Farm Intensification

(paper supporting the blog TB, Badgers and Cattle in The UK: A Campaign Ripe For A Re-boot, at http://threeworlds.campaignstrategy.org)

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Introduction

Dominic Dyer of the Badger Trust describes contemporary bovine TB as a 'disease of intensive farming'.

The intensification of farming – increasing yields and outputs from a given unit area by greater use of factors such as technology, energy and chemicals and increasing economic viability, for instance by merging small farms into larger ones – has long been recognized as environmentally damaging.

More than two decades ago, in 1998 an English Nature report on sustainability of agriculture by Mark Tilzey argued for 'a whole countryside approach' built not 'on the basis of managerialist 'symptom management', but rather by 'addressing generic causes deriving from the unsustainable practices of mainstream farming activity'. Tilzey wrote:

'Farm wastes are a major cause of water pollution, particularly from dairy farms. They are a significant source of nitrogen and phosphorus, heavy metals, pathogenic organisms, ammonia and methane emissions … These results of course are a product of production concentration and intensification; a return to more extensive management would resolve many of these issues'.

A 'return to more extensive management' means reversing nearly all the trends that have dominated livestock farming since the mid Twentieth Century.

From the 1920s to the Second World War cattle farming was 'traditional' and extensive (low density herds outdoors). Some cattle were kept out-doors year round and many were grazed on grass pastures in summer and fed, mainly on hay, indoors in the winter. With hay (long grass cut and dried in fields on sunny days) no longer needed for horse-power on farms, most hay meadows were ploughed up, often converted to arable farming, and biodiverse low-productivity grasslands resown and fertilised to make them more productive of bulk grass (mainly perennial rye-grass or annual Italian rye-grass). Mechanisation continued in the 1960s and intensification of farming with fields enlarged and drained, greater inputs of artificial fertiliser, herbicides and pesticides, use of supplementary animal feed rather than grass or hay, increased rapidly once Britain joined the European Economic Community (now EU) in 1973.

Ex hay meadow in Swaledale now resown and cut for silage

Surviving hay meadow at Muker in Swaledale

By making greater and more intensive use of the land, flora and fauna was eliminated. Over 97% of flower-rich hay meadows pastures for example have been lost since 1935 (this is from a 1980s survey and more have been lost since then). Intensive agriculture is now widely recognized as the major cause of nature destruction in Britain and in the EU. Overall inputs to farming started to decline in the 1990s (and productivity increased) partly because policies were introduced to lower subsidies but the pattern of structural change has continued.

'Traditional' mixed livestock and arable farms started to disappear particularly in Eastern England as crops like Oil Seed Rape and winter-sown cereals were introduced, using high inputs of fertiliser.

Sue Everett who founded a nature-recovery organisation Flora Locale providing local provenance seed for restoration projects commented to me:

'Traditional mixed farms started to disappear across most areas of lowland Britain where, with inputs and bigger machinery and the climate not too wet, as soon we we went in the EEC (1973) because of the arable area payments regime. From the heavy clay lands of the midlands and places like the Vale of Aylesbury to the Berkshire downs and chalklands of southern England, arable with no livestock became prevalent.

To start with the arable farming to some extent fed off the soils that had been built up when much of this land had been permanent grassland and when environmental constraints of the land played a role in the choice of how the land was farmed. Environmental constraints were chucked out of the window, leading to soil erosion and increasing pollution of watercourses as huge areas of land were converted from pasture or meadow to arable cultivation.

One field on the Berkshire downs (level land) lost half its topsoil by the time it was restored to permanent grassland under an environmental stewardship scheme 30 years later around 2006. This was one of the fields I provided seed for'.

Dairy farming became ever more concentrated in the wetter south and west, which favoured grass growing, and many pastures were resown to create monocultures of perennial rye grass, eliminating flowers and hundreds or thousands of insects and other wildlife species that survived in diverse pastures.

Surviving ancient hay meadow at Wendlebury Meads in Oxfordshire

Perennial rye grass field

By the 1990s, many dairy farmers were feeding cattle by growing maize (aka 'corn' in the US), and making a lot more silage (a form of pickled vegetation designed for feeding to ndoor livestock). New American Holstein cattle bloodlines were introduced which were less hardy but produced hugely more milk. The RSPCA has argued that:

'The modern dairy cow is probably the hardest-working farm animal and possibly the most vulnerable … . There is a particularly vulnerable period in the cow's physiological cycle that makes her susceptible to metabolic and infectious disease, notably, the pre- and post-partum period where the cow moves from pregnancy to high milk production resulting in major nutritional, hormonal and metabolic stresses that have to be carefully managed. There needs to be a complete re-evaluation of cattle husbandry methods and associated risk of bTB'.

Keeping high-milk-producing cattle most or all of the time in sheds produced large amounts of slurry (cow faeces). Similar intensification took place in pig and poultry farming.

So, as noted above in the discussion of siloed science, in general terms, the history of UK cattle-TB spans a period of 'extensive farming' from the early C20th through to the 1960s, in which a low point of disease was reached by use of cattle farming control measures. The current TB epidemic began in the 1970s and sped up to reach the current sustained high levels of infection, broadly in step with industrialisation and intensification of UK farming.

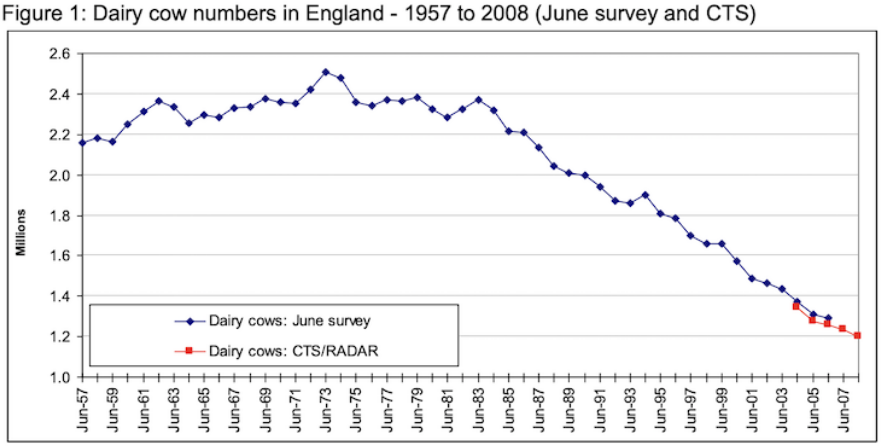
This raises the question, not much discussed in the welter of reports on TB, cattle and badgers, of whether the nexus of changes involved in farm intensification have themselves

encouraged TB as a disease, and made it harder to get rid of, and so whether to do so, significant changes in farming may be needed rather than just badger culling. While the well-being of badgers alone may not weigh heavily in this calculation, the net benefits to society of cleaning up and downsizing intensive cattle farming could be enormous.

Intensification has meant specialisation (each farms typically doing more of fewer things, eg just growing cereals or milking dairy cows) and (for decades as an aim of policy), producing more per unit area. This has meant fewer not more cattle, with numbers peaking in 1974 at over 15 million and then falling 5 million by 2015, while milk produced per cow increased.

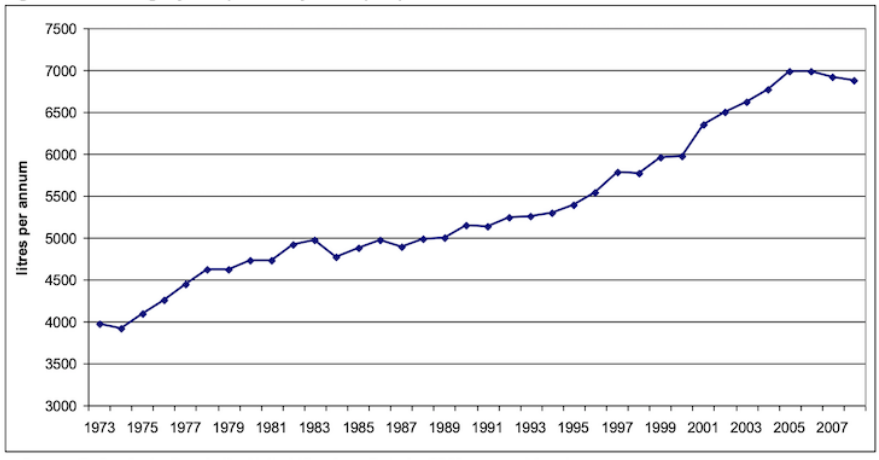
Dairy herds have tended to become bigger, and fewer, and concentrated on a few high-yielding types of cattle. A 2019 global study of dairy intensification notes that 'in the UK, for example, between 1995 and 2017 the number of dairy farms fell from around 35,000 to 13,000 while average herd size tripled'. Consequently the number of dairy farmers and workers has fallen precipitously (from nearly 200,000 in the 1950s), while the use of contractors going from farm to farm, has increased.

Figure 1: Dairy cow numbers in England - 1957 to 2008 (June survey and CTS)



Source: Defra, June Survey and CTS data from RADAR system.

Figure 2: Average yield per dairy cow (UK)



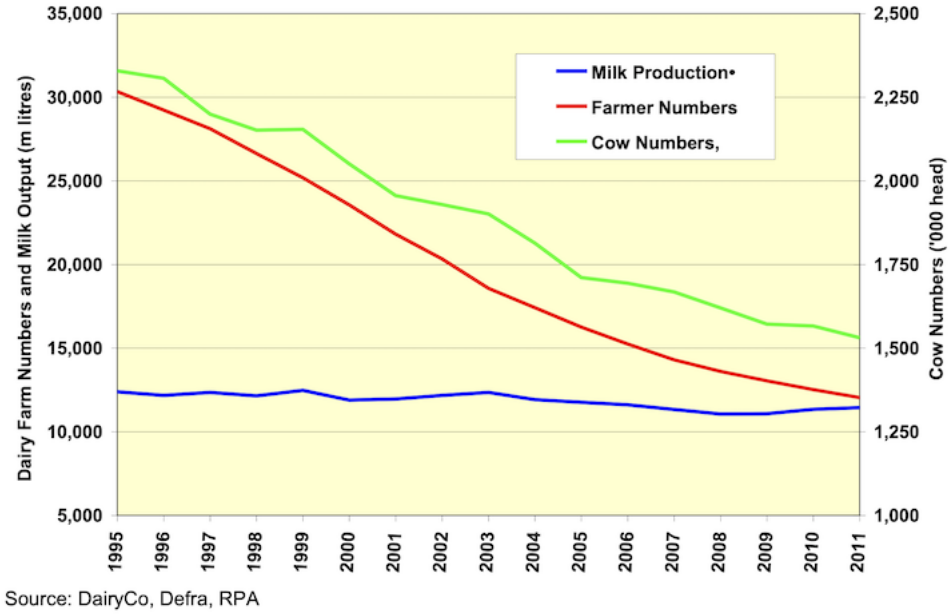
Source: Defra, Agriculture in the United Kingdom. Data for 2008 are provisional.

Intensification of dairy farming post 1973 (entry to EEC): numbers of cows decreased while yield per cow increased – Source Defra

The main driver for larger herd sizes is generally assumed to be lower unit costs of milk production. In the US, where the process is further advanced, 'in 2010, cost of production per litre of milk was more than three times higher for farms with fewer than 50 cows than for farms with more than 2000 cows'. However a 2013 UK study by the Dairy industry group Dairy Co 'The structure of the GB dairy farming industry – what drives change' - found that 'Larger herds do not currently achieve a higher milk price than smaller units'. It also noted:

1. *Restructuring in the GB dairy industry has been considerable – on average there has been a loss of over 1,100 farmers per year across GB since 1995. However, over this period total milk output has been relatively stable with both average herd size and average yield per cow increasing to compensate for declining producer numbers.*
2. *Milk production in Great Britain has moved west over the past few years. This is partly due to the more favourable conditions for growing grass in the west and partly due to the wider range of options available to dairy farmers in the Midlands and East (both farming and non-farming).*

Figure 2: Trends in the GB dairy sector: 1995 to 2011



Source: DairyCo, Defra, RPA

From: *The structure of the GB dairy farming industry – what drives change*

It also observed:

dairy farmers further west exhibit an element of comparative advantage where they are able to produce milk at a lower cost by utilising a higher proportion of forage. Agricultural land prices may also influence this shift, with development pressures from urban areas, 'lifestyle buyers' as well as alternative agricultural sectors increasing relative values in the south east and midlands especially.

Further evidence for this westward shift is the fact that within both Scotland and Wales there is evidence of increasing milk production in western areas such as Dumfries & Galloway, Pembrokeshire and Carmarthenshire, for example

And:

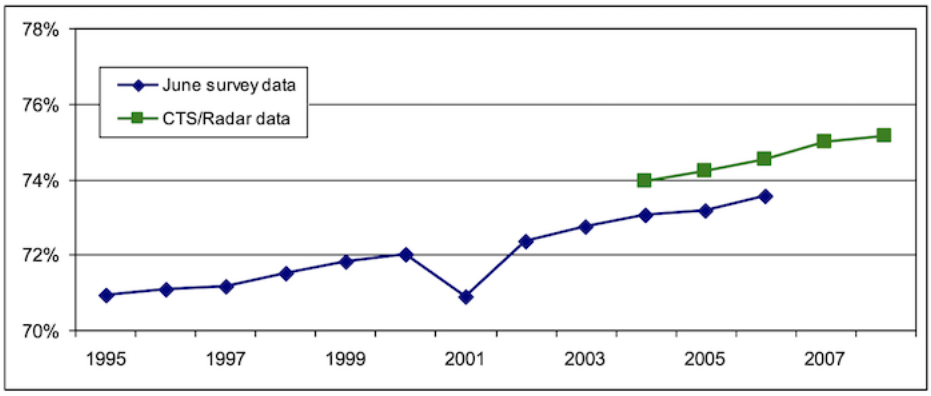
Lastly, many of the major milk buyers/processors are located along the major transport networks on the western side of the country. There are considerations of cause and effect, with milk processors for manufactured products particularly wishing to be in located within extensive 'milk fields' to minimise transport costs. Once the plants are in place, however, they are a fixture and may, in turn, encourage greater milk production nearby.

