www.nutrientmanagement.org.uk

@tried_tested

Professional Nutrient Management Group

Update report on nutrient management planning

July 2015

The purpose of this report is to present the trends and current status of nutrient management on farms linking to production and environmental benefit

This report has been produced in partnership with Catchment Sensitive Farming (CSF)

Summary

This is the third in a series of reports on nutrient management planning and practices for the Professional Nutrient Management Group (PNMG).

The main source of statistical data on nutrient management planning was the series of Farm Practices Surveys published by Defra (Defra 2014a). Since the last report for PNMG in 2012, there have been small changes in the percentages of farms possessing a nutrient management plan, taking professional advice for producing a plan or regularly updating their plan. Possession of a nutrient management plan was reported by 88% of cereal farms representing 93% of the land area for this farm type and by 83% of other crop or general cropping farms representing 94% of the land area for this farm type. These might represent saturation levels of uptake. Although there is scope for improvement in grazing livestock farms where only 30% reported possessing a nutrient management plan, uptake potential is lower than for arable cropping for various social or geographical reasons.

Compared to 2012, in 2015 fewer farmers reported possessing a manure management plan, or conducting nutrient analysis or assessment of manures. This was surprising as during this period, a low cost manure analysis service based on NIRS and the updated and extended MANNER-*NPK* had been launched. About half of farms that spread manures reported never calibrating manure spreaders. On the other hand, use of covers on slurry tanks and on manure heaps on solid bases increased from 2011 to 2015.

Around one half of all farmers with a nutrient management plan reported a financial benefit and one third reported an environmental benefit. These percentages have increased in recent years. The main motivation for creating a plan was reassurance of seeing a return for the work put in.

As in 2012, grazing livestock farms remained lowest in use of planning tools. Tried & Tested plan continued to make progress in these farms, use being reported by 24% of grazing livestock farms in LFAs in 2015 (21% in 2009). Use of the Tried & Tested plan also increased in dairy farms, from 12% of farms in 2012 to 21% in 2015. This success could be reinforced and might be a model for other paper-based planning tools for these farms.

Use of fertiliser nitrogen, which had decreased steadily since around 1985, seemed to have stabilised in the past five years. The ratio of fertiliser nitrogen to phosphate and potash decreased from a peak in 2009 but probably remains too wide to be sustainable in the long-term. Only 9-10% of arable and grassland soils were at target indices for both P and K. Use of fertiliser sulphur continued to extend across the area of main arable crops and increased in recent years on grassland. Use of lime appeared to have decreased somewhat in recent years with the exception of tillage crops in Scotland. Soil pH was lower than 6.0 in 20% of the arable soil samples analysed and lower than 5.5 in 21% of grassland samples.

Annual tray testing of fertiliser spreaders was conducted by 40% of farmers who spread manures. This proportion might be greater for spreader contractors.

Priority areas for improvement seemed to be manure management, uptake of effective nutrient management planning and practices by grazing livestock farms, use of soil analytical results for adjusting fertiliser application and tray-testing of fertiliser spreaders.

Contents **Page**

1.0 Introduction

In 2010, the Professional Nutrient Management Group (PNMG) commissioned a report to

i. collate and report evidence of nutrient management planning during the period following publication of the Tried & Tested nutrient management plan;

ii. review this information in the context of historical data;

iii. identify gaps in advice and support on nutrient management planning.

The *Report on nutrient management planning* was published in September 2010. This clarified the terms 'nutrient management', 'nutrient management planning' and 'nutrient management practices'. A follow-up report, *Update report on nutrient management planning*, was published in January 2013. This is the third report in the series, and deals with recent developments in nutrient management planning and practices.

2.0 Nutrient management planning

2.1 Source of data

The main source of statistical information on nutrient management planning was the series of Farm Practice Surveys conducted by Defra (Defra 2015a). The surveys sample farms in England above certain sizes (50 cattle, 100 sheep, 100 pigs, 1000 poultry or 20 ha of arable crops or orchards) so might not reflect fully practices on all farms or in the UK as a whole. The 2014 survey sampled 6000 of the 60,000 eligible farms.

Items directly relevant to nutrient management planning were included in surveys from 2006 though not all items were included every year (Appendix 1). Coverage of nutrient management became more comprehensive and consistent from 2009.

Farm Practices Survey data are analysed routinely on a holding basis with results reported as percentage of holdings. In the 2014 and 2015 reports, nutrient management items were analysed also on a land area basis. Usually, but not invariably, reported values were greater on a land area than on a holding basis (Appendix 2).

2.2 Nutrient management planning in 2015 and changes since 2012

There were some changes among the components of nutrient management planning since the 2012 survey though the increase in uptake of plans seen between 2009 and 2012 was not maintained (Table 1).

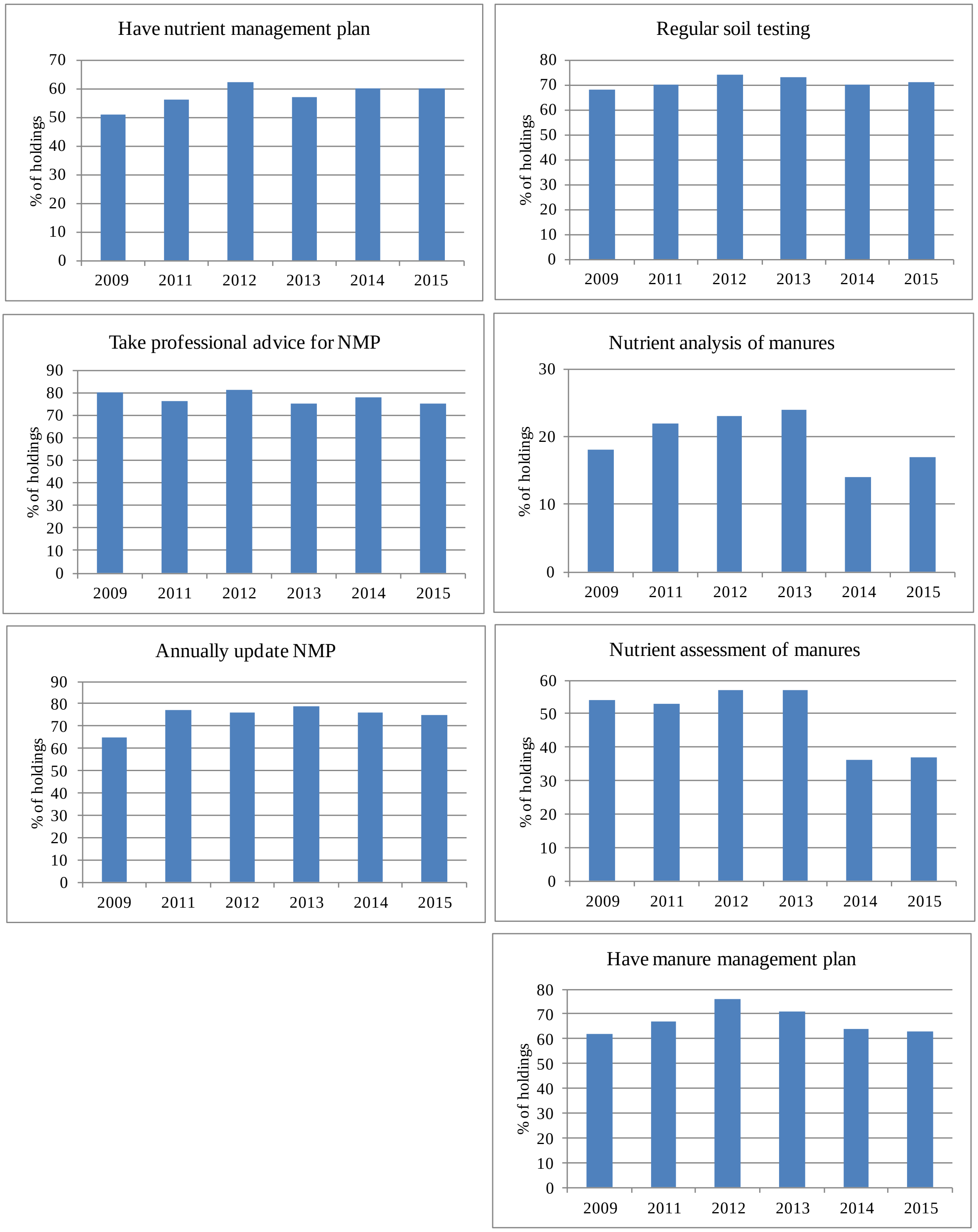
Table 1 Components of nutrient management planning in 2015
(% of all holdings, 2012 values in parentheses)

	Have nutrient management plan	Take professional advice for NMP	Annually update NMP	Regular soil testing	Nutrient analysis of manures	Nutrient assessment of manures	Have manure management plan
Small	52 (52)	73 (80)	71 (73)	64 (66)	13 (12)	31 (44)	51 (62)
Medium	66 (62)	77 (79)	78 (82)	75 (78)	16 (27)	44 (67)	74 (85)
Large	78 (78)	78 (83)	79 (77)	88 (85)	30 (37)	45 (70)	84 (89)
Northeast	52 (54)	68 (89)	66 (68)	68 (62)	9 (16)	34 (44)	67 (77)
North west	46 (54)	72 (82)	54 (64)	60 (65)	13 (19)	25 (47)	64 (81)
Yorkshire	62 (61)	79 (74)	78 (73)	75 (72)	18 (26)	40 (62)	69 (71)
East midlands	70 (64)	76 (81)	85 (78)	75 (84)	19 (21)	43 (64)	68 (78)
West midlands	57 (58)	70 (83)	68 (85)	71 (71)	17 (17)	45 (57)	62 (74)
East	83 (84)	82 (85)	87 (83)	93 (96)	34 (49)	45 (70)	63 (83)
South east	60 (63)	77 (79)	78 (74)	68 (76)	15 (27)	35 (65)	44 (67)
South west	50 (58)	73 (79)	69 (76)	63 (69)	16 (19)	33 (52)	62 (77)
Cereals	88 (84)	85 (85)	82 (82)	94 (96)	29 (33)	47 (73)	72 (78)
Other crops	83 (79)	80 (81)	82 (78)	94 (93)	34 (44)	40 (76)	74 (82)
Pigs and poultry	45 (57)	78 (83)	78 (83)	63 (76)	35 (44)	36 (63)	55 (75)
Dairy	77 (71)	75 (74)	69 (75)	83 (80)	27 (30)	43 (67)	90 (90)
Grazing (LFA)	30 (25)	50 (66)	44 (42)	40 (32)	3 (7)	20 (29)	48 (66)
Grazing (lowland)	31 (37)	60 (84)	62 (69)	45 (53)	5 (10)	29 (43)	48 (65)
Mixed	72 (75)	73 (78)	83 (77)	83 (86)	14 (16)	52 (63)	73 (81)
All farms	60 (62)	75 (81)	75 (76)	71 (74)	17 (23)	37 (57)	63 (76)

