



SOUTH OF SCOTLAND ALTERNATIVE LAND USE RESEARCH

Prepared by SAC Consulting and SRUC

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Leading the way in Agriculture and Rural Research, Education and Consulting

This report was prepared by SRUC; SAC Consulting Division and Scotland's Rural College

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Abbreviations

LCA	Land Capability for Agriculture
LFA	Less Favoured Area
SAC Consulting	– the consulting division of SRUC
SoS	South of Scotland
SRUC	Scotland’s Rural College

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1. Aims of the project

This study has been conducted in response to a call from Scottish Enterprise in partnership with the South of Scotland Economic Partnership (SOSEP) for an analysis of a range of alternative crops, including energy, protein, pharmaceutical, forestry, industrial crops, field scale vegetables and salad crops, to determine their opportunities for production, processing and market development in the South of Scotland (SoS). The work was funded by SOSEP for the new South of Scotland Enterprise agency (SOSE).

The South of Scotland is a large geographical area with a wide range of topography, weather conditions and soil types. While typical land uses have long been beef, sheep, arable and forestry, changing markets and subsidy systems, environmental change and technological advancement in production and processing show increasing potential for assessing the viability of growing alternative crops in the South of Scotland.

The full range of alternative crops is massive, for example there are over 300 species of clover (*Trifolium*) alone, and new methods of agronomy and processing are enabling more crops to reach market viability (e.g. extracted plant proteins, first UK lentil harvest in 2018 etc.). From consultation with stakeholders, the project has selected a small number of alternative crops considered to be of most interest and potential for the South of Scotland, and the following report provides an appraisal of overall opportunities, steps for further development, and appraisals for each of the crops in turn has been produced.

Further to this, the study provides several other main sources of information, included in the appendices:

- A set of factsheets reviewing agronomic, supply chain and market opportunities of these crops to provide advice for producers on novel crops with the most potential for successful growing and marketing
- Decision support tools to help growers evaluate the potential market for alternative crops and the potential yield given their growing conditions
- Links to existing technical and market information on production of these crops

2. Opportunities for alternative crops in the South of Scotland

2.1. Current agricultural land uses in the South of Scotland

The South of Scotland (The Scottish Borders and Dumfries & Galloway) covers 1.12 million ha of the southernmost band of Scotland, spanning the hills of the Southern uplands, and lowland areas in coastal areas of the south-west and east of Hawick. Both agriculture and forestry are important in the SoS's rural economy, covering around 825,000 hectares, 74% of the region's land area. Compared the rest of Scotland the climate is favourable which leaves a wider range of cropping and livestock options open to farmers.

Table 1: Number of holdings with crops and grass and area of crops and grass by sub-region, June 2017. (Source: Economic Report on Scottish Agriculture, 2017, Scottish Government).

	Scottish Borders land use area (ha)	Dumfries & Galloway land use area (ha)	% of sub-regional agricultural area	Scotland land use area (ha)	% of total area in Scotland
Crops and fallow:					
Wheat	22,986	3,846	3.3%	109,489	24.5%
Barley: Winter	7,950	2,406	1.3%	47,509	21.8%
Spring	16,067	7,716	2.9%	243,838	9.8%
Total	24,017	10,122	4.1%	291,347	11.7%
Oats, triticale and mixed grain	6,067	881	0.8%	33,241	20.9%
Rape for oilseed and linseed	6,825	c	0.8%	34,188	20.0%
Potatoes	2,275	227	0.3%	29,285	8.5%
Peas and beans for combining	994	c	0.1%	3,707	26.8%
Stockfeeding crops ⁽¹⁾	2,034	2,346	0.5%	15,992	27.4%
Vegetables for human consumption	2,185	65	0.3%	19,546	11.5%
Orchard and soft fruit	19	10	0.0%	2,165	1.3%
Bulbs, flowers and nursery stock	2	14	0.0%	964	1.6%
All other crops	1,769	314	0.3%	13,057	15.9%
Fallow land: 5 years or less	2,231	1,036	0.4%	34,778	9.4%
more than 5 years	84	480	0.1%	3,781	14.9%
Total crops and fallow	71,488	19,794	11.1%	591,540	15.4%
Grass and rough grazing:					
Grass under 5 years old	24,464	30,877	6.7%	206,254	26.8%
Grass 5 years old and over	109,855	200,410	37.6%	1,112,553	27.9%
Sole right grazing	139,798	148,271	34.9%	3,134,733	9.2%
Common grazing ⁽²⁾	0	0	0.0%	584,062	0.0%
Total grass and rough grazing	274,117	379,558	79.2%	5,037,602	13.0%
Utilised Agricultural Area (UAA)⁽²⁾	345,605	399,352	90.3%	5,629,142	13.2%
Woodland	30,011	34,784	7.9%	560,145	11.6%
Other land	4,536	10,782	1.9%	149,054	10.3%
Total agricultural area⁽³⁾	380,152	444,917	100.0%	6,338,340	

(1) Includes lupins and maize.

(2) Utilised agricultural area excludes woodland and other land such as yards and derelict land etc

(3) Inclusion of common grazing land brings total agricultural area in Scotland to a higher level than that published in the June agricultural census

c data suppressed to prevent disclosure of individual holdings.

The SoS holds the greatest number of dairy farms in Scotland, and is one of the most productive regions for beef and sheep output. The region also accounts for 15% of Scotland's crop area, with predominantly cereal production, but potatoes and vegetables also grown, and arable farms larger than the Scottish average. Orchards and soft fruit account for just 29 hectares, and bulbs, flowers and nursery stock 16 hectares, together less than 0.1% of the regional agricultural area, and 2.9% of the whole of Scotland. Other crops make up 2,083 hectares, or 0.3% of regional agricultural area, with the vast majority of this in the Scottish Borders.

Table 1 details the areas of crops grown in the SoS, as a proportion of agricultural area in the South of Scotland and the whole of Scotland. The data is taken from the June 2017 Economic Report on Scottish Agriculture.

The key economic sectors in the South of Scotland have been experiencing decline but there is still potential to increase value added from them and to diversify and grow the economy into new sectors, including around forestry, renewable energy and business service activities.

2.2. Climatic and land suitability for alternative crops

In order to evaluate the area of land suitability for alternative crops in the SoS, data for Scotland's Land Capability for Agriculture (LCA) was downloaded, and the data for the South of Scotland (i.e. The Borders and Dumfries and Galloway) extracted.

Land Capability for Agriculture is a dataset compiled by the James Hutton Institute, which uses soil maps, landscape/topographic and climatic information to be interpreted into land classification maps, which ranks land on the basis of its potential productivity and cropping flexibility. Class 1 land is the highest agricultural value, and Class 7 is the lowest.

Table 2 shows the types of LCA classifications and their descriptions, followed by the area in hectares of each classification in the South of Scotland, and the percentage of total land area. Figure 1 shows the percentage areas.

