Welsh Government




Indicative economic assessment of the 170 kilograms of nitrogen per hectare per year limit of the Control of Agricultural Pollution Regulations

January 2025

CONTENTS

EXECUTIVE SUMMARY

E1. This report presents indicative estimates of the number of Welsh farms potentially affected by the annual limit of 170kg of nitrogen (N) from livestock per hectare per year prescribed under the Water Resources (Control of Agricultural Pollution) (Wales) Regulations (hereafter CoAP). Indicative estimates of the aggregate farm-level and supply-chain costs of compliance are also presented. The findings presented may contribute to any future Regulatory Impact Assessment (RIA).

E2. The analysis presented draws pragmatically upon best available data. However, estimates must be treated cautiously as offering indicative insights rather than definitive conclusions. This reflects multiple data uncertainties and limitations inherent to the modelling approach and its assumptions. As such, results should be interpreted with care, considering their caveats, context and need for further research.

E3. For example, reported June Agricultural Survey (JAS) livestock data do not align perfectly with CoAP categories, farm areas and livestock numbers vary across different official data sources, and average unit costs for exporting N, renting land and/or destocking to comply with the 170kg N limit may not reflect local circumstances. Equally, multiplier analysis of wider supply-chain effects necessarily involves additional assumptions. Such caveats are noted and discussed throughout the report.

E4. Moreover, the analysis focuses solely on the 170kg N limit but Welsh farms are also subject to other related regulatory controls. These include minimum required slurry storage capacity and prescribed timings for slurry applications but also importantly constraints related to phosphate (P) levels from livestock sources (under Environmental Permitting Regulations 2010, EPR). However, data limitations mean that an assessment of these combined regulatory interventions was not possible.

E5. The uniform 170kg N annual threshold is one element of a package of measures to reduce nitrate and phosphorus emissions. Such measures address short-term risks of substantial retrospective EU infraction costs and longer-term EU competition requirements to maintain a Level Playing Field. Variation in regulatory approaches is compatible with the latter provided that equivalence of outcomes is maintained. However, whilst the EU-UK Trade Cooperation Agreement allows for regulatory divergence, failure to maintain equivalence would potentially threaten UK farm exports to the EU (worth c.£2.8bn in 2023, of which c.£0.3bn were Welsh and much of it livestock related).

E6. The various interacting uncertainties are accommodated analytically by approximating lower and upper-bound situations. Estimates are shown for farms in receipt of public support payments in 2019, for all farms and then for only commercial units. As a base year, 2019 represents the position before farms are likely to have adopted mitigation measures, meaning that estimated CoAP effects will not be diluted by any more recent changes to management practices.

E7. The headline results are that only a minority of farms overall are estimated to potentially be affected. However, farm-type strongly influences the likelihood of an individual farm being impacted. In particular, as would be expected, poultry and dairy farms are more likely to be affected since their management systems tend to be more intensive. Lowland arable and upland grazing farms are less likely to be affected.

E8. The estimated likelihood of being potentially affected also increases with farm size, as measured by Standard Labour Requirement. This reflects the tendency for larger farms to have greater livestock numbers managed more intensively. Similarly, the estimated proportion of commercial units potentially affected is higher than that for all farms, reflecting that the latter includes many small units with relatively low stocking densities whereas commercial units tend to be larger and managed more intensively.

E9. The difference between lower and upper-bound estimates is relatively narrow for most farm-types. However, they do differ more markedly for the two most affected farm-types of dairy and poultry, ranging from c.33% (462 farms) to c.63% (843 farms) and c.41% (40 farms) to c.51% (50 farms) respectively for commercial units. This reflects sensitivity to assumptions regarding livestock categories and therefore nitrogen coefficients. In particular, the assumed milk yield band for dairy cows has a strong influence. Many poultry units will also already have mitigation measures in place whereas dairy farms will not.

E10. Mitigation measures for affected farms to achieve compliance with the 170kg N limit include exporting excess N, renting-in additional land and destocking. The latter is the most disruptive and costly to implement, and hence is less likely to be chosen than either renting-in land or exporting N. Estimated aggregate farm-level costs if all mitigation was through destocking are c.£46m to c.£113m. Impact cost estimates necessarily assume all affected farms adopt only the mitigation measure under consideration. In reality, farms will likely adopt a mixture of approaches to suit their particular circumstances.

E11. The equivalent figures for only renting-in land or only exporting N are c.£10m to £22m and c.£1m to c.£3m respectively (although land rentals also represent a possible income stream for other farmers). However, where the local need for additional land to rent or to export excess N to is high, such as in South West Wales, it would be expected that local prices and export haulage distances would rise.

E12. On-farm mitigation measures have implications for the wider supply-chain. For example, most notably, destocking directly implies lower demand for upstream suppliers' inputs and lower availability of raw materials for downstream processors. Renting-in land and exporting N have less direct implications but would still be expected to generate some knock-on effects. For example, land rented-in may previously have been used for other purposes whilst exporting is an additional work task to be accommodated.

E13. Although supply-chains linkages (including cross-border flows) are not known with certainty, illustrative economic multiplier analysis suggests that destocking would result in c.£64m to c.£156m of lost Welsh Gross Value Added (GVA), predominantly from the dairy sector. The equivalent figures for renting land are c.£25m to c.£56m (albeit possibly partially offset by rental income to other farmers) and c.£1m to c.£4m for exporting excess N. This again highlights destocking as the costliest mitigation measure.

E14. Illustrative multiplier analysis also suggests reductions in labour requirements across the supply-chain. These are based on farm-level SLR, which mask considerable variation in efficiency across farms and productivity improvements over time. It also assumes an optimistically short notional working year for farmers of 1900 hours. As such, estimated changes in SLR totals should not be interpreted literally in terms of numbers of jobs but rather as an indication of the relative magnitude of pressures for change.

E15. The lower and upper-bound estimates for reductions in SLR associated with destocking are from c.1560 to c.5501, and c.579 to c.2374 for renting-in land (the effect of displacing its previous use). Exporting N is assumed to not cause any reductions. Again, this highlights the relative ranking of destocking as the costliest mitigation measure but also the sensitivity of estimates to underlying data uncertainties.

E16. The choice of approach taken by any farm will depend on the individual farm circumstances and local opportunities; a mix of mitigation measures would be expected across the population. Some farms may undoubtedly decide to cease trading, retire or change enterprise. Yet reducing stock numbers, changing enterprise mixes or exiting the industry are unlikely to be triggered solely by the issue of N loading. Other factors associated or not with CoAP regulations may also play a part in any such decision.

E17. Nonetheless, in practice, reducing herd size is unlikely to be the first-choice compliance option in most cases. Moreover, even if chosen it is unlikely to involve a pro-rata reduction in all livestock categories. Rather, more nuanced changes in herd composition, such as contracting-out heifer rearing and culling less productive animals, may be preferred. Such adjustments are likely to mitigate impacts to an extent.

E18. Equally, whilst renting-in land and exporting excess N are more attractive compliance options, their practicality depends upon the local availability of land. In-turn, this will be influenced by factors beyond CoAP, including general buoyancy of the rural property market and pressures for woodland creation.

E19. Notwithstanding their necessarily purely indicative nature, the estimates presented in the report are sufficient to reveal likely relative impact patterns and magnitudes. Refinement of estimates and/or a future RIA would require additional, more robust data and/or some ground-truthing of results. For example, in relation to the milk yield band of individual dairy farms, the monthly livestock headcount of individual farms, the number and size of livestock farms, and actual supply-chain linkages. Although it is more likely that more heavily stocked farms will be constrained by limits on P, any quantitative assessment of the potential impacts of limits on phosphate applications will require collation of soil P index scores across Wales. The particular vulnerability of the dairy sector is apparent and merits further research.

Indicative economic assessment of the 170kg/N/ha/yr limit of the Control of Agricultural Pollution Regulations

1 INTRODUCTION

1. This report presents indicative estimates of the number of Welsh farms potentially affected by the 170kg of nitrogen (N) per hectare per year limit prescribed under the Water Resources (Control of Agricultural Pollution) (Wales) Regulations (hereafter CoAP). Indicative estimates of the aggregate farm-level and supply-chain costs of compliance are also presented. The findings presented may contribute to any future Regulatory Impact Assessment (RIA).

2. The analysis presented draws upon the best available data and various assumptions. However, although pragmatic, the approach must necessarily be viewed as offering only indicative rather than definitive results. This reflects multiple uncertainties related to some underpinning data and the need for simplifying modelling assumptions. Reported June Agricultural Survey (JAS) livestock data, for example, do not align perfectly with CoAP livestock categories, farm areas and livestock numbers vary across different official data sources, and average unit costs for exporting, renting and destocking may not reflect all local circumstances. Such caveats are noted and discussed throughout the report (see Annexes for further detail on data, assumptions and methodology used).

3. Moreover, the analysis focuses solely on the 170kg N limit yet farms are also subject to other related regulatory constraints. For example, minimum required slurry storage capacity and prescribed timings for slurry applications but also importantly to phosphate (P) levels from livestock sources. The latter arises because, whilst not widely recognized, WG and NRW have stated that the application of livestock manures in excess of crop phosphate requirement would be considered to be a breach of the Environmental Permitting Regulations 2010 (EPR) rather than CoAP per se. However, data limitations mean that an assessment of the combined regulatory interventions was not possible.

4. The uniform 170kg N annual threshold is one element of a package of measures intended to reduce nitrate and phosphorus emissions. Such measures address (time-limited) EU risks of substantial retrospective infraction costs and, in the longer-term the need to maintain a Level Playing Field. Variation in regulatory approaches is compatible with EU competition requirements for a Level Playing Field, provided that equivalence of outcomes is maintained. However, whilst the EU-UK Trade Cooperation Agreement allows for regulatory divergence, failure to maintain equivalence would potentially threaten UK (and hence Welsh) farm exports to the EU (worth c.£2.8/bn in 2023, of which c.£0.3bn were Welsh and much of it livestock related).[1]

5. The various interacting uncertainties are accommodated here by approximating lower and upper-bound situations. Estimates are shown separately for all farms in receipt of public support payments in 2019 and for only commercial units in receipt. As a base year, 2019 represents the position before farms are likely to have adopted mitigation measures, meaning that estimated CoAP effects will not

[1] https://ahdb.org.uk/dairy/trade-dashboard & https://www.gov.wales/welsh-food-and-drink-exports-hit-record-high

be diluted by any more recent changes to management practices. Together with data limitations, this modelling choice reinforces that the analysis is not relative to a more complex baseline in which some farms have already adapted to various new regulatory constraints. However, insights from this report may contribute to a future Regulatory Impact Assessment.

6. **Section 2** presents estimates of the number of farms affected, split by farm-type and size. The latter is based on Standard Labour Requirements (SLR), which reflect farm hectarage and livestock numbers. Farm types are based on the dominant farm enterprise in terms of estimated Standard Output (SO), but other enterprises may still be present (e.g. beef on a dairy farm, poultry on an LFA grazing farm). Whilst convenient, average SLR and SO coefficients are themselves subject to some uncertainty.

7. **Section 3** presents financial estimates for different ways (i.e. exporting N, renting-in land, destocking) by which affected farms could potentially comply with the 170kg N constraint. **Section 4** presents an analysis of potential wider supply-chain effects. **Section 5** offers further discussion and some recommendations.

8. The headline results are that only a minority of farms overall are estimated to potentially be affected but farm-type strongly influences the likelihood of an individual farm being impacted. In particular, as would be expected, poultry and dairy farms are more likely to be affected. Whereas many poultry units will already have mitigation measures in place dairy farms are likely to be faced with such requirements for the first time.

9. The results also show that whilst destocking is one way for an affected farm to comply with the 170kg N limit, it is more expensive than either renting-in more land or exporting N to another farm and hence unlikely to be the first choice in most cases. However, in some areas, limited local availability of land for rent or export is likely to increase the cost of renting or exporting as alternatives. Supply-chain multipliers amplify the wider impacts of compliance measures, with destocking again having the largest potential negative effect.

10. Notwithstanding their necessarily purely indicative nature, the estimates presented are sufficient to reveal likely impact patterns of complying with the 170kg N threshold and likely orders of magnitude. Further refinement of impact estimates and/or a future Regulatory Impact Assessment would require additional and more robust data to be collected.

11. This applies particularly to phosphate-related constraints since soil P-index scores for individual fields on each farm are a prerequisite for any country-wide quantitative analysis. These data have never been comprehensively gathered. It is therefore impossible to determine how many farms may effectively be phosphate limited.

2 NUMBER OF FARMS AFFECTED

2.1 Indicative farm results

12. Tables 1a to 1d present lower-bound values for the number of farms estimated to exceed the 170kg N threshold. Tables 2a and 2d present the equivalent upper-bound estimates. Tables 3a and 3b focus on dairy farms, as a farm type more likely to exceed the threshold but also subject to additional uncertainty about estimation of N loadings due to the influence of (assumed) milk yields. Table 4 focuses on poultry farms, as another farm type more likely to exceed the threshold but also subject to particular data uncertainties. In all cases, estimated potential to exceed the threshold reflects the baseline stocking densities and does not include possible mitigation measures – these are considered in Section 3.

13. Table 1a shows a lower-bound estimate of 812 farms potentially affected by the 170 kg N/ha limit. Table 1b shows this to be c.5% of all farms in receipt of support payments in 2019. Yet there is considerable variation by farm type, with c.33% of dairy farms and 12% of poultry farms being affected. By contrast no cereal, cropping or horticulture farms are affected by the imposition of the regulation. The proportion of farms affected also increases with farm size, albeit not consistently (because SLR also reflects non-livestock activities). Tables 1c and 1d exclude non-commercial farms (classed as those with less than €25k of Standard Output and fewer than 5ha, unless specialist pig or poultry). This lowers the estimated number of farms affected to 741 but (because the population denominator also shrinks, and by more) increases the overall percentage affected to c.8%. Again, within this revised population of farms, dairy (c.34%) and poultry (c.41%) are most likely to be affected.