Source: Farm Practices Survey, 2012, 2015

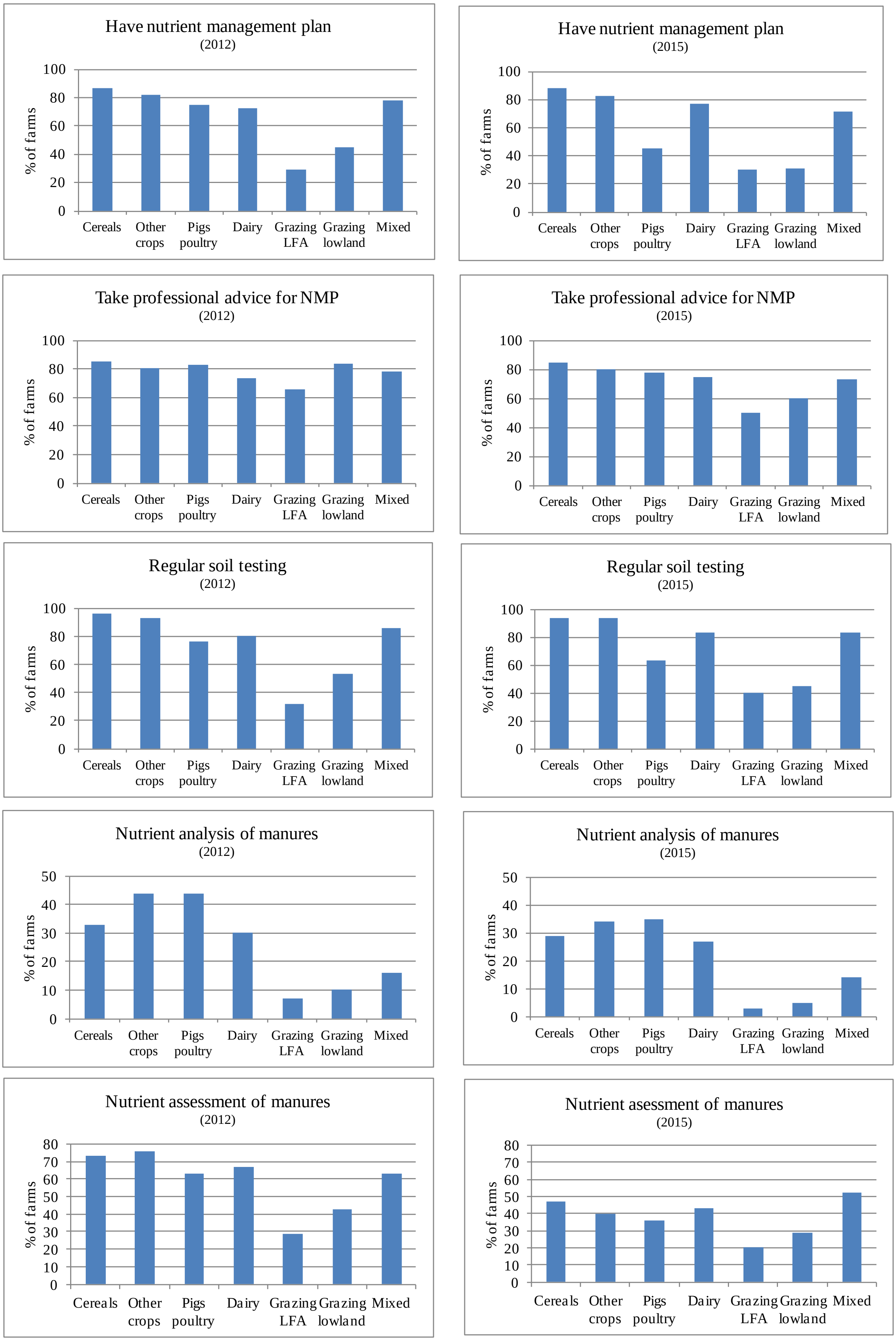
Most noticeable recent change is the apparent reduction in manure analysis or nutrient assessment and in possession of a manure management plan especially in pig and poultry farms (Fig 1). Wording in the questionnaire differed slightly between 2012 and 2015 for manure analysis and assessment but was unchanged for possession of a manure management plan. Therefore the changes indicated probably reflect real reductions. Owing to the relatively small numbers of pig and poultry farms, their exclusion from calculations has only a small effect on percentage values for all farms in Table 2 (for example <1% for possession of a manure management plan). The general impression is that, since 2012, something of a plateau has been reached in nutrient management.

Fig 1 Trends in nutrient management since 2009 (Farm Practices Survey)



LFA grazing farms continued to lag behind other farm types in adoption of nutrient management planning and there was little sign of great progress since 2012. The differences between grazing farms and other types are shown more clearly in diagrammatic form (Fig 2).

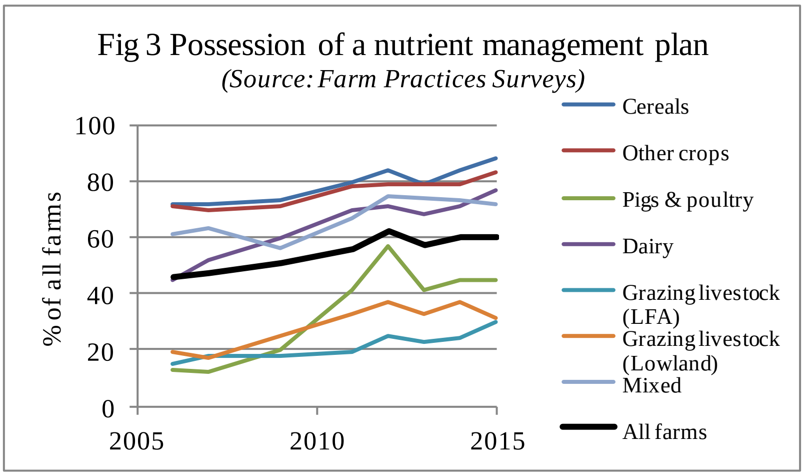
Fig 2 Nutrient management in different farm types in 2012 and 2015 (Farm Practices Survey)



2.3 Possession of a nutrient management plan

In 2015, 60% of all farms reported possessing a nutrient management plan (Table 1). These farms represented 76% of land area (Appendix 2). Cereal farms (88%, up from 84% in 2012 representing 93% of the land area for this type) and other crops or general cropping farms (83%, also up from 79% in 2012 and representing 94% of land area for this type) were most likely to have a nutrient management plan. It is possible this represents saturation uptake. Grazing LFA farms (30% representing 31% of land area for this type) and grazing lowland farms (31% representing 43% of land area for this type) were least likely to have a nutrient management plan.

Numbers of farms possessing a nutrient management plan were reported in Farm Practices Surveys of 2006, 2007, 2009, 2011, 2012, 2013, 2014 and 2015. Between 2006 and 2012, there were substantial increases in percentages of farms possessing a plan but since then increases have been smaller (Fig 3). An increasing trend remains in cereal, dairy and grazing livestock (LFA) farms but in other farm types a plateau seems to have been reached.



2.4 Preparation of nutrient management plans

The 2012 Farm Practices Survey indicated use of PLANET had increased substantially in pig and poultry farms and in lowland grazing farms from 2009. These increases were not maintained in the 2015 survey (Table 2). However, Tried & Tested made some further progress in dairy farms.

Table 2 Method of creating a nutrient management plan in 2015
(% farms with a plan, 2012 values in parentheses)

	PLANET	Muddy Boots	Tried & Tested	Farmade/ Multicrop
Cereals	23 (29)	20 (22)	16 (13)	20 (17)
Other crops	24 (30)	23 (21)	17 (20)	17 (21)
Pigs and poultry	22 (26)	19 (6)	22 (22)	15 (15)
Dairy	31 (28)	14 (12)	21 (12)	3 (5)
Grazing (LFA)	9 (0)	7 (22)	24 (21)	1 (4)
Grazing (lowland)	21 (27)	11 (19)	15 (16)	5 (2)
Mixed	25 (32)	20 (14)	16 (20)	6 (5)
All farms	23 (28)	17 (20)	18 (16)	12 (11)

Sources: Defra Farm Practices Survey, 2012, 2015

Between 2012 and 2015, there was little change in the sources of professional advice used in preparation of nutrient management plans, the main source remaining fertiliser advisers/agronomists (Table 3). In 2012, animal nutritionists were reported as a source of professional advice by around 30% of dairy and grazing livestock enterprises in LFAs but in 2015, the percentages for these farm types had decreased to 14% and 8% respectively.

Table 3 Source of professional advice in 2015
(% of holdings with a plan, 2012 values in parentheses)

Fertiliser adviser/agronomist	85 (82)
Animal nutritionist	3 (7)
FWAG adviser	1 (4)
Other	13 (13)

Sources: Defra Farm Practices Survey, 2012, 2015

2.5 Tried & Tested

The paper-based Tried & Tested nutrient management plan was launched in March 2009 and revised in 2014.

The Farm Practices Survey indicated that 60% of all farms reported possession of a nutrient management plan and 18% of those with a plan reported use of Tried & Tested. This amounts to some 6480 farms (60,000 eligible farms x 60% with a plan x 18% using Tried & Tested). The corresponding numbers for 2012 and 2009 were 6051 and 3400 respectively.

Number of farms underestimates usage as the Tried & Tested plan is used by advisers. For example in July-September 2014, 47% of Tried & Tested materials were requested by advisers and 22% by farmers (remainder were requested by PNMG partners). In 2014, 9994 Tried & Tested materials were distributed, an increase of 12.5% against 2012.

Other items under the Tried & Tested brand include Think Manures, the leaflet New to Nutrient Management Guide and USB memory sticks holding the Tried & Tested plan, the Fertiliser Manual and NVZ guidance.

2.6 PLANET

PLANET, software for nutrient related decision-making and recording based on the Fertiliser Manual (RB209), developed by ADAS with funding from Defra was launched in 2004. The latest version, 3.2.2, was introduced in March 2014 and covers England, Wales and Scotland. The Defra Farm Practices Survey for 2015 indicated that around 14,000 farms (23% of the 60,000 farms eligible for the survey) reported use of PLANET. This is consistent with the more than 14,000 registered users reported by ADAS. In addition, the calculation component of PLANET software has been incorporated in farm management packages from Muddy Boots, Farmade and Pear Agri and in the AHDB Fertiliser Calculator for potatoes.

2.7 MANNER-NPK

More than 10,000 copies of MANNER v3 had been distributed by 2010 (Chambers *et al.* 2010). The software was then developed to provide estimates for crop available phosphate, potash, sulphur and magnesium as well as nitrogen in manures. The new version, MANNER-*NPK* was launched as stand-alone software in February 2013 for free download. MANNER-*NPK* also is incorporated in PLANET. MANNER-*NPK* was developed by ADAS and Rothamsted Research North Wyke, with funding and support from AHDB, CSF, DARD, Defra, Environment Agency, Natural England, Scottish Government, Tried and Tested and WRAP for use throughout the UK.

2.8 Manure analysis

At the time of the 2012 report, it was expected that introduction of Near Infra-red Reflectance Spectrometry (NIRS) (AHDB 2011) for fast analysis of manures would result in more widespread manure analysis. An analysis service based on NIRS has been offered and promoted by Eurofins since 2011. However, the Farm Practices Survey of 2015 indicated a decrease in nutrient analysis of manures from 23% of farms in 2012 to 17% in 2015 (representing 26% of land area) (Table 1).

2.9 Soil testing

The Professional Agricultural Analysis Group (PAAG, comprising the main UK laboratories that offer routine soil analysis) produces annual reports in which soil analysis data are summarised. The 2014 report included data from around 135,000 whole field arable soil samples and 60,000 grassland soil samples (PAAG 2014). Samples from top fruit, turf and horse paddocks and those taken for soil mapping were excluded. Allowing for work by non-participating laboratories, the number of routine advisory soil samples taken in 2013/2014 probably was around 250,000. This is the same as the estimate for 2012. The agricultural area of the UK for which soil testing would be recommended (arable and horticultural crops, temporary and permanent grass but excluding rough grazing) was around 13,250,000 ha in 2014 (Defra June Survey). The 250,000 soil samples therefore are equivalent to an average 53 ha/sample. If fields are sampled on average every four years, this is equivalent to around 13 ha/sample. This seems an encouraging intensity of sampling and consistent with the 71%

of farms that reported regular soil analysis (Table 1). These farms represented 85% of agricultural land area (Appendix 2).

2.10 Advisers

Advisers are important as they assist farmers in nutrient management planning and they have a magnifier effect on uptake of some planning tools. A proportion, probably a large proportion in some cases, of these planning tools is used by advisers rather than directly by farmers. Numbers of these tools distributed therefore can lead to underestimates of their impact. This probably applies especially to PLANET, MANNER and Fertiliser Manual/RB209 where the adviser can use one copy of the tool on behalf of several farmers. The magnifier effect will be less for paper-based plans like Tried & Tested that are one copy per farm (but the adviser can be a distributor for these tools, so promoting their use).

Advisers on nutrient management include those employed by organizations (commercial companies, Environment Agency, Defra, Natural England) or by farm consultants (often members of AICC or BIAC). Most nutrient management advisers who deal directly with farmers are now FACTS Qualified Advisers or members of the Feed Advisers Register.

FACTS was introduced in 1992 and converted to an annually renewable scheme in 2002. Since then, entrance to FACTS has been by examination only. The number of FACTS Qualified Advisers has increased steadily since the scheme was introduced, exceeding 3000 in 2014.

Changes to the scheme in 2015 require FACTS Qualified Advisers (FQAs) to be members of the BASIS Professional Register and to have access to the technical information service. The information service comprises email and phone help-lines, quarterly newsletter and on-line library. This provides email and phone communications with all of the advisers allowing messages and new information to be disseminated rapidly and cheaply to almost all farm advisers dealing with nutrients.

The Feed Advisers Register was established in 2013 as a commitment to improve efficiencies in animal feeding practices and to reduce nutrient emissions,. There are now 1180 members involved in demonstrating key competencies necessary to remain on the Register. Initially the competences were designed around whole farm feed planning and links to animal health and fertility – important for greenhouse gas reduction. Further competences are being developed for ammonia reduction and will incorporate elements of Catchment Sensitive Farming.

2.11 Catchment Sensitive Farming

Catchment Sensitive Farming (CSF) was launched in 2005 to help farmers achieve Water Framework Directive and SSSI objectives. In the first seven years of operation, advice was delivered to 16,133 farms across seventy nine catchments. Of the measures recommended in one-to-one advice, 62% were adopted (CSF 2014). Uptake of advice was greatest for mixed, cereals and general cropping farms and least for grazing (LFA) and dairy farms.