Table 6: Regional dairy cow numbers and changes (2004-2008)

NUTS1 regions	2004	2005	2006	2007	2008	Change 2007/8	(Th. Head) Change 2004/8
NE	19	18	17	17	16	-4.6%	-18.3%
NW&M	307	294	293	290	281	-3.2%	-8.5%
Y&H	110	105	103	100	97	-2.6%	-12.0%
EM	99	93	91	88	84	-4.5%	-15.0%
WM	198	187	185	181	176	-2.8%	-11.1%
E	27	25	24	23	22	-4.3%	-19.6%
SE&L	94	87	86	82	79	-3.6%	-13.1%
SW	488	466	460	456	444	-2.5%	-9.0%
England	1,343	1,276	1,259	1,236	1,199	-3.0%	-13.1%

Source: Defra, RADAR

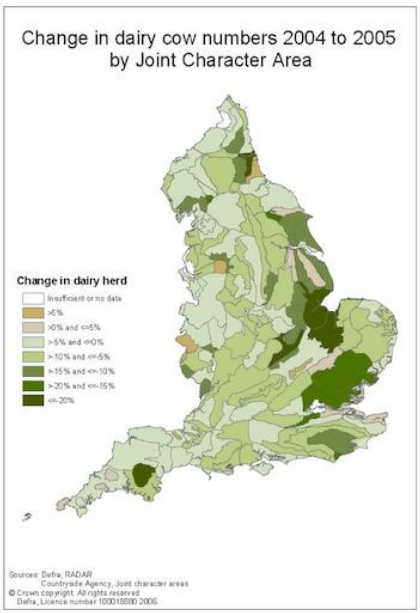
Figure 16: Proportion of dairy cows in the west of England (a)

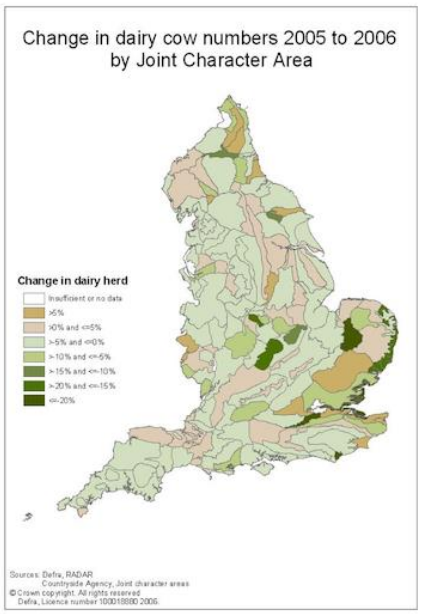


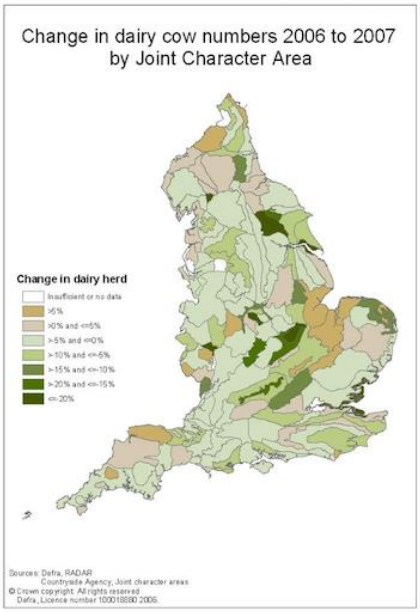
(a) North West, West Midlands, South West.
Nb Regional distributions affected by Foot and Mouth Disease in 2001. Data at June each year.

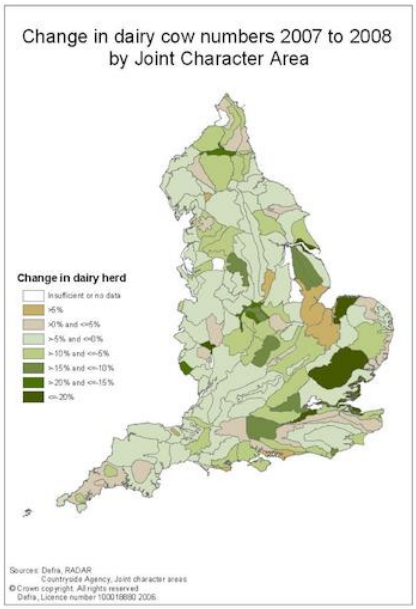
Concentration of dairy cows in the south west of England 2004-8 - Defra

These effects of concentrating dairy in the west and increasing herd sizes will obviously have also geographically concentrated any negative environmental effects of intensive dairying, and possibly 'intractable' TB problems involving badgers. The push-pull effect of also concentrating distribution infrastructure may pose a challenge to de-escalating dairy intensification.

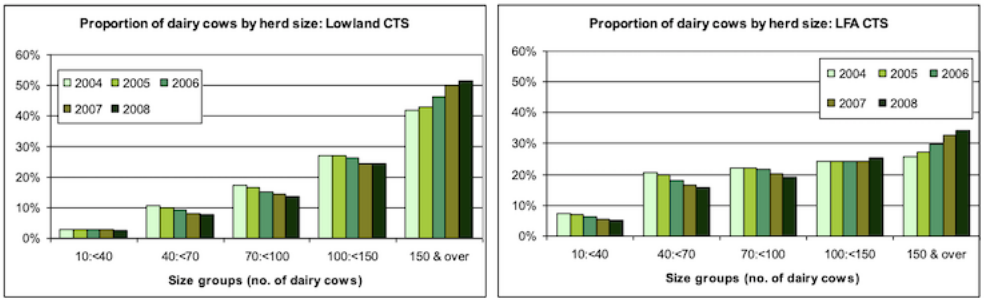








Above: losses of mixed farming underlie the greater reductions in dairy farming in the centre and east in the 2000s – Source Defra



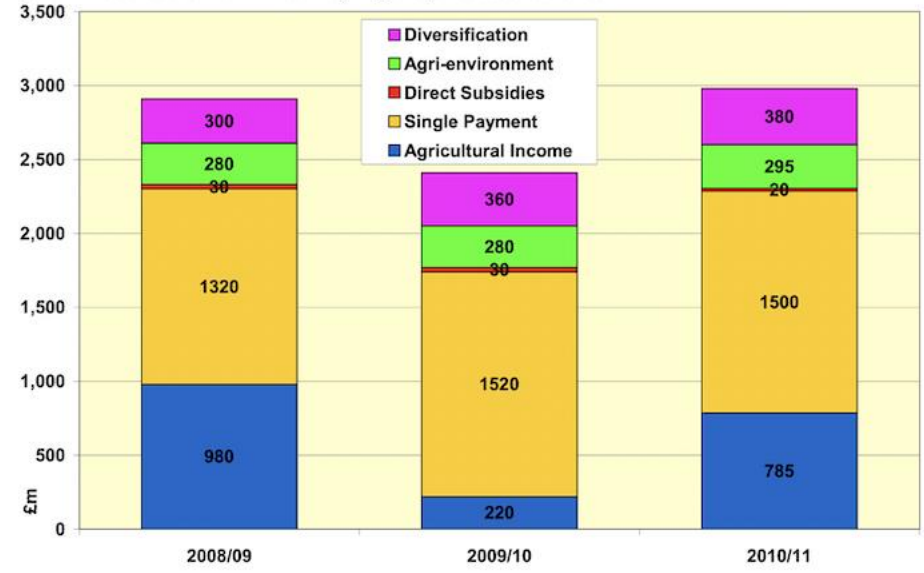
Source: Defra, CTS/RADAR.

Increasing dairy herd size, particularly in the lowlands in the 2000s – Source Defra

Dairy Farming Income

The DairyCo report also provided this analysis of dairy farm income.

Figure 21: Sources of farm income (England): 2008/09 to 2010/11

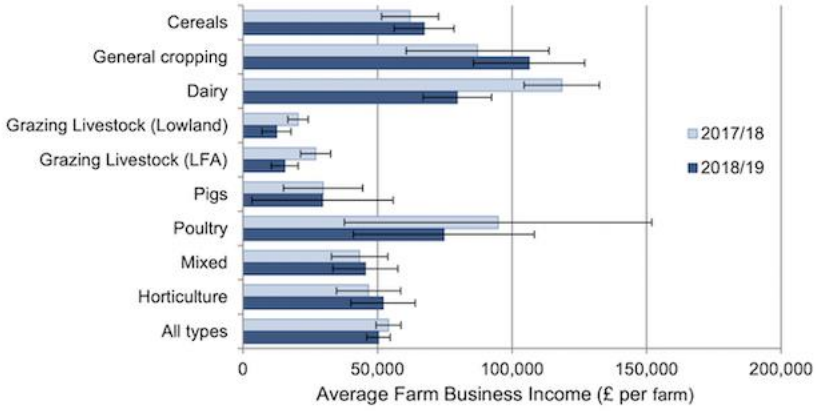


Source: Defra

From the above it appears that the great majority of dairy farm income between 2008 and 2011 was public subsidy of various forms (agri-environment, direct subsidy, single farm payment, and possibly with some public finance behind 'diversification').

The latest (2018/19) Defra Farm Accounts survey show that dairy farming had the highest net profit (Farm Business Income) of any farm sector in 2017-18:

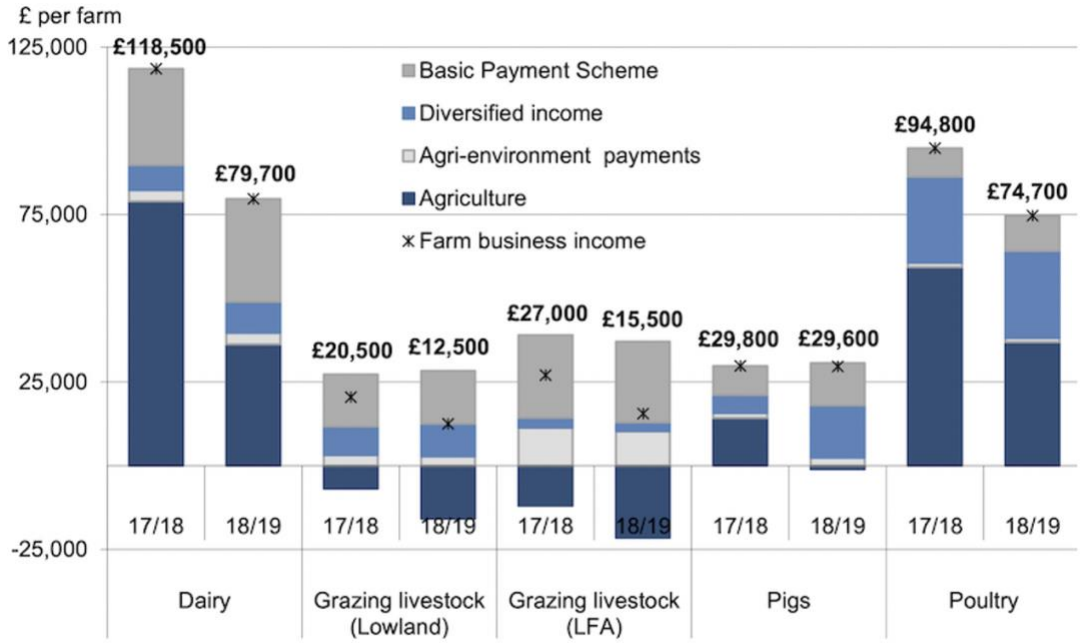
Figure 1: Average FBI by farm type with 95% confidence intervals - England, 2017/18 and 2018/19



Source: Farm Business Survey, England

Dairying also has the highest percentage of farm businesses with a profit of over £75,000 a year. Other livestock grazing is far less profitable.

Figure 11: Average FBI broken down by cost centre for livestock farms, 2017/18 and 2018/19



Source: Farm Business Survey, England

The figures in bold above each column are the average FBI per farm. FBI can be lower than the total height of the bars where average income from agriculture is below zero.

Data from the survey shows (below) that an average of a third of dairy farming income was subsidy (in the form of Basic Payment Scheme and Agri-Environment) between 2017 and 2019, while for lowland grazing livestock it was over 100% and for grazing livestock in Less Favoured Areas (uplands) it is over 150% (as the farms made a loss and gained subsidies).

SPLIT OF FARM BUSINESS INCOME BY %						
Dairy						
	2017/18		2018/19		AVERAGE	
Agriculture	£79,000	*66.67%*	£36,300	*45.55%*	**£57,650**	***58.17%***
Agri-environment	£3,300	*2.78%*	£3,300	*4.14%*	**£3,300**	***3.33%***
Diversification	£7,500	*6.33%*	£9,400	*11.79%*	**£8,450**	***8.53%***
Basic payment scheme (BPS)	£28,700	*24.22%*	£30,700	*38.52%*	**£29,700**	***29.97%***
	£118,500		£79,700		**£99,100**	
% of Agri-environment & BPS [subsidy]		*27.00%*		*42.66%*		*33.30%*
Grazing Livestock (Lowland)						
	2017/18		2018/19		AVERAGE	
Agriculture	(£6,800)	*-33.17%*	(£15,800)	*-126.40%*	**(£11,300)**	***-68.48%***
Agri-environment	£3,200	*15.61%*	£2,800	*22.40%*	**£3,000**	***18.18%***
Diversification	£8,500	*41.46%*	£9,700	*77.60%*	**£9,100**	***55.15%***
Basic payment scheme (BPS)	£15,600	*76.10%*	£15,800	*126.40%*	**£15,700**	***95.15%***
	£20,500		£12,500		**£16,500**	
% of Agri-environment & BPS [subsidy]		*91.71%*		*148.80%*		*113.33%*
Grazing Livestock (LFA)						
	2017/18		2018/19		AVERAGE	
Agriculture	(£12,000)	*-44.61%*	(£21,500)	*-138.71%*	**(£16,750)**	***-79.01%***
Agri-environment	£11,300	*42.01%*	£10,300	*66.45%*	**£10,800**	***50.94%***
Diversification	£3,000	*11.15%*	£2,700	*17.42%*	**£2,850**	***13.44%***
Basic payment scheme (BPS)	£24,600	*91.45%*	£24,000	*154.84%*	**£24,300**	***114.62%***
	£26,900		£15,500		**£21,200**	
% of Agri-environment & BPS [subsidy]		*133.46%*		*221.29%*		*165.56%*

Source: own commissioned analysis of Defra statistics

A 2020 Defra analysis of the performance of dairy farms found that herd size was positively associated with higher performance of both the farm business as a whole and the solely agricultural part (the only other factor this was true of, was being an organic farm).

In UK dairy, many of these changes (except being organic) have been identified as raising the risk of cows contracting TB, and are themselves linked.

For example, maize, a crop actually best suited to the warmer drier south-east, is now most commonly grown for cattle feed in the south-west, and is sown late in the season, frequently on land used to spread cattle slurry. An infected cow sheds 400 times as many TB bacteria as a badger, slurry can spread TB over fields and is more likely to be washed into watercourses in autumn and winter when there is more rain. Slurry-moving contractors machinery was first identified as a farm-to-farm TB risk in the 1970s. Badgers are omnivores and are attracted to maize to eat.