Table 1a: Lower-bound estimates of number of farms potentially exceeding 170 kg N/ha limit, by farm type and SLR farm size. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0	0	3	0	18	22	1	2	0	1	47
Part	0	0	2	0	21	21	0	1	0	5	50
Small	0	0	21	0	32	46	3	1	0	4	107
Medium	0	0	58	0	15	13	1	0	0	7	94
Large	0	0	127	0	26	20	4	0	1	12	190
Very large	0	0	257	0	34	11	7	3	0	12	324
Total	0	0	468	0	146	133	16	7	1	41	812

Table 1b: Lower-bound estimates of percentage of farms potentially exceeding 170 kg N/ha limit, by farm type and SLR farm size. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0%	0%	5%	0%	1%	3%	0%	0%	0%	0%	1%
Part	0%	0%	4%	0%	1%	5%	0%	0%	0%	56%	2%
Small	0%	0%	11%	0%	2%	12%	3%	0%	0%	21%	4%
Medium	0%	0%	20%	0%	1%	10%	3%	0%	0%	41%	6%
Large	0%	0%	34%	0%	2%	18%	8%	0%	100%	48%	11%
Very large	0%	0%	57%	0%	4%	19%	13%	19%	0%	67%	23%
Total	0%	0%	33%	0%	2%	7%	3%	0%	2%	12%	5%

Table 1c: Lower-bound estimates of number of farms potentially exceeding 170 kg N/ha limit, by farm type and SLR farm size. Commercial units only.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0	0	3	0	6	9	0	1	0	0	19
Part	0	0	2	0	16	12	0	1	0	5	36
Small	0	0	21	0	22	39	3	0	0	4	89
Medium	0	0	57	0	13	13	1	0	0	7	91
Large	0	0	126	0	25	19	4	0	1	12	187
Very large	0	0	253	0	33	11	7	3	0	12	319
Total	0	0	462	0	115	103	15	5	1	40	741

Table 1d: Lower-bound estimates of percentage of farms potentially exceeding 170 kg N/ha limit, by farm type and SLR farm size. Commercial units only.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0%	0%	14%	0%	2%	7%	0%	17%	0%	0%	3%
Part	0%	0%	4%	0%	2%	5%	0%	6%	0%	56%	3%
Small	0%	0%	12%	0%	1%	13%	3%	0%	0%	21%	4%
Medium	0%	0%	20%	0%	1%	10%	3%	0%	0%	41%	6%
Large	0%	0%	34%	0%	2%	17%	8%	0%	100%	48%	11%
Very large	0%	0%	57%	0%	4%	20%	13%	19%	0%	67%	22%
Total	0%	0%	34%	0%	2%	11%	5%	5%	11%	41%	8%

14. These patterns are broadly as might be expected. For example, arable farms will have little or no livestock relative to their land area whilst dairy and poultry production systems are typically more intensive in terms of stocking densities and bought-in feed (particularly for larger enterprises) than beef and sheep systems. Farms with more livestock will also use more labour and hence be defined as larger in terms of SLR. Excluding non-commercial farms reduces the overall number of farms but proportionately removes more of the smaller scale ones. This results in an increase in the estimated percentages affected of the remaining units. The fact that the percentage of dairy farms affected varies only modestly between the two cases reflects that almost all dairy farms are commercial units, so the differences from Tables 1a and 1b to Tables 1c and 1d are minimal. By contrast, many smaller farms categorized as specialist poultry are non-commercial, meaning that their exclusion increases the estimated percentage of poultry farms potentially affected. As dairy and poultry farms are the farm-types most likely to be potentially affected, key uncertainties associated with their data are considered further in Tables 3 and 4.

15. A surprisingly high number (albeit a small proportion) of LFA grazing and Lowland grazing farms are estimated to be affected. Whilst some of these farms do host a subsidiary poultry or dairy enterprise which explains their inclusion, many of them do not. Rather, they have implausibly high stocking densities (e.g. double-digit Grazing Livestock Units, GLU, per ha) which suggests either over-estimation of livestock numbers and/or under-reporting of land areas. Over half of such farms have not provided a June Agricultural Survey (JAS) return in the past decade, implying that their livestock and/or area data may be outdated/inaccurate.

16. Mirroring the lower-bound estimates presented above, Tables 2a to 2d present equivalent upper-bound estimates. The difference between the two sets of results reflects different assumed N coefficient values and/or assumed distribution of non-breeding ruminant livestock over the year. Specifically, where there are underlying uncertainties (see Annexes), upper-bound estimates assume higher N coefficient values and constant numbers of ruminant youngstock (as well as breeding stock) across the year. Lower-bound estimates assume lower N coefficient values, variable ruminant youngstock headcounts (to allow for seasonal trading patterns) and less conservative farm areas. As noted previously, given the multiple sources of uncertainty, both sets of results should be viewed only as indicative approximations.

17. Table 2a shows a total of 1487 farms (as an upper-bound) to be potentially affected by the 170 kg N/ha limit. Table 2b shows this to be approximately 9% of the population of all farms in receipt of support payments in 2019. Tables 2c and 2d exclude non-commercial farms. This raises the estimated number of farms affected to 1346, but increases the overall percentage affected to c.15% (because excluding non-commercial farms reduces the overall number of farms but proportionately removes more of the smaller scale ones). Again, within these results dairy (61% to 63%) and poultry farms (15% to 51%) are most likely to be affected, arable farms (0%) are the least likely. As before, a number of LFA and lowland grazing farms are also shown to be potentially affected, with the absolute number and percentages being higher than in the lower-bound case due to more conservative assumptions about the baseline area on such farms.

Table 2a: Upper-bound estimates of number of farms potentially exceeding 170 kg N/ha limit, by farm type and farm size. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0	0	5	0	57	27	1	2	0	2	94
Part	0	0	8	0	79	27	0	1	0	5	120
Small	0	0	63	0	96	56	3	1	0	5	224
Medium	0	0	156	0	45	21	2	0	0	9	233
Large	0	0	257	0	50	23	4	0	1	17	352
Very large	0	0	367	0	58	13	10	3	0	13	464
Total	0	0	856	0	385	167	20	7	1	51	1487

Table 2b: Upper-bound estimates of percentage of farms potentially exceeding170 kg N/ha limit, by farm type and farm size. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0%	0%	9%	0%	2%	4%	0%	0%	0%	1%	2%
Part	0%	0%	17%	0%	5%	6%	0%	0%	0%	56%	4%
Small	0%	0%	34%	0%	5%	15%	3%	1%	0%	26%	8%
Medium	0%	0%	56%	0%	4%	15%	5%	0%	0%	53%	14%
Large	0%	0%	69%	0%	5%	20%	8%	0%	100%	69%	21%
Very large	0%	0%	81%	0%	7%	23%	18%	19%	0%	72	32%
Total	0%	0%	61%	0%	4%	9.0%	3%	0%	2%	15%	9%

Table 2c: Upper-bound estimates of the number of farms potentially exceeding 170 kg N/ha limit, by farm type and SLR farm size. Commercial units only.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0	0	4	0	16	10	0	1	0	1	32
Part	0	0	8	0	58	17	0	1	0	5	89
Small	0	0	62	0	75	48	3	0	0	5	193
Medium	0	0	155	0	42	21	2	0	0	9	229
Large	0	0	253	0	49	22	4	0	1	17	346
Very large	0	0	361	0	57	13	10	3	0	13	457
Total	0	0	843	0	297	131	19	5	1	50	1346

Table 2d: Upper-bound estimates of percentage of farms potentially exceeding 170 kg N/ha limit, by farm type and SLR farm size. Commercial units only.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	0%	0%	18%	0%	6%	8%	0.0%	17%	0.0%	10%	6%
Part	0%	0%	17%	0%	7%	7%	0.0%	6%	0.0%	56%	7%
Small	0%	0%	34%	0%	5%	16%	3%	0.0%	0.0%	26%	8%
Medium	0%	0%	55%	0%	4%	16%	5%	0.0%	0.0%	53%	15%
Large	0%	0%	69%	0%	5%	20%	8%	0.0%	100.0%	68%	21%
Very large	0%	0%	81%	0%	7%	23%	18%	19%	0.0%	72%	32%
Total	0%	0%	63%	0%	5%	13%	6%	5%	11%	51%	15%

18. The differences between the upper and lower-bound estimates reflect variation in assumptions made to accommodate various underlying uncertainties. In the case of dairy farms, a key uncertainty relates to the milk yield band (and hence N coefficient) that each farm falls into: less than 6000 litres; between 6000 litres and 9000 litres; or over 9000 litres per cow per year. For the upper-bound, it is assumed that all dairy farms fall into the top milk band; for the lower-bound it is assumed that they all fall into the bottom band. Tables 3a and 3b illustrate the effects on headline dairying results of varying these assumptions whilst holding other assumptions constant. As might be expected, it is apparent that dairy farm results are sensitive to the assumed milk banding.

Table 3a: Variation in estimated number of dairy farms affected by 170 kg N/ha threshold under different milk yield band assumptions, by farm size.

	Lower-bound						Upper-bound					
	All farms			Commercial			All farms			Commercial		
Farm size	<6kl	6k – 9kl	6k – 9kl	6k – 9kl	6k – 9kl	6k – 9kl	6k – 9kl	6k – 9kl	>9kl	<6kl	6k – 9kl	>9kl
Spare	3	3	4	3	3	4	4	4	5	4	4	4
Part	2	2	6	2	2	6	2	4	8	2	4	8
Small	21	47	58	21	47	58	26	54	63	26	54	62
Medium	58	104	140	57	103	139	70	125	156	69	124	155
Large	127	209	235	126	206	232	166	229	257	165	226	253
Very large	257	319	356	253	314	350	285	347	367	281	341	361
Total	468	684	799	462	675	789	553	763	856	547	753	843

Table 3b: Variation in estimated percentage of dairy farms affected by 170 kg N/ha threshold under different milk yield band assumptions, by farm size.

	Lower-bound						Upper-bound					
	All farms			Commercial			All farms			Commercial		
Farm size	<6kl	6k – 9kl	>9kl	<6kl	6k – 9kl	>9kl	<6kl	6k – 9kl	>9kl	<6kl	6k – 9kl	>9kl
Spare	5%	5%	7%	14%	14%	18%	7%	7%	9%	18%	18%	18%
Part	4%	4%	13%	4%	4%	13%	4%	9%	17%	4%	9%	17%
Small	11%	25%	31%	12%	26%	32%	14%	29%	34%	14%	30%	34%
Medium	20%	37%	49%	20%	37%	49%	25%	44%	55%	24%	44%	55%
Large	34%	56%	63%	34%	56%	63%	44%	61%	69%	45%	61%	69%
Very large	57%	70%	79%	57%	70%	78%	63%	77%	81%	63%	76%	81%
Total	33%	49%	57%	34%	50%	59%	40%	55%	61%	41%	56%	63%

19. Alongside dairy farms, poultry farms are the other farm-type potentially most affected by the 170kg N threshold. Whilst there is some uncertainty around the precise choice of N coefficients to apply, a larger source of uncertainty stems from significant discrepancies between different official data sources. This uncertainty extends to both the number of farms with poultry and the number of birds on each farm. Such discrepancies are attributed to the challenges of reconciling datasets compiled for different purposes at different times and with different spatial and/or temporal coverage.

20. Table 4 illustrates crudely the degree of variation stemming from some of this uncertainty about the relevant population. The "value used" and "estimated all farms affected" refer back to Tables 1 and 2 and relate to all farms in receipt of support payments (and confirm that larger farms in terms of flock size are more likely to be affected). The "Low", "Mid" and "High" values are derived from three different official data sources, with notable differences in terms of the total number of farms (albeit mostly in relation to very small flocks) and total number of birds.

21. Relative to other farm-types, the absolute number of affected poultry farms is likely to remain small regardless of which population figures are used. Equally, many commercial poultry units will (unlike most dairy farms) already be deploying mitigation methods and hence already incurring some of the compliance costs estimated here. Nonetheless, estimation of potential impacts on poultry farms could be improved if better data were available. Current efforts to update the official poultry register may help in this regard.

Table 4: Variation in estimated percentage of poultry farms affected by 170 kg N/ha threshold under different population assumptions, by flock size.

Flock size	Number of poultry farms				Number of birds (k) on poultry farms				Estimated all farms affected	
	Value A	Value B	Value C	Value used	Value A	Value B	Value C	Value used	Lower-bound	Upper-bound
<50	36	866	2316	214	1k	11k	26k	3k	1 (0%)	1 (0%)
51 to 8k	79	105	498	37	87k	88k	302k	59k	1 (3%)	1 (3%)
8k to 16k	30	26	49	17	333k	322k	548k	212k	3 (18%)	3 (18%)
16k to 24k	45	17	62	11	780k	317k	1085k	208k	2 (18%)	5 (45%)
24k to 32k	11	22	28	12	293k	614k	739k	348k	4 (33%)	6 (50%)
32k to 40k	74	18	96	16	2414k	610k	3241k	539k	8 (50%)	12 (75%)
>40k	22	39	126	25	1637k	5506k	17360k	3776k	22 (88%)	22 (88%)
Total	297	1093	3175	332	5545k	7468k	23303k	5144k	41 (12%)	50 (15%)

2.2 Caveats

22. The results presented above are subject to several important caveats. First, although they draw on official Welsh Government data it is apparent that there are some information gaps and possible errors. For example, a proportion of JAS records are seemingly somewhat dated, implying that as a result of the passage of time, some livestock numbers and/or areas may now be incorrect. It is also possible that some farms are not reported at all, particularly in the poultry sector. Furthermore, restricting attention to farms in receipt of support payments neglects a large number of very small holdings recorded in the JAS. This restriction may also exclude some very intensive pig and poultry units with very small land footprints.

23. Second, selecting 2019 as the base-year allows estimation of potential effects relative to a position before mitigation measures would already have become widespread. However, changes to livestock numbers and farm businesses in the intervening years due to (e.g.) Covid, market conditions and other policy measures may amplify or dampen the estimated effects. Moreover, CoAP itself plus the Environmental Permitting Regulations (EPR) encompass multiple constraints on farming practices (e.g. in relation to slurry storage and spreading plus phosphate applications), yet effects of the 170kg N threshold are considered in isolation here.

24. Third, contemporary formal and informal arrangements for moving livestock and manure between farm holdings (either within or between businesses) and renting land are not necessarily captured well by current reporting systems.[2] Hence it is possible that some farms estimated to be affected are already

[2] Addressing this is not a trivial task since it would require collecting more detailed information on fluid business structures and farm management practices.

undertaking unobserved management actions and incurring some of the compliance costs estimated here (either by coincidence for other reasons or in anticipation of the regulations). For example, where farms (e.g. larger poultry units) have previously deployed mitigation measures, the marginal change experienced now will be less than the total implied i.e. some farms may already have adjusted at least partially to having to undertake some mitigation measures.