The impact of CSF activities on nutrient and sediment movement to water was estimated by modelling for three scenarios:

- Current - the effect of current CSF measures and implementation rates across the CSF catchments
- Optimised - a theoretical maximum reduction achievable by CSF, it involves applying the ten most effective measures per pollutant to each farm in our catchments and estimating their combined effect using current implementation rates
- Maximum - the greatest change to water quality achievable without catchment scale land use change, this applies all measures to all farms, and assumes a 95 per cent implementation rate

Modelling predicted that current CSF activities reduced nutrient and sediment loads to water by 6-12% (Table 4) though there were large variations among catchments. The estimated reductions demonstrate the effect targeted and consistent advice can have in changing farm practices. Soil management plans and reduced cultivation systems were found to be amongst the most successful activities for sediment reduction and integrating fertiliser and manure nutrient supplies and establishing cover crops, for nutrients.

Table 4 Median reductions predicted for CSF scenarios (for CSF target areas within Phase 1 Priority Catchments)

Pollutant	Agricultural load reduction (%)			In-river concentration reduction (%)		
	Current	Optimised	Maximum	Current	Optimised	Maximum
Dissolved phosphorus	7	24	58	7	24	49
Total phosphorus	9	33	68	7	29	49
Nitrate	6	29	64	3	14	39
Sediment	12	47	82	5	21	34

Source: Catchment Sensitive Farming Evaluation Report – Phases 1 to 3

2.12 Levy funded R&D

AHDB-funded R&D is a major source of new information and ideas that promote change in nutrient management.

Cereals and oilseeds sector: More than 50% of cereal and oilseed levy income is invested in research and knowledge transfer and a significant part of this relates to crop nutrition Current projects include sulphur use, phosphorus management, nitrogen requirement of winter barley, minimization of nitrous oxide emission, automated nitrogen fertiliser management and the collaborative project End-o-sludg. The research strategy for 2015 to 2020 (AHDB 2015) includes improvement of nitrogen use efficiency and improved targeting of crop inputs among priorities.

Horticulture sector: The research strategy includes optimization of fertiliser use through precision application techniques and development and dissemination of guidelines on crop nutrient utilization (AHDB 2013a).

Potato sector: Research projects include the LINK phosphorus use project in which the Cereals and oilseeds sector also participates. The fertiliser calculator, based on the Fertiliser Manual (RB209) for England and Wales and SRUC Technical Notes for Scotland, was launched in 2013 (AHDB 2013b).

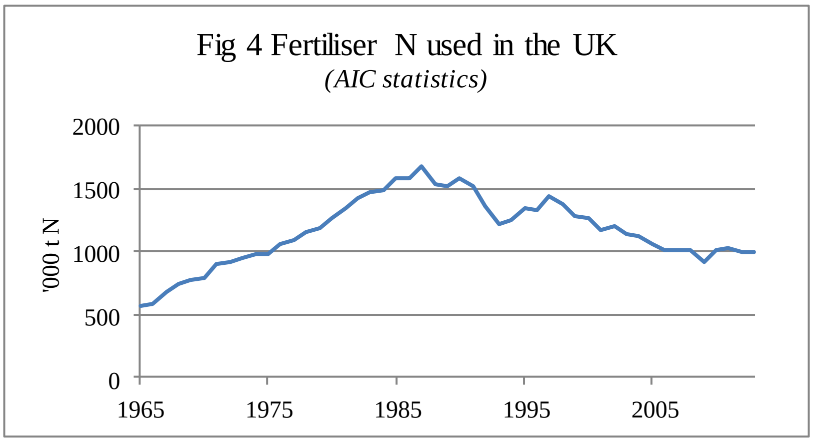
Sheep sector: Current research projects include assessment of grass and clover varieties for suitability in low and zero applied inorganic nitrogen systems, LINK project on breeding grass and white clover for improved phosphorus use.

Dairy sector: Current research projects include herbage varietal testing under reduced nitrogen input and effects of slurry applications on the behaviour and performance of dairy cattle.

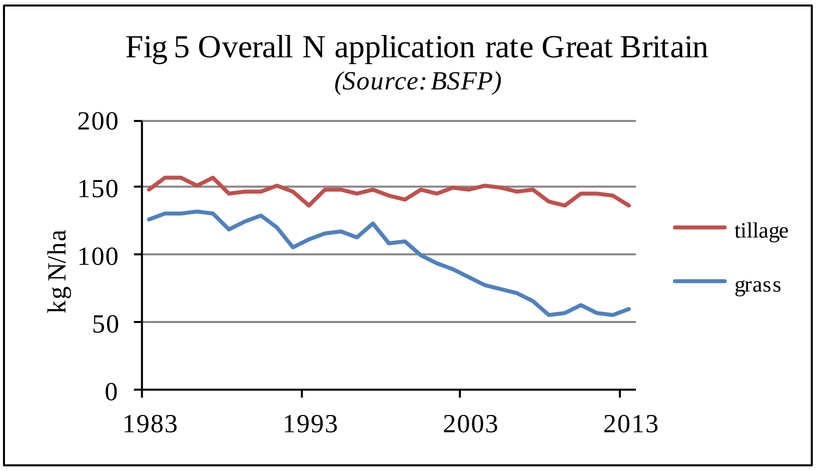
3.0 Nutrient management practices

3.1Use fertiliser nitrogen

Use of manufactured fertiliser nitrogen peaked in the UK around 1985, subsequently declined significantly but seems to be stabilizing at around 1 million tonnes N annually (Fig 4).

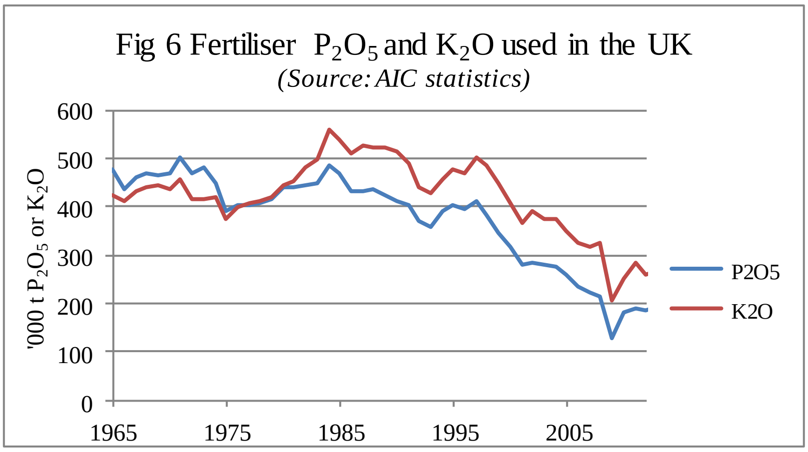


The decrease in nitrogen usage in Great Britain seems to have been mainly in grassland (Fig 5).



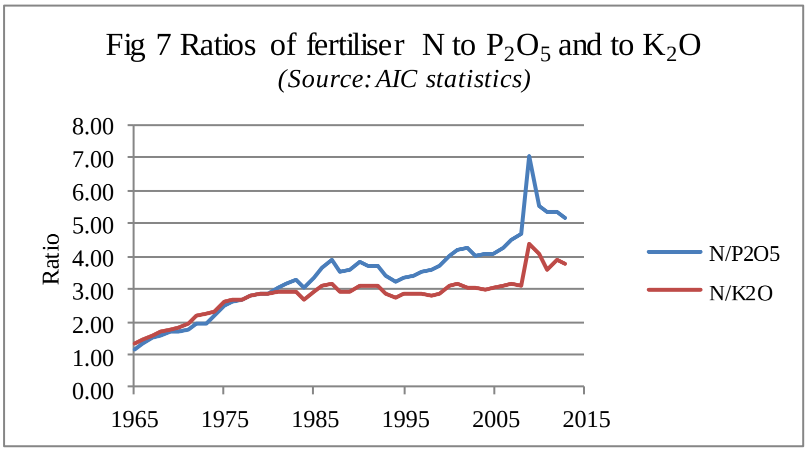
3.2 Use of fertilser phosphate and potash

From peak usage around 1985, application of phosphate and potash in the UK has decreased significantly and steadily (Fig 6). However, there are clear regional differences. Usage of phosphate and potash in England/Wales and in Scotland seem to have diverged since the early 1980s. British Survey of Fertiliser Practice data indicate the decline in usage in England and Wales has not occurred in Scotland. In 2012/13, phosphate and potash were applied to around 45% of arable land and 38% of grassland in England/Wales. Corresponding values for Scotland were around 86% for arable land and 58% for grassland.

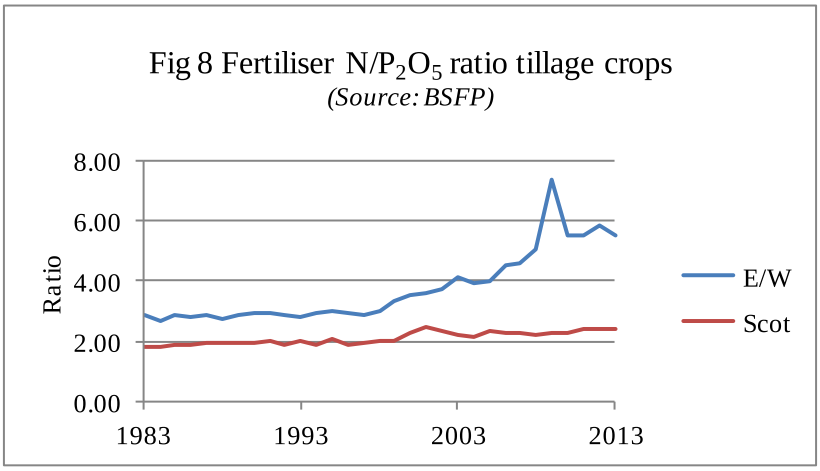


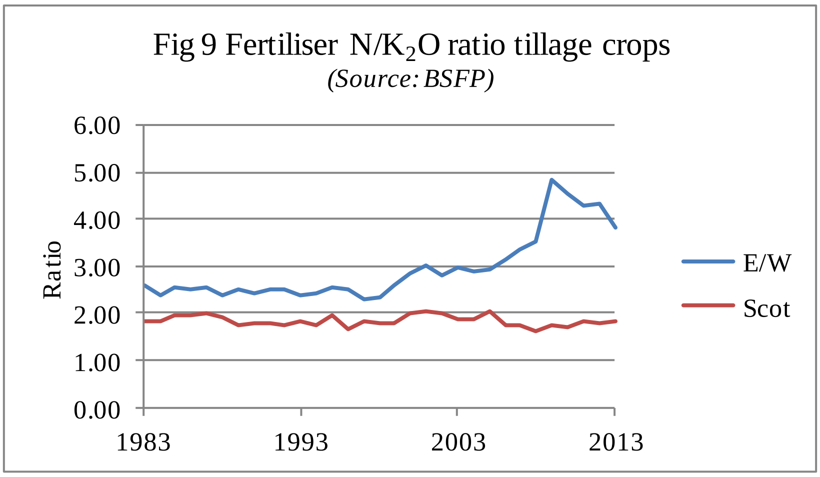
3.3 Ratio of fertiliser nitrogen to phosphate and potash

For the UK, the ratios of fertiliser nitrogen to phosphate and to potash increased steadily from 1960, showed a short-lived increase in 2009 but have since returned to the long-term trend line (Fig 7). However, it seems likely that the UK ratios remain too wide for long term sustainability of balanced soil nutrient supply.



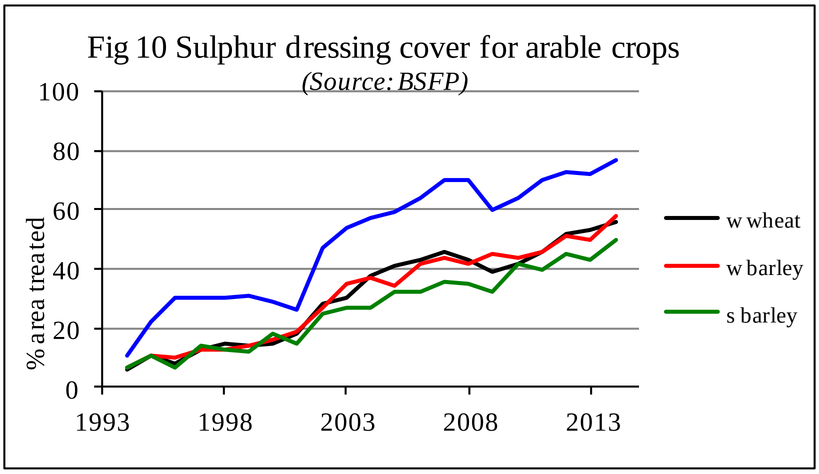
British Survey of Fertiliser Practice data indicate the upward trend in fertiliser nitrogen to phosphate and potash ratios has not occurred in tillage crops in Scotland (Figs 8 and 9).

