to the production of local speciality food in the meat and dairy sector. It is very difficult to predict the processing costs and value added. However the small-scale nature of such projects would contribute to diversification of local industry and might help to improve farmers and producers incomes and attract further investment in the region. There is already Mozarella production in Wales by ACC Manufacturing, who have interests in traditional products.

*Environmental impacts*

Water Buffalo can feed on lower quality forage than cattle, therefore lower fertiliser inputs are required and there is a lower risk of nitrate pollution. However, stocking rates can be 10-20% higher than for cattle which could have an adverse impact on soil compaction and erosion. Water buffalo can be a beneficial management tool. They feed on a wide range of low quality forage and break up scrub with their horns. However, these characteristics may have a detrimental impact on other habitats for

example where scrub is of value. There is also the potential for hedge destruction, therefore additional fencing which must be either electric or stronger than that for cattle is required and this could impact on the landscape value in some circumstances.

### 6.2.6 Wild Boar

At present there are 2,000 breeding sows, distributed on 100 farms in the UK. Meat is noted for its leanness and gamey flavour. Each animal yields 45-50 kg of meat at 9-12 months. Male boar is only suitable for meat production up to two years of age after which meat becomes too strong for any use other than sausages. It can be sold fresh, frozen or processed into hams, pate, pies and sausages. There is high demand for meat in restaurants, hotels and specialist food outlets but the market should be secured before production begins. The British Wild Boar Association estimates the UK market to be worth £2 million.

Wild boar can be dangerous animals and an annual licence is required under the Dangerous Wild Animals Act, costing £50-100 per year. Initial set-up costs are high as specialised fencing is required and stock are currently expensive due to limited supply.

*Socio-economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated in the methodology; this is because most the enterprise is relatively small and the knock-on effects are likely to be limited.

Gross margin are estimated at £515/sow (Nix, 2002). Assuming a stocking rate of 5 sows/ha this yields £2,500/ha. Labour requirements are low; one person can manage 50 sows

Table 6.12 Induced and indirect effects on cash flow associated with boar production.

| *Species* | *Gross margin (£/ha)* | *Type II multiplier* | *Total Value Added (£/ha)* |
|---|---|---|---|
| Wild boar (meat) (£/ha) | 2,500 | 1.5 | 3,750 |

Other estimates put gross margins as low as £334/sow, giving a yield of £1668/ha (www.kernowwildboar.co.uk).

*Processing activities*

The associated processing activities of this enterprise are likely to be small and related to the production of local speciality food. It is very difficult to predict the processing costs and value added.

*Environmental impacts*

The rooting behaviour of boar results in the destruction of pasture vegetation that can result in soil erosion, runoff and pollution of watercourses with sediment and nutrients. Bare pastures may also be a landscape issue and the high fencing required (1.8 m) may add to the landscape impact. Feral populations may cause significant damage to the native fauna and flora. Plant diversity has been reduced in severely rooted areas, feral boar are known to damage bluebell beds in woodland and there is also the possibility of undermining established trees. A study in the US reported that vegetation cover and leaf litter were so greatly reduced that two small mammal species were nearly eliminated from densely rooted areas. Boar may also predate ground-nesting birds. However, it has been suggested that in some circumstances rooting may help tree establishment, increase nutrient cycling and limit bracken spread.

### 6.2.7 Rabbits

In the late 1990's rabbit production decreased dramatically due pressure from Chinese and Eastern European imports and campaigns by animal welfare protestors. In 2001 UK production was 250,000 rabbits/annum, producing around 500 t meat/annum. Potential for import substitution to Europe is large, especially to France where consumption is 4kg/head (compared to 6 grams in the UK). New Zealand White or Californian stock is used. The former fattens quickly; the latter are slower growing but produce a carcass preferred by some processors. Young does are bought in at 12 weeks and mated at 16-20 weeks. Bucks are bought in at 16 weeks and first mated at 20 weeks. A doe can have a useful life of 10-12 litters over 18 months; less productive animals may be culled sooner. The market requires whole carcasses 2-3kg weight (8-10 weeks) or portioned pre-packed rabbit, depending on the outlet. There are only a few buyers and processors of rabbit meat in the UK and they do not cover the UK fully. As a consequence, transport costs may be significant. The demand for the meat is seasonal (larger during winter) and this may pose problems.

*Socio-economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. The multiplier used is lower than the one indicated initially; this is because most of the enterprises identified are relatively small and the knock-on effects are likely to be limited.

Table 6.13 Induced and indirect effects on cash flow associated with rabbit meat production.

| *Species* | *Gross margin (£/doe)* | *Type II multiplier* | *Total value added (£/doe)* |
|---|---|---|---|
| Rabbit (meat) (£/doe) | 45-55 | 1.5 | 67-83 |

Gross margins are estimated to be £45-55/doe. One person, employed full-time, can look after 300 does, giving a return of 14-17K. Angora rabbits are extremely labour

intensive, and markets suffer the same problems experienced by mohair goat producers.

*Processing activities*

The introduction of some processing facilities could contribute to the creation of employment and value added in the region. However, the impact on farm employment and processing activities exerted by this enterprise is likely to be small as a consequence of the small scale of the enterprise. It is very difficult to predict the processing costs and value added for such an enterprise where the product is sold raw without processing. However, the small-scale nature of such projects would contribute to diversification of local industry.

*Environmental impacts*

Disposal of waste is the major potential environmental impact of indoor rabbit production. The need for heating and lighting may mean higher energy use and therefore $CO_2$ production. Escaped animals are unlikely to cause significant impact on biodiversity because they would represent only a small increase to existing populations.

## *6.3 Enterprises with moderate limits to uptake or development problems which currently limit realisation of market potential.*

### 6.3.1 Flax

Flax has significant potential in the automotive industry, but since area aid payments were reduced, its profitability in the rotation has declined. The current area is only 2-3000 ha and processing plants have closed. Flax is mainly cultivated in Russia and Ukraine with further small amounts in France and Belgium. Flax fibre is hollow and able to absorb up to 12% of its own weight in water, it also dries quickly, and is anti-static. These are characters seen in man-made synthetic fibres such as fibreglass. The fibres are twice as strong as those of cotton and five times as strong as those of wool.

*Socio economics*

The table below illustrates the gross margin analysis, including the induced and the indirect effects. It is assumed as a dual purpose crop that 0.75 t/ha of seed is harvested (worth £125/ha), and 1.5 tonne of straw is produced (worth £50/tonne delivered). Transport costs will eat into this margin, but flax is currently being processed in Wales at Bangor.

Table 6.14 Induced and indirect effects on cash flow associated with flax production.

| *Crop* | *Typical gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Linola | 280 | 1.78 | 498 |

*Processing activities*

After harvest and natural retting, fibres have to be decorticated and baled (first processors). Bales are then sold to the composites or to the paper industry. In the first case, substrate suppliers (*e.g.* Biofibre in UK) further process the natural fibre to produce non-woven materials. Alternatively, the fibre bales are acquired by pulping mills for the production of fibre pulp.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Linseed-flax is spring sown and slow to establish so erosion risk will be high in susceptible situations. The fibrous rooting of flax is beneficial for soil structure. Flax is likely to have little impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Linseed is visible in the landscape with its small white or blue flowers, but these are only present for a short period in summer. There are unlikely to be any impacts on the existing genetic resource base but benefits for invertebrate species may be observed during the short flowering period. Spring sowing following overwinter stubbles may provides a food source for higher trophic groups, particularly bird species. Flax is unlikely to pose a weed threat to native habitats.

### 6.3.2 St Johns Wort

In Germany St Johns Wort is the most popular prescription drug for the treatment of depression (>200,000 prescription per month filled for a single brand (Jarsin) compared to about 30,000 of Prozac). It represents a niche market (in 1998 the UK retail market was worth £10-11 million for sales of St Johns Wort alone (see Table 4.8)

Currently this is grown in very small quantities in the UK. In 2000, only 2ha was grown on set-aside land in the UK. This is grown on special buy-back contracts details of which are held commercially. The prospects for production in Wales are therefore very limited, with very limited potential for added processing unless it can be processed as part of a suite of oil crops in Wales to justify investment in suitable processing capacity.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Perennial herb crops like St John's Wort are likely to be beneficial for soil structure and reduce the risk of erosion. Perennial crops are likely to have a positive impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be lower than those associated with broad-acre arable crops as fewer cultivations and agrochemical inputs are required. Impacts on landscape are difficult to quantify and may depend on circumstances and scale of planting. The crop produces large yellow flowers and grows up to 90cm tall and it would therefore have a visual impact in the landscape.

Cultivars developed for commercial production could potentially cross with native strains, though this warrants further investigation and confirmation. St John's Wort is pollinated by a wide number of invertebrates who would benefit from its cultivation. St John's Wort is unlikely to pose a weed risk to native habitats.

### 6.3.3 Valerian

Valerian targets a niche market for insomnia treatment. The dried rhizome and roots have been advocated for use as a minor tranquilliser and sleep aid for more than 1000 years. The roots contain from 0.3% to 0.7% of an unpleasant smelling volatile oil which contains bornyl acetate and the sequiterpene derivatives valerenic acid and acetoxyvalerenic acid. Also present is 0.5% to 2% of a mixture of lipophilic iridoid principles known as valepotriates. These bicyclic monoterpenes are quite unstable and only occur in the fresh plant material or material dried under 40°C.

Currently valerian is grown in very small quantities in the UK. In 2000, only 20ha was grown on set-aside land in the UK. This is grown on special buy-back contracts details of which are held commercially. The prospects for production in Wales are therefore very limited, with very limited potential for added processing unless it can be processed as part of a suite of oil crops in Wales to justify investment in suitable processing capacity.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Perennial herb crops like Valerian are likely to be beneficial for soil structure and reduce the risk of erosion. Perennial crops are likely to have a positive impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be lower than those associated with broad-acre arable crops as fewer cultivations and agrochemical inputs are required. Impacts on landscape are difficult to quantify and may depend on circumstances and scale of planting. The crop produces pale pink/white flowers, long leaves and grows up to 150cm tall and it would therefore have a visual impact in the landscape. Cultivars developed for commercial production could potentially cross with native strains, though this warrants further investigation and confirmation. Valerian is pollinated by a wide number of invertebrates who would benefit from its cultivation. Valerian is unlikely to pose a weed risk to native habitats.

### 6.3.4 Borage

Borage is a popular source of Gamma Linoleic Acid (GLA). The market is well established but highly volatile. The oil content of the seed is 30-40% by weight. Between 23 and 24% of the oil is GLA, which is about twice that found in evening primrose. The oil is used as a nutritional supplement and in cosmetics.

UK production peaked in the early 1990's at around 2000-3000 ha, but currently is probably below 500 ha. The EU markets are prone to flooding with imports from Canada, New Zealand and China. Speculative production is not advised. Careful attention to detail is required for successful production. Rainfall at the time of maturity July/Early August can cause problems with seed shed.

*Socio-economics*

The table below illustrates the magnitudes of the induced and indirect effects with respect to the wider value added (gross margin) from borage production. This is based on an average yield estimate of 0.4 t/ha (up to 0.75 t/ha can be achieved in 'good' years) and a seed value of £1550/t (higher prices (1,700/t) could be available for clean crops contracted for specific uses).

Table 6.15 Induced and indirect effects on cash flow associated with borage production.

| *Crop* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Borage | 420 | 2.67 | 1,092 |

With respect to employment, it is assumed the cultivation of oilseed crops requires roughly the same effort as spring OSR.

*Processing activities*

The extraction process for borage, evening primrose and echium is very similar. Seeds are crushed at 40°C (cold crushing) and oil in the resulting meal is extracted with solvents. Extraction costs £275/t for 50 tonne seed lots (D. Coupland, Springdale Group; personal communication). This includes cost of meal disposal. Further processing costs (refining, bleaching and deodorising) are of the order of £480/t of oil (D. Coupland, Springdale Group; personal communication). The retail value of the resulting oils is of the order of £150-£280/kg.

The development of small producer groups linked to processing facilities could help to protect against the volatile market conditions.

Table 6.16 presents a combined economic analysis for the oil processor and retailer sector (data on retailer costs were unavailable). It is evident that there is a large margin to cover production costs (transport, margins *etc.*) and retailer costs (marketing, distribution, margins *etc.*).

Table 6.16. Returns to the processing and retail sector for oil derived from borage

| | *Low* | *Average* | *High* |
|---|---|---|---|
| GLA content (kg/t of seeds) | 47.6 | 69.3 | 95 |
| Retail price (£/kg) | 153 | 218 | 283 |
| Retail output (£/t of seeds) *(1)* | 7,283 | 15,110 | 26,885 |
| Seed price (£/t) | 1,500 | 1,500 | 1,500 |
| Extraction costs (£/t of seeds) | 275 | 275 | 275 |
| Refining costs (£/t of seeds) | 23 | 34 | 46 |
| Total costs (£/t) *(2)* | 1,798 | 1,809 | 1,821 |
| *(1) – (2)* (£/t of seeds) | 5,485 | 13,301 | 25,064 |

In order to benefit from the production of oilseed crops it is necessary to invest in crushing facilities and marketing to retain monetary value in the local economy. This is particularly so for speciality products where the crop is usually grown in the locality of crushing plants to reduce transport costs (that can be significant for small quantities). The cultivation of speciality crops occurs on contract which requires a company to provide contracts, subcontracts to crushers and access to the end-users or other downstream processing industries.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Borage is spring sown and grows rapidly so erosion risk will be low in susceptible situations. Borage is likely to have a small positive impact on soil organic matter content by return of crop dry matter after harvest. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Borage is visible in the landscape with its abundant production of pink/blue flowers, but these are only present for a short period in summer. There are unlikely to be any significant impacts on the existing genetic resource base, but benefits for invertebrate species may be observed during the short flowering period. It is reported to attract a wide range of wildlife. Spring sowing following an overwinter stubble may provide a food source for higher trophic groups, particularly bird species. Borage is a persistent weed species in cultivated soils but is unlikely to pose a weed threat to native habitats.

### 6.3.5 Evening Primrose

Evening Primrose is a popular source of Gamma Linoleic Acid, the market is well established but highly volatile. Evening primrose is grown under contract to supply the demand for GLA in nutritional products, cosmetics and pharmaceuticals, but UK production is currently undermined by cheap imports. The world market is currently over supplied and China produces 80% of the worlds supply as well as processing the oil. Contracts are likely to remain scarce. As with borage it requires attention to agronomic detail for success.

Extraction is as for borage (see section 6.3.4 Above).

*Socio-economics*

Evening primrose is currently one of the least profitable of all the oilseed crops considered (£290/ha). The table below illustrates the magnitudes of the induced and indirect effects with respect to the value added (gross margin).

Table 6.17 Induced and indirect effects on cash flow associated with evening primrose production.

| *Crop* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Evening primrose | 290 | 2.67 | 774 |

Gross margin to the grower is estimated at £290/ha (based on a yield of 0.7 t/ha @ £800/tonne) which is not competitive with other crops in the rotation.

With respect to employment, it is assumed the cultivation of oilseed crops requires roughly the same effort as spring OSR.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Evening primrose is spring sown and grows rapidly so erosion risk will be low in susceptible situations. Evening primrose is likely to have a small positive impact on soil organic matter content by return of crop dry matter after harvest. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Evening primrose is visible in the landscape with its abundant production of yellow flowers, particularly in the evening when the flowers open. The flowers are present for an extended period in summer and are pollinated by butterflies, moths and bees. There are unlikely to be any significant impacts on the existing genetic resource base though there is potential for cross pollination with native cultivars, though this warrants further investigation and confirmation. Benefits for invertebrate species and other wildlife are likely. Spring sowing following an overwinter stubble may provide a food source for higher trophic groups, particularly bird species. Evening primrose is unlikely to pose a weed threat to native habitats.

### 6.3.6 Echium (Vipers Bugloss)

Echium is a popular source of Gamma Linoleic Acid, the market is well established but highly volatile. It also contains the rarer stearidonic acid (SdA), which is an important intermediate in the production of a number of important compounds in the body. It also has 'anti skin wrinkle' properties and is currently used in cosmetics. Echium is probably the best agricultural source of omega-6 oils at present and could be used to replace existing sources which include blackcurrant seed oil and evening primrose oil.

*Socio-economics*

Echium is potentially a very profitable oilseed crop (£520/ha). The crop is cultivated for extraction of stearidonic acid (12% of seed weight) and seed prices are high at £3,500/t. Current UK production is around 200 ha. The table below illustrates the magnitudes of the induced and indirect effects with respect to the value added (gross margin).

Table 6.18 Induced and indirect effects on cash flow associated with echium production.

| *Crop* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Echium | 520 | 2.67 | 1,388 |

Echium can be used for GLA production, but its main application is for the extraction of stearidonic acid. Data on production costs are not available given the small amount produced in UK, and prices of the oil vary significantly according to the level of refining. Croda's highly refined echium oil costs £100,000/t. The high price is due to the limited quantities available, high seed price, high refining costs and oil loss (up to 20%) during the process.

With respect to employment, it is assumed the cultivation of oilseed crops requires roughly the same effort as spring OSR.

*Processing activities*

The extraction process for borage, evening primrose and echium are very similar (See borage above), though attention to detail is of greater concern with echium, where the oil has a significantly higher value.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Echium is summer (sown into standing crop) or autumn sown and grows rapidly so erosion risk will be low in susceptible situations. It is likely to have a small positive impact on soil organic matter content by return of crop dry matter after harvest. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Echium is visible in the landscape, it grows up to 90cm tall and produces violet/blue flowers. The flowers are pollinated by butterflies, moths and bees. There are unlikely to be any significant impacts on the existing genetic resource base, though this warrants further investigation and confirmation. Benefits for invertebrate species and other wildlife are likely. Spring sowing following an overwinter stubble may provide a food source for higher trophic groups, particularly bird species. Echium is unlikely to pose a weed threat to native habitats.

### 6.3.7 Peppermint

In 2001, 170 ha of peppermint and 95 ha of spearmint were grown in UK. Given an average yield of 75kg/ha, total UK peppermint production is estimated at 13 tonnes (Tavish and Harris, 2002). This is equivalent to 1.6% of total UK imports. Peppermint is mainly grown for menthol, while spearmint is mainly grown for carvone. They are both widely used in the confectionery industry. The UK is a net importer of mint oil, in 2000 the UK imported 1,200 tonnes of peppermint oil.

The production of mint in the UK is largely controlled by a co-operative supported by Botanix Ltd. Botanix provides advice on agronomy, marketing services, selects suitable plants and genotypes, and distils and analyses the oil *etc.* This requires a large investment in both physical and human capital (James McRill, Botanix Ltd.).

*Socio-economics*

The tables below illustrates the costs of production, gross margins and the associated induced and indirect effects with respect to the value added to the economy.

Table 6.19 Induced and indirect effects on cash flow associated with peppermint production.

| *Crops* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Peppermint | 620 | 1.78 | 1,104 |

Table 6.20 Costs of peppermint production

| | *Year 1* | *Years 2-4* |
|---|---|---|
| Revenues (£/ha) | 1,305 | 1,305 |
| Variable costs (£/ha) | 849.9 | 247.65 |
| Distillation costs (£/ha) | 262.5 | 262.5 |
| Gross margin (£/ha) | 192.6 | 794.85 |
| Net Present Value (£/ha) | 2240 | |
| Equivalent annual value (£/ha) | 626 | |

Source: McTavish and Harris (2002).

The return is very favourable compared to many arable crops in the rotation. Peppermint is not likely to have a big impact on farm employment, since it is likely to be cultivated on a small scale.

In such a limited market, growing on contract is advised. As peppermint is a perennial with a 4-year cropping life, long term contracts would be required to stimulate uptake.

*Processing activities*

Botanix provides distillation, refining, marketing and sale services which are charged to the mint producers. The cost of distillation ranges between £3.20-£3.80/kg oil. After year 2 a double harvest can be expected. Oil yield is in the region of 75 kg/ha pa (for four years) and the average sale price is £17.40/kg.

Table 6.20 highlights the difference in profitability from year 1 to years 2-4. This arises from the first years planting costs (material and labour). To make results comparable with other conventional crops the Net Present Value (NPV) and the Equivalent Annual Value (EAV) have been calculatyed. Interest rates have been assumed at 8%.

Mint oil production is a highly profitable activity. However, to exploit the market a large amount of investment is required to achieve a high quality end product. The final price of the oil depends on the quality and is very sensitive to variations in global production. Uncertainties associated with the market may discourage many farmers

from growing it compared to more familiar crops. More effort needs to be put in to increase mint yields (by improved agronomic practices or by selecting new varieties) and in reducing costs of production.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. As a perennial, erosion risk will be low in susceptible situations. It is likely to have a positive impact on soil organic matter content. Carbon dioxide emissions from energy consumption are likely to be lower than for broad-acre arable crop production, due to lower fertiliser and agrochemical input. However the crop needs to maintained in an almost weed-free state to avoid contamination of the harvested crop. Peppermint has minimal impact on the landscape, it grows up to 80cm tall and produces small clusters of lilac/pink flowers. The flowers are pollinated by butterflies, moths and bees. There are unlikely to be any significant impacts on the existing genetic resource base, though this warrants further investigation and confirmation. Benefits for invertebrate species and other wildlife are likely. Peppermint is unlikely to pose a weed threat to native habitats.

### 6.3.8 Foxglove

The drugs digitoxin and digoxin are obtained from the leaves of this species and used in orthodox medicine for heart disease; they increase the strength of heart contractions and regulate the heartbeat. The compounds were discovered in the common foxglove (*Digitalis purpurea*), but compounds in Grecian foxglove (*Digitalis lanata*) are up to four times as potent (Bremness, 1994).

The potential for production in Wales is very limited due to soil and climatic limitations *etc.* The crop is currently not commercially grown in the UK, and grower returns are currently unclear, but could be expected to at least match those of conventional oil crops in the rotation.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Forms a ground hugging rosette canopy during establishment so it is anticipated that erosion risk will be minimised in susceptible situations. It is likely to have a small positive impact on soil organic matter content by return of crop dry matter after harvest. Carbon dioxide emissions from energy consumption are likely to be lower than for broad-acre arable production, due to lower fertiliser and agrochemical input. Foxglove is visible in the landscape, it grows up to 150cm tall and produces spikes of bell-shaped mauve flowers. The flowers are pollinated by bees. There are unlikely to be any significant impacts on the existing genetic resource base from cultivated species, though this warrants further investigation and confirmation. Benefits for invertebrate species and other wildlife are likely. Foxglove is unlikely to pose a weed threat to native habitats.

### 6.3.9 Poppy

Poppy is grown for the production of morphine. Total legitimate cultivation is thought to be 247,000 ha (2002). The UK Home Office has approved three-year trials by United Oilseeds. In 2002, 400 ha have been underwritten. United Oilseeds supplies the Edinburgh based pharmaceutical company MacFarlan-Smith (producing 30% of the worlds morphine). Major competitors are Tasmania and also other EU Countries. The seeds can be harvested and sold for culinary uses.

United Oilseeds expect there to be potential for several thousand hectares to be grown in the UK over the next few years as a valuable niche crop. So far all has been grown under contracts to United Oilseeds.

*Socio-economics*

The table below illustrates the gross margin and the associated induced and indirect effects.

Table 6.21 Induced and indirect effects on cash flow associated with poppy production.

| *Crops* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Poppy | 571 | 1.78 | 1,016 |

Poppy is cultivated on a very small scale (around 1,000ha grown for harvest 2002 in he UK) and is therefore unlikely to have a big impact on farm employment.

*Processing activities*

The market for poppies is extremely limited and highly specialised. Morphine extraction requires specialised equipment and staff as well as high levels of investment. The seed market is also very limited.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Poppy is spring sown and grows rapidly so erosion risk will be low in susceptible situations. It is likely to have a small positive impact on soil organic matter content by return of crop dry matter after harvest. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Poppy is visible in the landscape, it grows up to 60-150cm tall and produces flowers which range in colour from white to pink or lilac. The flowers are attractive to bees and other pollinating insects. There are unlikely to be any significant impacts on the existing genetic resource base, though this warrants further investigation and confirmation. Spring sowing following an overwinter stubble may provide a food source for higher trophic groups, particularly bird species. Poppy is unlikely to pose a weed threat to native habitats as it prefers nutrient rich disturbed soils.

*Processing activities*

The introduction of some processing facilities could contribute to the creation of employment and value added in the region, but these are likely to be very limited.

### *6.4 Enterprises with major limits to uptake or development problems which currently limit realisation of market potential.*

#### 6.4.1 Snails

Snails represent a very small market. They can be sold fresh, frozen or made into snail pate or other dishes. Consumption in the UK has expanded considerably over the past decade although most are currently imported. European consumers prefer snails gathered from the wild. Production of snails in France and Eastern Europe has recently declined. Disease risk is high and snails are also susceptible to stress and handling problems. Set-up costs could be high for an indoor production unit. A suitable building and cleaning system will have to be installed. General spacing requirements are 250sq feet per 100,000 snails.

*Socio economics*

Running costs are in the region of £4,000/tonne. Income from snails can be in the region of £8-12/kg depending on the market outlet. 200,000 snails would produce 2-4 tonne per year and employ one man full-time (intensive indoor) and return in the region of £8K-£22K which leaves little for investment.

*Processing activities*

There are very limited opportunities to add significant value to the product.

*Environmental impacts*

The need for heating and lighting results in high energy use. Feral populations of non-native species could become a pest and could out compete native species.

#### 6.4.2 Worm Farming

Worms enterprises incur large set-up costs (in the region of £12-54,000/1000m$^2$) and require expertise. However, many market outlets exist, though some are seasonal and it is advisable to have multiple outlets and/or a contract with a worm company. Production can be in the region of 60kg of worms per week from 1,000m$^2$ unit.

*Socio-economics*

Price per kg can range from £2.50-£20 giving an overall return of between £600 and £1,600 per month. A return can also be made from worm casts. A 1,000m$^2$ unit requires around 20 hours per week to manage. A typical return of between 14-36K per man year invested should be expected, but as noted above demand can be seasonal.

*Environmental impacts*

The need for heating and lighting results in high energy use. If manure heap rather than contained systems are used, the run-off must be contained to avoid pollution.

*Processing activities*

There is very little opportunity to add value locally

### 6.4.3 Alternative uses of sheep wool

*Socio-economics*

75% of UK wool is used for carpets and is unable to compete with finer quality Australian wool for clothing markets. Prices are currently low, from 2p/kg for Herdwick fleeces and up to 70p/kg for Cheviot fleeces, in many cases upland breeds fail to cover the cost of clipping. New markets are being developed as insulation but they are currently three times more expensive than traditional materials. Other market outlets developed so far have been very limited in uptake. There appears to be little scope in the short term for increasing the value of wool, any new and novel uses will be vulnerable to imports.

The wool from fleeces of the predominant upland sheep breeds is tough and resilient but it is often grey in colouration which limits demand compared with whiter wools which are readily and cheaply available and more easily dyed. In addition, the wool fibres tend to be short and wavy compared with wool fibres from traditional lowland breeds. While there have been some limited specific markets developed, such as in carpet yarns, these so far have been niche (*i.e.* Lakeland Herdwick loop pile carpets) and limited in size. The bulk of UK fleeces are currently of a grade more suitable for carpeting than clothing and fabric outlets. Virtually all UK wool goes into carpeting but this has to compete with New Zealand imports. Wool sales currently only represents a small part of upland farm income (2-3%) but if the value of wool could be increased by only £1/ewe (which would still mean a lower price than that for UK lowland fleeces) then this could add between £9 and £14/ha in income to upland farms. There would be bigger gains for the rural economy where processing is carried out either in or close to rural communities.

Non woven applications using novel 'water needle' technologies could make use of the coarse short fibres derived from upland breeds but markets for these tend to be low value, such as in geo-textiles *etc.* Currently there is a need to develop a generic solution to optimise use of wool which represents a wide range of quality in each batch.

### *6.5 Enterprises with moderate limits to uptake or development problems which will limit realisation of market potential in the short-term*

#### 6.5.1 Meadowfoam

Meadowfoam oil is of extremely high quality, comparable to that of a sperm whale. Meadowfoam has the highest level of C20:1, C22:1 and C22:2 fatty acids of any seed oil. However, dependence on bees for pollination and weather at harvest can make growth and production challenging. Seed meal is high in glucosinolates making it unsuitable for use in animal feed.

Meadowfoam requires a sunny position, but suffers from botrytis a fungal disease encouraged by cool wet conditions. Without adequate fungicide protection this may result in problems with reliability of Meadowfoam production in Wales. Further agronomic and breeding work will be required to commercialise this species.

*Environmental impacts*

Meadowfoam can be either autumn or spring sown and it grows rapidly so erosion risk will be low in susceptible situations. It is likely to have a small positive impact on soil organic matter content by return of crop dry matter after harvest. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Meadowfoam is unlikely to be very visible in the landscape until flowering. The plant produces a flowering stem from a basal rosette which produces a canopy covered with small white flowers that resembles foam and reaches up to 30cm tall. Nectar production is low but the crop is still likely to be attractive to bees and other pollinating insects. There are unlikely to be any significant impacts on the existing genetic resource base. Spring sowing following an overwinter stubble may provide a food source for higher trophic groups, particularly bird species. Meamdowfoam is unlikely to pose a weed threat to native habitats.

#### 6.5.2 Miscanthus for fibre

Miscanthus has been commercialised for bioenergy production but also has potential in fibre markets. The crop is suited for the production of Medium Density Fibreboard (Hague, 1997). However the market is quite volatile due to large investments in MDF production plants in SE Asia. Paper produced from Miscanthus is suitable for printing and office uses as well as for wrapping and food packaging. Miscanthus is worth £70/tonne dry matter in fibre markets, compared to 20-40/tonne in energy markets.

*Socio-economics*

The table below illustrates the associated gross for fibre production. To account for induced and indirect effects, the cereals type II income multiplier has been used. The calculated gross margin is based on output of 12 t/ha DM at 70/tonne for fibre market.

Table 6.23 Induced and indirect effects on cash flow associated with miscanthus fibre production.

| *Crop* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Miscanthus | 805 | 2.67 | 2149 |

In the first year cultivation of miscanthus requires:
Ploughing - 1.4 hours/ha
Planting (chopping and spread) - 0.3 hours/ha
Fertiliser application - 0.4 hour/ha
Harvesting (modified maize harvester) - 3.2 hour/ha.

In the following 15-20 years:
Fertiliser application - 0.4 hour/ha
Harvesting - 3.2 hour/ha

On average the cultivation of 100 ha of miscanthus would require 370 man hours per year or 0.2 man years. Taking into consideration the induced effects (indirect effects) employment could be raised to 0.31 (0.35) man years per 100 ha.

*Processing activities*

At present little data is available for miscanthus. Bical are being offered contracts for miscanthus fibre and it is anticipated that this demand could grow. Development of local processing could retain added value in the Welsh economy.

*Environmental impacts*

Miscanthus is perennial and quick to establish, in addition a significant level of stubble and trash is left on the ground after late winter harvest, so there is significant ground cover present for almost the whole of the year so erosion risk will be greatly reduced. A significant amount of the canopy is shed (*i.e.* all the leaves) which will add to the soil organic matter content. Miscanthus requires few inputs, carbon dioxide emissions from energy consumption are likely to be lower than for wheat production. The crop can be up to 3-4m tall and so is visible in the landscape. There are unlikely to be any impacts on the existing genetic resource base. Miscanthus provides a dense canopy which provides an ideal habitat for larger mammals such as deer. Miscanthus is unlikely to pose a weed threat to native habitats.

### 6.5.3 Calendula

Calendula has a number of uses. Dye can be extracted for colouring and flavouring food. The flowers are also used to produce an essential oil used in the natural remedy and cosmetics sector. The seed oil may have applications in paints, coatings, personal care products and some industrial nylon products. The seeds contain 40-45% oil, 50-55% is highly conjugated calendic acid and 28-30% is the non-conjugated linoleic acid (bothC18:3).

In Western Europe, 6 million tonnes of paints are used with a value of € 15 bn (CEPE, 2002). Vegetable oils currently account for 1% of the market for paint binders, equivalent to 225,000 tonne/annum (Carr, 2000). Calendula oil could substitute for tung oil. Tung oil is a widely used, non-edible, vegetable oil produced from the fruit of the tung tree. It is used as a protective coating, solvent and/or drying agent in various paints, varnishes, resins and printing inks. Its superior drying properties allow it to be sold at a premium compared to other vegetable drying oils such as linseed oil (Glaser, 1996). Tung oil is mainly produced in subtropical regions (primarily China and South America). Estimated world production ranges around 50,000 t/annum . (see table 6.24).

The world supply of tung oil is volatile, since production is very sensitive to adverse weather conditions (Glaser, 1996). The UK is estimated to import around 5,000 tonne/year of tung oil at a price of £800-£1500/tonne.

Table 6.24: Major producer of tung oil

| *Country* | *Tonnes/annum.* |
|---|---|
| China | 42,000 |
| Paraguay | 4,000 |
| Argentina | 3,000 |
| Brazil | 1,000 |
| Total | 50,000 |

Source: Glaser, 1996

*Cosmetics*

There is a wide range of calendula cosmetics on the market. Calendula oil (extracted from the blossoms) is sold as a natural product to treat damaged or sunburnt skin. The skincare market was worth £756 million in 2000.

The potential for production in Wales is limited to specific coastal areas of southern, south western and north western areas of Wales (see GIS map in appendix).

*Returns and processing*

Calendula is currently not being commercially cropped in the UK, but is receiving interested attention. Market price for the crop is currently uncertain and will depend on the end uses. The crop is not dual-purpose, it can be grown for the seeds (oil production) or for the flowers (essential oil production). Potential contractors for the crop claim that the minimum return for the crop, to be competitive with other arable crops, is likely to be in the region of £400-600/ha.

Oil extraction is mechanical, with hexane extraction. Given the small quantities likely to be involved, extraction costs are slightly higher than those for conventional oilseeds at £80-100/t. The extraction process also separates calendic from linoenic acid which offers the opportunity of sale for different end uses. At present there are no uses for the meal.

*Environmental impact*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Calendula is spring sown and grows rapidly so erosion risk will be low in susceptible situations. It is likely to have a small positive impact on soil organic matter content by return of crop dry matter after harvest. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Calendula is visible in the landscape during flowering, it grows up to 50-75cm tall and produces large yellow/orange flowers. The flowers are attractive to bees and other pollinating insects. There are unlikely to be any significant impacts on the existing genetic resource base. Spring sowing following an overwinter stubble may provide a food source for higher trophic groups, particularly bird species. It is unlikely to pose a weed threat to native habitats.

### 6.5.4 Woad

Woad leaves are used to produce indigo, its use has been replaced by production of synthetics. Currently demand for natural dyes is around 5% of the dyes market, but there is a trend towards increasing use in niche high value markets. Natural and synthetic indigo are chemically identical.

Indigo is used in the greatest volume by the dyeing industry (DTI, 1995), the factors influencing use of natural indigo are consistency of supply and price. It is estimated that European demand for indigo would be satisfied by approximately 50,000ha of woad. Natural indigo is valued at £30-36/kg. However, where environmental considerations are important, synthetic indigo is made from analine, formaldehyde and hydrogen cyanide which are all very hazardous chemicals.

*Socio-economics*

Table 6.25 illustrates an estimated the gross margin for woad and the potential induced and indirect effects associated with production.

Woad is currently not cultivated in the UK. However, the UK market is estimated to be 40Mt/yr. Given a yield of 20-40 kg/ha, 1000-2000 ha would be required to supply the whole UK market.

*Processing activities*

Indigo extraction from leaves occurs through a steeping process. This involves the extraction of the indigo precursors (*indican* and *isatan B*) by immersion of the washed leaves in hot circulating water. Alkali (usually calcium hydroxide) is then added to the water to raise the pH and air is pumped in. This allows the formation of indigo, which is insoluble and precipitates out in fine particles over 24 hours (Hill, Gilbert and Cooke, 2000). Yields of indigo are quite variable. On average 20t/ha of fresh leaves will provide .1-0.2% indigo (20-40kg/ha)[3]. Based on this, an economic analysis at the farm and processing level can be estimated (Table 6.25).

[3] This considers the production of three crops per year, as suggested by Hill, Gilbert and Cooke, 2000.

At the processing level, costs of woad are significant. The analysis presented draws on an estimate provided in Hill, Gilbert and Cooke (2000). This assumes processing costs of £12 per tonne of fresh leaves. Such costs vary according to the indigo content of the leaves. In the analysis a margin of £4 per kg of indigo is assumed. This data relates to a small-scale extraction process. Scaling up could require considerable investment.

It is important to distinguish between the plant yield (fresh weight per ha) and indigo yield (per tonne of fresh leaves). The fresh leaf yield is likely to be improved through breeding and selection in the future. A yield of 30t/ha could be attained in ten years time. The indigo yield at present is in the range of 1-2kg/t of fresh leaves. Indigo content increases with solar irradiation (Hill, Gilbert and Cooke, 2000). Further increase in the indigo yield are anticipated (Hill, Gilbert and Cooke, 2000).

Table 6.25 Gross margin for woad production

| | Low indigo content | High indigo content |
|---|---|---|
| Leaf yield (t/ha) | 20 | 20 |
| Indigo content in leaves (kg/t) | 1 | 2 |
| Indigo yield (kg/ha) | 20 | 40 |
| *A) Industry Analysis* | | |
| Natural indigo price (ex-VAT) (£/kg) | 31 | 31 |
| Production costs (£/kg)[4] | 16 | 10 |
| Farm gate price (£/kg)[5] | 15 | 21 |
| *B) Farm analysis* | | |
| Farm gate price | 15 | 21 |
| Revenue (£/ha)[6] | 300 | 840 |
| AAPS (£/ha) | 200-204 | 200-204 |
| Total revenue (£/ha) | 500-504 | 1040-1044 |
| Costs (£/ha) | 300 | 300 |
| Farm margin (£/ha) | 200-204 | 740-744 |

Source: University of Bristol.