An extensive 2016 literature review of TB in UK and Ireland noted:

Intensive management practices that increase cattle to cattle contact within a herd are associated with an increased risk of bTB incidents [116]. Case-control studies have found dairy herds kept in cubicle housing [95] and covered yards [71] have a substantially increased risk of bTB. This type of housing may be a proxy for the effects of greater stress or reflect a more intensive management system that increases cattle contact rates. This is supported by studies in GB that found the presence of a loafing yard or paddock adjoining cattle housing [114] and not providing housing for cattle [75] reduced the risk of bTB

It stated:

some clear and consistent patterns have emerged across a broad range of infection prevalence and environments. Prominent are the increased risks associated with animal age, contact with a wildlife reservoir and the size of the herd. Purchasing strategies and management practices that favour intensive production, also promote increased contact among cattle (housing) and with wildlife (fragmentation, farm size) at the expense of hygiene and biosecurity.

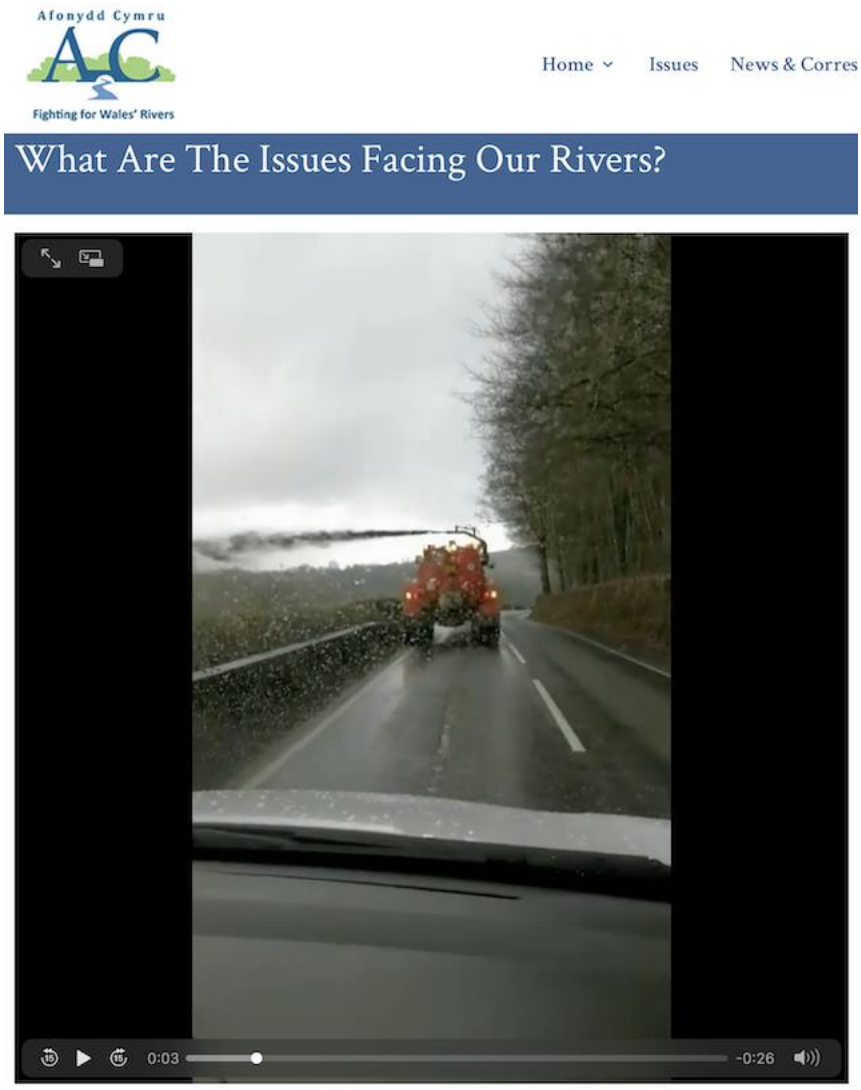
This is not to suggest that every intensive cattle farm will suffer from TB. For example while silage 'clamps' are a known risk, the same review says:

Feeding from the ground either at pasture or during housing [115], storing silage in clamps [93] and feeding green foods/kale or barley have been associated with an increased risk of a bTB incident [114]. These findings could be potentially attributed to increased contact with wildlife. Silage, in particular maize silage [118] is attractive to badgers, and was found to be associated with badgers entering farm buildings in one study [119], but visits to silage clamps were rare in another larger scale study [120]. The storage and feeding of silage from clamps is associated with persistent breakdowns [93] [breakdowns = TB outbreaks in a herd] *potentially related to the clamps being more accessible to badgers. Feeding hay rather than silage/concentrates has been reported as protective [93, 95, 121], and a case- control study found herds fed silage had a greater risk of a breakdown [116]. In one study, all farms that*

experienced a persistent breakdown were fed grass silage, although 85% of the TB-free farms also did so [93].

However it seems highly probable that some practices inherent in the intensive model make it more likely that cattle will contract and spread TB, whether via badgers or not, and that badgers will get TB and be able to transmit it back to cattle, and that with less intensive farming, bovine TB in the UK would be more easily suppressed or eliminated.

Slurry and Cattle Movements



Video by Afonydd Cymru of slurry being spread from a farm tanker driving along a Welsh road

The 2018 Godfray Review observed that:

In a survey of over 1,000 farmers in the south-west, over 90% of dairy farmers and 85% of livestock farmers used contractors. The movement of slurry tankers without being washed or cleansed within and between farms was identified as a potential risk factor in an outbreak of bovine TB in Cornwall nearly 45 years ago. A recent study in Northern Ireland found an

association between increased risk of bovine TB and the use of contractors for spreading slurry.

And:

We note recent evidence that the potential for bovine TB to be dispersed by spreading slurry or manure on the land may have been under-appreciated. We believe obtaining more evidence on this transmission route, and then if appropriate mitigating it, is important.

In its report on TB, *It's Not All Black and White* the RSPCA states 'With modern management systems in larger dairy herds, it is increasingly the case that dairy replacements are reared elsewhere and then introduced to the herd shortly before calving'. It points out that Godfray reported:

'1.7m cattle were moved within and between different risk areas in England in 2016. Movements between non-contiguous parts of a single farm business, which may be some distance apart, are not included in this figure. This number of movements has remained broadly similar over time and includes substantial numbers moving from higher to lower-risk areas. Even if a small fraction of the animals that are in transit is infected, the very large number of movements suggests this could be a potentially important source of new infections."

A 'spatial analysis' (GIS) study of cattle movements from 1987 to 1997 which was conducted for DEFRA between 1999 and 2003 set out to investigate why bovine TB persisted as 'hot spots' in 'large parts of the Southwest and the Midlands', and what role climate, badgers and trace-deficiencies (ie mineral soil deficiencies) might play. After a huge amount of effort to standardise data it found that:

'The overall spatial trend of the disease throughout the period was for it to spread progressively from the core areas of Cornwall and Gloucestershire, to which it was largely confined to in the mid-1980s, into surrounding counties. This spread was gradual in the first half of the period (1987-1992), but increased exponentially during the second half (1992-1997)'

But analysis showed:

'the situation was more complex than indicated. Firstly, the disease was never absent from other parts of the country, with most counties of England and Wales experiencing breakdowns, albeit it a low level, in the earlier, contained period. Secondly, in the core high-incidence areas, the disease situation was not static, with high incidence parishes "flaring" up for a year or two, before settling down again …

It distinguished between 'endemically infected areas', 'non-endemic areas', 'and those which switched from being largely free of the disease to becoming endemic during the period'.

In ‘endemic counties like Cornwall ‘with rigorous annual testing’ ,’the disease was successfully controlled once it was detected’. And ‘the essential problem in these areas appears to be a failure to prevent new infections entering into herds’.

While the source of this was ‘undoubtedly’ local, ‘as throughout the period movement-on tracing was rigorously undertaken’ it was not possible to say if this was down to ‘neighbouring cattle herds or the reservoir of infection in badgers’ … ‘due mostly to the lack of key data, particularly on wildlife density, infection status, and the patterns of local cattle movements’.

‘In the consistently non-endemic areas, *such as the Midlands and the North, most of the disease was attributed, following an epidemiological investigation, to purchase of animals from infected areas. In these areas, despite the low frequency of testing (i.e. every 3-4 years), the disease was successfully contained, and the disease control system can be retrospectively considered to be both cost-effective and successful’.*

In other words TB got into the herds in the North and Midlands through cattle movements, and was then contained?

In counties *‘such as Hereford & Worcestershire & Gwent, which were largely free of disease in 1987, but has become endemically infected by 1997’,* here *‘the disease quickly became established over a large part of the counties, particularly in the southern section bordering Gloucestershire, in a relatively short time’.*

The authors ‘conjectured’ that this was if ‘the four-yearly surveillance system’ had been ‘more frequent’… ‘the "take-off" of the disease might have been slower’.

They concluded:

‘While such an analysis will enable answers to key questions of the role of climate and trace-elements in the maintenance of the disease, it will not be able to elucidate completely the disease-environment interaction … because … ‘a key variable - badger density - is missing, and the lack of such data remains a critical problem for future spatial analyses’.

So in common with many studies it suggested that cattle movement introduced the disease into new areas, where it was sometimes controlled by cattle testing (and removals from herds) but not in other cases, and that inadequate data meant factors such as transmission between cattle and badgers, and climate and soil minerals could not be determined.

Herd Size

Numerous studies have found larger herds are a TB risk. The most obvious reason is that while the standard SICCT test (Single Intradermal Comparative Cervical Test) has high specificity (meaning it gives very few false positives), it is only 50-80% sensitive, meaning that it ‘misses’ 20-50% of cattle infected with TB. The larger the herd, the more likely it will include at least one ‘missed infection’ and the greater the potential consequences if that

animal then infects others. (This is exactly the same reason that coronavirus control measures include 'social bubbles' of limited size).

This 'testing issue' also means that many critics perceive conclusions based on historic SICCT test results as unreliable. In 2019 a group of vets and conservationists appealing to UK Prime Minister Boris Johnson not to go ahead with a new badger cull wrote that 'The failure of this standard skin test leaves a huge occult burden of tens of thousands of infected cattle in the high risk area (HRA) alone'.

The RSPCA has stated:

'We believe there is enough evidence to support the theory that there is a large, undetected reservoir of bTB in the cattle population (Christl A. Donnelly and Nouvellet 2013), and that this is increasing due in part to continued reliance on an inadequate testing regime, suboptimal cattle management and poor biosecurity'

Maize

Soil runoff from a maize field – from Runaway Maize by the Soil Association

"from my own experience in Essex, and I know that was a clear bTB area, as soon as I started introducing the growing of maize, and maize for game shooting, which stays in the ground for quite a long time, I had a very significant badger population move in. Then the issue of haymaking against silage making; we're perhaps missing some of the indicators that we should be looking at, and we should learn from, as to how agriculture changed over the 1960s, 1970s, and 1980s. I think that's important"

[Mark Thomasin-Foster, former National Chairman of the Farming and Wildlife Advisory Group and Chairman of the Minister's Panel on Badgers and bTB (1987–1997), speaking at Wellcome Trust panel on the history of bovine TB in the UK 1965 - 2000 in 2014].

"… unfortunately what tends to happen is that we almost farm badgers in places in the West Country. We have short pasture, well fertilized, grow lots of maize, all things badgers love, and if there's more food you're going to have more badgers. No two ways about it. I also think we've concentrated too much on badgers; we should be looking more into the cattle, cattle that can have some sort of immunity".

[David Williams, badger researcher, Chairman of the Badger Trust, trainer in badger ecology for the Mammal Society and Chartered Institute of Environmental and Ecological Management, also speaking at the Wellcome Trust panel].

Growing maize is a relatively recent development in the UK. It increased from around 8,000 acres in 1973 to 197,000 hectares in 2017 and is strongly associated with dairy farming. (Another source cites figures of 500ha in 1980 and 164,000ha in 2010). A Defra Agricultural Change and Environment Observatory report from 2009 shows (below) that the area under maize increased rapidly in the early 1990s, primarily for feeding to dairy cows. More recently a survey found that maize is also being favoured by farmers because it is less affected by weather which is bad for growing grass and making silage.

Figure 29: Area of maize grown on holdings with dairy cows by region

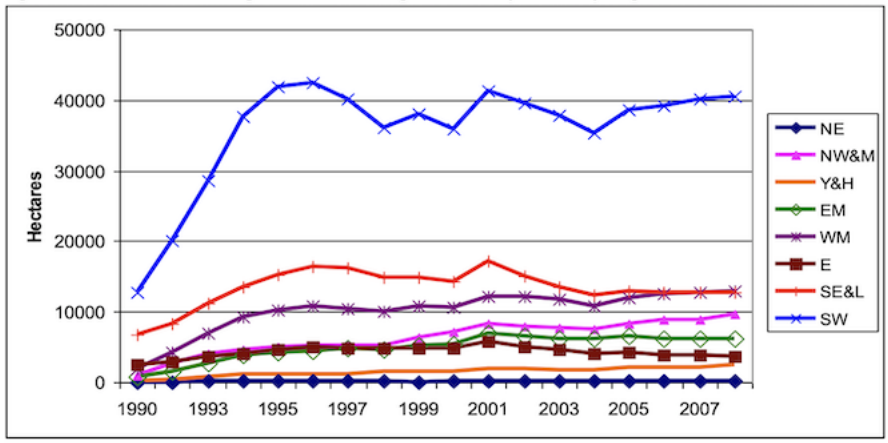
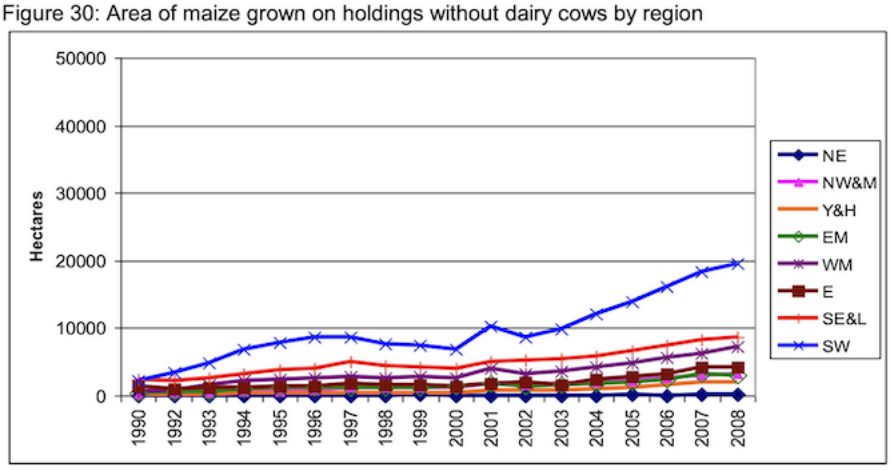


Figure 30: Area of maize grown on holdings without dairy cows by region

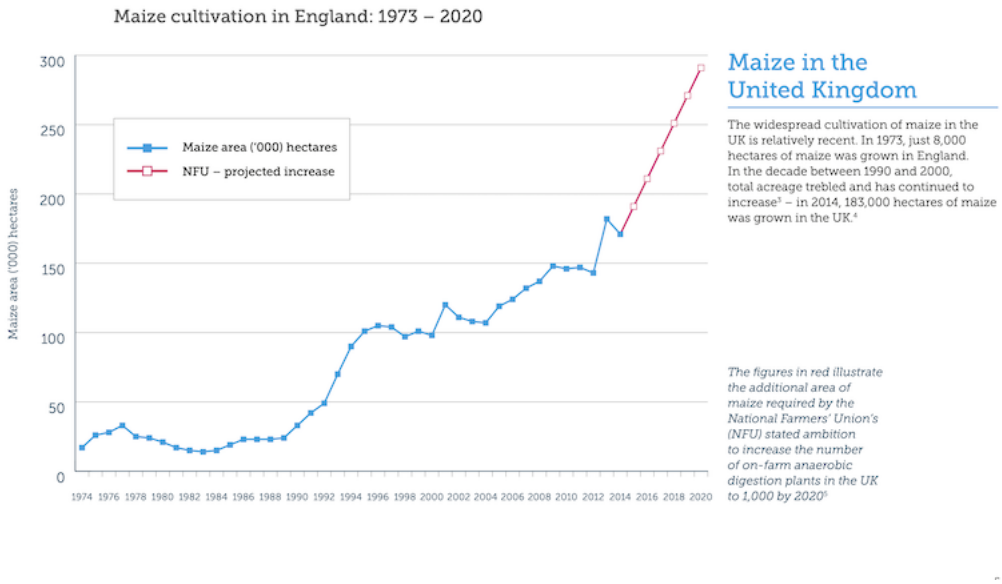


Defra 2009

DEFRA noted in 2009 'Dairy enterprises are becoming increasingly concentrated in the wetter west of England, where there is more likelihood of soil damage' and 'forage maize is a major cause of run-off and erosion, due to ruts left by harvesting machinery and drill rows after planting'. In 2007 another DEFRA study had found growing more maize was likely to cause an increase in climate changing gases, nitrate leaching and ammonia emissions.