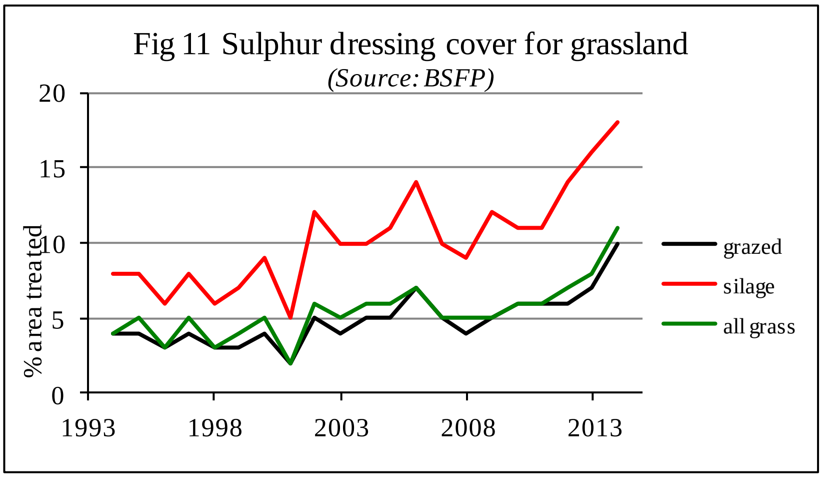




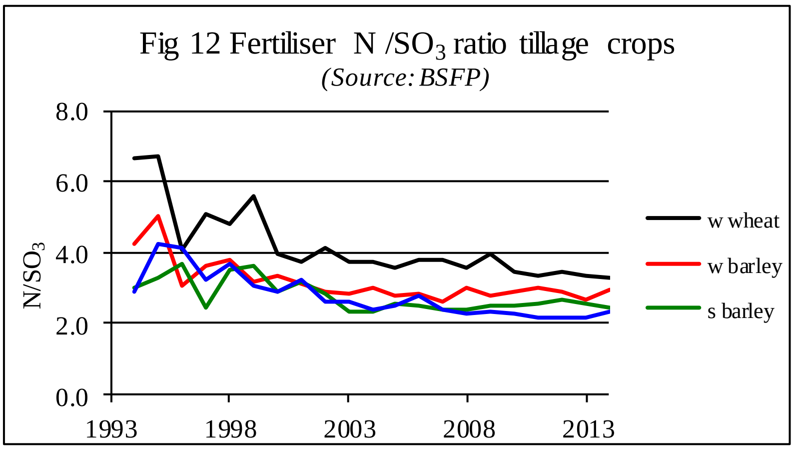
3.4 Use of fertiliser sulphur

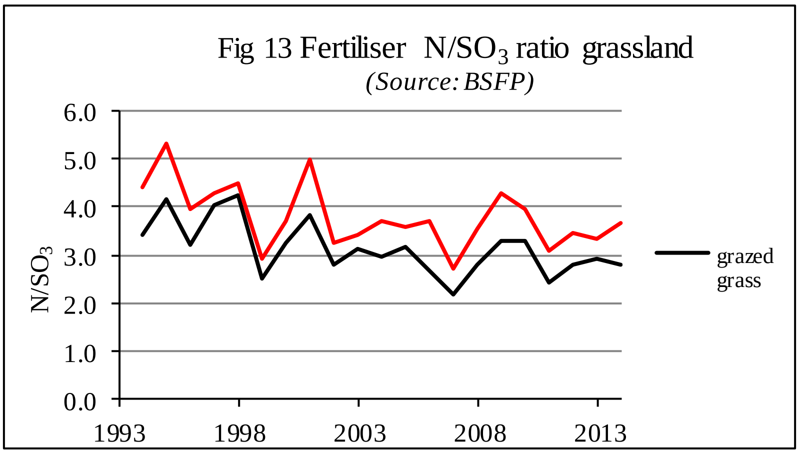
For the past twenty years use of fertiliser sulphur has increased steadily in arable cropping. In 2012/13, nearly 80% of the oilseed rape area and 50-60% of the cereal area received fertiliser sulphur (Fig 10). After many years of low usage, application of fertiliser sulphur to grassland has increased in recent years (Fig 11).





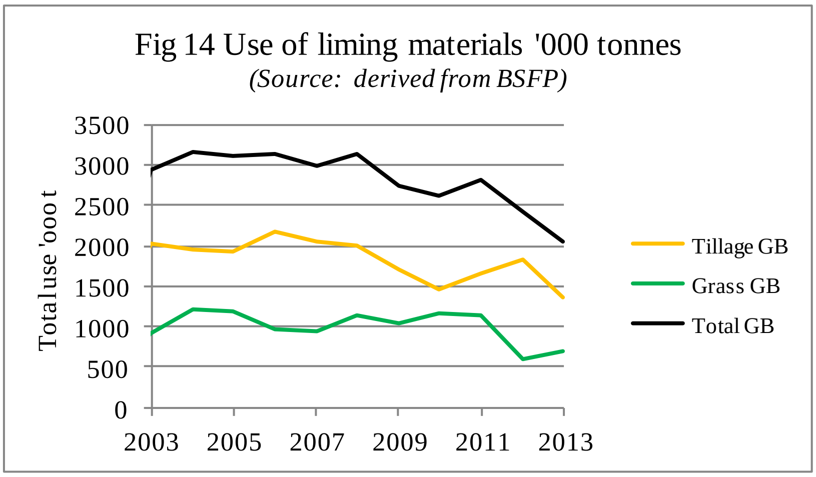
The ratio of fertiliser nitrogen to sulphur (SO_3) in both arable crops and grassland seems to be converging at around 3/1 (Figs 12 and 13) equivalent to a N/S ratio of 7/1.



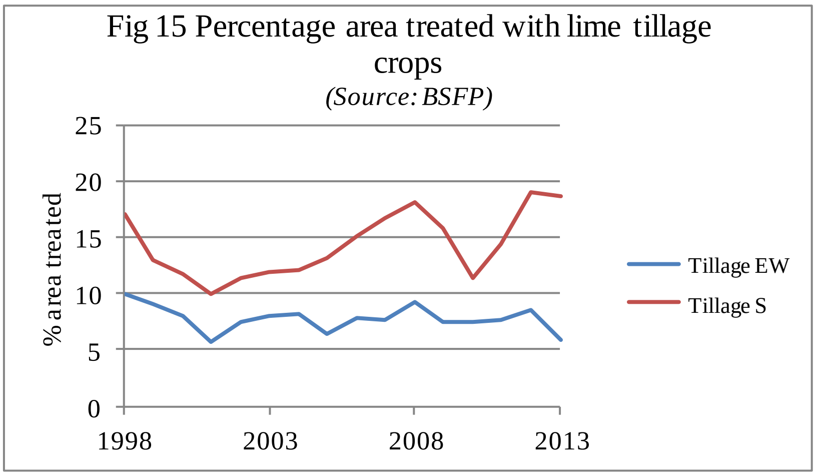


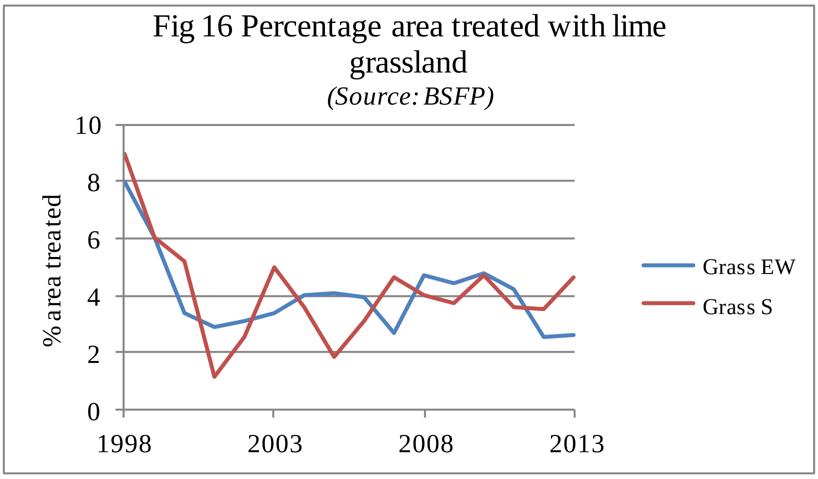
3.5 Use of lime

Use of lime in Great Britain seems to have decreased over the past decade. The British Survey of Fertiliser Practice provides data on percentage area treated and rates of application for liming materials. From these, total application amounts were calculated to indicate trends (Fig 14). Total volume does not take account of the different effectiveness of various liming materials so is a crude measure. However, the downward trend seems clear.



The percentage of tillage crop and grass areas to which lime was applied differed between tillage crops and grassland and, for tillage crops, between England/Wales and Scotland (Figs 15 and 16). The average liming intervals of around fourteen years in tillage crops in England/Wales and twenty five years in grassland appear inadequate to maintain soil pH in the long term. In the PAAG report for 2013/14 soil pH was lower than 6.0 in 20% of arable samples and lower than 5.5 in 21% of grassland samples.





3.6 Spreading fertiliser

Most manufactured fertiliser is spread using twin disc machines though a pneumatic spreader is still offered by Kuhn/Rauch. Maximum claimed bout width for disc spreaders has increased in a linear way for more than sixty years at a rate of around 7m/decade (Fig 17).

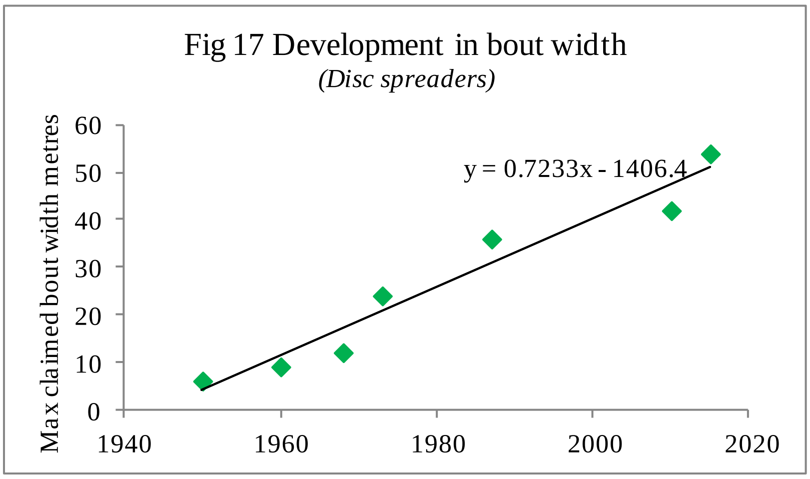


Fig 17 Development in bout width
(Disc spreaders)

With a maximum claimed bout width now greater than 50m and with 36m common in practice, there is a pressing need to ensure evenness of spreading. This depends on regular, at least annual, tray-testing of spreaders. The British Survey of Fertiliser Practice has provided annual information on this since 2006. The percentage of farms reporting annual tray-testing has remained at around 40%. The Farm Practices Survey for 2012 gave a corresponding value of 50%. Around 30% of farms reported never checking spread pattern and a further 10% tray-tested less frequently than annually (Fig 18). There has been some growth in professional testing of fertiliser spreaders. SCS (Spreader and Sprayer Testing Ltd) now conduct around 3000 tray tests on fertiliser spreaders annually but in 1999 tested fewer than 300 (SCS 2015).

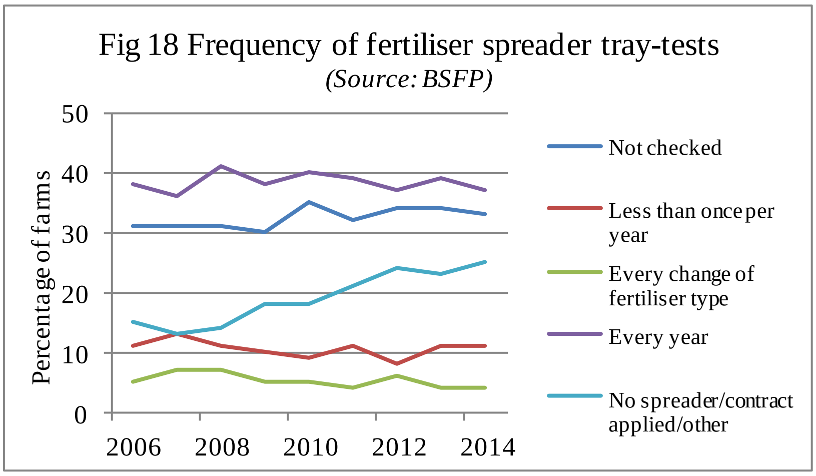


Fig 18 Frequency of fertiliser spreader tray-tests
(Source: BSFP)

Development in spreader technology, where sensor-controlled flow rate is now common, has reduced the need for manual spreader calibration. The same might happen for spread pattern management. Rauch has introduced radar-sensing of spread pattern and if this technology proves reliable and effective there could be reduced need for tray-testing. In the meantime, there seems scope for improvement in spreader testing and setting.