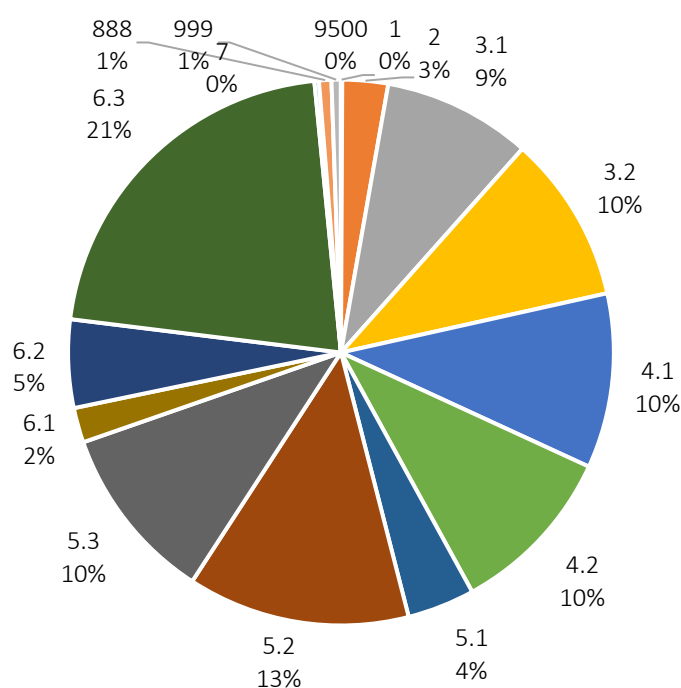
This data shows that the majority of land in the South of Scotland (56.8%) is comprised of grassland or rough grazing (i.e. LCA 5.1 and above), and is unsuitable to grow any other types of crops. In this study, the most suitable land for the crops investigated is LCA 3.1 and above, accounting for just 11.6% of the total land area in the South of Scotland. Much of this land, as illustrated in the accompanying map of LCA classifications, is in the East of the Borders, and some pockets in coastal areas of Dumfries and Galloway.

There are, however, notable limitations to what this data can show, primarily that the data only describes land that is capable for agricultural use, and not whether the land is actively farmed, or whether it is used for types of farming according to its LCA classification. It can therefore only give us an estimate of farming potential for the area, as opposed to a snapshot of agricultural activity in the area, relevant for considering potential displacement of current crops through introducing alternative new crops. Current agricultural land uses in the South of Scotland are presented in section 2.1.

Table 2: Total and percentage of Land Capability for Agriculture (LCA) classifications in the South of Scotland.

LCA	Description	Area (ha)	%
1	Land capable of producing a very wide range of crops	1,270	0.1
2	Land capable of producing a wide range of crops	45,705	2.7
3.1	Land capable of producing consistently high yields of a narrow range of crops and/or moderate yields of a wider range. Short grass leys are common	148,614	8.8
3.2	Land capable of average production though high yields of barley, oats and grass can be obtained. Grass leys are common	167,685	9.9
4.1	Land capable of producing a narrow range of crops, primarily grassland with short arable breaks of forage crops and cereal	174,854	10.4
4.2	Land capable of producing a narrow range of crops, primarily on grassland with short arable breaks of forage crops	171,393	10.2
5.1	Land capable of use as improved grassland. Few problems with pasture establishment and maintenance and potential high yields	67,442	4
5.2	Land capable of use as improved grassland. Few problems with pasture establishment but may be difficult to maintain	222,419	13.2
5.3	Land capable of use as improved grassland. Pasture deteriorates quickly	177,195	10.5
6.1	Land capable of use as rough grazings with a high proportion of palatable plants	34,868	2.1
6.2	Land capable of use as rough grazings with moderate quality plants	88,187	5.2
6.3	Land capable of use as rough grazings with low quality plants	362,837	21.5
7	Land of very limited agricultural value	4,521	0.3
888	Built-up land	12,392	0.7
999	Inland water	9,334	0.6
9500	Uncoded islands	76	0
TOTAL		1,687,523	

Figure 1: Percentage of Land Capability for Agriculture (LCA) classifications in the South of Scotland.



A map of showing the distribution of LCA classifications in the South of Scotland is included in the Appendix.

Table 2 summarises the LCA classifications estimated as most suitable for the production of each of the selected crops studied. The table shows that many of the crops studied would be suitable to grow only on land classified as LCA 3.1 or less, i.e. prime agricultural land, just 11.6% of the South of Scotland’s land area. Considering that much if not all of this land is currently utilised for growing crops, there would be a significant competition for new and alternative crops for this land.

This presents two key options for future land use and alternative crops; should the focus be placed on identifying and developing the higher value crops on this land (e.g. pharmaceutical crops, soft fruits), potentially displacing some current crops and impacting existing industries dependent on them (e.g. milling, malting, vegetable processing, dairying etc.), or on those with scope to develop less utilised and lower quality land (e.g. reed canary grass, short rotation forestry and daffodils)?

Different LCA classes of land have been identified that may be able to support the production of specific crops. In practice it is likely that only a proportion of the land in each LCA class may be able to generate sufficient yield of the crop and to a high enough quality to make the crop economically viable.

Table 3: Land area potentially agronomically suitable selected alternative crops in the South of Scotland.

Crop	LCA	Land area suitable	% total land area
Pharmaceutical crops			
Cannabis	1-2	46,974	2.8%
Poppies	1-3.1	195,589	11.6%
Daffodils	1-5.1	776,962	46.0%
St Johns Wort	1-3.1	195,589	11.6%
Soft fruit			
Strawberries	1-3.1	195,589	11.6%
Blueberries	1-3.1	195,589	11.6%
Raspberries	1-3.1	195,589	11.6%
Mushrooms	1-5.3	1,176,577	69.7%
Short rotation forestry	1-5.3	1,176,577	69.7%
Fibre and energy crops			
Hemp	1-3.1	195,589	11.6%
Miscanthus	1-2	46,974	2.8%
Reed canary grass	1-5.3	1,176,577	69.7%
Bark for tannins	1-5.3	1,176,577	69.7%
Ancient cereals	1-3.1	195,589	11.6%
Sugar beet	1-3.1	195,589	11.6%
Essential oil	1-3.1	195,589	11.6%
Cut flowers	1-3.1	195,589	11.6%

3. Appraisals for key alternative crops

The final list of 10 factsheets were chosen in consultation with agricultural stakeholders within SRUC and a wider network of contacts in the South of Scotland. Initially an email was circulated internally and with external contacts, asking for suggestions of alternative crops that may have scope for investigation to develop production in the South of Scotland. The initial list was extensive, with over 50 suggestions spanning energy, fibre, forestry, pharmaceutical, essential oil, forage, arable and horticultural crops.

In order to develop a methodology for assessing viability, interest and potential for further investigation, a scoring system was developed to consider: climatic suitability; output per hectare; land quality requirement; transportation costs of raw materials; need for specialist processing; local market demand; and scalability of production and the market. This scoring system was weighted so that the climatic suitability of growing the crop in the South of Scotland was identified as more critical for the development of a crop than, for example, need for specialist processing or investment in supporting infrastructure; this was based on the context of the study, and interest from the South of Scotland Economic Partnership in identifying areas in which they may be able to support alternative agricultural industries going forward.