In 2015 the Soil Association (SA) published a report Runaway Maize, which described maize as probably the fastest expanding crop in the UK, and a 'national scandal' because of it's 'severe negative impacts on public goods such as soils and freshwater'. It stated that the NFU wanted the area of maize to increase by 125,000 ha, land which could otherwise produce a million tonnes of wheat or over five million tonnes of potatoes. Maize is typically grown with much higher pesticide use than grass.

It wrote that 'use of maize for silage is now known to have a significant negative effect on the nutritional content of both milk and meat. Eating maize may also make both badgers and cattle more susceptible to TB'.

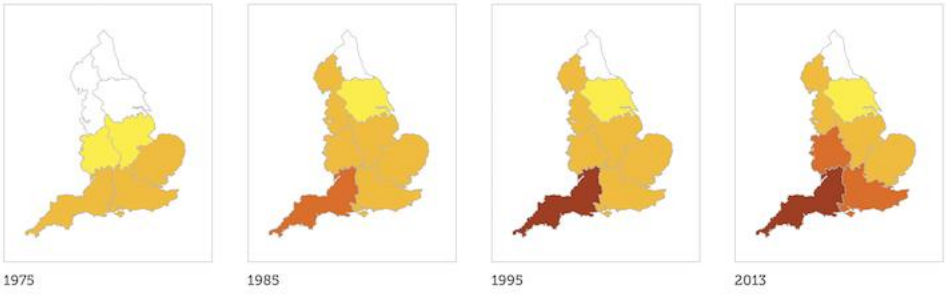


From *Runaway Maize* by the Soil Association (2015).

The report noted 'estimates suggest that during the storms and heavy rainfall in the winter of 2013/14, every 10 hectare block of damaged land under maize stubble produced the equivalent of 15 Olympic swimming pools (more than 375 million litres) of additional runoff', and 'research published in 2014 found that 75% of late-harvested maize sites showed high or severe levels of soil degradation'. (Anyone living in an area where maze is grown does not need a report to see this: soil frequently stains water running across roads and into rivers from maize fields after rain).

The SA called for an end to subsidies for growing maize for AD biogas digesters (and instead apply them to waste materials), an end to several subsidies, and for compliance with officially recognised best practice in maize growing to be made mandatory.

Growth in maize cultivation in England: 1975 – 2013



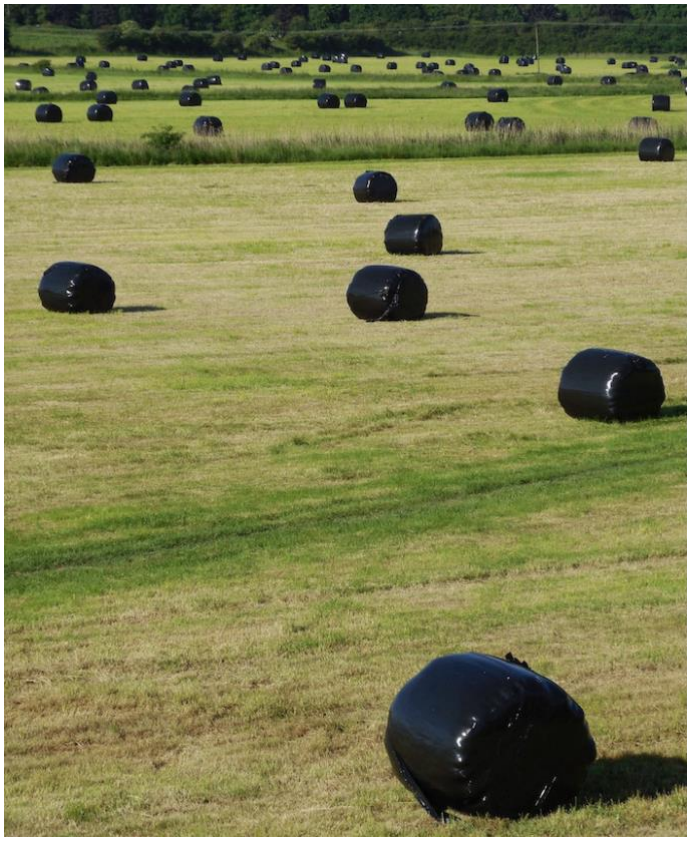
From *Runaway Maize* by the Soil Association (2015).

The spreading distribution of maize is strikingly similar to both the distribution of dairy cattle and the spread of TB in cows. On TB the SA noted:

'There is anecdotal evidence (with some theoretical scientific basis) that maize is responsible for encouraging the spread of bovine TB in badgers (which eat maize cobs), and for making cattle fed on maize more susceptible to TB, because maize is low in selenium. Some farmers believe that TB infection can be successfully managed by feeding selenium supplements to both cattle and badgers. It is suggested that maize, deficient in a number of trace elements, including selenium, may result in a greater susceptibility to the spread of bovine TB. No scientific research has been done to investigate this theory, although the Soil Association has long called for more research to be conducted to establish if any link exists'.

Silage

Silage is what's in most of the large bales wrapped in plastic that are now a familiar sight in the countryside. Before plastic bales, silage was transported to 'clamps' (heaps, pits or bunkers usually covered with plastic sheeting to encourage anaerobic fermentation to convert green plant material to 'silage').



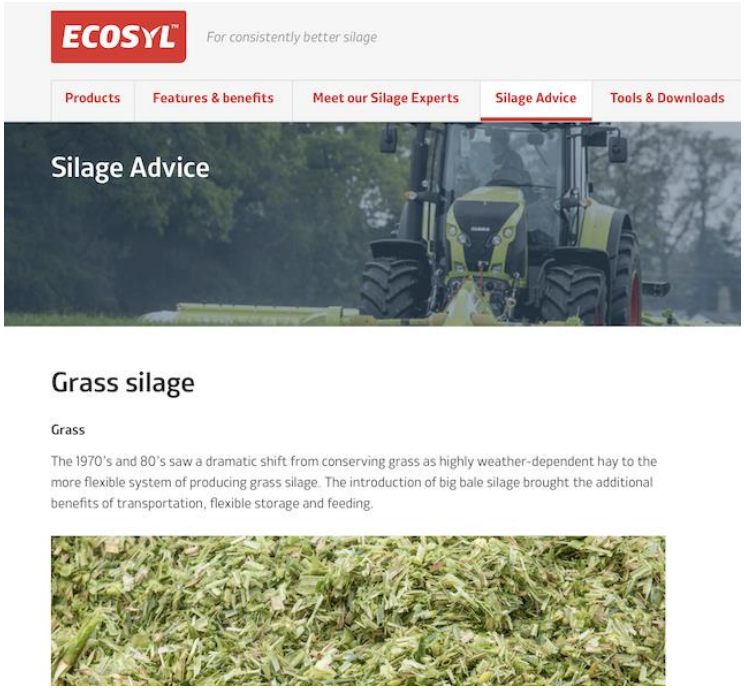
Silage bales, Norfolk – Chris Rose

Ecosyl, a company which makes silage additives, explains:

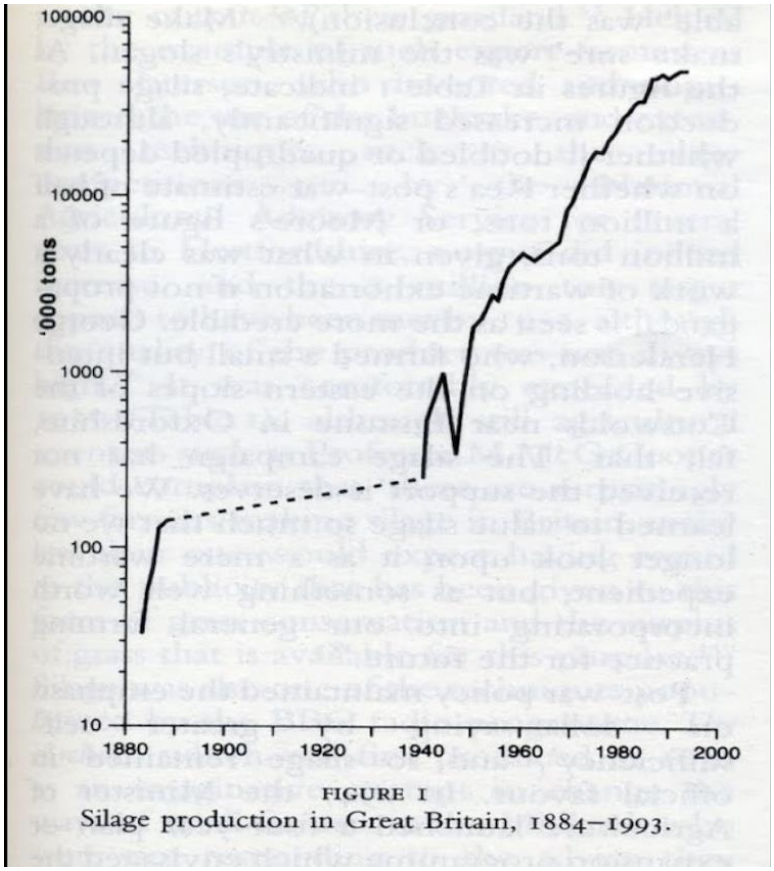
'*The 1970's and 80's saw a dramatic shift from conserving grass as highly weather-dependent hay to the more flexible system of producing grass silage. The introduction of big bale silage brought the additional benefits of transportation, flexible storage and feeding.*

Grass silage is basically pickled grass. The aim is to retain as much feed value as possible by encouraging lactic acid bacteria to ferment grass sugar to produce lactic acid.

The lactic acid lowers the pH and prevents the growth of spoilage micro-organisms, allowing a stable preservation of grass as silage. To achieve this, there must be sufficient sugar available and fermentation must occur as quickly as possible in and air must be excluded throughout (anaerobic conditions). This can be done in a silage clamp or in big bales'.



From the Ecosyl website



Silage production increased after WW2 and continued. From https://www.bahs.org.uk/AGHR/ARTICLES/44n1a5.pdf

Silage (in the UK most often made from a rye-grass monoculture which supports almost no wildlife) is another element of farm intensification with a damaging effect on nature. Many former hay meadows, even in areas like the Yorkshire Dales National Park, are now fertilised grassland cut for silage. This eliminates most of the flora in favour of a few 'productive' grasses and because silage is increasingly cut several times in a season, is often fatal to ground-nesting birds, contributing to the decline of the skylark and of the curlew. As it is increasingly cut early in the season, silage-making also often kills leverets, young hares.

Making silage in Swaledale, Yorkshire Dales – Chris Rose

Ecosyl writes:

In 1970 about 80% of the grass conserved was as hay but this had fallen to less than 30% by 1990 due to a 5-fold increase in silage ...

Good hay is more palatable than silage due to the high sugar content and the reduced protein breakdown. The breakdown of hay in the rumen also results in a more synchronised release of energy and protein. Its main disadvantage is its reliance on having 5 or 6 days of good weather, something which cannot normally be guaranteed in the UK.

In order to aid the drying process it is preferable to have a stemmy, low yield crop, the latter usually achieved by application of low levels of fertiliser. The crop at harvest is therefore already of relatively low nutritive value. Further losses in feed value will be incurred during field drying, especially in poor weather, and this can result in a very variable product.

Silage is made from more digestible material and is not so reliant on the weather. Techniques for making silage have improved greatly over the last few years, making it possible now to produce high quality silage routinely. All in all, silage making

makes more efficient use of the grass, reducing the need for bought-in feeds and increasing profitability.

The RSPB notes that: 'silage is generally cut too early and too frequently to produce seed or allow birds to complete nesting and the high levels of fertiliser used severely reduces the variety of species and habitats'.

Like slurry, silage has a very high 'Biological Oxygen Demand' (the amount of oxygen it takes up in water) and so is extremely damaging to the life of streams and rivers. In the 1980s an ADAS (Agricultural Development Advisory Service) estimated that 20 – 45% of silage was lost from storage, and although by 2002 this was reduced to 15 – 25% by use of better equipment, effluent was still the main pollution threat.

The farming industry is generally enthusiastic about silage, describing it as 'progressive'. A survey of over 150 dairy farmers found 89% wanted to increase their milk from forage (silage), and '60% stated that first cuts have become earlier over the past three years and 44% reported shortening their cutting intervals'. "We are clearly seeing a significant shift towards a more progressive approach to grass silage-making amongst UK dairy farmers," said Germinal GB's Ben Wixey in 2018. "This move to earlier and more frequent cutting is often referred to as 'multi-cut'.

The 2000 Phillips Review for MAFF on cattle TB and husbandry noted that in the aftermath of silage cutting, where cattle were turned out onto cut fields, they tended to favour the remaining longer grass at the edges, which were also more likely to be frequented by badgers for latrines and marking their territory. Unlike silage, hay making was a 'significant negative' risk in studies. It also reported that low cutting for silage could expose more soil, which is often ingested by cattle anyway, and is a TB risk.


