

What will the Scottish sheep industry look like in 2040 and how resilient will it be to livestock disease?





EPIC, Scotland's Centre of Expertise on Animal Disease Outbreaks, has been established with the overarching purpose of providing expert advice on animal health and disease outbreaks to policy-makers from the Animal Health and Welfare Division at Scottish Government.

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Acknowledgements

We are very grateful to the participants of the two scenario planning workshops held in February 2014 that focused on the sheep industry in Scotland. We would particularly like to acknowledge the significant contributions to these workshops by John Reynolds (SAMI Consulting). We thank Lee-Ann Sutherland for her input. We would also like to thank Ian Hutchinson, Rachel Creaney, Anna Conniff, Kathryn Gilchrist and Kirsty Holstead for acting as scribes.

The views expressed in this report are those of participants in the workshops held by EPIC in its capacity as a Centre of Expertise on Animal Disease Outbreaks. These views are not necessarily endorsed by EPIC scientists. They do not represent Scottish Government policy.

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Summary

- In February 2014, EPIC conducted a two day workshop using scenario planning methodology to examine the future of the sheep industry in Scotland with a time horizon of 2040. A wide range of participants were given the role of scenario planners, tasked with engaging in strategic thinking through a series of carefully crafted exercises that resulted in the creation of four scenarios set in 2040. The focal question addressed was ‘What will the Scottish sheep industry look like in 2040 and how resilient will it be to livestock disease?’
- EPIC scenario planning workshops have created a new space for dialogue amongst a diverse group of sheep industry participants. These include representatives from the Scottish sheep retail sector, farming, forestry and wildlife sectors, veterinarians, epidemiologists, social scientists and Scottish Government policy makers.
- This exercise has facilitated social learning enabling stakeholders to build strategic partnerships by sharing experiences, understanding one another’s constraints and exchanging knowledge.
- Information-rich narratives based on important drivers of change (demand, Government prioritisation and technological innovation) for the Scottish sheep industry have been developed.
- Consideration of disease risk and transmission in each scenario helped to identify potential future vulnerabilities in disease control, surveillance and contingency planning. Strategies that could be implemented today to address these future vulnerabilities were developed.
- Key questions for policy makers have been framed which consider what actions might be taken now to mitigate future threats or optimise future opportunities, considering issues such as the role of cooperative approaches for disease control and maximising abattoir-based surveillance.
- EPIC is using these scenarios to determine how drivers of change will have an impact on industry demographics and the risks of disease introduction and disease spread as well as disease control strategies. Modelling disease incursion will help EPIC scientists understand how the risks of exotic pathogens are altered in different futures. This will improve future tools for disease outbreak prevention and management.

Scottish sheep production – a changing industry

Sheep production is hugely important to Scotland, shaping its landscape and history, and providing an important contribution to its economy and employment. Scotland's national flock currently stands at 6.6 million sheep (2.6 million breeding ewes), comprising around 20% of the UK flock.¹ In turn, the UK has over a quarter of the total EU sheep flock. The sheep sector makes up 7.5% of agricultural output in Scotland (not including agricultural support).² Nearly a third of Scottish farmers have sheep, often alongside other types of livestock, particularly beef cattle.² Sheep production is especially important in rural hill and upland areas where there are often few alternative sources of employment.

The sheep sector has received additional support, in one form or another, since the 1940s. Initially aimed at boosting post-war production, support is now linked to a number of economic, social and environmental aims, including supporting farming and rural communities in areas with land of low production value. This is particularly relevant in Scotland, where 85% of land is classified as 'Less Favoured Area'. Since the 1990s, the emphasis of payment schemes has changed from direct support, to decoupled payments, which are no longer tied to both land area and head of sheep. Currently common agricultural policy (CAP) reform looms, with further significant changes likely.

The Scottish flock is currently at its smallest for years, after peaking at just below 10 million sheep between 1990 and 2000.³ The decline in sheep numbers is thought to be due to both farmers leaving sheep farming and down-sizing of flocks. It is associated with a general down-turn in the economic viability of hill farms, the foot and mouth disease (FMD) outbreak in 2001, livestock reductions related to agri-environment schemes, and changes in the way that livestock farmers are subsidised.⁴ Historically, the Scottish sheep industry has a three tier stratified production system with sheep bred to best suit conditions on the hills, uplands and lowlands, and large numbers of sheep sold as store sheep for finishing on the lower ground. However, the traditional three tier structure has been gradually changing, associated with a reduction in hill sheep and an increase in the proportion of crossbred ewes (from 32% in 1971 to 56% in 2012 in GB⁵) over the last 50 years. Generally, the sheep industry is closely linked to the cattle industry and the decline in sheep numbers mirrors a concurrent decline in numbers of beef cattle.

Globally, sheep meat consumption was 13 million tonnes in 2012 and is projected to increase to over 15 million tonnes by 2019.⁶ The Scottish sheep market is primarily aimed at meat production, with 3 million finished lambs producing meat worth £249 million in 2011.⁷ Almost 40% of Scottish lambs are sold for slaughter outwith Scotland, mainly to plants in England and Wales. Although the domestic market for lamb is still important, UK lamb consumption decreased by nearly two thirds between 1990 and 2010 and lamb now makes up less than 10% of meat consumed in UK.² Consumers view lamb as an expensive product, and it is outcompeted by demand for other meats, particularly chicken, which is regarded as both cheaper and healthier. UK does also import lamb, predominantly from New Zealand. In 2013 UK imported 98,900 tonnes of sheepmeat.²

Over half of the finished lambs slaughtered in Scotland are exported, mostly in carcass form. Scotland is a net exporter of lamb meat, with most Scottish lamb going to the EU. France is Scotland's most important lamb meat export market, generating nearly three quarters of sales revenues in 2012.⁸ Exports to new markets, such as Hong Kong, are increasing.

¹ June 2013 Scottish Agricultural Census (<http://www.gov.scot/Publications/2013/10/5891>).

² QMS Scottish Red Meat Industry Profile, Quality Meat Scotland, 2014.

³ Scottish Agricultural Statistics 1982 to 2013 (www.scotland.gov.uk/Resource/0046/00460161.pdf).

⁴ Holland, J. P., Morgan-Davies, C., Waterhouse, T., et al. (2011). An Analysis of the Impact on the Natural Heritage of the Decline in Hill Farming in Scotland. Scottish Natural Heritage Commissioned Report No. 454.

⁵ Pollott, G., The breeding structure of the British sheep industry 2012, EBLEX, 2014.

⁶ OECD-FAO Agricultural Outlook 2010-2019, OECD/FAO, 2010.

⁷ Nfus.org.uk

⁸ QMS Scottish Red Meat Industry Profile 2013 edition, Quality Meat Scotland, 2013.

The reliance of the sheep sector on the export market makes it particularly vulnerable to the impacts of exotic disease outbreaks. Over the last twenty years, diseases such as transmissible spongiform encephalopathies (scrapie in sheep and bovine spongiform encephalopathy (BSE) or ‘mad cow’ disease in cattle) and foot and mouth disease (FMD) have had a major impact on the sheep sector. For example, the BSE outbreak in the 1990s led to changes in abattoir processing in order to remove the tissues at highest risk of carrying disease that have had an impact on the processing cost of sheep to the present day. The FMD crisis cost the UK economy approximately £8 billion. The additional loss of gross revenue to tourism in Scotland was estimated to be £200–250 million.⁹ Around 643 900 sheep were culled in Scotland and sheep export markets were lost for one year.⁹ The wide-ranging impacts of this outbreak included changes to farmer and sheep demographics (reduction in sheep numbers, number of farmers leaving the industry), and new statutory requirements aimed at reducing the risk of disease spread (introduction of movement standstills).