Table 6.26 Induced and indirect effects on cash flow associated with woad production.

| *Crops* | *Gross margin (£/ha)* | *Type II multiplier* | *Total value added (£/ha)* |
|---|---|---|---|
| Woad | 200-700 | 1.78 | 356 – 1,246 |

[4] These include leaves processing costs of £12/t and a margin of £4/kg of indigo.
[5] This is the leaves price for 1kg of indigo equivalent.
[6] This is obtained by multiplying the indigo equivalent price (£/kg) by the indigo yield (kg/ha).

*Environmental impacts*

Woad is grown as a biennial or short-lived perennial. Maintenance of crop cover means that erosion risk will be low in susceptible situations. Woad is likely to improve soil organic matter content over time. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Woad is a moderately tall herb which is unlikely to have a significant landscape impact. It produces numerous yellow flowers. There are unlikely to be any impacts on the existing genetic resource base. There are likely to be benefits for native invertebrate species during the flowering period. Woad can be an invasive weed species if not controlled adequately, but as a short lived perennial it is not likely to be a persistent problem.

### 6.5.5 Gold of Pleasure/Camelina

The oil from the seeds contains an excellent balance of useful fatty acids (including α-linolenic and linoleic acid), some which are rarely found in other oil crops. Those fatty acids are known to reduce cholesterol level in the blood and are good for heart and cardiovascular health. Seed oil content averages at 37% by weight.

*Processing activities*

It is necessary to understand that in order to benefit from the added value associated with production of such crops it will be necessary to invest in crushing facilities and marketing.

*Environmental impacts*

The impact of crop production on the environment will depend on factors such as soil type, slope, precipitation and crop production system. Camelina can be autumn or spring sown and it grows rapidly so erosion risk will be low in susceptible situations. Camelina is likely to have a small positive impact on soil organic matter content where waste material is returned to soil. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Camelina produces woody stems and bears small yellow flowers so is likely to have little impact on the landscape. There are unlikely to be any impacts on the existing genetic resource base. Camelina is attractive to bees during the flowering period. Camelina can be a persistent weed problem.

### 6.5.6 Oats for industrial use

Naked oats are grown for their oil content, 14-15%. The oil has a potential value in the body care market. Oats also have industrial applications as a starch product due to the small uniformly sized starch granules. The starch product can be used in dusting and baby powders, antiperspirants, blush and eye shadow. The ingredients are also being investigated for use in animal and pet care products. Furfural is also produced from the fibrous residue of oat crops, this is used in the manufacture of furan, an intermediate in the synthesis of pharmaceuticals, agricultural chemicals, stabilisers and fine chemicals.

Attempts have been made to commercialise many of these aspects, but extraction methods for different fractions differ and prevents wider exploitation of plant reserves. Investment funding for development of oat fractionation is required but industry does not see a sufficient financial reward for this investment at present. Some limited extraction of oat oils continues.

The agronomy of oats is well studied and documented.

*Environmental impacts*

Impacts will be similar to those of winter wheat, but spring sowing of oats could reduce the need for agrochemicals *etc*. Oats are already grown in Wales and pose no significant problem to the natural environment compared to current crops.

### 6.5.7 Mugwort

Recently artemisinin (anti-malarial agent) has been produced from Annual Mugwort.

*Environmental impacts*

As a perennial, mugwort would provide benefits in terms of reducing soil erosion risk and improvements in soil organic matter content over time. Mugwort grows rapidly in the second year and produces a bushy plant bearing numerous small red-tinged yellow flowers. Grows up to 30-120cm tall. It is likely to have a limited impacts on the landscape. Can be an invasive weed.

## *6.6 Enterprises with major limits to uptake or development problems which limit realisation of market potential in the short-term*

### 6.6.1 Yarrow

An aromatic, bitter herb that reduces inflammation, increases perspiration and relieves indigestion. It is also effective in lowering blood pressure and relaxing spasms. The principal constituents of Yarrow oil are:- Azulene (up to 51%), pinenes, caryophyllene, borneol, terpinol, cineol, bornyl acetate, camphor, sabinene and thujone, amongst others. Azulene levels vary according to source (Lawless, 1995). Yarrow is also a possible source of hypoallergenic rubber for human contact (Duke and duCellier, 1993)

*Environmental impacts*

As a perennial, yarrow would provide benefits in terms of reducing soil erosion risk and improvements in soil organic matter content over time. Yarrow grows rapidly, but only up to 8-45cm tall. It produces dense numbers of white or pink-tinged flowers It is therefore likely to have a limited impacts on the landscape, except when in flower. Flowers are rich in nectar. Yarrow hybridises freely with closely related species.

### 6.6.2 Madder

The roots of Rubia tinctorum are well known as a source of the anthraquinone dyestuff, alizarin (1,2-dihydroxyanthraquinone). Alizarin is the parent form of many dyes and pigments, including mordants. Anthraquinone dyes occur in the free state in the plant as glucosides. The importance of madder ceased after the synthetic production of alizarin from coal on a commercial scale.

Harvesting the crop can be very time consuming, development of effective methods of removing the roots fro clay soils are still being developed.

*Environmental impacts*

As a biennial/perennial (cropped for 24-30 months), madder would provide benefits in terms of reducing soil erosion risk and improvements in soil organic matter content over time. Madder grows at a moderate rate and produces prickly stems up to 1m tall. It is evergreen and flowers in June. It is likely to have a limited impacts on the landscape.

### 6.6.3 Native Grasses for fibre

Significant steps have already been taken to convert grass into materials suitable for industrial use. Investment from both national and regional funds has been made in the Netherlands. A syndicate incorporating Plant Research International and 8 other Dutch partners has invested time and research into running pilot studies. Grass crops have proved to be particularly useful. The basic fractions recovered include A) fibres (75% of DM or more from 1st cut grass) with uses in the paper and board market or in horticulture markets as a peat substitute B) a protein concentrate and C) sap/juice concentrate which has uses in the animal feed sector (high nutritional value) or could be fermented to produce bioethanol. Sap fractions can be further refined to produce a range of secondary products including feed protein, white protein (for food uses) and sugar fractions (such as inulin). The most valuable outlets identified have been with use of grass fibre from ecological or organic sources which add value to the final product. The fibre component has uses in both low value outlets such as in biomass for energy or fermentation as well as higher value outlets as a compost and peat replacement, which is currently the most promising outlet. Research into secondary products derived from sap is still required to identify if there are any particular additional added value compounds which would increase returns. As there are a number of potential market outlets available to the products of grass fractionation this should provide buffering to changes in market price in any one outlet. Dutch conditions suggest that the process is viable with a minimum plant size capable of processing at least 30,000 t of dry matter, equivalent to the output from around 10,000ha of natural grassland. With low yielding upland grasses a larger area may be required in the UK.

### 6.6.4 Bog Myrtle

Bog-Myrtle has been used in Scotland to produce an essential oil that acts as a midge repellent. At present the market is not well developed and there are technical problems in commercialising the crop.

*Socio-economics*

No statistics are currently available regarding the production and yields of bog-myrtle as a commercially grown crop. It is thought that bog-myrtle could provide a valuable source of income to farmers with peat bog on their land.

*Environmntal impacts*

As a native of Wales, bog myrtle is already well established. Harvesting the crop is likely to reduce the return of organic matter to soil. Over exploitation could also run the risk of depleting this native resource. Use of mechanical harvesting could also be detrimental in wet soil conditions.

## *6.7 Enterprises with moderate limits to uptake or development problems which limit realisation of market potential in the medium-term*

### 6.7.1 Euphorbia (Spurge) spp

*Euphorbia lagascae* has a high seed oil content, commonly ranging from 48-52%. The fatty acid profile is dominated by the epoxy fatty acid, vernolic acid which comprises between 58% and 67% of the total oil content. Such functionalised oils are of significant interest to the lubricant and polymer industries looking for biodegradable replacements for mineral oils and new oil feedstocks with potential new properties

*Socio-economics*

To be commercially viable *E. lagascae* must be comparable to other mainstream oilseed crops such as linseed and industrial oilseed rape. To produce a gross margin comparable with major oilseeds *E. lagascae* would be required to achieve yields of about 1.25t/ha. To date, in Southern England, trial plot yields of 0.9-1.4t/ha have been recorded averaging 1.1t/ha over a four year period.

*Environmental impact*

Euphorbia can be autumn or spring sown but grows relatively slowly, so erosion risk will be moderate in susceptible situations. Euphorbia is likely to have a small positive impact on soil organic matter content where waste material is returned to soil. Carbon dioxide emissions from energy consumption are likely to be lower than for wheat production, due to lower fertiliser and agrochemical input. Euphorbia produces stout hollow stems up to 120cm tall, but flowers are indistinct. Flowers have limited value to pollinators (pollinated by flies). Unlikely to establish as a weed species. The plant contains latex which can cause blistering

### 6.7.2 Nettle

Nettle has potential in the niche apparel market. No data on prices are available as it has not yet been cropped commercially. However, articles of clothing have been produced for demonstration of its potential by leading Italian fashion houses. The high quality fibre produced in the nettle plants is comparable to hemp and flax, and constitutes up to 17% of total plant weight. The fibre has high tensile strength, fineness, low specific weight and an average length of 4 metres. If agronomic and processing barriers are removed nettle has the greatest potential in long fibre pulping and textile markets.

Environmental impacts

As a perennial, nettles would provide benefits in terms of reducing soil erosion risk and improvements in soil organic matter content over time. Nettles grow quickly producing stems up to 1.5 m tall which would be visible in the landscape, but flowers are small and indistinct. The plant is known to be valuable to a number of insect and caterpillar species. The plant has the potential to become a weed in uncontrolled situations, but requires fertile soils. The potential of cultivars bred for fibre production to cross with native species requires further investigation.

## *6.8 Enterprises with major limits to uptake or development problems which limit realisation of market potential at least in the medium-term*

### 6.8.1 Giant Reed

Giant reed has been studied for biomass energy and for pulping. With respect to pulping (relevant for the natural fibre sector) it is thought that giant reed is suitable for the production of good quality pulp (Duke *et al*, 2000). However, giant reed has not yet been used commercially, so no information is yet available on prices. The fibre produced by the crop is of high quality and has a long, thin structure making it suitable for a wide variety of uses. The high quality fibre can be used to produce a wide range of paper grades.

The potential for production in Wales is likely to be limited to particular localities in the south, west and north west Wales (see GIS map in appendix).

*Environmental impacts*

As a tall (up to 6m) perennial, giant reed could provide benefits in terms of reducing soil erosion risk and improvements in soil organic matter content over time. Giant reed would be very visible in the landscape due to its height and structure. It is expected to have little value to insects. Its dense nature would provide cover for larger mammals.

### 6.8.2 Reed Canary Grass (for fibre)

Reed canary grass is currently being evaluated as a fuel crop but also has potential as a source of fibre for pulping.

Potential for production in Wales is very limited to pockets in eastern, north west and southern areas of Wales (see GIS map in appendix).

*Environmental impacts*

As a tall (up to 0.6-2m) perennial grass species, reed canary grass could provide benefits in terms of reducing soil erosion risk and improvements in soil organic matter content over time. Giant reed would not be very intrusive in the landscape. It is expected to have little value to insects. Its dense nature would provide cover for larger mammals.

### 6.8.3 Sea Buckthorn

Sea buckthorn takes several years to establish fully and fruits after 4 years. The leaves, berries and fruits have a high nutritional and medicinal value. The seed pulp contains essential oils with medicinal uses. Mature berries are very high in vitamin C and have principally been used to help improve resistance to infection. Berries are also mildly astringent and can be used to treat skin irritation and eruptions. Further breeding is required to improve yield and develop thornless cultivars and to improve harvesting techniques. An appropriate mix of male and female plants is required for pollination.

*Environmental impacts*

Sea Buckthorn is a hardy deciduous woody shrub reaching 2-4m in height under cultivation. It will reduce the risk of soil erosion in susceptible situations. It is wind pollinated so of little value to pollinating insects. Leaves have a silver grey colour. Berries are yellow/orange and borne in large numbers on the stems. It can fix nitrogen so fertiliser requirement is low. It is a native of Wales so the risk of out-crossing from any commercially developed cultivars would need to be evaluated.

### 6.8.4 Henbane

Roots, leaves, flowers and seeds are used for their alkaloids which are sedatives and tranquillisers. As such there are likely to be legal controls placed on its commercial production. Henbane is used to treat pain affecting the urinary trait, abdominal cramping and Parkinson's disease. All parts of the plant are potentially poisonous, particularly the roots.

Production is likely to be limited to specific coastal areas in Wales due to climatic and soil limitations (see GIS map in appendix)

*Environmental impacts*

Annual and perennial forms of henbane exist. The annual form is unbranched and the perennial form is branched and both produce yellow flowers. It would have some benefit to pollinating insects. It is unlikely to have a significant impact on the landscape when not in flower. The plant has a strong odour which means it should not be grown close to residential or public areas.

## 7.0 PRIORITISATION BASED ON GROWER RETURNS AND IMPACTS ON THE REGIONAL ECONOMY

Based on the scoring methodology outlined in section 2.5, where some market information was available, enterprises were scored to derive overall indices of returns to the producer sector, the regional economy and potential to enhance Welsh agriculture and tourism. In some cases these scores are very subjective being based on limited information or extrapolation from experience gained with related enterprises.

### *7.1 Crop enterprises*

Overall crop scores for returns to the grower sectors are similar across a wide range of crops. This score actually reflects on the scale of returns that the grower could expect compared to current enterprises, the potential demand for product and the ease of access to market. In many of the highlighted cases market demand is low compared to current arable crops, so area of production will be very limited. However the actual returns that growers could receive vary from £400-450/ha for industrial oil and healthcare oils and fibre crops (*e.g.* HEAR, crambe, borage, hemp and miscanthus (for fibre)), which is typical of returns from current oilseed crops. In contrast specialist crops such as echium, peppermint, woad and poppy can realise returns of £500 – £700/ha, but areas of production are very limited where UK areas are of the order of only a few hundred hectares and are likely to remain low.

With many industrial oils, unless material can be retained in Wales for processing then there is little opportunity to add wider value, this is likely to be the case for crops like borage, evening primrose, crambe, HEAR and poppy *etc*, where crops are grown on contract and loads are shipped to a central processing facility. Unless local markets can be developed to add additional value to the basic oils then there is likely to be little likelihood of retaining added value in the Welsh economy. Fibre crops offer more potential for added processing and Wales would appear to suit growth of crops such as hemp flax and miscanthus, (which although being evaluated as an energy crop also shows potential for use in technical fibre production). As UK facilities for such crops are still being developed to meet growing EU demand there is opportunity to develop facilities in Wales, building on developments at the Biocomposites Centre in Bangor. There would also be potential added benefits to the wider economy though production of natural textiles with outlets for tourism *etc*. In the longer term, novel crops such as nettle offer possibilities to add interest and value to this niche market and could help diversify the markets of fibre processing plants to protect against market volatility and competition *etc*.

With other 'niche' crops such as echium (healthcare), calendula (essential oil), woad (dye) and peppermint, there is potential to add value in the locality by developing small extraction facilities and adding further value by developing products locally. In general with such crops the tonnages for processing are low (for example 7 tonnes of peppermint is processed in the UK) but of high value. In some cases further development is required to commercialise crops (*e.g.* woad). Ideally industrial extraction and processing plant could be utilised to cope with a range of plants to diversify risks in the face of volatile markets. In many cases there would

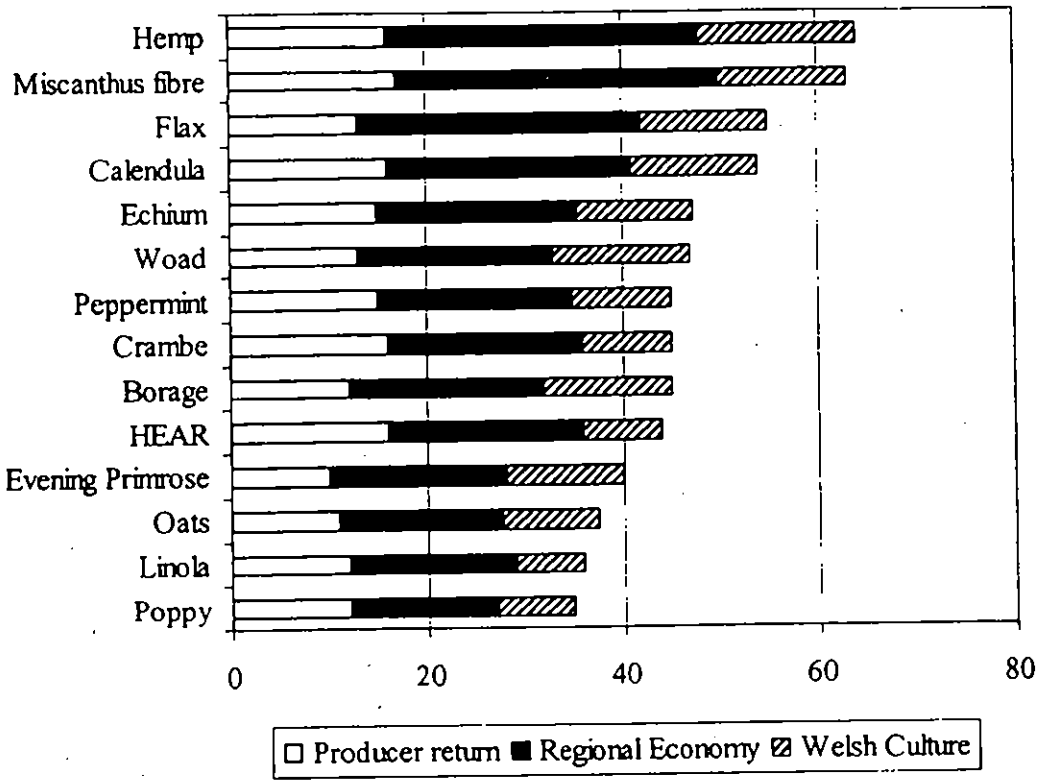


Figure 7.1 Scores for returns to the producer sector, the regional economy and value to Welsh culture for plant enterprises

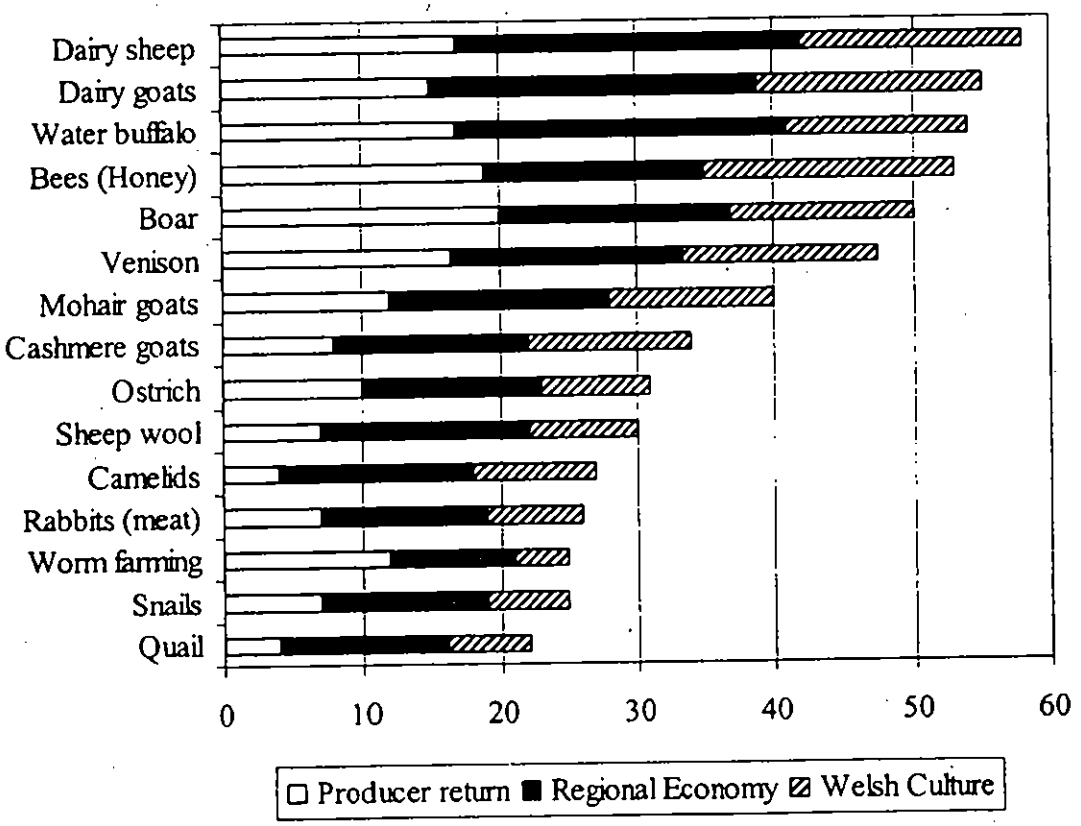


Figure 7.2. Scores for returns to the producer sector, the regional economy and value to Welsh culture for animal enterprises

also be benefits to local tourism for example through the development of natural dyes and use of natural yarns and fibres *etc.*

*7.2 Animal enterprises*

A number of the most promising animal enterprises rely on adding value to produce (Figure 7.2). There is a growing interest in alternatives to cows milk and more importantly in processed products such as goats and sheep cheese which can be locally branded. More novel enterprises such as mozzarella production from water buffalo also offer potentially high returns to the farmer. However, only those with the best grassland pasture are likely to be able to capitalise on such enterprises. These enterprises offer the opportunity to add significant value to the local economy and to raise the profile of Welsh produce, but there would need to be significant investment to stimulate development of these enterprises.

There is increasing demand for novel meats such as venison and wild boar and potential for increasing production in Wales. Wild boar offers very high returns, but it is a licensed operation and requires careful management. Marketing has proven to be difficult to date. With venison, Wales has the capability to capitalise on production by developing breeding enterprises in the uplands and links to finishing enterprises in the lowlands which could be used to help increase returns for the less profitable upland breeding units.

There is potential to exploit the natural habitat for honey production, however opportunities to access the premium end of the market by utilising upland heather may be more limited due to the low yield of heather honey seen in recent years in Wales. Cheap imports mean that the market price for mixed-flower honey is low. This is an enterprise which though limited in size, offers opportunities to add value locally. Additional revenue could be obtained by selling native bees to other parts of the UK to enthusiasts keen to restore native bee populations. Development of any flowering non-food crop may also provide an opportunity for specialist honey production alongside. With the exception of oilseed crops, there is little value from most arable crops in terms of potential for honey production.

The markets for ostrich and camelids appear to be saturated and limited by problems in selling by-products abroad (ostrich hides). Profitability is linked to breeding enterprises, but as the returns from fibre production (camelids) and meat (ostrich) are low, it is unlikely that breeding markets are sustainable long-term. Profitability of current ostrich enterprises relies increasingly on direct marketing of meat through farmers markets *etc.* to ensure the best returns.

In the longer term there is potential to add value to upland sheep fleeces which are currently virtually worthless in the face of high quality Australian and New Zealand imports. The use of processed fleeces for building insulation is being investigated, but current costs make the final product three times as expensive as current insulation materials, though insulation based on wool may have some benefits in terms of fire retardation *etc.* which could result in valuable niche markets. While such developments are unlikely to result in an improvement in returns to farmers, it would have wider benefit to the rural economy.

*7.3 Access to processing facilities in Wales*

As part of the study, data on the range and location of processing facilities for dealing with crop and animal products was collated and mapped (Appendix VII). Wales has existing facilities for processing flax fibre at Bangor and this facility is now being used to process the national fibre crop, as other facilities are now defunct. This means that there is a focus of expertise in the North Wales area for processing fibre crops. The close links of this facility with the Biocomposites Centre at Bangor means that there is a cluster of key expertise in fibre extraction and down-stream processing of fibre crops. This expertise could be used to develop a number of alternative generic fibre crops, looking to crops which are currently well developed as well as those that may show potential in 3-5 or 5-10 year timescales.

There are no seed oil crushing or refining plants of any commercial size located in Wales. The nearest large scale crushing and refining plant is located in Liverpool (Cargill). This is a high throughput mill dealing with commodity oilseed crops and imported seed. Similar crushing and refining plants are located in Yorkshire and Kent. In all cases this would significantly add to transport costs in hauling oilseeds out of Wales. Wales is therefore generally at a disadvantage to the rest of the UK where commodity oilseeds are concerned. This adds to the problem of the short growing season and risk of wet conditions at harvest which does not favour oilseed production in Wales. However, small scale processing of niche crops could still provide a useful income stream. There are facilities for small scale extraction and refining of high value oils by Statfold Seed Oil developments based in Tamworth Staffordshire, which is within relatively easy reach of North, East and South East Wales, particularly where high value oils are concerned (*i.e.* pharmaceuticals or essential oils *etc*). However, for areas such as Pembrokeshire, Carmarthenshire and Ceredigion to benefit from their potential for novel oil crop production, installation of small scale crushing and refining plant should be considered for South West Wales

Large scale dairy processing facilities in Wales are limited to three locations North Wales (Pwllhei (Caernarfon Creameries), Llanrwst (Snowdonia Cheese) and Denbigh (ACC)). In addition there are two ACC dairies in South Wales (Llangadog and Cardiff) but these only deal with the supply of milk, cream and butter. Cardiff does have facilities for canning milk but there is unlikely to be demand for this for sheep and goats milk . ACC produces 10% of the UK Cheddar as well as speciality cheeses. Clearly there is existing expertise in cheese production in Wales. To take advantage of the significant areas identified as having potential for dairy sheep, goat or water buffalo production, particularly in South Wales, there would need to be development of local processing facilities. Appropriate location of small scale processing facilities would make it easier to brand produce for small niche outlets interested in speciality cheeses *etc*. There is a significant amount of hygiene and other legislation which would have to be complied with, plus significant set-up costs, which means that piecemeal development is unlikely.

Based on its traditional livestock markets, Wales is relatively well supplied with abattoirs, though there are gaps in coverage in the northern half of mid-Wales in areas around Southern Gwynedd, Northern Powys and in some areas of South East Wales. A significant number of Welsh abattoirs have been awarded status as organic registered abattoirs. This suggests that many existing Welsh abattoirs are prepared to

deal with small volume processing and the interruption to normal processing that this entails. It also suggests that they would be willing to deal with issues of separation and maintenance of produce identity, which is key to assurance where branded products are concerned.

Steps are being taken to add value to wool fleeces. An old wool depot at Dinas Mawddwy, Gwynedd is being renovated as part of a project involving the British Wool Marketing Board, WDA, Cymad and Gwynedd County Council. The plan is to develop a plant which will produce thermal insulation from low grade wool collected from North West Wales. Up to 1.5 million kilos will be processed per annum.

*7.4 Support*

To aid development, in many cases support for market development will be required to help stimulate enterprises. With novel animal species, costs of fencing and measures to prevent escape can be considerable and may require assistance in the short term. Marketing is a time consuming and costly process, closing the gap between producer and purchaser is required to stimulate development. Where further on-farm or centralised processing is required, then assistance with costs of investment and business planning will be required. Support for the development of co-operatives for development or marketing could also assist enterprise development. In addition, training will be required in areas such as animal handling for novel species and food hygiene regulations *etc* for those involved in the food sector.

## 8.0 TOP 10 PRIORITY ENTERPRISES FOR WALES FOR THE SHORT AND MEDIUM TERM

*8.1 Plant species*

Wales has the potential to develop a natural fibre industry building on experiences with flax. Current research programmes in North Wales are evaluating the potential of hemp and flax fibre crops in Wales, with the aim of improving performance. This has highlighted that flax has performed better than hemp in North Wales in recent years, but this may not be the case in all areas of Wales. Miscanthus has been developed in the UK as an energy crop, but markets for fibre are also developing which give significantly higher returns to growers. Miscanthus prefers wetter climates and should be evaluated in more detail as a potential fibre crop in Wales. Longer term, other fibre crops like nettle are starting to be commercialised for niche outlets. This is another crop which appears to have significant potential in Wales. Capitalising on existing Welsh experiences and knowledge in the area of fibres, all fibre crops should receive high priority for further research and development in Wales. Development of a generic fibre industry in Wales could capitalise on such markets and ensure that the added value obtained from processing fibre remains in Wales. The added value of being associated with a 'natural' product may also add to the social benefits associated with a domestic fibre industry, adding opportunities for tourism.

Wales has a limited ability to capitalise on oilseed markets. Where the growing season extends into late August there is a risk of wet conditions leading to

deterioration of crop samples, loss of seed in species sensitive to pod shatter and risk of total crop loss where species are swathed and left in the field to dry prior to harvesting. For bulk commodity crops such as HEAR, crambe, borage and evening primrose, there is also a lack of high throughput processing facilities which means that seed has to be transported out of the region, adding to costs and loss of added value to the economy. Such crops are also subject to significant swings in profitability due to cheap imports. There is potential to grow high value crops for pharmaceutical or essential oils markets, but of the most promising crops identified, poppy, peppermint, valerian and St Johns wort, there are already strong established players and in many cases established processors. For crops which are still not yet fully commercialised such as Calendula and Echium there could be potential to develop new markets and associated processing facilities, but such development lags well behind the lead developed for fibre crops. There could also be potential for very small niche markets supplying medicinal and herbal plants for tinctures and condiments on a local scale, though such enterprises are by their nature very small in size, with small plots of plants.

Oats are already widely grown in Wales and developments to commercialise novel products from oats have centred on areas close to Wales, which is seen as a good source of raw material. Technical barriers to extraction have to be overcome to maximise exploitation but there is significant potential for Wales to capitalise on such developments in the mid to long term (3-5 year period) once technical developments are achieved. In the interim small scale markets exist for oat oils and oat starch.

Production of Woad is not currently commercialised in the UK and therefore offers an opportunity to establish a small niche industry to counter imports. Indigo produced from woad is a valuable dye product and could compliment the development of any natural fibre developments arising from domestic fibre processing to produce a range of unique textiles or other added value products. Natural textiles dyed with natural dyes are able to command premium prices in high fashion markets. The crop needs further research and development to commercialise production. Areas of potential production are also clustered in Wales, which suggest opportunities exist in coastal areas of Wales and arable areas to the West of Wales.

There could be potential for other medicinal herbs and plants such as bog myrtle and sea buckthorn which are native to Wales, but significant further development of such crops is required to commercialise production.

*8.2 Dairy processing enterprises*

The UK cheese market is worth £1.4 billion per annum. Speciality cheeses are showing strong growth and are worth in the region of £17 million per annum. UK speciality cheeses account for sales of 60,000 tonnes. Imports of speciality cheese are increasing, 183,000 tonnes were imported in 1991 and imports of fresh cheeses grew by 13% to around 59 thousand tonnes. The UK exports around 70,000 tonnes of cheese.

Clearly there are opportunities for development of niche markets in the speciality cheese sector for dairy sheep and dairy goat cheeses. Water buffalo are technically more difficult animals to deal with as milking animals and may suffer from being

non-native to Wales, which could make branding and marketing more difficult.

*8.3 Meat and other added value animal enterprises*

UK sales of game and exotic meats amounted to £35 million in 1999, but sales of some, like ostrich have slumped. Marketing has traditionally been through small suppliers, however, farmers markets, mail order and the internet now offer a direct sales route. Venison and wild boar appear to offer the best returns and opportunities for Welsh farmers. However, the success of venison will depend on the ability to source calves for finishing, which is where the best margins are obtained. In this case linking of upland and lowland breeding units needs to be stimulated to optimise success.

Of the other species considered, the market for ostrich is now very small and significant efforts will be required to turn this around. The market for quail appears saturated and the returns on intensive rabbit and snail farming are unlikely to stimulate much uptake.

For animal fibres, the profitability of cashmere goats and camelids rests on selling breeding stock for which there is a limited market, so high financial returns are unlikely to be realised. Mohair goats can be run with sheep, but again the financial return from fibre sales covers little more than costs of production so there is unlikely to be significant take up.

Development of facilities to add value to low value fleeces is an important step. There will be a need to niche market insulating materials and any other developed products, as such materials are likely to be more expensive than the materials being replaced. If this development relieves some of the costs for upland sheep farmers this will be welcome, but greater benefits may accrue to the community through local processing.

Honey production has potential to add value in Wales as a complimentary enterprise to farming, though it is labour intensive which means returns on invested labour are low compared to other enterprises considered. The preference of Welsh beekeepers for native bees may also add value and provide opportunities for sale of native bees to other parts of the UK. Mixed flower honey prices are falling in the face of cheap imports and the best returns are likely to be realised through local marketing and branding.

*8.4 Final prioritised list*

On the basis of the information and data generated during this study, the 10 crops/enterprises deemed most likely to be successfully in Wales, and most likely to add value to the wide community in the short and medium term are listed in Table 8.1.

These represent enterprises where there are currently least barriers to adoption and technical leads or developed processing facilities exist in Wales. It also includes a longer term speculative indication of enterprises that could have a significant impact on Welsh agriculture given sufficient investment and development in the interim.

Table 8.1 Top 10 prioritised enterprises for Wales

| Timescale | Plants | Animals |
|---|---|---|
| 0-3 year | Hemp & or Flax* | Dairy Sheep |
| | Miscanthus | Dairy Goats |
| | | Wild Boar |
| | | Venison |
| 3-5 years | Nettle | Wool – added value |
| | Woad | |
| | Oats | |

* Depending on identified potential in different areas of Wales

These enterprises represent non-traditional areas where further development and investigation should primarily be focussed to provide the greatest returns for Welsh farmers and the wider Welsh economy. That is not to say that other enterprises discussed in this study should be dismissed, only that they are currently considered to be of a lower priority than those listed above. Markets can change significantly and quickly and technical developments to overcome some of the constraints highlighted through different sections of this report means that a watching brief should be kept on all the enterprises highlighted in the initial prioritised list, as these are known to have possible potential in Wales.

## 9.0 RECOMMENDATIONS FOR FURTHER WORK

This study is not the end but a starting point in an exercise to identify novel crop and animal species for Wales. There are a number of technical, practical, logistical, market and support actions required to realise the potential of any enterprise identified in this study. Across a very broad range of crop and animal enterprises this study has analysed and sifted data and prioritised plants and animals for further investigation on the basis of the best available information. In some cases detailed information is lacking and further work will be required on a local basis to assess the feasibility of developing the above prioritised enterprises and plans to site processing facilities. The GIS data used in the mapping exercise highlights potential (but not necessarily exclusive) areas of production of various enterprises and should provide a focus for attention at a local scale.

Specific areas for further work and development

- Sources of data used in the study highlighted that prioritised plant species could be grown in areas of Wales, but data on the potential agronomic performance and potential is very limited in some cases. Further work is required for many of the less well commercialised species to assess and demonstrate the potential for commercial production in Wales. Trial plots could be established at college or demonstration farms.

- Improved agronomic data and inclusion of more sophisticated models of local climate variation and higher resolution soil and land use data would provide

more detailed local crop area maps within the broad areas outlined as 'suitable' by GIS maps generated in this study.

- With more detailed information on novel crop agronomy requirements and production potential in Wales, supported by more detailed local GIS maps, it would be possible to determine the most likely catchment areas for siting of processing facilities to minimise costs of transport.

- For medicinal plants and other crops with metabolites of commercial interest, there is a need to establish levels of biologically activity and determine how this is affected by locality of production. Such species tend to be genetically diverse in the absence of well established breeding programmes. Variation in local climatic conditions can also affect accumulation of metabolites.

- Where novel crop cultivars are introduced, particularly from non UK breeding programmes, an assessment should be undertaken of potential risks to the native flora , in particular where species have close relatives in the wild.

- In some cases more basic research work may be required to ascertain and demonstrate potential, particularly in relation to fibre crops and methods of processing *etc.* Ideally, generic processing methods need to be developed to enable a range of fibre crops to be exploited by single processing facilities to minimise costs of processing. Methods for optimising the processing of medicinal and healthcare plants also need to be investigated where improvements in processing can significantly improve returns. Development of small scale flexible oil extraction plant capable of dealing with multiple feedstocks could open markets for novel oils, healthcare and pharmaceutical crops.

- Consideration should be made towards development of mobile processing facilities for rural areas where transport is more costly.

- Markets for any by-products of processing need to be developed to reduce the costs of processing, there is a need to utilise the whole plant and minimise waste. However, care is required to avoid disrupting other valuable existing markets (*i.e.* bedding straw markets) by dumping waste.

- Demonstration and technology transfer initiatives will be required to stimulate development of novel enterprises. Links could be developed between potential and existing growers/producers. Specialist trained staff would help inform growers/producers about developments, current and potential markets and what was happening in Wales and the wider UK to enable better informed decision making.

- Ongoing work on flax and hemp should help to identify the most suitable fibre crop for commercial development in Wales. This work reports in 2004 and should identify areas where further development work is required.

- Links need to be developed with industry and companies offering contracts for novel crops to maintain a flow of information relating to market and quality

demand and future developments. In addition there is a need to ascertain the potential for Welsh farmers to get involved in developments.

- Where on-farm processing is proposed, support and information is required in relation to issues such as record keeping and traceability, registration of food businesses, hygiene regulations and standards *etc*.