Hay bale and uncut hay at Fritton Common, largest surviving hay meadow in Norfolk with red clover and oxeye daisy

Slurry and Farm Pollution of Rivers

Hardly any British rivers are in a good ecological condition, and although 'overflows' from the country's creaking sewage system are much more obvious, intensive farming is a major reason why. Water pollution from farming (nitrates from fertiliser, run-off from leaking slurry pits and silage clamps, pesticides and polluted soil washing from fields) began to

increase rapidly in line with intensification in the 1980s – 1990s. Sometimes it forms a discernible stream of its own but most of it moves in hard-to-identify trickles and rivulets, or percolates through soil, insidious but in vast quantities.

'Total failure' on English river water quality

By Roger Harrabin
BBC environment analyst

17 September

All of the rivers, lakes and streams in England are polluted, says the Environment Agency.

Although some progress in overall water quality was made from 2000 - 2016, it has since '[plateaued]' with the government unlikely to meet its target that 75% of rivers are healthy by 2027.

Some large agricultural installations are specifically regulated but chronic farm pollution from millions of individual fields and small streams goes largely uncontrolled, and has become worse in recent decades. In 2017, [an investigation] by *The Guardian* and the Bureau of Investigative Journalism found that:

'Serious pollution incidents in the UK from livestock farms are now a weekly occurrence, leading to damage to wildlife, fish, farm livestock and air and water pollution.

The [Environment Agency] in England and its devolved counterparts in Wales and Scotland recorded 536 of the most severe incidents between 2010 and 2016, the worst instances among more than 5,300 cases of agricultural pollution in the period across Britain. In England and Wales the figures relate to pig, poultry and dairy farms whereas in Scotland they refer to all livestock farms.

… even serious pollution incidents may not be prosecuted, and farms that have caused pollution continue to receive subsidies.

There is no official estimate of the cost of the damage caused, or the cost of clean-ups, but many farmers appear to be struggling with the price of preventing pollution, a situation that may deteriorate as farm incomes are threatened by the turmoil of Brexit. In many cases the breaches are likely to be the result of underinvestment in equipment such as slurry stores. … some farmers may be ignoring pollution risks and regard the fines incurred if caught as a cost of doing business. One exasperated inspector noted in a log following farm inspections that the culprits were "leading criminal lifestyles".

… Dairy farms account for the great majority of the recorded instances of agricultural pollution: of the 3,700 recorded in both England and Wales from 2010 to 2016, just over 2,000 involved dairy farms

… more than 1,000 instances of non-compliance with regulations at large intensive farms were identified in each of the last three years: 1,201 in 2014, 1,330 in 2015 and 1,265 in 2016

… the cost of farming in an environmentally responsible fashion remains high. Removing slurry that is not needed costs about £12.50 a ton for a contractor to put it into bags, which cost £600 each. A new slurry store for 100 cows could cost between £7,500 and more than £100,000. Nicola Dunn, water quality advisor for the National Farmers Union, said … "Farms with insecure futures cannot justify such expenditure"

Video from the Bureau of Investigative Journalism/Guardian investigation

In 2020, data from the Environment Agency (EA), the main government body charged with controlling pollution in England, showed only 558 river water bodies out of more than 3,700 in England met its own criteria for 'good' ecological status in 2019, and just three were rated 'high'. (The River Till and two sections of the River Coquet, both in Northumberland).

The Agency itself acknowledged in October 2020 that it lacked both the resources (staff, equipment, budgets and systems) to tackle water pollution, as well as legal powers.

EA Chairman Sir James Bevan was quoted in ENDS magazine as saying:

"Farming, particularly the dairy sector, is causing an increasing number of pollution incidents, but the EA lacks the powers and resources to tackle this effectively"

The previous year, the EA stated 'At the current rate of progress it will take over 200 years to reach the Government's 25 Year Environment Plan target of 75% of waters to be close to their natural state' and noted that it's 'government funding has been cut by 57% since 2010, from £120m to £52m. This has undoubtedly affected our ability to protect and enhance our waters'. Unearthed, the investigative arm of Greenpeace, reported that water pollution sampling the EA had fallen 50% since 2013. In Wales it was reported in 2020 that just 1% of farms met standards for managing slurry.

Inadequate resourcing was reflected in the EA's efforts to inspect farms. The Salmon and Trout Conservation charity and DEFRA board member Ben Goldsmith both cited a statistic that on its current frequency, the Agency would visit each farm once in every 263 years. Rachel Salvidge of ENDS reported that WWF, the Angling Trust and Fish Legal had begun legal action against DEFRA and the EA for failing to protect designated nature sites from water pollution, breaching the EU Water Framework Directive. In September EA data showed not a single river or lakes in England met the Directive's highest standards.

It is strikingly similar position to 2001, when the BBC reported that:

'The Environment Agency says the quality of river water in England and Wales has improved by more than 30% in the past decade and further investments are already underway. But the agency admits there is still a serious problem and says farming practices will have to change if Britain is to comply with the new legislation'.

New Concern

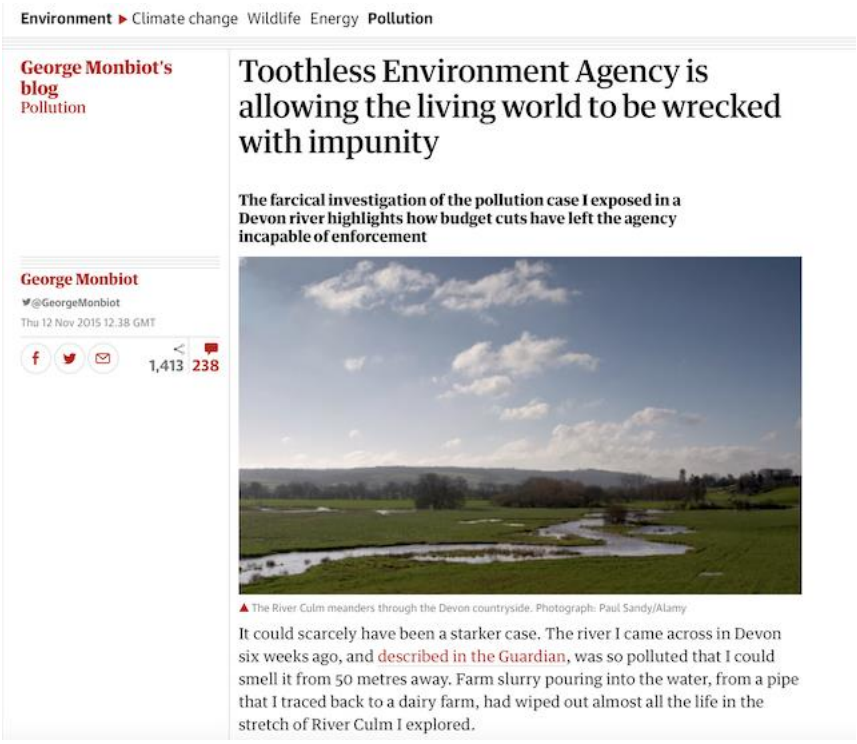
Perhaps because the folk-memory of some rivers so polluted by heavy industry that nothing lived in them and foam covered their surface in the 1950s, and the even older memory that it was not until the House of Commons had to abandon its sittings due to the stench of the Thames, that the Victorians started building a proper sewer network, for generations water pollution has been quite literally a 'backwater' issue in the UK. That's changing, not least due to farming.

Angler Feargal Sharkey, formerly lead singer with the band The Undertones, has been waging his own one man struggle with the EA over dying rivers, on twitter and in the courts. His cause celebre is England's once gin-clear chalk streams, an ecosystem found almost nowhere else in the world, and now liable to be choked by 'sewage fungus' and other agricultural pollution. Residents of the Wye Valley whose River Wye runs much of the border between England and Wales, have also banded together to oppose farm pollution, in their case down to chicken farms as well as cattle farming.

Residents crowdfunding action against farm pollution on the Wye

A few cases of slurry spills get publicity. An agricultural college at Plumpton in Sussex for instance which in 2020 was fined for killing 1500 fish after spreading "a high amount of cow slurry" as fertiliser. Or the 30,000-gallon slurry spill causing 'devastating' fish kill on four miles of the ecologically valuable Grange River in Northern Ireland also in 2020. Or the 100,000 litres of slurry which killed hundreds of fish including brown trout, stone loach, bullhead, lamprey and minnows along 10km of the Southleigh Stream near Colyton in Devon. That spill, also reported this year, resulted from a faulty slurry storage tank and was reported by the farmer himself. ENDS reported that after locating 400 dead fish the EA said "The River Axe is a salmonid river. Assessment of the full extent of the fish kill was hampered by discoloration of the water caused by the pollution and it is likely the final total of casualties was much higher." Devon Wildlife Trust said the river was already in poor condition largely due to agricultural pollution.

Much more agricultural pollution however goes undetected by the limited official system. In 2015 campaigning Guardian journalist George Monbiot reported on his discovery of sewage fungus downstream of a polluting dairy farm on the River Culm in Devon.



Environment ▸ Climate change Wildlife Energy **Pollution**

George Monbiot's blog
Pollution

George Monbiot
@GeorgeMonbiot
Thu 12 Nov 2015 12.38 GMT

1,413 238

Toothless Environment Agency is allowing the living world to be wrecked with impunity

The farcical investigation of the pollution case I exposed in a Devon river highlights how budget cuts have left the agency incapable of enforcement

▲ The River Culm meanders through the Devon countryside. Photograph: Paul Sandy/Alamy

It could scarcely have been a starker case. The river I came across in Devon six weeks ago, and described in the Guardian, was so polluted that I could smell it from 50 metres away. Farm slurry pouring into the water, from a pipe that I traced back to a dairy farm, had wiped out almost all the life in the stretch of River Culm I explored.

Monbiot wrote:

I reported the pollution to the Environment Agency's hotline. It told me it was taking the matter seriously. So when I received its report on the outcome of its investigation, I nearly fell off my chair.

It had decided to take no action against the farmer, as "the long-term ecological impacts on the environment were fortunately low". How did it know? Because there was "no evidence of a fish kill".

Why in the name of all that's holy should there be evidence of a fish kill? This is a chronic pollution case, not an acute one. Fish kills are what you see when a sudden poisoning occurs, as pollutants are flushed into a healthy living system. Chronic pollution deprives fish of their habitats and prey, but no investigator in their right mind would expect to see them floating belly up in the river as a result. They are simply absent from places where you would otherwise have found them.

And if a riverbed covered in nothing but sewage fungus suggests a "low" ecological impact, I dread to think what a high one looks like.

The same inability to distinguish between an acute event and a chronic one was revealed by another of the agency's statements: the pollution "had a short-term impact". The slurry had plainly been pouring out of the pipe for months, as the luxuriant growths of sewage fungus show. It would doubtless have continued, had I not reported it.

The Environment Agency also told me that it had inspected the farm, and found no problems with the infrastructure, as there was plenty of space for slurry storage under the floor of the barn where the cows were kept. But, the problem, as I had explained to them, had nothing to do with slurry storage in the barn. It was caused by leakage from the outdoor slurry lagoons, where I found cow manure pouring down the hill.

Here, as a reminder of what I saw, are some of the pictures I took:

Sewage fungus on the river bed:

▲ Sewage fungus on the bed of the river Culm. Photograph: George Monbiot

Slurry pouring from a pipe cut into the riverbank:

▲ Slurry pours from a pipe into the river Culm. Photograph: George Monbiot

Monbiot noted that this was not an isolated case. 'Freedom of Information requests by the environmental group Fish Legal reveal that the agency sent its investigators to visit just 16% of reported fish kills'. (In Devon, just 3% were investigated and in Cornwall 0%, whereas in Norfolk where there are few dairy farms it was 61% - although see this report of dairy farm pollution of a Norfolk chalk stream from 2020). He pointed out that an analysis by the RSPB and the Wildlife Trusts revealed that new cuts in government spending on wildlife

conservation, air quality and water pollution meant a reduction of nearly 80% in real terms since 2009-10.

Campaigning ecologist Sue Everett regularly tweets about slurry pollution of rivers, soil erosion and other aspects of pollution from intensive farming in the West Country.

Everett is also editor of Conservation News in the (resolutely offline) magazine *British Wildlife*. Here are some extracts from her reports:

***On the farm 31.5** June 2020*

Unsustainable dairy

… 'yet another major slurry spill in south-west England. The 100,000 litre spill from a slurry tank entered a tributary of the River Axe near Colyton in south Devon in early May.

The Axe is already in poor condition owing to pollution from agriculture, but its lower reaches are a designated Special Area of Conservation, Natura 2000 site and SSSI, and the estuary is a Marine Conservation Zone.

Back in February, the Environment Agency, in an internal 'no holds barred reveal-all' report, laid bare a catalogue of regulatory breaches by the dairy farming industry, resulting in serious environmental damage to the river Axe catchment across Devon, Somerset and Dorset. Details of the report have been summarised online by FlyFishing & FlyTying (https://bit.ly/2LkpmH2), which reveals that, during a regulatory clampdown, 95% of farms did not comply with storage regulations and that 49% of farms were polluting the river Axe.

"Despite over a decade of advisory visits in the period up to 2016," it says, "The catchment continued to decline and there were no significant improvements in farming practices."

Sounds just like my part of Somerset. The Environment Agency has this year followed up third party reports, but has insufficient feet on the ground, and enforcement with penalties is almost non existent.

Thus, farmers carry on, knowing they will not get money deducted from their Basic Farm Payment, nor be fined. They may receive a gentle reminder, to improve their slurry storage and tell their operators (often young lads with no or little knowledge of the rules) to be more careful.

The Axe report also revealed that when farmers had money to invest they used this to build new housing and robotic milking parlours, enabling an increase in herd size and likely worsening pressure on inadequate waste management infrastructure.

In my local area, the story is also one of investing in bigger machinery to harvest silage, fewer farms and increasing herd size in a landscape already under severe pressure from excess nutrient production and its disposal on land.

Another unsurprising conclusion from the EA report was that the Red Tractor accreditation scheme is irrelevant for demonstrating environmental sustainability, including compliance with environmental law ...

Close to home, one dairy farm has a new sign, indicating it is a member of a supermarket sustainable dairy group. Its hedges are among the worst managed in the area, and was one of the farms reported for breaching farming rules for water last winter. We have a crisis across pastoral Britain and a widespread avoidance of the rules aiming to protect water. It is time ministers intervened, and the dairy industry got its house in order.

A start would be with the major milk buyers, whether supermarkets and, in this area, cheesemakers. Meanwhile, relax and listen to a story of my local countryside before intensive dairy farming messed it up - https://bit.ly/3bnqESW. Ironically, part of the small corner of Somerset featured in this interview has just evicted intensive dairy and is being prepared to enter a Knepp-style rewilding scheme.