Endemic diseases, whilst less dramatic, affect sheep welfare and production efficiency. Changes in the environment, in the regulatory approach, or even in the pathogen itself, can influence the impacts of endemic diseases over time. The distribution of liver fluke has increased in Scotland over the last few decades, with particularly high levels of disease in 2012 highlighting the impact that liver fluke can have. These trends may be associated with changes in climate, with warmer, wetter weather providing more available habitats for its snail intermediate host. Increasing concerns around the development of resistance to flukicides suggest their use for control might not be sustainable. The disease is responsible for considerable economic losses, estimated at £50 million in Scotland alone, due to direct production losses, poor reproductive performance and livers condemned at slaughter. For sheep scab, which was eliminated in 1952 but reappeared in the 1970s, a general move towards deregulation in disease control over the last 25 years has led to an increase in sheep scab incidence. Sheep scab is now considered to be endemic in Scotland. Control has been difficult without a coordinated approach, but government and industry are trying to tackle this problem together.

This complex interplay of environmental, social, political, economic and technical factors that influence the disease picture in the sheep industry changes over time, and new factors may develop. For example, emission reduction targets aimed at reducing climate change have led to a focus on greenhouse gases (GHGs) produced by livestock. With healthy animals associated with a lower carbon footprint, reducing GHG production has emerged as a new driver for disease control.

The devolution of animal health policy and budget from Westminster to Scottish Government in 2011 now allows more flexibility in disease policy in Scotland. Whilst some issues of disease control and livestock production are prescribed within EU legislation, the ability to make policy decisions at the Scottish level has allowed Scotland to follow different strategies to the other UK administrations for issues such as electronic identification (EID) of sheep.

The shape of the Scottish sheep industry in the future will be determined by different drivers, developments and influences that will act internally and externally to influence the nature and structure of the livestock industries, including their exposure to change and impact of disease. The aim of this work is to explore potential future possibilities, in order to empower today’s decision makers to develop and evaluate current contingency plans to ensure the resilience of the Scottish livestock industries.

⁹ RSE Inquiry into Foot and Mouth Disease in Scotland, Royal Society of Edinburgh, 2002.

Scenario Planning

What is Scenario planning?

- Scenario planning is a tool to enable qualitative, structured, medium to long-range strategic thinking about possible futures, and depends on strong trans-disciplinary collaboration between scientists, industry representatives, policy-makers and relevant stakeholders. The process includes the systematic examination of current trends and foreseeable developments that are played-out in plausible ways to create a road-map to different future scenarios. This process also considers potential threats and opportunities, including those at the margins of current thinking and planning.
- Scenario planning takes participants from looking at the drivers that have influenced the industry in the past, to thinking about what drivers are likely to be important in the future. The drivers that are likely to have the biggest impact, but also have unpredictable outcomes, are used to identify axes. Scenarios are created that sit at different points along the various axes to represent a number of potential futures and narratives are developed that describe how the sheep industry might look in 2040 under these different conditions. Drivers that are thought likely to have high impact but with more predictable outcomes are also considered across the scenarios. It is important to emphasize that the scenarios are not predictions of the future, but rather tools for thinking about how policies put in place today may help to maximise opportunities, or mitigate threats, that could occur in the future.

In this report, EPIC presents a summary of the scenario planning work examining the future of the sheep industry in Scotland, with particular reference to its resilience to disease, with a time horizon of 2040. This work was the result of a two-day workshop held in February 2014. Participants included representatives from the Scottish sheep retail sector, farming, forestry, wildlife, land use, climate change, veterinarians, epidemiologists, EPIC scientists and Scottish Government. Participants were given the role of scenario planners, tasked with engaging in strategic thinking through a series of carefully crafted exercises that resulted in the creation of four scenarios set in 2040. EPIC's aim in developing these scenarios is to consider how disease incursions and disease spread may be different in the future, and how our control strategies may need to adapt, given that the industry and risk profile are inherently uncertain.

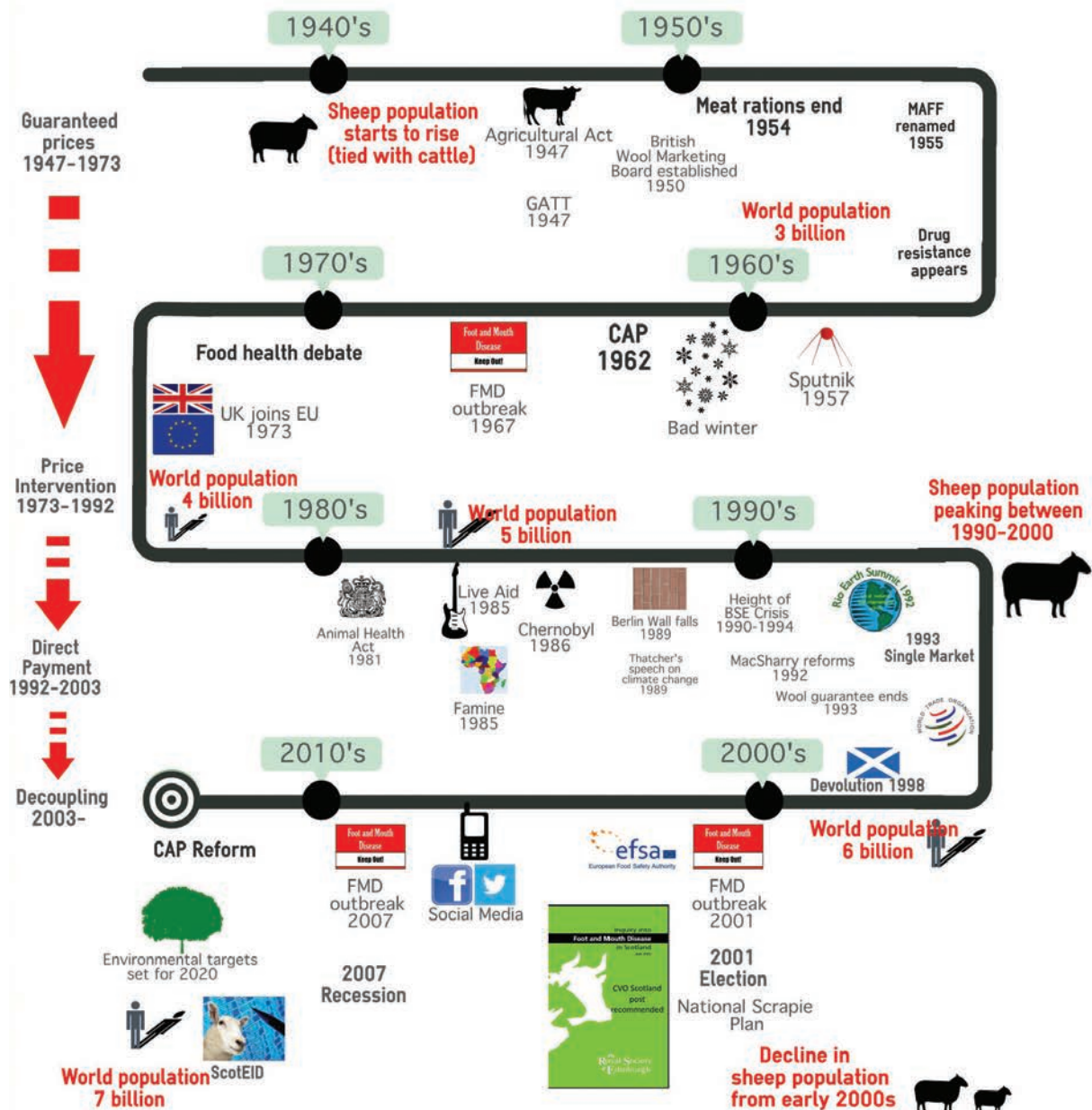


Drivers of change in the Scottish sheep industry

During the workshop, a historical timeline was developed to facilitate participants to think about and discuss the drivers that have influenced the sheep industry in Scotland since 1940. The timeline was partly pre-populated by the organisers, and developed further during the workshop, and included events which participants thought had been directly important to the evolution of the sheep industry in Scotland in its present day, as well as other exogenous factors which may have had an indirect impact. The aim of this exercise was to consider drivers that had influenced the sheep industry and its resilience to disease in the past, to help identify the drivers that were most likely to be important in the future.