Currently there is no register of fertiliser spreader operators equivalent to the NRoSO national register for sprayer operators. However the Agricultural Engineers Association is consulting with industry on a standard spreader testing protocol and operator training opportunities.

3.7 Precision farming

In the 1990s, precision farming in the context of nutrients comprised soil mapping by grid sampling for P, K, Mg and pH and crop sensing for nitrogen. New technologies such as GPS have been introduced since then and the scope of precision farming has grown to include slurry injection, automatic recording of applications and other techniques. Precision farming, once the preserve of large farms, is becoming integrated with conventional farming as it is adopted more widely. For example, some 240 tractor-mounted N-Sensors and 200 hand0-held N-testers are now in use in the UK, many by contractors (Yara personal communication). By 2012, the N-Sensor had been used on UK farms covering more than 200,000 ha (Yara 2012).

Statistical data on the use of precision farming techniques are sparse. However, some were provided by the Farm Practices Surveys of 2009 and 2012. There were increases in uptake of all technologies recorded during this period (Table 5).

Table 5 Use of precision farming technologies in 2012 (2009 values in parentheses)

	% of farms
GPS	22 (14)
Soil mapping	20 (14)
Variable rate application	16 (13)
Yield mapping	11 (7)
Telemetry	2 (1)

Source: Farm Practices Surveys

The percentages in Table 5 are not additive as several techniques are likely to be used on a farm. The Farm Business Surveys of 2012/13 and 2013/14 included a question on use of precision farming techniques (Defra 2015a). In 2013/14, 18% of farms reported use of these techniques (16% in 2012/13).

In December 2014 and January 2015 the Greenhouse Gas Action Plan (GHGAP), National Farmers Union (NFU) and the National Association of Agricultural Contractors (NAAC) conducted research into the uptake of precision technology by farm contractors. Members of the National Association of Agricultural Contractors and of the National Farmers Union that have contracting operations were invited to take part in an online survey to which eighty contractors responded.

Table 6 Percentage of contractor respondents that use technologies (NFU 2015)

	% of contractors			
	used <2 years	used for 2-5 years	used >5 years	not used
Real time (eg N-Sensor) variable rate	3	6	1	90
Slurry injection	0	1	9	90
Trailing hose/shoe	4	4	6	86
Automatic recording of applications	6	9	14	71
Application map - variable rate	15	23	14	49
Variable rate spreader	16	30	14	40
Auto-steer	16	29	21	34
GPS	12	40	40	8

Techniques more commonly used show significant levels of adoption in the past two years. This suggests present strong growth in adoption of precision farming techniques at least among this group of contractors.

3.8 Spreading manures

The 2014 Farm Practices Survey included incorporation of manures spread on tillage land. The question specified 'manure' and 'slurry' though most farmers would understand 'manure' as 'FYM'. Lack of incorporation within one week was reported by 7% of farms for manure and 11% for slurry (Table 7). More interesting would be the extent of incorporation within six hours during which could reduce ammonia emission and within twenty four hours which, with some exceptions, is required in NVZs. The 2001 Farm Practices Survey included incorporation on the same day as application (1-7% of farms depending on type) and within twenty four hours (8-35% of farms).

Table 7 Incorporation of manures applied to tillage land

	% of all farms	
	Manure	Slurry
Plough	58	48
Disc/tine	13	20
Other	4	10
Don't incorporate within 1 week	7	11

Source: Farm Practices Survey

More interesting is the extent of incorporation within six hours during which could reduce ammonia emission and within twenty four hours which, with some exceptions, is required in NVZs. The 2001 Farm Practices Survey included incorporation on the same day as application (1-7% of farms depending on type) and within twenty four hours (8-35% of farms). Data on manure volume basis were reported in the British Survey of Fertiliser Practice for 2007 to 2014. In 2014, around 15% of all manure was incorporated within six hours, 28% within in 6-24 hours and 35% within one week (Table 8). The high proportion of pig slurry not incorporated could be due to the use of this manure for top-dressing winter sown cereals.

Table 8 Percentage of manure incorporated in tillage fields

	% manure volume				
	Not incorporated	<6 hours	6-24 hours	1-7 days	>1 week
FYM	5 (3)	13 (10)	28 (29)	45 (48)	9 (9)
Cattle slurry	34 (35)	12 (6)	12 (20)	24 (25)	18 (11)
Pig slurry	54 (80)	19 (10)	16 (5)	11 (4)	0 (0)
Poultry FYM	4 (7)	15 (9)	63 (64)	16 (15)	3 (4)
Other	15 (2)	24 (25)	44 (48)	15 (19)	1 (6)
Total	14 (12)	14 (12)	28 (32)	35 (35)	9 (8)

Source: BSFP 2014, 2012 values in parentheses

Less than half of manure was reported as incorporated within twenty four hours indicating potential for improvement.

The Farm Practices Survey in 2013, 2014 and 2015 included the calibration of manure spreaders. Strictly, ‘calibration’ refers to the checking of rate of application but many farmers might interpret it as tray testing. There is some uncertainty therefore about the meaning of the results but in any event around half of farmers who spread manure reported never calibrating their spreaders (Table 9).

Table 9 Calibration of manure spreaders

	% of all farms
Never	51 (58)
Whenever there is significant change in manure or slurry characteristics	18 (29)
Whenever manure or slurry is tested	2 (4)
Every year*	19
Less often than every year*	7
Other frequency	3 (9)

* options added in 2015

Sources: Farm Practices Survey 2015, 2013 values in parentheses

3.9 Manure storage

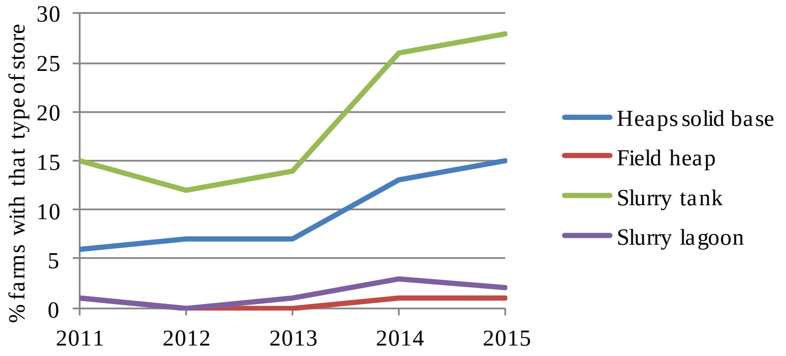
Information on manure storage was collected in the Farm Practices Survey in 2011-2015. Solid manure in heaps was the most common form of storage. About the same percentage of livestock farms reported slurry storage in tanks as in lagoons (Table 10).

Table 10 Methods of manure storage in 2015

	% of farms with livestock
Solid manure stored in heaps on solid base	58
Solid manure stored in temporary heaps in fields	68
Slurry stored in a tank	24
Slurry stored in a lagoon without strainer	15
Slurry stored with strainer facility	7
Slurry in another type of store	2

There was evidence of improvement in the management of manure storage. In 2015, 8% of farms with livestock reported having a slurry separator, an increase from 3-4% in previous years. There were increases in the proportion of slurry tanks and of manure heaps on solid base that were covered (Fig 19). In all years, 13-17% of farms that stored manure reported an intention to enlarge, upgrade or reconstruct their storage facilities. If maintained, these trends should steadily reduce ammonia emission from livestock manures.

Fig 19 Farms where manure stores are covered
(Source: Farm Practices Survey)



3.10 Soil Indices

The Professional Agricultural Analysis Group (PAAG) has published information on soil P and K indices in a series of annual reports since 2009. PAAG membership includes the main laboratories offering soil analysis for crop advisory purposes in the UK and the data published are summaries of their aggregated analytical data.

In 2013/14, 10% of arable and 9% of grassland soil samples were at target indices for both P and K (Tables 11 and 12) indicating scope for improvement. These percentages have remained between 8% and 11% since 2009 with no evidence for any upward or downward trend. 27% of arable and 36% of grassland soil samples were below target P index (2) and 31% of arable and 41% of grassland soil samples were below target K index (2-). The ability of the crops to take up and utilize nitrogen will be compromised at these low P and K indices leading to restricted crop growth and increased risk of nitrogen loss to the wider environment. 43% of arable and 33% of grassland soil samples were above target index for P. Phosphate application can be reduced or eliminated on these soils to allow the index to decrease. Again, there have been no clear upward or downward trends in these percentages since PAAG began publishing records.

Soil pH was lower than 6.0 in 20% of arable samples and lower than 5.5 in 21% of grassland samples.

Table 11 Percentages of samples in P and K Indices

(PAAG, total 129806 samples)

	P Index		
K Index	<target	target	>target
<target	12	9	10
target	8	10	13
>target	7	11	20

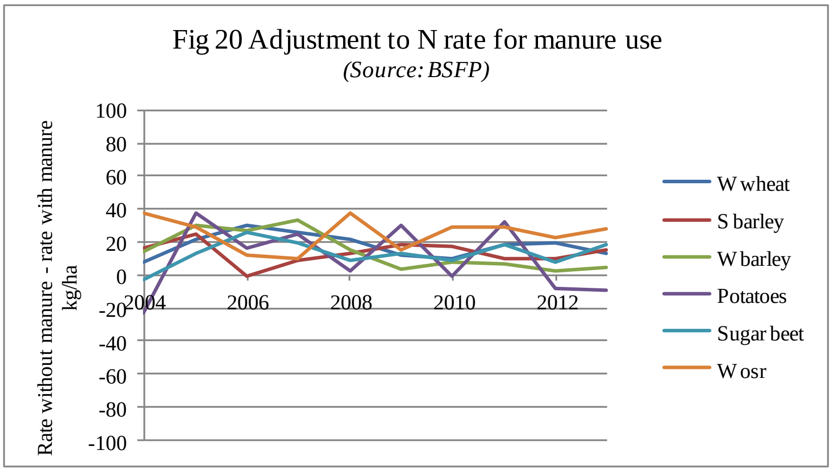
Table 12 Percentages of grass samples in P and K Indices

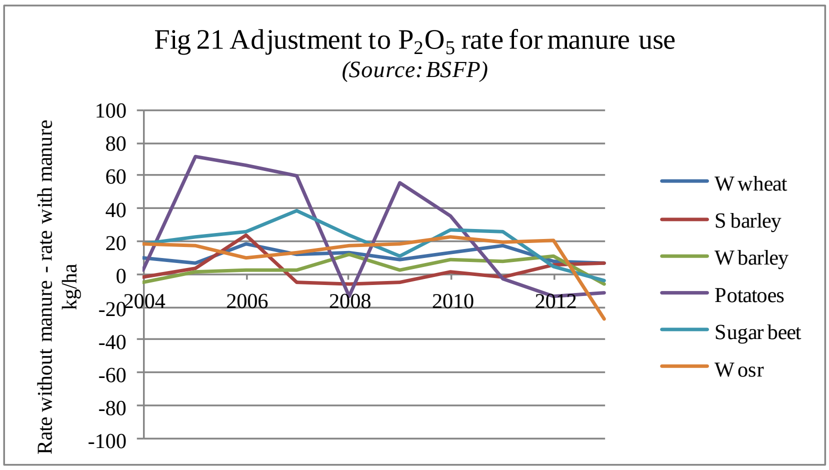
(PAAG, total 59448 samples)

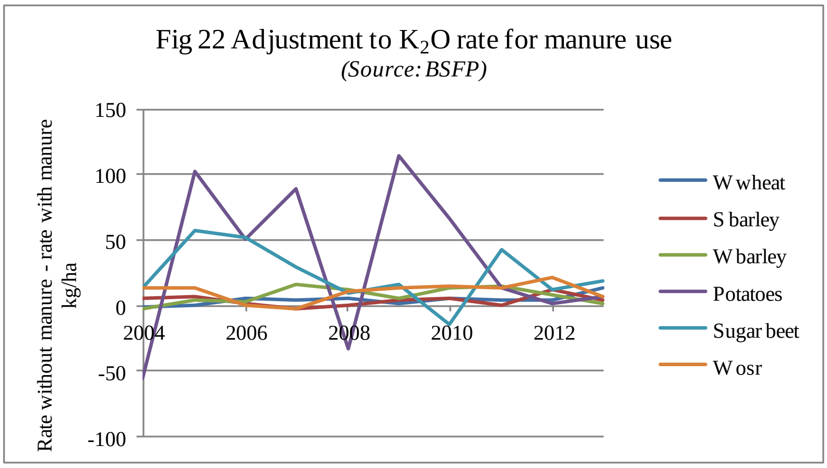
	P Index		
K Index	<target	target	>target
<target	19	13	9
target	10	9	9
>target	7	10	15

3.11 Allowance for nutrients in manures

The British Survey of Fertiliser Practice includes tables showing average field rates of nutrient application for fields where manures were applied and for those where no manure was applied. For a given crop, the difference between these rates is some indication of the adjustments made to fertiliser use where manure is applied. Typical application rates (BSFP 2012) of 24 t cattle or pig FYM/ha or of 30 m^3 cattle or pig slurry/ha will supply around 10-30 kg crop available N/ha, 40-140 kg total P_2O_5/ha and 70-190 kg total K_2O/ha. The Survey does not specify which type of manure was used but these are the amounts that might be used to adjust fertiliser applications. In most cases where manures are applied, no other applied potash would be needed. The Survey data show adjustments to fertiliser nitrogen rates that are reasonably consistent with the likely amount applied in manures, around 20 kg N/ha (Fig 20). However, adjustments to fertiliser phosphate and, especially, potash were mostly less than 20 kg/ha and smaller than the amounts likely to have been applied in manures (Figs 21, 22). Information in the diagrams must be treated with caution as the fields were not paired and, if no phosphate for example had been applied, no adjustment was possible. Nevertheless, the apparent adjustments to phosphate and potash use seem smaller than those that could be achieved and there is no evidence for an improving trend.