- For game meat enterprises, there is a need to assess the feasibility of production at a local scale and to identify market outlets. Establishment of enterprises on demonstration farms would help stimulate interest and focus attention. For both venison and boar there are high start up costs, associated with fencing and stock purchase. Assistance in these areas could support development.

- Advantage should be taken of specialist and local knowledge where it exists to develop plans for exploitation of dairy sheep and goat enterprises. In many cases co-operative ventures are likely to be the best way of developing these enterprises and reducing the level of risk to individuals. A full business appraisal is required to assess the potential for such enterprises either linked to a large central processing facility or associated with development of local processing co-operatives.

- For beekeeping, further specialist investigation into the market for sale of native bees is required.

- For all enterprises where added value is being sought, there is a need to develop branding and marketing expertise to establish local and regionally distinctive products.

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**Appendix I. Sources of information used to derive a list of potential crop and animal enterprises for Wales**

**Information on plants**


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## Appendix II – Parameters used to define crops suited for production in Wales

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Amaranth | Annual | Light | 200mm/yr | Soil at sowing – 18.5-24°C | No | | Mid-May-mid-June | Mid-September | 2 (food) |
| Artichoke | Perennial | Sand, loam, clay | Low | Can tolerate to – 10°C | Yes | Yes | July | September-October | 1 (non-food) |
| Barberry | Perennial | Heavy clay-loam, also dry, shallow | | | Yes | No | October-November | September-October | |
| Bog-Myrtle | Deciduous shrub | Light-heavy | Relatively high | Relatively warm | Yes | | Late Spring-early Summer | August-September | 2 |
| Borage | Annual | Chalk, sand and stony soils preferred | Relatively low | | Yes | | March-mid May | July | 3 |
| Brown Knapweed | Perennial | Well drained fertile, alkaline soils | Can tolerate drought | Relatively warm – sunny position | Yes | | Early Summer | Autumn (the following season) | |
| Bugloss | Annual/ Biennial | Light sand and chalk | | | Yes | | April-May | July-August | 1 |
| Calendula | Annual | Light, easily warmed, moist | Relatively high | | Yes | | Late March-April | September | 2 (cosmetics) |
| Canary Grass | Annual | Any, moist | Relatively high | | Yes | | Early Summer | Autumn | 1 |
| Caper Spurge | Biennial | Light, well-drained, alkaline | Relatively low | | Yes | | Spring | July-September | 2 |
| Caraway | Biennial | Any – fertile, water retentive | Low at flowering, high at maturity | Any – cool/warm | Yes | | Autumn or March-April | Late June-early July | 1 |
| Catmint | Perennial | Light, sandy soil | Reasonably low | Relatively warm – sunny position | Yes | | Early Summer | September-October | 1-2 |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Chamomile | Perennial | Light, sandy soil-heath land | Relatively low | Relatively warm | Yes | | Early Summer | June-August | 2-3 |
| Chicory | Biennial/ Perennial | Deep, fertile, well-drained. Chalk and limestone | Dry summer period required | Soil – 10°C at planting | Yes | | Mid-April | October – November | |
| Clary Sage | Biennial/ Perennial | Well-drained, light, sandy | Relatively low, not too wet in winter | Relatively warm – sunny position required | Yes | | Spring | Mid-Summer – September | 2 |
| Comfrey | Perennial | Any although heavy clay preferred | Relatively damp throughout season | Not too warm/sunny | Yes | | Spring | July | 1-2 |
| Common Club Moss | Evergreen fern | Rough spongy peat, heaths, moors | Relatively damp throughout season | Not too warm/sunny | Yes | | Spring | Spring (the following year) | |
| Common Snapdragon | Perennial | Well-drained, light. Also clay. | Relatively low | Relatively warm - sunny position required | Yes | | July-August | September | |
| Cordgrass | Perennial | Any – arable soils to peat, brackish soil | Relatively high | Relatively warm | Yes | | Spring | February (June to October if sustainable) | |
| Coriander | Annual | Light, moist soil | Relatively low | Hot summer but cool spring required | Yes | | Spring | Mid-Autumn | 1-2 |
| Cotton | Annual | Sandy loam, loam or granulated clay loam | At least 500mm/yr | Between 20-35°C, below 15°C not suitable. Adequate sunlight | No | | June/July | 120 days after emergence (October-November) | |
| Crambe | Annual | Various, preferably sandy loams | Moderate | 15-25°C during the main vegetative stage | Yes (to – 7°C) | | Late April | August | 3 |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Damson | Perennial | Loamy soil and limestone, prefers chalk but can grow well on heavy clays | Relatively high, requires moist soil throughout season | Relatively warm | Yes | Yes (but not maritime exposure) | Spring - Autumn | October | |
| Dill | Annual | Light, well-drained | Relatively low | Relatively warm | No | No | March-July | Early Autumn | 2-3 (food) |
| Dyers Bugloss | Biennial | Fertile, well-drained | Moderate | Relatively warm – sunny position required | Yes | | July | August (the following season) | |
| Echinacea | Perennial | Deep, rich sandy loam | Relatively low | Relatively warm – sunny position required | Yes | | Spring – early summer | Autumn | |
| Elder | Perennial | Any – prefers moist loamy soil | Relatively high | Relatively warm – sunny position required | Yes | | Spring | Flowers – late spring Berries – early autumn | 2 (dye) |
| Eruca | Annual | Tolerates most soil types | Relatively low | Relatively warm | Yes (not too extreme) | Yes | Spring/Autumn | Throughout the year | 2 |
| Evening Primrose | Annual/ Biennial | Dry, well-drained, fertile sandy loam | Relatively low | Warm and sunny, annual temperature of 8-14°C | Yes | Yes | March/April or July/August | September/ October | 2 |
| Fennel | Annual/ Biennial | Any – prefers sandy, well-drained | Relatively low, wet autumn will kill the plant | Relatively warm – cold autumn will kill the plant | Yes | Yes | Spring | Autumn | 2-3 (food) |
| Fenugreek | Annual | Well-drained, loamy soil | Relatively low | Warm sunny position required | Yes (not too extreme) | No | Late March/early April | Mid-September | |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Feverfew | Perennial | Any – prefers well-drained loamy soil | Can tolerate low or high rainfall | Sunny position required, can tolerate warm or cool conditions | Yes | Yes | Mid-Spring | July/August | |
| Field Scabious | Perennial | Well-drained, chalky soil | Relatively low | Very cold hardy plant, sunny position required | Yes | | Spring | When shoots reach 10-15cm, on a regular basis | |
| Foxglove | Biennial | Light, dry soil rich in organic matter, acidic | Can tolerate low or high rainfall | Not too warm, shaded area required | Yes (to –25°C) | | Spring/Autumn | Late summer/autumn | 2-3 (pharm) |
| Giant Horsetail | Perennial | Best suited to compost so it could be difficult to grow on general soils | Relatively high, damp conditions ideal | Cooler position preferred, shaded area is ideal | Yes | | Spring | Autumn | |
| Giant Reed | Perennial | Moist, deep fertile, well-drained soil | Requires damp conditions | Requires 10-12°C to start growth in Spring | Yes | | Late Spring | Generally after growth has ceased in December | 1-2 (fibre/ pulp) |
| Gold of Pleasure | Annual | Adaptable to any soil type | Adaptable to low or high rainfall | Prefers cooler conditions | Yes (not too extreme) | | Autumn/Spring | August | 2 |
| Greater Periwinkle | Perennial | Any – light to heavy clay soil | Low, can tolerate drought | Warm conditions preferred although can grow in any | Yes, but not in the early stages | | Late Spring (after last frost) | | |
| Heather | Perennial | Light, acidic soil although preferably poor peat | Can tolerate low summer and high winter rainfall | Requires a warm, sunny position | Yes, but not in the early stages | Yes | Spring or summer after last frost | Autumn onwards | |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Hemp | Annual | Rich, loamy soil with plenty of moisture and humus | Sufficient moisture although it is sensitive to water-logging and drought | Good growth when cooler, heat late in the season hastens growth. Cool spring limiting | No | | Early March-mid May | August-October | 2-3 |
| Henbane | Annual/ Biennial | Sandy, alkaline soil | Relatively low | Relatively warm – sunny position required | Yes | | July | Autumn | 2 |
| Henna | Perennial | Any – prefers heavy water retentive soil | Relatively high, damp conditions preferred | Annual temperature of 19.9-27.5°C | No | | Spring | Two harvests – April/May and October/ November | |
| Honesty | Biennial | Light soil is preferred | Relatively high | At least 10 weeks of 5°C to vernalise over winter | Yes | | May (June-August latest) | Late summer | 1-2 |
| Jasmine | Perennial | Well-drained loam | Relatively low | Best with night temperatures <14°C and day temperatures <21°C | Yes (although not too extreme) | No | Late Spring/early Summer | Take flowers throughout season when visible | |
| Jerusalem Artichoke | Annual | Light, well-drained, loamy soils | Relatively high | Can tolerate cold but requires sun and a long warm summer to flower | Yes | Yes | Early Spring | October/ November | 2 (Sugar/ biomass/ fuel) |
| Kenaf | Annual | Various types are suitable | Relatively high | Daily mean temperature in the growing season of >20°C | No | | April | July-September | |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Lallemantia | Annual/ Perennial | Light, well-drained soil | Ample moisture required | Minimum temperature for germination is 2-3°C. Sunny position. | Yes (not too extreme) | | Spring (no later than mid-April) | August-September | |
| Lavender | Perennial | Light, well-drained, warm sandy soil, not too acidic | Relatively low | Warm sunny conditions are ideal | Yes | | Seed – March/May Cuttings – June/August | August-October | 2 (small market) |
| Lesquerella | Winter Annual | Well-drained, does not suit soil in Western England | Annual rainfall 250-400mm | High temperature required, does not suit Western England climate | Yes (not too extreme) | | Late Summer/early Autumn | Late Spring/summer | 2-3 |
| Linola | Annual | Light, well-drained soil, humus rich. | Relatively high | Low temperatures can be tolerated | Yes | Yes | Late Spring | August/September | 3 (small contracts) |
| Linseed | Annual | Light, well-drained, humus rich soil | Should be 700-750mm during the season | Ample sun required but not too hot | No | No | Mid-March/mid-April | August/September | 3 |
| London Rocket | Winter Annual | Most soils successful | Relatively high | Plants dislike hot weather, this causes them to die off | Yes (not too extreme) | | Spring or Autumn | Autumn | |
| Lupins | Annual | Fertile, free-draining medium loam is best suited | Relatively low | 1400°C acc. heat units during the growing season for podfill | Yes (not extreme) – some species better than others | | March-April or autumn | Late September-early October | 2 (protein) |
| Madder | Biennial/ Perennial | Light, sandy, well-drained soil | Relatively low | Warm sunny position | Yes | | Summer | September (the following year) | 1 (dye) |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Maize | Annual | Slightly acidic, well-drained soils | Relatively low | Minimum temperature for germination is 10°C, minimum for seedling growth is 13°C | No | | April/May (after last frost) | September/ October | |
| Marigold | Annual | Well-drained, heavy clays and sandy soils are most suitable | Relatively low | Requires a relatively warm, sunny position | No | | After last frost | August/ September | 1-2 (dye) |
| Marsh Grass | Perennial | Can tolerate all soil types, deep, rich, moist soil is preferred | Moderate | Relatively warm, sunny position required | Yes | | Summer | No use for harvested crop | 1 (biomass) |
| Meadow foam | Winter/ Spring Annual | Tolerates all soil conditions | Can tolerate high winter rainfall but must be dry in July. Moisture supply in October need to be good for establishment | Warm in July, requires a sunny position in winter. Soil temperature to be low at germination, above 17°C can induce secondary dormancy | Yes | | Early-mid October or Spring | Late Summer | 2 (lubricants) |
| Milk Thistle | Annual/ Biennial | Well-drained fertile soil, preferably chalk | Relatively low | Relatively warm, sunny position required | Yes | | March/April or May-August | Late summer as annual or summer the following year if grown as biennial | 2-3 (pharm) |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date - | Market Developments |
|---|---|---|---|---|---|---|---|---|---|
| Milkweed | Perennial | Well-drained, light rich or peaty soils | Moderate rainfall required | Best suited to cool winters and warm summers, southern UK more favourable. Sunny position. | Yes (not too extreme) | | Late Spring or early summer | Spring onwards | 1 |
| Miscanthus | Perennial | Heavy, moist soils. Dark coloured soils are more favourable | Relatively high | Winter temperatures must not be too low | No (spring must be frost free) | | Spring or summer after the last frost | February/March the second season | 1-2 (fibre/ biomass/ paper) |
| Mugwort | Perennial | Well-drained, loamy soil, not too acidic | Sufficient moisture is important | Relatively warm, sunny position is important | Yes | | Spring/Summer | From summer in the second season | 2-3 (pharm) |
| Mustard | Annual | Well-drained fertile soil, will tolerate all soils except heavy clays | Moderate rainfall is required | Long days and sunny position are required | Yes | | March | August/ September | 2-3 (food) |
| Nasturtium | Annual (or Perennial) | Rich, light well-drained soil | Relatively high | Warm sunny position required | Yes (not extreme or late) | | April | Late summer (or continuously if perennial) | 2 |
| Nettle | Perennial | Loose, deep rich soil, high in organic matter and nitrogen | Relatively high | 600-800day° to 3250day° over a base of 7° required. Sunny position is essential | Yes | | Summer | Summer (the following season) | 1-2 (fibre) |
| Oats | Annual | Most soils, good drainage is important, preferably acidic | Annual rainfall 700mm | Cooler regions are more suitable, sunny position ideal | Yes | | Autumn or early Spring | August-October | 3 (wax) |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Oilseed Rape | Annual | Well-drained, prefers heavy land. Ideally well-structured clay loam soil | Relatively high | Cooler conditions are preferred | Yes | | Winter crop - Late August-early September Spring crop - late March-early April | July or August/September | 3 (erucic acid) |
| Peppermint | Perennial | Any except heavy clays | Moist conditions are essential | Warm and sunny position required | Yes | | Autumn or spring | August-October | 2-3 small essential oils) |
| Poppy | Annual | Well-drained sandy loam, heavy clays should be avoided | At sowing adequate moisture is required, dry after establishment | Warm weather after establishment | Yes (not too extreme) | | Late March | Late July | 2-3 (small) |
| Potato | Annual/ Perennial | Any, although preferably not heavy clays. Lighter soils preferred | Relatively high | Cool conditions with plenty of sun | No if the tubers are to be harvested | | Late March-April | Early September onwards, earlies from June onwards | |
| Quinoa | Annual | Rich, moist, well-drained soils | Relatively low | Can tolerate warm or cool conditions | Yes (except at flowering) | | April | August | 1 |
| Rain Daisy | Annual | Any, although it is best to avoid heavy clays | Relatively high, damp conditions preferred | Cooler conditions preferred | Late frosts should be avoided | | April | August | 1 (pharm) |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Reed Canary Grass | Perennial | Wet, nutritionally poor. Suited to areas along rivers, streams, lakes and pools | Can tolerate extremely damp conditions – up to 49 days under water. Suited to wetter western areas of the UK | Cool temperate climates are preferred. | Yes | | Summer | Autumn onwards | 1 (biomass/ fibre) |
| Rose | Perennial | Most soils are tolerated, heavy clays are more favourable | Relatively low, waterlogged soils not suited | Both warm and cool temperatures are tolerated | Dislikes severe frosts late in the season | | Summer | Summer/autumn in the second year of growth | 2-3 (essential oil) |
| Safflower | Annual/ Biennial | Well-drained, deep fertile, sandy loam soils. The plant dislikes heavy clay soils | Relatively low, excessive rainfall at flowering will effect yield | Hot climates are best, germination will occur as low as 2-5°C and the plant can tolerate temperatures as low as -7°C once at rosette stage | Yes but frost after elongation stage can cause substantial damage and sometimes even crop loss | | Spring | Autumn | |
| Sage | Perennial | Light, alkaline and relatively dry soils | Relatively low | Relatively warm sunny position is ideal | Yes | | Spring/Summer | August/ September | 2-3 |
| Scarlet Haw | Perennial | Well-drained, loamy soil is ideal, any can be tolerated (including heavy clay) | The plant requires relatively high rainfall but can tolerate drought | Relatively warm, sunny conditions are ideal | Yes – plants are hardy to at least -18°C | Yes | Best established from 1-2 year old whips | Seeds ripen in October, trees take 5-8 years before bearing fruit | |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Sea Buckthorn | Perennial | Deep, well-drained, sandy loam soils. Can be grown on river banks | Annual rainfall 400-600mm, can survive spells of drought or flood | Temperatures of –40-40°C can be tolerated | Yes | Yes | Late Spring | Late August-early September | 1 (speciality oils) |
| Skull-Cap | Perennial | Moist, acidic, calcareous soils are best | Relatively low | Relatively warm, sunny position | Yes | | Late Spring | Summer in the third or fourth season | 1-2 |
| St. John's Wort | Perennial | Calcareous soils, should be fertile and not too dry | Relatively high | The plant will geminate at 10°C, requires sunny position | Yes (not too extreme, may struggle in Northern regions) | | Autumn or Spring | June to August | 2-3 (niche) |
| Stinking Hellebore | Evergreen Perennial | Any, prefers well-drained rich loam. Grows well on heavy soil and chalk | Relatively high, the plant dislikes drought | The plant requires warm conditions | No | No | Summer | Autumn onwards | |
| Stock | Biennial/ Perennial but grown as Annual | Ideally warm sandy soil, will grown on a range of soils | Adequate water supply essential | Relatively warm, sunny position | Yes | | Mid-late Spring | August | |
| Sugar Beet | Annual/ Biennial | Deep, well-drained, stone-free soils | Relatively high | Relatively warm conditions, especially at germination | Yes – not too severe | Yes | Mid-March/late April | September-December (January if not too severe frost) | |
| Sunflower | Annual | Deep, moderately rich soil | Relatively low | Requires 20-25°C for seed production, sunny position | Yes (not extreme) | Not too strong | Mid-Spring | September/ October | 3 (oils) |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Switch Grass | Perennial | Moderately deep, dry sandy or clay loam soils | Relatively low | Relatively cool season | Yes | | Late Spring | Autumn | (biomass/ fibre) |
| Thyme | Perennial | Well-drained sandy soil is ideal | Adequate moisture but dislikes wet conditions, particularly in winter | Ideally relatively warm, plants are hardy to -15°C. Thrives in full sun | Yes | | Spring | Throughout the summer, sparingly in first season | 2 (food) |
| Valerian | Perennial | Rich moist, heavy loam | Adequate moisture | Relatively warm, sunny position required | Yes | | Late summer/spring | From autumn in the second season | 2-3 (pharm) |
| Viper's Bugloss | Biennial | Light, dry sandy soils | Relatively low | Relatively warm, sunny position. Requires 15°C at germination | Yes (not too extreme) | | Either February-May/August-November | August-October | 2-3 (essential oils) |
| Weld | Biennial | Well-drained, calcareous soils | Relatively low | Relatively warm, sunny position required | Yes | | Spring | August/ September | 1 (dye) |
| Wheat | Annual | Best on rich, well-drained soils | 300mm water supply to reach potential yield | Lower temperatures in summer reduce yield loss, higher temperatures speed up growth | Yes | Yes | Late September (occasionally Spring sown) | September | |
| Wild Leek | Biennial | Any, can tolerate heavy clay soil, prefers light soils | Relatively low | Relatively warm, full-sun position | Yes | Yes | Late Summer/Autumn | August | |

| Plant | Life Cycle | Soil Type | Rainfall | Temperature | Frost Tolerance | Wind Tolerance | Sowing Date | Harvest Date | Market Development |
|---|---|---|---|---|---|---|---|---|---|
| Woad | Biennial | Good loamy soil is required | Relatively low | Relatively warm position in full sun | Yes (hardy to −15°C) | | Spring or August | Regularly throughout the season | 2 (dye) |
| Yarrow | Perennial | Any, preferably well-drained | Relatively low | Relatively warm, sunny position | Yes | Yes | Summer | July-September | 2 (dye/ pharm) |
| Yew | Perennial | Can tolerate all, ideally heavy clays | Can tolerate high or low rainfall | Can tolerate warm or cool conditions | Yes | Yes | Autumn | September-November | 2-3 (small pherm) |

## Appendix III –Agronomic information on preliminary listed crops

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Amaranth | Fresh shoot yields of 20t/ha | | | Slow and poor seedling emergence in temperate areas due to low soil temperature<br>Short growing season |
| Artichoke/Cardoon | Experimental yields of 20-30t/ha of dry matter | | Varieties with minimum wastage. | Requirements for high nutrition, it is therefore costly to produce.<br>Problems with illnesses and weeds |
| Bog-Myrtle | N/A | | | Climatic conditions warm, moist<br>Will only grow on raised peaty wetlands |
| Borage | Average seed yield 0.2-1.0 t/ha, average 0.35t/ha | 0.625t/ha could be achieved in Northern Europe | | Much of the seed is lost at harvest through shedding. Powdery mildew is the main disease threat. |
| Bugloss | N/A | | | Extreme climates |
| Calendula | Average - 0.38t/ha | 0.5-0.6t/ha in future | Oil content should be increased by 50-100% from 16.6-19.2% | Harvesting is a limiting factor due to the amount of seed shedding. |
| Canary Grass | 5-6tDM/ha | Up to 10tDM/ha | | |
| Caraway | Seed yield 1.6-1.9t/ha<br>Carvone content 1% | Up to 3.0t/ha has been produced across Europe as biennials | Low shatter varieties have recently been produced | Seed shatter at harvest.<br>High rainfall at flowering and drought at maturity |
| Caper Spurge | Plot yields in the UK of over 2t/ha in the biennial form and 1.2t/ha in the annual form | | Reduction of oligocyclic, polyfunctional dipterene esters<br>Harvesting technique that does not damage seed | Presence of oligocyclic, polyfunctional dipterene esters prevent large scale production |
| Catmint | 4.4t/ha | Up to 6.7t/ha in optimum conditions | | No herbicides are currently available for use on Catmint. The plants will only last for three years, after which the yield and quality will be reduced due to weed infestation and competition |
| Chamomile | Average oil yield of 750kg/ha. 20-25t/ha fresh weight | Up to 1250kg/ha should be possible | Seed selection and distillation techniques are currently being reviewed to reduce yield loss | Harvesting techniques should be improved to reduce yield loss |

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Chicory | Average fresh root yield around 50t/ha | Potential to reach 60t/ha fresh root yield | | Susceptibility to Sclerotinia and Rhizoctonia spp means an adequate rotation is essential<br>Wet summers are unfavourable |
| Clary Sage | 5t/ha plant material | Optimum yields will be achieved after the first two summers of production | | It takes approximately 800kg of plant material to distil 1kg of essential oil |
| Comfrey | 223t/ha fresh weight 15t/ha DM | In the tropics up to 22-30t/ha DM can be achieved | | Once the crop has become established it can be very invasive |
| Common Snapdragon | N/A | | | |
| Cordgrass | 10-20tDM/ha | | Establishment from seed | |
| Coriander | Average 870kg/ha seed | 2100kg/ha seed yield is achievable | | |
| Cotton | | | | Unsuitable climate in UK |
| Crambe | 2t/ha, 30-40% oil content | | Improved germination is currently being researched | Bird damage<br>Low temperatures at sowing or flowering |
| Dill | In the USA 670-1370kg/ha, not commonly grown commercially yet in the UK | | | Sensitive to environmental stresses |
| Dyers Bugloss | N/A | | | |
| Echinacea | Not yet commercially grown in the UK | | | |
| Elder | Average yield of 1-1.5t/ha in year 1 | Potential yields of 15t/ha should be achieved in the third year of production | | Limited economic uses |
| Eruca | | | | Cooler climates may restrict production potential |

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Evening Primrose | 0.49-1.2t/ha for biennial varieties, 0.57-0.74t/ha for annual varieties | Potential yield is 2.5t/ha | | Seed shedding at harvest, therefore desiccation is essential. The spring crop is limited by late establishment, late harvest and sensitivity to drought |
| Fennel | 87kg oil/ha | | | Risk of bolting in cooler climates |
| Fenugreek | Seed yield 1-3t/ha | | | Slow, weak growth occurs in cool, wet soils |
| Feverfew | 200lbs plant material from 10,000 plants | | | The plant must not be allowed to heat up prior to drying or processing. The processing facilities should be on-site or very close to prevent this happening |
| Field Scabious | Up to 0.35 t/ha for the annual plants and 0.7t/ha for the perennial plants | | Extend information available on basic agronomy, reduce flowering variability | Optimum plant population unknown. Variability in earliness and length of flowering period. Limited information available on basic agronomy |
| Foxglove | N/A | | | |
| Giant Reed | 20-30t/ha DM annually | 34t/ha DM annually (takes 3-5 years to reach) | Increase seed viability, germination and establishment | Much agronomy information is currently unavailable. Seed dormancy, viability, germination and establishment are unknown. |
| Gold of Pleasure | Maximum yield to date has been 2.28t/ha, oil content of 37-43% | Potential yield of 2.6t/ha fresh weight | Chemical control may be necessary if problems of Botrytis and Sclerotinia persist | Mild wet winters encourage weed growth and competition. Small seed size causes problems at sowing. |
| Heather | | | | |
| Hemp | 6.2t/ha | 7.5t/ha | Aim to produce cultivars with zero THC drug properties | High drug hemp creates drug policing problems. Late harvesting of the crop makes dew retting unreliable. Harvesting techniques are currently ineffective. |
| Henbane | 665kg/ha in the first year and half this amount in the second year of production | | | Requires too much hand labour to make production economical. The plants are subject to legal restrictions in some areas due to their toxicity. |
| Henna | Yield in the first few years is low, increasing to 1.7t/ha DM | 2.0t/ha DM may be achieved with added irrigation | | Temperature is a limiting factor in UK. |

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Honesty | Seed yield 1.8-2.9t/ha, oil content 32.4% | | An annual, late winter or spring sown variety is required to optimise potential. | Mechanical harvest is currently a problem. The biennial nature of the crop can be a problem due to the high vernalisation requirements. |
| Jasmine | 1.2-2.0t/ha in the first year, 3.0-4.0t/ha in the second year. | | Improving the quality and virus status of the crop | The crop can not tolerate strong winds. The plants need to overwinter in the glasshouse in the first year as frost protection. |
| Jerusalem Artichoke | Vary with soil, cultivar and season. 100t/ha fresh weight has been achieved | | Improvement of storage capacity | Requires an exceptionally warm summer in the UK to flower. Storage capacity of the tubers is limited. |
| Kenaf | 1-2t/ha fibre, 12-18t/ha biomass production | Potential to reach up to 3-3.5t/ha fibre in favourable conditions | The crop is though to grow better in upland situations, this is currently being researched further and the outcome will be known in the future | The plants are frost tender and therefore have a limited growing season in the UK, temperature could be a limiting factor. Growth can be affected by both water shortage and water logging. |
| Lallemantia | Currently oil yields are low | | Improve oil yields | The minimum temperature required at germination of 2-3°C. |
| Lavender | Average 11kg/ha oil<br>16t/ha fresh herb<br>4-5t/ha fresh flowers | 35-45kg/ha oil in favourable conditions | | High quality oil is produced at medium altitudes in Mediterranean temperatures, Lavandin oil produced in the UK is of much lower quality. |
| Lesquerella | N/A | Seed yields of 2.5t/ha should be achievable | Improve oil yields | Low oil content, small seed size, indeterminate growth habit. |
| Linola | 0.5-1.5t/ha | 2.0t/ha | | Clashes with sunflower market. |
| Linseed | 0.5-1.5t/ha | 2.0t/ha | | The crop is slow to establish in cold weather, harvesting may be a problem if the crop is late to mature, lodged or incompletely desiccated. |
| Lupins | 1.5-3.0t/ha | 4.7t/ha has been achieved in the UK on trial basis | Winter hardy varieties have been produced | The crop requires a well-drained, south facing site. Harvest is late, occasionally into November. Soya is a major competitor, currently over 2 million tonnes of Soya is imported annually into the UK. |

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Madder | 15-20t/ha fresh weight | | | Harvesting the roots is time consuming, it is particularly difficult to remove the roots from clay soils. The plants set only small amounts of seed, the best method of propagation is to take cuttings which is also time consuming and labour intensive. |
| Maize | Grain yield 4-5t/ha, plant material 40t/ha | | Insecticide resistance and herbicide tolerance are desired traits in this crop | Minimum temperature for germination is 10°C, seedling growth is slow. |
| Marigold | N/A | | | The plants are frost tender and the length of the growing season is therefore a limiting factor. |
| Marsh Grasses | Average 10-12t/ha DM | Up to 15t/ha DM | | Marsh Grasses generally produce lower yields than other biomass crops such as Miscanthus. |
| Meadowfoam | Yields are very variable, between 0.3-1.3t/ha, average yield is 0.8t/ha | Up to 1.3t/ha can be achieved | Aiming to achieve consistent field development and performance. | Poor pollination occurs if conditions are cool and damp at flowering (June/July) |
| Milk Thistle | Data currently unavailable | | | |
| Milkweed | Average yield 12.3t/ha | 22.5t/ha is achievable with the developed new crop (2 cuts per season) | | Only 1-3% of flowers produce mature pods. The seed is light, therefore vast amounts have to be grown to produce a reasonable yield. |
| Miscanthus | Average yield 14t/ha (oven dried) from the second year of production | | | Harvest is required January to April when the ground is often wet. Vulnerable to late spring frosts and not suitable on drought prone soils where yield will be significantly reduced. |
| Mugwort | Oil yield 25kg/ha | | | The crop will not set seed and rarely flowers in the UK |
| Mustards | B.juncea 1.2-1.5kg/ha<br>*S.alba* 0.6-0.95kg/ha | | | Need to attain seed at a value and quality to match the relatively cheap bulk produced North American produce. |

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Nasturtium | N/A | | | The plant is readily attacked by black aphids |
| Nettle | 7.5-8.0t/ha DM (17% fibre) | | | The plants need to be harvested more than once per year to maintain fibre quality |
| Oats | Winter varieties 5.25-8.25t/ha. Spring varieties 4.5-6.5t/ha. | | | The risk of lodging and difficult harvest. The crop must be fully mature and ripe when harvested as the grain is susceptible to heating and moulding in store if at all immature or damp. |
| Oilseed Rape/ Turnip Rape | Winter varieties 2.5-4.0t/ha, spring varieties 1.5-2.5t/ha. Turnip rape 20% lower yield than spring oilseed varieties | | Breeding programmes are currently in progress aiming to improve oil quality, and hybridity in the crop (uniformity and performance). Also the crop is being bred with herbicide resistance present. | Rotational considerations may limit the potential of expanding the cropping area to a certain extent. Production is limited by the Blair House agreement, area grown is not to exceed a given value |
| Peppermint | 35-44kg/ha peppermint oil | 60kg/ha peppermint oil achievable | | All weeds must be eradicated from the ground to avoid the flavour of the oil being spoilt |
| Poppy | Average seed yield 1.5t/ha, similar yields of capsule material | Potential yield of up to 2t/ha is achievable | | Opium is only formed in warm temperate climates. Adequate moisture at sowing, followed by warm, dry weather after establishment is important. |
| Potato (for starch) | Early 17.5-27.5t/ha, second earlies 40t/ha, maincrop 32.5-52.5t/ha. | Slightly higher yields can be achieved using irrigation | Improvements in starch quality and processing benefits are the important requirements. Insect and disease resistance are also being researched. | The seasonal character of the potato cultivation and the geographical location restrict the prospects of growth of the potato starch industry. |
| Quinoa | Average seed yield is 3.5-4.0t/ha, DM content 8.8t/ha at flowering | | | Uneven, slow harvest |
| Rain Daisy | 0.5-1.5t/ha | 2-2.5t/ha is achievable | Improve seed retention | Seed maturation and flowering are asynchronous. The plant is frost sensitive therefore the length of the growing season is limited. |

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Reed Canary Grass | 4t/ha DM<br>12t/ha fresh weight | Slightly higher yields can be achieved under a multi-cut system | | The plant is frost sensitive when young. |
| Rose | Maximum yield is produced in year five, 3t/ha is satisfactory | | Reduce yield variability of flowers and oil. | Around 400-450kg of roses are required to produce 1kg of rose concentrate, this produces 520kg of alcohol-soluble substitute. |
| Safflower | Floret yield 70-100kg/ha, seed yield 785kg/ha wind pollinated, 1,700kg/ha bee pollinated | | Earlier maturing varieties would improve production potential in the UK. | Proportion of seed hull can handicap commercial production, thin hulls cause harvesting problems but increase seed oil and protein content. The plant is susceptible to wet weather diseases. The climate in the UK is warm enough to establish the crop but temperature is too low and the rainfall too high at flowering to produce consistent acceptable yields. |
| Sage | 20t/ha fresh product (oil content up to 2%) | | | Plants must be replaced every 3-4 years to maintain yields and quality. |
| Sea Buckthorn | 5t/ha (in Germany – similar conditions to UK) | 10t/ha could be achieved | Harvesting – hormone treatment to facilitate fruit release | |
| Skull-Cap | Further research is required to produce yield data | | | Further research is required. |
| St. John's Wort | N/A | | | The crop is not fully hardy and growth potential is limited in the UK |
| Sunflower | Average seed yield 1.2t/ha | Potential in warmer climates of 2.5t/ha | To produce earlier maturing cultivars for successful production in the UK | Cold wet seasons, lack of early maturing cultivars selected for UK production. |
| Switch Grass | 12t/ha | | Improve yield to allow better competition with Miscanthus | Needs replanting every 8 years as opposed to Miscanthus which lasts 20 years |
| Thyme | 11.8l/ha oil<br>5t/ha fresh herb | | | Climate may be limiting in the UK, the growing season may be too short for commercial production. |

| Plant | Current Yield | Yield Expectations | Breeding Programmes | Constraints to Increased Production |
|---|---|---|---|---|
| Valerian | Currently produced on such a small scale that yield data is unavailable | | | |
| Vipers Bugloss/ Purple Vipers | Data currently unavailable | | | There are limited marketing opportunities as commercial companies are not prepared to promote echium oil to consumers. |
| Weld | Data currently unavailable | | | |
| Wheat | Average 7.75t/ha | Potential to exceed 9t/ha | Improved overall yields of starch and disease resistance. | The crop is susceptible to a large number of diseases |
| Woad | Can be forage harvested three times per year, but yield figures are currently unavailable | | | No commercial varieties are currently available. |
| Yarrow | 4.95l/ha oil<br>16t/ha fresh herb | | | Oil is low quality |
| Yew | Data currently unavailable | | | Cultivation from seed is difficult, propagation by cuttings is much easier. |

**Appendix IV – Summary of husbandry and market information on animal enterprises**

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Bee** | **Honey**<br>20-40kg per hive | 30,000 beekeepers in the UK, most with less than 40 hives (the EU regards a professional beekeeper as one who operates at least 150 hives). Bees forage in a 2-3 mile radius of the hive, and the honey production takes on the flavour of the main nectar sources available in this zone over the season.<br><br>Readily saleable product providing it is well presented.<br><br>Half the honey used in the EU is imported (mainly from China, Argentina and Mexico), and in recent years prices have been declining. | Typical production of 20-40kg of honey per hive at a return of £3-5/kg (£60-£200 per annum) (material running costs of.£20-£30/year)<br><br>0.5 man hours per hive per week required April-August, plus honey extraction twice a year. | - Skills necessary for swarm control etc<br>- Hives need to remain dry and weather proof<br>- Risk of varroa mite infestation and loss of hive<br>- EU regulation on honey expected by August 2003.<br>- Imports and reducing costs of imported honey – affects mixed-flower honey and 'neutral' honey that can be easily blended. . |
| **Camelids** | **Fibre**<br><br>See below by species | Strong demand for fine fibres – esp. from hand spinners and weavers.<br>Currently demand met by imports but there is room for substitution provided a commercial quantity is made available. The long term market is unlikely to expand to any significant level where major spinning companies are involved. Around 1000kg is required to justify a machine-spinning run.<br>There are over 1000 Camelids in UK and 50 members of Owners and Breeders Association.<br>Preference for white fleeces for dying.<br>Significant additional value can be obtained from breeding. | | - High capital cost of stock<br>- Low fibre yields, so should be seen as a long term project.<br>- Marketing direct too spinners so limited market<br>- No market for meat<br>- Unlikely to be a major alternative enterprise.<br>- Market for bred animals likely to remain limited<br>- White and coloured fleeces must be uniform in colour. |

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Camelids (Continued)** | Alpaca – 3-4 kg fibre/year<br><br>Typically returns £105/head/year @ £30/kg | Fibre quality similar to fine wool (18-30 microns). | Raw fibre - £70/kg.<br>Spun fibre - £200/kg.<br><br>@ 15 head/ha, typically costs match fibre returns. Value is added by income from breeding (approx £5K/head) at current prices (£1K for males (fibre) and £9K for females) | - Profitability appears to rest on income from breeding |
| | Llama – 1.5-2 kg fibre/year | Fibre commonly sold as 'Alpaca' | Raw fibre - £35/kg<br><br>Spun fibre - £85/kg | |
| | Guanaco 0.7 02 kg fibre/year (***Protected species***) | Licensed herd in Wales (Esgyrn)<br><br>Similar fibre quality to cashmere (16-18 microns) | | Classified under the Dangerous Wild Animals Act 1976. As a protected species permits and certificates are required to trade in fibre products. |
| | Vicuna (***Protected species***) | Only one private enterprise in Europe in Devon. – v.fine fibre (<15 microns) | | EEC agreement not to trade in Vicuna, as it is a protected species. |