Historical Timeline

1940's - 2014



The most dramatic change to the industry is the major reduction in ewe numbers. This is associated with decoupled subsidy payments, but also to a number of other drivers, including the close relationship between the sheep and beef cattle industries, prioritisation of other land uses, such as forestation, and shock events such as the FMD outbreak in 2001, or adverse weather events, that cause farmers to leave the sheep industry. Loss of farmers is leading to “a continued holing out of the middle farming demographic”. The labour issues are exacerbated by increasing specialisation and young people being less interested in farming, which means that “you just can’t find the people to do it”, and “gathering becomes a nightmare”.

The traditional stratification system has “already broken down really” and there has been a “staggering” shift away from hill breeds. Changes in breed preferences have also been driven by the influence of the supermarkets, which make specific demands on carcass conformation.

The cattle and sheep industries are closely interlinked. Loss of hill cattle has led to land use changes that are affecting sheep production, such as changes in plant communities reducing grazing quality and increasing tick abundance. Population growth and economic development are fundamental drivers of the global food market. New Zealand was observed to have been more successful at identifying new markets for lamb, particularly in Asia. The relationship between more local economic prosperity and the sheep industry was less clear, with one comment that “farming usually does well in recessions”. Global energy costs were acknowledged to influence production. The impact of newer energy sources such as biomass and wind was uncertain.

It is difficult to drive new technology and development in the sheep sector due to its small size (it’s a “minority species”). Participants commented that the sheep industry would need a “shot in the arm” to bring about the level of technological advances that have happened in the dairy sector over the last 10 years. The issue of effective control for diseases such as fluke is also a challenge.

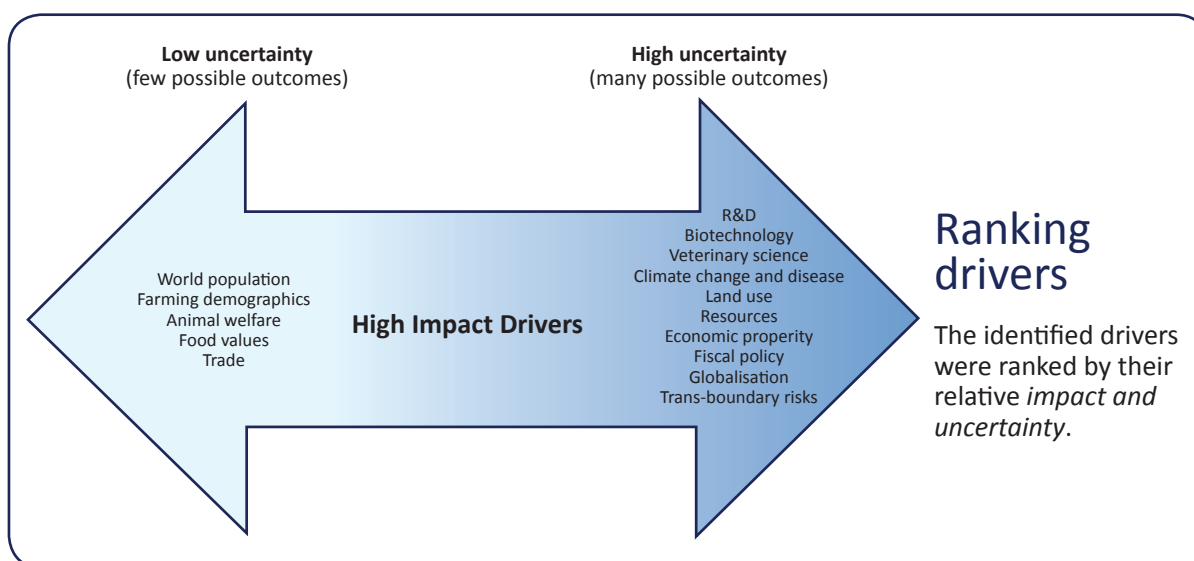
Despite minor trends for consumers to buy locally and ethically, consumer preferences remain predominantly based on price. Lamb is popular mostly with an older consumer demographic and is struggling to attract younger buyers. Trends towards eating less saturated fats have also played a role.

Drivers of Change for the Scottish Sheep Industry					
Population/ Demographics	Technology	Economy	Society	Environment	Politics
World population	Biotechnology	Globalisation	Education	Climate change and disease	Scottish independence
UK population	Information technology/ digital age	Localisation	Health and wellbeing	Climate change and agriculture	Influence of EU
Farming demographics	Changing systems of production	Trans-boundary risk	Food values	Future land use	Governance
Consumer demographics	Influence of renewables	Developments in retail sector	Animal welfare values		National Policy
	Veterinary science	Economic prosperity			Fiscal Policy
	Research and development	Global trade			
		Marketing			
		Food/security bioeconomy			
		Energy costs			

Drivers of Change

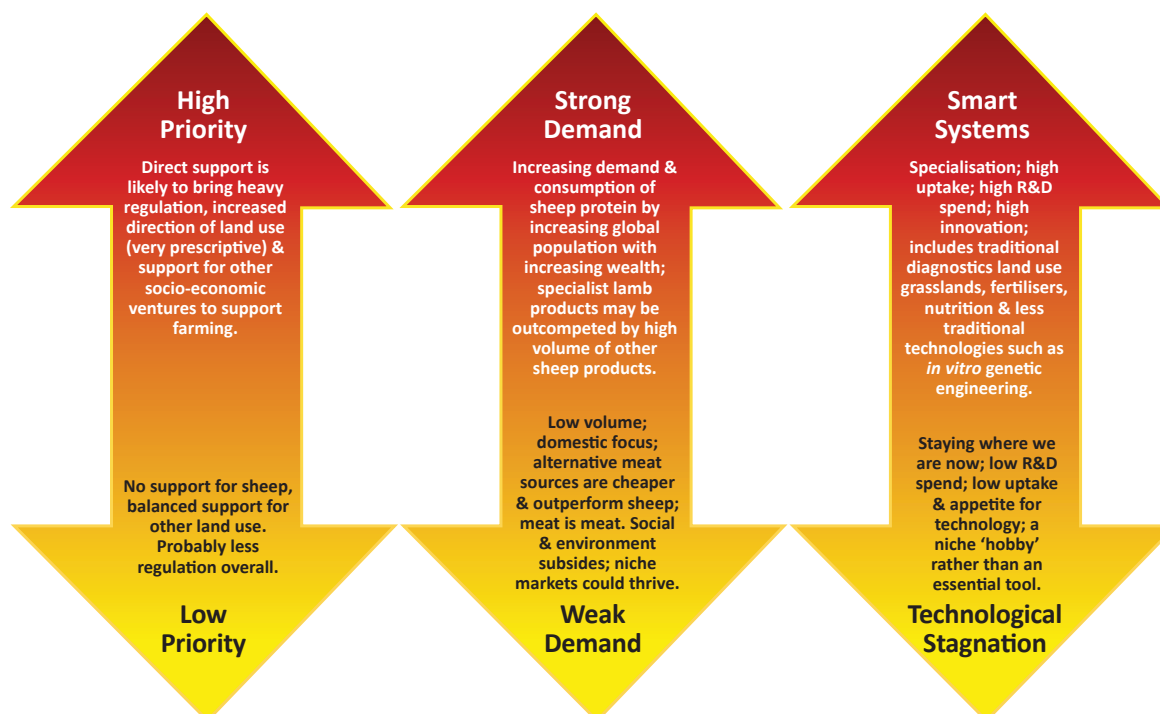
The historical timeline was used as a tool to prompt consideration of ‘driving forces’ which shape the future environment for sheep diseases in Scotland. An initial list of drivers was developed before the workshop, and refined with participants following the historical timeline discussion.