3.11 Actions related to greenhouse gas (GHG) emission

In 2013, 2014 and 2015 the Farm Practices Survey collected data on actions related to GHG emission. Around 60% of all farms reported taking actions that could reduce GHG emission (Table 13). Larger farms were more likely to report actions.

Table 13 Farms currently taking action to reduce GHG emissions from the farm (2013 values in parentheses)

	% of farms
Small	54 (55)
Medium	64 (63)
Large	76 (76)
Northeast	56 (58)
North west	54 (48)
Yorkshire	62 (62)
East midlands	64 (68)
West midlands	58 (63)
East	73 (69)
South east	57 (61)
South west	58 (61)
Cereals	72 (73)
Other crops	71 (68)
Pigs and poultry	62 (64)
Dairy	78 (68)
Grazing (LFA)	44 (45)
Grazing (lowland)	44 (51)
Mixed	66 (66)
All farms	61 (62)

Sources: Farm Practices Surveys

Recycling waste materials from the farm and improving nitrogen fertiliser accuracy were the most commonly reported actions (Table 14).

Table 14 Percentage of all farm taking actions to reduce GHG emission (2013 values in parentheses)

	% of farms
Recycling waste materials from the farm	51 (53)
Improving nitrogen fertiliser application accuracy	40 (46)
Improving energy efficiency	44 (42)
Increasing use of clover in grassland	23 (24)
Improving nitrogen feed efficiency	17 (19)
Improving efficiency in manure/slurry management & application	28 (17)
Increasing use of legumes in crop rotation	16 (14)
Taking other actions	3 (3)
No action taken	39 (39)

Source: Farm Practices Survey

4.0 Farmer opinions and motivations

4.1 Benefits of nutrient and manure management plans

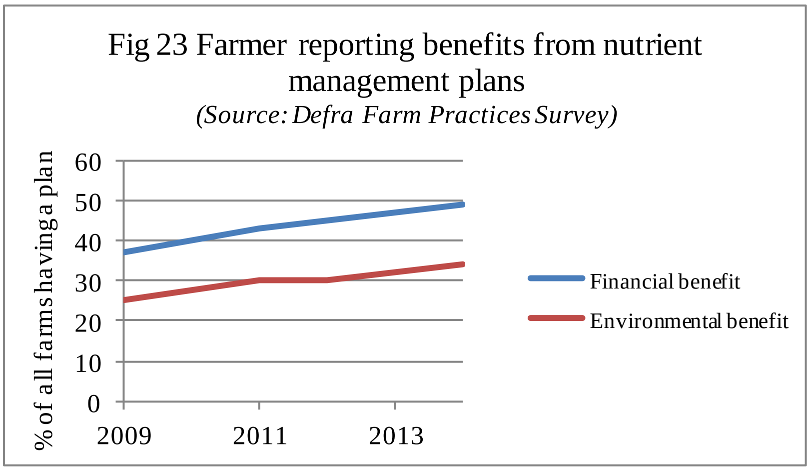
The Farm Practices Survey in 2009, 2011, 2012 and 2014 included questions on perceived financial and environmental benefits from having a nutrient management plan. Around half of farmers reported a financial benefit and one third an environmental benefit with no real differences between farm sizes or regions (Table 15). Pig and poultry farms were less likely to report a financial benefit while pig and poultry and other crop farms were less likely to report an environmental benefit.

Table 15 Percentage of farms reporting financial and environmental benefits of a nutrient management plan in 2014 (2013 values in parentheses)

	% of farms having a plan	
	Financial benefit	Environmental benefit
Small	48 (41)	35 (30)
Medium	50 (41)	31 (27)
Large	49 (48)	34 (32)
Northeast	48 (28)	41 (34)
North west	57 (38)	49 (22)
Yorkshire	45 (48)	30 (30)
East midlands	46 (42)	32 (25)
West midlands	49 (44)	24 (30)
East	44 (39)	31 (25)
South east	53 (50)	35 (38)
South west	52 (47)	43 (39)
Cereals	45 (41)	34 (28)
Other crops	57 (43)	29 (27)
Pigs and poultry	33 (34)	33 (28)
Dairy	53 (43)	37 (26)
Grazing (LFA)	50 (38)	37 (24)
Grazing (lowland)	48 (45)	38 (40)
Mixed	50 (49)	29 (36)
All farms	49 (43)	34 (30)

Source: Farm Practices Survey

Similar information was collected in surveys in 2009, 2011 and 2012 and there were clear increasing trends in reported benefits (Fig 23).



4.2 Motivation needed to create management plans

Information on the motivation needed to introduce a nutrient management plan was collected in the Farm Practices Survey in 2013 and 2014. Responses for the two years were reasonably consistent (Table 16). Similar information was collected for manure management plans in the 2014 survey (Table 17).

Table 16 Motivations to create a nutrient management plan for those without one in 2014 (2013 values in parentheses)

	% of farms
More time	28 (27)
More money to pay an adviser	26 (29)
If nutrient management tools made it easier to understand	18 (23)
Reassurance of seeing a return for the work put in	48 (53)
No motivation	22 (20)

Table 17 Motivations to create a manure management plan for those without one in 2014

	% of farms
More time	19
Reassurance of seeing a return for the work put in	26
Knowing where to look for advice and guidance	12
If professional advice was available to produce the plan	10
If published guidance was available to assist in producing plan	17
No motivation	47

Source: Farm Practices Survey

The main motivation for introducing a nutrient management or manure management plan was reassurance of seeing a return for the work put in.

5.0 Nitrogen use efficiency

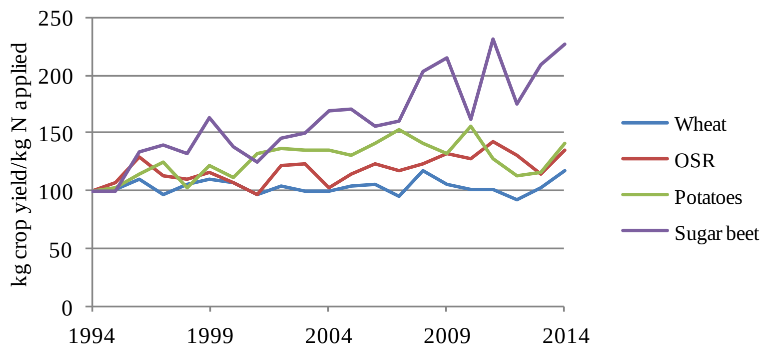
5.1 Method of calculation

In this report, nitrogen use efficiency (apparent NUE but for brevity called NUE here) for arable crops is the ratio of crop yield (kg/ha) to input of manufactured fertiliser nitrogen (kg N/ha). NUE values calculated in this way must be interpreted with care (see below) but this method was the only one that could be applied to available national data. For grassland, the population of grazing livestock expressed as livestock units was used as a measure of production, again because this was what available data allowed. These are the same as the methods of calculation described in the 2012 report.

5.2 Arable crops

UK average yield data were available from Defra statistics for four main arable crops: wheat, oilseed rape, maincrop potatoes and sugar beet. Overall nitrogen application rates for GB (England, Scotland and Wales) were available from The British Survey of Fertiliser Practice. The discrepancy between UK and GB was unlikely to have affected calculated trends significantly (for sugar beet, not at all). Calculated trends, normalised so that the 1994 value for each crop = 100, are shown in Fig 24.

Fig 24 Nitrogen use efficiency (NUE) index
(1994 = 100)



Over the period 1994 to 2014, NUE for wheat remained stable. There were some increases in oilseed rape and potatoes and a very large increase in sugar beet.

Care is needed in interpreting these trends as there are three factors that can influence NUE calculated in this way:

a) Application rate of nitrogen: as 40-50% of crop yield typically is supported by non-fertiliser nitrogen supply, NUE calculated as yield/nitrogen applied, will increase as nitrogen rate decreases. If no fertiliser nitrogen is applied, there will still be a substantial crop yield so NUE will be infinitely large.
b) Changes in crop yield due to practices that are not related to crop nutrition, for example variety improvement or changes in pest and disease control.
c) Changes in nutrient management practices.

There is evidence that all three of these factors operated during the period 1995 to 2013. Trends in yield (1994 = 100) showed a large increase for sugar beet but much smaller increases for the other crops, especially wheat (Fig 25). Overall nitrogen application rates were quite stable for wheat and oilseed rape but decreased significantly for potatoes and, especially, for sugar beet (Fig 26). Trends for the four crops can be summarised:

Wheat: no significant changes in yield, nitrogen rate or NUE.

Oilseed rape: No significant change in nitrogen rate, small increases in yield and NUE.

Maincrop potatoes: Small increase in yield, reduction in nitrogen rate and increase in NUE.

Sugar beet: Large increase in yield, large decrease in nitrogen rate and very large increase in NUE.

Sugar beet has seen an increase in NUE simultaneous to an increase in yield. In this crop there have been real technical improvements in agronomic practices and/or variety development. The same applies, to a lesser extent, in oilseed rape. The increase in NUE in potatoes could be due to a decrease in nitrogen application without any other changes. The situation in wheat is disappointing with apparent stagnation in yield, nitrogen use and NUE.

Fig 25 UK crop yield index (1994 = 100)
(Source: Defra statistics)

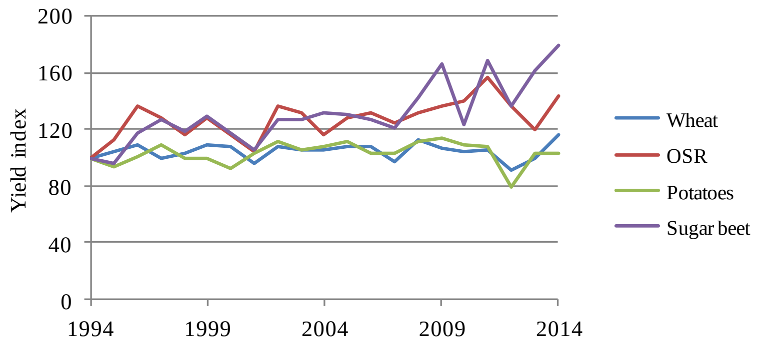
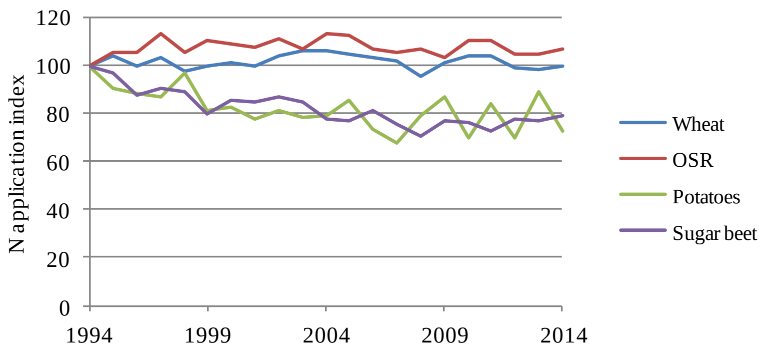