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Deer** | **Venison**<br><br>Average live weight at slaughter/sale<br>Lowland – 100kg stags, 80 kg hinds (56% kill out)) (90-140 kg for cull animals)<br>Upland 40-45 kg (56-75 kg for cull animals) | There are 36,000 farmer red deer in the UK, the majority in England and just under 1000 in Wales.<br>Lowland farms rear calves for venison (@14-16 months old) or breeding (v limited market) following weaning, while hill and upland farms usually sell calves at weaning for fattening on lowland farms.<br><br>Consumption of venison is increasing in the UK and demand is strong for low fat meat. Marketing is becoming more orderly. Two marketing co-operatives have been established, one in Scotland and one in England (Midlands), which has stabilised prices and the supply chain. Other outlets include farm sale via shops, direct to restaurants, mail order or farmers markets.<br><br>There is an established British Deer Farmers Quality Assurance Scheme. | £3.00-£3.20/kg in autumn.<br><br>Direct marketing to caterers >£4.00/kg (but requires marketing)<br><br>Gross margins – lowland (breeding and venison) £370/ha (for 18 ha / 100 hind unit)<br>Hill/upland calf production £125-£250/per ha of forage (depending on forage use/costs) [also assumes access to unimproved hill outrun]<br>Finishing Stag Calves (Lowland) - £740-750/ha | - Supply of weaned stag calves may be limited. Most stags are available in autumn causing over supply and low price at this time of year.<br>- 1.85m double fence required (£4-6/m) (internal 1.6m high) plus handling areas for vet treatment. (Fencing lower for calf finishing unit)<br>- high initial set up costs, £200-300 for breeding hinds (£800 for pedigree), £700-£1200 for breeding stag. (Typical establishment cost for 100 hind unit of around £60K for stock and fencing)<br>- Outwintered breeding hinds will need supplementary feeding – silage/hay/ swedes/turnips. Concentrates are also required to supplement forage in winter, pre-calving and during lactation.<br>- In finishing units where calves are overwintered, a covered yard is required, with high pen divisions<br>- Outbreaks of TB have occurred in farmed deer. Movement orders may be implemented and slaughter may follow in cases of TB test reactors.<br>- Training required to enable compliance with pertinent regulations and welfare etc.<br>- Imports from New Zealand could threaten market. |

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| Goats | <u>Mohair</u><br>Kids – 3.5kg<br>Young – 5kg<br>Adult – 6kg | Britain processes 60% of the worlds mohair, almost all of which is imported. The UK produced 25 tonne/year from 5,000-7,000 animals (many kept as a semi commercial or hobby basis). 10 tonnes of this is used directly by producers or sold to home spinners.<br>The market for mohair is large taking into account the opportunity for import substitution. World prices are subject to fluctuations and are volatile, increasing financial risks to producers. Prices have been increasing in recent years following a slump, but have declined again recently. Fibre can be marketed through the British Mohair Marketing (for a levy of 45p/kg). Meat can be marketed to add value. | Fibre price -<br>Kids – £16.75/kg<br>Young - £3.60/kg<br>Adult – £2.25/kg<br><br>Best returns from breeding/fibre enterprise that can return £495/ha. However depends on returns from breeding and high quality fleece from kids, excluding these reduces profitability significantly | - World price fluctuations<br>- High levels of kemp in the fleece reduce the value/kg of fibre. Value of fibre decreases with age of animal.<br>- Initial cost of stock<br>- Housing required for winter, and field shelter in summer.<br>- High standard of fencing required<br>- Need more management input than sheep |

*Continued overleaf*

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Goats (continued)** | **Cashmere**<br><br>Feral animals 30-50 grams/ year<br><br>Improved animals 100-200 grams/ year | 3,000 tonnes of cashmere produced worldwide. Scotland presses over 1000 tons of imported cashmere per annum, mostly imported from New Zealand. 50 UK producers with 2,500 animals. Potential for UK herd of 2 million breeding females.<br><br>Scottish Cashmere Producers Assoc, aims to increase national herd to 10,000 animals. They also provide a central marketing operation for collection, grading, processing and marketing.<br><br>Premium for white cashmere over coloured. *(continued overleaf)*<br>Prices are more stable than for mohair<br><br>10-20 goats/100 ewes can compliment each other on rough grazing without a requirement to change stocking rates due to complimentary grazing nature | £70/kg<br><br>Gross margin in the region of £10-£30/head with the potential to add between £100 and £600 in value to a 100 ewe sheep flock. | - Winter housing is necessary to maintain fleece quality<br>- Natural shelter required from wind and rain<br>- Difficult to maintain fibre quality and yield<br>- High standard sheep fencing required with electric wire.<br>- May need to increase height of fences in handling pens. |

***Continued overleaf***

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Goats (continued)** | **Milk**<br>500-1200 litres/lactation (4 litres per day at peak) | England dairy goat population is static at around 33,000 animals. Most kept in small herds. Typical herd size of 200 for milk production, 100 for cheese.<br><br>There is a well established market for milk, cheese, yoghurt and ice cream, marketed by the farmers co-operative Goat Farmers UK. 75% of British production for cheese production.<br><br>Milk prices are vulnerable to variation and depend on security of market | £0.35-0.55/litre wholesale<br>£1.00-£1.20/litre retail<br><br>Cull stock £20/head<br><br>Meat £25/head | - Dry well-ventilated milking parlour required for herds >50 goats.<br>- High set-up costs – including £13,000 for milking parlour for 12+ goats, plus £10,000 for new pasteurisation and carton sealing machine, plus 1 years working capital etc<br>- Disease susceptibility<br>- field shelter and fencing required<br>- additional labour requirement of 1 person /100 goats<br>- 70% of forage derived from conserved feed. Need other livestock to compliment goat grazing (10-12 goats with 900-1200 kg cattle/ha)<br>- Susceptible to same diseases as sheep<br>- Codes of practice for hygiene and welfare |
| | **Meat** | Meat is marketed through Goat Meat Producers Ltd (co-operative)<br>Perceived as the healthy product. | Up to £25/animal Liveweight | |

*Continued overleaf*

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Ostrich** | **Meat & leather**<br><br>95-110kg at 12-14 months<br>25-35kg de-boned meat | Quite a strong home market, processors are unable to source enough birds. Produces a lean red meat with low fat and high protein content (though cholesterol content is similar to beef and lamb). Often found at farmers' markets<br>The hides are a valuable feature depending upon quality – with export markets in the Far East<br>In the wider EU meat is imported from outside the EU<br>UK population of 10-12,000 birds, which includes 2,000 breeding females, among 100 producers.<br>Reports to the UK government estimate an EU market of 8,000 tonnes/annum, but industry estimates are significantly higher than this, and could require up to 0.8 million birds per year.<br>A number of high street retailers stocked Ostrich following the BSE crisis, but only Sainsbury continue to stock it and sell 300kg/week. Most of this is sourced for the US due to concern over rearing the birds in the UK climate. Currently looking at UK sourced material. M&S and ASDA have just started to stock smoked UK product. | Wholesale - £3-5/kg<br>Retail - £8-13/kg<br><br>£35-120 per bird<br><br>Estimated gross margin of £778/ha on a breeding enterprise and £1620 (£80/bird) on a meat production enterprise. – but unlikely to remain viable on meat production alone | - Classified as a wild exotic bird, keeping them requires a licence from the Local Authority (£50-350), plus costs of annual inspection.<br>- Annual safety and welfare inspection, to be paid for by the producer<br>- International industry provides competition, led by South Africa. Much of the demand is currently met through imports.<br>- Increasing global production, and collapse in leather market in the Far East (due to financial collapse) has depressed prices. Viable enterprises will need to develop dual outputs of both leather and meat. May be difficult to sustain markets.<br>- Production is subject to UK Poultry Meat Regulations.<br>- Previous reliance on selling breeding birds for profit (pyramid selling) may have damaged the image of the enterprise. Most of these markets have now collapsed.<br>- Investment would be required in facilities and management to breed replacements to keep costs down. High fencing required. |

| | | | |
|---|---|---|---|
| | | | Young birds ideally require heated concrete floors under shelter.<br>- Limited slaughter facilities – but low throughput units in Shropshire and Monmouth.<br>- Current lack of clear regulatory framework for Ostrich production.<br>- Likely to be concerns over animal welfare from retailers.<br>- EU recommendations for training for ratite handlers, that they should only be kept in areas, and environmental conditions where they can be kept outdoors for most of the day, and confined for less than 10 days per month. Likely to need access to housing in winter in Wales. |

*Continued overleaf*

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Pheasant and Partridge** | **Meat** | Exploited for sport and meat, meat would not be viable without the sporting link. The exploitation of shooting is currently optimised and unlikely to see much growth | | - For meat production, after incubation, birds are removed to a relatively confined space with relatively low light intensity. When rearing for sport, birds are released to outdoor runs and wooded pens prior to release. |
| **Quail (Japanese)** | **Meat**<br><br>150g – 230g live weight<br><br>**Eggs**<br><br>Up to 240 eggs per annum | UK consumption is around 75 tonnes/year (10,000-12,000 birds/week). UK market is met mainly from home production which is about 10,000 birds/week, with imports at 1,500 birds per week<br>Considerable quantities are consumed on the continent. In the UK it is a limited gourmet market. | Fresh 90p/bird<br>Frozen 75p/bird<br><br>80p - £1.20 per dozen | - UK market appears to be almost saturated and time and effort would need to invested to grow this.<br>- Environmental Health restrictions on processing facilities<br>- Requires investment in an insulated, well ventilated, intensive battery production unit, which would be lit for 16hrs per day for all year round production. |

*Continued overleaf*

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Rabbits** | **Meat**<br><br>2.6kg live weight<br>Production target is 45-50 meat rabbits/doe/year | In the early years UK production was 2-3,000 tonne/annum. With 5000 tonnes being imported from China and Eastern Europe. Potential for export to France. In the late 1990's rabbit production decreased dramatically due to the violent campaign by animal welfare protestors. Production in 2001 was in the region of only 250,000 rabbits producing around 500 tonnes of met.<br>Starter unit size of 25-30 does, average size unit of 50-100 does. Requires minimal land.<br>Market requires whole carcasses 2-3kg average (8-10 weeks) weight or portioned pre-packed rabbit depending on the outlet. Woldsway Foods is the major UK processor of rabbit meat and report that they are actively seeking more rabbits/new producers. Generally buyers and processors are few in number and limited in UK coverage. Consumption can also be seasonal (winter peak) | £1.20/kg liveweight<br><br>Typical return of £45-55/doc<br><br>1 man required full time per 300 does | - Marketing outlets need to be secured.<br>- High (25%) mortality – requires good stockmanship. Also need to adjust production to match seasonal winter demand.<br>- Possible animal rights activist interference – it is an intensive enterprise.<br>- Food hygiene regulations (if slaughtering).<br>- Welfare regulations for hutch size and ventilation.<br>- Collection usually requires at least 1000 rabbits, though they may collect as few as 350-400 (depending on convenience). Co-operative marketing may be required to solve transport problems.<br>- Draft free, well ventilated and insulated building required with artificial lighting. Processing and storage facilities required depending on outlet. Start up packages for 100 doe unit typically £9K. Planning permissions is likely to be required. |

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| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Sheep** | **Milk**<br><br>150-600 litres per lactation (210 day lactation) | There are approximately 200 flocks of dairy sheep, totalling 12,000 ewes.<br><br>Minimum economic herd size of 250-300 ewes, but 400-500 for average lactation.<br><br>There are currently 40 different varieties of sheep cheese, yoghurts, milk drinks and ice-creams available. There is room for import substitution and also a market for people allergic to cows milk. Competes with goats milk, but cheeses are main output. Most milk sold through farm gate and health food shops. | 75p/litre<br>Cheese - £6-7 per kg (retail sales 40-60% higher)<br><br>Based on 250 litre production a margin of £97/ewe is possible, (excluding labour and machinery maintenance costs etc). | - Hygiene & Food safety legislation etc.<br>- Finding a market.<br>- Trading standards.<br>- Rates on processing facilities.<br>- set up costs e.g. milking system £3-10K, pasteurisation equipment £2-5K, yoghurt batch system £7K, carton equipment £4K, plus costs of stock and working capital for a year during set-up. |
| | **Wool** | 75% of UK wool used for carpets and is unable to compete with finer quality of Australian wool for clothing markets. 80% of UK clip is exported. Prices are currently low, and in many cases with upland breeds fail to cover the cost of clipping. New markets are being developed as insulation but they are currently three times more expensive than traditional materials. Other market outlets developed so far have been very limited in uptake. | From 2p/kg for Herdwick fleeces up to 70p/kg for Cheviot. | - Appears to be little scope in short term for increasing the value of wool.<br>- Any new and novel uses will be vulnerable to imports. |

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| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Snails** | **Gourmet Food** | Snails can be sold fresh, frozen or made into snail pate or other dishes. Consumption in the UK has expanded considerably over the past decade although most are currently imported. European consumers prefer snails gathered form the wild.<br>Production of snails in France and Eastern Europe has recently declined.<br>The main market is hotel and restaurant trade buying in bulk. | Direct sales - £8.00/kg<br>Restaurants - £10-12/kg<br>Processors - £3-4/kg<br><br>200,000 snails would provide 2-4 t/year and employ 1 man full time (intensive indoor) (running costs £4k/tonne). | - Risky<br>- Essential to seek out niche market.<br>- Disease risk is high (fungal and respiratory problems).<br>- Susceptible to stress and handling problems.<br>- Only the intensive indoor rearing techniques are likely to suit the Welsh climate. Requires and insulated, heated, sealed and disinfected building. Water supply needs to be filtered. Require 250sq feet per 100,000 snails.<br>- Set up costs – building £4-25K, cleaning system £3-6k, capital for up to 18 months. |

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| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Water Buffalo** | **<u>Milk production</u>** | No special licence required except for milking. Demand for buffalo milk is strong. High in calcium and protein but low in cholesterol. Used to make mozzarella, mature cheeses, yoghurts, ice creams and drinking milks.<br><br>Potential UK market is estimated at 25 million litres/annum, and is not limited by EU quota. Current production is int ehregion of 2-3million litres/annum. Most is marketed through the Water Buffalo Co-operative.<br>Scope for a UK herd of around 100,000 lactating buffaloes.<br><br>Suckler Cows qualify for SCPS payments | Typical gross margin of £1012/head, (excluding transport and grass forage costs) | Milking premises need to be licensed As with cattle, need to be registered with animal health office and British Cattle Movement service.<br><br>Problems in heat detection and timing of AI, therefore hormones required to synchronise oestrus cycle. Success rates can be low, especially in summer months.<br><br>Tankers do not collect milk, producers must deliver. |
| | **<u>Meat</u>**<br><br>Killed out at 24-39 months at 420-520 kg<br><br>Typically £3/kg Dead weight | Has less than half of the fat of lean beef and BSE free status<br><br>Killing out % is low compared to cattle at 47-48%, but balanced by premium for meat<br><br>Bulls and steers qualify for CAP payments (BSPS) | Typical gross margin of £475/head, (excluding transport and grass forage costs) | Attention to detail and marketing skills are required |

***Continued overleaf***

| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Wild Boar** | **Meat**<br><br>45-50 kg at Slaughter (9-12 months). Kill out = 65% | 100 farms in UK with 2,000 breeding sows<br>Meat is noted for its leanness, gamey flavour and speciality image and can be sold fresh or frozen or processed into hams, pate, pies and sausages. There is a high demand for meat in restaurants, hotels and specialist food outlets but the market should be secured before production begins. The British Wild Boar Association (BWBA) estimate the UK market to be worth £2 million. The BWBA has launched a quality assurance scheme, backed by the MLC. BWBA standardises breeding, production and marketing.<br><br>Reared outdoors with arks or Indoors with a run out. | £180-250/carcass, joints £4-6/kg, saddles and haunches £8-13/kg, smoked hams £16-20/kg.<br><br>1 person/50 sows with 5-6 sows/ha (outdoors)<br><br>Gross margin of £334-515/sow (around £1700-2500/ha) | - Vital to secure market first<br>Meat from male boar is only suitable for two tears then it becomes too strong except for sausages.<br>- Annual licence is required under the Dangerous Wild Animals Act (£50-100/year)<br>- Limited supply of breeding stock<br>- High cost of fencing and security – high tensile stock fence (1.8m high and 0.5m buried) plus internal electric wire. In addition an internal fence 1.1m high with 2 electric wires on top and a stand-off wire on each side.<br>- Dangerous animals.<br>- set up costs: £3-3.5 k/ha for fencing, young boars £350-500, in-pig sows and adult boars £500-700. |

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| Animal | PRODUCT & YIELD | MARKET | RETURN | CONSTRAINTS |
|---|---|---|---|---|
| **Worms** | Fishing bait; and high protein animal feed. Also sold for use in domestic compost heaps and for recycling local authority waste.<br><br>60 kg of worms per week from 1,000 $m^2$ unit | Many market outlets exist, though some are seasonal it is advisable to have multiple outlets, and/or a contract with a worm company – the prices paid vary considerable between companies and depends on the type of contract and what assistance with set-up costs is provided. This has proved to be a volatile venture in the past | A 1000 $m^2$ unit can bring in between £600 and £1600 per month according to companies involved in the industry, but the price/kg of worms varies considerably within the industry from £2.50 to up to £20. A return can also be made from worm casts.<br><br>A 1000$m^2$ unit requires around 20 hours per week to manage. | - Requires expertise and attention to detail is required in management of the compost heap<br>- Market outlets can be a problem in some areas<br>- Competition if fierce for markets<br>- Moles may become pests<br>- Weights and measures and Trades Descriptions Act applies<br>- Sale as fishing bait is seasonal<br>- Start up costs can be high, and vary among the industry, typically 12 to 54k/1000$m^2$, this would require approx half an acre. |

**Appendix V. Environmental impacts of livestock species.**

| | Dairy Sheep | Deer | Goats | Rabbit | Wild Boar | Camelids | Water Buffalo | Ratites | Quail | Snails | Worms | Bees |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Soil** | | | | | | | | | | | | |
| Erosion | 0 | 0 | -/0 | 0 | -- | + | (-) | -/0 | 0 | 0 | 0 | 0 |
| Structure | 0 | 0 | 0 | 0 | -- | + | - | -/0 | 0 | 0 | 0 | 0 |
| Organic matter | 0 | 0 | 0 | 0 | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nutrient status | 0 | +/0 | +/0 | 0 | - | -/0 | -/0 | 0 | 0 | 0 | 0 | 0 |
| **Water** | | | | | | | | | | | | |
| Pollution | 0 | 0 | 0 | -/0 | -/0 | -/+ | -/0 | 0 | -- | -/0 | -/0 | 0 |
| Flood risk | 0 | 0 | 0 | 0 | -/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Air** | | | | | | | | | | | | |
| Odour | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NOx emissions | 0 | + | + | 0 | | + | +? | ? | 0 | 0 | | 0 |
| Methane | 0 | 0 | | | | | -? | | | | | 0 |
| $CO_2$ emissions | 0 | 0 | - | - | 0 | - | 0 | - | - | - | - | 0 |
| **Landscape** | 0 | - | - | 0 | - | 0 | +/- | -- | 0 | 0 | 0 | 0 |
| **Biodiversity and habitats** | | | | | | | | | | | | |
| Genetic resource[1] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diversity[2] | 0 | -- | -- | - | - | -/0 | +/0 | 0 | 0 | -/0 | 0 | +/(-) |
| Habitats[3] | 0 | -- | -- | - | --/+ | +/0 | +/0 | 0 | 0 | -/0 | 0 | + |

[1] Existing genetic resource base (species used for food production), [2] Current diversity of native plants and animals, [3] Status and ecological value of wildlife and semi-natural habitats.

Key to classification: 0 no effect, -/0 could have a detrimental impact in some circumstances, + or - some positive or negative impact, ++ or -- significant positive or negative impact, (+) or (-) extrapolation but no direct evidence, ? Insufficient information on which to base a judgement.

## Appendix VI. Environmental impacts of crop species

| | Crambe | Hemp | Linola/ Linseed /Flax | OSR | Calendula | Gold of Pleasure | Meadow Foam | Miscanthus | Mugwort | Oats | Woad | Euphorbia | Nettle |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Soil** | | | | | | | | | | | | | |
| Erosion | 0 | -/0 | -/0 | 0 | -/0 | 0 | 0 | + | + | 0 | + | 0 | + |
| Structure | 0/+ | + | 0/+ | 0/+ | (0) | (0) | (0) | -/0 | (0) | 0 | + | 0 | + |
| Organic matter | 0/+ | + | - | + | (0) | (0) | (0) | + | (0) | 0 | + | 0 | + |
| **Water** | | | | | | | | | | | | | |
| Flood risk | 0 | 0 | -/0 | 0/+ | - | -/0 | -/0 | + | + | 0 | + | 0 | + |
| **Air** | | | | | | | | | | | | | |
| Odour | 0 | 0 | 0 | -/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $CO_2$ emissions | - | (0) | + | 0 | +/0 | +/0 | +/0 | +/0 | + | 0 | (+) | (+) | (+) |
| **Inputs** | | | | | | | | | | | | | |
| Fertiliser | - | N- P+ | + | +/0 | (+) | (+) | (+) | + | (+) | (+) | (+) | (+) | 0 |
| Herbicides | -/0 | + | + | + | (+) | (+) | (+) | + | (+) | 0 | (+) | (+) | (+) |
| Insecticides | 0/+ | + | -/0 | -/0 | (+) | (+) | (+) | + | (+) | 0 | (+) | (+) | (+) |
| Fungicides | 0 | 0 | 0/+ | 0/+ | (+) | (+) | (+) | + | (+) | +/0 | (+) | (+) | (+) |
| **Landscape** | 0 | -/0 | 0 | 0 | - | 0 | - | - | 0 | 0 | 0 | 0 | 0 |
| **Biodiversity** | | | | | | | | | | | | | |
| Genetic resource[1] | (-) | - | (-) | (-) | 0 | 0 | 0 | 0 | (-) | 0 | 0 | (-) | - |
| Diversity[2] | 0 | + | ++ | + | ++ | 0 | + | 0 | 0 | + | + | - | ++ |
| Habitats[3] | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 | - | 0 | - | 0 | (-) |

[1] Existing genetic resource base (species used for food production), [2] Current diversity of native plants and animals, [3] Status and ecological value of wildlife and semi-natural habitats.

Key to classification: 0 no effect, -/0 could have a detrimental impact in some circumstances, + or - some positive or negative impact, ++ or -- significant positive or negative impact, (+) or (-) extrapolation but no direct evidence, ? Insufficient information on which to base a judgement.

**Appendix VI. Environmental impacts of crop species (cont)**

| | Bog Myrtle | Madder | Yarrow | Borage | Evening Primrose | Foxglove | Poppy | St. John's Wort | Valerian | Giant Reed | Henbane | Peppermint | Reed Canary Grass | Sea Buckthorn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Soil** | | | | | | | | | | | | | | |
| Erosion | -/0 | + | + | -/0 | -/0 | -/0 | -/0 | + | + | + | -/0 | + | + | + |
| Structure | - | 0 | + | + | + | +/0 | 0 | + | + | -/0 | 0 | + | + | + |
| Organic matter | - | + | + | 0 | 0 | + | 0 | + | + | + | 0 | + | + | + |
| **Water** | | | | | | | | | | | | | | |
| Flood risk | 0 | +? | + | - | - | 0/+ | - | + | + | + | - | + | + | + |
| **Air** | | | | | | | | | | | | | | |
| Odour | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $CO_2$ emissions | + | +? | +? | + | + | + | + | + | + | + | + | + | +/0 | + |
| **Inputs** | | | | | | | | | | | | | | |
| Fertiliser | 0 | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | 0 | (+) | (+) | (+) | (+) |
| Herbicides | 0 | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) |
| Insecticides | 0 | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) |
| Fungicides | 0 | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) |
| **Landscape** | 0 | 0? | -/0 | - | - | - | - | -/0 | -/0 | - | 0 | 0 | -/0 | - |
| **Biodiversity** | | | | | | | | | | | | | | |
| Genetic resource[1] | - | (-) | - | - | - | - | (-) | - | - | 0 | - | (-) | - | - |
| Diversity[2] | + | 0 | + | ++ | ++ | + | ++ | + | + | 0 | ++ | + | 0/+ | 0 |
| Habitats[3] | -/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (0?) | 0 | 0 | 0 | 0 |

[1] Existing genetic resource base (species used for food production), [2] Current diversity of native plants and animals, [3] Status and ecological value of wildlife and semi-natural habitats.

Key to classification: 0 no effect, -/0 could have a detrimental impact in some circumstances, + or - some positive or negative impact, ++ or -- significant positive or negative impact, (+) or (-) extrapolation but no direct evidence, ? Insufficient information on which to base a judgement.

**Appendix VII. Processors of plant and animal products in Wales and the wider UK**

| Facility | Name | Contact Details/Location | Details |
|---|---|---|---|
| **Fibre processing** | BioComposites Centre<br>(J.B.Fibres/BioFibre Ltd) | Gary Newman<br>University of Wales<br>Bangor<br>Gwynedd<br>LL57 2UW<br>Tel: 01248 370588<br>Fax: 01248 370594<br>E-mail: biocomposites@bangor.ac.uk | Hemp and flax fibre processor |
| **Oil Crushers** | Unitrition International | Olympia Mills<br>Barlby Road<br>Selby<br>North Yorkshire<br>YO8 5AF<br>Tel: 01757 244111<br>Fax: 01757 244088<br>E-mail: info@unitrition.co.uk | Specialist in oilseed crushing and raw material upgrading. Specialist batch extraction plant which allows processing of small volumes of specialist seeds |
| **Oil Refiners** | John L Seaton & Co Ltd | Bankside<br>Hull<br>HU5 1RR<br>Tel: 01482 341345<br>Fax: 01482 447157 | Process and supply a wide variety of vegetable oils and related products for use in technical applications from oils such as linseed, rapeseed, castor, soyabean, fish and sunflower oil. Processed oils include refined oils, oxidised (blown) oils, thermally polymerised (stand) oils and oleoreinous varnish media. In addition we toll manufacture a wide variety of specialised products such as printing ink mediums and varnishes |

| | | | |
|---|---|---|---|
| | Anglia Oils Ltd | King George Dock<br>Hull<br>HU9 5PX<br>Tel: 01482 701271<br>Fax: 01482 709447<br>E-mail: info@angliaois.co.uk | Europe's leading innovator in the production of vegetable oils. Uniquely flexible production capacity and a product base of over 40 oils. Deals with rapeseed and sunflower oils. Also personal care ingredients; Borage, Evening Primrose, Gold of Pleasure and Hemp. |
| | Van den Bergh Foods Ltd | London road<br>Purfleet<br>Essex<br>RM19 1SD<br>Tel: 01708 863300 | The largest margarine factory in the world, producing 250,000 tonnes of branded margarine and oils for the UK export market per annum |
| | Karlshamns Ltd | 220 Wincolmlee<br>Hull<br>HU2 0PX<br>Tel: 01482 586747<br>Fax: 01482 587004<br>E-mail: info@karlshamns.co.uk | One of the worlds leading manufacturers of high value-added speciality vegetable fats. |
| **Oil Crushers and Refiners** | A.D.M. | Church Manor Way<br>Erith<br>Kent<br>DA8 1DL<br>Tel: 01322 436966<br>Fax: 01322 437536 | Handling, distribution and processing of oilseeds and grains, including production from them of specialist processed products. UK's biggest oilseed crusher (700,000 tonnes of oil throughput per year) |
| | Cargill | Crosby Road South<br>Liverpool<br>L21 4PS<br>Tel: 0151 9226261<br>Fax: 0151 9338208 | Providing a broad range of yellow goods and masa flours, supports customers through Europe and Asia with value-added service and knowledge. Throughput of 300,000 tonnes of oil per year. Niche crushing refinery for |

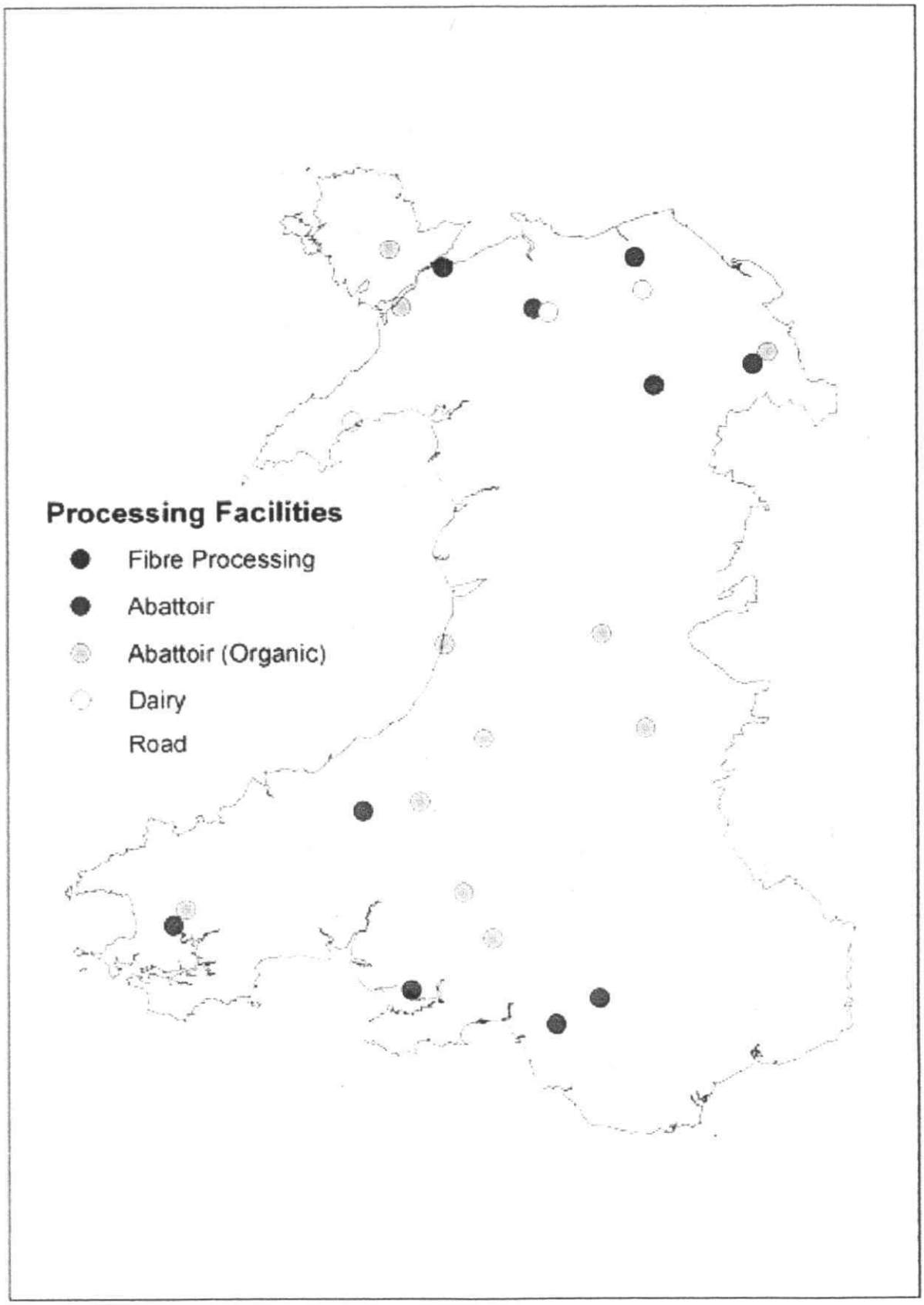
| | | | |
|---|---|---|---|
| | | | linseed, maize and HEAR is base at Hull. |
| | Statfold Seed Oil Developments Ltd | Ashby Road<br>Tamworth<br>Staffordshire<br>B79 0BU<br>Tel: 01827 830871<br>Fax: 01827 830875 | Refining, Cold-pressing<br>Statfold grow and process quality oil crops to produce the highest quality oils that the markets demand. |
| **Speciality Oil Processing** | Biochem Wales Ltd | Woodstock<br>Fron Park Road<br>Holywell<br>Flintshire<br>CH5 7US<br>Tel/Fax: 01352 714640 | Producers/processors of small scale speciality oils |
| **Abattoirs** | Conway Valley Meats | Cae Pys<br>Parry Road<br>Llanrwst Gwynedd<br>LL26 0DG<br>Tel: 01492 641861 | |
| | D & J Thomas | Gardden Road Rhosllanerchrugog<br>Wrexham<br>Clwyd<br>LL14 2EN<br>Tel: 01978 840376 | |
| | T.W.M. Ltd | Unit 1<br>Glanlliedi Business Park Dafen<br>Llanelli Dyfed<br>SA14 8PD<br>Tel: 01554 774001 | |
| | W.T. Maddock | The Old Abattoir<br>Rear of Bridgend Road<br>Maesteg Mid Glamorgan<br>CF34 0AJ<br>Tel: 01656 739073 | |

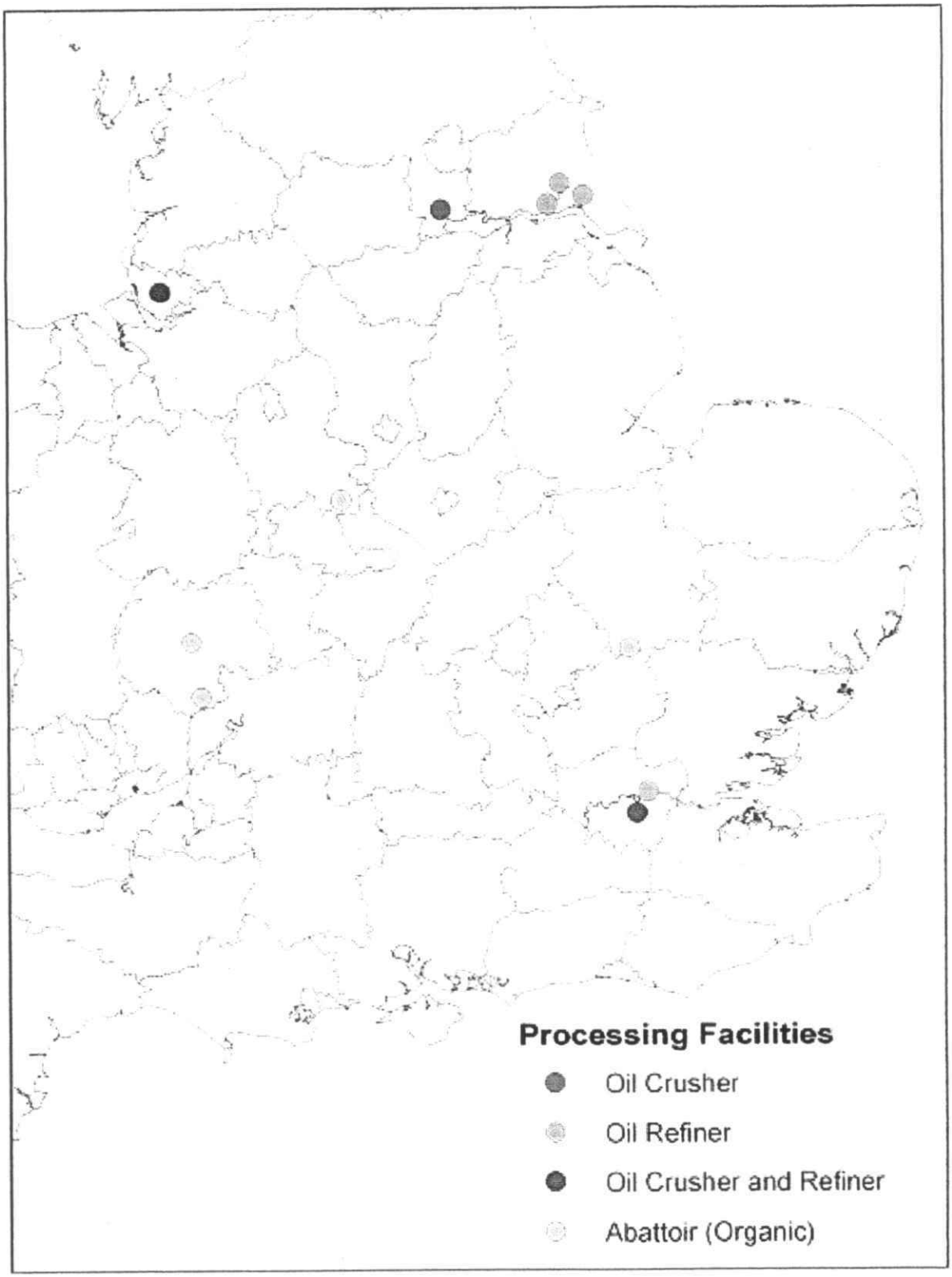
| | | | |
|---|---|---|---|
| | Owen G Owen Ltd | Ty Newydd Abattoir Waen<br>St.Asaph<br>Clwyd<br>LL17 0DS<br>Tel: 01745 583577 | |
| | J.E. Tudor & Sons | Slaughter House rear of Howard Street<br>Treorchy<br>Mid Glamorgan<br>CF42 6AR<br>Tel: 01443 772585 | |
| | Pembrokeshire Meat Co | Woodfield<br>Withybush Road<br>Haverfordwest<br>Dyfed<br>SA62 4BW<br>Tel: 01437 769965 | |
| | G.R. Evans | The Abattoir<br>Ty Gwyn<br>Corwen<br>Clwyd<br>LL21 9BU<br>Tel: 01490 412999 | |
| **Abattoirs (organic)** | Cig Môn | Ystad Farchnata<br>Llangefni<br>Anglesey<br>LL77 7JA<br>Tel: 01248 750212<br>Fax: 01248 750119 | Abattoir, meat processing |
| | Oriel Jones & Sons Ltd | Lladd-dy Parc Teifi<br>Llanybydder<br>SA40 9QE<br>Tel: 01570 480284 | Abattoir, meat processing |
| | Black Mountain Foods | Cwm Cochied<br>Cwmdu | Wholesale |

| | | | |
|---|---|---|---|
| | | Llandeilo<br>SA19 7EE<br>Tel: 01558 685018 | |
| | Huw Evans | Cig Oen Caron<br>Y Lladd-dy<br>Tregaron<br>SY2 6NN<br>Tel: 01974 298964 | Abattoir |
| | Livestock Marketing Ltd | Aberystwyth<br>Tel: 01970 624011 | Livestock dealer, meat processing |
| | Cambrian Organics | Horeb<br>Llandysul<br>Ceredigion<br>SA44 4JG<br>Tel: 01559 363151<br>E-mail: info@cambrianorgaincs.com | Meat processing, wholesale, retail |
| | Cwmni Cig Arfon Cyf | Ystad Ddiwydiannol<br>Caernarfon<br>LL55 2BD<br>Tel: 01286 673201 | Abattoir, meat processing |
| | Meadowland Meats Ltd | Phocle Farm<br>Phocle Green<br>Ross-on-Wye<br>HR9 7BF<br>Tel: 01989 780711<br>Fax: 01989 780722 | Meat processing |
| | Golden Valley Organics | Bali Hai<br>Binedor<br>Hereford<br>HR2 6PD<br>Tel: 01432 870646 | Meat processing |
| | Mountain Rose Products and Services | Rhos y Mynydd Farm<br>Heol Hir<br>Gwauncaegurwen | Abattoir, meat processing, poultry only |

| | | | |
|---|---|---|---|
| | | SA18 1PL<br>Tel: 01269 824952<br>Fax: 01269 825147 | |
| | Welsh Hook Meat Centre | Woodfield<br>Withybush Lane<br>Hwlffordd/Haverfordwest<br>SA62 4BS<br>Tel: 01437 768876 | Meat processing, wholesale, retail |
| | Hamer International Ltd | Oakley park<br>Llanidloes<br>SY18 6LX<br>Tel: 01686 412114<br>Fax: 01686 413803 | Abattoir |
| | Graig Farm | Dolau<br>Llandrindod Wells<br>LD1 5TL<br>Tel: 01597 851655<br>Fax: 01597 851991 | Meat processing, wholesale, retail |
| | ABP Ellesmere | Hordley<br>SY12 9BL<br>Tel: 01939 270333<br>Fax: 01939 270405 | Abattoir, meat processing, cattle only |
| | Jones Bros | Stansty Lodge<br>Mold Road<br>Wrexham<br>LL11 4YF<br>Tel: 01978 265820<br>Fax: 01978 759261 | Abattoir, meat processing |
| | Organic Livestock Marketing Cooperative (OLMC) | 8 The Lanterns<br>Royston<br>Herts.<br>SG8 7BX<br>Tel: 01763 250313<br>Fax: 01763 248923 | Livestock dealer, meat processor |