Ranking drivers and constructing axes



Constructing axes

The high impact, high uncertainty drivers prioritised by participants were used to construct three axes along which a logical and systematic grouping or cluster of drivers of change could be represented. In this workshop, four axes were initially considered: 'Technology', 'Priority for the Sheep Industry', 'Market Demand' and 'Climate Change'. 'Climate Change' was subsequently incorporated as a driver within the other three axes.



Climate change uncertainty was considered across all 3 axes.

Once drivers had been identified, participants ranked the drivers for their relative impact and then uncertainty. Ranking for impact was conducted individually, with each participant identifying what they thought were the three most important drivers, followed by a plenary discussion. Ranking for uncertainty was conducted in plenary. In this instance, uncertainty does not refer to the likelihood that an event will occur, but refers to the range of outcomes that can result from a driver. A large number of potential outcomes equates to high uncertainty. When there was substantially polarised discussion over uncertainty of a driver, that driver was explicitly considered to result in high uncertainty. Drivers that were identified as high impact but low uncertainty were not included further in development of the axes. However, these were considered later in scenario development. For example world population, which participants felt was a high impact driver, was thought likely to follow a general increasing trend, and would therefore be considered across all scenarios.

In plenary discussion, the drivers which were ranked of high importance and high uncertainty were grouped into themes, or critical uncertainties. These critical uncertainties were expressed as axes, representing a continuum of possibilities between two extreme endpoints. The four critical uncertainties that emerged were discussed in small groups and also in plenary to develop the ideas further.

The axis around **priority and support** also considered issues such as land use and regulation. High priority for the sheep industry was associated with direct support, but also with more prescriptive land use and higher regulation. In a low priority situation, there is a lack of socio-economic support for the sheep sector, potentially associated with increased emphasis on other land uses, but also with decreased regulation, whether at the local, national or regional level.

Demand was considered to cover both the spectrum of low to high demand, but also local to global markets, and is linked to national and global prosperity. A situation with high global demand could occur when despite global population increase, the per capita income is high, and global markets for lamb increase, particularly for specialised and luxury products. Low demand was associated with a situation where a high global population has a generally low per capita income, leading to increased demand for low cost meat or alternative protein sources. There is low demand for lamb as a high-end product, the remaining market is local only.

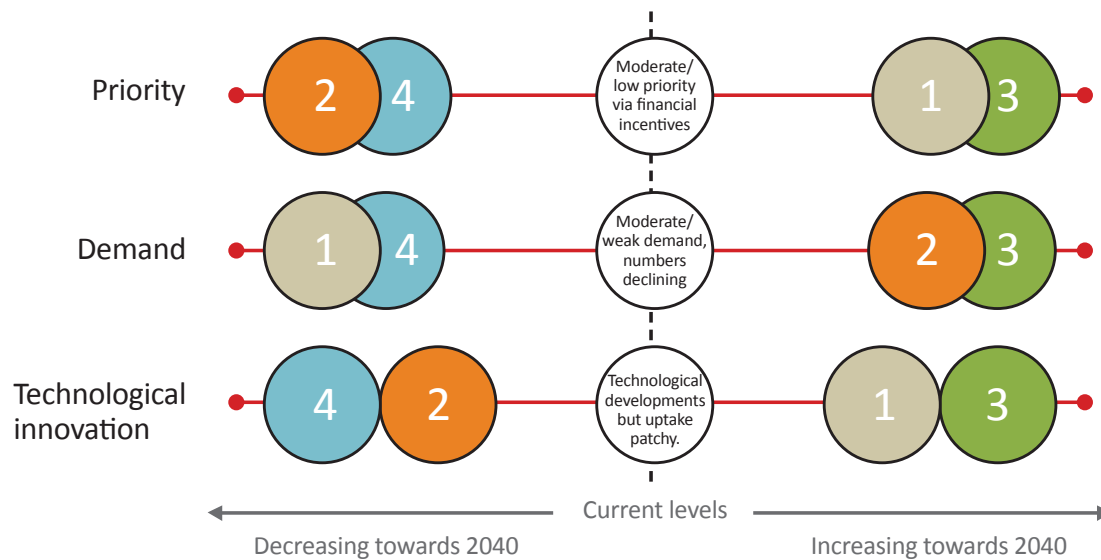
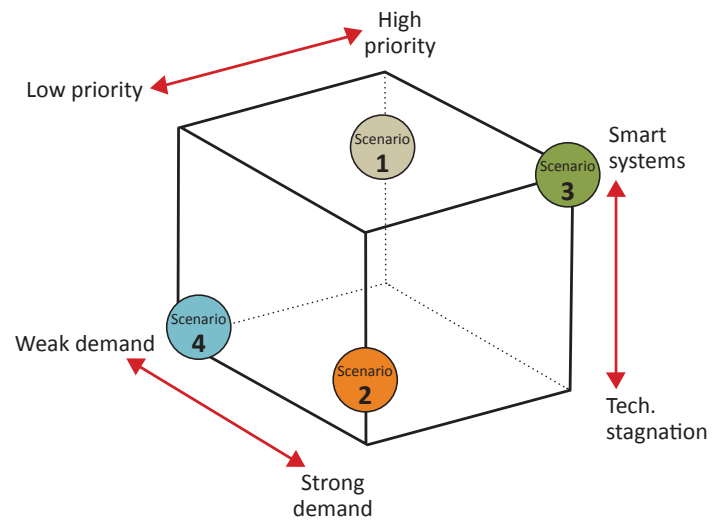
The uncertainties around **technology** ranged from technological stagnation to smart systems and encompassed a number of areas including development of new medicines and vaccines, genetic developments and big data systems for management. Technological innovation was associated with a situation where impetus from the sheep sector drives high uptake and innovation. This may be particularly associated with intensification and industrial agriculture, and is likely to be strongest when sheep production is doing well and farmers are more willing to take risks. Stagnation was linked to an industry not engaging with technological advances, and low investment in research and development.

Climate change encompassed uncertainties around the potential changes that could impact the sheep industry, and the influence of climate on disease. Discussion of the extremes illustrated some difficulties with this axis. Changes due to climate were thought to be likely, hence low uncertainty. What was thought to be uncertain was the nature and extent of these changes. Developing plausible extremes of these changes requires significant expertise. Whilst the participants included climate change experts, in the absence of sufficient experts for each small group to address this issue effectively, attempts to do so may not be robust. Therefore it was decided to consider climate change across all scenarios, rather than use it as a specific axis.

Developing scenarios

The Cube

The axes were plotted on a cube. Four scenarios were constructed to represent potential futures at different points along the axes. The scenario end points were characterised by participants, followed by a 'back-casting' exercise to describe specific events which unfold in a consistent and plausible manner along the time-line.



The three axes identified were combined into a three dimensional space ("the cube"). Plenary discussion was used to identify any particularly likely or unlikely positions within the cube, i.e. combinations of the axes that might not be plausible. Within plenary discussion, four interesting and plausible positions were identified, and allocated to small groups of participants. Participants were offered the opportunity to move to another scenario if they preferred. In facilitated small groups, the participants initially characterised their scenario in 2040, considering how the combination of drivers might play out. They then filled in the time between now and 2040 with events or trends which unfold in a consistent and plausible manner along the timeline. Drivers which had previously been identified as high impact, but low uncertainty, were also considered in each scenario. Scenario names were chosen by the participants.