Slurry stories from Wales

The same magazine, has published another blog (see https://bit.ly/2yPqhmK) about the draft Water Resources (control of agricultural pollution) for Wales 2020 and a sub-group on agricultural pollution on the Wales Land Management Forum.

This aims to develop new ways of thinking, gathers and reviews evidence, and feeds into policy areas. The minutes of the meeting held last November give an illuminating insight into tensions between farmers and contractors - according to the National Association of Agricultural Contractors, (NAAC) its members are responsible for 70% of slurry spreading in UK.

It is cited that "1. Many farmers were not testing their slurry and were using it as a waste product; 2. Some farmers were spreading slurry in the period immediately before heavy rain with a view to it washing off. In support of this one agricultural contractor described refusing a contract to spread in anticipation of heavy rain only for another contractor to do the work. The agricultural contractor examined a nearby stream after the application to find it heavily contaminated with slurry. 3. Some farmers were not prepared to adapt to a changing climate. 4. Some fields were being repeatedly spread with slurry. Contractors would say that they are spreading on a whole farm basis when they were spreading on one field. This was due to there being insufficient storage or insufficient land upon which to spread. One experienced adviser stated that, only one of a hundred inspected farms was compliant with The Slurry, Silage and Agricultural Fuel Oil (SSAFO) regulations governing (in this instance) the safe storage of slurry'.

Welsh slurry spills 31.1 October 2019

In 2016, 44,000 gallons of slurry from an anaerobic digestion plant leaked into a five-mile stretch of the River Teifi, near Tregaron, Ceredigion. Natural Resources Wales (NRW) will not prosecute, but Pencefn Feeds Ltd, the owner and operator of the plant, had to pay £40,000 in out-of-court costs – £15,000 to the West Wales Rivers Trust for the restoration of the habitat, £5,000 to the Countryside Alliance Foundation to fund education activities, and £20,000 to cover NRW's costs. The subcontractors responsible for the broken pipe which led to the leak had gone out of business, and so escaped having to pay anything. Another 120,000 gallons of slurry from a faulty slurry store ended up in a Teifi tributary last April, killing 10,000 fish.

River-monitoring

The hot, dry summer has highlighted the stress that rivers are under. Nick Measham, Deputy CEO of Salmon and Trout Conservation (S&TC), reports that this is true particularly of southern chalk streams, where algal growth and sediment are choking life to a seemingly unprecedented extent. Nick also says that, elsewhere in England and Wales, slurry spills are occurring with distressing frequency. The destructive impacts of pollution and abstraction are being increasingly evidenced through an expanding network of volunteers taking part in the Riverfly Census (www.riverflies.org) and via the SmartRivers initiative (https://bit.ly/2lpFwWl).

31:3 February 2020

At home, the rain has hardly stopped since mid September. Sodden fields in Somerset, already damaged by harvesting maize have been further damaged by the relentless dumping of slurry, regardless of this being in contravention of farming rules for water. Our rivers don't stand a chance of achieving 'good' ecological status so long as this nonsense carries on. I and numerous others are desperate to see an end to the ruination of nature and the wider environment by intensive livestock farming and the cultivation of maize.

31:6 August 2020

A Freedom of Information Request made by the Liberal Democrats has confirmed something everyone already knows, that perpetrators of waste and pollution crimes largely go both undetected and unpenalised. The LibDems FOI request, reported by Sandra Laville in The Guardian (https://bit.ly/32EUKd6), reveals that only 3.6% of complaints made via the Environment Agency's pollution hotline resulted in any form of sanction. In the majority of the 3.6% of cases where action was taken, this was mostly in the form of advice or warning letters.

… If it's slurry going too near the river, or other breaches of farming rules for water, then an EA advisor may visit to advise. However, inspections are rare and staff thin on the ground.

One farm has had repeated visits, as rules are often breached, despite this being one where the responsible farmer was actually prosecuted a few years ago when his slurry killed many thousand fishes. The advice is often to increase slurry storage or make it secure (not necessarily enforced), and to have in place a nutrient management plan. The latter has been required for several years, but I don't see a lot of science happening, or plans adhered to, when the slurry gets poured on the ground in winter.

One river campaigner has suggested different sanctions are needed, in the form of community sentencing, involving perps doing graft on a river restoration project plus an approach similar to vehicle speeding offences, such as attendance at a training course, for which they must pay.

Taking a prosecution is an expensive and often time-wasting exercise, especially if results could be achieved more effectively another way. Nevertheless, there are some significant criminals around, both individuals and businesses, large and small, who should be to be taken to court but escape justice due to the current pathetic enforcement regime and inadequate feet on the ground (see below). There is no doubt the current softly-softly approach to enforcement encourages 'business as usual'.

So resources, and the government's preference for voluntarism rather than regulation and enforcement, are significant problems but the underlying driver of the agricultural pollution disaster is more fundamental. Intensive farming is an industrial business, like the chemicals industry whose products it uses so much of but conducted outdoors, as if it was a benign 'land use activity' in harmony with nature.

Toxicity of Farm Pollution

If regulation is to be used, it needs to recognize that farm pollution is a very toxic substance.

Farm wastes, especially from livestock, are more polluting than human sewage effluent. The Code of Good Agricultural Practice explains:

'Biochemical Oxygen Demand (BOD) is used to show the polluting strength of livestock manures and organic wastes. It is a measure (in mg/litre) of the amount of oxygen needed by micro-organisms to break down organic material. Crude sewage which only has a BOD of

200-300mg/litre can severely damage surface waters while milk (140,000 mg/litre), silage effluent (30,000 to 80,000 mg/litre), pig slurry (20,000 to 30,000 mg/litre) and cattle slurry (10,000 to 20,000 mg/ litre) are extremely polluting. Even dirty water (1,000 to 5,000 mg/litre) is a very high risk material'.* * From washing off slurry

In a 1994 review of sustainable agriculture and regulation, academics from Newcastle University's Centre for Rural Economy wrote:

Livestock effluents are found to be regulated as an end-of-pipe technical fix which takes the quantities and nature of pollutants produced as given. Pesticides, on the other hand, are most strongly regulated at the point of registration rather than at the point of use, and the challenge of sustainable development has not yet called into question agriculture's continuing dependence upon chemical techniques for crop protection

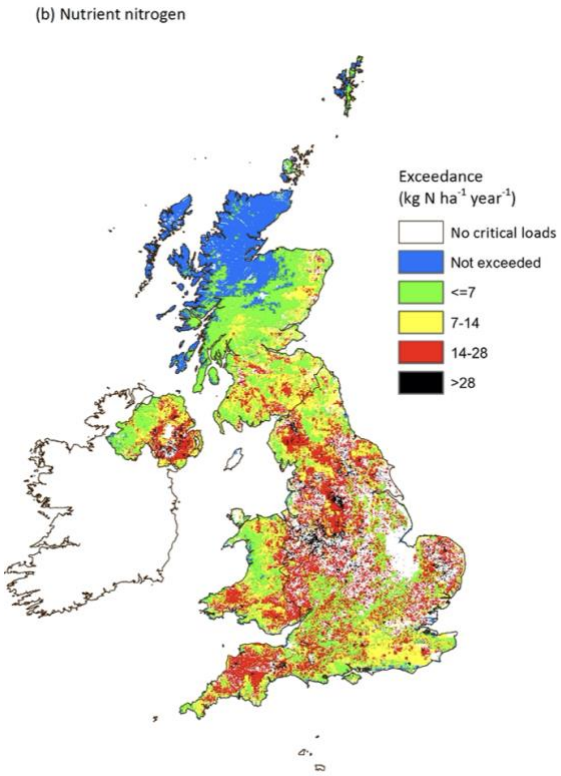
That's still true of 'livestock effluents'. Since then, environmentalist have arguably made some headway in altering political perceptions of farm pollution by pesticides and their impact on insects; reframing chemicals like 'neonicotinoids' as 'bee killers' affecting 'pollinators'. But this has yet to be achieved with 'livestock effluents'.

As it happens there is also evidence that nitrate pollution (as found in farm fertiliser, slurry or silage) helps kill off insects.

Nitrogen Toxicity

A largely unremarked 2018 study by three German researchers from the Potsdam Institute 'tested the response of six common butterfly and moth species to host-plant fertilization using fertilizer quantities usually applied in agriculture'.

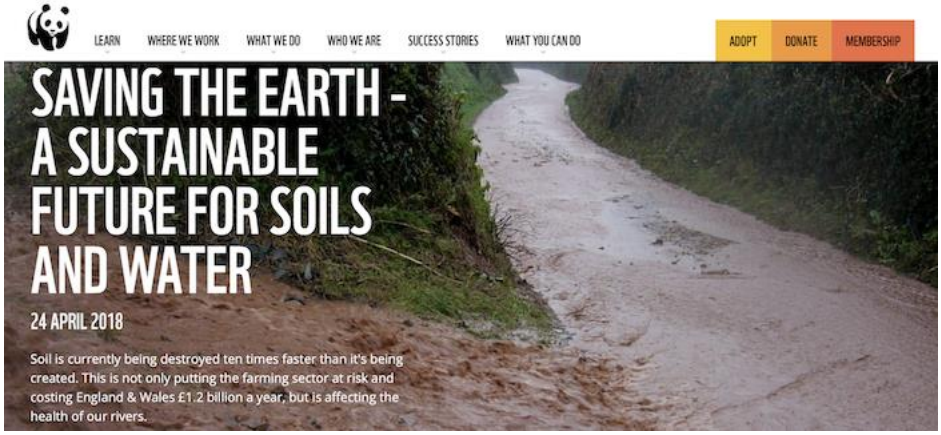
They found that 'fertilization increased the nitrogen concentration of both host-plant species [sheep's sorrel and common meadow grass], and decreased the survival of larvae in all six Lepidoptera species* by at least one-third' (*the butterflies small heath, small copper, sooty copper and speckled wood, and the moths straw dot, and blood vein).



Map showing average 'Critical Load' exceedances for nitrogen in 2013-15. A Critical Load is the maximum level that a habitat (eg a heath, peatland, forest, lake, river) can endure without ecological damage. Almost all the UK is above critical loads for forms of nitrogen pollution, except NW Scotland. Source: CEH

Many other studies show that (various forms of) nitrogen in air pollution make conditions too 'rich' for many fungi and wild plants, and are too high in most of our 'protected areas'. (Further research shows that N2O or nitrogen dioxide, a gas given off in combustion as in vehicle engines also damages insects. Over time, the nitrogen in N2O can also end up having a fertilising effect).

Soil Damage



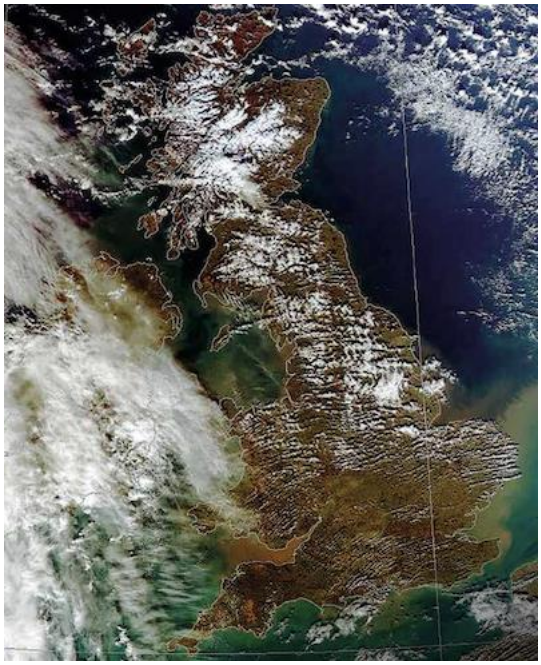
This 2018 report by WWF, the Angling Trust and the Rivers Trust Soil warned that erosion and the pollution of watercourses 'is putting the entire £8bn farming industry at risk' (*Guardian*) and 'poor farming and land management practices are causing soil to be destroyed at approximately 10 times the rate it is being created'. The Environment Agency states that intensive agriculture has caused arable soils to lose 40 to 60% of their organic carbon.

£10m a year needed to ensure England's soil is fit for farming, report warns

Soil erosion and water pollution caused by poor farming practices mean land could become too poor to sustain food crops by the end of the century

▲ Soil is being destroyed at approximately 10 times the rate it is being created, figures show. Photograph: West Country Rivers Trust

A harvested maize field (*Guardian* report).



‘This satellite image, taken on 16 February in 2014, shows how soil is washed off our fields and out into the sea’. Photograph: NEODAAS/ University of Dundee. Reproduced in a [National Trust strategy document](#) ‘Playing Our Part’ in 2015.

From Sue Everett, Conservation News in *British Wildlife*: Floods and mud 31.2 December 2019:

This autumn is one of the wettest on record - all three previous records having been set within the past 20 years. The prolonged period of rainfall, that began in mid September, has led to serious flooding in South Yorkshire, Derbyshire, Herefordshire and Lincolnshire.

A Briefing Note: Severity of the November 2019 floods has been issued by the Centre for Ecology and Hydrology - see https://bit.ly/2rjsfRE. In the wet south-west, maize fields harvested in October were haemorrhaging soil and water (aptly called "flood mud" by colleague Ted Green), in similarity to previous wet autumns that have been experienced in recent years.

The conditions did not stop the slurry tankers going out in force - storage being at capacity, the stuff had to go somewhere even if the nutrients in the waste do not match the needs of the growing crop - in contravention of the unenforced farming rules for water. Unsurprising then that there are moves afoot to set up a national campaign (see www.toomuchslurry.co.uk) over the despoilation of country lanes, rural air, fields and rivers from the overproduction and disposal of slurry and digestate.

Ammonia Air Pollution

Anyone who has experienced old-fashioned 'smelling salts' or been close to a slurry pit or intensive chicken farm dung heap will be familiar with the gas ammonia. It's toxic, which may be why our noses are sensitive to it. Ammonia (along with methane, hydrogen sulphide and carbon dioxide) is produced by decaying slurry and creates air pollution,

harming human health and acidifying the environment. Farmers have drowned in slurry pits. Farming produces 87% of ammonia emissions in the UK, with almost half (47%) coming from cattle.

In 2019 Gary Fuller of Imperial College wrote in *The Guardian*:

Ammonia from fertiliser and slurry mixes with air pollution from cities, traffic and industry to add to the particle pollution that plagues many parts of the world. It is estimated that halving ammonia from farming could avoid about 52,000 premature deaths from air pollution across Europe each year and 3,000 in the UK.

Fuller also highlights the role ammonia pollution from intensive farming plays in Britain's spring smog peaks, writing 'when factory emissions and traffic exhaust mix in the air with ammonia from farms. Fertiliser for seedlings, slurry spread on fields and animals let out from their winter housing together cause more ammonia in spring than at any other time of year'. In 2014 a spring smog episode was found to have caused 600 premature deaths in the UK. Clouds of pollution from farming can spread over hundreds of kilometres affecting towns and cities as well as countryside. In February 2015 particulate air pollution blanketed Eastern England with the greatest concentrations in Norwich.