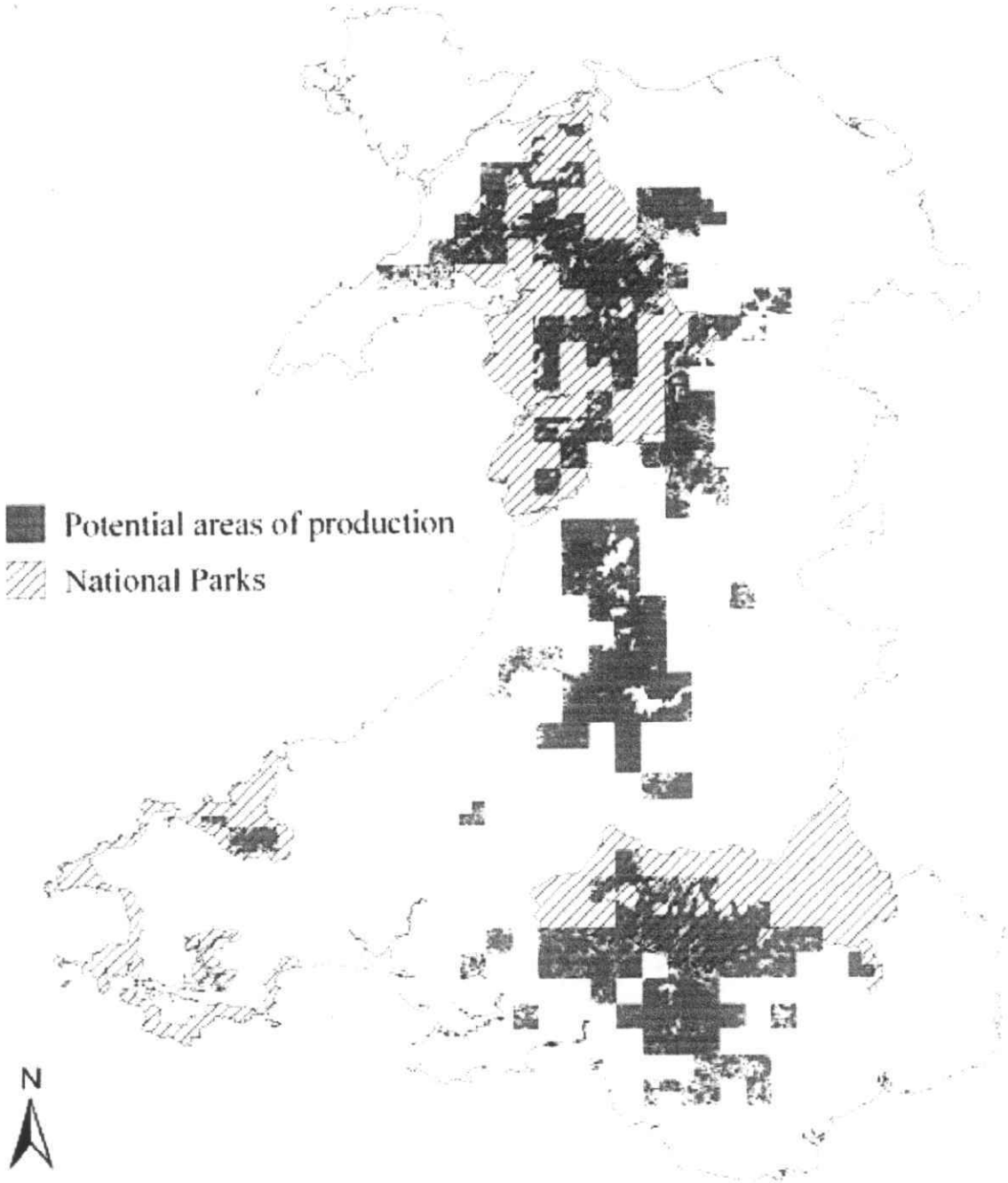
| | | | |
|---|---|---|---|
| **Dairies** | South Caernarfon Creameries Ltd | Rhydygwystl<br>Chwilog<br>Pwllhei<br>Gwynedd<br>LL53 6SB<br>Tel: 01766 810251<br>Fax: 01766 810578 | Cheese producers |
| | Snowdonia Cheese Company | Bryn Morfydd Mawr<br>Llanddoged<br>Llanrwst<br>Gwynedd<br>LL26 0UU<br>Tel: 01492 642520 | Cheese makers and suppliers |
| | A.C.C. Manufacturing | The Creamery<br>Llandyrnog<br>Denbigh<br>Clwyd<br>LL16 4HH<br>Tel: 01824 790215 | ACC is the largest milk processor in Wales, there are three Welsh creameries making traditional products of the highest quality. They have recently invested in a cheese grating line, which produces cheddar, Mozzarella and blends. |
| | A.C.C. Milk | Station Road<br>Llangadog<br>Carmarthenshire<br>SA19 9LY | Manufactures a wide range of UHT, canned milk, butter, powder and bulk dairy ingredients. |
| | A.C.C. Milk | Newport Road<br>Cardiff<br>CF23 9YG | Produces fresh milk and cream |
| **Wool Processing Plant** | Dinas Mawddwy Wool Factory | Dinas Mawddwy<br>Gwynedd | Producing insulation material from wool |


Processing Facilities
Fibre Processing
Abattoir
Abattoir (Organic)
Dairy
Road


Processing Facilities
Oil Crusher
Oil Refiner
Oil Crusher and Refiner
Abattoir (Organic)

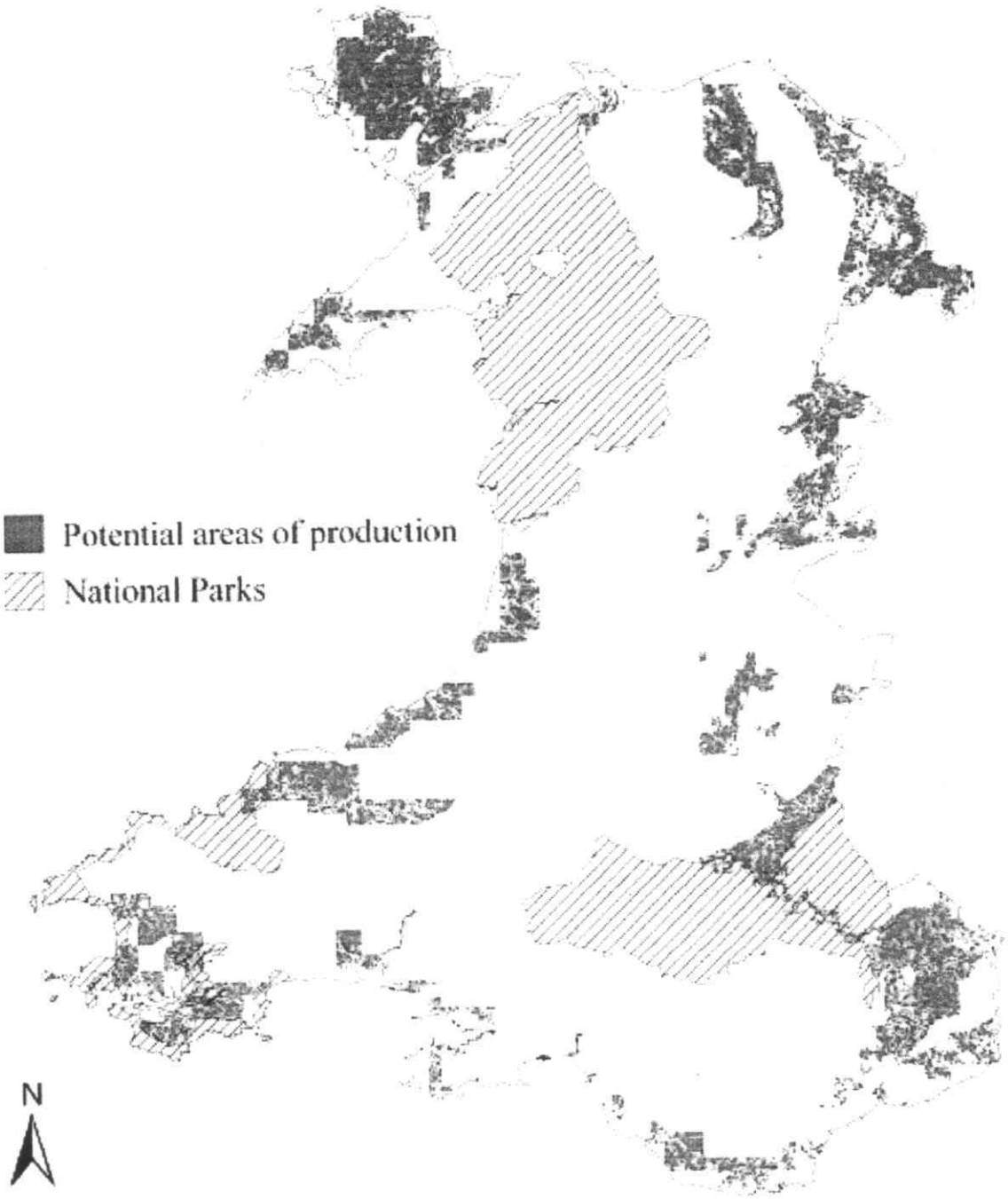
## Appendix VIII – GIS maps for prioritised crops and animals

# Bogmyrtle




Soil information provided by NSRI

# Borage




Soil information provided by NSRI
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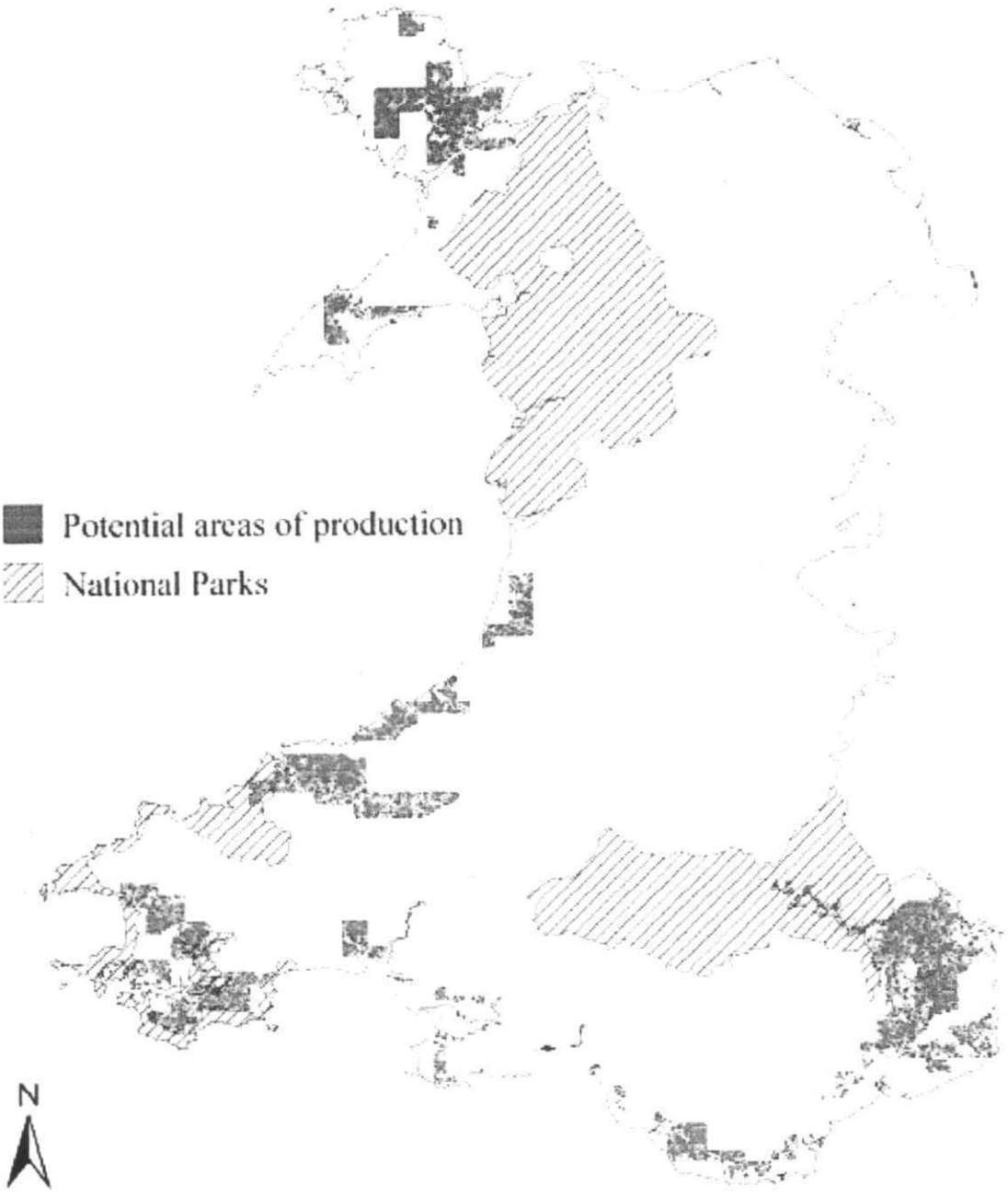
# Calendula

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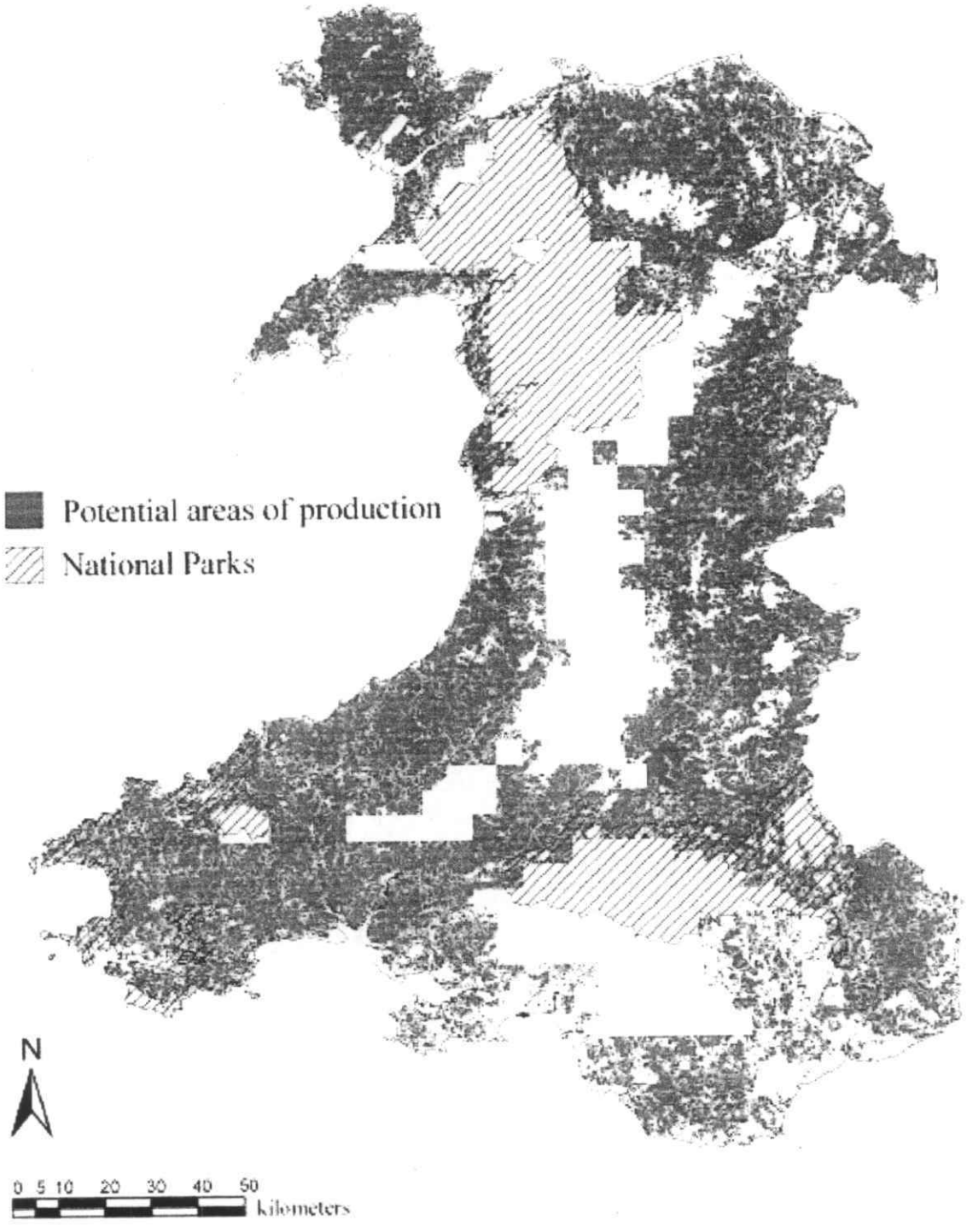
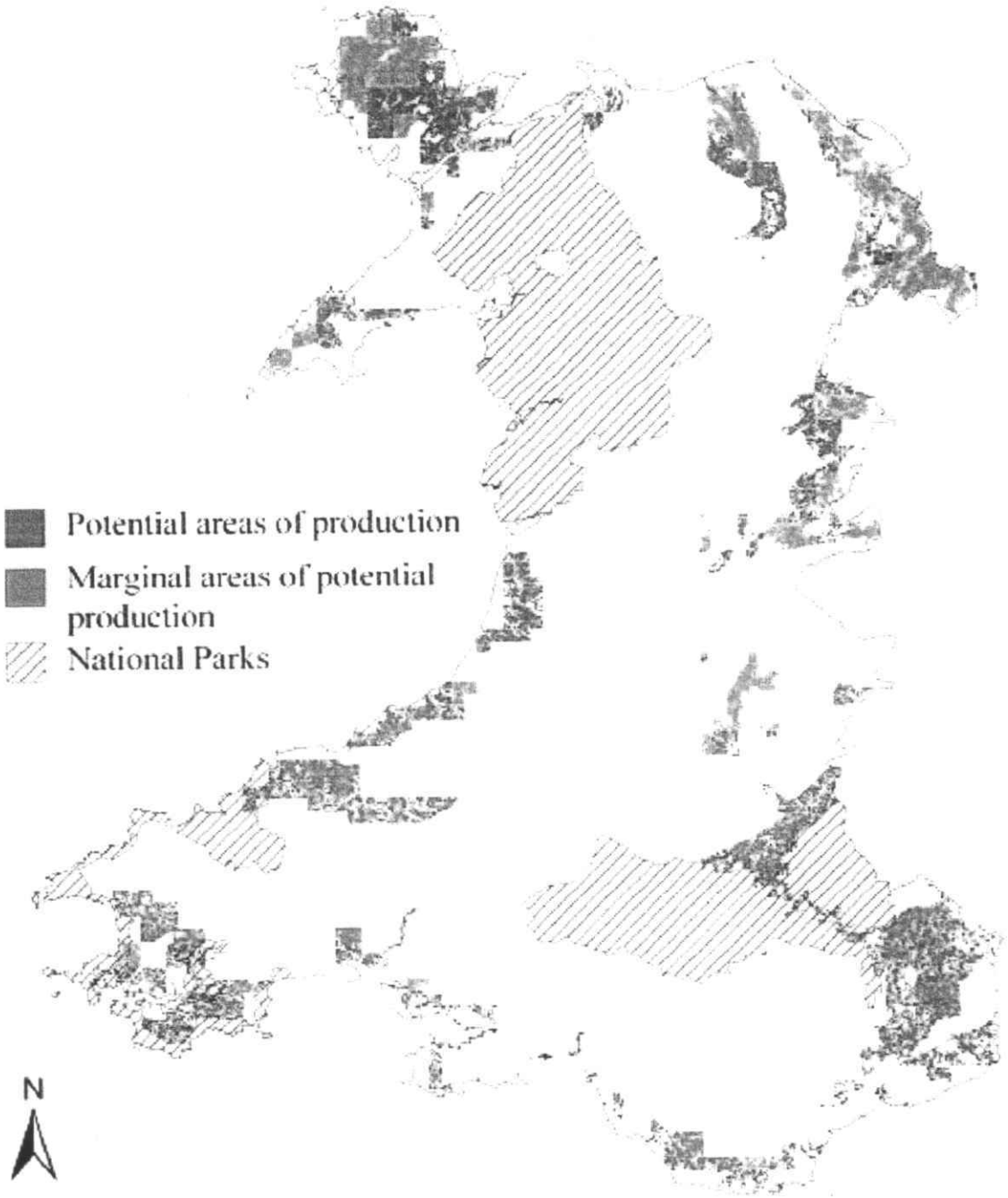
# Camelids

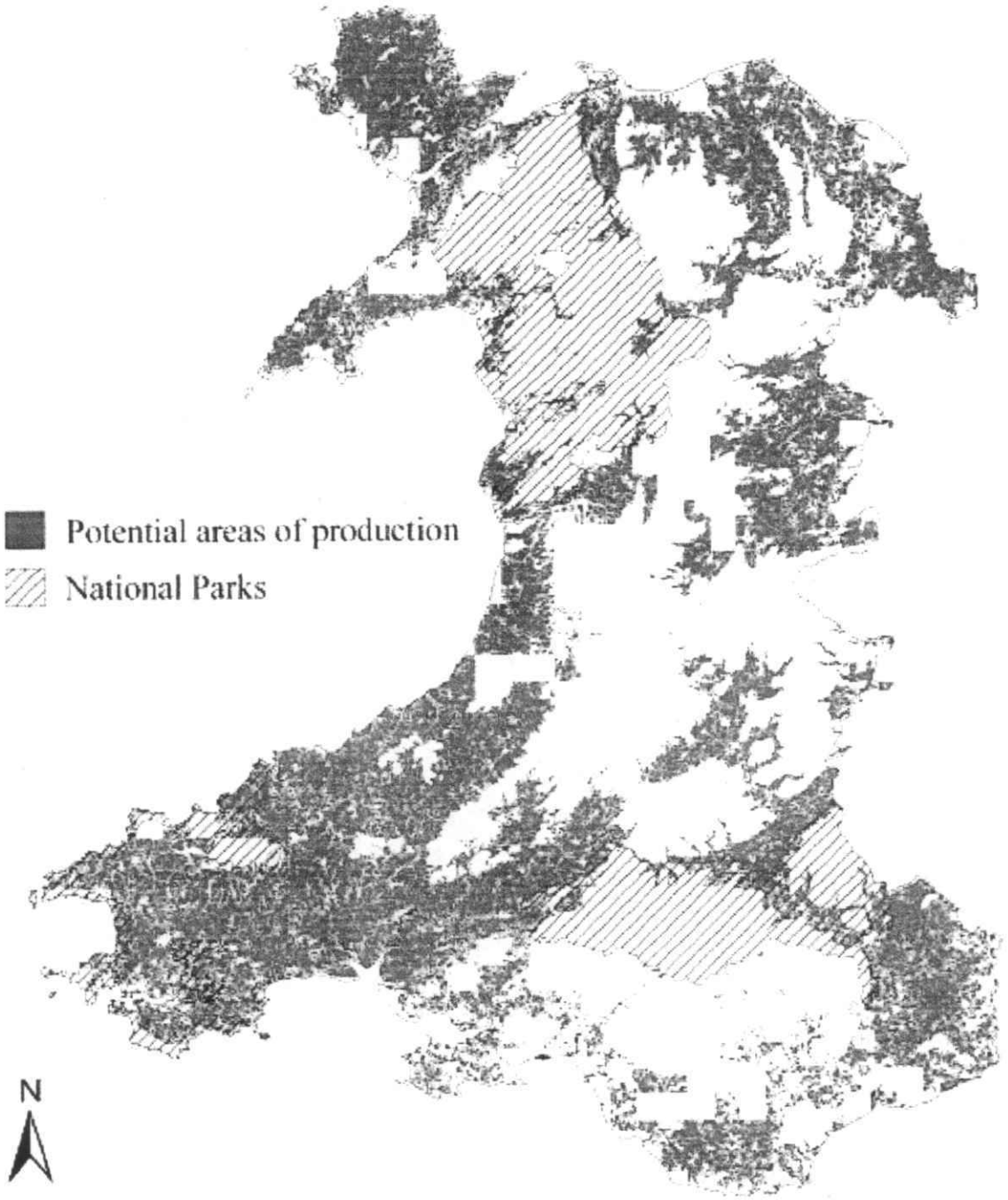

Potential areas of production
National Parks
N
0 5 10 20 30 40 50
kilometers

# Crambe



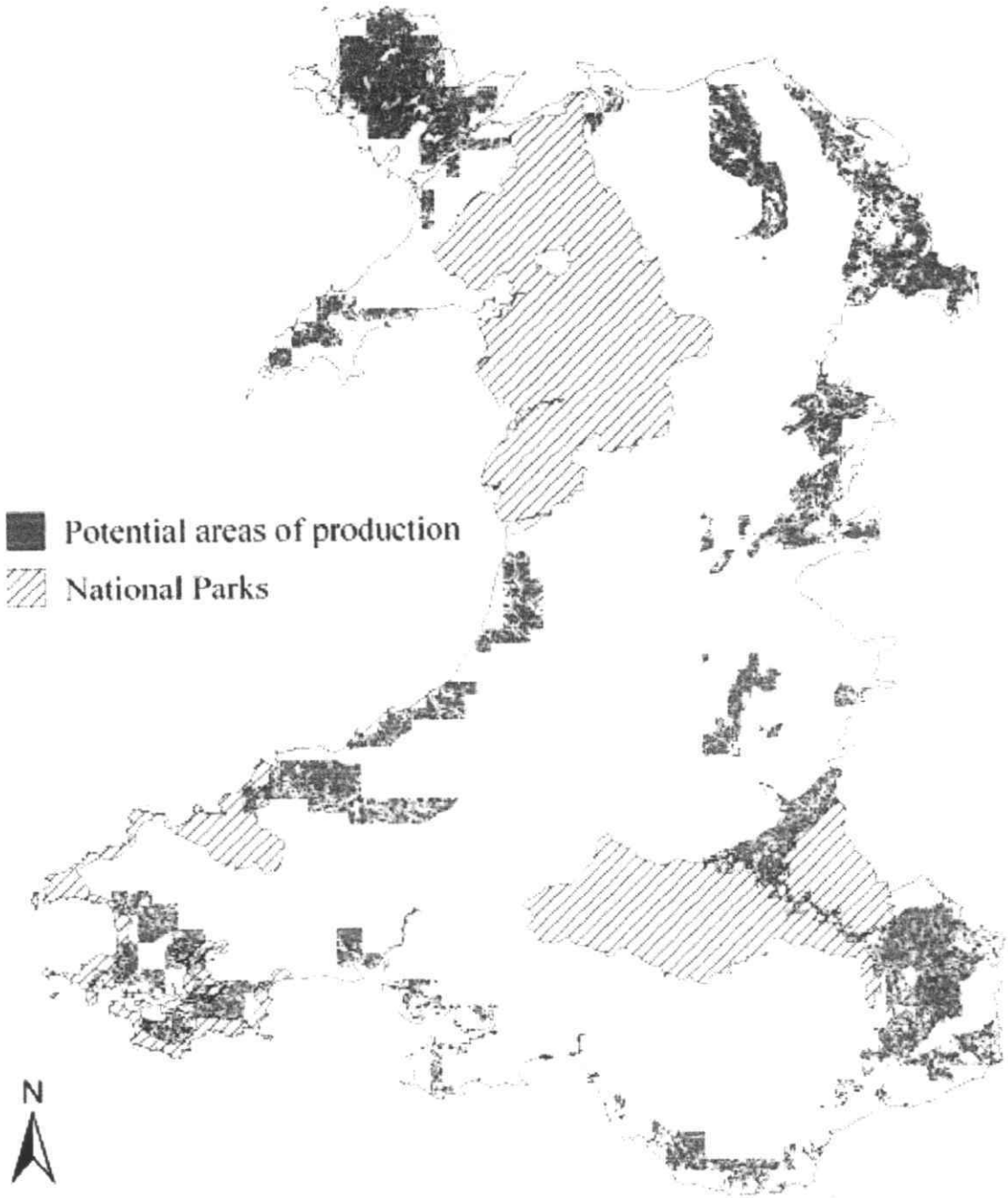

Soil information provided by NSRI

# Dairy Sheep



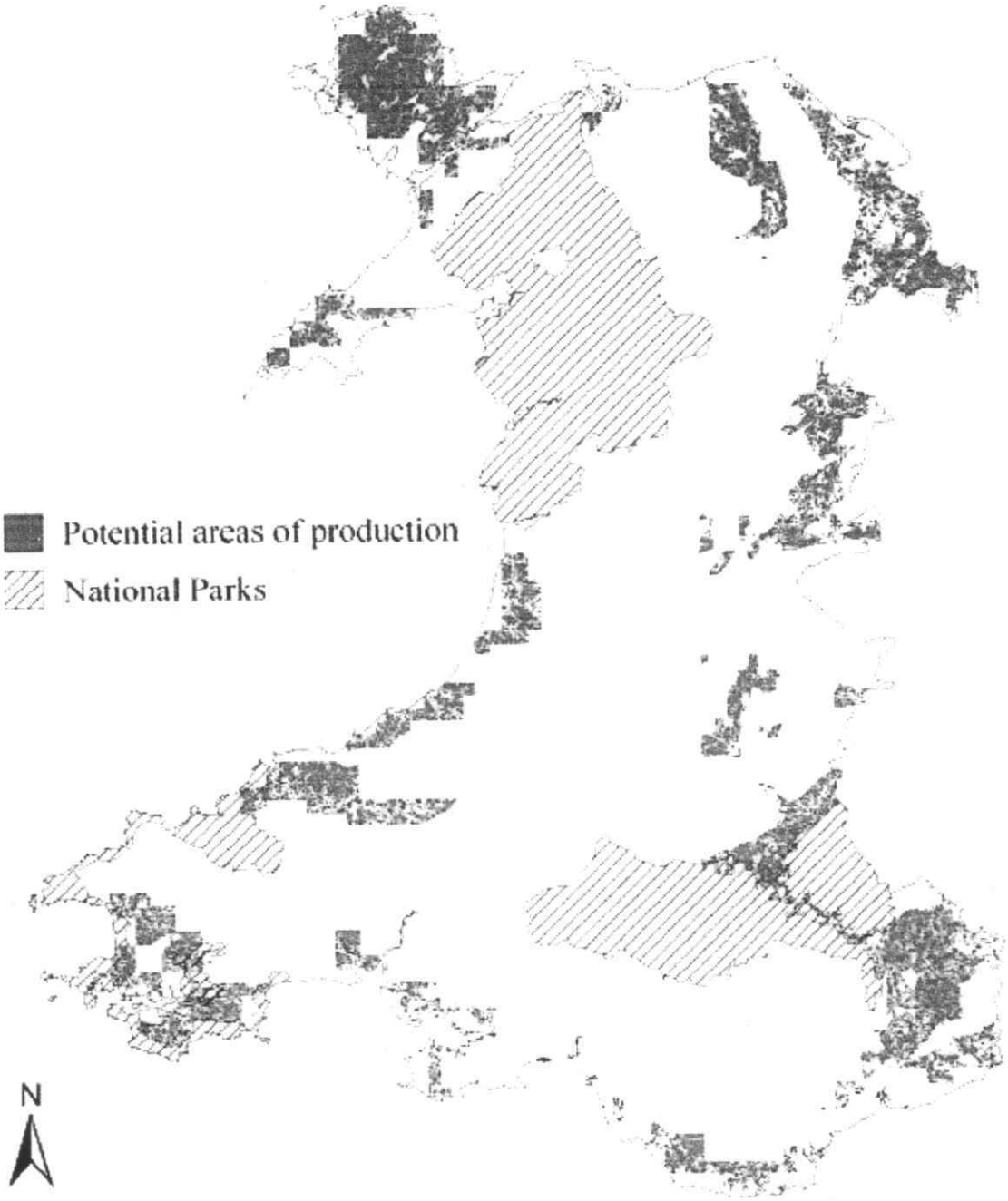

Soil information provided by NSRI

# Euphorbia




Soil information provided by NSRI

# Evening Primrose

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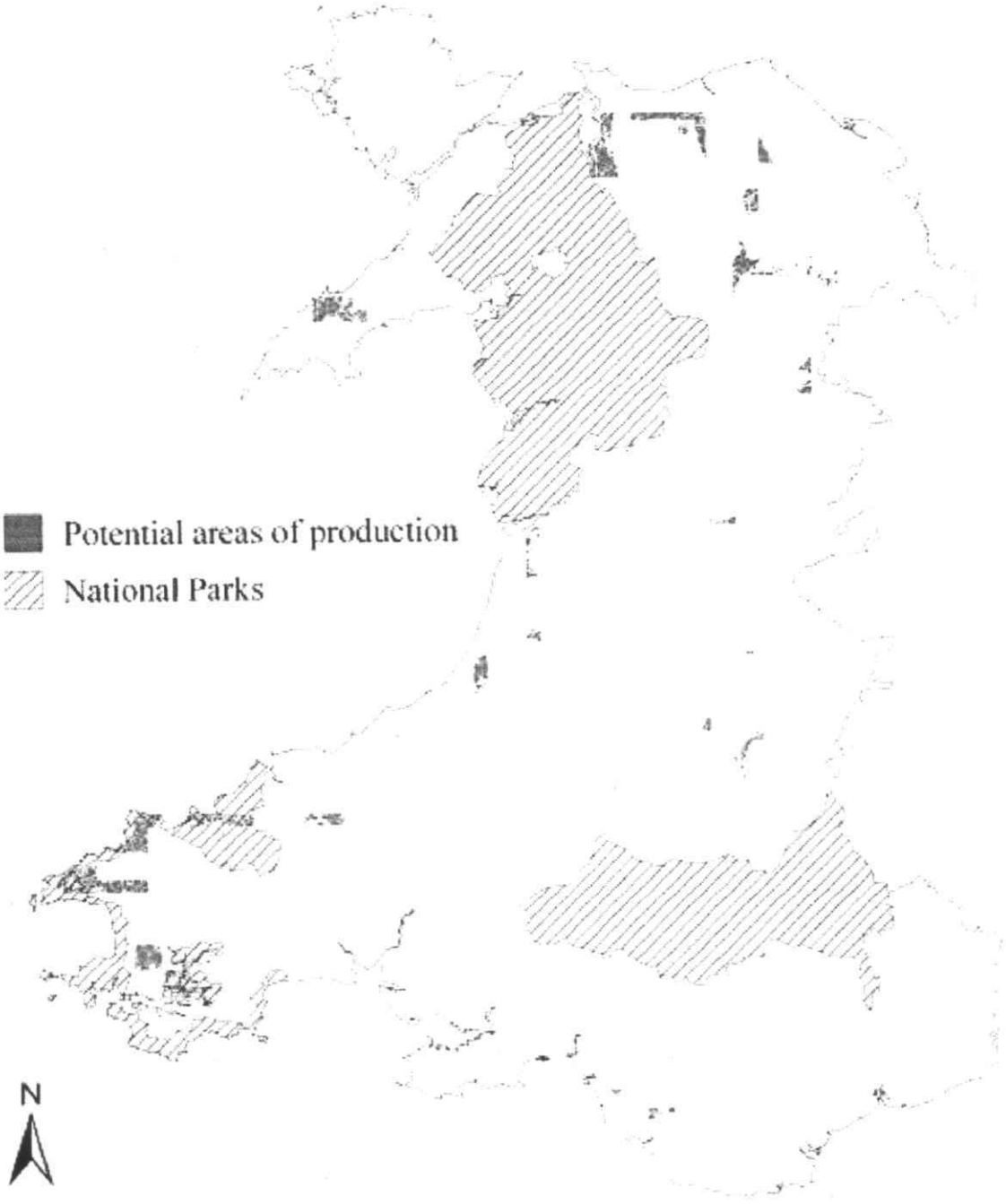
# Foxglove