The scored list was then discussed with specialists within SRUC and the South of Scotland Economic Partnership, considering production, processing and market level barriers and opportunities of each crop. Due to several of the crops overlapping in terms of sectoral knowledge and discussion, some crops were grouped to produce the following final list of ten factsheets:

1. Pharmaceutical crops
2. Soft fruits
3. Mushrooms
4. Short rotation forestry
5. Fibre and energy crops
6. Bark for tannin extraction
7. Ancient cereals
8. Sugar beet
9. Nutraceutical crops
10. Cut flowers

The accompanying factsheets provide a guidance for producers and processors considering diversification into these areas, covering production, processing and market considerations and opportunities.

The following section will not repeat the content of the factsheets, but will provide an appraisal of the opportunities and barriers for further investigation and development of each of the crops/groups of crops in turn.

3.1. Pharmaceutical crops

The South of Scotland is well-suited to the production of certain pharmaceutical crops, daffodils in particular. The lack of local markets and specialist processing facilities were seen as the major barrier to production.

If daffodils were to be grown in upland areas this leaves a large proportion of the South of Scotland as suitable – potentially up to 46% if LCA 1-5.1 land was considered – and with less competition with other existing or potential crops than those suitable for more prime land. Poppies and St John’s Wort are more restricted, with around 12% of land suitable based on an estimate of LCA 3.1 or higher, and medicinal cannabis even more so, at just 2.8% of the land suitable, assuming it requires a quality of land of LCA 2 or higher. It is unclear as to whether medicinal cannabis will grow unprotected in southern Scotland due to climatic limitations as well as legal restrictions; field trials and collaboration with the Home Office would be required to investigate further.

The need for adapted and specialist machinery and equipment is also especially important in considering opportunities for production, such as suitable harvesting machinery for daffodils in upland areas, and the investment of protected cropping systems for medicinal cannabis, which may increase the potential production area. Harper Adams University have been designing and trialling equipment for daffodil production in the uplands, although this is still in research phase.

Developing pharmaceutical crop production would also benefit from specialist guidance and assistance on licensing, and facilitation of conversations between producers and industry. For example, despite there being growing awareness of the use of medicinal cannabis in the medical community, and evidence that it may be beneficial for various conditions and illnesses, many cannabidiol (CBD) products are currently imported from other countries due to legislative restrictions on growing in the UK. While the market for CBD products, through and outwith prescriptions, is growing, the ability for the UK to supply this demand is more constrained. Furthermore, lack of processing facilities were identified as a weakness for developing the pharmaceutical sector in the South of Scotland; conversations along the supply chains would enable a fuller discussion of the potential for processing capacities and Research and Development in the region, and how farmers may be able to support that.

While there is scope to grow various pharmaceutical crops in the South of Scotland, and the gross margins appear attractive, it is difficult to assess the exact market potential and scalability of these crops in a largely closed market dealt through contracts with pharmaceutical processors. It would be recommended that any producer considering growing pharmaceutical crops primarily contacts relevant pharmaceutical companies and processors to discuss their requirement for further production capacity.

Strengths	Weaknesses
A range of crops suitable for different classifications of land and areas High value output per hectare	Lack of trials and knowledge of crop potential Existing connections with pharmaceutical industry undeveloped Lack of local markets and processing facilities Some specialist machinery needed
Opportunities	Threats
Strong and growing demand for CBD products from hemp Links to R&D for regional value capture	Private market with little public information on demand and international competition

3.2. Soft fruits

It is possible to grow soft fruits, particularly under cover, to a commercial scale in the South of Scotland; however, the competition from the East of Scotland, due to operations there being better established, with good links with supermarkets, and a higher proportion of suitable land, has created a barrier for soft fruits in the South of Scotland.

Most soft fruits would be most suited to land of LCA 3.1 and higher, or 11.6% of the SoS land area. Considering the high output per hectare of soft fruit production, a limited amount of space is less of a problem than the high costs of establishing necessary on-farm infrastructure, a costly and risky undertaking in a currently undeveloped regional market.

Furthermore, supply chain risks add to uncertainty from a producer end. In particular, there is high labour requirements in picking and packaging of soft fruit, and difficulties in attracting such labour, at present and with further difficulties predicted following the UK's exit from the EU. Established producers in the East of Scotland also have strong links with supermarket buyers which will not form overnight for new producers outwith this area; like commercial mushroom production (see section 3.3), new soft fruits producers would likely have to begin by selling to wholesalers until they can guarantee on quality and volume of crops to supermarkets. In addition to these factors, with the EU providing the majority market for UK soft fruit exports, and EU tariffs on many soft fruits, this will eat into margins for producers after Brexit.

There may be potential to further investigate support for diversification into soft fruit in the SoS in the future, particularly in establishing routes to local, regional and national markets for producers, although the current economic and labour situation is likely to make soft fruits too uncertain a gamble for the near future. There may be potential for the region, particularly the south western coastal fringe to offer differential climatic conditions (milder winters) that may complement production on the East coast (earlier production).

Strengths	Weaknesses
High output per hectare and high value crop Strong consumer markets for fresh soft fruit Milder climate in the south west	Strong competition with well-established production systems in the East of Scotland High establishment costs
Opportunities	Threats
Proximity to key markets, north and south of the border	Export markets and tariffs making a dent in gross margins Uncertainty of season demand for labour, particularly post-Brexit and with Covid-19

3.3. Mushrooms

Mushrooms can be produced commercially on land classified as LCA 1-5.3, 69.7% of the South of Scotland area, providing a good high-value-output opportunity to utilise areas with otherwise relatively low value output per hectare. Other options for land in higher LCA categories to move to higher-value enterprises are largely forestry-related; forestry is expanding rapidly in the South of Scotland, with mixed reaction from local communities, due to concerns about the aesthetic of the changing environment, and a lack of value capture in rural areas from forestry. With the short shelf life of mushrooms, the South of Scotland is also geographically well-placed to reach large markets.

The high capital costs of establishing mushroom production facilities is a major barrier to the industry. The cost of buildings depends on many factors, including the size of operation, and conversion of existing building or building new units, but for a commercial scale operation the Nix Pocketbook estimates that 8 rooms each of 200 m² are required, at an establishment cost of £200,000-300,000.

As an enterprise, commercial mushroom production faces similar challenges to soft fruits. Labour is a large cost, but unlike soft fruit control of the growing environment can enable production all year round in an indoor system; employment of all-year-round labour, rather than seasonal labour, may make obtaining a workforce and passing through the government's new post-Brexit permit scheme more manageable. Mushrooms also face similar issues of building new supply chains and reaching a market, where new producers are expected to sell through wholesalers initially before reaching the consistent quality and volume of production needed for supermarkets. Producers should expect a longer return on investment and period of risk than perhaps with other crops due to initial capital outlay and the need for investment in and development of specialist skills.

While there is little opportunity to add value to mushrooms through processing, there may be potential to investigate production of exotic and premium mushroom varieties, such as shiitake, oyster and portobello. Exotic mushrooms are a small but high-value fraction of the market, with many unusual species grown around the world and exported dried, to increase an otherwise short shelf-life, and little or no existing commercial production of these species in the UK.