In the Netherlands, ammonia air pollution has been linked to the deaths of young cattle.

Alongside ammonia emissions, intensive livestock farms can produce 'bioaerosols' in the shape of microscopic dust particles 'from the animals themselves, their food, bedding and waste', which can also include fungi and bacteria. A review paper on bioaerosols from farming by Imperial College and Public Health England noted: 'four studies of asthma in children found increased reported asthma prevalence among children living or attending schools near an intensive farm" but 'at present in the UK, most farmers do not normally monitor and control emissions to air unless specifically required to do so as a result of local complaints'.

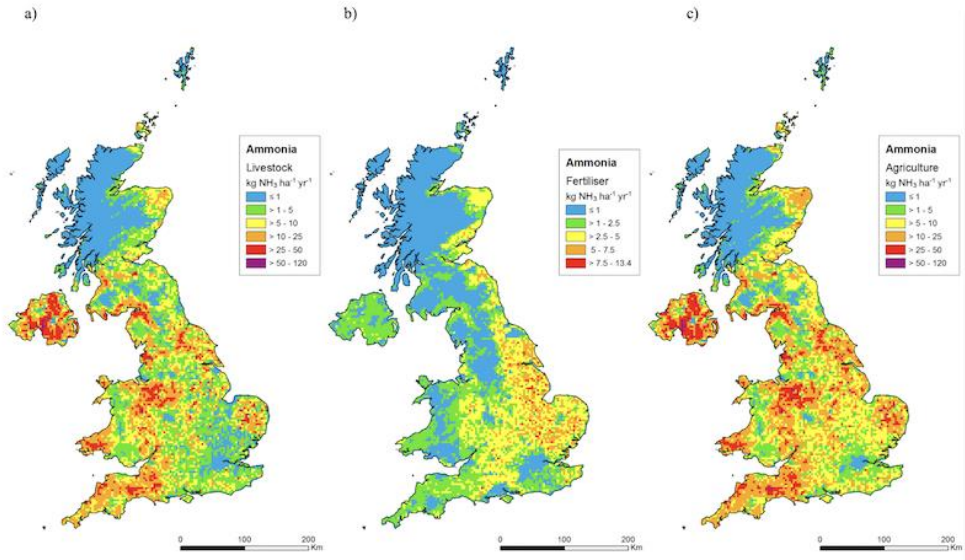
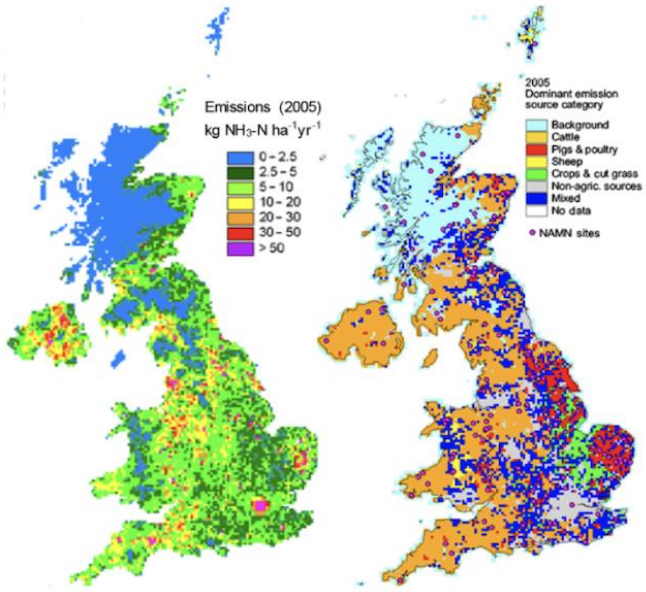


Figure 1: UK ammonia emissions from a) livestock manures, b) fertilisers and c) total agriculture (c = a + b) for 2015 (Units: kg NH_3 ha^{-1} $year^{-1}$).

Source CEH – ammonia from livestock, fertiliser and agriculture as a whole (2015)

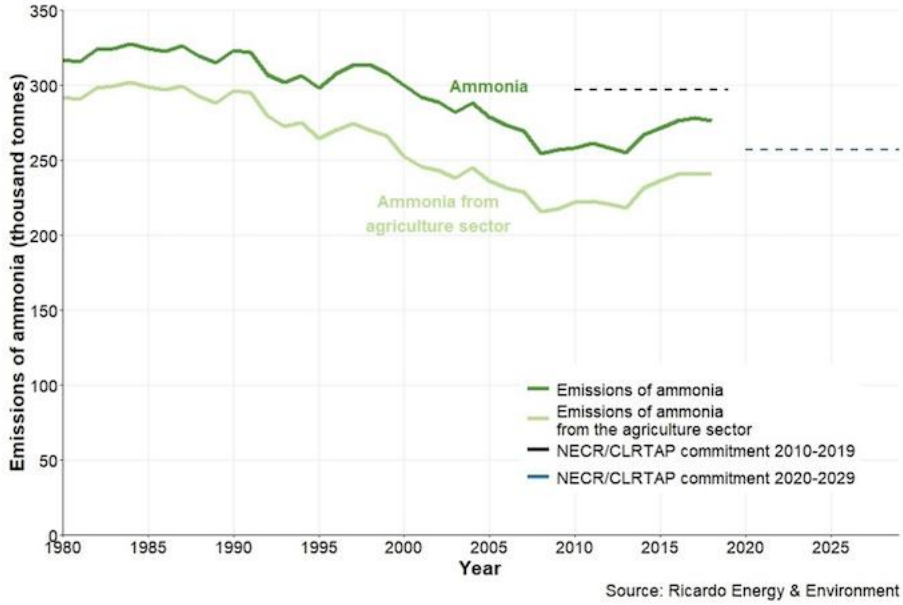


Ammonia emissions (source CEH) showing the dominance of cattle (orange, right) in the west of the country and pigs in the East

Farm ammonia emissions reached high levels in the 1990s, prompting efforts to reduce them for example with better covers on slurry pits. Overall they fell 19% between 1990 and 2017. The UK met a European Union target to cut 2005 ammonia emissions 7.5% by 2010 and according to David Burrows at ENDS Magazine, expected to meet the next (8% by 2020). Instead they jumped 3.7% above 2005 levels due to milk quotas ending and the import of cheap urea-based fertilisers. (Defra is now consulting on a ban on these).

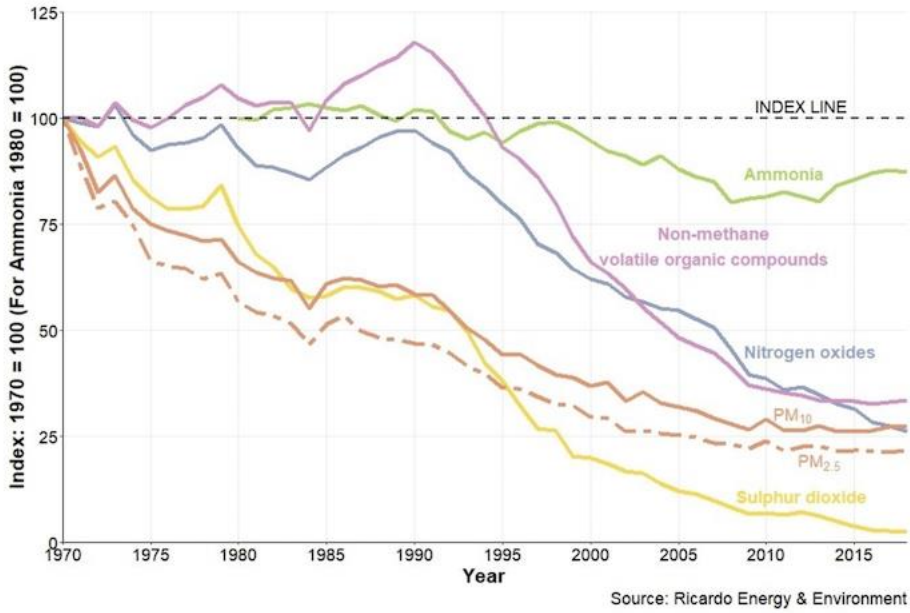
2. Trends in total annual emissions of ammonia in the UK, 1980 to 2018

Figure 8: Annual emissions of ammonia in the UK: 1980 to 2018



Source Defra (ammonia was not measured until 1980)

Figure 1: Trends in annual emissions of particulate matter (PM10 and PM2.5), nitrogen oxides, ammonia, non-methane volatile organic compounds, and sulphur dioxide, 1970-2018 (1980-2018 for ammonia)



The index line is a comparator that shows the level of emissions if they had remained constant from the beginning of the time series.

Emissions of ammonia have not fallen in line with most other air pollutants, mainly because emissions from agriculture have not been subject to the sort of controls and system changes applied in industry. Source Defra

Government 'guidance' on ways of minimising ammonia emissions (such as rapid soil injection of slurry) and financial help has been available to farmers for decades but Professor Tom Misselbrook, a specialist in soil and atmosphere interactions at Rothamsted Research told ENDS in 2019 that uptake of ammonia-emission mitigation has been "relatively small".

Pollution 'Baked In' By Design

Not for the first time government is now considering a permitting system for intensive cattle farms (by 2025), presumably legally binding, and this is resisted by the industry with, for example, a lot of debate about what counts as an 'intensive' farm. But from an environment and health perspective what counts is not just curbing emissions from a minority of large point emitters but all the sources of emission, including the many farms making up the equivalent of 'small and medium sized' enterprises, or SMEs.

There are already plans and regulations for many of these pollutants but there is little political understanding that short of moving all intensive farming indoors and applying zero-emission technologies (a proposal made in this blog), such pollution is 'baked in' to the basic model of conventional intensive agriculture. Farm intensification may be a cause of both 'intractable' bovine TB, and insectageddon.

Back in 1998 when English Nature was allowed to say things which its successor Natural England is not now, Mark Tilzey produced this policy schematic for his analysis of agriculture and sustainability:

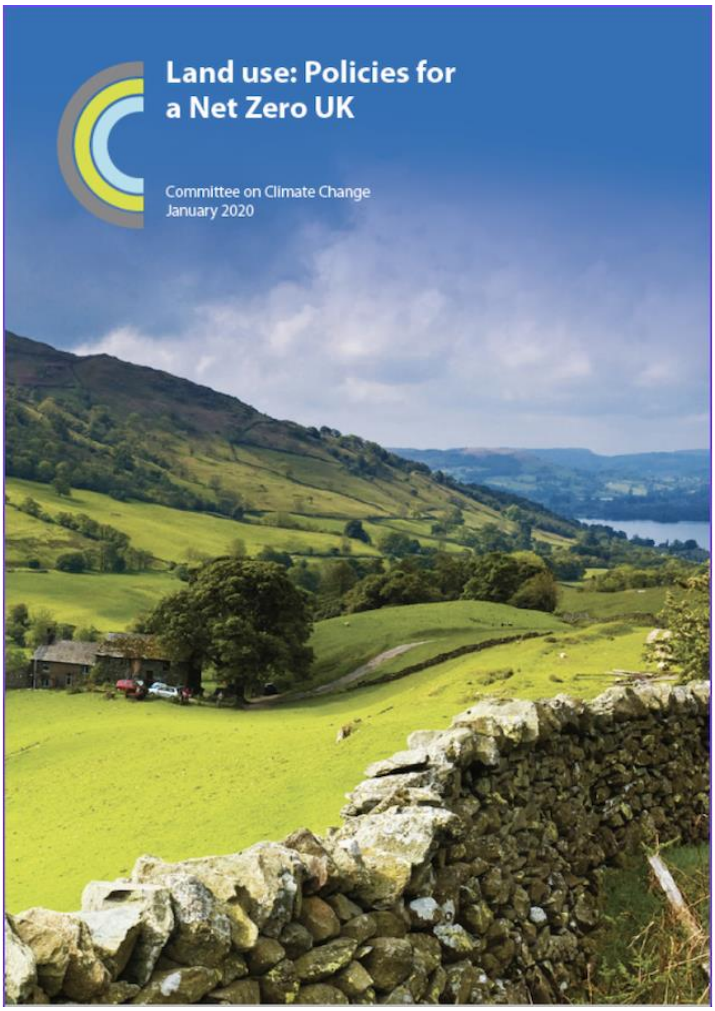
> The total structure of analysis is as follows:
>
> Symptom
> ↓
> Generic issue
> ↓
> Generic cause
> ↓
> Physical objective
> ↓
> Shorter-term Policy Objectives (symptom management) = Optimal use of ELMS, expedient use of commodity supply control measures, regulation, advice and expansion of such mechanisms in scope and scale where feasible.
> ↓
> Longer-term Policy Objectives (addressing generic cause) = Removal of 'productivist' system of support and replacement by 'green' interventionism (recoupling) based on direct payments, regulation and appropriate marketing structures.

Most of the badger and TB debate and too much of the issue of pollution is stuck at the top, around symptoms. Some percolates as far as 'symptom management'. In theory the government's aspirations for public money for public goods in its proposed Environment and Agriculture legislation might carry it into 'addressing generic causes', which in this case means de-escalating or containing intensive farming. It is possible but doubtful that's what

the government has in mind. (The Greener UK coalition pointed out on 6 October, the "landmark" Environment Bill has gone "missing" and not been seen in Parliament for 200 days).

Climate-Heating Pollution

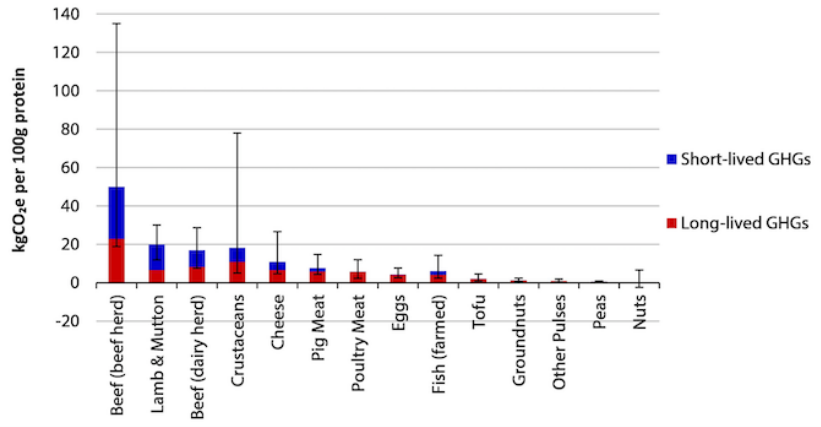
Modern intensive agriculture is a huge source of climate-heating pollution, mostly in the shape of emissions of the greenhouse gases methane, carbon dioxide and nitrous oxide. While emissions from sectors such as waste, many industries and power generation have declined markedly in recent decades, those of agriculture (along with transport), have not.