The four scenarios developed are presented on the following pages. For each scenario, the situation in 2040 is described. In addition, opportunities and challenges presented in the scenario are listed, and key comments on resiliency to foot and mouth disease, liver fluke and sheep scab presented. In the first scenario, 'Sheepishly smart', regulation is high (at EU or regional level), government prioritisation of the industry is low but technological innovation continues to be supported. Demand for product is moderate to weak at both local and global levels. The demand for sheep imports and exports is weak so competition within the industry is high. Scenario 2, 'Opportunity knocks for some', is defined by a combination of moderate government prioritisation and moderate technological innovation, in association with low government regulation and reasonably strong local and global market demands. In scenario 3, '3 bags full', there is support for technological innovation, government prioritisation of the sector, low regulation (at EU or regional level) and strong local and global demand for sheep products. In scenario 4, 'Silence of the lambs', the government does not prioritise the livestock sector, regulation is low and demand for product is weak at both local and global levels. Technological research and development have stagnated.

Opportunities and challenges

Although some scenarios might appear more positive than others, all scenarios contain both potential opportunities and challenges. Participants considered what opportunities and challenges might exist in their scenario. The degree to which these opportunities and challenges promoted or inhibited industry capacity to: detect disease, assess risks, respond to a disease emergency and recover from such an event provides insight into the resilience of the different scenarios to disease threats.

Impacts of disease

Participants were also asked to consider how resilient their scenario would be to disease, by looking at the spread, impact and control of FMD, liver fluke and sheep scab. These diseases were selected to represent a range of different characteristics, as they differ in transmission routes and transmission rates, strategies for prevention and control, and the potential impact of climate change on disease. Participants considered how parameters such as overall number of sheep, size of flocks, imports/exports and movements of sheep might influence disease incursion, and spread, and various control options might be implemented in their scenarios.

Foot and Mouth Disease	Liver Fluke	Sheep Scab
Foot and mouth disease can spread quickly between animals and on surfaces such as vehicles. The risk of incursion is related to regulation, imports and the disease situation in trading partners. Currently control is heavily regulated and involves a stamping out policy in GB but vaccination is also an option.	Traditionally, liver fluke has been found in wetter parts of the UK. Recently, it has been reported in new areas. The fluke spends part of its life cycle inside a snail host which likes warm wet conditions, and the increased frequency of disease may be associated with a changing climate. Availability of effective products is a concern as resistance can develop.	Previously eradicated in GB, sheep scab is hard to control without central regulation. Caused by a parasitic mite which lives on the skin surface, it is a major source of economic loss in affected flocks and a serious threat to sheep welfare. It is passed on via contact with live mites, e.g. sheep-to-sheep contact at markets or in livestock lorries.

Scenario 1

Sheepishly Smart

The Scottish sheep industry in 2040 is driven by the need to minimise GHG production. The agricultural sector has been seen as a key opportunity to enforce the global GHG regulations so a stringent tax was placed on the volume of GHGs produced by livestock and national level support provided for low carbon agriculture. Genetically engineered trees adapted to high altitude growing conditions have resulted in increasing forestry on hills to further cut the national carbon deficit. Consequently, the sheep industry is concentrated on the low ground. The production of these high-performing sheep is semi-intensive. Highly intensive sheep production, which is dependent on the use of phosphates and other fertilisers, is unaffordable because of the rising costs of fuel driven by the enormous rise in car ownership in Brazil, Russia, India and China (BRICs).

Red meat is taxed by the volume of GHGs that are produced. As a result, the relatively smaller volume of methane production makes sheep meat considerably cheaper than beef so there is reasonable demand for sheep meat in the UK. The increased market for sheep meat in the BRICs is satisfied by a very large sheep industry in Southern Africa. This market is relatively inaccessible to the Scottish market due to the higher production costs resulting from increasing fuel and phosphate prices. Fortunately, the UK market has been protected from Southern African exports by substantial restrictions placed on the import of meat following the break up of the EU. High government support is given to farmers to adopt low GHG livestock production for the domestic market. The high levels of state support are directed towards the biotechnology sector and include subsidies to support the rearing of low GHG livestock. The state also levies import tariffs on agricultural products following the withdrawal of the UK from the EU.

The successful production of ewes with the Thoka gene was an important technological breakthrough resulting in ewes with four teats that can sustain 3 or 4 lambs per pregnancy. The corresponding reduction in the number of ewes required in the population further reduces the GHG impact of lamb compared to beef. Vaccines have been developed against diseases, including scab and fluke, to increase production efficiency, which also helps to reduce GHG emissions.

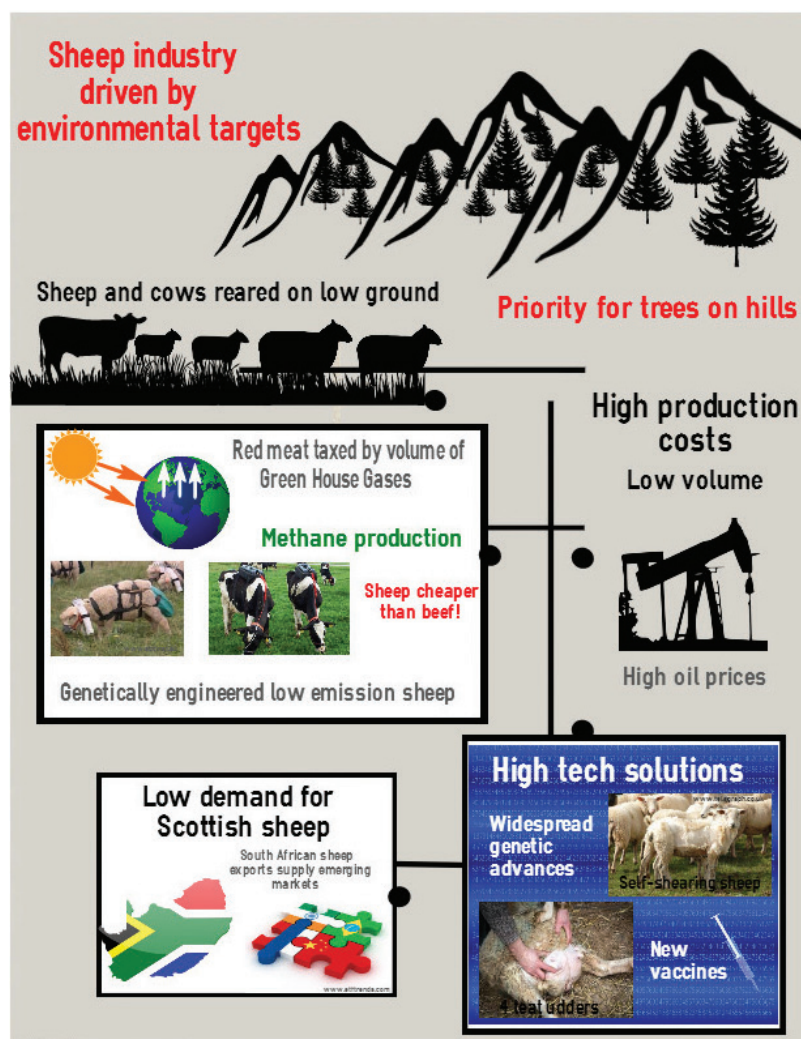
Foot and Mouth Disease	Liver Fluke	Sheep Scab
Intensification improves biosecurity but also leads to greater within-flock and between-flock transmission rates, despite the enhanced biosecurity. Control is through slaughter of infected flocks along with vaccination using an enhanced vaccine. Exports are very low so there are few concerns about the impacts of vaccination on trade. Import regulations minimise the risk of introduction through live animals and products, but climate change may increase the introduction risk via wind.	Exposure to liver fluke habitat increases, but there are effective treatments and vaccines to eradicate the disease. The greater intensity increases transmission risk – “a sheep’s worst enemy is another sheep”. For treatments “as soon as it’s there it’ll be used”, particularly as moving sheep to lowlands would reduce options for control. However, in spite of the greater potential for transmission, control options and tighter regulations will see fluke close to eradication in 2040.	Scab exposure is higher, but as with fluke, effective treatments and vaccines will eradicate scab. The move to enclosed lowland pasture leads to a large improvement in biosecurity as “fencing is more effective for scab than for FMD” and less contact with feral or stray sheep. Generally sheep scab is under control and “by 2040 we may be back to the 1950 rate”.