AHDB have recently established the Mushroom Grower Group to support mushroom producers around the country, although production remains largely centralised with a small number of large operations (e.g. Monaghan Mushrooms). Lessons could be learnt from Ireland for supporting mushroom producers collectively and reach markets of scale; 80% of Irish mushroom producers are in producer organisations (set up through an EU scheme), allowing them to work together to optimise production costs, stabilise prices and strengthen their position in the market place. Compost is also a key input cost to mushroom businesses, and there could be scope to create a regional specialist composting facility, estimated at a cost of £250,000, given sufficient producer and market demand. A crucial question for further investigation, however, is how would Scottish mushroom production stack up financially against established competition in Ireland and the Netherlands, or could established international producers be considered for collaboration in expanding production.

Strengths	Weaknesses
Good land availability Suitable climate High output per hectare	Specialist skills needed High capital outlay to establish operations Connection to retail markets not established
Opportunities	Threats
Potentially changing markets post-Brexit Short shelf life and good regional market for fresh mushrooms Alternative high-value mushroom species	Competition from established producers in Ireland, UK and mainland Europe Labour requirements and uncertainty Market space for expanding production?

3.4. Short rotation forestry

There is a large amount of area suitable for Short Rotation Forestry in the South of Scotland. While willow, commonly used for SRF in England, has shown to be less productive north of the border, other species are more suitable, including alder, notofagus, poplar, and sycamore, as well as new species of eucalyptus have been trialled and identified as having potential in Scotland. SRF can be produced on land of LCA class 5.3 and above, or 69.7% of the agricultural land area.

Infrastructure required to support SRF is similar to conventional forestry, in that access roads to and from plantations should be considered and costs associated (e.g. reinforcing roads and widening gateways) accounted for. Articulated truck access nearby is also an important consideration as this will reduce transportation by using a purpose-built forwarder. There is good regional capacity for forestry logistics, and proximity to markets compared to areas of forestry further north make transportation costs competitive.

For planting new sites, grants are available for traditional forestry tree species but not for energy crops, therefore eucalyptus species would not be eligible. There is more scope, from a financial point of view, for eucalyptus on sites recently felled and due for replanting, given grants are generally not available for replanting anyway.

There is also strong demand for biomass for heating and combined heat and power plants in the south of Scotland, such as Britain's first wood-fuelled power station in Lockerbie, and the Renewable Heat Incentive (RHI) has created strong demand for chips/pellet/fuel for biomass boilers for the next 10-20 years. Historically energy companies have sought to buy woodchip on a long-term fixed-price contract. While this provides more security for themselves and suppliers, it may also act as a barrier for farmers who may want to benefit from future rises in the spot market. It is suggested that developing more flexible and transparent contracts may facilitate more uptake of SRF at a farm-level. Similarly, a study by Warren et al (2016) in the south of Scotland found that "whilst financial factors are influential, even large potential profits would be insufficient to persuade many farmers to adopt SRC... [and] policy design needs to be more precisely tailored to the motivations, viewpoints and risk perceptions of the target audience." They found that farmers were not opposed to SRF, but often see it as an innovation quite different from and incompatible with their usual farm enterprises, and a 'risky, long-term commitment'.

¹ Warren, C. R., Burton, R., Buchanan, O., & Birnie, R. V. (2016). Limited adoption of short rotation coppice: The role of farmers' socio-cultural identity in influencing practice. *Journal of Rural Studies*, 45, 175-183.

Unlike straw-like fibre and energy crops, boilers are more suitable for wood fuel. A large amount of biomass heating facilities have been installed on farms and estate over the years. Electricity production by biomass is being used at various locations across the south of Scotland. Two pellet producers are based in Girvan and Grangemouth. There is also scope for local markets too, such as for wood stove fuel.

Strengths	Weaknesses
Good land availability	High investment costs
Suitable crops	Grants not available for some species
Existing regional capacity	Different skillset for some farmers
Opportunities	Threats
Demand for biomass	Contracts limiting farmer uptake
Opportunities for regional processing	Long-term investment and risk
Possible links to carbon targets and funding	Competition with annual biomass crops

3.5. Fibre and energy crops

There are several options of fibre and energy crops that are worth considering for the South of Scotland; those included in this study were hemp, miscanthus and reed canary grass, although flax may also be worth further investigation. Of the three, miscanthus would be the most challenging to grow and restricted in potential area, only suitable for LCA 1-2 land, just 2.8% of the total land area. Hemp has a wider scope, suitable for much arable land (LCA 1-3.1, at 11.6% of land area), and has shown to play a beneficial role as a break crop in arable rotations. The crop with most expansive potential however was reed canary grass, which can grow sufficiently in land up to LCA 1-5.3, accounting for just under 70% of the South of Scotland's total land area, and can withstand wet soils, flooding, and low fertility soils. Costs of establishment too were relatively low and use existing farm machinery for both hemp and reed canary grass, whereas miscanthus rhizomes are expensive.

There is also strong demand for biomass for heating and CHP plants in the south of Scotland. However, relatively few boilers are designed for the use of straw and it has different properties from wood fuel including higher silica and chlorine content; because of this it has limited market demand in comparison to timber biomass, and the crop receives a lower price. Anaerobic digestors are able to utilise such crops better than non-specialist boilers, but are dependent on uncertain subsidies and do not guarantee better returns. Higher-value uses of biomass are needed to create more viable opportunities to drive biomass expansion in the South of Scotland.

For example, in addition to hemp's role in managing arable rotations, there is opportunity to develop hemp fibre and medicinal cannabis (CDB) markets in parallel, gaining more value from the one crop (see section 3.1 on medicinal cannabis). In terms of hemp fibre processing, the bulky and low value nature of the crop means that proximity of primary processing facilities becomes key to the viability of the crop. The development of mobile processing units is one avenue that could facilitate smaller scale production to be viable in the south of Scotland region.

The use of biomass for straw bedding, such as in poultry units, may also offer a higher return, as an alternative to woodchips and sawdust; small-scale or localised processing facilities,

particularly for reed canary grass, might enable the crop to be processed on- or near- farm to meet this market and create higher value from the crop.

The Borders has a historic textile sector which continues to support the economy of the region despite the contraction of spinning and garment manufacturing in recent years. The region retains significant expertise in the design and marketing of textiles and with the growth in demand for sustainable textiles there could be opportunities to expand the supply of locally grown fibre. Further to textile processing, hemp operations in England have created new building materials out of hemp and other fibres, such as hempcrete, a concrete alternative used for construction, natural insulations and fibreboard; given the increased attention to sustainability in building standards and low carbon alternatives, there is huge scope to research and develop these ideas, adding further value to the fibre crops and integrating production, processing and industry close to Scotland’s central belt.

Strengths	Weaknesses
Good land availability Suitable crops Existing on-farm capacity	Limited current regional processing capacities, for biomass, AD and building materials
Opportunities	Threats
Low-carbon/sustainable materials markets Existing regional textile processing On-farm processing for bedding	Competition with forestry products, and cost of developing building material processing facilities – needs more study

3.6. Tannins from bark

The production and market for tannins produced from bark or other plants materials is as yet undeveloped, and still in the research phase. However, once the production process is refined and ready for commercialisation, the South of Scotland is well-placed to produce more than the quantity needed of raw materials required for processing. Spruce and pine are already common in forestry in the South of Scotland, and a high proportion of the land area (69.7%) is suitable for these types of forestry. Woodland planting targets will also continue to encourage further planting in coming years, and the ability of tannins to reduce methane production from ruminants complements the positive carbon effect of the production of raw materials.