Ruminant meat (cattle and sheep) is on average the most intensive farning source of climate changing emissions – Committee on Climate Change

The worst offending farm sector is livestock, both because 'ruminant' animals such as cattle and sheep produce methane in their guts, and because converting vegetable protein to animal protein is inherently inefficient in energy terms. Numerous global analyses have identified a need for humans to shift towards a plant-based diet if climate change is to be tackled, and for reasons of health. The UK's statutory Committee on Climate Change (CCC) has pointed out that 'ruminant meat **'**is on-average the most GHG-intensive source of protein' (GHG = greenhouse gas).

Figure 5.1. Lifecycle GHG emissions associated with different protein sources



Source: Poore, J. & Nemecek, T. (2018) Reducing food's environmental impacts through producers and consumers. *Science*, 360 (6392), 987-992.
Notes: Solid bars indicate the production weighted global mean GHG-intensity of different food categories from studies looking at production across the world. Lifecycle emissions are expressed on the basis of equal protein content. Error bars indicate the 5th and 95th percentile of studies within the database. GHG emissions are aggregated using the GWP_{100} metric. Long-lived GHGs refer to CO_2 and N_2O and short-lived GHGs to methane.

Source: Committee on Climate Change

In 2019 the EAT-Lancet Commission on Food, Planet and Health (involving the medical *Lancet* journal) published a global "healthy and sustainable diet" or "Planetary Health Diet", which is mainly plant-based. It said 'A planetary health plate should consist by volume of approximately half a plate of vegetables and fruits; the other half, displayed by contribution to calories, should consist of primarily whole grains, plant protein sources, unsaturated plant oils, and (optionally) modest amounts of animal sources of protein'. In countries like the UK, this means 'a greater than 50% reduction in global consumption of less healthy foods such as added sugars and red meat'.

The year before, the UK's statutory climate advisers, the Committee on Climate Change (CCC), called for a farming 'revolution' if Britain was to to meet its climate goals. It wrote: 'In 2016 cattle and sheep directly accounted for around 58% of agricultural emissions, while there are additional soil emissions associated with growing their feed'. It's Chairman, former agriculture Minister Lord Deben, declared it was absolutely central and essential to have "less and better meat consumption".

Dads Army – BBC tv comedy

In its annual 'progress report' the CCC said it was 'shocked' that government climate action was adequate in only one of 25 key sectors it had identified the year before, 'ramshackle' and 'run like Dad's Army' (the title of a BBC sitcom based on a UK WW2 volunteer reserve army often referred to as 'dad's army').

In January 2020 the CCC published Land Use: Policies For a Net-Zero UK proposing a significant cut in meat consumption and land use change. On diet, it noted that the UK average daily consumption of beef and lamb is around 28g per person per day, whereas the Eatwell guideline is 5g per person per day'. (Eatwell being the official government health guidance).

It added: 'in our Net Zero report [2019], we identified at least a 20% shift away from beef, lamb and dairy to alternative protein sources per person by 2050, while a more ambitious reduction of 50% may be needed', and, while 'grassland cannot be used continually to offset ongoing methane emissions from livestock ... converting grassland to forest can increase the amount of carbon stored'.

The Committee highlighted the fact that 'beef from dedicated beef herds generally has the highest level of total GHG emissions and of long-lived GHG emissions'. Beef rearing is more subsidised than dairy farming, and beef from the dairy herd is more similar in its climate-emissions to lamb. But dairying produces a lot of slurry causing ammonia pollution. The CCC said its proposals to improve emission controls and cut back on dairy farming could '*deliver air quality improvements, which have a value over the lifetime of the measures of £10.5 billion … The largest co-benefit from an air quality perspective* [particularly ammonia] *is the reduction in livestock numbers due mainly to diet change. This contributes £3.9 billion of benefits from air quality improvements'*.

Reducing agricultural gas pollutants is not straightforward. For instance the CCC notes that **'**while fixed slurry covers can reduce ammonia emissions by 72% to 95% depending on the type of cover, there is a weak beneficial impact on non-CO_2 emissions, as reductions in N_2O are partly offset by an increase in methane due to the storage of slurry in anaerobic conditions'.

Similarly, on the spreading of slurries and digestate using low-emission spreading equipment' … while shallow [soil] injection … can reduce ammonia emissions by up to

around 70% compared with surface broadcast application, there could be a corresponding increase in N_2O emissions due to an increase in the readily available nitrogen in the soil as a consequence of less ammonia loss'.

These and many other greenhouse-gas related issues are technical and soluble but require far more disciplined and rigorously applied controls of farming methods than the UK is achieving at present. The CCC proposes the extension of legal 'environmental permitting to the dairy and intensive beef sectors from 2025' (currently only applying to intensive pig and poultry sectors). In December 2020 the government proposed a raft of changes to agriculture rules. Sue Everett commented to me:

'The agricultural reform package that includes grants for slurry infrastructure and new rules for covering slurry stores and doing away with slurry spreaders (dribble bars will be the norm - then slurry apps will be less visible, but arguably just as damaging to rivers) does not tackle the underlying problem in that there are too many cows and pigs, producing too much waste, that cannot be safely disposed of without damaging land and landscapes. And sending it to biodigesters just fuels the growing of fibre to co-digest with it as slurry cannot be digested without fibre'.

An obvious and more-or-less missing ingredient in the policy approach, certainly in England, remains strategic land use change. As Ian Boyd implied, if we need to reduce the impact of a range of livestock pollution problems (air, water and climate for ecological and health reasons), and we also need to reduce the amount of meat and dairy produced for healthier diets, an obvious step is to cut the size of the sector itself.

Transitioning Problematic Farming

"When in a hole," goes an old political dictum, "first stop digging". This requires political leadership when there is a substantial agri-business-political-complex still committed to heading in the wrong direction but it has to happen.

There is no shortage of thinking, advocacy or knowledge but as the exasperated CCC pointed out, in England at least we have a failure to organise effectively. Pilot and small scale projects in the public and private sector now need to be turned into that 'farming revolution': one of greening and modernization.

Spurred partly by the disastrous impacts of climate-change-related flooding, and the scope to sequester carbon in soils, a lot of attention (if not in truth, much widescale action) has focused on the uplands. It's now time to extend this to down-sizing intensive livestock farming in the lowlands.

Rewilding and Old Trees

From a carbon sequestration and nature-recovery (biodiversity-enhancement) point of view, the biggest gains will come from forms of 're-wilding'.

Many studies have inicated the greater environmental benefits of natural regeneration, or 'tree regeneration' or 'woodland restoration' over tree-planting and in September 2020 a major international study published in *Nature* showed that the potential for natural forest regrowth to lock away carbon had been significantly under-estimated, and is often a cheaper option and better for wildlife. Report lead author Susan Cook-Patton told *The Guardian* that "If seed sources are nearby and the site isn't too degraded, then diverse forests can likely grow back by themselves". This is what is happening at former dairy/arable farm Knepp, Sussex, where as in much of England, hedges and existing woodland fragments provide many nearby seed sources.

Old trees kept amidst new growth at Knepp wilding project – www.knepp.co.uk

Another priority for rewilding should be old trees. The conventional assumption is that young trees grow faster and so lock up more carbon. An extensive analysis in *Nature* in 2014 showed this is wrong. Big old trees are far better at exctracting carbon from the air and storing it. The study, entitled *Rate of tree carbon accumulation increases continuously with tree size* 'estimated mass growth rates from repeated measurements of 673,046 trees belonging to 403 tropical, subtropical and temperate tree species,spanning every forested continent'. It found that:

'large, old trees do not act simply as senescent carbon reservoirs but actively fix large amounts of carbon compared to smaller trees; at the extreme, a single big tree can add the same amount of carbon to the forest ***within a year*** *as is contained in an entire mid-sized tree'.*

(my emphasis)

'The apparent paradoxes of individual tree growth increasing with tree size despite declining leaf-level and stand-level productivity can be explained, respectively, by increases in a tree's total leaf area that outpace declines in productivity per unit of leaf area and, among other factors, age-related reductions in population density'.

So retaining old trees and allowing existing trees to age rather than felling them and replanting with young trees, should be an objective, and plantations of young trees should be a last resort. This would be particularly true for rewilding of farmland with established trees in woods, fields, copses or hedgerows.

In many places, particularly in tourist or well populated regions (ie almost all of England) this will also maximise the potential economic gain in terms of recreation opportunities as well as in ecosystem services such as flood prevention. Similar locational factors apply to planted forests. In its Second Report, *The State of Natural Capital: Restoring our Natural Assets* (2014), the governments Natural Capital Committee highlighted the difference in optimal location for creating new woodland, if the decision was made on minimising costs, or if it was made on maximising all benefits to society. Proximity to users is a major driver in the latter equation.

As the British Ecological Society observed, 'allowing for the value of recreation, woodland planting would be more focused around inhabited areas to give maximum benefits to both timber output and communities. The overall social value of planting in upland areas is -£66 million per year, whereas it is £546 million per year when near communities'. The difference flows from using two different decision rules. In the first, woodland creation is determined by minimising costs. In the second by maximising all benefits to society.

Downsizing the Problem

Taking livestock farming out of production in areas with 'intractable' TB problems would help de-escalate and downsize the practical and political problem. This could operate alongside vaccination of badgers and cattle and better farm practices to reduce TB, be achieved quite quickly, and save money for the taxpayer.

Lots of research shows that a large part of British farming is uneconomic without subsidy, and that's without 'true cost' accounting including disbenefits like pollution. For example in September this year, a Sheffield University study found that sheep farmers would be better off growing trees and being paid in 'carbon credits'. They would become part of the climate solution rather than the problem. Professor Colin Osborne, lead author of the study, told *The Independent*: "Sheep farming in the UK is not profitable without subsidies, but forests that sell carbon credits can be economically viable – so it makes sense for the Government to help farmers transition.

The standard objection to this, particularly regarding upland sheep farming, is that such farming is a way of life, which merits continuing public subsidy in a way that other occupations do not. This sometimes comes from the farming community but just as often, if not more so, from people outside farming who just don't like change.

An emerging success story of farmers working collaboratively with Natural England and other agencies to transition from sheep-farming is Howgill Fells, close to the Lake District in the Yorkshire Dales. *The Guardian* reported in October 2020:

'For two decades, Pratt has been managing two upland wildflower meadows (of which there are only 1,000 hectares – 2,470 acres – left in Britain), in return for a £7,000 annual payment. He is now seeing some wildlife start to come back elsewhere on the fells. "When I was a young lad there was a lot of heather behind the house but it mainly disappeared because of pressure from sheep. Now there are fewer sheep on the hills, it's back and it's really noticeable. It's good for wildlife, it's good for black grouse and it's good for hares," he says'.

Pratt is giving up sheep and retiring. Through a Common Graziers Association, over twenty other farmers in the area have reached agreements to plant native trees such as hawthorn, rowan, willow and birch, across hundreds of hectares on Ravenstonedale fell, Tebay Fell and the Lake District. Pratt said "They're doing them all over. Some farmers don't like trees but most people get this payment and seem satisfied".

'Un-managing the land': sheep make way for trees in Cumbria's uplands

Sheep grazing has dominated the Howgill Fells for over a century, but with shifting agricultural subsidies and urgent calls to address biodiversity loss, change is coming

▲ John Pratt is poised to retire from uplands farming after 55 years. Photograph: Rebecca Cole/The Guardian

For William Wordsworth the Howgill Fells was a romantic landscape, for rewilders they could be home to wolves, and for farmer John Pratt, these hills are home. "I was hoping this day would never come. I shan't say it will break my heart, but it will," says Pratt, who is selling his sheep and retiring after 55 years of uplands farming. "I've had a flock of sheep since I was 14, so I'm ready for a break," he adds.

From 2020 Guardian article by Phoebe Weston

Frank Hunter, chair of the Ravenstonedale Common Graziers Association said "I'm all for it … I think we'll be making more use of the land out there, other than just a means of grazing sheep … "I think we've got to accept that the landscape will look very different" the Guardian wrote:

Hunter believes farmers will be more actively involved in managing tree plantations in the future and will use grazing animals such as sheep as a management tool. Their meat will sell at a premium and will help the land deliver "ecosystem services" that the farmer can be paid for'.

That may seem a long way from intensive dairy in the South-West but equally radical action is inescapable if the social and environmental impact of such farming is to be reversed.

Another indication of a possible transition route for dairying is the success of 'organic' dairy. As mentioned above, a 2020 Defra analysis found that only herd size and being organic were factors associated with greater economic success among dairy enterprises. In most cases these are probably two different sets of dairy farms, large intensive ones selling large volumes of low-margin milk, and very much smaller organic ones selling milk and cheese at more directly and at higher prices.

Micro-organic dairy farms are probably regarded by Defra as niche but supporters hope that like micro-breweries and personal computers before them they could be part of a future model: smaller but better.

Alex Heffron has a waiting list for milk at his micro-dairy

In 2019 Alex Heffron from Mountain Hall farm in Wales wrote in a Sustainable Food Trust blog:

While most farmers struggle to get a fair price, our farm, Mountain Hall, can't produce enough milk to sell from our micro dairy, and that's at £2 a litre. We have a waiting list that's probably as big as we can ever hope to supply, and it continues to grow every month, even though we do zero advertising. It's not yet providing us with a full livelihood, but it is now making a small profit — and that's without any agricultural subsidy.

We're still growing slowly in size, but with a little investment this year, next year it should be able to provide a full-time livelihood for my wife and I, and it's already providing a part-time income for two additional farm workers.

While £2 a litre for milk is understandably expensive for people on a low-income, our customers are paying for the price of a production system that has fewer externalities – costs that are not accounted for directly within the production system that society pays for indirectly through taxes, public spending and other 'hidden' costs.

From chatting to many people about dairy farming, I believe there's a growing collective sense that the public feels dairy farms are becoming too big. In response to this, there is an increasing number of micro and small dairies, like ours, that have growing demand for their milk. There's Stroud Microdairy, Old Hall Farm and Calf at Foot Dairy in Norfolk, Taw River Dairy in Devon, Smiling Tree Farm and Babbinswood in Shropshire, Plaw Hatch Farm in Sussex, to name a few. Micro dairying isn't easy, but then farming never was. It is tapping into a local demand for milk with a face on it from people who care.

… Of course, there'll always be a market for cheap milk, but realistically how will farms in the UK continue to produce milk at the price demanded by the commodity milk market? It's a race to the bottom that few will win.

… For new entrants to farming micro dairying offers a more accessible option to those who'd like to get into dairying, but don't come from a farming background. Crucially, it offers the farmer a direct connection with their customer, giving them control of their business.

[More on micro dairies here, here and here. In most cases their business model is based on direct customer service and high welfare methods to give higher margins, sometimes including delivery of milk in bottles].