25. Fourth, the mechanics of estimating kg N/ha for the livestock and land reported require some further assumptions. Specifically, N coefficients per animal are designed for slightly different age and type categories to those used by the JAS, thereby requiring a degree of assumed equivalence (see Annex A) which may introduce some errors (particularly for assumed dairy milk yield banding). In addition, the JAS reports only a snapshot of livestock numbers in June rather than offering a temporal profile throughout the year. Whilst this may be reasonable for breeding animals' profile over the year, it will introduce estimation errors if non-breeding animal numbers fluctuate markedly month by month. The presentation of upper and lower-bound estimates is an attempt to crudely identify overall sensitivity of results to these interacting assumptions, yet the nuances of actual livestock trading patterns will inevitably not be well represented.[3]

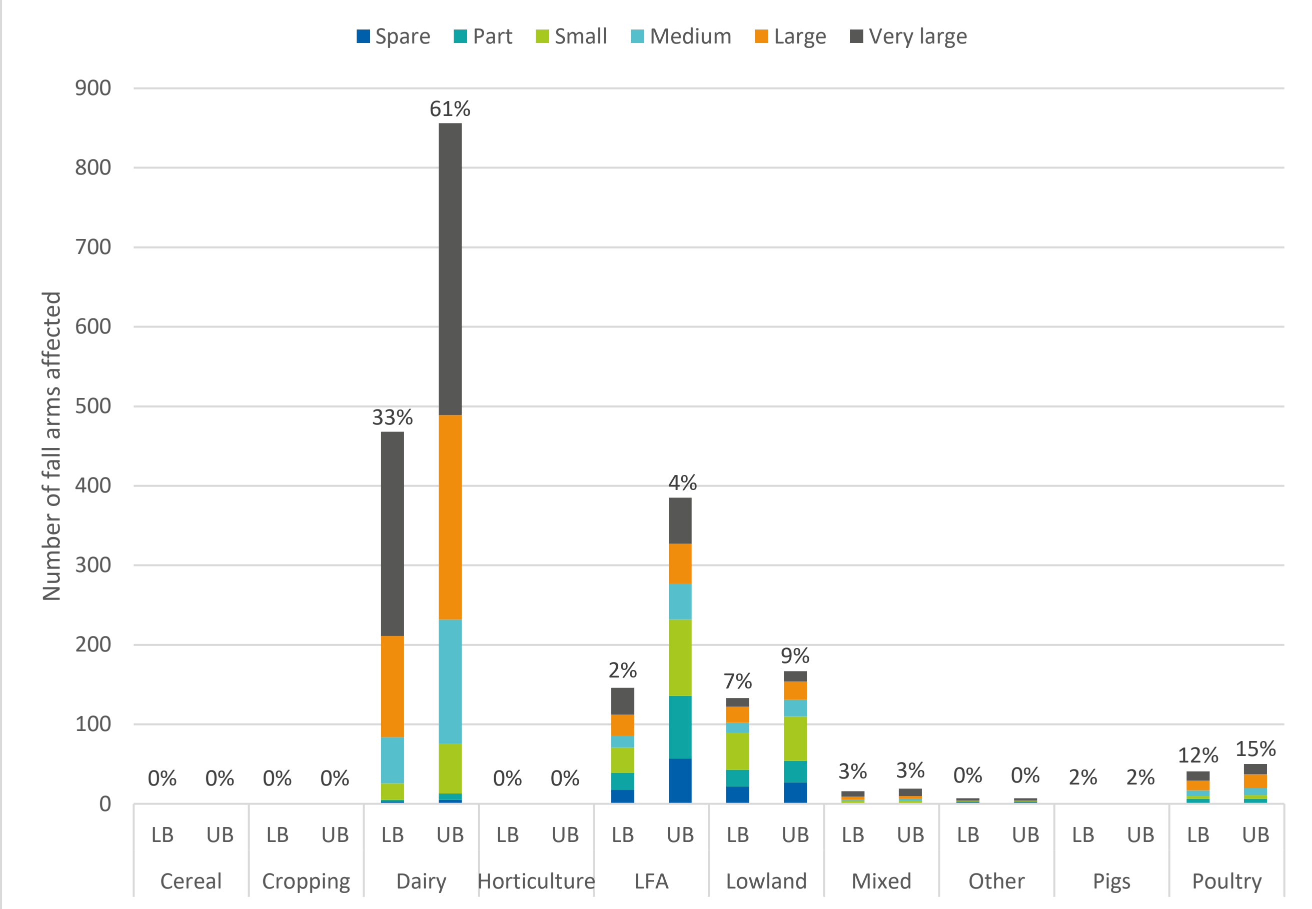
2.3 Discussion

26. Notwithstanding the noted caveats, the estimated results conform broadly to expected patterns and relativities. For example, cereal, cropping and horticulture farms will have little or no livestock relative to their land area and hence would not be expected to be affected by the 170kg N threshold. Similarly, extensive beef and sheep grazing systems, especially in hill and upland areas, will typically have relatively light stocking densities and limited reliance on bought-in animal feed such that they too would not generally be expected to be affected. By contrast, more intensive dairy and poultry production systems reliant upon high stocking densities and/or bought-in animal feed would be expected to be affected. Equally, farms with greater numbers of livestock will often (but not always) be expected to engage in more intensive management, and therefore larger farms (as defined in terms on SLRs) would be more likely to be affected. All of which is consistent with the results presented.

27. As shown by the relative magnitude of upper and lower-bound estimates, the sensitivity of results to underlying assumptions is also as expected. For example, assuming higher unit N coefficient values and higher livestock numbers throughout the year increases the number of farms estimated to be affected whilst assuming lower values and livestock numbers decreases the number of farms estimated to be affected. Similarly, estimates for dairy farms are particularly sensitive to the assumed milk yield band chosen, whilst excluding non-commercial farms decreases the total number of farms estimated to be affected but increases the percentage affected since commercial units are more likely to be managed more intensively.

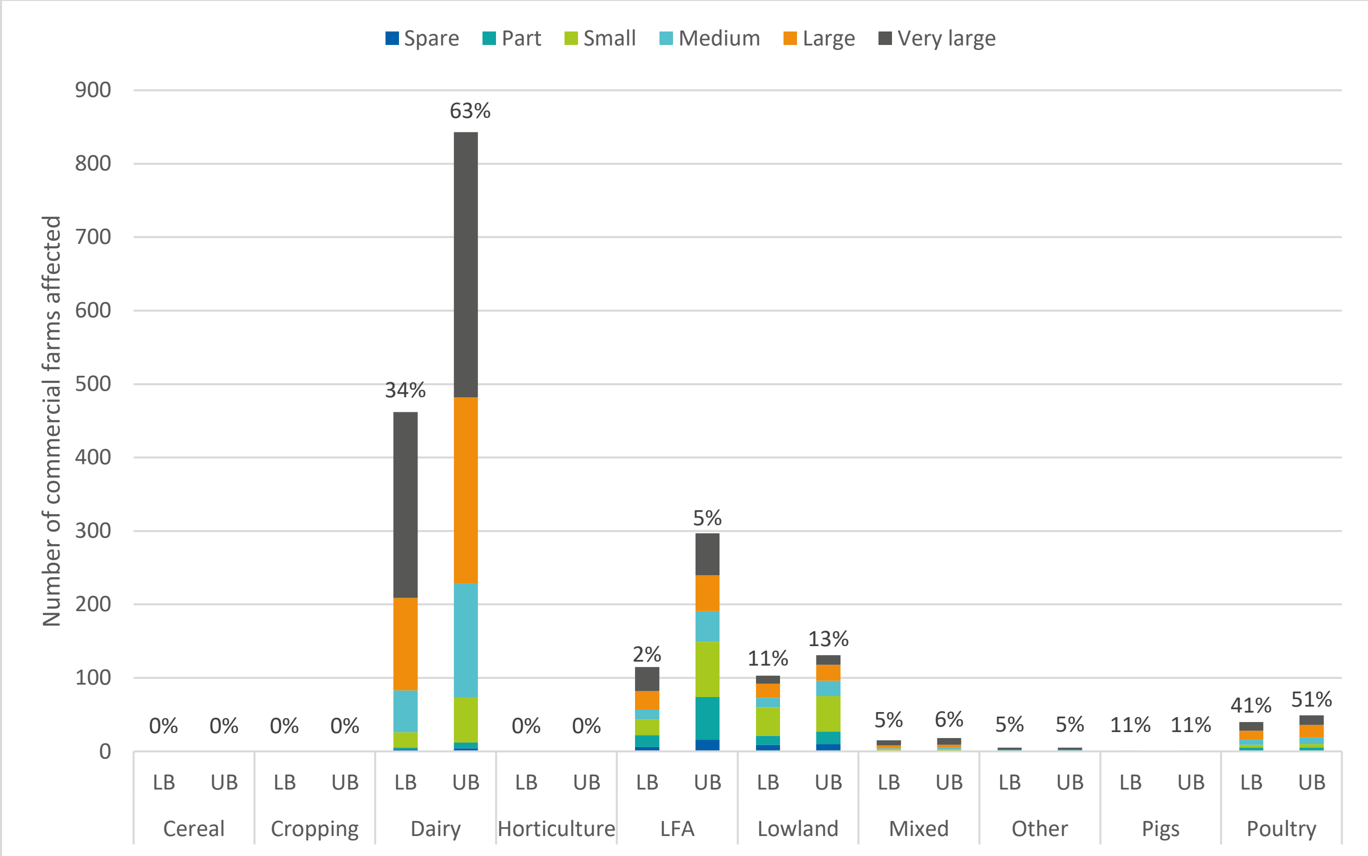
[3] Doing so would require access to more temporally-granular data. This might be feasible for cattle via CTS, but other species are not recorded in the same way.

Figure 1: Lower-bound (LB) and upper-bound (UB) estimates of farm potentially exceeding 170kg N threshold, by farm-type and size. All farms.



28. Judging the numerical accuracy of the estimates is, however, challenging. This relates partly to data and modelling uncertainties but also to the potential for unrecorded management actions on affected farms to already be addressing the apparent need to adjust N production and/or disposal. For example, the upper-bound estimates appear high compared to available expert opinion but the latter already includes observed (but unrecorded in the JAS) management responses (see also paras 22 and 23 above). Figures 1 and 2 summarise graphically the results presented previously in Tables 1a to 1d and 2a to 2d.

Figure 2: Lower-bound (LB) and upper-bound (UB) estimates of farms potentially exceeding 170kg N threshold, by farm-type and size. Commercial farms.



29. As such, the results should be interpreted as indicative of the overall gross number of farms needing to adjust their management relative to the baseline whilst acknowledging that some (especially poultry units) will already have at least partially adapted on-farm practices. Hence the additional net impact on farms will be lower than shown here. Section 3 uses the indicative numbers of affected farms to crudely estimate the compliance costs of different management responses.

3 ESTIMATED COMPLIANCE COSTS

3.1 Indicative cost results

30. Individual farms could seek to comply with the CoAP 170kg N constraint in different ways. For example, they could rent or purchase additional land to increase the denominator for calculating their N rate per hectare. This will incur additional land costs. Equally, they could export their excess N to other landowners. This would avoid additional land costs but will incur tankering costs for hauling slurry or manure. Farms could also reduce their N numerator by destocking. For example, reducing the size of their breeding herd or flock, changing trading patterns for non-breeding stock, and altering how breeding replacement animals are managed. This would incur income foregone through reduced production and/or additional costs through outsourcing some livestock rearing.

31. Tables 5a to 5d, 6a to 6d, and 7a to 7d respectively present lower and upper-bound cost estimates for each of these three compliance options. The estimates derive from the results shown in Tables 1a to 2d combined with assumed average unit costs. The latter are taken from published sources and relate to gross margins per head of livestock, rental prices for short-term lets, and haulage costs over 10km (see Annex B). As before, the results are caveated and should be taken as indicative. Also, rows and column total may not sum precisely due to rounding. Although individual farms might be expected to adopt different combinations of mitigation measures, in the absence of information on the likely distribution of uptake, each option is treated as mutually exclusive. Consequently, the different costs cannot be summed – each is already an overall total.

32. Table 5a to 7d illustrates that ranking different compliance options by aggregate cost places export tankering as the cheapest, followed by renting additional land and then destocking as the most expensive option. Moreover, reflecting the small scale of non-commercial farms, including or excluding them from calculations has little impact on headline aggregate costs, which are lower-bounds of c.£1m, c.£9m, and c.£46m respectively for exporting, renting and destocking or upper-bounds of c.£3m, c.£22m and c.£114m respectively. In all cases, reflecting the relative number and scale of the different farm-types estimated to be affected by the 170kg N/ha/yr threshold, the estimated compliance costs are borne most heavily by dairy farms.

33. As larger farms contend with higher absolute quantities of excess N and dairy farms were shown in Section 2 to be the most affected farm-type, these patterns are as expected. Whilst destocking is an option, it is an expensive option (i.e. income foregone impacts arising from lower revenue throughput, even though some variable costs are saved). Moreover, it often interferes with established management systems and can undermine enterprise viability given fixed cost overheads. By contrast, exporting N or renting additional land require less drastic management systems and represent simpler additions to variable costs. However, this relative attractiveness does not disguise the fact that they do still represent an additional cost burden for affected businesses.

Table 5a: Lower-bound estimates of compliance costs incurred through exporting excess N. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Medium	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Large	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.2m
Very large	£0.0m	£0.0m	£0.7m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.9m
Total	£0.0m	£0.0m	£0.8m	£0.0m	£0.1m	£0.1m	£0.0m	£0.0m	£0.0m	£0.2m	£1.2m

Table 5b: Upper-bound estimates of compliance costs (£m) incurred through exporting excess N. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Medium	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.2m
Large	£0.0m	£0.0m	£0.4m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.4m
Very large	£0.0m	£0.0m	£1.7m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£2.0m
Total	£0.0m	£0.0m	£2.2m	£0.0m	£0.3m	£0.1m	£0.0m	£0.0m	£0.0m	£0.2m	£2.8m

Table 5c: Lower-bound estimates of compliance costs incurred through exporting excess N. Commercial farms.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Medium	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Large	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.2m
Very large	£0.0m	£0.0m	£0.6m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.9m
Total	£0.0m	£0.0m	£0.8m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£1.2m

Table 5d: Upper-bound estimates of compliance costs (£m) incurred through exporting excess N. Commercial farms.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Medium	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.2m
Large	£0.0m	£0.0m	£0.4m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.4m
Very large	£0.0m	£0.0m	£1.7m	£0.0m	£0.2m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£2.0m
Total	£0.0m	£0.0m	£2.2m	£0.0m	£0.2m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£2.8m

Table 6a: Lower-bound estimates of compliance costs incurred through renting land for excess N. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.2m	£0.0m	£0.0m	£0.0m	£0.1m	£0.4m
Medium	£0.0m	£0.0m	£0.2m	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.3m	£0.6m
Large	£0.0m	£0.0m	£0.8m	£0.0m	£0.1m	£0.2m	£0.0m	£0.0m	£0.0m	£0.2m	£1.3m
Very large	£0.0m	£0.0m	£5.5m	£0.0m	£0.6m	£0.1m	£0.1m	£0.0m	£0.0m	£0.7m	£7.0m
Total	£0.0m	£0.0m	£6.5m	£0.0m	£0.9m	£0.6m	£0.1m	£0.0m	£0.0m	£1.4m	£9.5m

Table 6b: Upper-bound estimates of compliance costs (£m) incurred through renting land for excess N. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.2m
Small	£0.0m	£0.0m	£0.2m	£0.0m	£0.2m	£0.3m	£0.0m	£0.0m	£0.0m	£0.1m	£0.8m
Medium	£0.0m	£0.0m	£0.9m	£0.0m	£0.2m	£0.1m	£0.0m	£0.0m	£0.0m	£0.3m	£1.5m
Large	£0.0m	£0.0m	£2.8m	£0.0m	£0.3m	£0.3m	£0.0m	£0.0m	£0.0m	£0.3m	£3.7m
Very large	£0.0m	£0.0m	£13.7m	£0.0m	£0.9m	£0.2m	£0.1m	£0.0m	£0.0m	£1.0m	£15.9m
Total	£0.0m	£0.0m	£17.6m	£0.0m	£1.7m	£0.9m	£0.2m	£0.0m	£0.0m	£1.8m	£22.2m