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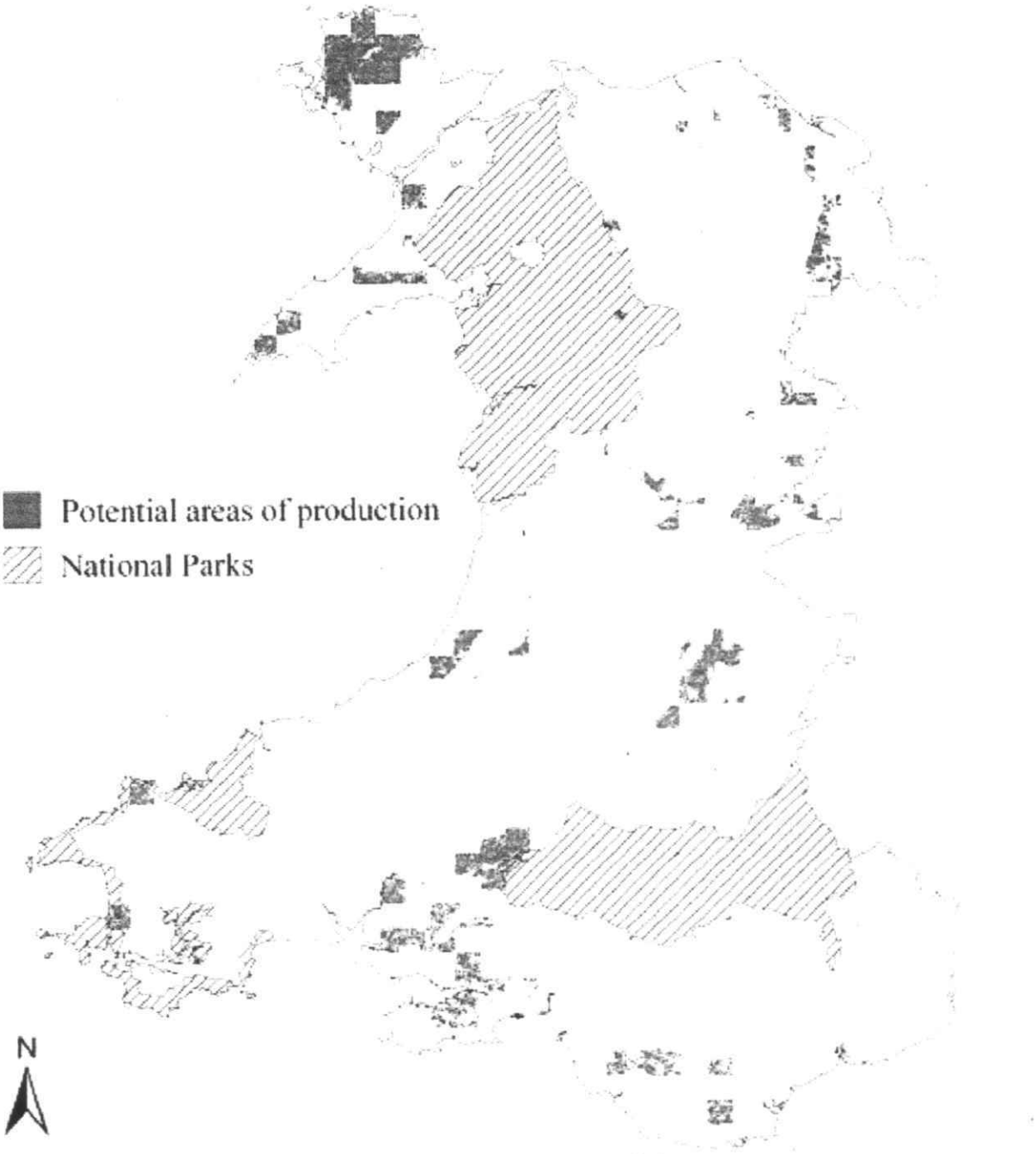
# Giant Reed

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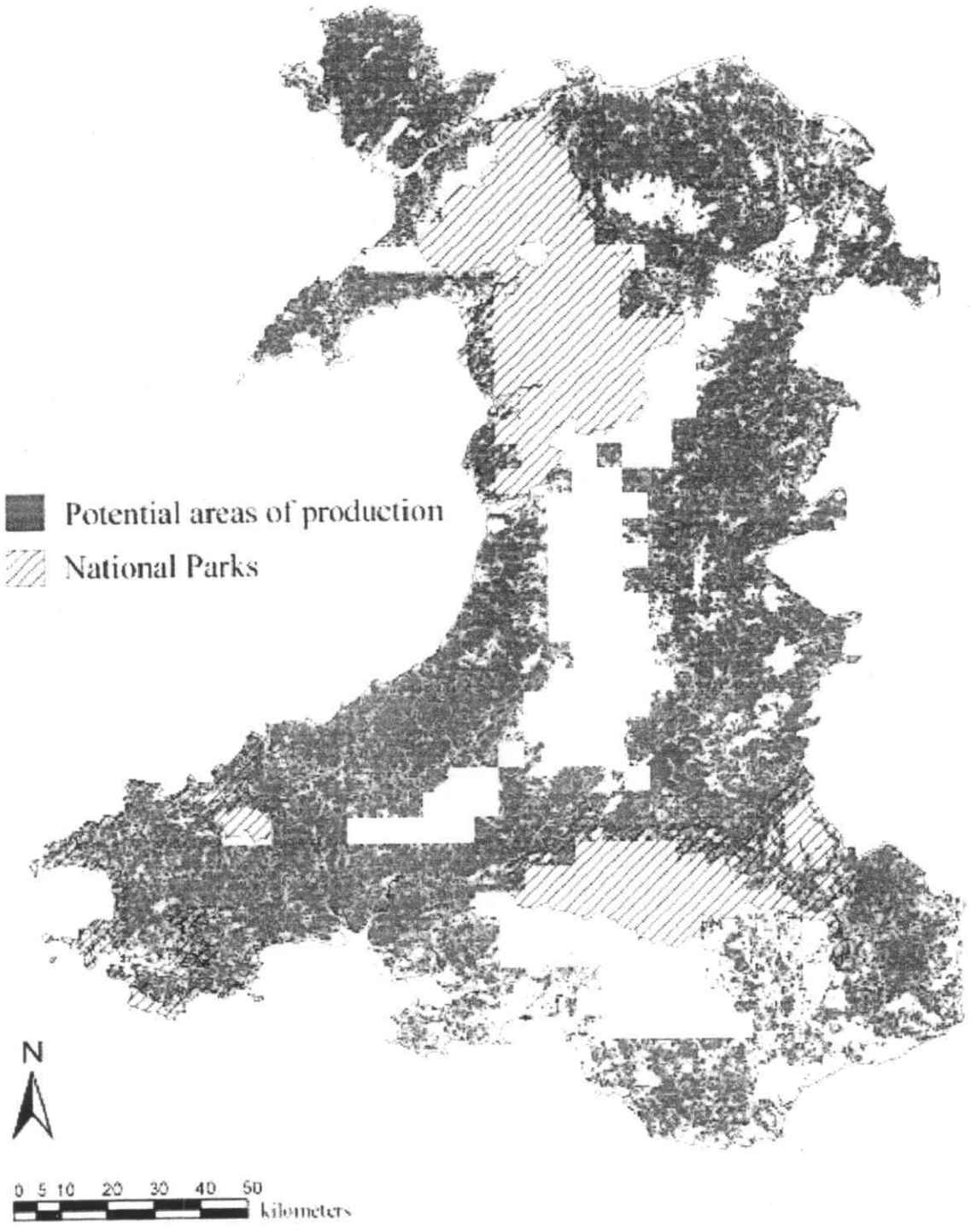
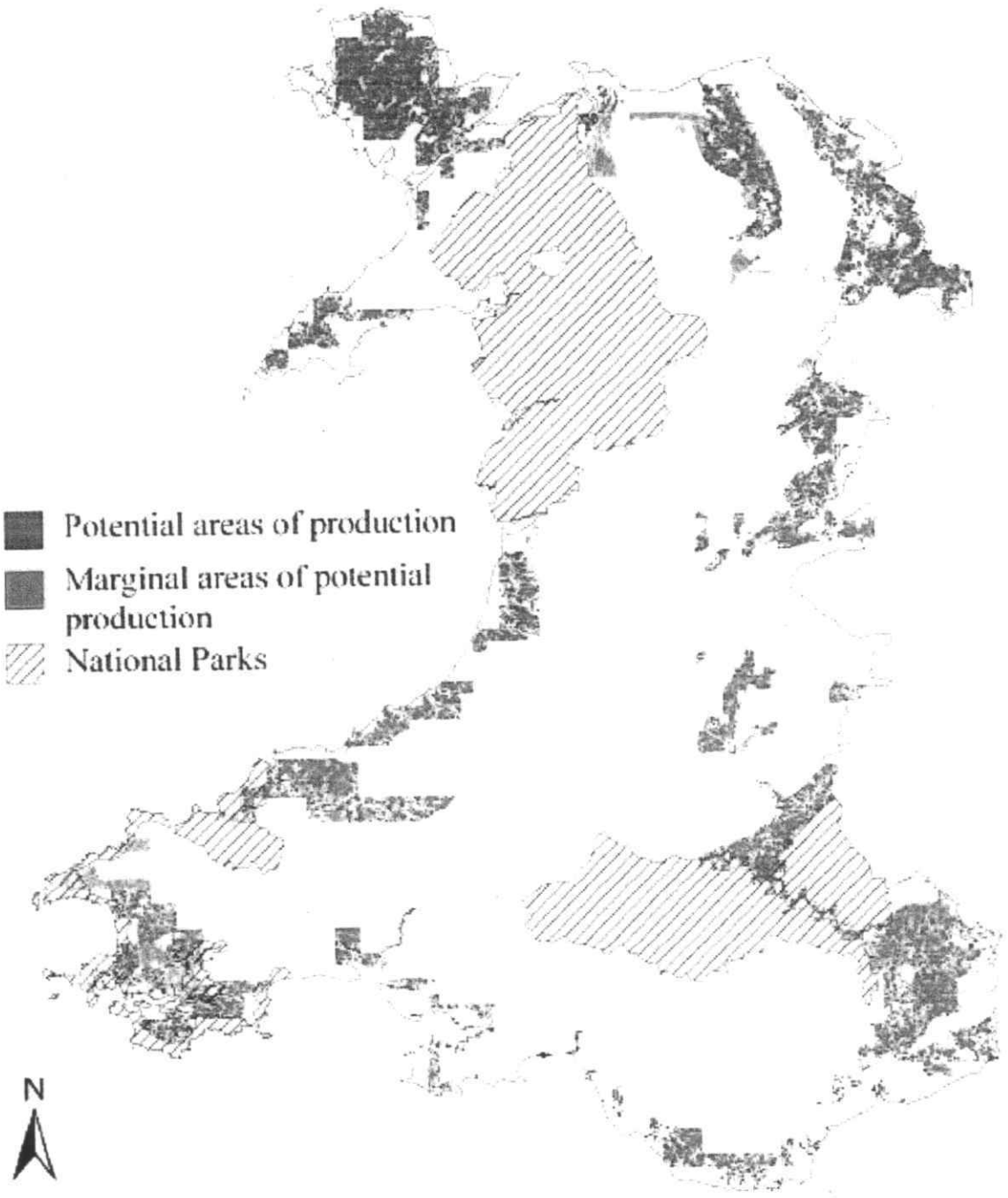
# Goats


Potential areas of production
National Parks
N
0 5 10 20 30 40 50
kilometers

# Gold of Pleasure

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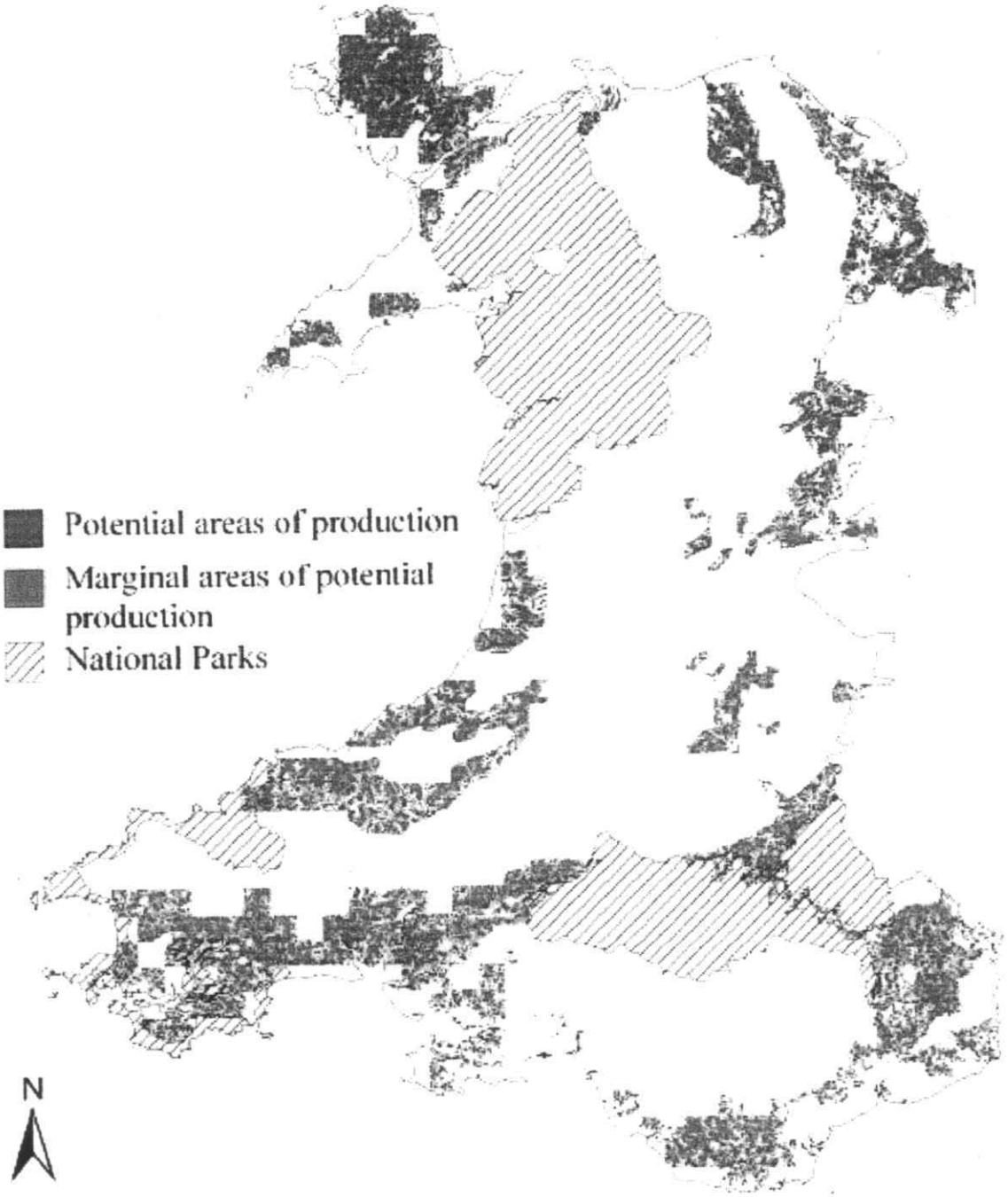
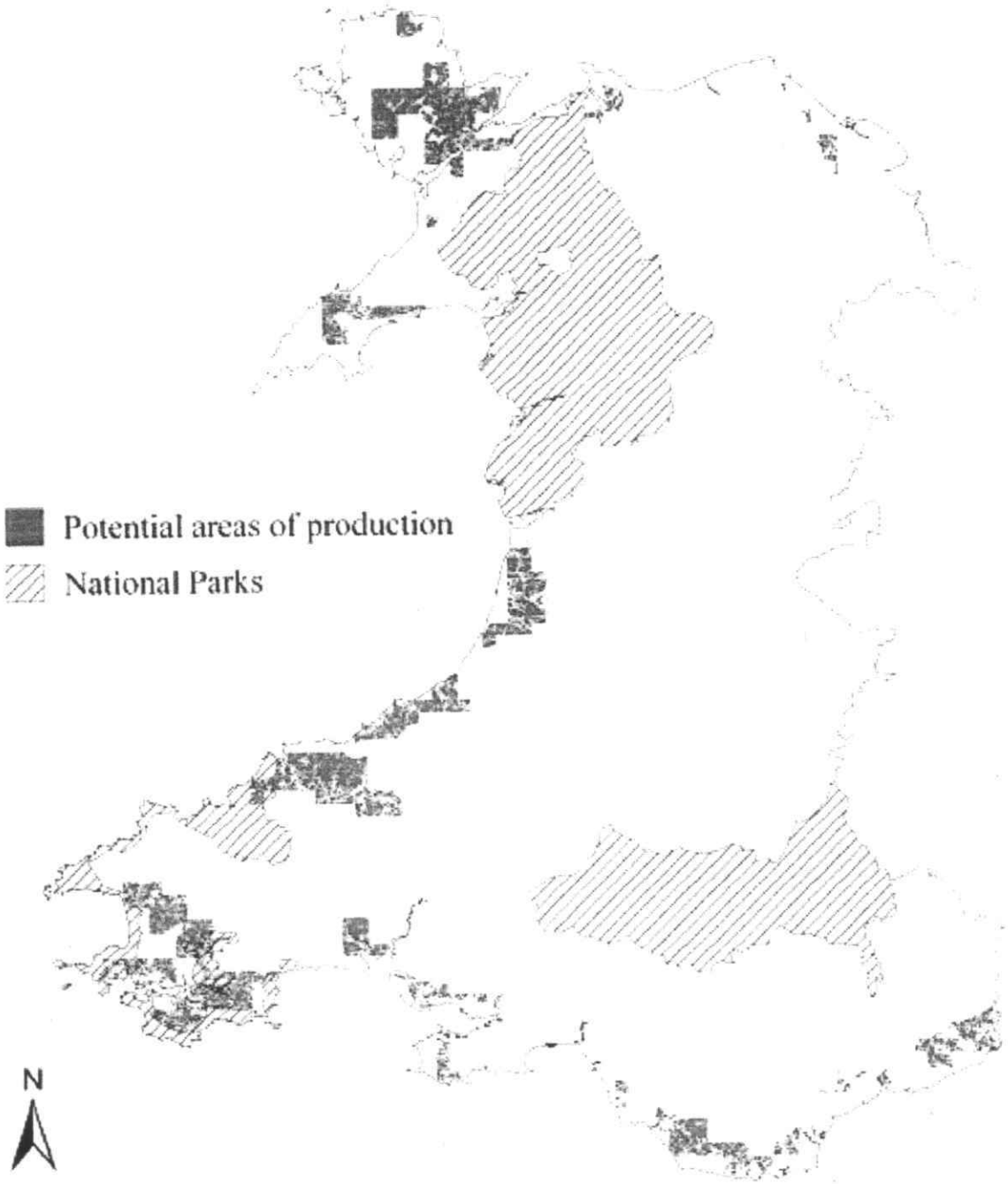
# Hemp




Soil information provided by NSRI

# Henbane

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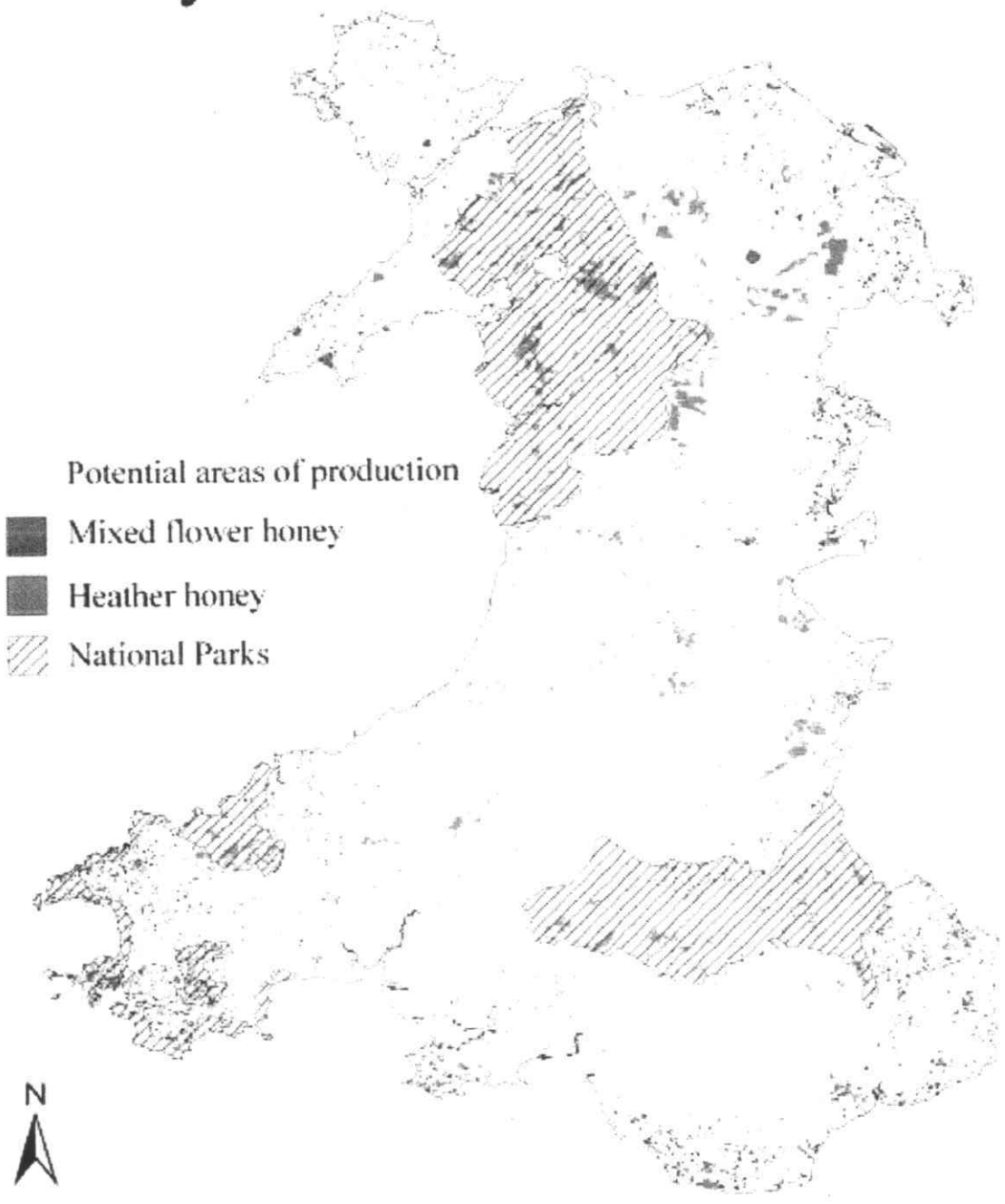
# Honey

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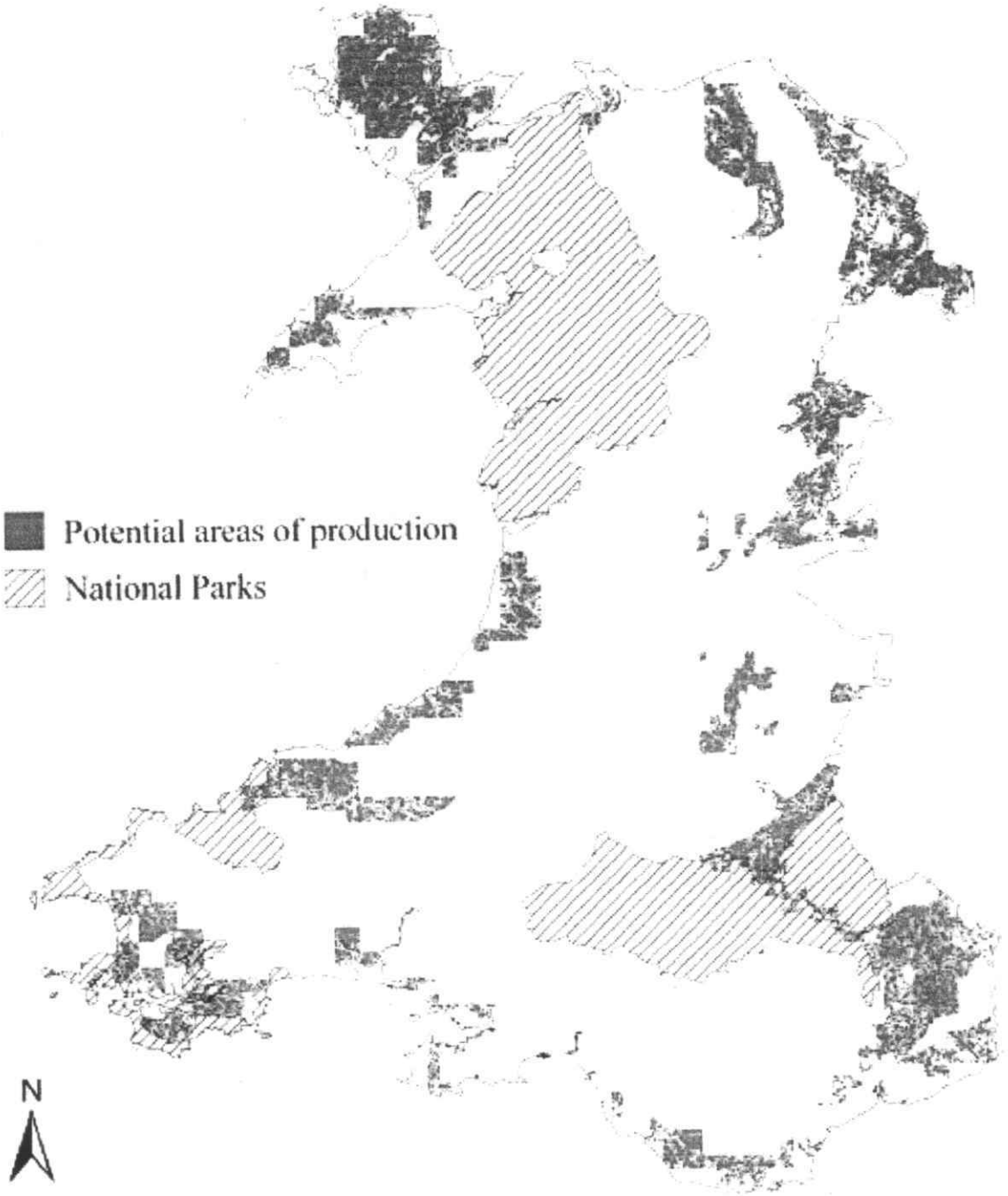
# Linola

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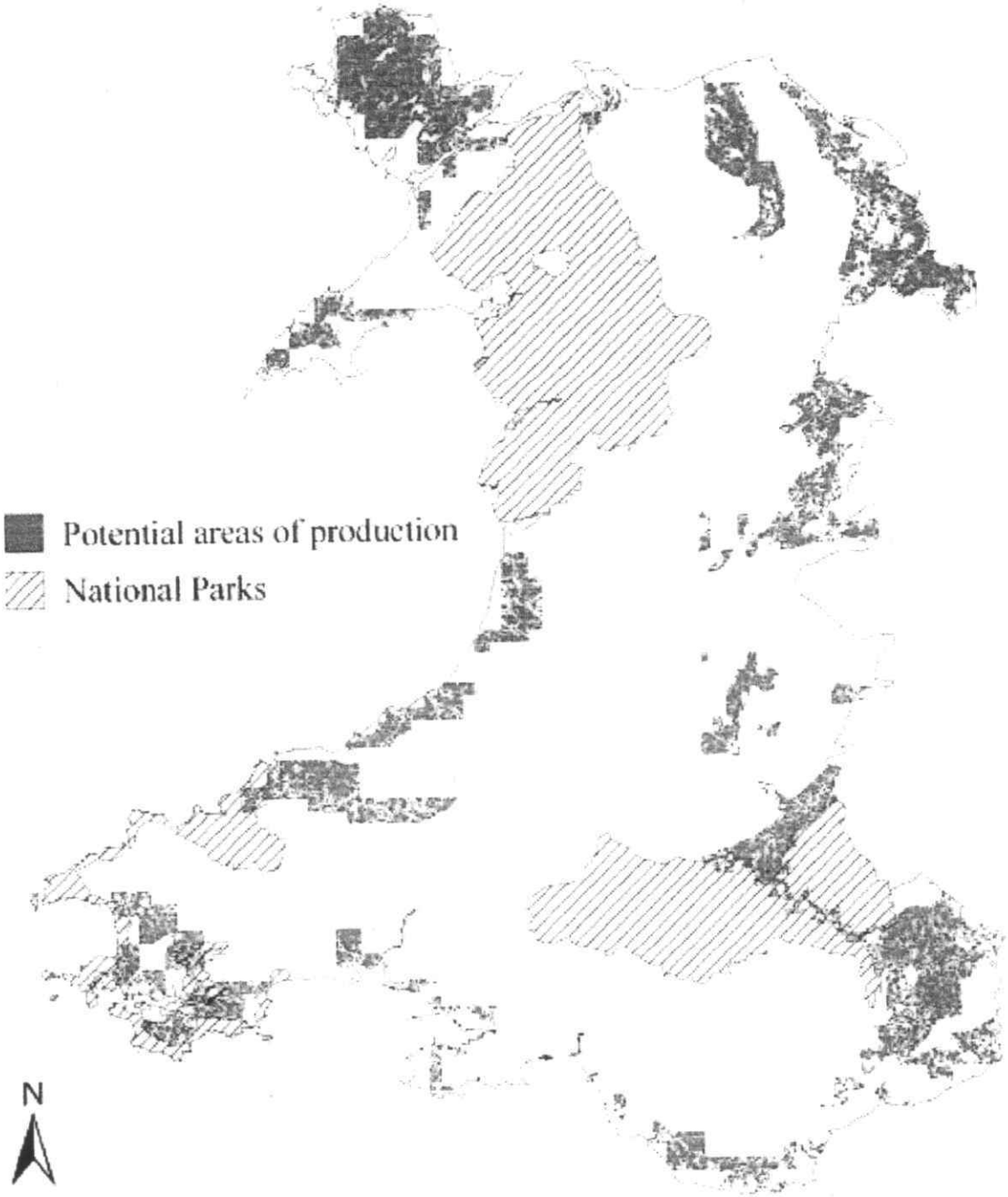
# Linseed/Flax

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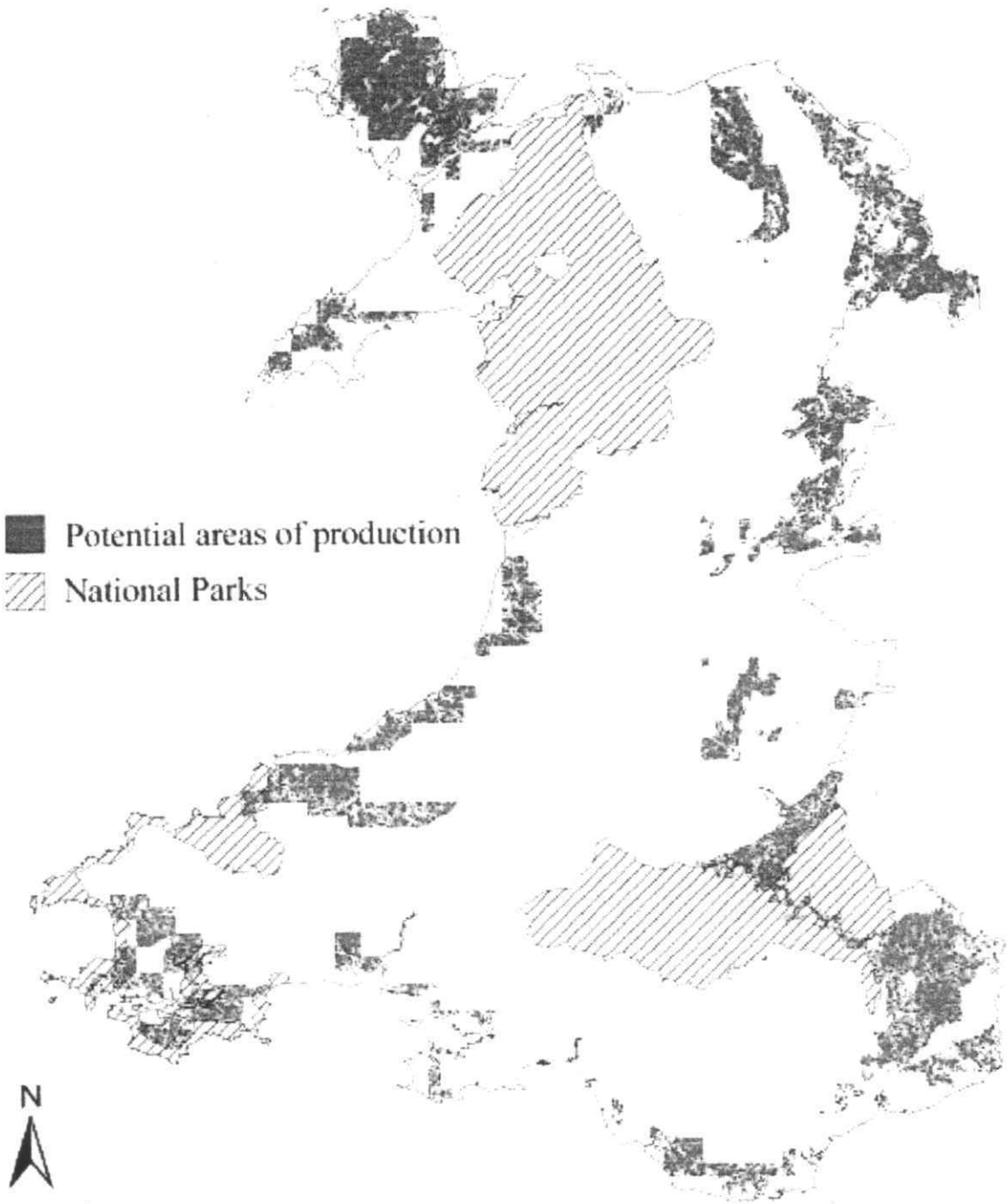
# Madder