The market for bark products is not well developed due to the high level of investment, time and complexity of bark processing. There is much scope for product development and bioprocessing of bark, however, including energy and biogas production, sorbents, compost and mulches, building and insulating materials, and extraction of antioxidants, immunomodulators. anti-inflammatory agents, lignin, suberin, botulin as well as tannins (see Jansone et al, 2017). Further analysis of the costs of processing and production, as well as yields per hectare and price per ton of harvested bark versus the conventional market price for bark, in order to outline gross margins for the whole supply chain as a first step towards assessing feasibility of commercialisation.

Strengths	Weaknesses
Good land availability Abundant suitable raw materials	Limited current regional processing capacities Still in research phase
Opportunities	Threats
Low-carbon/sustainable materials markets Regional processing and development of R&D Various potential high-value products, in addition to tannins	Competition with forestry products Cost of developing processing facilities and cost of production

3.7. Ancient cereals

It is possible to grow ancient cereals in the South of Scotland, and the range of types offer options adaptation to various environmental conditions. However, suitable land is naturally existing arable land, around LCA 1-3.1, which accounts for 12% of highest quality land area in the South of Scotland and will be already mostly utilised. Growing ancient cereals would therefore displace other existing crops, which raises various questions about the attractiveness to producers do so, and the risks and profitability of markets for ancient cereals in relation to the current crop. Ancient cereals may attract a premium, but the market is much smaller, more volatile, and comes with greater complexity in finding a buyer than conventional cereals.

Processing of ancient cereals is also currently limited to smaller scale processing facilities due to the smaller quantities of cereals involved compared to conventional cereals, which in turn is determined by the more niche final markets, each a barrier to upscaling.

There is scope to support interested producers in developing ways to collaborate in scaling production to perhaps achieve more attractive quantities for processors to buy, and in linking stakeholders along the supply chain to better support and facilitate a growing market. Due to the specialised and adaptable skills required to process ancient cereals, supporting the development of a regional food network has potential to support small to medium local businesses with a focus on local, artisan and heritage techniques, as well as facilitate growing consumer interest in alternative cereals, food provenance and heritage.

However it should be noted that the market has a natural ceiling, and it would be advised that support to the development of ancient cereal supply chains focuses on strengthening regional networks rather than attempting to scale up to a market similar to conventional cereals.

Strengths	Weaknesses
Higher value potential for niche crops that conventional cereals Existing on-farm skills and machinery	Small, more variable and complex markets Limited and small-scale processing capacity
Opportunities	Threats
Development of regional milling and baking capacities Demand for ancient cereals and derived artisan products	Natural ceiling of market – mainstreaming ancient cereals would devalue them Long-term sustainability of market interest

3.8. Sugar beet

Sugar beet must be produced on good quality agricultural land, of LCA 3.1 and higher, 11.6% of the South of Scotland's most sought-after agricultural land. A second requirement for land used for sugar beet production is the proximity to processing facilities, of which there is currently none in the South of Scotland, limiting geographical area by logistics as well as land suitability.

In a study by the Bioeconomy Consultants (NNFCC) last year, it was estimated that 20,000 hectares of sugar beet would be required to supply a new plant in Scotland, and the beet would have to come from within a 60-mile radius of the plant. In the South of Scotland 20,000 hectares would account for 10% of the current suitable land area, as opposed to 3% of the area available in the East of Scotland, where an existing study is ongoing into the potential for new plant development. There are two key challenges in the need for 20,000 hectares of production, in that: this land will already mostly be used for crops; this land is largely concentrated in East of Borders and coastal areas of Dumfries and Galloway, therefore not geographically proximate.

There are other challenges in establishing sugar beet supply chains, that are not unique to the South of Scotland. For farmers a crucial one is the price they are currently paid for the crop which, with haulage costs, makes sugar beet currently uneconomical relative to imported sugar beet. However, if incentives were provided for low-carbon energy production, (i.e. for facilitating production of biofuel for petrol blends), and further bioprocessing of by-products into biochemicals, bioplastics and mycoproteins were developed, it may become a more viable crop for farmers. There is currently a collaborative Rural Innovation Support Service (RISS) project underway aiming to open conversations with industry and government to enable this to happen.

In the immediate stages there would need to be strong collaboration with the farming sector, bioprocessing industry and government to facilitate the establishment of a supply chain, and to ensure long term production of both sugar beet and the derived products, a contract model would need to be built that ensures stability to farmers, long-term supply to processors, and balances risk throughout the supply chain. Support and organisation of farmers in particular would be essential to this.

It does not seem likely, therefore, that sugar beet production is an immediate option for an alternative crop in the South of Scotland, given the complexity of supply chain arrangements, scale needed, geographical limitations, and competition with an ongoing project in a better-suited area. However, in the medium-term there could be lessons to learn from the pilot project, and wider benefits that the South of Scotland may be able to place itself to capture. For example, are there areas in the East of Scotland that may be close enough to Fife or Angus to supply a potential new plant. Or is there scope to investigate a cross-border project with the North of England to establish a new regional hub (there has historically been sugar beet grown in Northumberland and sent to the closed plant in Cupar)?

Strengths	Weaknesses
Existing on-farm skills and machinery Hugely improved yields Ongoing investigation into supply chain viability East of Scotland	Sufficient land available within proximity of potential plant? No current processing facilities, and high cost of establishment Sugar beet production currently uneconomic
Opportunities	Threats
New, higher-value by-products possible through bioprocessing Growing demand and requirements for biofuel products – interest in low-carbon and sustainable alternatives	Need for industry and government buy-in for investment Dependence on subsidies to enable beet production to maintain production Instability along supply chain

3.9. Nutraceutical and essential oil crops

Nutraceutical crops have been trialled in the South of Scotland, and in some cases grown commercially in the past, borage in particular. While the climate makes the production window tighter, which can be challenging for the ripening of seeds, production may still be possible in areas more suitable for oilseeds, and existing areas of oilseed rape production, albeit more limited than in areas further south. The higher prices per tonne of crop may offset the reduced yield.

Contracts are available for producers in the South of Scotland, although currently production tends to be in England closer to sites of processing, in largely centralised operations. It may be technically feasible to press borage seeds with a small-scale cold press, but it should be recognised that cold presses are less efficient at extraction of oil than conventional large scale solvent extraction methods. Cold pressing will result in a lower oil yield, and since the oil is of very high value, this would seem to be a major disadvantage for small scale processing. However, development of more localised and higher-tech processing facilities, given sufficient regional production, might increase the viability of production in the South of Scotland. Further to this, the greater potential to utilise feed meal by-products may enhance viability of small-scale processing, which could be a valuable resource for livestock production in the region, particularly for finding locally-produced and more lower-carbon-footprint alternatives to soya meal in livestock diets. There may also be potential to develop bioprocessing for higher-value products, such as cosmetics, supplements and materials such as coatings and paints.

Strengths	Weaknesses
Existing on-farm skills and machinery Commercial production possible	Little or no current processing facilities Crops not best suited to environment
Opportunities	Threats
Scope for local/regional processing New, higher-value by-products possible through bioprocessing	Reduced yields vs competition of more commercialised production further South

3.10. Cut flowers and bulbs

There are a wide range of cut flowers that can be grown in the South of Scotland, in the open or in protected systems, with the suitability for climates and soil types varying greatly. Roughly speaking, however, land of LCA 1-3.1 is considered good land for producing cut flowers commercially. While that is just a fraction of the South of Scotland’s land area, and competing with other crops, floriculture provides a high output per hectare, with commercial operations able to run from just a few hectares.