Opportunities

- Increased lowland farming and intensification allow individual level animal management.
- The greater availability of technology helps to ramp-up and extend the use of EID systems for detailed recording of individual animal data and traceability.

Challenges

- Intensive breeding and selection of sheep potentially leaves animals vulnerable to more existing and new diseases.
- Enhanced monitoring is likely to detect acute disease, but there could be high risk of chronic infections such as transmissible spongiform encephalopathies.



Scenario 2

Opportunity knocks for some

In 2040, the traditional three tier system is a thing of the past. Prices for sheep are volatile and affect the type of production systems in place. The removal of subsidies has resulted in many farmers leaving the sheep industry. Weaker businesses have downsized and moved into hobby farming or crofting. Stronger players (“professional farmers”) have concentrated on expanding their businesses. Local demand is strong, so a small group of professional farmers are “sitting back and making money”.

Although global demand remains strong, the Scottish industry has lost out to competition from other states with better technology and industry support. This has led to smaller numbers of farm businesses overall although the sheep population has not declined. The industry is concentrated into professional breeding centres (with high volumes of sheep bred for uniformity and high quality desirable commercial traits) and crofters and hobby farmers (where sheep are produced as a secondary venture) in lowland and upland areas. Sheep on hills were supplanted by trees after government support moved towards forestry; hill farms no longer exist. The professionals buy or rent more disparate parcels of land to stock greater numbers of sheep (“megaflocks”). There is huge fragmentation of the industry (“sheep are... all over the place”) but highly commercial farmers are concentrated on the best upland and lowland areas.

Technology is available, but has stagnated in certain sectors due to lack of incentives and support for some farmers in uptake, lack of resources for research and development and a precautionary approach taken by Scotland on imports of new pharmaceuticals and radical technologies developed in China. Although the EID system has been in use for years, most farmers still don’t have on-farm scanners. Large-scale sheep farmers have moved into “easy-care” systems and rely on in house technology for pathology, diagnostic testing and disease control programmes (similar to the pig and poultry industries). There is a trend towards internet purchases of unlicensed new drugs (particularly vaccines) by some, creating a small black market. Decreased infrastructure for disease surveillance and control measures leaves UK vulnerable to disease incursions and the disease status of the Scottish sheep industry means that Scotland can no longer supply to some markets. There is no foreseeable change in this status, as resources, infrastructure and support for disease control are lean (“QMS is dead”). This has been made worse by a warmer, wetter climate, because emerging, exotic and endemic diseases have increased in prevalence. Abattoirs have closed due to lack of state support and this, together with the reliance on disparate land parcels, has meant that disease outbreaks spread more quickly and more widely.

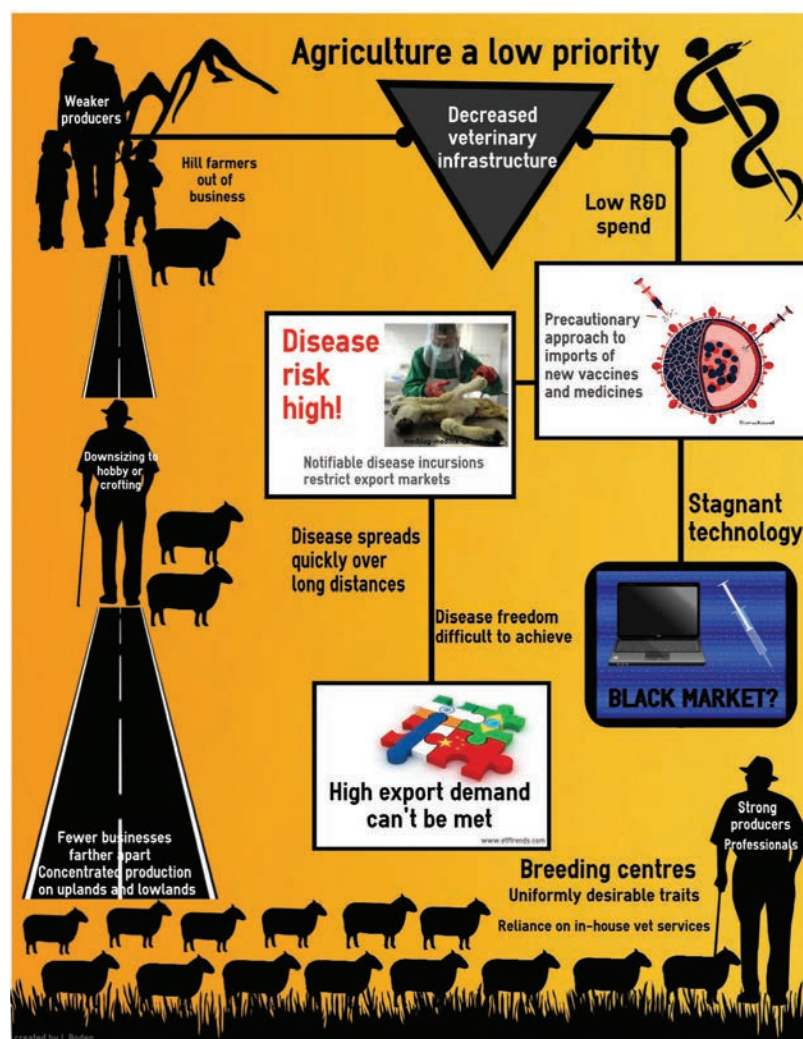
Foot and Mouth Disease	Liver Fluke	Sheep Scab
<p>Biosecurity is a casualty of technology stagnation. The numbers of sheep on professional farms is far greater than in recent history, so disease spreads quickly within flocks. With increased intra-business movements over longer distances, the spread of disease between flocks is frequent and fast. Compartmentalisation might be an option for “megaflocks”. Big businesses operate in silos, making decisions through their in-house veterinary infrastructure as government-led surveillance and disease control is non-existent.</p>	<p>More sheep are grazing on the middle hills and lowland, so fluke presents a significant problem. However, climate plays a large role in this, with important regional differences. As veterinary services are lean, farmers are responsible for fluke management. If drug resistance increases, exclusion may be more common where possible. Although advances in treatment may occur in other countries, technology has stagnated due to a precautionary approach to new medicines. This stimulates black markets for desperate or entrepreneurial farmers.</p>	<p>Scab is easily detected and treated if a good management system is in place. Professionals emphasise good biosecurity because they are willing and able to take action. Hobby farmers are limited by their knowledge. If vaccination is available, farmers may use it excessively, promoting resistance. Regulation of scab has moved away from national regulation towards farmer discretion. There are pockets of uptake of new or alternative control therapies driven by the professional breeding centres, who are most likely to be early adopters.</p>

Opportunities

- A bimodal industry structure (large producers and hobbyists) promotes increased cohesion. This could be an opportunity to increase resilience of industry-led and industry-funded approaches to disease control.
- The need for cheaper drugs may stimulate lobby pressure for pharmaceutical reform.