Table 6c: Lower-bound estimates of compliance costs incurred through renting land for excess N. Commercial farms.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.2m	£0.0m	£0.0m	£0.0m	£0.1m	£0.4m
Medium	£0.0m	£0.0m	£0.2m	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.3m	£0.6m
Large	£0.0m	£0.0m	£0.7m	£0.0m	£0.1m	£0.2m	£0.0m	£0.0m	£0.0m	£0.2m	£1.3m
Very large	£0.0m	£0.0m	£5.4m	£0.0m	£0.6m	£0.1m	£0.1m	£0.0m	£0.0m	£0.7m	£7.0m
Total	£0.0m	£0.0m	£6.4m	£0.0m	£0.9m	£0.6m	£0.1m	£0.0m	£0.0m	£1.4m	£9.4m

Table 6d: Upper-bound estimates of compliance costs (£m) incurred through renting land for excess N. Commercial farms.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.2m
Small	£0.0m	£0.0m	£0.2m	£0.0m	£0.2m	£0.2m	£0.0m	£0.0m	£0.0m	£0.1m	£0.8m
Medium	£0.0m	£0.0m	£0.9m	£0.0m	£0.2m	£0.1m	£0.0m	£0.0m	£0.0m	£0.3m	£1.5m
Large	£0.0m	£0.0m	£2.7m	£0.0m	£0.3m	£0.2m	£0.0m	£0.0m	£0.0m	£0.3m	£3.7m
Very large	£0.0m	£0.0m	£13.5m	£0.0m	£0.8m	£0.2m	£0.1m	£0.0m	£0.0m	£1.0m	£15.7m
Total	£0.0m	£0.0m	£17.4m	£0.0m	£1.6m	£0.8m	£0.2m	£0.0m	£0.0m	£1.8m	£21.9m

Table 7a: Lower-bound estimates of compliance costs incurred through livestock disposal to avoid excess N. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.2m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.2m	£0.2m	£0.0m	£0.0m	£0.0m	£0.5m	£0.9m
Medium	£0.0m	£0.0m	£0.8m	£0.0m	£0.1m	£0.2m	£0.0m	£0.0m	£0.0m	£1.2m	£2.2m
Large	£0.0m	£0.0m	£3.0m	£0.0m	£0.4m	£0.3m	£0.0m	£0.0m	£0.0m	£1.3m	£5.0m
Very large	£0.0m	£0.0m	£30.6m	£0.0m	£2.4m	£0.2m	£0.2m	£0.0m	£0.0m	£3.8m	£37.3m
Total	£0.0m	£0.0m	£34.3m	£0.0m	£3.2m	£1.0m	£0.2m	£0.0m	£0.0m	£6.9m	£45.7m

Table 7b: Upper-bound estimates of compliance costs (£m) incurred through livestock disposal to avoid excess N. All farms in receipt of support.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.3m	£0.1m	£0.0m	£0.0m	£0.0m	£0.1m	£0.5m
Small	£0.0m	£0.0m	£0.6m	£0.0m	£0.4m	£0.3m	£0.0m	£0.0m	£0.0m	£0.5m	£1.9m
Medium	£0.0m	£0.0m	£3.9m	£0.0m	£0.4m	£0.2m	£0.0m	£0.0m	£0.0m	£1.2m	£5.8m
Large	£0.0m	£0.0m	£13.4m	£0.0m	£0.9m	£0.5m	£0.0m	£0.0m	£0.0m	£1.4m	£16.3m
Very large	£0.0m	£0.0m	£81.5m	£0.0m	£3.1m	£0.3m	£0.6m	£0.0m	£0.0m	£4.2m	£89.7m
Total	£0.0m	£0.0m	£99.4m	£0.0m	£5.3m	£1.4m	£0.7m	£0.0m	£0.0m	£7.5m	£114.2m

Table 7c: Lower-bound estimates of compliance costs incurred through livestock disposal to avoid excess N. Commercial farms.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.2m
Small	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.2m	£0.0m	£0.0m	£0.0m	£0.5m	£0.8m
Medium	£0.0m	£0.0m	£0.7m	£0.0m	£0.1m	£0.2m	£0.0m	£0.0m	£0.0m	£1.2m	£2.2m
Large	£0.0m	£0.0m	£2.8m	£0.0m	£0.4m	£0.3m	£0.0m	£0.0m	£0.0m	£1.3m	£4.8m
Very large	£0.0m	£0.0m	£30.4m	£0.0m	£2.4m	£0.2m	£0.2m	£0.0m	£0.0m	£3.8m	£37.0m
Total	£0.0m	£0.0m	£34.0m	£0.0m	£3.1m	£0.9m	£0.2m	£0.0m	£0.0m	£6.9m	£45.1m

Table 7d: Upper-bound estimates of compliance costs (£m) incurred through livestock disposal to avoid excess N. Commercial farms.

SLR size	Cereal	Cropping	Dairy	Horticulture	LFA	Lowland	Mixed	Other	Pigs	Poultry	Total
Spare	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m	£0.0m
Part	£0.0m	£0.0m	£0.0m	£0.0m	£0.3m	£0.0m	£0.0m	£0.0m	£0.0m	£0.1m	£0.4m
Small	£0.0m	£0.0m	£0.6m	£0.0m	£0.4m	£0.3m	£0.0m	£0.0m	£0.0m	£0.5m	£1.7m
Medium	£0.0m	£0.0m	£3.8m	£0.0m	£0.4m	£0.2m	£0.0m	£0.0m	£0.0m	£1.2m	£5.7m
Large	£0.0m	£0.0m	£13.2m	£0.0m	£0.9m	£0.5m	£0.0m	£0.0m	£0.0m	£1.4m	£16.0m
Very large	£0.0m	£0.0m	£80.6m	£0.0m	£3.0m	£0.3m	£0.6m	£0.0m	£0.0m	£4.2m	£88.8m
Total	£0.0m	£0.0m	£98.2m	£0.0m	£5.0m	£1.3m	£0.7m	£0.0m	£0.0m	£7.5m	£112.7m

3.2 Caveats

34. The results above are presented subject to several important caveats. First, as the estimation of compliance costs necessarily builds upon the physical estimates of excess N and numbers of farms affected, all of the caveats noted in Section 2 still apply. Second, further uncertainty arises from the assumed unit costs applied to the different compliance options. Whilst the figures used reflect industry benchmarks, as averages they mask variation across the farm population. For example, individual farms will achieve different Gross Margins, negotiate different rental prices and face different distances to haul slurry. In particular, geographical concentrations of excess N production will increase local competition for land which may increase haulage distances and/or raise land rental prices. It should also be noted that the aggregate short-term rental area and cost estimated above are of a similar magnitude to the baseline figures of c.46k ha and c.£13m reported in the Welsh Total Income from Farming (TIFF) estimates.[4] Doubling demand for rental land would have an upward impact on rental prices.

35. Third, the analysis does not extend to potential longer-term dynamic effects on farming systems and business structures. If farms revisit capital investment plans for on-farm infrastructure (e.g. sheds, milking parlours, slurry storage) to adjust fixed costs rather than simply variable costs, additional impacts may arise. This is more likely if destocking is implemented, but exporting N or renting land may still prompt further changes.

36. Fourth, increased costs or income foregone for affected farms may represent increased margins for other farms. For example, farms receiving exported N may save on purchased fertilizer, land rented may be owned by other farmers, and destocking may create opportunities for other farms in relation to rearing youngstock. Whilst such possibilities are unlikely to be distributed evenly across the farm population, they do mean that the aggregate costs presented here may overestimate actual industry costs since other farms may gain.

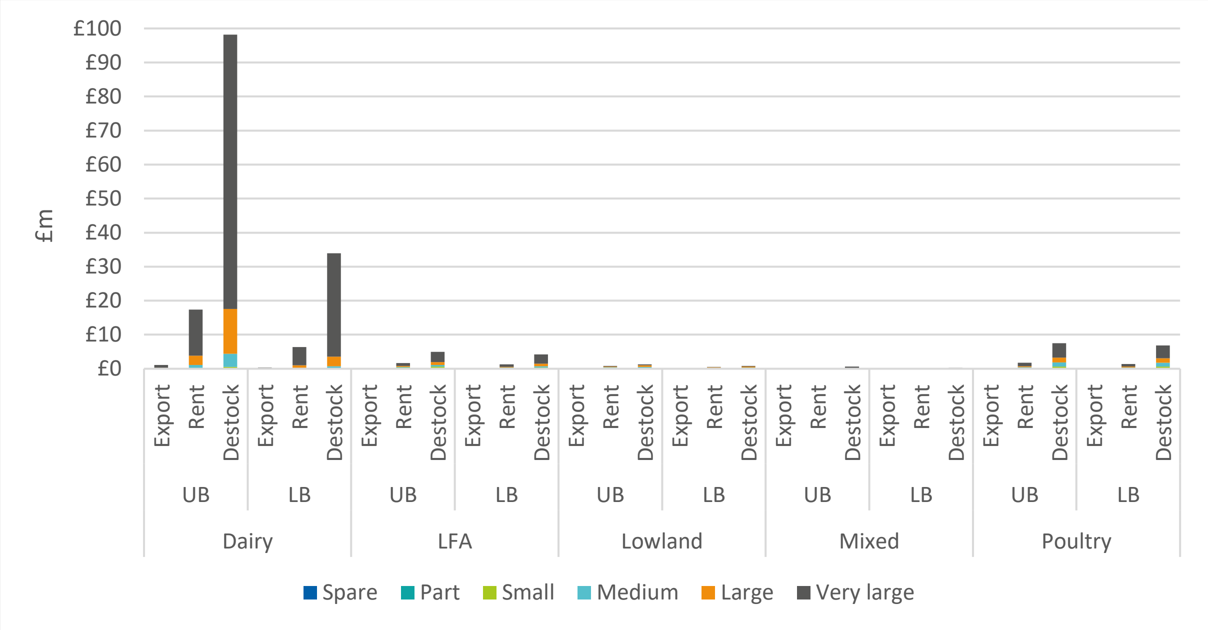
3.3 Discussion

37. Notwithstanding the noted caveats, the estimated compliance cost results conform broadly to expected patterns and relativities. Figure 3 summarises the headline results, highlighting the concentration of costs amongst larger farms across all farm-types and predominantly in the dairy sector. It also illustrates the relative orders of magnitude between the three options, with exporting N being cheaper than renting land, which in turn is cheaper than destocking. Although presented as mutually exclusive here (and hence not to be added together), a mix of mitigation measures would be expected across the farm population. Figure 4 uses upper and lower-bound maps to show the estimated spatial distribution of the balance between a need for extra land and the availability of 'spare' land potentially available for renting or for exporting excess N to. Farms in red grid squares (each being 2.5km by 2.5km in size) need to access spare capacity in neighbouring squares, which will be easier if nearby grid squares are green or yellow rather than orange. It is apparent that some areas, notably in the south-west

[4] Aggregate agricultural output and income: 2023 [HTML] | GOV.WALES See also farm-rent-land-values-2009-10-to-2016-17.ods

and north-east, may face upper-bound challenges in this regard and hence competition may raise their costs of renting-in and exporting. Edge effects of being near the coast (and unable to access land in all directions) will be real, but those along the border are probably exaggerated due to excluding data for England.

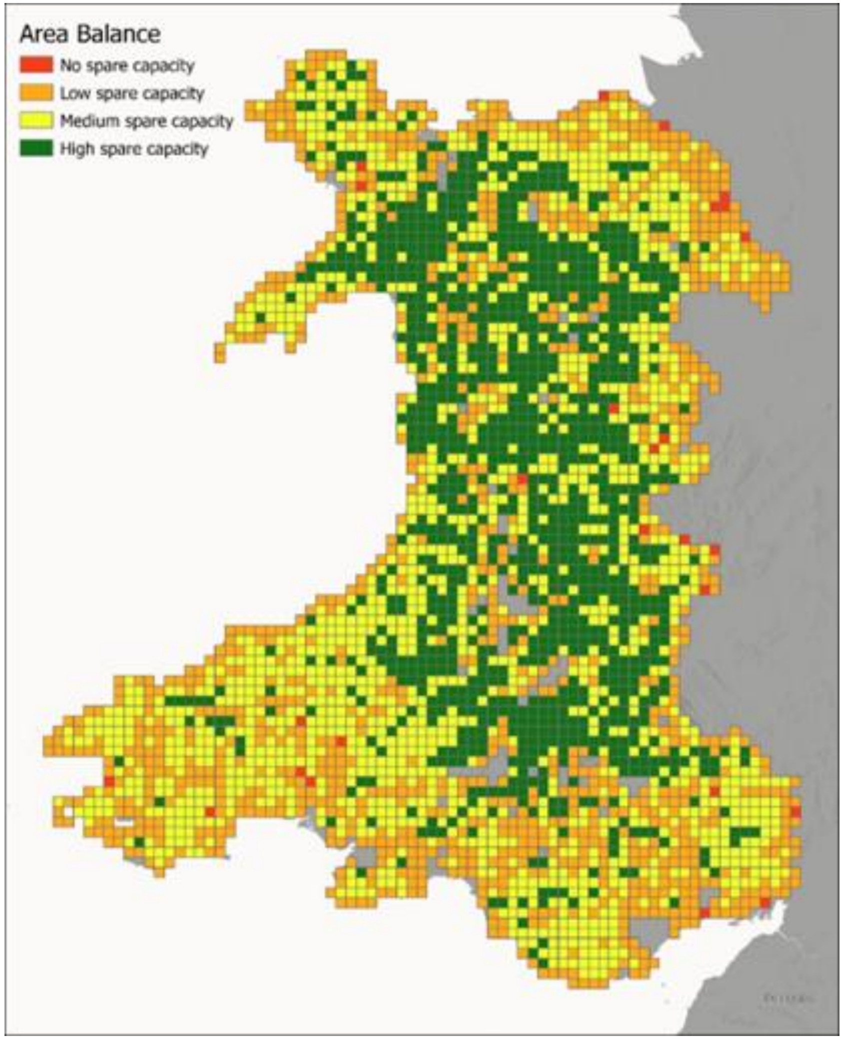
Figure 3: Upper (UB) and lower-bound (LB) estimated compliance costs for different options, by farm-type and farm size. All farms.