With many commercial growers, particularly outside of the south of England, using protected systems, establishment costs and a highly competitive international market are the main barriers for diversification. Cost of production versus producers in Africa and South America, and year-round demand for flowers are likely to be the biggest market challenges to navigate for new producers. On the other hand, consumer interest in provenance and environmental impact of their shopping habits, and increasingly in seasonality, may be a benefit to British producers if the industry is able to communicate this well and sway shoppers towards a greater diversity of flowers.

Much also depends on the intended market for producers; while supermarkets may demand consistent quantities of specific types of flowers, more local and regional markets, or selling through wholesalers to florists and outlets selling mixed bouquets may offer opportunity for the producer to widen the range of flowers grown and the growing season. Producing for local and regional markets, and supporting collaboration with local businesses, is one way that the cut flower industry could capture value and skills within the South of Scotland, with otherwise little regional processing involved in floriculture.

Similar to pharmaceutical crops, there is relatively little information publicly available on commercial flower production, with knowledge highly specialised and markets well-guarded. It would be worthwhile for horticulturalists to further investigate which species of flowers would be most suitable in the South of Scotland, and most viable for various market outlets within and beyond the region, to better support and provide information to interested potential producers.

<p>Strengths</p> <p>Suitable land, small land requirement and high value output per hectare Polytunnels enable wider seasons</p>	<p>Weaknesses</p> <p>Less sunlight that producers further south, potentially affecting production High labour requirements and establishment costs</p>
<p>Opportunities</p> <p>Steadily growing market demand Consumer interest in local, sustainable, seasonal floriculture Proximity to regional markets Potential for regional collaboration</p>	<p>Threats</p> <p>Strong international competition, particularly with popular flower and on costs of production Private and specialist market, with little public information</p>

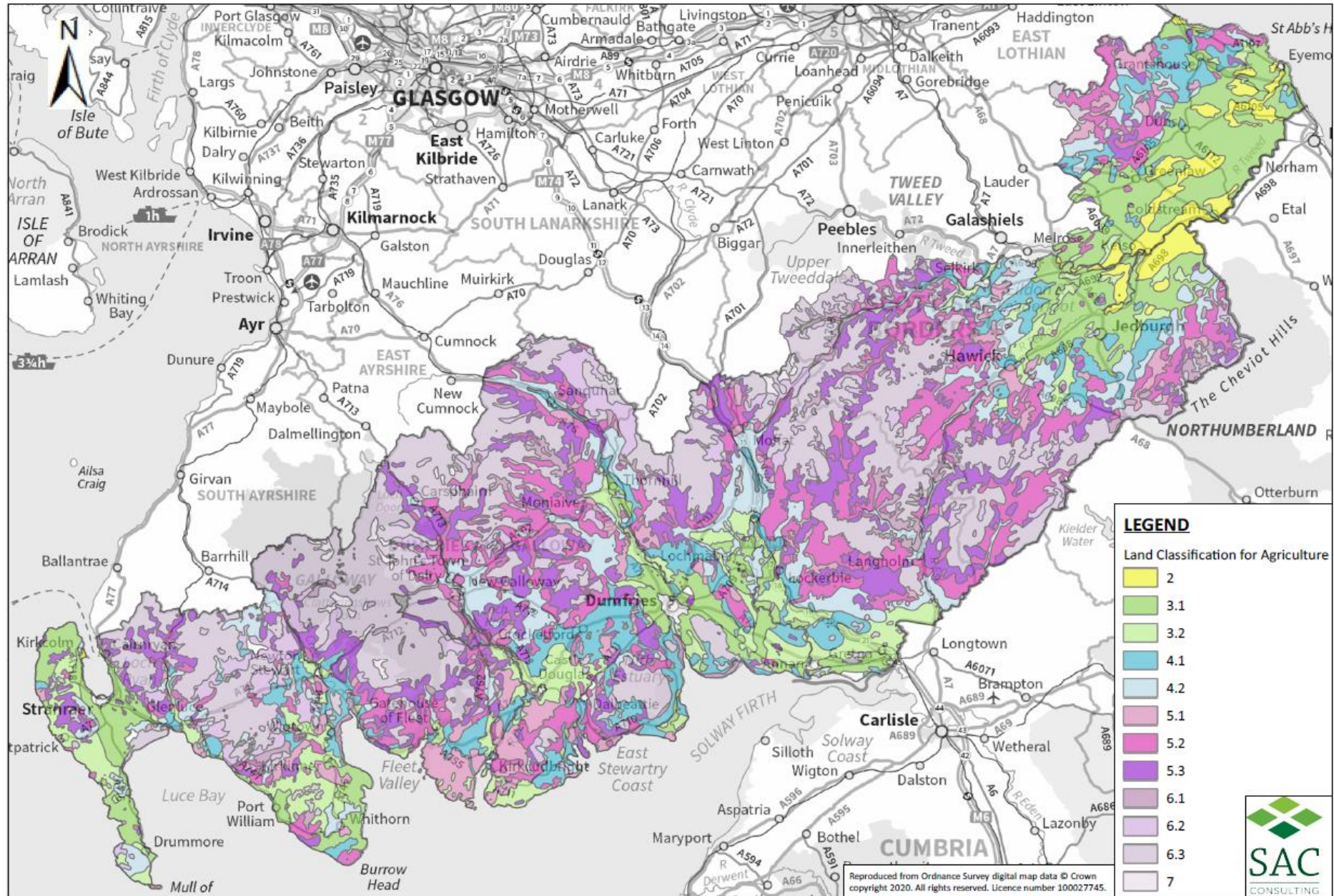
4. Recommendations for further research

This study has worked to highlight some of the key opportunities for alternative crops in the South of Scotland, including the availability and suitability of land, and the processing facilities and market conditions needed to foster their development. Crucially, while the Land Capability for Agriculture indicates limitations on the production of many crops, this can help in identifying ways in which these crops may be processed and marketed to achieve a higher value, and which crops may be beneficial for utilising otherwise less agriculturally productive land. Trials of potential crops in the region are recommended as essential next steps to determining the feasibility of their wider uptake.

The information collated and presented in the factsheets is aimed primarily at producers, to give an overview of opportunities for producing and processing the crop, and practicalities to be considered when investigating diversification into that crop. The supporting decision trees (see Appendices II-IV) provide a framework of questions for these stakeholders to analyse their suitability for producing an alternative crop, and begin to break down steps they may need to take to investigate the opportunities and risks involved for their business. It would be beneficial to make the set of factsheets, decision trees, and list of sources for further information publicly available through a website, to provide some initial guidance for producers. There is potential to take these resources further in holding future meetings to engage groups of interested farmers and establish innovation groups, particularly for crops where production of a greater scale, or requiring new and adapted skills, may be required to support processing and marketing opportunities.