Challenges

- There may be 'cowboys' amongst the large producers who have the means to cheat the system.
- Industry may not want to take the responsibility for funding programs of surveillance and disease control.
- Expensive drug licencing limits drug availability to combat endemic, exotic and emerging diseases.



Scenario 3

Three Bags Full

Structural support for the industry has been enhanced with technological developments assisting an industry that is basking in a period of high demand from a buoyant global market for sheep produce. A steady stream of technology breakthroughs and discoveries have boosted the industry and kept it highly competitive. From robotics to genetics and veterinary treatments, sheep farmers are enjoying the benefits of the digital age advancements. “Collie Drones” patrol the hills where high numbers of sheep are kept by technologically savvy farmers who have good incomes. EID has made strides forward from the unpopular and limited system of 2014 to a system that delivers direct benefits to farmers by consolidating Food Chain Information and sheep health records in ways that farmers find practically useful. Veterinary medicine has made numerous advances including improved control of parasites and diseases such as Sheep Pulmonary Adenomatosis.

Unexpected marketing and scientific spin-offs have included a popular “aphrodisiac” and what became known as “Scottish Cashmere” – a genetically driven, fine wool fibre. Farmer education has been a great enabler for uptake of technology and farmers have developed modern, efficient businesses. The climate is challenging for farmers with increasing variability and extreme weather events, but for Scotland the effect on sheep has been largely positive: a longer grass growing season. Public concerns with other sources of meat due to food scares have proved serendipitous for the industry. In general people demand sheep meat and value it highly. Global markets, particularly the Middle East and China, are open to premium Scottish sheep produce and a good price for lamb signifies a boom-time for the Scottish sheep industry. There is demand from the Middle East for quality Halal products due to failures in internal production systems connected to climate change. At regional and European level, policy strongly supports the industry. Extensive sheep are an important natural resource and sheep are winners over beef in the subsidies merry-go-round.

“The shadows at the carnival” include environmental degradation caused by overstocking as the market demands greater volumes of sheep. Tracing and tracking, enabled by EID and other digital technologies and embraced at the policy scale has been used to tackle rogue traders by 2040 but not before these scandals had raised the profile of weaknesses in governance of the supply chain. More sheep equals more disease and the industry remains potentially vulnerable to exotic disease threats.

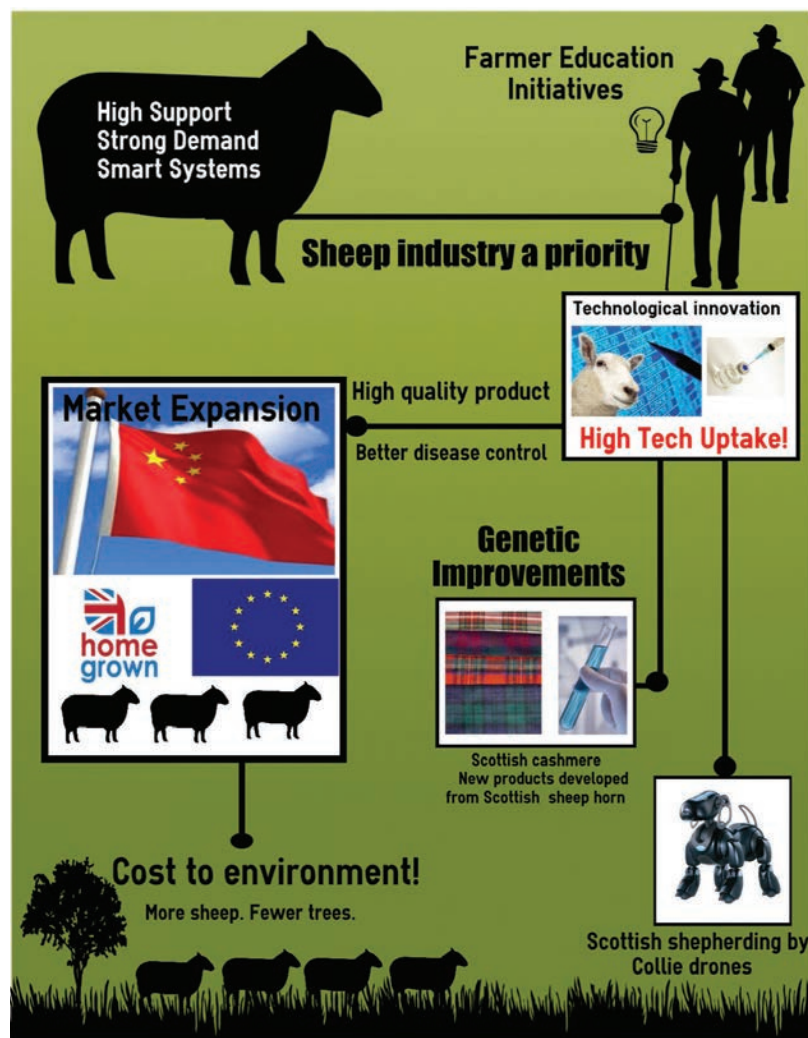
Foot and Mouth Disease	Liver Fluke	Sheep Scab
Although technology development promises robotics, genetics and vaccines, the expanded sheep industry provides a bigger reservoir for disease, incentives for malpractice and environmental degradation. Better biosecurity, a more educated workforce and effective ID and traceability (“you’d know where the sheep are coming from”) assist disease control alongside compulsory vaccines. However, the increased density and numbers of sheep may increase vulnerability to disease, particularly in the hills. Even in this scenario, FMD control may still rely on slaughter (“if it’s FMD within a flock, then it’s goodbye flock”).	Grazing on snail habitats is an increasing inevitability with more sheep and “no such thing as snail-free grazing”. The technology sceptics thought effective treatment was “cloud cuckoo [land]” and that snails are “part of the ecosystem”. However, some participants proposed “high intake for scientific research” leading to resistant sheep, “fluke resistant snails”, and effective vaccines, thus eliminating the need for quarantine or treatment.	The nature of scab with its hard-to-detect-early symptoms and the mite’s tenacity living up to 14 days “on anything” made it difficult for some to see dramatic progress especially with the toxicity of known effective treatments preventing their use. Yet the group’s minority of high optimists thought that tough movement restrictions and quarantines combined with effective biosecurity from the highly educated workforce of 2040, allied to new vaccines and genetics, could get on top of the problem.

Opportunities

- In the high-tech world of 2040, increased biotechnology and a technology-savvy workforce achieve high biosecurity.
- Resources flowing into the industry drive training and education programs to improve disease control.
- Genetic improvements could yield significant benefits in disease control.

Challenges

- A warmer, more humid Scotland has increased numbers of ticks and other parasites.
- A monoculture of a large sheep population heralds new vulnerabilities for large disease outbreaks.
- Environmental degradation is a concern through over-grazing and loss of diversification.



Scenario 4

Silence of the Lambs

Demand is low and local. Global prosperity is low and the hoped for expanding markets of China and the Middle East have not materialised for Scotland. The production costs for lamb in Scotland remain relatively high compared to other countries, and with cheap protein production the priority for the increasing global human population, there is no significant export demand for Scottish lamb. Within Scotland, a fairly poor economic outlook has led to a focus on cheap, high volume protein production. As other protein sources, such as chicken, are cheaper to produce, lamb is only profitable if production costs can be kept very low. However, a small market remains among the more affluent for high quality lamb products, so some producers have gone towards artisan-style production.

Declining direct support for the sheep sector and the direction of subsidies at other land uses, means people can make more money from wind farms and trees. The lack of support, combined with reduced demand, has meant that sheep production has polarised (“continued hollowing out of the middle”). In upland and hill areas, sheep are put on land which can’t be used for other industries, but production is only feasible if costs are kept very low. This leads to “New Zealand style production” – extensive ranch systems with minimal intervention, which are only feasible because there is also little regulation (“drenched if they’re lucky”). There is little veterinary input or disease surveillance (“just count the bodies”). This raises some welfare issues. However there are also some health benefits as selective breeding and natural selection lead to “easy”, healthier sheep. The lack of support has contributed to a continuing trend to declining succession, and loss of family farms. This was exacerbated by a series of extreme weather events, which pushed more people out of farming (“no one likes uncertainty”).