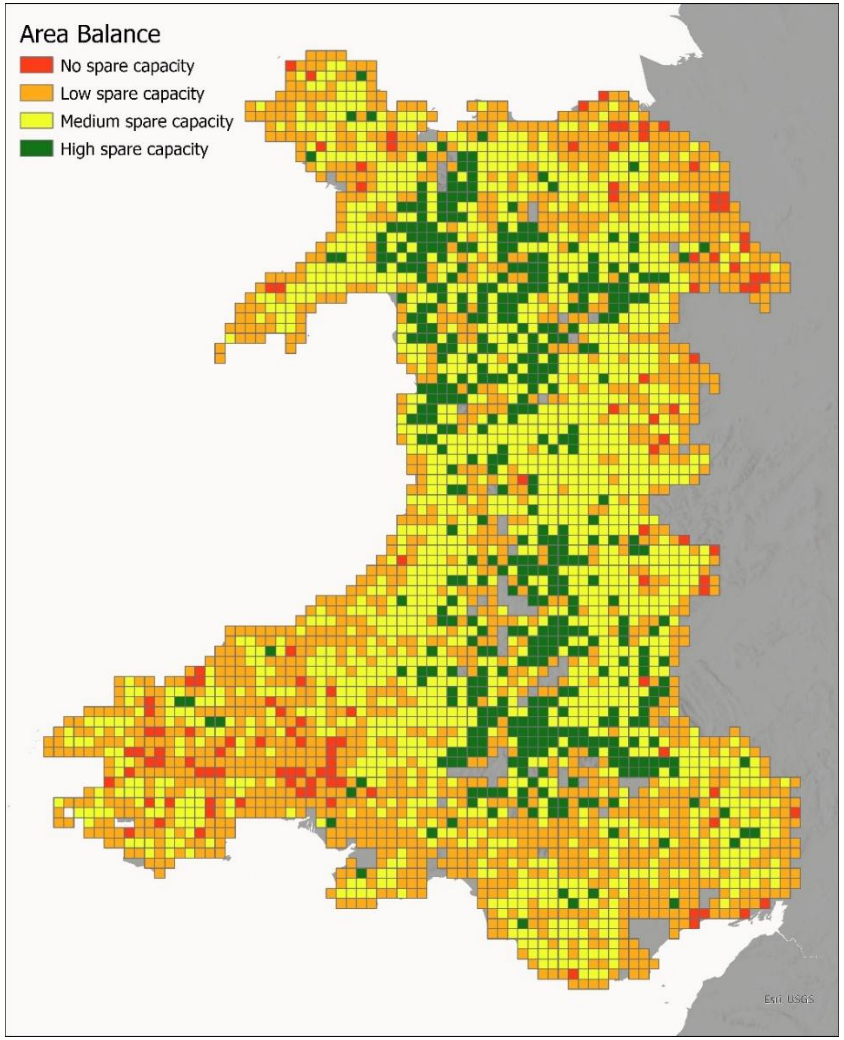
38. Welsh Government figures for Total Income from Farming (TIFF) suggest that variable costs across all sectors were approximately £1.5bn in 2023, and agricultural Gross Value Added (GVA) was c.£0.7bn. Simplistically, this implies that exporting N or renting land would add c.0.1% to c.0.2% to variable costs and reduce agricultural GVA by c.0.2% to c.0.4%. By contrast, destocking would reduce costs but (ignoring possible gains on other farms) lower agricultural GVA by c. 6.6% to c.16%.[5] Given that the majority of farms estimated to be affected are dairy farms, the majority of such costs and GVA impacts would fall on the dairy sector.

[5] Aggregate agricultural output and income: 2023 [HTML] | GOV.WALES. Such calculations are crude since TIFF does not treat rental costs as variable but more importantly TIFF values are themselves estimates and vary from year-to-year.

Figure 4: Estimated spatial variation in 'spare' land potentially available for local renting-in or local exporting of excess N (2.5km by 2.5km grid squares)



Lower-bound



Upper-bound

4 WIDER SUPPLY-CHAIN EFFECTS

4.1 Indicative multiplier results

39. Farms do not operate in isolation but are part of a wider supply-chain, reliant upon upstream providers of goods and services but also themselves providing raw materials for downstream customers. For example, inputs are purchased from vets, feed suppliers, machinery dealers and contractors whilst outputs are sold to abattoirs, creameries and (importantly) other farms. Moreover, farmers and farm workers are also an important segment of the rural workforce, contributing to local economic vibrancy through spending of household earnings beyond solely business-related activities.

40. Figure 5 shows selected upstream and downstream elements of these supply-chains.[6] Although spatial proximity does not necessarily indicate actual supply-chain linkages, comparing the geographical distributions in Figures 4 and 5 illustrates the potential for regional differences in supply-chain impacts. Further research would be needed to confirm such patterns given that inputs and outputs can be transported across longer distances and that supply-chains span borders. For example, Welsh farms have access to suppliers and buyers outside of Wales (notably creameries in England), and downstream Welsh buyers have access to farms outside of Wales (notably for sheep from England and Scotland).

41. Aggregate supply-chain and local economic linkages can be quantified, albeit imperfectly, by economic ‘multiplier’ effects. These express how the effects of on-farm activities ripple outwards beyond the farm-gate in terms employment, output and GVA. For example, a decrease in on-farm production leading to lower on-farm employment, output and GVA will result in less demand for input supplies, leading to additional upstream reductions in employment, output and GVA. Equally, if buyers are unable to source alternative suppliers (including imports), on-farm reductions will be amplified downstream.

42. Published Input-Output (I-O) tables present estimated aggregate multiplier values for agriculture as a whole.[7] However, different agricultural enterprises (e.g. dairy, poultry, beef, sheep) require different combinations of inputs and sell to different buyers. Moreover, the rural economy’s structure varies geographically. Hence attempts are also made to disaggregate overall multipliers into those which are more enterprise-specific and regionally-specific.[8] These disaggregated multipliers are used here to generate indicative supply-chain impact estimates of different options which could be taken up to enable compliance with the 170kg N/ha/yr requirement. Table 8 presents summary indicative estimates of potential impacts on farms and other parts of the supply-chain, subject to additional caveats regarding underlying assumptions and data (NB. backward and forward output multiplier results overlap and should not be simply added together).

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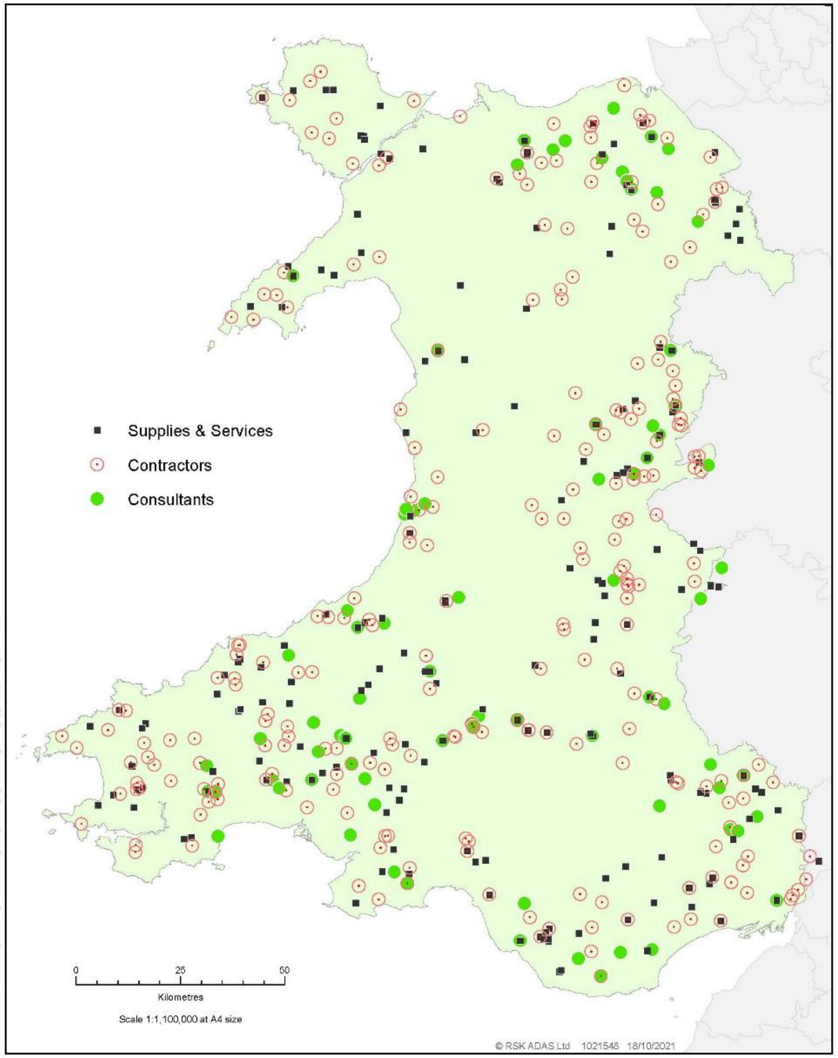
[6] Illustrative relevant downstream data taken from https://data.food.gov.uk/catalog/datasets/1e61736a-2a1a-4c6a-b8b1-e45912ebc8e3 . Upstream data taken from public listings of suppliers.

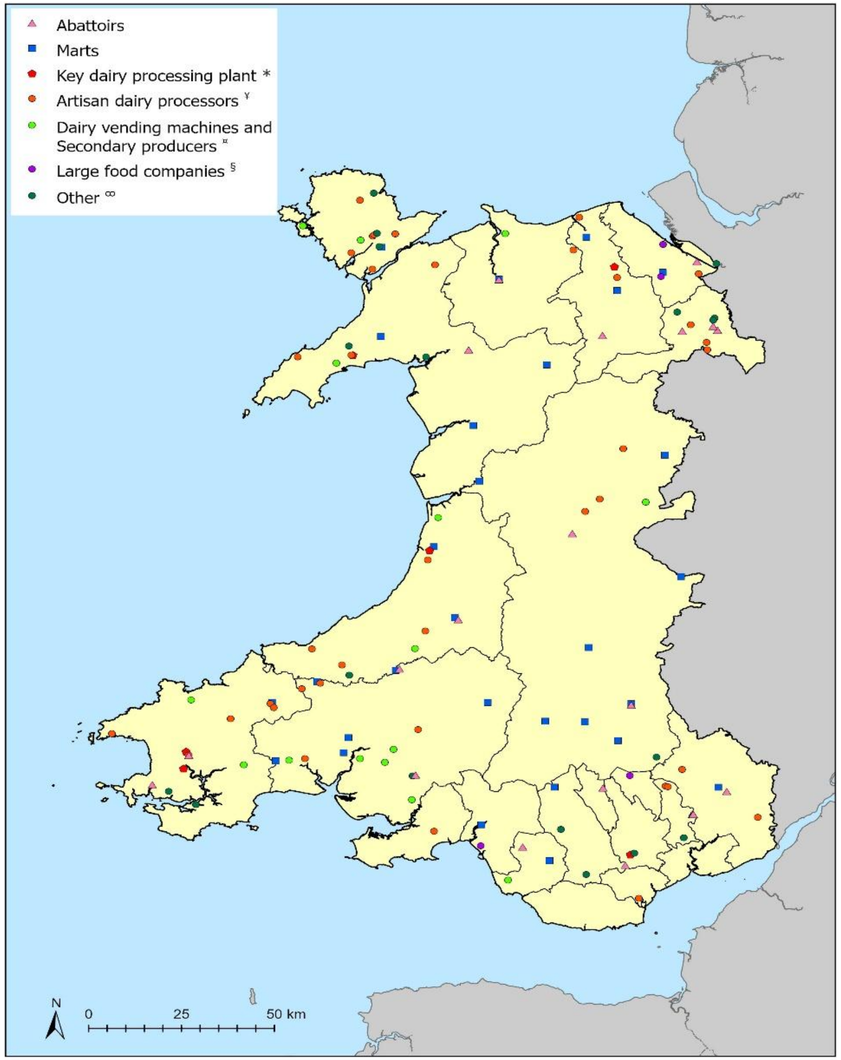
[7] UK input-output analytical tables: product by product - Office for National Statistics

[8] Thomson, S. et al., (2021) Evaluating the significance of agri-supply chains in rural economies: Inter-industry dependency insights from disaggregating UK Input-Output tables. Updated report to Defra.

Figure 5: Maps of selected, illustrative agri-food upstream and downstream supply-chain elements across Wales



Upstream elements



Downstream elements (see Annex B for key description)

43. Destocking is the most expensive compliance option for farms, incurring estimated on-farm reductions in Gross Margin of between c.£47m and c.£114m. This impact is amplified along the supply-chain to become a larger c.£64m to c.£156m total reduction in GVA. Similarly, on-farm output reductions of c.£95m to c.£538m are amplified along the supply-chain to become c.£174m to c.£1,338m in total. Of these totals, the dairy sector accounts for over half of the lower-bound estimate, rising to over 90% of the upper-bound estimate, reflecting significant shrinkage of national milk and dairy-beef production.

Table 8: Illustrative estimated wider multiplier effects of estimated on-farm compliance options

	On-farm						On-farm plus wider supply-chain							
	GVA		Output		Labour (SLR)		GVA		Output (backward)		Output (forward)		Labour (SLR)	
Mitigation option	LB	UB	LB	UB	UB	LB	LB	UB	LB	UB	LB	UB	LB	UB
Destocking	£46m	£114m	£95m	£538m	1307	4541	£64m	£156m	£174m	£1072m	£214m	£1338m	1560	5501
Renting-in land														
If sheep displaced	£15m	£34m	£31m	£69m	479	1068	£18m	£39m	£52m	£118m	£57m	£127m	579	1292
If cattle displaced	£22m	£48m	£48m	£108m	878	1959	£25m	£56m	£82m	£184m	£91m	£203m	1063	2379
rental income offset	*£9m*	*£22m*	-	-	-	-	-	-	-	-	-	-	-	-
Exporting excess N	£1m	£3m	-	-	-	-	£1m	£4m	-	-	-	-	-	-

44. Destocking would also lead to lower on-farm labour usage. This reduction is estimated as between c.1307 and c.4541 SLR, but multiplies across the supply-chain to c.1560 to c.5501. Of these, the dairy sector accounts for c.75% in the upper-bound case and c.35% in the lower-bound case, with the poultry sector accounting for c.15% and c.47% respectively. However, it should be noted that SLR are not directly interpretable as jobs since they assume an average time input for activities and a notional working year of 1900 hours. Given the nature of farming, a longer notional working year might be more appropriate, as might varying SLR coefficients by farm size to reflect economies of scale. Both would lower the headline results at the farm level and therefore across the supply-chain. Separately, it should also be noted that at least some supply-chain jobs potentially at risk will be across the border in England rather than in Wales.

45. Renting-in additional land is a less costly option at the farm-level than destocking. Supply-chain effects of renting-in land are also less significant and arise indirectly. Specifically, as an alternative to destocking, renting-in land retains production levels for those farms doing so. However, rented-in land may previously have been used for production by another farm and hence there is still potentially scope for a reduction in aggregate output.