The appraisals presented in this report are intended to summarise opportunities and barriers for alternative crops to industry stakeholders, to create a basis for further investigation into crop-related market development. It was not within the scope of the report to map existing processing and logistics requirements for each of the crops, although this may be a useful exercise for individual crops of particular interest to respective industries. An analysis of Farm Business Survey data (available through Edina at a charge) would give an indication of existing areas of agricultural activity in the region, in comparison to the areas of potential for production identified through the publicly-available LCA dataset. Disaggregation of Dumfries & Galloway and The Borders would also allow for more tailored strategies to be developed. It is clear, however, that for many of the crops studied, focused collaboration of stakeholders along the supply chain would be essential in: establishing the viability of the crop for all stakeholders; managing the risk in diversifying into new products; and creating the momentum to push forward necessary research, development and investment.

Appendix I: Map of Land Capability for Agriculture (LCA) in the South of Scotland



Appendix II: Decision support tree – Agronomy and production

The questions below are intended to be used at the very start of any consideration of growing alternative crops. This is one of 3 documents this on focusses on agronomy and growing the crop. The others focus on harvesting, processing and marketing of the crop.

The South of Scotland Economic Partnership can offer advice on development potential of a crop in the South of Scotland, or please contact your local agricultural consultant for technical advice.

Question	Crop Requirement	Conditions on your farm	Comments / suggestions
<p>What conditions are required for germination or early establishment of the crop?</p> <p>Soil type</p> <p>Soil temperature</p> <p>Seed treatment</p> <p>Period of dormancy</p>			
<p>Are there any specific soil / field requirements?</p> <p>Soil type</p> <p>Free draining</p> <p>Soil pH</p> <p>Depth of soil</p> <p>Compaction</p>			

Slope Lack of shade			
Are there specific machinery needed for sowing, tillage?			May be worth considering using contractors and/or machinery rings
Weed control Tolerance to perennial weed infestation Herbicide suitability and availability			For some crops information on weed control may be available from horticulture sector.
Pest control Slugs, snails Pests specific to the crop			If much of the published information is from other countries. It is worth checking with an established grower in the UK.
Weather Tolerance to: <ul style="list-style-type: none"> • Frosts • Droughts • Heavy rainfall 			Covering crop in spring may be a possibility. Irrigation may be needed for some crops

Appendix III: Decision support tree – Harvesting and processing

The questions below are intended to be used at the very start of any consideration of growing alternative crops. This is one of 3 documents this on focusses on harvesting and processing the crop. The others focus on agronomy , growing and marketing of the crop.

The South of Scotland Economic Partnership can offer advice on development potential of a crop in the South of Scotland, or please contact your local agricultural consultant for technical advice.

Question	Crop Requirement	Conditions on your farm	Comments / suggestions
<p>What conditions are required for harvesting?</p> <p>Dry matter of the crop</p> <p>Maturity of crop</p> <p>Sugar content of crop (sunshine)</p> <p>Specific dates linking to markets</p>			<p>If crop requires to be at a higher DM than can be achieved at cutting will field losses be high.</p> <p>Check information on likely losses if crop must be very mature before harvesting</p>
<p>Are there any specific soil / field requirements?</p>			

Soil type			Weather conditions may interact with soil type.
Free draining			Is no contamination of the crop with soil important
Are there specific machinery / staff needed for harvesting?			
Need for trained staff			May be worth considering using contractors and/or machinery rings
Specialist machinery			
Storage			
Short and long-term storage			
Specific quality assurance standards			The quality assurance standards required to sell the crop are essential
Temperature and humidity standards			
Processing			
Will crop be processed on site or is processing a specialist activity off-site			The added value is often in the processing part of the chain

Appendix IV: Decision support tree – Marketing

The questions below are intended to be used at the very start of any consideration of growing alternative crops. This is one of 3 documents this on focusses on marketing the crop. The others focus on agronomy, growing and harvesting, processing of the crop.

The South of Scotland Economic Partnership can offer advice on development potential of a crop in the South of Scotland, or please contact your local agricultural consultant for technical advice.

Question	Market Requirement	Ability to meet market requirement	Comments / suggestions
<p>What market demand is there?</p> <p>Level of demand/market interest</p> <p>Level of competition with other producers?</p> <p>Scale of demand e.g. local, regional, national</p> <p>What types of market outlets are most viable? e.g. wholesaler, contract sales, retailers, local shops, direct sales etc.</p> <p>Is a contract needed before producing to assure a market?</p>			

<p>Does the crop need processing?</p> <p>Is on-farm processing needed?</p> <p>Will buyers do the processing, and if so what requirements do they have for the crop?</p>			
<p>Can you reach the market, in terms of logistics and distribution needs?</p>			
<p>Are there ways that you can add value to the crop?</p> <p>e.g. alternative markets, increase processing on-farm</p> <p>Are there different or a variety of market outlets that might add value or distribute demand/risk?</p> <p>Are there different quality assurance schemes which relate to the crop?</p>			

Appendix V: Further information sources

Agricultural Budgeting Costing Book, November 2019 – can be ordered here:

<https://abcbooks.co.uk/product/abc-budgeting-costing-book/>

John Nix Pocketbook, 2019 – can be ordered here:

<https://www.thepocketbook.co.uk/product/john-nix-pocketbook/>

SAC's Farm Management Handbook - www.fas.scot/publication/farm-management-handbook-2019-20/ - Production guides for main crops in Scotland, including fertiliser recommendations, seed rates, annual market prices, harvesting suggestions, and a section on alternative crops.

Bangor University's Centre for Alternative Land Use: Factsheets -

<http://www.calu.bangor.ac.uk/technotes.php.en>

SAC Consulting's Technical notes – Available via the Farm Advisory Service website:

www.fas.scot

Yara crop nutrition guides – www.yara.co.uk – fertiliser recommendations for various novel crops including linseed, miscanthus, lupins, and sunflowers

RB209 sections 3, 4, 6 and 7. (www.ahdb.org.uk/nutrient-management-guide-rb209) Provides fertiliser recommendations on a variety of crops including forage, cereal, fruit and vegetable crops.

Red Tractor Crop Modules. Available at: <https://assurance.redtractor.org.uk/standards/fresh-produce-crop-protocols?&p=5>

Information for specific crops mentioned can be found in the following sources:

Pharmaceutical crops

The Horticulture Development Council's Narcissus Manual, available here:

<https://ahdb.org.uk/knowledge-library/narcissus-manual>

'Yellow Gold': Innovative systems for sustainable daffodil-derived galanthamine production in the uplands. A presentation from Harper Adams University, Agroceutical Products Ltd and Aberystwyth University. Further information available here:

[https://pure.aber.ac.uk/portal/en/projects/yellow-gold-innovative-systems-for-sustainable-daffodil-derived-galanthemine-production-in-the-uplands\(fbb01de1-6108-4e88-85c2-f23ec28f6d54\).html](https://pure.aber.ac.uk/portal/en/projects/yellow-gold-innovative-systems-for-sustainable-daffodil-derived-galanthemine-production-in-the-uplands(fbb01de1-6108-4e88-85c2-f23ec28f6d54).html)

Bioeconomy Consultants (NNFCC) Hemp (*Cannabis sativa*) Crop Factsheet. Available here:

http://www.adlib.ac.uk/resources/000/236/251/Crop_Factsheet_Hemp.pdf

Agricultural Budgeting Costing Book, November 2019 – can be ordered here:
<https://abcbooks.co.uk/product/abc-budgeting-costing-book/>