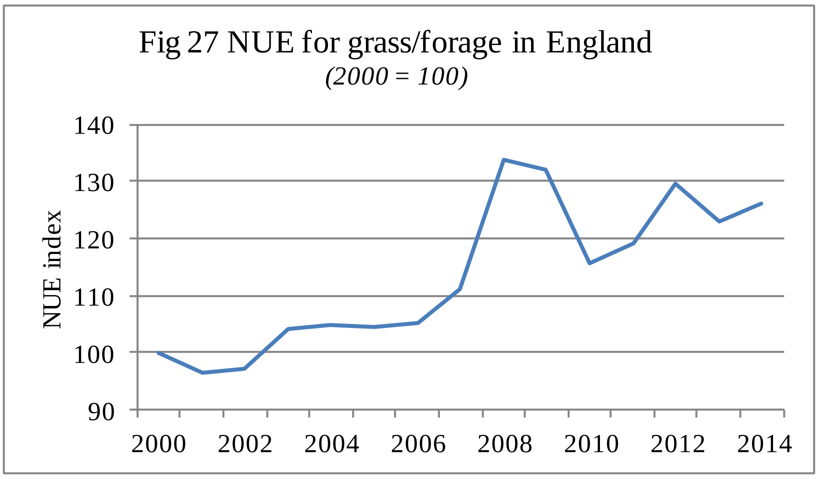
Fig 26 GB nitrogen application index (1994 = 100)
(Source: Defra statistics)

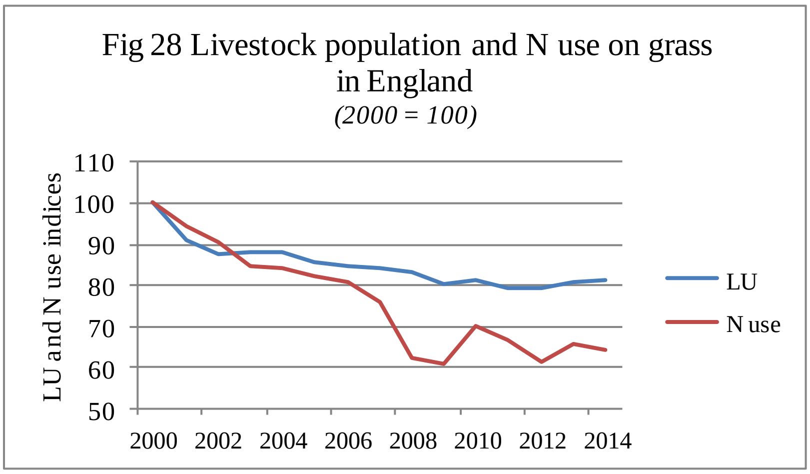


5.3 Grassland

A different approach was needed for grassland to take account of the data that were available. As described in the 2012 report, NUE for grassland is defined here as the ratio of total grazing livestock (cattle + sheep) population expressed as livestock units (LU) to input of manufactured fertiliser nitrogen (kg N). Data used for nitrogen input were application rates (kg N/ha) from the British Survey of Fertiliser Practice and grassland area from Defra statistics (all grass minus rough grazing). In order to minimize the effect of sheep maintained on uplands to which fertiliser was not applied, NUE was calculated for England rather than GB or UK. Grass area data for England were available from Defra statistics and nitrogen rates for England/Wales were available from the British Survey of Fertiliser Practice. Details of the method of calculation are in Appendix 2.

Calculated in this way, NUE tended to increase to 2008 but to remain roughly stable since (Fig 27). As with arable crops, changes in NUE could be due to those in nitrogen input or in agronomic practices. Total grazing livestock population in England decreased from 2000 but there was a proportionally greater decrease in nitrogen use on grass (Fig 28). Overall, the data indicate a substantial increase in grassland NUE since 2000 probably due to extensification rather than to improvements in nutrient management practices.

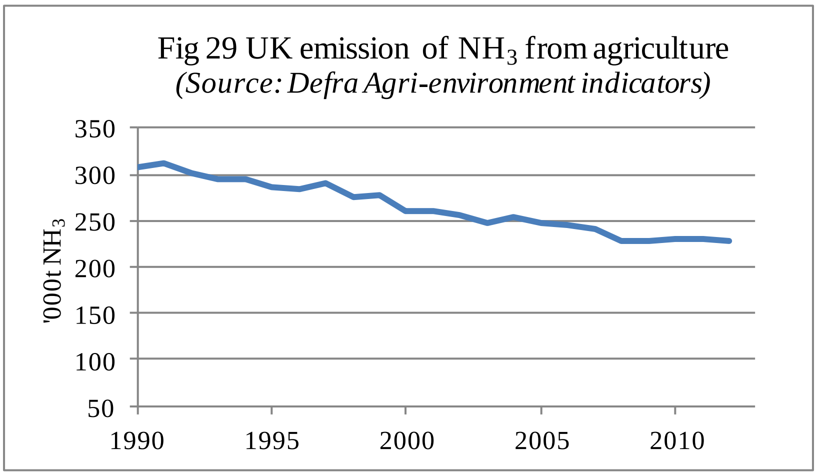


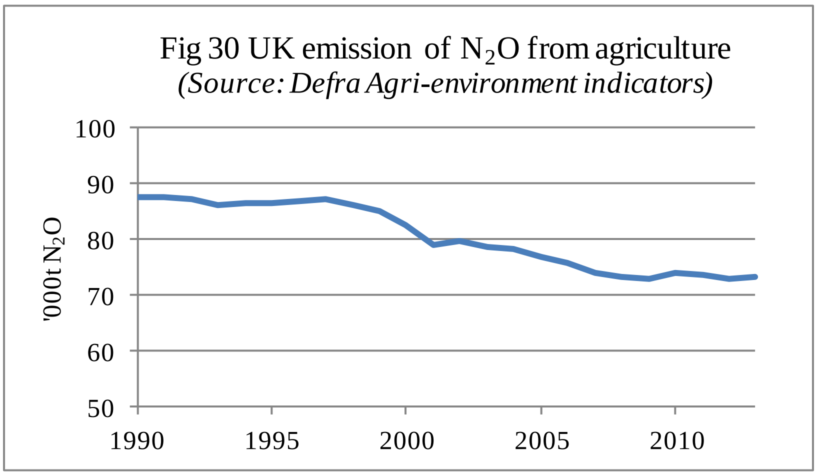


6. Environmental impact

6.1 Emissions to air

Changes in nutrient management practices are reflected in emissions of nutrients to the wider environment. Over the past twenty five years, emissions of ammonia and nitrous oxide from UK agriculture have decreased by around 26% and 17% respectively (Figs 29 and 30). The decreases in livestock population and in fertiliser nitrogen use on grassland (Figs 5 and 28) no doubt have contributed to these reductions in emissions. As livestock population and nitrogen use on grass have stabilised in recent years, further reduction in emissions will depend on improvements in nitrogen management and especially in the storage and use of manures.



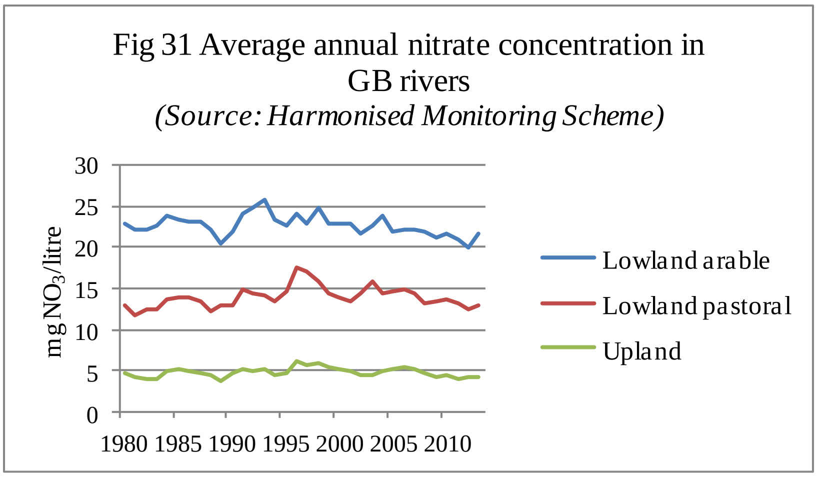


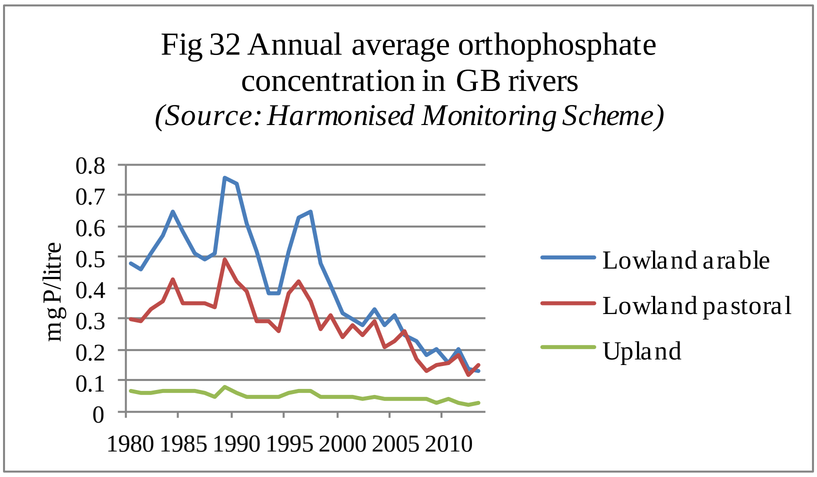
6.2 Emissions to water

In 2006, it was reported that agriculture contributed 61% of the nitrate load to surface waters in England and Wales (ADAS 2006), 26% of the total phosphorus load to waters in England, 22% in Scotland and 57% in Wales (Defra 2006).

The Harmonised Monitoring Scheme provided data for nitrate and orthophosphate concentrations in rivers in Great Britain (Defra 2014b).

Nitrate concentration in rivers in Great Britain has decreased slightly in lowland areas during the past twenty years (Fig 31) but orthophosphate concentration has decreased markedly (Fig 32). The decrease in orthophosphate probably is due largely to phosphate removal from wastewater at sewage treatment works.

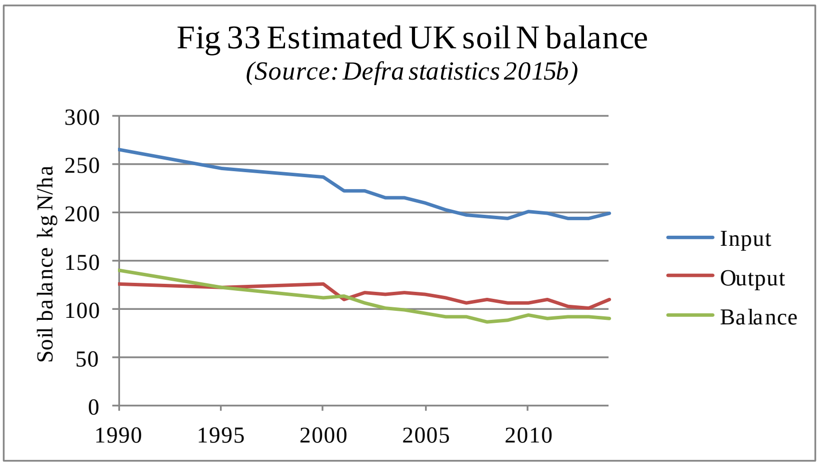


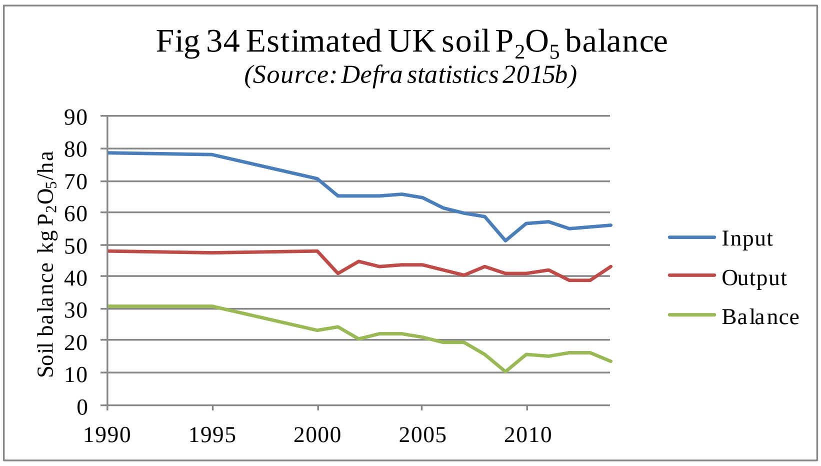


6.3 Soil nitrogen and phosphate balances

Defra publish annual estimates of soil balances for nitrogen and phosphorus for the UK and England using methods developed by OECD and adopted by Eurostat (Defra 2015b). Input sources are manures, mineral fertilisers, atmospheric deposition and biological fixation. Removals taken into account are crop production and fodder production for livestock, including grazing.