46. Estimation of such indirect production displacement is somewhat speculative since the previous baseline use of land that might be rented-in is unknown. At one extreme, it may not have been used productively at all or only very lightly, in which case the displacement effect would be minimal. For example, where land is poor quality rough grazing or activity can be relocated elsewhere on a farm. At the other extreme, land may have been used intensively and displacement could be significant. For example, high yielding silage fields or farms with no under-utilised areas.

47. If it is assumed for illustrative purposes that rented-in land will be pasture previously grazed by beef cattle or sheep at a stocking density of 1 Grazing Livestock Unit (GLU) per ha, displacement would be c.36.9k GLU (lower-bound, all farms) to c.82.3k GLU (upper-bound, all farms). If only sheep were displaced, the on-farm reduction in production would be c.£31m to c.£69m, amplified to c.£52m to c.£82m by backward multipliers or c.£56m to £127m by forward multipliers. On-farm GVA reductions of c.£15m to c.£34m would amplify along the supply-chain as c.£18m to c.£39m, and SLR reductions of c.479 to c.1068 on-farm would lead to c.579 to c.1292 reductions in total. If only cattle were displaced, the on-farm reduction in production would be c.£48m to c.£108m, amplified to c.£82m to c.£184m to include upstream suppliers or c.£91m to £203m to include downstream suppliers. On-farm GVA reductions of c.£22m to c.£48m would amplify along the supply-chain as c.£25m to c.£56m, and SLR reductions of c.878 to c.1959 on-farm would lead to c.1063 to c.2370 in total. As above, SLR figures should not be interpreted in terms of jobs per se but rather as indications of reduced requirements for labour.

48. These illustrative impacts will, however, be smaller if displacement is less than assumed above. For example, fewer animals will be displaced from the farm now renting land-out if the land was previously grazed only lightly and/or there is scope elsewhere on that farm to increase stocking densities. Similarly, affected farms renting-in additional land may be able to use it to increase their overall efficiency (without increasing N generated from livestock e.g. producing more own-grown fodder on rented-in land to substitute for bought-in feed).

49. Moreover, rental payments will at least partially offset financial impacts at the aggregate level. That is, whilst parcels of land may no longer generate previous agricultural output they nonetheless will generate rental income for the land owner, who may be another farmer. This income will itself stimulate economic activity, but it is difficult to predict how it might be spent. For example, it could be used to support agricultural activity elsewhere on a farm but equally it could be used for non-farming purposes. In the latter case, any multiplier effects would be felt outside of agricultural supply-chains. Simplistically, the rental payments of c.£10m to c.£22m can be compared to the estimated on-farm GVA loss of c.£15m to c.£48m as a crude indicator of the potential for partial offsetting gains at the aggregate level. If rental values rise through increased local competition for land, costs will rise for some farms but so too will rental income to other farms.

50. Exporting of excess N is the least costly option at the farm-level (and would remain so even if unit costs rose significantly to reflect longer haulage distances). Moreover, no baseline production need be displaced from land receiving exported N and exported N may improve the productivity of receiving land by reducing requirements for artificial fertilisers, thereby reducing costs for importing farms. Hence no directly production-related negative supply-chain impacts are anticipated. Indeed, ironically, additional expenditure on transport to haul slurry may have a modest positive multiplier effect through increased demand for fuel, machinery and servicing from upstream suppliers. Nonetheless, the cost for farms exporting excess N does represent additional expenditure which may influence on-farm production indirectly. For example, through efforts to cut costs elsewhere and/or productive tasks foregone due to staff time being displaced onto hauling slurry. However, the nature of such possibilities is highly uncertain and they do not readily lend themselves to multiplier analysis. Moreover, suitable land to export to may not be readily available locally, which will increase costs. Simplistically, the costs of exporting (c.£1m to £3m) could be interpreted as a reduction in on-farm GVA, multiplying up to perhaps c.£1m to c.£4m across the supply-chain.

4.1 Caveats

51. The supply-chain effects presented above build upon the compliance cost estimates which in turn built upon the physical estimates of how many farms are potentially affected by the 170kg N constraint. As such, the previously noted caveats apply. In addition, whilst a recognized methodology for estimating agricultural economy impacts, multiplier analysis itself invokes various assumptions and is subject to various data uncertainties.[9]

52. First, multipliers represent fixed, linear relationships between inputs and outputs. Yet these may not be an accurate portrayal of actual production relationships. This is, especially true if sectors are experiencing significant pressures for change which would be expected to stimulate different ways of combining inputs to generate some current outputs as well as to generate different outputs. That is, economic systems are dynamic and shocks (such as new regulatory constraints) remould production relationships and patterns. As such, multiplier analysis shows where pressure for change will be felt rather than predicting what that change will necessarily be. In addition, the data used to estimate multipliers are often somewhat sparse and/or dated which can impair their accuracy: Input-Output tables for Wales are not available for all years and published multiplier coefficients used here were derived from Input-Output tables for 2013.

53. Second, similar problems apply to SLR coefficients. For example, economies of scale mean that larger farms often require less labour per animal, yet such variation across different farm sizes is not reflected in average coefficients. Moreover, published coefficients have not been updated for over 15 years, meaning that improvements in farm productivity are also not reflected. Given innovation and increasing farm size in dairying over the past decade, results derived using average SLR are hence likely to over-estimate actual changes in on-farm labour usage, with multipliers then amplifying this over-estimation along supply-chains. Equally, the notional 1900 hours in a working year may not reflect actual working patterns on farms: using a notional longer working year would lower the SLR totals. In turn, this would lead to lower multiplier totals too.

54. Third, whilst the impacts of destocking can be analysed straightforwardly using multipliers, the effects of renting land (whilst clearly less severe) are indirect and estimation invokes additional assumptions. Similarly, potential supply-chain effects of exporting excess N are not readily apparent through multiplier analysis, yet may exist. In addition, the assumed unit costs of renting-in land and exporting excess N would be expected to rise with increased demand for land to spread N on.

55. Fourth, the cross-border nature of supply-chains (and their ability to reconfigure) makes it difficult to determine precisely how dependent any given chain is on local farm production. For example, given that c.50% of current Welsh milk production is processed in England,[10] downstream supply-chain impacts of a reduction

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[9] e.g. see Midmore, P. (1993) Input-Output Models in the agricultural Sector. Avebury; Lloyd, J.H. (2003) Analysing the regional and national economic consequences of moving towards sustainable farming systems within the UK. University of Glasgow; and Lindberg, G. (2011) Linkages: Economic Analysis of Agriculture in the Wider Economy. University of Uppsala.

[10] Welsh milk balance | AHDB

in the Welsh milk field could potentially be felt entirely in England. Similarly, Welsh input suppliers may be already selling into England. However, without access to commercially-sensitive information on private trading arrangements, it is not possible to undertake such detailed analysis.

56. Fifth, resources released by changes in production patterns may find alternative uses that will at least partially offset headline reductions in output, Welsh GVA and employment. However, no account is taken of such possibilities here and any such possibilities may not be uniformly available across Wales.

4.2 Discussion

57. Notwithstanding the noted caveats, the estimated wider supply-chain impacts of compliance with the 170kg N constraint are indicative of possible patterns and magnitudes of pressure for change. In particular, the most expensive on-farm option of destocking clearly has potentially significant wider implications. Consistent with the on-farm results presented previously, the estimated wider impacts fall disproportionately upon the dairy sector. However, although the scope for disruption is apparent, actual net impacts would be expected to be less due to the cross-border nature of supply-chains, their ability to re-configure and the potential for displaced resources to find alternative uses.

58. More fundamentally, the higher on-farm cost of destocking relative to other ways of managing excess N make it the least likely option to be pursued by farmers. Rather, opportunities for exporting N and/or renting additional land will be preferred. These options also have markedly less significant implications for the wider supply-chain. However, the scope for renting and/or exporting may be constrained locally by competition for land, potentially raising compliance costs (although these would probably still remain well below those of destocking).

59. Collectively, the results presented throughout this report confirm that meeting the 170kg N CoAP requirement will impact upon Welsh agriculture and its associated supply-chains. In particular, dairy farms are most likely to have to adopt mitigation measures, thereby incurring additional costs which will have implications beyond individual farms.

60. Refinement of the results presented could be attempted if additional data became available. In particular, greater clarity on farm areas and seasonal livestock numbers plus (especially) milk yield bands for dairy farms would be helpful. Equally, information on actual local supply-chain configurations rather than national-level patterns could improve impact estimates.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Implications of available data

61. It is important to understand that no countrywide survey of livestock N loading, or of livestock numbers and available farm area throughout the year has been carried out. The information on which this assessment has been based has therefore been derived from surveys and returns completed for other purposes. Each farm is unique and the data can only represent a snapshot of the situation at the moment at which it is gathered, and reflects only that which is gathered in that exercise. Consequently the information can, at best, only reflect a partial picture of the actual circumstances of a farm. Hence, as stressed repeatedly throughout the report, all results are necessarily indicative and subject to various caveats.

62. The analysis is presented as lower and upper bound estimates, and in respect of assessment of cost options for compliance, assumes that 100% of the farms under consideration will adopt the approach in question – for example that all dairy farms anticipated to be over the limit prior to the introduction of the legislation will reduce livestock numbers across the board in order to reduce N production to the required level, or alternatively that all farms will export manures to achieve the same result. In reality some will reduce numbers, some will rent or buy land and some will export manures.

Available area

63. Reported farm areas may misrepresent actual utilized land. For example, land taken on an informal or short-term basis may not be captured well by current statistical or administrative exercises. Similarly, a farm may simply not report all of its area. In such cases, the overall area of the farm for the purposes of the N loading calculation will be understated and the likely loading figure calculated through this assessment will be an overestimate. For many farms this is not an issue, but for others where the business model is dependent on temporary land or grazing arrangements then the variance may be significant.

64. A number of upland / LFA grazing livestock farms were identified as being likely to exceed the 170kg N loading limit, primarily as their reported livestock numbers appeared unrealistically high for the associated acreage – some were apparently virtually landless. Given the operational and productivity constraints of such farms it seems improbable that many of those identified would actually exceed the loading limit, and the apparent high figures are likely to be a product of the way in which the data is gathered rather than a reflection of the farm's actual situation. Under-accounting for common grazing may be one possible explanation, although it has been included where data permitted.

65. Overall the available area of active farms is therefore more likely to be understated than to be overestimated. Data limitations associated with reported farm area mean that the upper-bound figures are therefore more likely to be an overestimation of the number of farms which would exceed the limit, than an underestimate.

Ruminant livestock numbers.

66. The JAS data reflects stock on the farm on the day of the return. Whilst numbers of breeding sheep and cattle, and of dairy cows on a holding are normally relatively constant throughout the year, numbers of youngstock and some other species fluctuate with the seasons and the farm's business model. Farms buying store lambs to finish over the autumn and winter period will report no sheep in a June survey, those grazing cattle over the summer and selling in the autumn sales will report cattle which will only be on the farm for half the year.

67. Whilst presenting lower and upper bounds is an attempt to approximate such effects, individual nuances will not be well captured. For example, as it is not possible to link the N loading of the store lambs with the holding on which they were born, the figure for those farms will therefore have been underestimated. Conversely the assumed N output of the grazing store cattle will be around double the actual figure.

68. For many farms, the variance (if any) is unlikely to be significant – the N output of youngstock is low compared with that of mature animals and mature cattle in particular are likely to be present throughout the year. The overall N loading of upland and LFA farms sending sheep to winter on low ground (a relatively common practice which is not revealed by the JAS) will be overestimated in this assessment. Despite this, relatively few farms in these categories have been identified as being likely to exceed the N loading limit. Similarly, the impact of the N contribution of bought-in store lambs on a predominantly arable farm is rarely likely to be an issue. If the business has few, if any, livestock through much of the year, the overall loading will be low and the N production by the lambs of a few grammes of N per head per day is unlikely to take the farm above the 170kg N limit over the year.

69. The issue is likely to be of more consequence with dairy farms taking in tack sheep over winter, where the N contribution from the sheep cannot be identified by the methodology, and N loading will be underestimated. As dairy farms form the bulk of the businesses identified as likely to exceed the N loading limit, this underestimation may be important, though the contribution of the tack sheep to the overall N production will be relatively small in comparison with that of the dairy herd. Anecdotally, ceasing to take-in sheep has been sufficient to bring the farm loading figure below 170kg N per ha in some circumstances. Impact on direct farm income is small – payment might be between 60p and £1 per sheep per week – but the sheep can perform a valuable function in managing the growth of grass over winter and loss of them as a grass management tool may have implications for the performance of the grassland in the following spring.

70. The ruminant livestock numbers data are therefore more likely to result in an underestimate of the number of dairy farms which may exceed the limit (or the margin by which they exceed it) in respect of tack sheep, and overestimate the number of grazing livestock farms which will exceed the limit or the margin by which they exceed it.

Milk yield bands.

71. Sensitivity of results to the assumed milk yield band for dairy farms confirms that lack of information on actual milk yields for individual farms is problematic. Whilst the results presented offer approximate lower and upper bounds, without more precise data it is not possible to infer which is more likely. Moreover, higher band farms also have the option to reduce milk yields as another way of complying with the 170kg N limit, but modelling this would again require more data. Hence, given that dairy farms are estimated to represent the majority of farms affected, addressing this data gap would seem prudent.

Poultry

72. Data on poultry numbers are inconsistent and businesses with poultry are amongst the most likely to exceed the N loading limit before export of manures is taken into account. Hence efforts to generate better information would be welcome. However, specialist poultry producer numbers drawn from all data sources are relatively small, particularly in comparison with the number of dairy or grazing livestock farms. Given the way in which specialist poultry producers have traditionally operated, with many already exporting a large proportion of the manure generated, the introduction of the 170kg N limit is most likely to have a significant impact on businesses where the poultry unit is run in addition to the core activities of grazing livestock, and manures are retained for use on the holding. Based on WG standard figures a 32,000 bird free range poultry unit generates 48kg of N per day, 100 suckler cows and their progeny to 24 months will produce approximately 43kg N a day on average. These farms may fall within the category of grazing livestock, or be classed as poultry and may account for some of the apparently high N loading grazing livestock or mixed businesses.

Import and export of manures

73. The farm N loading calculation includes N in organic manures produced on or imported to the holding. No data is available on the baseline number or type of farms importing or exporting manure, or the quantities of manures involved. The influence of any existing manure export practices on farm N loading were therefore not taken into account in this assessment.

74. Without data, the implications of manure exports are impossible to quantify. Manure export has been standard practice for many intensive livestock units for years, where most or all of the manure from a pig or poultry unit is exported to neighbouring farms. Where units have conventionally exported manures for practical reasons, actual N loading on the home farm may be within the 170kg N limit, however as there is currently no way of identifying exports, the business will appear to exceed the limit, and frequently by a significant margin. Where export is standard practice, the introduction of the 170kg limit in itself does not affect the producer directly. However the numbers of farms in a position to import manures may decline and the number of farms needing to export (and quantity of manure which is needed to be exported) are both likely to increase.