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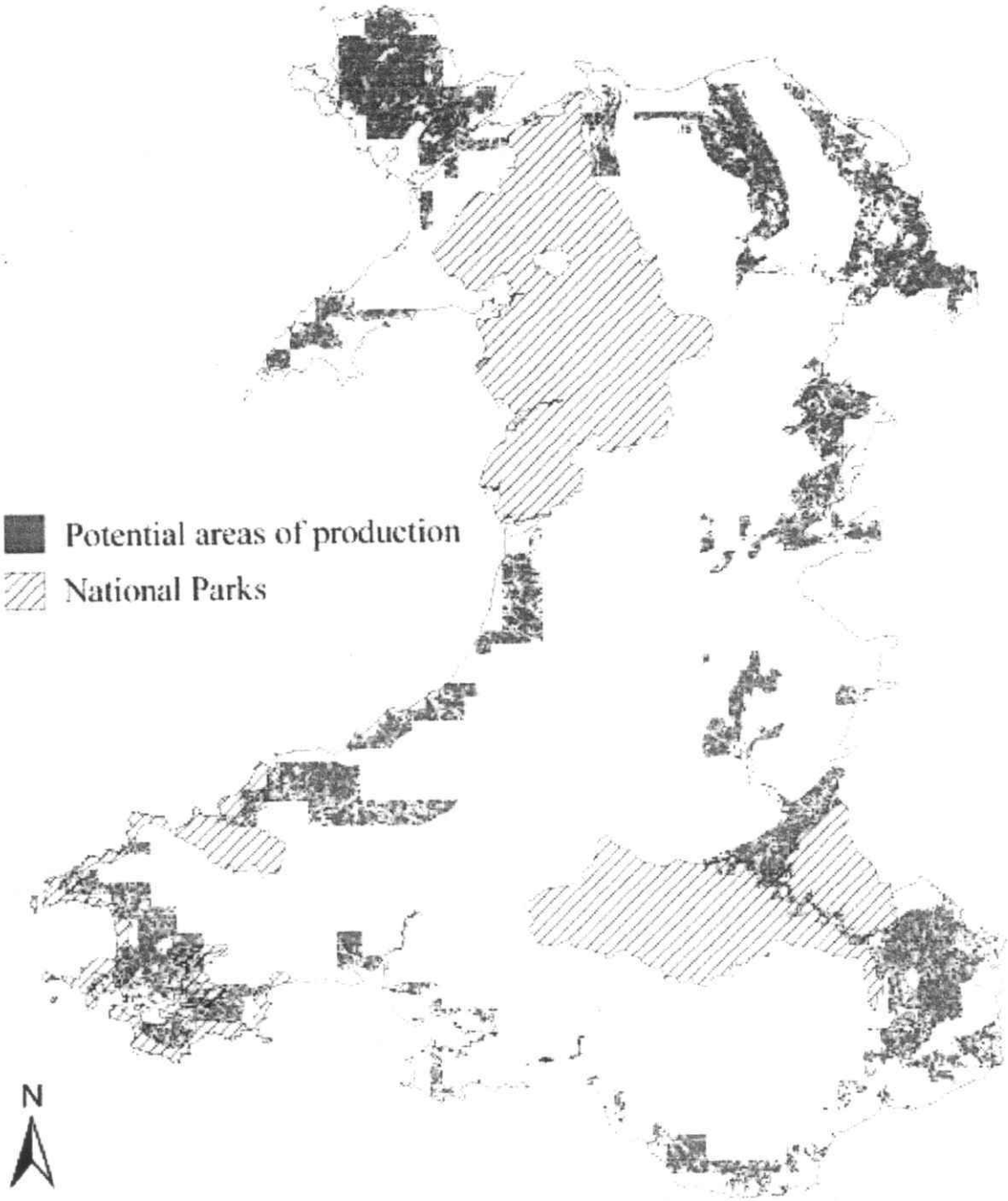
# Meadow foam

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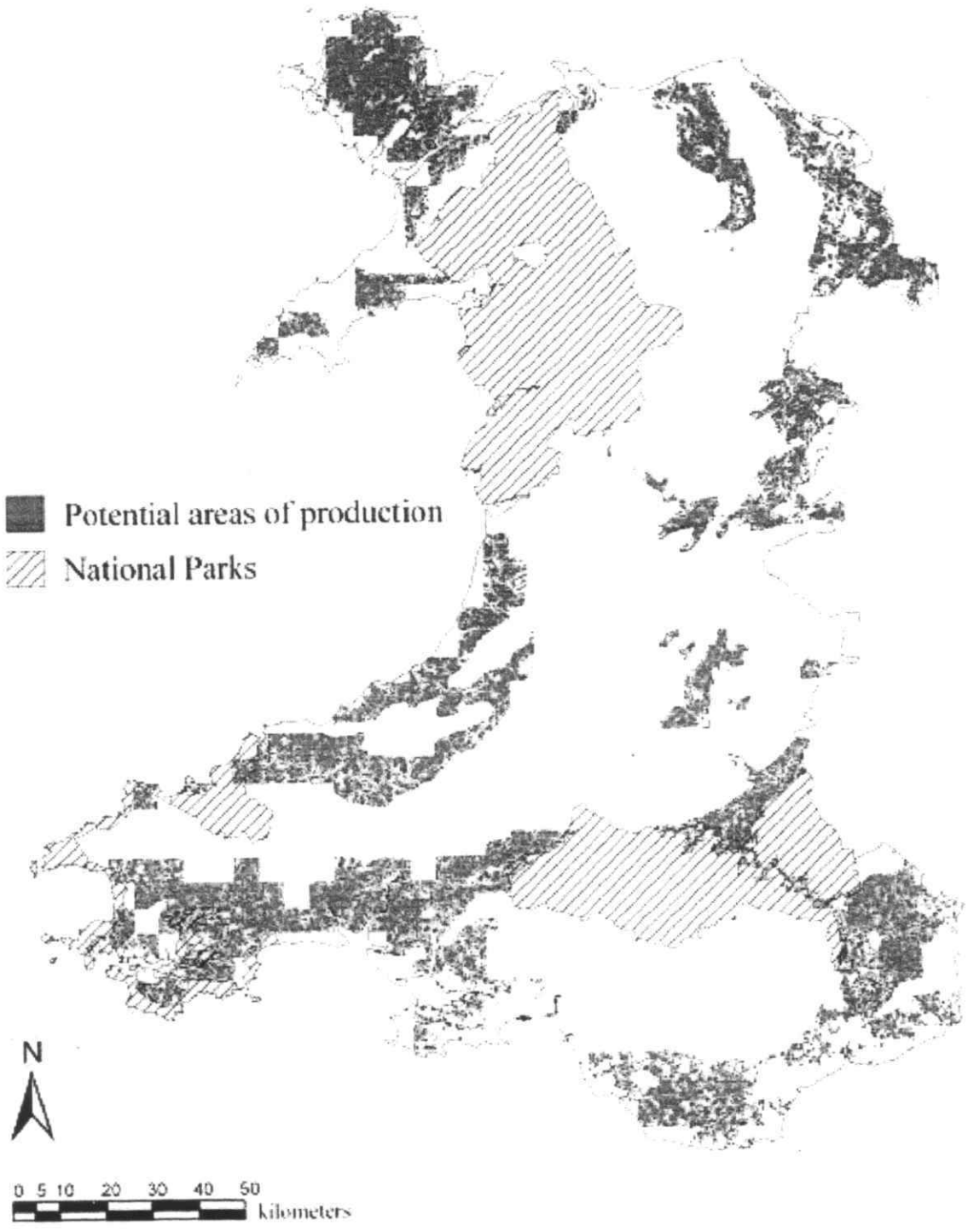
# Miscanthus

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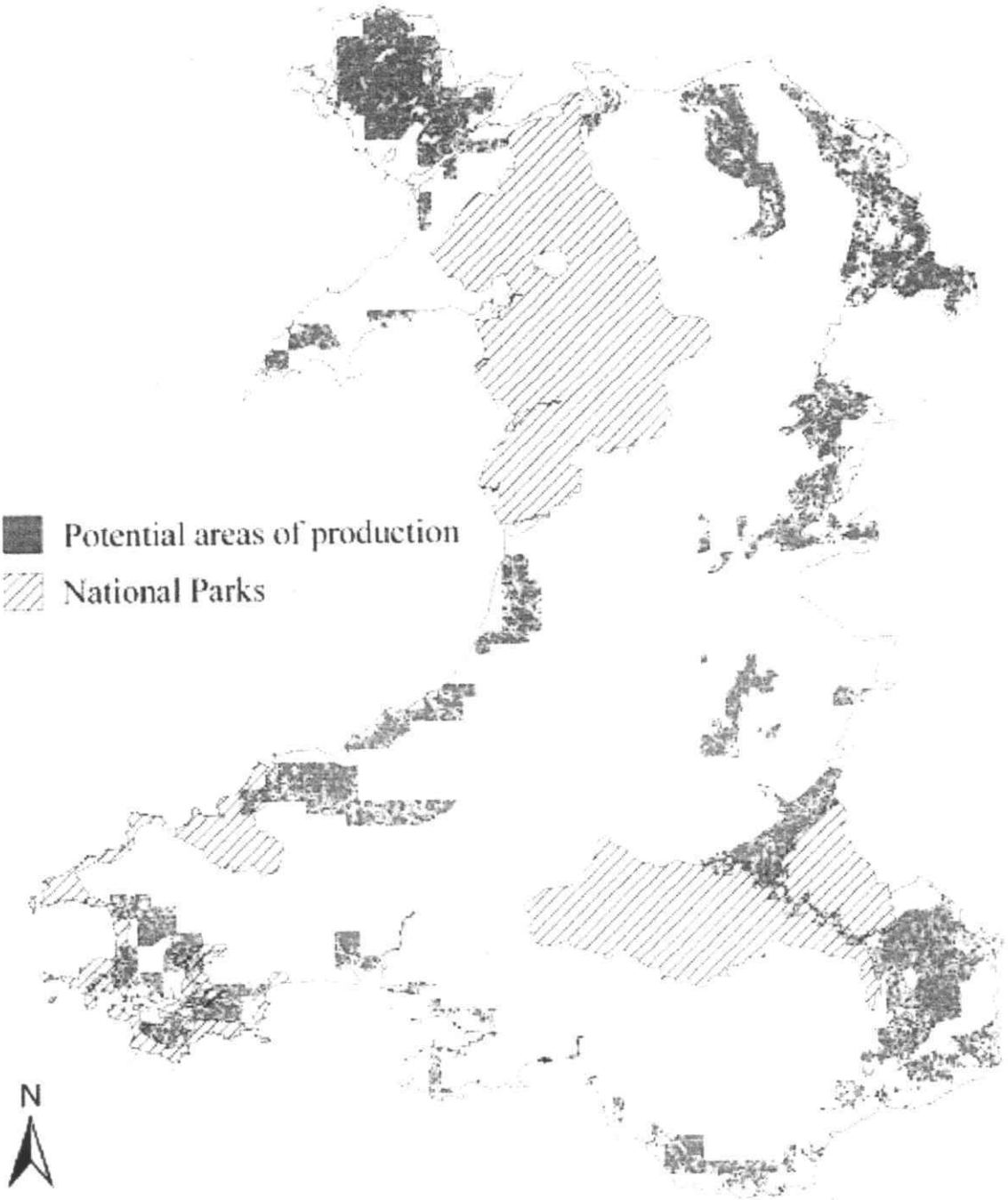
# Mugwort

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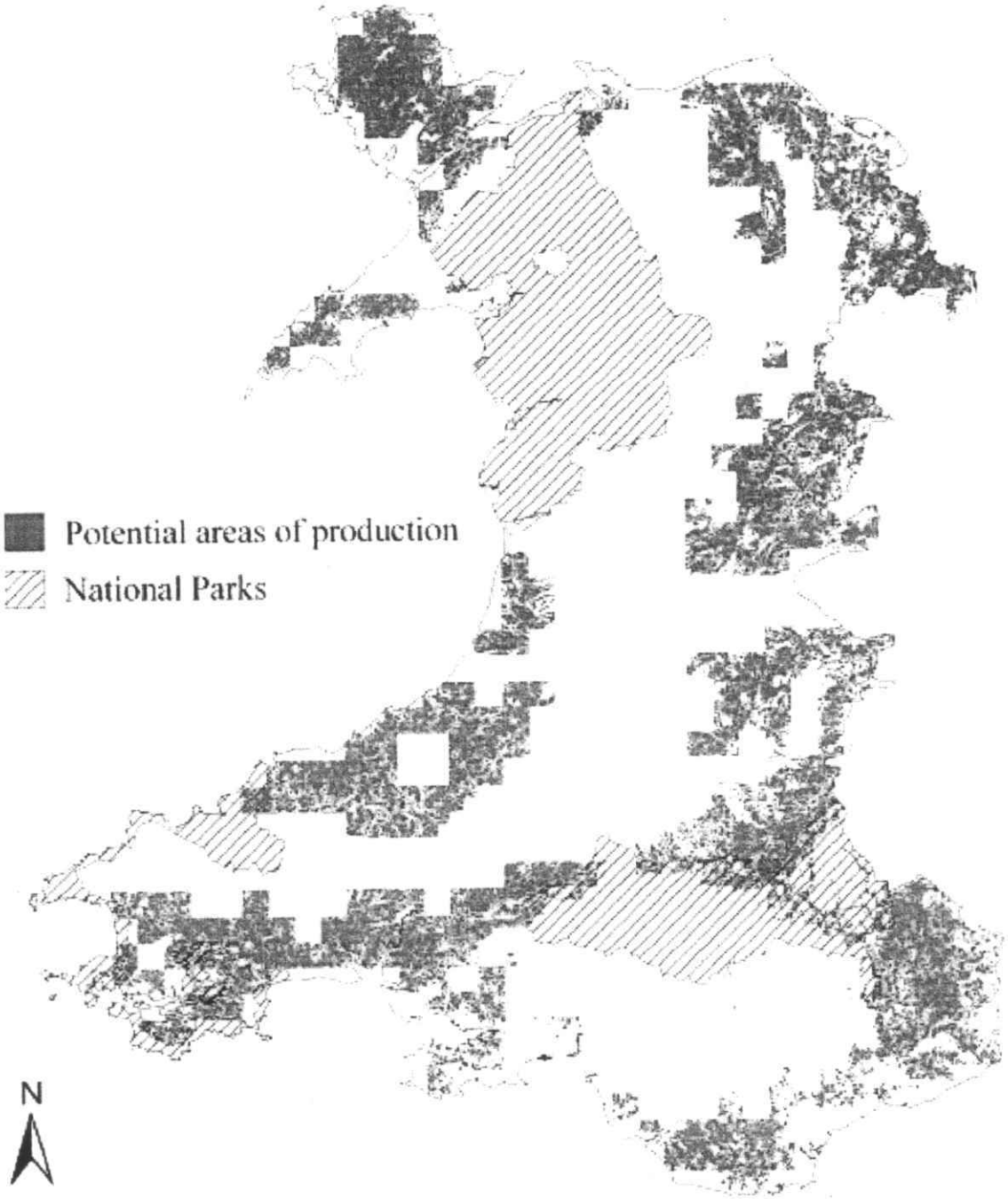
# Nettle

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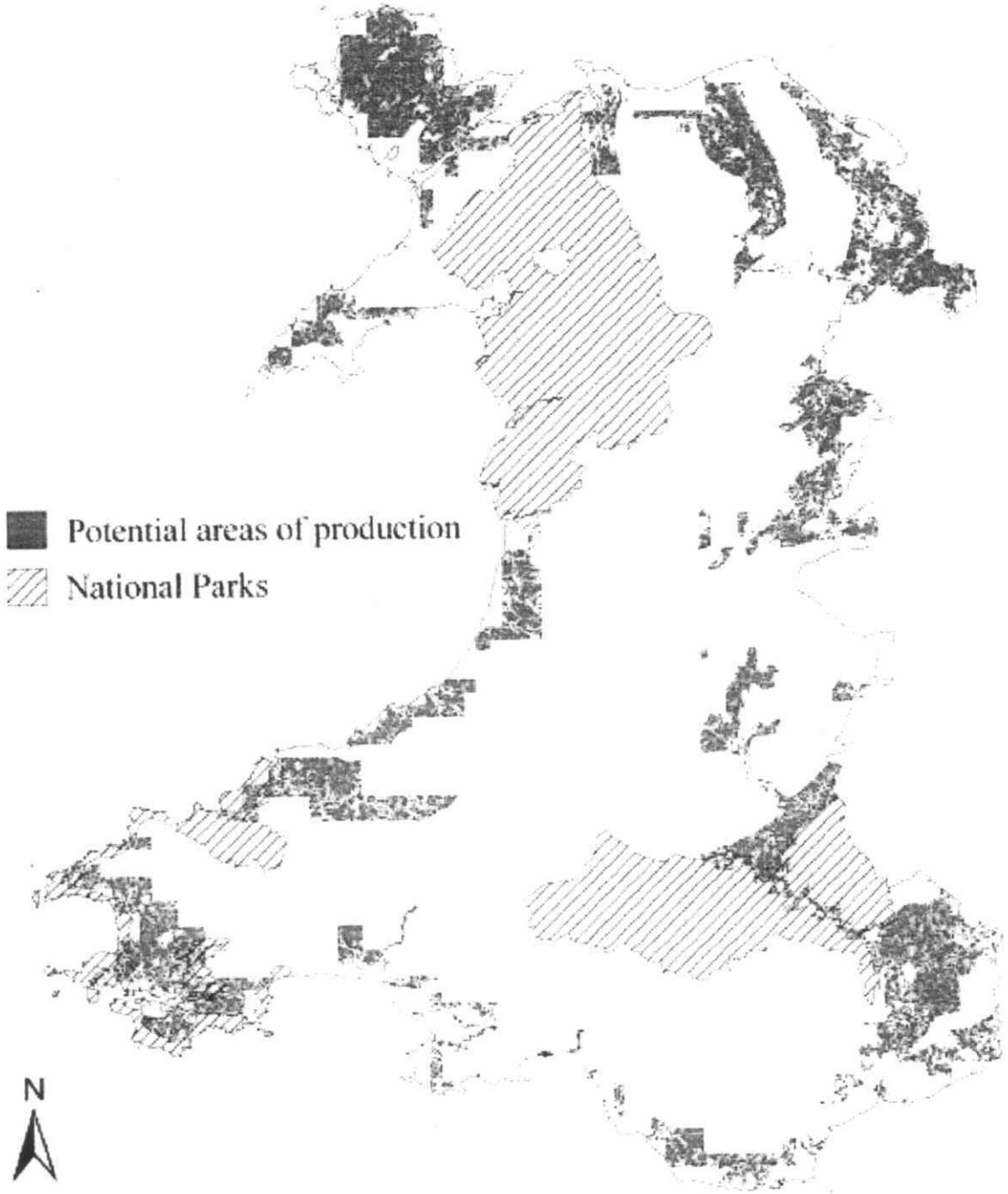
# Oats

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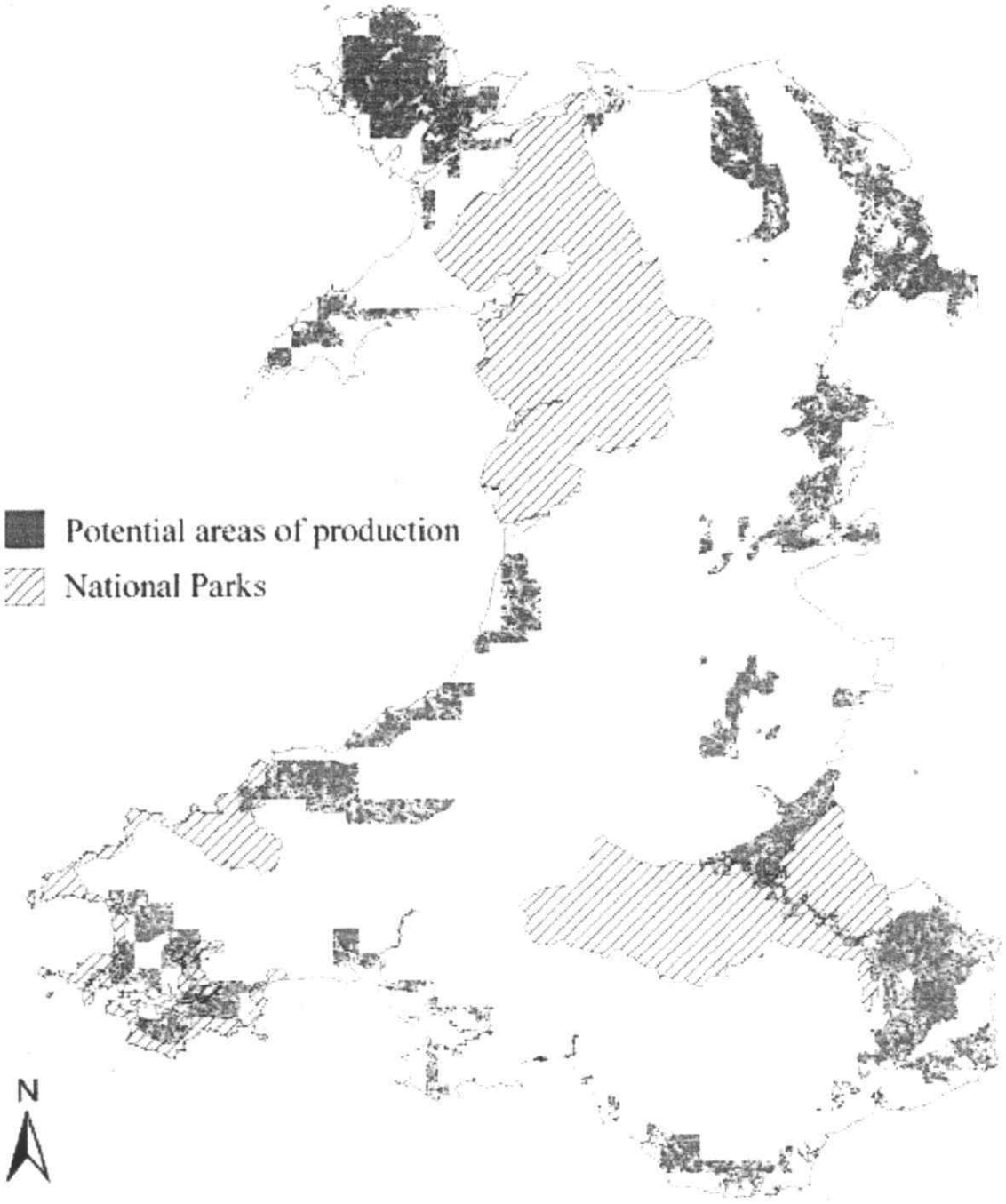
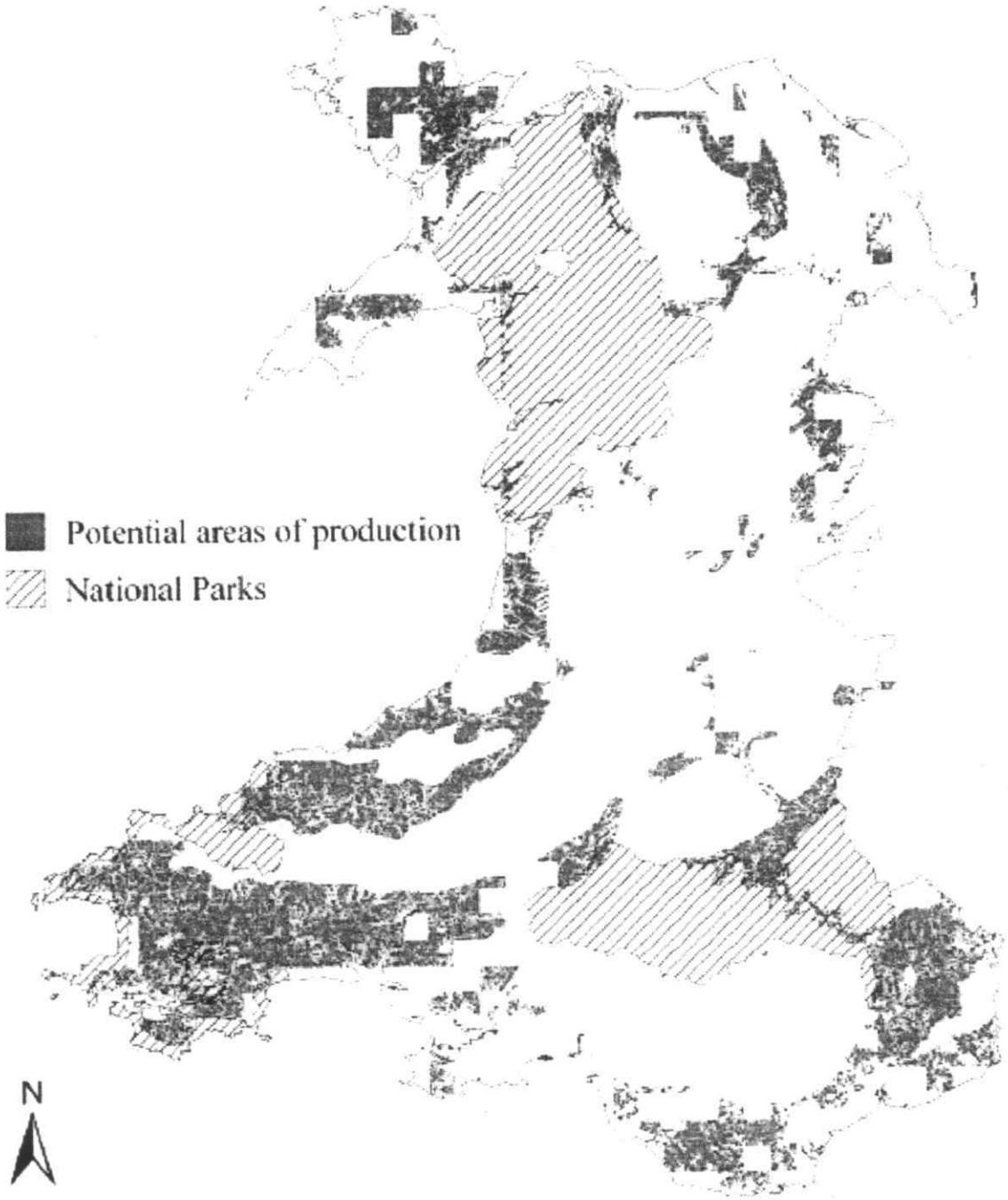
# Oilseed Rape




Soil information provided by NSRI

# Ostrich

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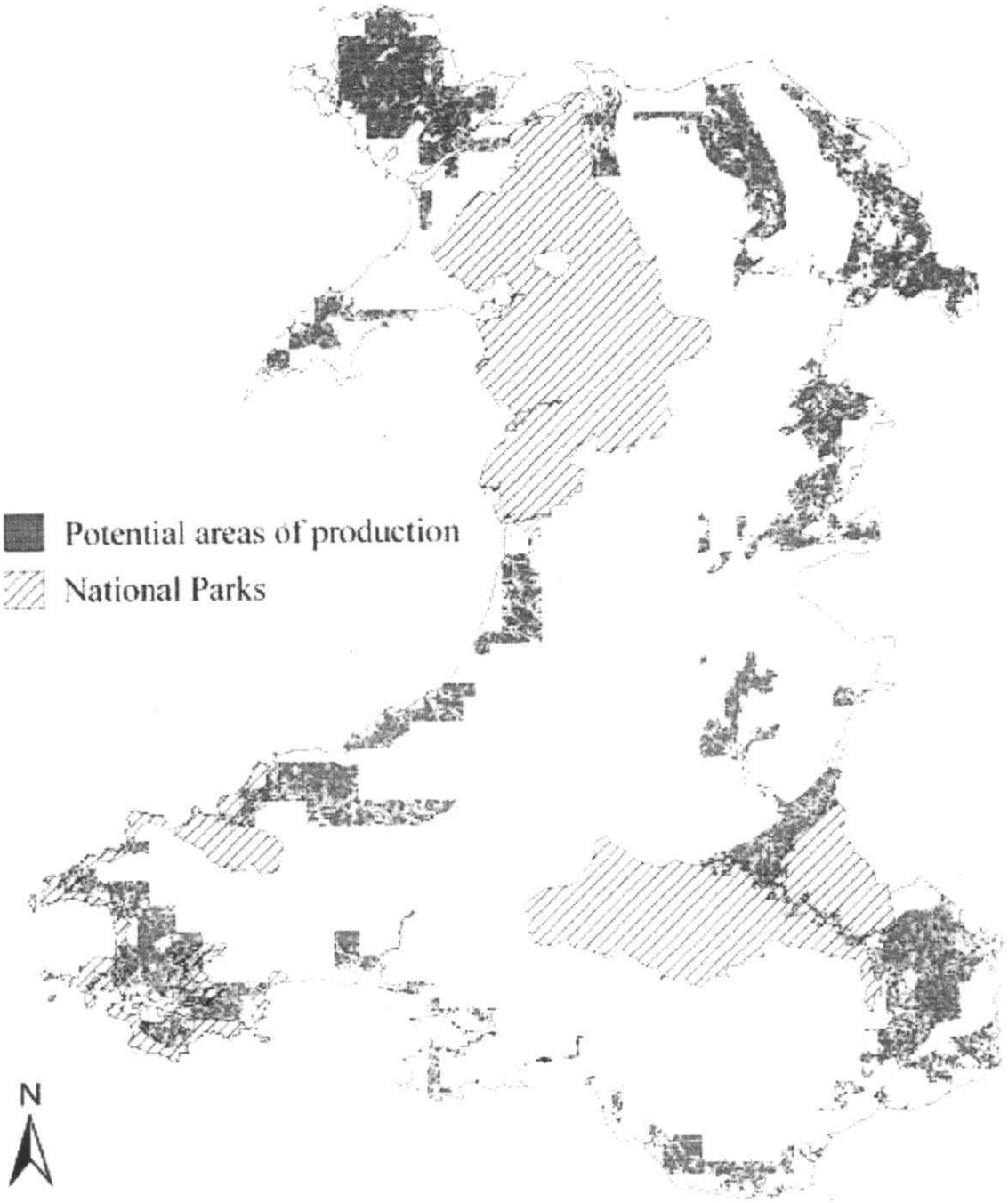
# Peppermint

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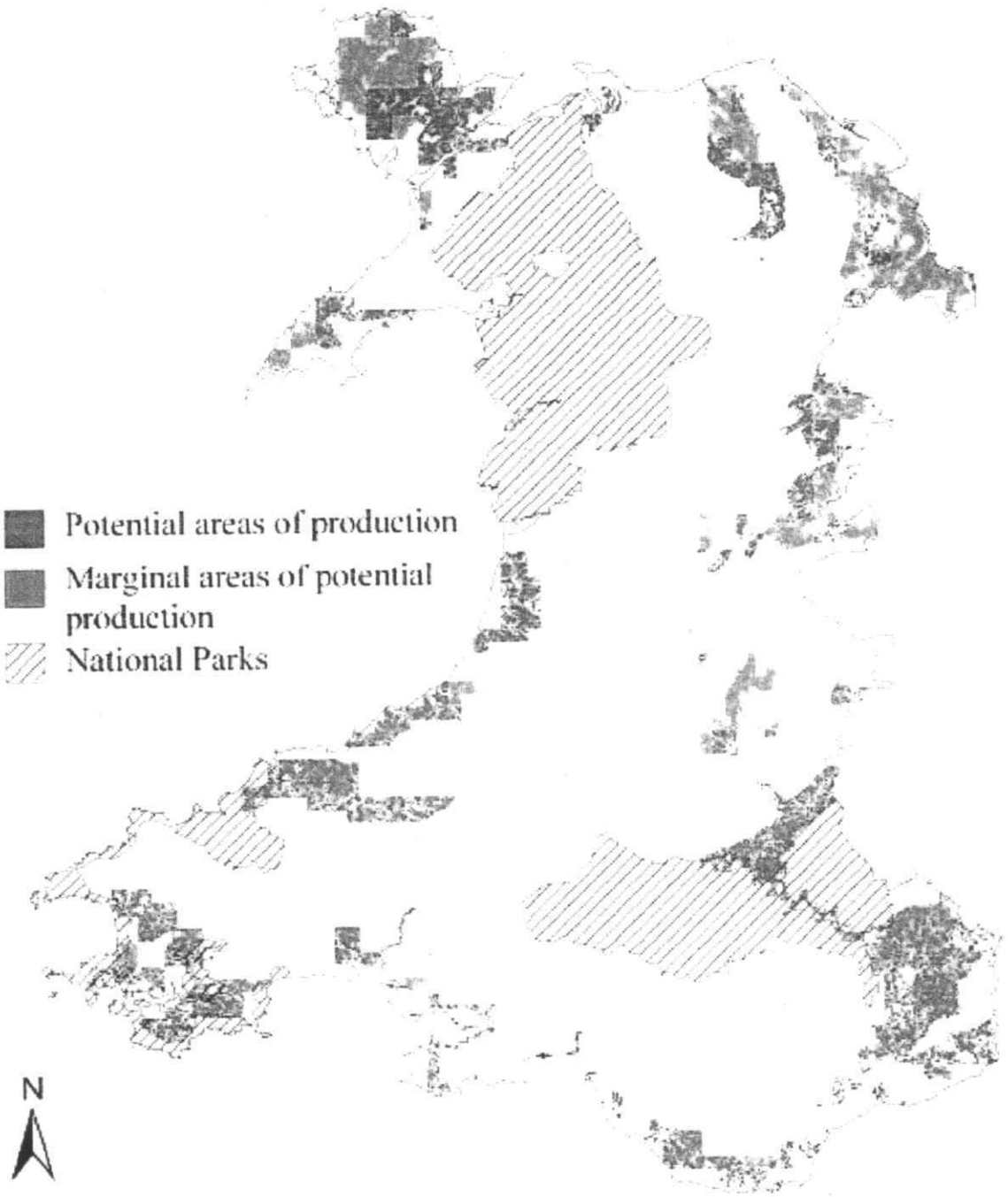
# Poppy

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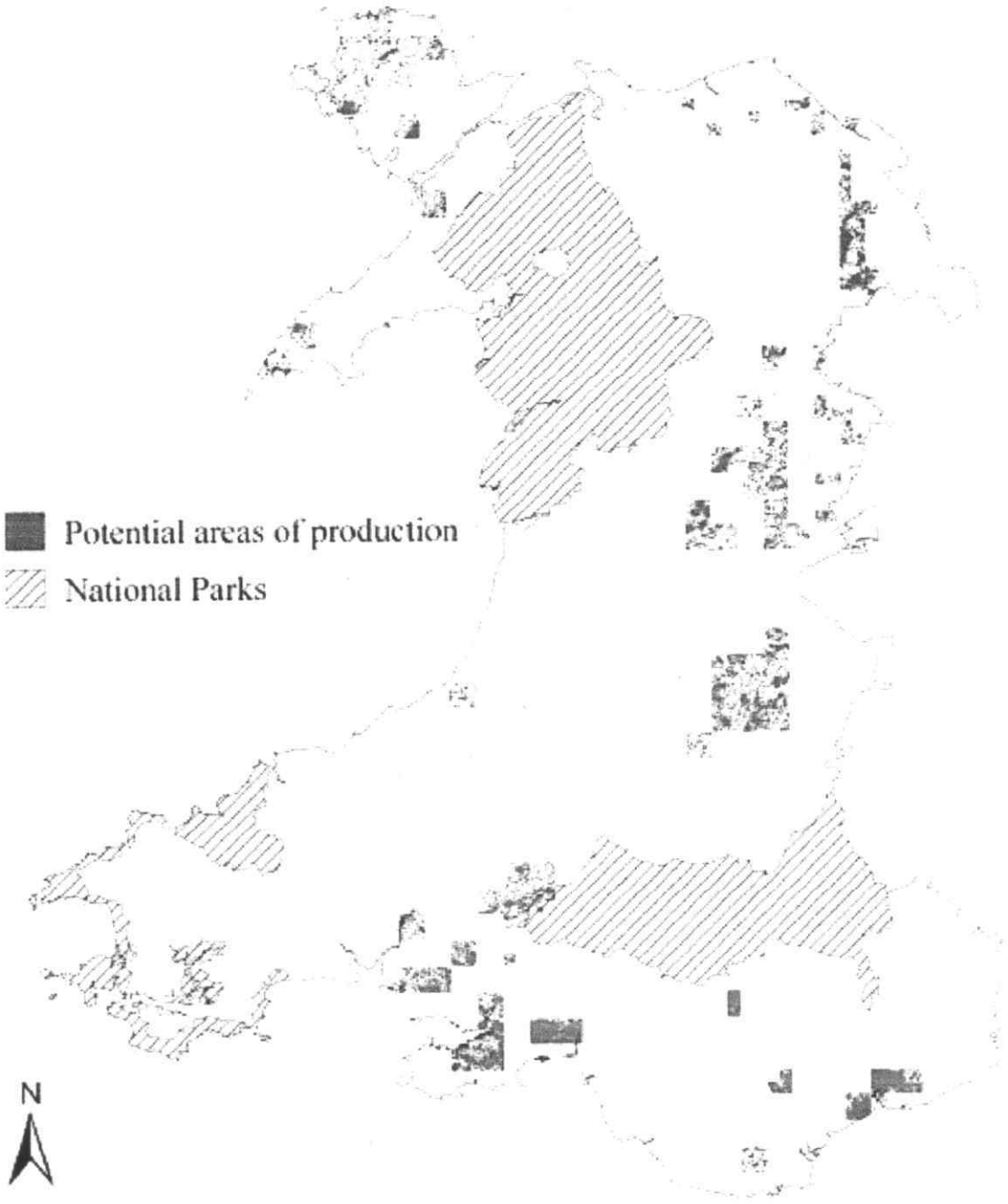
# Reed Canary Grass