Calculated in this way, soil nitrogen and phosphate balances have decreased by 35% and 57% respectively since 1990 (Figs 33 and 34).





7.0 Future requirements and opportunities

7.1 Aspects close to saturation

There are two aspects of nutrient management where uptake seems to be close to saturation (80+ of farmers, 90%+ of land area) and where continued wide-scale promotion might not be cost effective:

- Possession of a nutrient management plan among arable farms
- Regular soil sampling and analysis among arable and mixed farms

There will be instances where advice on uptake will be needed but these no longer seem to present major challenges. Other areas such as use of fertiliser sulphur to support nitrogen are making steady progress so are not priorities for promotion. However, there are several areas where change does need to be promoted.

7.2 Manure management

It seems that the nutrients in manures are not being exploited fully or at least their application is not resulting in a corresponding change in fertiliser use. Priorities for improvement are:

- Introduction of a manure management plan among mixed and grazing livestock farms
- Nutrient analysis and assessment of manures
- Appreciation of manures as nutrient sources and consequent adjustments to fertiliser use
- Rapid incorporation of manures
- Calibration of manure spreaders

7.3 Grazing livestock farms

These farms continue to have relatively low uptake of nutrient management tools. Partly this will be due to cost or complexity but the Tried & Tested nutrient management plan continues to make progress and this supports the promotion of other paper-based management tools.

7.4 Spreader calibration/tray testing and operator training

Accurate spreading of fertiliser is important for economic and environmental reasons but the proportion of farmer conducting annual tray-testing of spreaders (around 40%) has remained stable for several years. The importance of accurate spreading needs emphasis. A register of operators of fertiliser spreaders, similar to that operated by NRoSO for sprayer operators, might be considered.

7.5 Use of soil analysis to adjust fertiliser and lime use

While there might not be great scope for increasing the number of soil samples taken, data for soil indices and lime use indicate better use might be made of analytical results. The economic and environmental benefits from achieving target soil P and K indices and pH need to be promoted.

References

ADAS (2006) *Supporting paper D1 for the consultation on implementation of the Nitrates Directive in England*. Available at http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/environment/quality/water/waterquality/diffuse/nitrate/documents/consultation-supportdocs/d1-nitrateswater.pdf.

AHDB (2011) *Improved analysis of solid manures and slurries*. AHDB Information Sheet, Summer/2011. Available at www.ahdb.org.uk/projects/documents/AHDBImprovedanalysisofsolidmanuresandslurries.pdf

AHDB (2013a) *HDC Research and knowledge transfer strategy 2013*. Available at www.hdc.org.uk/sites/default/files/HDC%20RKT%20Strategy%20Final%20For%20website%20May%202013.pdf.

AHDB (2013b) Fertiliser calculator on show at BP2013. Information is at www.potato.org.uk/news/fertiliser-calculator-show-bp2013.

AHDB (2015) *Investing in innovation. Research and knowledge exchange strategy 2015-2020*. Available at www.hgca.com/media/592437/hgca-rke-strategy-2015-8pp.pdf.

BSFP (2012) British Survey of Fertiliser Practice. Latest and earlier reports are available at http://www.defra.gov.uk/statistics/foodfarm/enviro/fertiliserpractice/.

Chambers B J, Nicholson F A, Dampney P M R, Smith K A, Williams J R and Chadwick D R (2010) Nutrient management tools: the Fertiliser Manual and MANNER-NPK. In Treatment and Use of Organic Residues in Agriculture: Challenges and Opportunities Towards Sustainable Management. *Proceedings of the 14th Ramiran International Conference, Lisbon, 12-15th September 2010*. Available at www.ramiran.net/ramiran2010/docs/Ramiran2010_0248_final.pdf.

CSF (2014) *Catchment Sensitive Farming Evaluation Report – Phases 1 to 3 (2006-2014).* Available at http://publications.naturalengland.org.uk/publication/6510716011937792.

Defra (2006) *Project WT0701CSF Updating the estimate of the sources of phosphorus in UK waters*. Available at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=13635.

Defra (2014a) Farm Practices Survey. Reports for February 2014 and for earlier years and detailed statistics are available at www.gov.uk/government/collections/farm-practices-survey.

Defra (2014b) ENV-16 Harmonised Monitoring Scheme datasets. Available at www.gov.uk/government/statistical-data-sets/env-16-harmonised-monitoring-scheme-datasets.

Defra (2015a) Fertiliser usage on farms: Results from the Farm Business Survey, England 2012/13 and 2013/14. Available at www.gov.uk/government/collections/farm-business-survey.

Defra (2015b) UK and England soil nutrient balances 2014. Available at www.gov.uk/government/statistics/uk-and-england-soil-nutrient-balances-2014.

NFU (2015) *Precision of Contractor Operations Survey, December 2014/January 2015*.

PAAG (2014) *Collation of data from routine soil analysis 2013/14*. Available at www.nutrientmanagement.org/Library-publications/Library-publications/.

SCS (2015) Spreader and Sprayer Testing Ltd web site www.spreadcheck.com/about.html.

Yara (2012) N-Sensor Book 2012. Available at http://yara.co.uk/images/N_Sensor_book_2012_Yarai%20(1)_tcm430-94852.pdf.

Appendix 1 Relevant items included in Defra Farm Practices Surveys

	2006	2007	2009	2011	2012	2012 GHG	2013 GHG	2014 GHG	2015 GHG
Possession nutrient management plan	√	√	√	√		√	√	√	√
Take advice for nutrient management plan	√		√	√		√	√	√	√
Source of advice/recommendations			√	√		√	√	√	√
Update nutrient management plan			√	√		√	√	√	√
Method of creating nutrient management plan	√		√	√		√	√	√	√
Regular soil testing	√		√	√	√	√	√	√	√
Tools for calculating nutrient requirement	√	√							
Calibration/tray testing of fertiliser spreaders				√		√			
Financial benefit of nutrient management plan			√	√		√	√	√	
Environmental benefit of nutrient management plan			√	√		√	√	√	
Motivation to create nutrient management plan				√		√	√	√	
Possession manure management plan			√	√		√	√	√	√
Source of recommendations for plan			√	√		√	√	√	
Nutrient analysis of manures			√	√		√	√	√	√
Nutrient assessment of manures		√	√	√		√	√	√	
Calibration of manure spreaders							√	√	√
Incorporation of manures								√	
Motivation to create manure management plan								√	
GHG emission actions							√	√	√
Precision farming			√		√				

Computer controlled variable rate spreaders	√	√	

Appendix 2 Components of nutrient management planning in 2015 (% of all holdings, land area values in parentheses

	Have nutrient management plan	Take professional advice for NMP	Regular soil testing	Nutrient analysis of manures	Nutrient assessment of manures	Have manure management plan
Small	52 (65)	73 (77)	64 (76)	13 (17)	31 (39)	51 (60)
Medium	66 (75)	77 (80)	75 (78)	16 (16)	44 (46)	74 (74)
Large	78 (83)	78 (77)	88 (92)	30 (34)	45 (47)	84 (87)
Northeast	52 (51)	68 (78)	68 (69)	9 (11)	34 (40)	67 (65)
North west	46 (55)	72 (71)	60 (70)	13 (16)	25 (33)	64 (75)
Yorkshire	62 (72)	79 (79)	75 (85)	18 (26)	40 (42)	69 (79)
East midlands	70 (89)	76 (77)	75 (91)	19 (33)	43 (48)	68 (83)
West midlands	57 (77)	70 (73)	71 (86)	17 (25)	45 (56)	62 (76)
East	83 (94)	82 (78)	93 (98)	34 (49)	45 (40)	63 (81)
South east	60 (85)	77 (78)	68 (89)	15 (25)	35 (49)	44 (71)
South west	50 (69)	73 (74)	63 (81)	16 (23)	33 (46)	62 (77)
Cereals	88 (93)	85 (82)	94 (97)	29 (30)	47 (54)	72 (78)
Other crops	83 (94)	80 (77)	94 (98)	34 (54)	40 (39)	74 (87)
Pigs and poultry	45 (84)	78 (80)	63 (86)	35 (60)	36 (41)	55 (89)
Dairy	77 (81)	75 (75)	83 (90)	27 (33)	43 (47)	90 (91)
Grazing (LFA)	30 (31)	50 (65)	40 (52)	3 (4)	20 (27)	48 (58)
Grazing (lowland)	31 (43)	60 (69)	45 (55)	5 (6)	29 (38)	48 (62)
Mixed	72 (85)	73 (78)	83 (93)	14 (21)	52 (57)	73 (84)
All farms	60 (76)	75 (77)	71 (85)	17 (26)	37 (44)	63 (76)

Source: Farm Practices Survey 2015

Appendix 3 Yield and nitrogen rate data used to calculate NUE for arable crops

	Wheat		Oilseed rape		Maincrop potatoes		Sugar beet	
	t/ha	**kg N/ha**	**t/ha**	**kg N/ha**	**t/ha**	**kg N/ha**	**t/ha**	**kg N/ha**
1994	7.4	186	2.5	179	41.8	194	44.7	122
1995	7.7	193	2.8	188	38.9	176	43.0	118
1996	8.1	185	3.4	188	42.1	171	52.4	107
1997	7.4	192	3.2	203	45.4	169	56.5	110
1998	7.6	182	2.9	188	41.6	188	53.0	109
1999	8.1	185	3.2	197	41.6	158	58.0	97
2000	8.0	188	2.9	195	38.5	160	52.5	104
2001	7.1	185	2.6	193	43.0	151	47.0	103
2002	8.0	193	3.4	199	46.5	158	56.5	106
2003	7.8	197	3.3	191	44.2	152	56.6	103
2004	7.8	197	2.9	202	44.9	154	58.7	95
2005	8.0	195	3.2	201	46.6	166	58.5	94
2006	8.0	192	3.3	191	43.0	142	56.6	99
2007	7.2	190	3.1	189	43.1	131	53.8	92
2008	8.3	178	3.3	191	46.6	154	63.8	86
2009	7.9	188	3.4	185	47.7	168	74.0	94
2010	7.7	193	3.5	197	45.5	135	55.1	93
2011	7.8	193	3.9	197	45.0	163	75.4	89
2012	6.7	184	3.4	187	33.0	135	60.7	95
2013	7.4	183	3.0	187	43.0	173	72.1	94
2014	8.6	185	3.6	191	43.0	141	80.0	96

Appendix 2 Method of calculating grassland NUE

For calculating grassland NUE, conversion from livestock head to LU was:

	LU/head
Total breeding herd	
Dairy herd	1.00
Beef herd	0.60
Aged 2 years or more	
Dairy	0.60
Beef	0.60
Aged 1-2 years	
Dairy	0.30
Beef	0.30
Aged 2 years or more	
Bulls for service	1.00
Females for dairy herd replacement	1.00
Females for beef herd replacement	0.60
Aged 1- 2 years	0.30
Bulls for service	
Females for dairy herd replacement	
Females for beef herd replacement	
Other cattle	
Aged 2 years or more	
Male	0.80
Females intended for slaughter	0.80
Aged 1 - 2 years	
Other male cattle	0.30
Females intended for slaughter	0.30
Under 1 year	0.20
Calves intended for slaughter	
Other male calves (including bull calves intended for service)	
Other female calves	

These values were applied to livestock populations in Defra statistics to derive total LU for England.

Nitrogen use data used for calculating grassland NUE

	Grass area ha	Overall N kg N/ha	N used on grass tonnes N	N used on forage tonnes N	Total N used tonnes N
2000	3639057	95	345710	8000	353710
2001	3612249	90	325102	8000	333102
2002	3663347	85	311384	8000	319384
2003	3685774	79	291176	8000	299176
2004	3760869	77	289587	8000	297587
2005	3919877	72	282231	8000	290231
2006	4015614	69	277077	8000	285077
2007	4064898	64	260153	8000	268153
2008	4076549	52	211981	8000	219981
2009	3839174	54	207315	8000	215315
2010	3875056	62	240253	8000	248253
2011	3858799	59	227669	8000	235669
2012	3863730	55	212505	8000	220505
2013	3940892	59	224631	8000	232631
2014	3923532	58	227565	8000	235565

A constant value was used for nitrogen use on forage crops (maize, root and leafy forage crops) as there were no consistent data for individual crops in Defra statistics and the British Survey of Fertiliser Practice.

LU and nitrogen use data used for calculating grassland NUE

	Total LU	N applied to grass tonnes N
2000	4925682	353710
2001	4470473	333102
2002	4311361	319384
2003	4328992	299176
2004	4346398	297587
2005	4227476	290231
2006	4169094	285077
2007	4150402	268153
2008	4099821	219981
2009	3959885	215315
2010	3992370	248253
2011	3914527	235669
2012	3916215	220505
2013	3980119	232631
2014	3999970	235565