The number of people with expertise in husbandry and veterinary care of sheep has declined, although the low value of land and reduced regulation means there are some opportunities for new entrants into farming. In lowland areas, sheep producers cannot compete for land with other sectors. Producers keep small flocks if they can market an artisan product, otherwise costs are too high. Rotational systems or mixed sheep/arable systems become more popular to try and make best use of land. The stagnant market doesn’t stimulate development of new technologies for sheep production. Increasing resistance to veterinary drugs and lack of new products on the market create problems for control of endemic diseases.

Foot and Mouth Disease	Liver Fluke	Sheep Scab
Bioresecurity is low on commercial ranches. However, the lower stocking density in these extensive systems decreases within and between flock transmission. Diagnosis is difficult as sheep are rarely inspected, so disease “will rumble on”. Small producers encompass a wide range of farming types, with varying biosecurity, and could increase risk due to movement of animals and local spread between adjacent farms. Control still relies on slaughter of infected flocks, possibly with local compulsory vaccination strategies. Interventions depend on the buoyancy of other sectors - if the cattle sector is strong, FMD control in sheep is more regulated.	Fluke is a major challenge in this scenario and one of the biggest impact diseases for large sheep ranchers. Ranches are unable to avoid using infested areas for grazing, and with the addition of climate change increasing fluke risk, many ranches “will be riddled”. Even the small producers are relying on risky grazing areas. With low investment in technology and little development of new pharmaceuticals, effective treatment is a major problem. Although the sheep in ranch systems have minimal intervention, fluke treatment is one of the prime reasons for gathering, due to sheer necessity.	With low or variable biosecurity, infrequent inspections of ranches and sheep and little appetite for central control strategies, scab is an issue. In contrast to FMD and fluke, where cattle industry developments may help disease control in the sheep sector, scab is a low priority. Even if a vaccine becomes available, it is unlikely to lead to effective disease control in the absence of a national coordinated strategy. With no other new technological developments on the horizon, it is necessary to explore alternatives: “bog myrtle harvest – marinade, treat, eat”.

Opportunities

- Decisions are made at a more local level.
- Since there is little regulation, there may be an opportunity to streamline what regulation remains.
- Land use may be more strategic.

Challenges

- The frequency of inspection of animals in ranching systems is very low.
- Cost margins for each animal are low.
- With increasing global trade and low surveillance and technology, the unknown unknowns of the pathogen world represent a real risk.



Developing Strategies

The potential opportunities and challenges identified for each scenario provide an opportunity to consider how these might be exploited or mitigated. Participants devised a set of strategies that could be initiated in the present day, to mitigate future risks or exploit opportunities in the sheep industry relating to disease. Strategies considered desirable and effective in one scenario can be irrelevant or even counterproductive under a different set of circumstances that might plausibly emerge. The potential positive and negative impacts of the strategies were considered for each scenario. EU pharmaceutical legislative review was thought likely to have a positive impact in all scenarios. 'Cooperation rules' and 'come together right now' both incorporated cooperative approaches, but whilst aspects of these strategies were thought likely to be beneficial in all scenarios, other aspects were unappealing to some, with discussion focusing on the use of incentives versus penalties, who should be part of the cooperative and who should lead it, and the risks of a monolithic organisation versus a competitive market. Participants liked the idea of enhanced surveillance, especially increasing abattoir-based surveillance, although scenarios with low funding for the sheep sector were concerned how this could be funded.

Scenario 1

iSheep: Producers would be provided with the hardware to access national level databases to exploit existing EID technologies, for individual recording of animal data including slaughter weights and health status.

(h)iSurveillance: In combination with iSheep, information would be used for improved surveillance, with data collection ramped-up at abattoirs and through the veterinary agencies, and improved data exchange between the different units by streamlining databases.

Scenario 2

Come together right now: This co-operative knowledge exchange network would encompass all elements of the supply chain management to promote strong industry networks to replace Research and Development investment and to promote consumer knowledge and understanding of the product and the process.

EU Pharmaceutical Legislative Reform: This is a lobby for international legislative reform (at EU level) for veterinary pharmaceuticals, to encourage mutual acceptance of drug licences with respect to safety and efficacy, and harmonise international standards for drug licencing across all relevant sheep markets within and outwith the EU.

Scenario 3

Dolly Centre: An international reference laboratory is created, to be a world leader in sheep genetics to give Scotland a leading edge in both productive and disease resistant sheep, with a 'licence to splice' available to scientific partners contributing to the centre.

Sheep Squad: Like the Territorial Army, a national reserve would be ready to fight outbreaks. The service would be comprised of everyone who receives government funding to work in the area and all members would be required to spend part of their time participating in exercises and ensuring preparedness.

Scenario 4

Cooperation rules: This strategy is concerned with communication and cooperation through the supply chain. The strategy would rely on producers working cooperatively and making the most of the benefits this could bring, such as bulk buying power, as well as using the cooperative to provide knowledge transfer and education, and to ensure feedback of information through the supply chain.

Red tape ribbon to manage legislation: A review of the cost/benefits and effectiveness of existing legislation at a local scale aims to make the most of more local decision making and shorter chains between decision makers and farmers.

Adding Value/Future work

Key Questions for Policy-Makers

- What are the barriers to pharmaceutical legislative reform both within and outwith EU?
- If cooperative approaches became more widespread, what would be implications be for disease control? Should cooperative approaches be promoted? Does this have implications for control of disease epidemics, or only endemic disease?
- How can more use be made of abattoir-based data collection both for disease surveillance and for feedback to producers? What is the role of supermarkets here?
- A 'territorial veterinary army' was one of the recommendations for Scotland after the FMD outbreak in 2001. How much has this resource been developed? Should it extend to more than just veterinary personnel? Would it be feasible/useful for involvement to be an obligation of government funding?

The value of scenario planning lies not just in the development of the scenarios, but in the opportunities it creates for engagement with interested and informed parties, in this case, about the future of Scotland's different livestock industries.

The scenario planning outputs from both the sheep workshops, and cattle workshops held in 2013, is being incorporated into existing work in EPIC. Issues raised by the development of the scenarios are being explored in more depth by those with expertise in modelling disease transmission, formulating control strategies, and performing risk assessments, in order to better inform disease contingency planning for the livestock industry. In particular, the factors influencing the risk of disease introduction and industry demographics in each scenario will be assessed to consider the impacts that different drivers could have on disease spread and disease control in the future. Specific examples of the uses of the scenario planning work anticipated by EPIC are:

1. Use of EPIC's existing disease models with the parameters specific to each scenario to understand how disease might be best controlled in each proposed future.
2. Modelling disease incursion risks in each scenario to understand how the risks of different pathogens may differ in different scenarios.
3. Further assessment via modelling and through collection of survey data of the potential effectiveness of the strategies from the windtunnelling exercise both under present farming circumstances and proposed future scenarios.
4. Grounding EPIC's scientific program in 'real-world' knowledge by developing and maintaining stakeholder forums rich in practical expertise.

This will greatly enhance EPIC's preparedness for future major disease epidemics and highlights why fore-sighting exercises such as these are important and useful tools to enhance the timely delivery of robust long-term scientific advice in the context of the quickly evolving, current political landscape.



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Reference

Please reference this publication as follows:

EPIC (2015) "What will the Scottish sheep industry look like in 2040 and how resilient will it be to livestock disease?"