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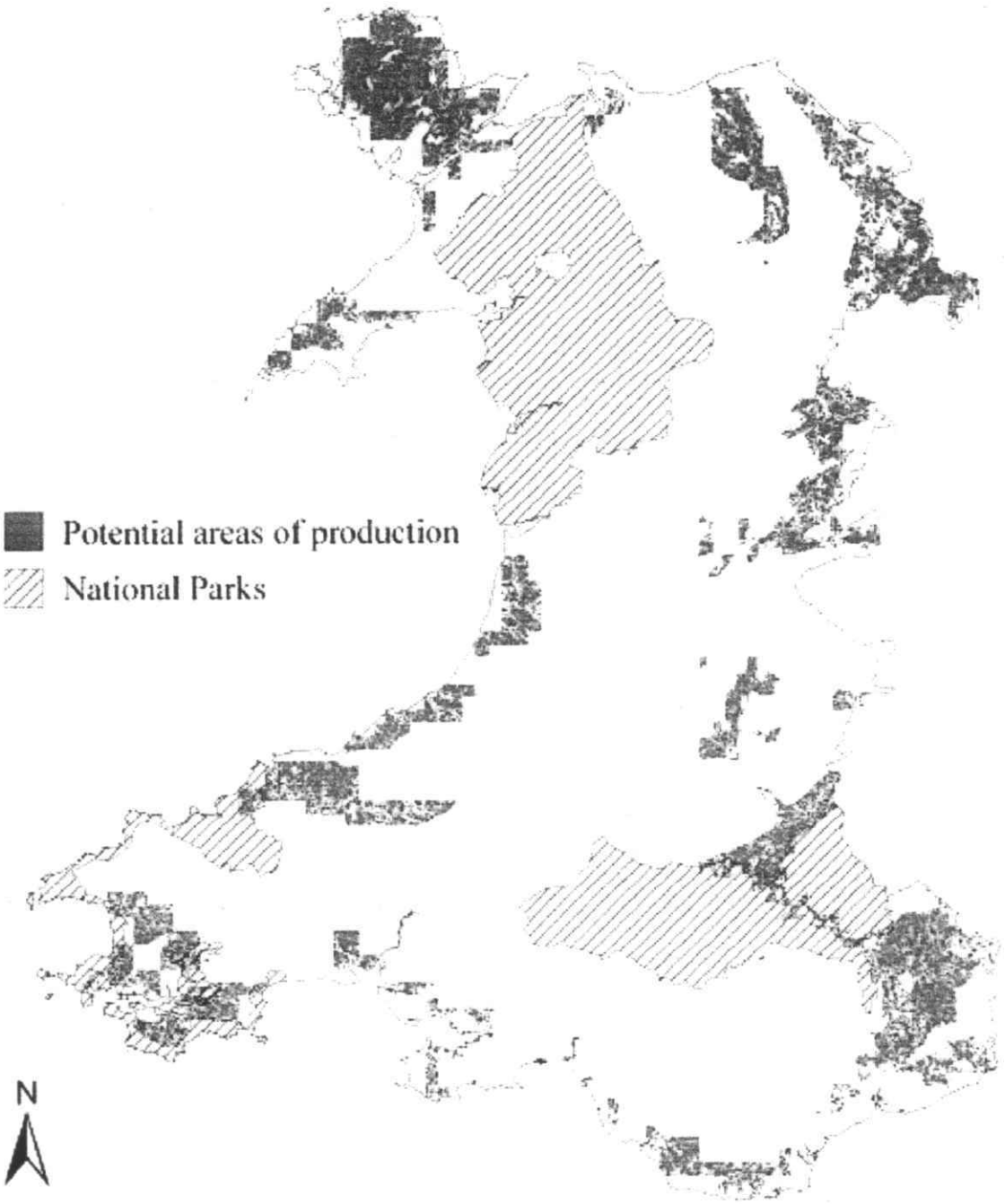
# Sea Buckthorn

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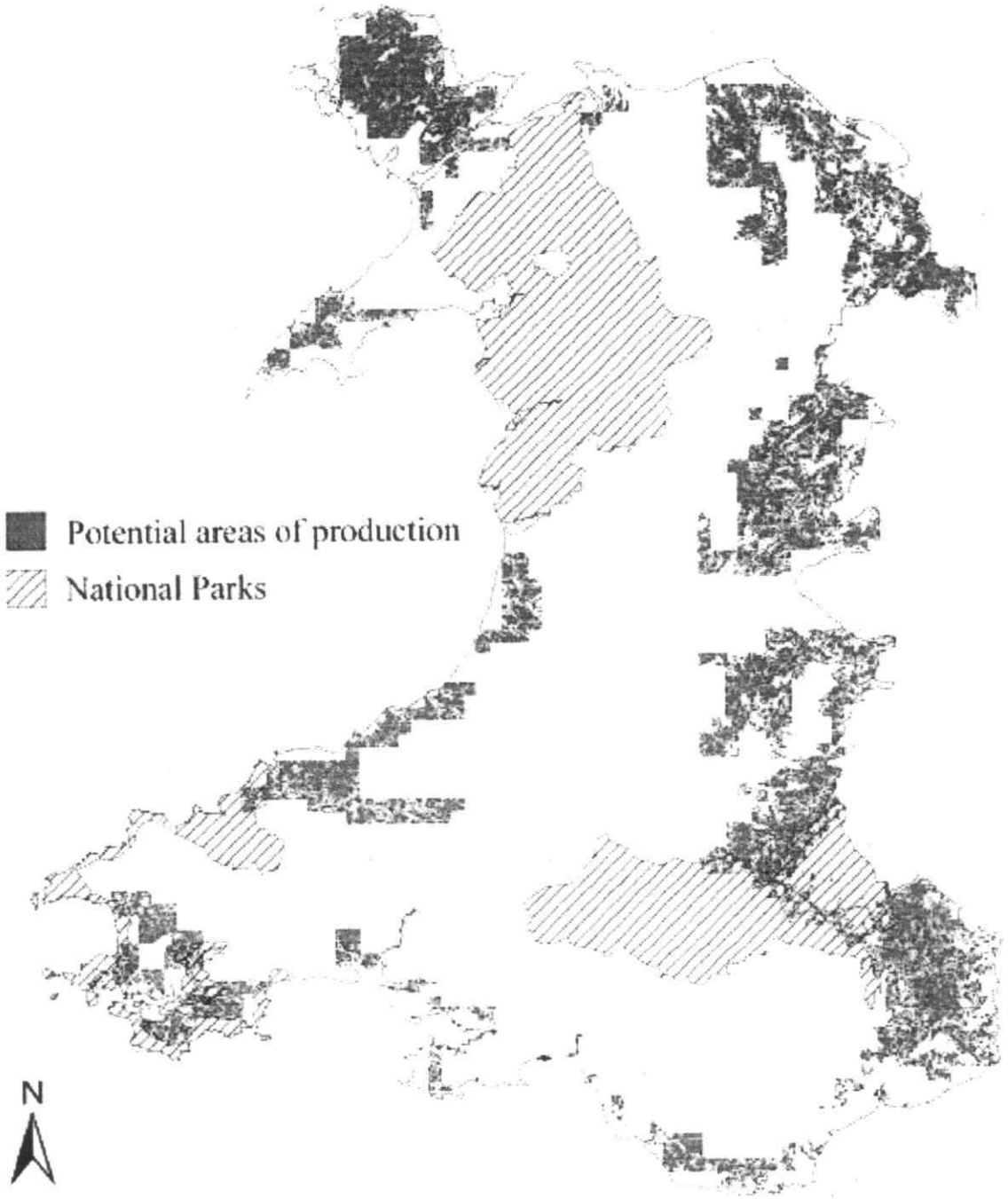
# St. John's Wort

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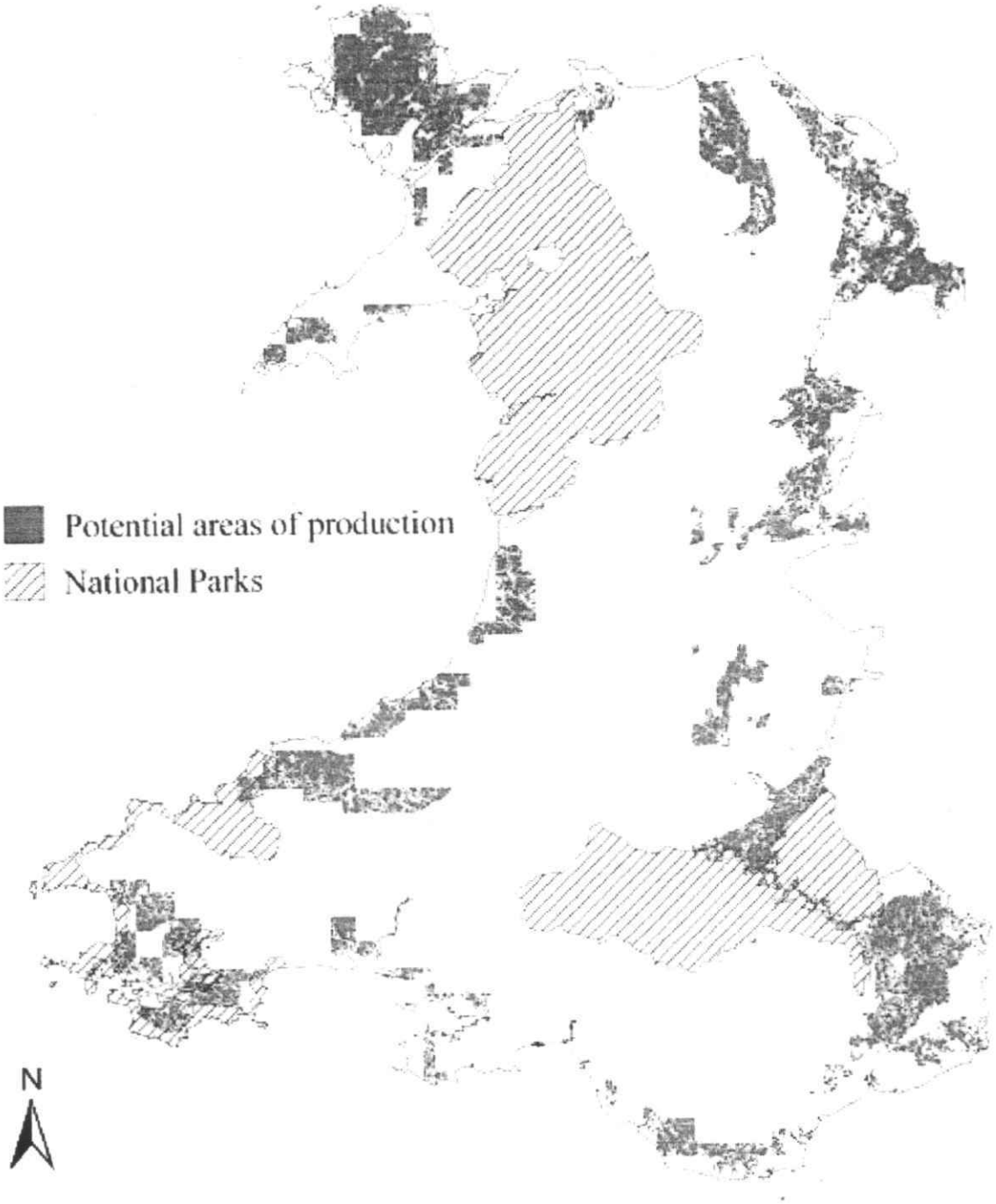
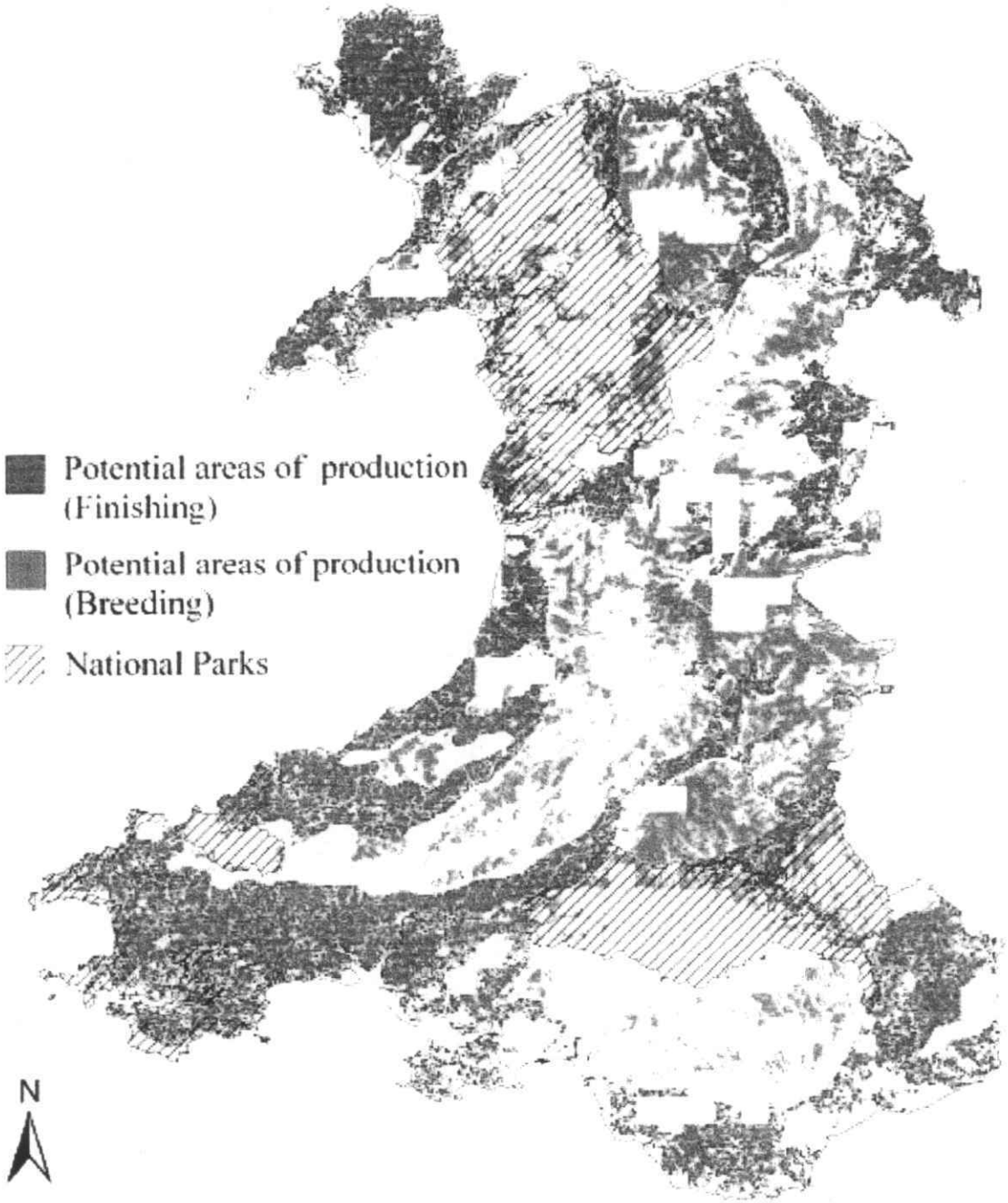
# Valerian




Soil information provided by NSRI

# Venison

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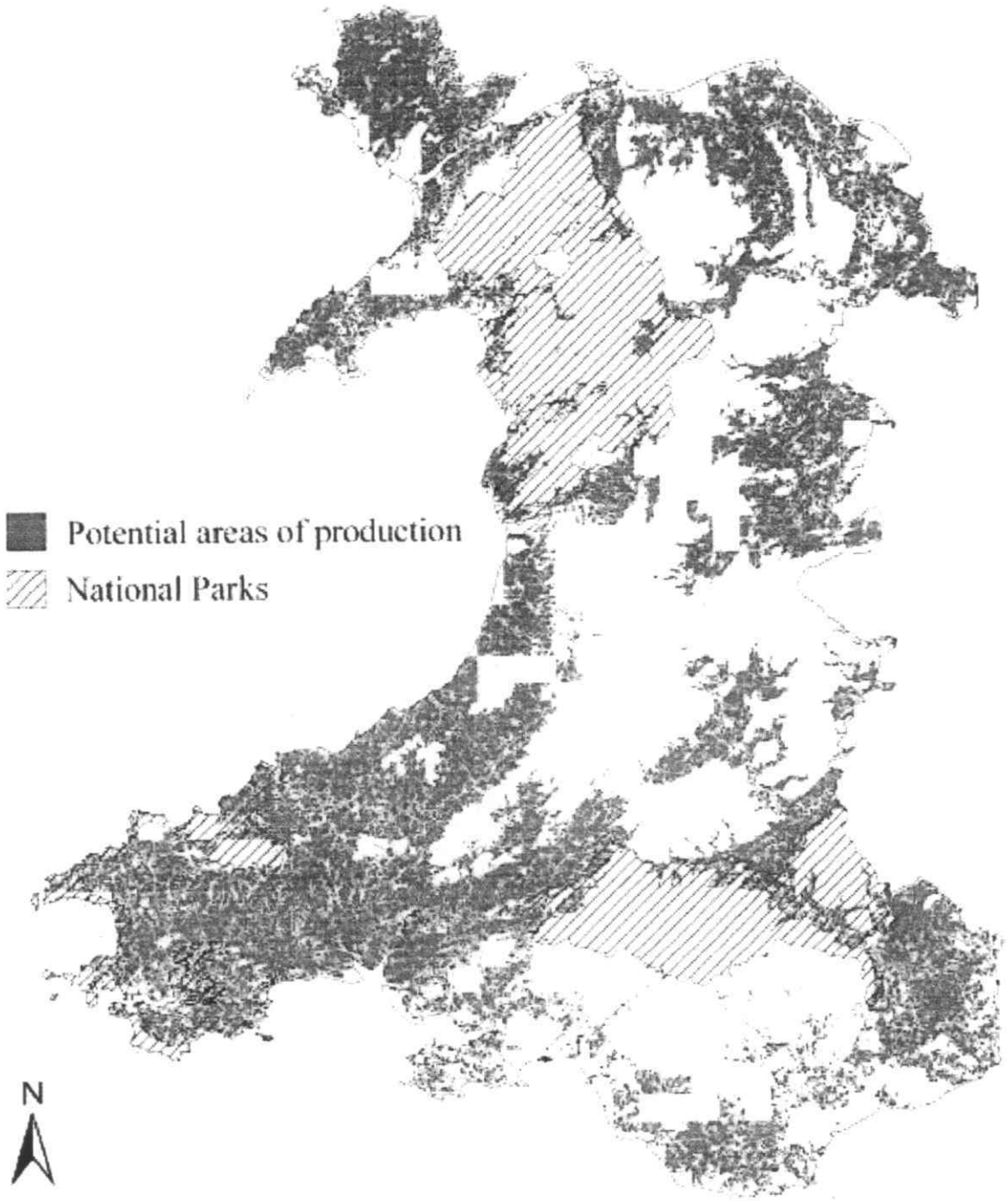
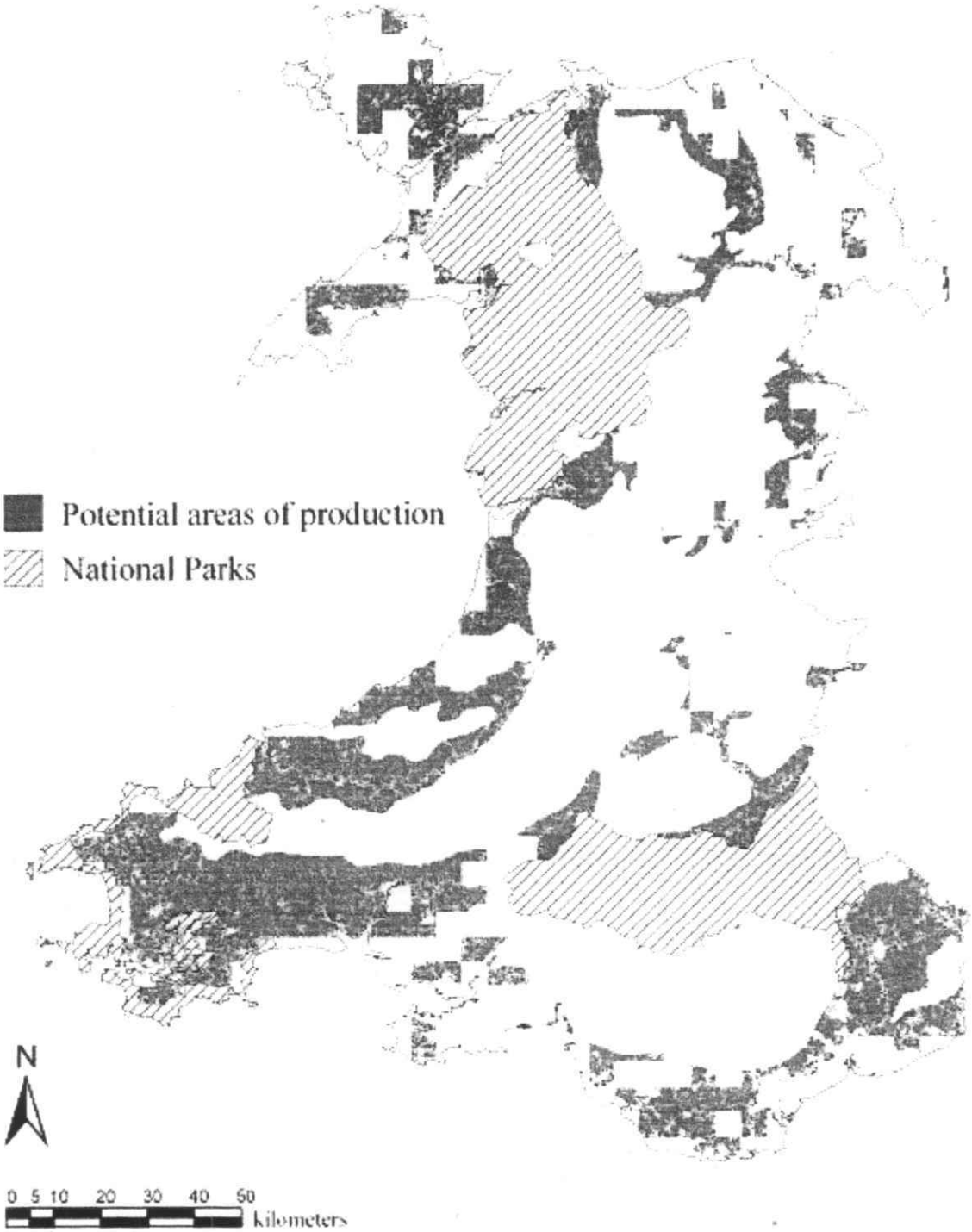
# Water Buffalo



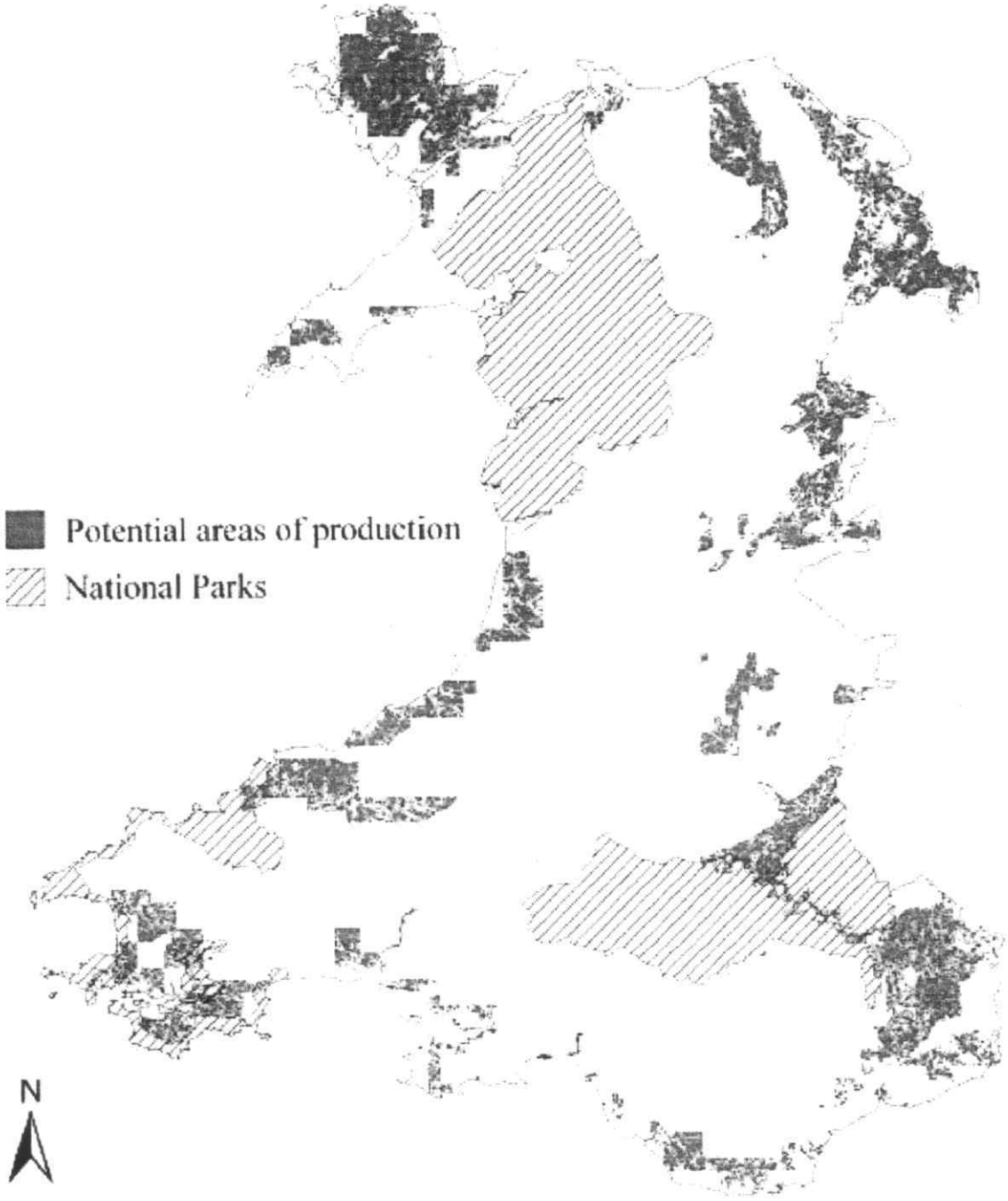

Soil information provided by NSRI

# Wild Boar




Soil information provided by NSRI

# Woad

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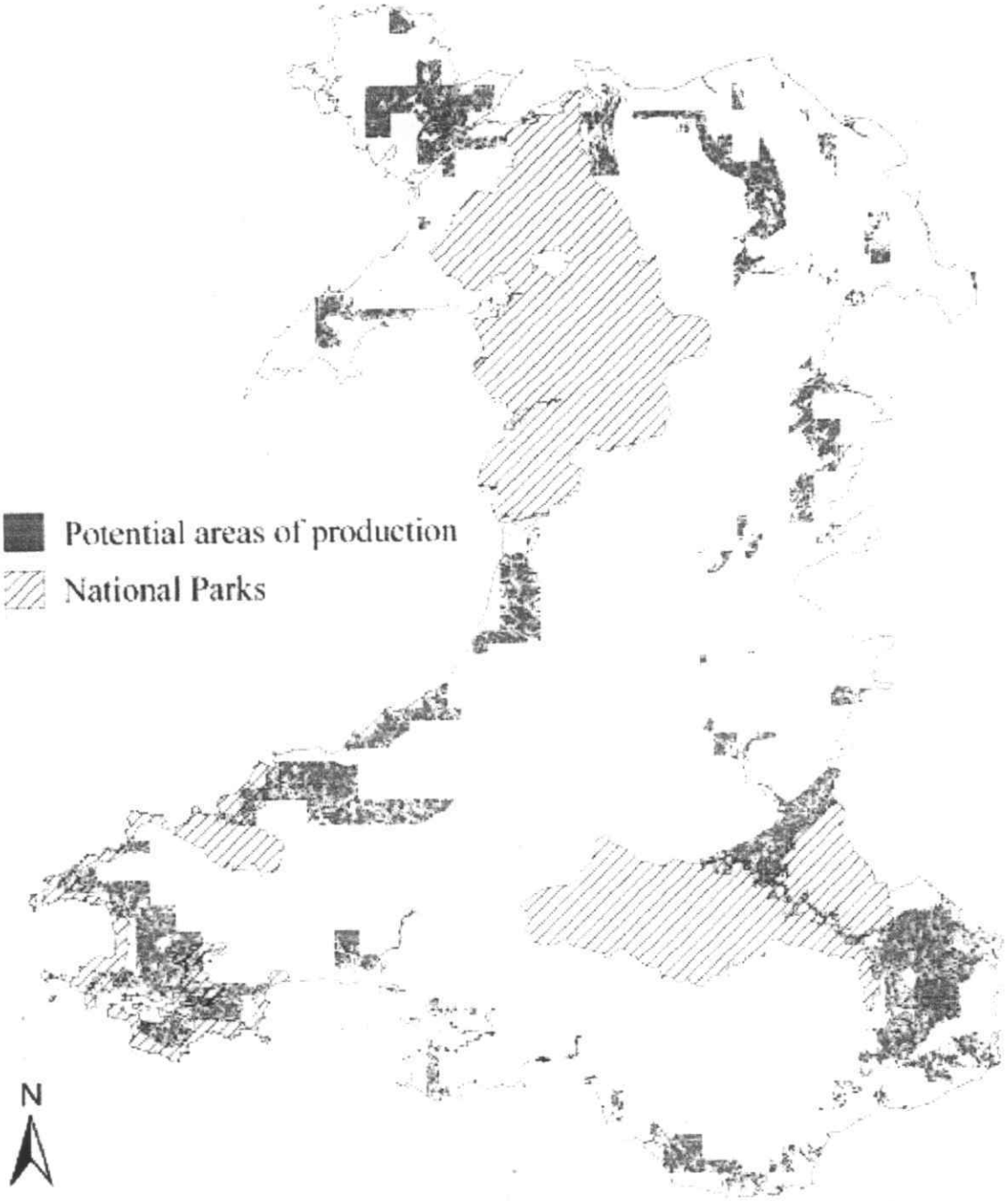
# Yarrow

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## Appendix IX - Feedback on Workshop Sessions

*The following points were highlighted during workshop discussion sessions, discussions during the main presentations and during informal discussion with project members during demonstration sessions.*

Key points

1. A whole market chain approach is important (partnerships) to foster successful development.
2. There is a need to highlight Wales/Welsh products – branding is increasingly important to market success.
3. There is a need to maximise the use of products from any enterprise e.g. to use all parts of the plant to minimise waste and add value
4. Match new crops to local climate, machinery and farm capability (*The broad nature of this study needs to be complimented by a local approach to development potential which takes account of individual farm capabilities and location of any processing facilities etc*).
5. Recognise inter-relationships between the enterprises e.g. Bees producing honey on borage/evening primrose etc. (*This could provide a means to develop complimentary new enterprises*).
6. Optimise local added-value wherever possible.
7. This study is only the start of the process of identifying potential alternative crop and animal enterprises for Wales.

**Individual workshops**

***Speciality Crops:***

General:

- Difficulty of the 'whole Wales' approach is that most of the crops identified are suited to the current arable area only and no further upland areas are being potentially utilised. (*There may be small area of potential production in sheltered upland areas for niche crops which would not be picked up by the GIS mapping undertaken in this study. However, there is potential for novel crops like nettle or use of grass for fibre highlighted in this study which could increase the use of upland areas for novel crop use).*

- Most of Welsh industry is classified as SME's/Micro-businesses, therefore small scale opportunities are required to suit their size.

Processing/Production:

- Hemp seed is currently being imported (20 tonnes/month) for hemp oil production at the crushing plant at Tamworth (Statfold) – a great deal is imported from France.

- Strength by numbers is important, growers need to congregate to satisfy markets and substitute for imports (*and also to gain as much control as possible over production to retain value in the community*).
- Individual farmers can not afford the change/or set-up new ventures alone, they need to amalgamate systems and utilise resources collectively.

- Central processing can prohibit development of some novel animal and crop enterprise by adding to costs of transport etc. Mobile processing facilities are a potential solution to this problem for some enterprises.

Links:

- A problem is finding information – a central contact point to feed information out to growers/industry would be helpful – (*Farming Connect has a view to set up a National Centre of Excellence (Wales) for novel crops to potentially overcome some of the problems).*

- Advisors should be made available to inform growers as to what is going on where, what is being grown or raised and what and where the current or potential markets are. This would help farmers make better informed and more confident choices and decisions.

- Links need to be made between existing and potential growers of new crops to encourage successful development.

- It is important to identify potential crops and a marketing partner.

Markets:

- Growth needs to be demand led not supply driven. Need to be able to prove there is a market for the product and that crops can be successfully grown.

- Need to overcome concerns about competition and the theory that there is always someone who can do better.

- Need to be able to identify Wales as being better able to meet demands than other countries, this can be best achieved using 'traditional products' and branding.

- Need to establish how to prevent 'flooding' the markets, in some cases using contracts/quota (agreement with the end-user). Mutual trust is important to generate confidence with the end-user or processor and a guaranteed price/value for the product.

Patents:

- There is no patent on raw material to protect returns for those investing time and effort in developing new crops.

- Plant breeders rights are often difficult to establish for minor crops.

*Commodity Crops:*

Wastes:

- Consider the possibility of using fibre crops and on-farm wastes for the production of compost and peat products.

- Need to avoid competing with other people's waste products. Need to identify direct threats from waste products (e.g. dry chipped cellulosic material – attracts a Landfill Tax subsidy of £10/tonne to remove it from the site of origin)

Processing:

- Small capacity processing capability is required. Flexible processing facilities are required to enable facilities to cope with several raw materials (which would spread costs, and reduce exposure to single markets) or problems such as seasonality

- Simple cold pressing facilities could be established to deal with small volume processing of valuable oil crops.

- Transport costs are difficult to quantify.

- Need to split 'large' area crops and small 'niche' crops (herbs etc), 'niche' crops will need to be grown to a predetermined specification.

Oil Crops:

- Wales' isolation may be a bonus for some crops, e.g. for reducing the risks of cross pollination etc.

- Volatile market competition with bulk commodity oils like soya.

- The problems associated with volunteers in following crops need to be evaluated, particularly where modified oil crops are grown in rotation with related crops for other outlets.

'Novel' Crops:

- Enthusiasts are required to develop a good relationship with the supplier and demonstrate feasibility.

- A willingness to share the risk between grower and 1st processor is important

Fibres:

- Analysis in the report suggested hemp could offer better returns compared to flax, due to higher yield. However, evidence in recent seasons suggests that flax could outperform hemp in North Wales due to environmental conditions (climate) and advantages in the harvesting process (hemp would require specialised equipment). *(In North Wales, the season can be curtailed by autumn weather which means hemp crops are harvested as soon as possible for fibre markets which may compromise on seed yield (though growers must wait until seed is set before cutting under EU regulations)).*

Flax is being undervalued ? Better reliability of production than hemp in North Wales. In-field stand retting method is good, better yields than from hemp so potential for dual purpose for both

fibre and oil production, but again wet autumn conditions may curtail seed harvest. Mechanisation solutions include potential to use stripper header for capsules left on standing crop left to ret in field.

Grass – Lignin content could have value for burning or compost ?

- Anaerobic digestion of grass to produce methane (burned on farm) is being investigated as a means of generating electricity.

Other areas for consideration.
Composting:

- Peat substitutes
- A potential use for woody/herbaceous crops ?
- Fibre processing by-products used as bedding compete with locally produced straw at £50-70/tonne delivered.
- Bracken – potential as a peat substitute ?

***Alternative Livestock:***

Bees:

- The Welsh Beekeepers Association (WBA) explained that bees could be potentially very important for some alternative crops because of their ability to assist pollination.

- The UK imports 20,000 Queen Bees every year. The WBA explained that it would be desirable to be able to source Queen Bees from the UK ideally from Welsh breeders. Each Queen Bee costs £20 on average. The WBA noted that 80% of native British bee species come from Wales, which offers a good breeding stock for Welsh beekeepers. The main limitation currently is the lack of financial support.

Study Methodology:

- It was suggested that the effect of climate change should be taken into consideration when producing the GIS maps. The accuracy of base layers used for the GIS analysis came into question. (*Accounting for climate change was beyond the scope of the current study. The method of GIS map generation was explained and the reasons for 'blockiness' in some maps. This results as a compromise on costs of some datasets. The maps provide an indication of the optimum areas of production to help determine potential clustered areas of production which would aid development and marketing etc*)

- Information on the location of AAPS registered land in Wales could potentially indicate where crops have been grown in the past. This information could be used as part of the GIS analysis.

- It was felt that the maps could turn many farmers off alternative agricultural enterprises because the percentage areas found suitable for many crops and animals were very small. Many farmers might not attempt to keep certain livestock unless their land had been highlighted. It may be better to identify land that is very suitable, land that could be used for livestock/crops and land that should not be used (*see notes above*)

- The maps should take into account market accessibility (*subsequent to the meeting the location of processing facilities in Wales and nearby processing facilities in England were mapped to assist in highlighting optimum areas for production*).

Processing and Marketing:

- The workshop felt very strongly that processing facilities should remain in Wales.

- Transport infrastructure will be a constraint for many farmers when marketing, calls were made to improve road links especially in mid-Wales and the western most areas.

- Early political support will be important to minimise the threat from cheaper and inferior imports. Yet some members of the workshop expressed concerns about involving politicians early in the development stage.

- The potential benefit of obtaining consumption figures for various animal products in order to quantify the markets was highlighted. (*The report contains market figures for some animals but it is difficult to obtain consumption figures for niche meat and processed products, additional efforts were put into sourcing data for the final report*).

- Discussions were held on the social profile of customers for different enterprises. Many felt that good knowledge of the customer is important when attempting effective marketing.

- The workshop felt that one possible structure for marketing new products would be through co-operatives/cluster of small producers in a defined geographical area.

- Representatives from Powys indicated that their area was well positioned to access the dense populations in the Midlands. Powys is also considered to be more suitable for livestock production rather than for growing crops.

- It was felt that poultry and game production has a good potential in Wales. (*Poultry production lies outside the enterprises considered in this study as it is a well developed mainstream enterprise in the UK and Wales. The potential for game derived form organised shoots is reported to be saturated)*

- There was some discussions as to whether the market for dairy sheep had come and gone when attempts were made to stimulate this industry some years ago, but there was some evidence of a revival in fortunes from some observers.

Traditional Breeds:

- The workshop generated several interesting ideas on producing meat and milk from traditional breeds of livestock. (*This lies outside the remit of the current study but the potential for rearing traditional breeds for developing new markets should be evaluated as a farm diversification option*)

EU Legislation and Regulations:

- Many spoke about their experience when trying to develop new slaughtering facilities. Information on EU legislation relating to slaughterhouses needs to be considered. Suitable locations for slaughtering facilities in Wales need to be identified.