Soft fruit

Red Tractor Crop Modules. Available at: <https://assurance.redtractor.org.uk/standards/fresh-produce-crop-protocols?&p=5>

Agricultural Budgeting Costing Book, November 2019 – can be ordered here:
<https://abcbooks.co.uk/product/abc-budgeting-costing-book/>

SAC's Farm Management Handbook - www.fas.scot/publication/farm-management-handbook-2019-20/

Mushrooms

John Nix Pocketbook, 2017. <https://www.thepocketbook.co.uk/product/john-nix-pocketbook/>

SAC Technical Note: Advice to prospective mushroom growers. Available at:
http://www.davidmoore.org.uk/Assets/Mostly_Mycology/Richard_Clarke/SAC_Advice2mushroomgrowers.pdf

Red Tractor Crop Modules. Available at: <https://assurance.redtractor.org.uk/standards/fresh-produce-crop-protocols?&p=5>

Vegetable Production and Practices, by Gregory E. Welbaum

Short Rotation Forestry

Warren, C. R., Burton, R., Buchanan, O., & Birnie, R. V. (2016). Limited adoption of short rotation coppice: The role of farmers' socio-cultural identity in influencing practice. *Journal of Rural Studies*, 45, 175-183.

WILLOW SHORT ROTATION COPPICE: Is it commercially viable? A factsheet produced by SAC's Rural Policy Centre in 2008. Available here:
https://www.sruc.ac.uk/download/downloads/id/103/willow_short_rotation_coppice_2008

John Nix Pocketbook, 2019 – can be ordered here:
<https://www.thepocketbook.co.uk/product/john-nix-pocketbook/>

SAC's Farm Management Handbook - www.fas.scot/publication/farm-management-handbook-2019-20/

COPPICE RESOURCES LTD Growers' Guide to Short Rotation Coppice. Available at:
<http://www.coppiceresources.co.uk/pdf/CRLGrowersGuide06a.pdf>

Fibre and energy crops

Commercial viability of alternative non food crops and biomass on Scottish Farms. A report by SAC Consulting. Available at:

https://www.sruc.ac.uk/downloads/file/632/commercial_viability_of_non-food_crops_and_biomass_on_scottish_farms

A NNFCC report for the DECC: Domestic Energy Crops; Potential and Constraints Review.

Available at: <https://www.gov.uk/government/publications/domestic-energy-crops-potential-and-constraints-review>

Energy From Crops (1996) – a book written by SAC Consultants on the biomass opportunities in the UK and Scotland, on farm and in the market. Donal P L Murphy, Andreas Bramm, Kerr C Walker (ed), 1996: Energy from crops. Semundo Ltd, Cambridge, UK.

NNFCC – <https://www.nnfcc.co.uk/publications-store> - Information and advice on bioenergy and biofuels crops and markets in the UK. Their publications include information on AD feedstocks, oilseeds processing and markets, supply and demand studies, processing requirements for energy crops etc.

Agricultural Budgeting Costing Book, November 2019 – can be ordered here:

<https://abcbooks.co.uk/product/abc-budgeting-costing-book/>

John Nix Pocketbook, 2019 – can be ordered here:

<https://www.thepocketbook.co.uk/product/john-nix-pocketbook/>

Home Office Low THC Cannabis (Industrial Hemp) Licensing Factsheet. Available at:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/825872/factsheet-cannabis-cbd-and-cannabinoids-2019.pdf

Planting and Growing Miscanthus, Best Practice Guidelines For Applicants to Defra's Energy Crops Scheme. Available at:

https://www.agmrc.org/media/cms/miscanthusguide_5C7ABFCA382E7.pdf

Teagasc, Miscanthus Best Practice Guidelines. Available at:

https://www.teagasc.ie/media/website/publications/2011/Miscanthus_Best_Practice_Guidelines.pdf

Bark

Blomstrand, B. M., Ptochos, S., Enemark, H., Thamsborg, S. M., Aasen, I. M., Steinshamn, H., & Athanasiadou, S. (2018). In vitro anthelmintic effects of bark extracts from *Picea abies* and *Pinus sylvestris* against sheep nematodes.

Jansone, Z., Muizniece, I., & Blumberga, D. (2017). Analysis of wood bark use opportunities. *Energy Procedia*, 128, 268-274.

BarkCure – a research project into condensed tannins from Norwegian pine and spruce bark - antiparasitic effects and potential commercial exploitation. <http://barkcure.no/>

Ancient cereals

Crop management for underutilised and minor grains. A factsheet produced by the Organic Research Centre. Available at: <http://cerere2020.eu/wp-content/uploads/2019/01/211205-6PA-Minor-grains-ORC-EN.pdf>

CROPQUEST: Spelt Wheat Food Potential, a report for Teagasc. Available at: <https://www.teagasc.ie/media/website/crops/crops/Spelt-Wheat-Food-potential.pdf>

Bangor University's Centre for Alternative Land Use: Factsheets - <http://www.calu.bangor.ac.uk/technotes.php.en>

Organic Arable. Contact details at: <https://www.organicarable.co.uk/about-us>

Agricultural Budgeting Costing Book, November 2019 – can be ordered here: <https://abcbooks.co.uk/product/abc-budgeting-costing-book/>

John Nix Pocketbook, 2019 – can be ordered here: <https://www.thepocketbook.co.uk/product/john-nix-pocketbook/>

Sugar beet

An Assessment of the Opportunities for Re-establishing Sugar Beet Production and Processing in Scotland; a report produced by the Bioeconomy Consultants (NNFCC). Available at: <https://www.nnfcc.co.uk/publications/report-sugar-beet-scotland>

Agricultural Budgeting Costing Book, November 2019 – can be ordered here: <https://abcbooks.co.uk/product/abc-budgeting-costing-book/>

Bringing sugar beet back to Scotland; a summary of the ongoing RISS project: <https://www.innovativefarmers.org/news/2020/february/bringing-sugar-beet-back-to-scotland/>

Nutraceutical crops

Agricultural Budgeting Costing Book, November 2019 – can be ordered here: <https://abcbooks.co.uk/product/abc-budgeting-costing-book/>

John Nix Pocketbook, 2019 – can be ordered here: <https://www.thepocketbook.co.uk/product/john-nix-pocketbook/>

The potential of specialist oil crops – a presentation by Neal Boughton, Technology Crops International. Available online.

Cut flowers

Backing British Blooms: The State of the British Cut Flower Industry, a report by the NFU.
Available at: <https://www.nfuonline.com/assets/63746>

SCP Evidence Base: Sustainable Commodities Case Studies: Cut Flowers. A report for Defra.
Available at: http://randd.defra.gov.uk/Document.aspx?Document=EV02019_6088_FRA.pdf

Sustainability in floriculture; a report by Wageningen University and Research. Available at:
<https://edepot.wur.nl/245180>

British flower power: how home-grown blooms can compete with cheap imports. A report for the Guardian. Available at: <https://www.theguardian.com/environment/2016/jun/11/british-flower-power-how-home-grown-blooms-compete-with-cheap-imports>