5.1 Farm management implications

Achieving compliance with the 170kg N loading limit

75. Farms which find that they are operating above the 170kg organic N per ha overall loading limit have three basic ways of achieving compliance – to reduce the N production from livestock, to reduce the N from livestock manures applied to the holding, or to increase the area of the holding to accommodate the manures produced.

76. The choice of approach taken by any farm will depend on the individual farm circumstances and local opportunities. Given the same problem, the right solution for a tenant in their 60s is unlikely to be the same as for an owner occupier in their 40s with clear succession.

77. Some farms may undoubtedly decide to cease trading, retire or change enterprise with the introduction of this aspect of the legislation. However a decision to reduce numbers or change enterprises (i.e., cease dairying and move to beef, sheep, heifer rearing etc.) or exit the industry is probably unlikely to be solely triggered by the issue of N loading. Other factors associated with the regulations such as the cost of additional slurry storage, or completely unconnected with CoAP - the need to invest in a new parlour, lack of profitability or ill health - may also play a part in any such decision. Without detailed information about a farm business it is impossible to identify the most appropriate response to the introduction of the 170kg N loading limit, and even with that information it is impossible to isolate the impact of the 170kg N loading limit from the influence of a host of other pressures.

Reducing N production

78. Whilst reducing N production by reducing herd size across the board is often cited as the most likely approach, in practice for many farms it is likely to be the last resort. Moreover, if destocking is deployed it is unlikely to involve a pro-rata reduction in herd size, youngstock numbers etc. Reducing livestock numbers by dropping or out-sourcing an enterprise (contracting out heifer rearing from 6 months to 23 months on a dairy farm for example) could be sufficient to bring a business from a loading of 198kg N per ha to 170kg N per ha – assuming a replacement rate of 30%, no livestock enterprises other than dairying and a herd average milk yield of 6-9000 litres per annum. Whilst this approach will increase operating costs it releases time, facilities and (potentially) slurry store capacity for the milking herd, whilst allowing cow numbers to be maintained. Such a move will bring both savings in feed / forage requirement and additional costs – potentially in the region of £11 per head per week (A Roberts ADAS pers comm).

79. The suitability of dropping an enterprise as a means of reducing N production will depend on the nature and size of the enterprise, its importance to the business and the extent to which the farm needs to reduce N production (possibly in combination with other measures such as export of manures or land rental). It is therefore impossible to estimate the number or proportion of businesses for which this may be a realistic option, or the proportion which may choose this approach.

80. Where a reduction in herd size and therefore all classes of livestock on the holding is the preferred option, the impact on the business will not be a pro-rata reduction in costs and income. Some costs will decline largely in proportion to the reduction in livestock numbers – for example feed costs. Other costs include an overhead element which is largely independent of stock numbers – slurry spreading by umbilical system is commonly charged on an hourly rate, with one rate for setting up and another for time spent spreading. Set-up costs are effectively independent of livestock numbers and will therefore remain constant, spreading time and cost will be reduced slightly. Importantly (whilst not directly linked to the 170kg N loading limit) as a substantial proportion of the contents of most slurry stores is rainwater, a reduction in livestock numbers does not normally result in a proportional reduction in slurry volumes or store capacity requirement.

81. Conversely whilst reducing herd or flock size in a beef finishing or poultry business is likely to result in a corresponding reduction in output and therefore income, with a dairy or suckler beef business it is likely that average output will increase for those animals which are retained. The mechanism by which reduction in numbers will be achieved is likely to be to cull and not replace poorer performing animals. The requirement for replacements will also be reduced allowing greater selectivity in choosing herd replacements. The genetic merit of the herd is likely to increase more quickly as a consequence and output is therefore likely to decline less than a straight reduction in numbers would suggest. The implications for milk processors for example are therefore likely to be smaller than might initially be anticipated. Unfortunately as with all of the compliance options the decision making process is individual and farm specific, it is therefore impossible to quantify the number of producers who may decide to take this approach.

Manure Export

82. The least costly and least disruptive option for many is likely to be export of manures to bring overall loading down to 170kg total organic N per ha. In order to be able to achieve 170kg N per ha loading through export, farms need to have sufficient exportable manures as well as sufficient available land to which to export.

83. Nitrogen production from intensive livestock or ruminants housed for a significant proportion of the year is largely in the form of manure or slurry which can be collected and stored and can therefore be exported. A heavily stocked business where livestock are not housed and manures are deposited in the field (such as outdoor pigs) may exceed 170kg N per ha loading but generate little or no exportable manure. Numbers of outdoor pigs in Wales are, however, believed to be negligible.

84. Export can be an attractive option where there is local demand for the manures as a fertiliser material – for example, a livestock farm in a predominantly arable area. Conversely in predominantly grassland areas with a high livestock density, opportunities for export will be limited and the option may either be unavailable, or the amounts for which there is an outlet within a reasonable distance is insufficient to bring farm loading down to 170kg N per ha.

85. Modelling shows that even within heavily stocked areas, there is (in theory) sufficient land area within 10km of production to bring Wales as a whole below the 170kg ha N loading. However export requires land to which manures can be applied by mechanical means. Areas which are too wet or steep, or subject to land management agreements will be unavailable, and export requires both a supplier and a willing recipient. Issues of soil damage, disease risk, transport costs, paperwork, spreading risk and opportunity, and local relationships mean that the volume of manures likely to be exported will inevitably be significantly lower than that which could in theory be exported.

86. The individual field application limit of 250kg total organic N per ha in any 12 month period does, however mean that export could be seen as a more attractive option for some than land acquisition. One hectare on a 12 month short term let being worth 170kg of N production to the tenant, but potentially 250kg if the landowner accepts the maximum rate of N applied as manures as an import. This could in theory have implications for water quality and other aspects of CoAP compliance if imports are being ‘dumped’ and applied at the maximum permissible rate. Whilst the total N loading figure can be achieved on grassland without breaching the N Max limit, it is not difficult to breach N Max on maize (150kg of fertilizer N / available N from organic manures) where high readily available N manures such as cattle slurry, digestate or poultry manure are applied along with di-ammonium phosphate as a placed starter fertiliser.

87. In theory, export of manures should result in a more even distribution within the catchment, a reduced risk of building phosphate indices, and a reduced risk of diffuse pollution. In practice this may not be the case. The maximum permissible individual field loading remains the same at 250kg total organic N per ha in any 12 month period. If export options are limited, exports may end up being focused on a small number of importers, or a limited number of fields where importers can make most use of the manures on those fields (such as maize, a reseed or catch crop). This affords a good practical opportunity to use manures, but presents a risk of application in excess of crop need (the RB209 nitrogen recommendation for grass establishment is a maximum of 50kg of available N for a conventional summer sowing).

Increasing Farm Area

88. Where land is available at a realistic cost, increasing farm size allows nitrogen production to be divided over a larger area, reducing loading. Rental or purchase of additional ground is a favoured option amongst farmers where the opportunity arises as it allows farm income to be maintained or increased (albeit with an increase in rental or mortgage costs) and potentially increases security of fodder supplies etc. Whilst the N production mapping exercise suggested that there was sufficient land within 10km to allow compliance to be achieved across Wales, and the issue of spreadability which restricts export opportunities is not relevant to increased farm area, availability of land and cost may be another matter. Availability is dependent on a landowner offering part or all of their holding for sale or rent, potentially limiting their own operations. Land normally becomes available due to a change in business or ownership circumstances – retirement, death, divorce or ceasing a key enterprise (e.g. going out of dairying). In the case of rental the landowner has to be willing to rent the parcel to the prospective tenant, and not all those who theoretically have a surplus of land are prepared or in a position to let or sell that ground, preferring to keep their options open.

89. Competition in the land market may therefore increase amongst those looking to expand their area for compliance as well as commercial reasons, against a backdrop of increased interest in the rural property market including from those looking to plant woodland for carbon off-set purposes. This is likely to drive up costs and further disadvantage smaller businesses, particularly newer and less established enterprises with smaller reserves and fewer economies of scale.

5.2 Phosphate considerations

90. All of the analysis presented above relates solely to the 170kg N constraint. Yet Welsh farms are subject to other related regulatory constraints. For example, minimum required slurry storage capacity and prescribed timings for slurry applications but also importantly to phosphate (P) levels from livestock sources. The latter arises because, whilst not widely recognized, WG and NRW have stated that the application of livestock manures in excess of crop (phosphate) requirement would be considered to be a breach of the Environmental Permitting Regulations 2010 (EPR).

91. Crop requirement as set out in the AHDB Nutrient Management Guide (RB209) is the economic optimum application rate for a given crop / nutrient combination, taking into account the crop available nutrient from soil reserves. It should be noted that the figures are economic optima based on a given ratio of crop value to purchased nutrient cost, and can also be adjusted with expected yield.

92. Soil reserves of phosphate will vary depending on soil type and parent material and the cropping and manure use history of the field. Phosphate available from soil reserves is conventionally measured by soil analysis and the result in mg/litre assigned to a series of indices from 0 to 9. Crop requirement at P index 0 is significantly higher than at index 4. As an example, for first cut silage at index 0 phosphate requirement (assuming an anticipated yield of 23t /ha fresh weight) is 100kg/ha declining to a maintenance dressing of 40kg at index 2 and 0 kg at index 4. The objective being to maintain soils at or around index 2 as a safe steady state.

93. Soils which are inherently phosphate rich, and/or more importantly where there has been a long history of manure use, are likely to have elevated soil indices and therefore a lower requirement for applied phosphate. Livestock manures contain both N and P, and in general crop P requirement is met before N needs are satisfied through the application of manures. In some circumstances P requirements may be the limiting factor rather than the CoAP N loading limit. As EPR pre-dates CoAP, farms where P was the limiting factor at 170kg N would be considered to be affected by EPR and not by the CoAP 170kg N loading limit.

94. The issue relates to manures which can be applied to land by mechanical means, and therefore primarily where the majority of the N loading is associated with housed livestock, and has not been taken to directly limit livestock numbers. P recommendations for grazed grassland make allowance for the phosphate recycled in manures deposited in the field by grazing animals. A farm with only grazing livestock and no crop requirement for P due to high P indices will therefore be limited by CoAP and not by EPR.

95. A hypothetical case study farm of 400ha with a 600 cow dairy herd, 140 herd replacements and 70 calves, all housed for 6 months of the year would produce 13,987kg of P in manures. With cropping of 10ha of spring barley and the remainder grassland for mowing (200ha first cut) and grazing (190ha) overall N loading would be 170kg per ha assuming no exports.

96. Phosphate requirement would be 41,154kg at index zero, 30,100kg at index 1, 18,100kg at index 2 and 4000kg at index 3. On this basis P would be the limiting factor where indices are on average over 2, but N will be the limiting factor below this level. The same applies if the herd is permanently housed as P requirement increases to 31,650kg at index 2 with the increased area of mowing ground, and P output in spreadable manures rises to 28,109kg with the increased housing period.

97. Unfortunately, although many farms have undertaken the requisite soil testing, data on P index scores across Wales have not been collated centrally. Consequently, there is currently no basis for assessing the distribution of soil P indices or of estimating the impacts of regulatory controls across the Welsh farm population in a similar manner to that presented above in relation to the 170kg N. Data from the Professional Agricultural Analysis Group (PAAG) - a consortium of laboratories providing soil analysis, suggests that 36% of approximately 135,000 samples from grassland soils taken in England and Wales and processed during 2018- 19 were above index 2, however the soils sampled are not necessarily representative of all soils, or more importantly of soils on dairy farms or farms with intensive livestock.

98. It can take several years to build up phosphate levels in soils, and equally to erode those levels by reducing inputs whilst maintaining off-take. We are not aware of any studies where the correlation between soil P index and stocking levels, or the stocking history of a farm and soil P indices have been published. However it would be reasonable to assume that farms with a history of being more heavily stocked (for example operating at the equivalent of 170kg or more total organic N loading) and/or heavy use of phosphate fertiliser are likely to have higher soil phosphate indices than farms with lower stocking levels. Unfortunately, whilst farms with theoretically high N loading levels can be identified from the data, it has not been possible to determine the number of such farms which have been operating at those levels for (for example) five or ten years.

99. Although we can presume that P levels will almost certainly be a limiting factor for some farms, effectively reducing the proportion where the CoAP 170kg limit is the legislative driver, it is not possible to estimate numbers. It is, however, reasonable to suggest that these are most likely to be specialist dairy and intensive livestock businesses.

5.3 Data and research recommendations

100. The analysis presented has drawn upon best available data and various assumptions to offer lower and upper bound estimates of impacts. Although pragmatic, this approach must necessarily be viewed as offering only indicative rather than definitive results. Whilst patterns and relative orders of magnitude seem plausible, confidence in the results could undoubtedly be improved if additional data became available. This leads to four specific recommendations for further data gathering/collation and research, either to refine the estimates presented here and/or to extend analysis to a full Regulatory Impact Assessment.

101. First, baseline data on farm areas and livestock numbers could be improved to fill gaps and improve consistency. In some cases, this may simply involve better coordination and consistency between existing databases held for different reasons. For example, information held by the JAS, RPW and APHA gives different perspectives on the same farm population. This is partly because equivalence between different farm identifiers is imperfect but also because relationships between farm holdings and farm businesses are often complex and fluid. In addition, the population of farms and livestock keepers is in a state of constant flux. Nonetheless, whilst perfect alignment between different 'live' systems may be unattainable, reconciliation between date-stamped contemporaneous snapshots to create an agreed better baseline could be feasible. The current updating of the poultry register may provide an opportunity to test this possibility.

102. Second, more granular data are required to capture variation in management practices across the highly heterogenous farm population. In particular, it would be helpful to know the actual milk yield band of dairy farms and to have some information on the actual headcount distribution of livestock across the year. The latter could potentially be extracted from CTS for cattle, but other species would probably require an additional data collection exercise of some form.[11] Milk yield bands might (with explicit permission from farmers) be available via commercial milk recording services or could be captured via an additional data collection exercise. Additional data collection need not be burdensome if it can be added into existing collection mechanisms.

103. Third, the absence of collated information on soil P index scores is a fundamental obstacle to further aggregate impact assessments. As such, ambitions should be set to at least start to collate results from soil tests to be undertaken under the proposed Sustainable Farming Scheme. Ideally, possibilities for collating existing results from past soil tests funded through WG via Farming Connect could also be explored.

104. Fourth, pending progress with the recommendations above, the results presented in this report could be sense-checked through visiting a limited number of farms (and possibly other supply-chain firms) to gauge how well current data, assumptions and estimated impacts reflect actual conditions on-the-ground. At the same time, given the potential for on-farm and wider supply-chain impacts, consideration could be given to how best to issue guidance and offer advice/training to farmers, input suppliers and downstream buyers regarding mitigation options and potential impacts.

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[11] The absence of individual traceability for other species hinders estimation of farm populations from movement data alone. In principle, on-line livestock registers could facilitate estimation, as could additional JAS questions.

6 ANNEX A - MATCHING LIVESTOCK CATEGORIES

105. The calculation of nitrogen emissions from livestock uses different coefficients for different types and ages of animal. Unfortunately, the CoAP coefficient categories are not identical to the categories reported in the June Agricultural Survey. Consequently, it is necessary to map approximate matches between the two category listings. This is presented in Tables A1 to A4 and Tables A5 to A8 below.

106. Whilst categories are equivalent in some cases, in many cases they are not. This requires either a merging of coefficient categories to match a more aggregated JAS category or apportionment of a JAS category across two or more coefficient categories. Hence some averaging or simply using upper and lower bound values is required. Sensitivity of results to these choices will reflect the relative abundance of each category and its coefficient weighting.

Table A1: Matching between poultry N coefficient categories (F1 to F10) and JAS poultry categories (N2 to NC6)

Coefficient category	N Coeff	JAS category	JAS population	Comment
F1 1,000 replacement layer pullet places, < 17 wks	210	N2 Egg production – growing pullets	0.3m	Equivalent
F2 1,000 laying hens in cages, >= 17 wks and over	400	N3 Egg production – pullets in laying flock	2.0m	Merge coefficient categories (could weight by age distribution if known)
F3 1,000 laying hen places, free range (note b), >=17 wks	530	N3 Egg production – pullets in laying flock		
F4 1,000 broiler places	330	N10 Broilers (table chicken)	4.9m	Equivalent
F5 1,000 replacement broiler breeder pullet places, < 25 wks	290	N6 & N7 Fowls for breeding	0.6m	Merge coefficient categories (could weight by age distribution if known)
F6 1,000 broiler breeder places, >= 25 wks	700	N6 & N7 Fowls for breeding		
F7 1,000 turkey places (male)	1,230	N15 Turkeys	0.1m	Merge coefficient categories (could weight by sex distribution if known)
F8 1,000 turkey places (female)	910	N15 Turkeys		
F9 1,000 duck places	750	NC6 All other birds	0.3m	Merge coefficient categories (assume all to be ducks rather than ostriches)
F10 1 ostrich	1400	NC6 All other birds		

N coeffs = annual kg N per 1000 bird places (with assumed occupancy rates); occupancy rate adjustment also applies

107. For poultry (Table A1), the category matching is reasonable for the dominant JAS population segments (N3 as F2 & F3; N10 as F4). Merging F2 with F3 and F5 with F6 requires some assumption about the appropriate weighted average. Coefficients are per place, so if JAS snapshot is accurate (i.e. not happening to fall between production cycles nor missing businesses) it can be taken as representative of annual places. NB. Turkey numbers will be an under-estimate due to the timing of the survey relative to their concentrated production later in the year. Aggregate reported JAS poultry headcounts are believed to under-estimate actual numbers (either under-reporting by known units and/or non-reporting by unknown units). In principle, APHA data may be more comprehensive but the basis for collection differs to that for the JAS and reconciling premises between the two data sources is beyond the scope of this project.

108. For cattle (Table A2), calves under 2 months are not reported separately from older calves in the JAS, so C1 is effectively folded into C2 and C7. Milk yield is unknown, so C4 to C6 are merged. Similarly, size of beef cows is unknown, so C10 & C11 are merged. Barren beef cows could be merged with slaughter animals. Bulls are not reported separately, but coefficients are similar to other males so can be merged. Seasonal distribution of non-breeding animals is likely to vary from JAS snapshot (e.g. animals for slaughter over year will be a higher number than shown) but is challenging to estimate for individual farms given variation in management systems (e.g. calving periods, buying and selling stock). Moreover, age classes are themselves 12 months wide, meaning that within-year timing of shifts between them is uncertain. In principle, CTS data could be used but not within the timeline of this project.

109. For sheep (Table A3), breeding animal categories (which dominate in terms of both emission coefficients and headcounts) align reasonably – albeit that LFA status may not correlate perfectly with breed size. Lamb categories do not align well, but some can be captured in other JAS categories and an approximation could be made for the non-overlapping months. Seasonal distribution of non-breeding animals is likely to vary from JAS snapshot but is challenging to estimate for individual farms given variation in management systems (e.g. lambing periods, buying and selling stock). Other species are relatively unimportant given their population sizes. In principle, EID Cymru may hold seasonal data but these may be difficult to extract/access within the project timeline.

110. For pigs (Table A4), breeding sow categories align reasonably – coefficients do not differ much between diet categories. Breeding boar categories are less similar, but headcount is low. Weaner, grower and finisher places align less well due to differences in weight thresholds. Coefficients are per place, so if JAS snapshot is accurate (i.e. not happening to fall between production cycles nor missing businesses) it can be taken as representative of annual places. In principle, APHA data may be more comprehensive but may be difficult to extract/access within the project timeline.

111. The ordering of information in Tables A1 to A4 is reversed in Tables A5 to A8, to show coefficient values to apply to JAS population categories. This is a more convenient format for actually implementing calculations. Again, whilst some category boundaries align others do not. For the latter, sensitivity analysis can be used to explore the impact of using minimum or maximum possible coefficient values, or some (weighted) average. However, for presentational ease, simpler upper and lower bound estimates capture the interactions between different assumptions.

Table A2: Matching between cattle N coefficient categories (C1 to C14) and cattle JAS categories (K201 to K211)

Coefficient category	N Coeff	JAS category	JAS population	Comment
C1: 1 calf (all categories) younger than to 2 months	1.4	-	-	Ignore to avoid double counting
C2: 1 dairy cow from 2 months and less than 12 months	29	K203 Dairy female <1	73k	JAS category includes younger calves, so will be over-estimate
C3: 1 dairy cow from 12 months up to first calf	61	K206 Dairy female 1-2 & K209 Dairy female 2+ no/offspring	118k	Merge JAS categories
C4: 1 dairy cow after first calf (over 9,000 litres milk yield)	115	K211 Dairy cow 2+ w/offspring	252k	Merge coefficient categories, but could weight by yield distribution estimated from CIS data
C5: 1 dairy cow after first calf (6,000 to 9,000 litres milk yield)	101	K211 Dairy cow 2+ w/offspring		
C6: 1 dairy cow after first calf (up to 6,000 litres milk yield)	77	K211 Dairy cow 2+ w/offspring		
C7: 1 beef cow or steer (castrated male) from 2 months and less than 12 months	28	K201 Male <1 & K202 Beef female <1	248k	JAS categories include younger calves, so will be over-estimate
C8: 1 beef cow or steer from 12 months and less than 24 months	50	K204 Male 1-2 & K205 Beef female 1-2	186k	Merge JAS categories
C10: 1 female for breeding 24 months and over weighing up to 500 kg	61	& K210 Beef female 2+ w/offspring	164k	Merge coefficient categories (barren cows fed less so included below, even though not necessarily for slaughter)
C11: 1 female for breeding 25 months and over weighing over 500 kg	83	K210 Beef female 2+ w/offspring		
C9: 1 female or steer for slaughter 24 months and over	50	K207 Male 2+ K208 Beef female 2+ no/offspring	80k	Merge coefficient categories (coefficients are similar so proportional split is relatively unimportant. Bulls not reported separately)
C12: 1 non-breeding bull 2 months and over	54	K207 Male 2+		
C13: 1 bull for breeding from 2 and less than 24 months	50	K207 Male 2+		
C14: 1 bull for breeding from 24 months	48	K207 Male 2+		

N coeffs = annual kg N per breeding animal or kg N per other animal for duration of category membership

Table A3: Matching between sheep (and miscellaneous) N coefficient categories (S1 to S8) and JAS categories (M2 to M14, P1 to P10)

Coefficient category	N Coeff	JAS category	JAS population	Comment
S1: 1 lamb, 6 to 9 months	0.5	M17: Lambs under 1	464k	JAS includes younger and older lambs, so will double-count with S3 & S4 and also with S2 unless reduced pro rata.
S2: 1 lamb, 9 months and over, to first lambing, first tupping or slaughter	0.7	M4: Sheep > 1 for slaughter M13 & M14: Other sheep >1	371k	JAS counts lambs elsewhere, so will slightly under-estimate here
S3: 1 sheep, less than 60 kg, after lambing or tupping. For ewes this includes one or more suckled lambs up to 6 months	7.6	M2: Sheep > 1 & M9: Rams for service (LFA)	4141k	JAS category differentiated on basis of LFA status
S4: 1 sheep, over 60 kg, after lambing or tupping. For ewes this includes one or more suckled lambs up to 6 months	11.9	M2: Sheep > 1 & M9: Rams for service (non-LFA)	381k	
S5: 1 goat	15	P5 & P6: Goats – breeding females	7k	Merge JAS categories
S6: 1 deer for breeding	15.2	P10: Farmed deer	1k	Merge coefficient categories
S7: 1 deer, other	12	P10: Farmed deer		
S8: 1 horse	21	P1 & P2: Horses & Ponies, occupiers & others	45k	Merge JAS categories

N coeffs = annual kg N per breeding animal or kg N per other animal for duration of category membership

Table A4: Matching between pig N coefficient categories (P1 to P11) and pig JAS categories (L1 to L14)

Coefficient category	N Coeff	JAS category	JAS population	Comment
P1: 1 weaner place, 7 to 13 kg	1	L14: Other pigs <20kg	6818	Merge coefficient categories (assume split by weight)
P2: 1 weaner place, 13 to 31 kg	4.2	L14: Other pigs <20kg		
P3: 1 grower place, 31 to 66 kg (dry fed)	7.7	L13: Other pigs 20 to 50kg	5555	Merge coefficient categories (assume split by diet)
P4: 1 grower place, 31 to 66 kg (liquid fed)	7.7	L13: Other pigs 20 to 50kg		
P5: 1 finisher place, 66 kg and over (dry fed)	10.6	L12, L11 & L10: Other pigs >50kg & L7: Barren sows	8760	Merge coefficient categories (split by diet irrelevant given identical coefficient)
P6: 1 finisher place, 66 kg and over (liquid fed)	10.6	L12, L11 & L10: Other pigs >50kg & L7: Barren sows		
P7: 1 maiden gilt place, 66 kg and over	11.1	L2 & L5: Breeding pigs - gilts	588	Merge JAS categories (weights not reported)
P8: 1 sow place, 66 kg and over, with litter, up to 7 kg, fed on diet supplement with synthetic amino acids	16	L1: Breeding pigs -sows	1764	Merge coefficient categories (assume split by diet)
P9: 1 sow place, 66 kg and over, with litter, up to 7 kg, diet without synthetic amino acids (low protein diet)	18	L1: Breeding pigs -sows		
P10: 1 breeding boar from 66 kg to 150 kg	12	L4: Breeding pigs – boars	245	Merge coefficient categories (assume split by weight)
P11: 1 breeding boar, 150 kg and over	17.5	L4: Breeding pigs - boars		

N coeffs = annual kg N per pig places (with assumed occupancy rates); occupancy rate adjustment also applies

Table A5: Matching between JAS poultry categories (N2 to NC6) and poultry N coefficient categories (F1 to F9)

JAS code	JAS description	N coeff code	N coeff (g/khd)	Occupancy rate	Value to use	Comment
n2	Egg production - growing pullets	F1	210	89%	0.1869	
n3	Egg production - pullets in laying flock	F2 or F3	400 or 530	97%	0.388 or 0.5141	Use min or max
n5	Fowls for breeding - hens - layer chicks	F5 or F6	290 or 700	92% or 95%	0.2668 or 0.665	Use min or max
n6	Fowls for breeding - hens - table chicks	F5 or F6	290 or 700	92% or 95%	0.2668 or 0.665	Use min or max
n7	Fowls for breeding - cocks & cockerels	F6	700	95%	0.665	
n10	Broilers (table chicken)	F4	330	85%	0.2805	
n15	Turkeys	F7 or F8	1230 or 910	90% or 88%	1.107 or 0.8008	Use min or max
nc6	All other birds	F9	750	83%	0.6225	

Table A6: Matching between cattle JAS categories (K201 to K211) and cattle N coefficient categories (C1 to C14)

JAS code	JAS description	N coeff code	Value to use	Comment
k201	Male <1	C7	28	Possibly adjust for calves <2mths, but also for transition to older class
k202	Beef Female <1	C7	28	Possibly adjust for calves <2mths, but also for transition to older class
k203	Dairy Female <1	C2	29	Possibly adjust for calves <2mths, but also for transition to older class
k204	Male 1-2	C8	50	
k205	Beef Female 1-2	C8	50	
k206	Dairy Female 1-2	C3	61	
k207	Male 2+	C9, C12, C13 or C15	50, 54, 50 or 48	Use minimum or maximum
k208	Beef Female 2+ no offspring	C9	50	
k209	Dairy Female 2+ no offspring	C3	61	
k210	Beef Female 2+ w/offspring	C10 or C11	61 or 83	Use maximum, on basis that all suckler cows weigh at least 500kg
k211	Dairy Female 2+ w/offspring	C4, C5 or C6	115, 101 or 77	Use minimum or maximum

Table A7: Matching between sheep (and miscellaneous) JAS categories (M2 to M14, P1 to P10) to N coefficient categories (S1 to S8)

JAS code	JAS description	N coeff code	Value to use	Comment
m2	Sheep >1 for further/future breeding	S3 or S4	7.6 or 11.9	Assume split by LFA status
m4	Sheep >1 for slaughter	S2	0.7	
m9	Rams for service	S4	11.9	Assumed not S3
m13	Other female sheep >1	S2	0.7	
m14	Other male sheep >1	S2	0.7	
m17	Lambs under 1	S1	0.5	Need adjustment to avoid overlap with other S categories
P5	Goats – dairy breeding females	S5	15	
P6	Goats – other breeding females	S5	15	
P10	Farmed deer	S6 or S7	12 or 15.2	Use minimum or maximum
P1	Horses and ponies, occupiers	S8	21	
P2	Horses and ponies, others	S8	21	

Table A8: Matching between pig N coefficient categories (P1 to P11) and pig JAS categories (L1 to L14)

JAS code	JAS description	N coeff code	N coeff (g/khd)	Occupancy rate	Value to use	
l1	Breeding pigs - sows	P8 or P9	16 or 18	100%	16 or 18	Use min, max or average
l2	Breeding pigs -gilts	P7	11.1	80%	11.1	
l3	Breeding pigs -other	P7	11.1	80%	11.1	Assumed same occupancy as gilts
l4	Breeding pigs -boars	P10 or P11	12 or 17.5	100%	12 or 17.5	
l5	Breeding pigs -gilts>50kg	P7	11.1	80%	8.88	
l7	Barren sows for fattening	P5 or P6	10.6 or 10.6	86%	10.6	Assumed same occupancy as finishers
l10	Other pigs >110kg	P5 or P6	10.6 or 10.6	86%	10.6	
l11	Other pigs 80 to 110kg	P5 or P6	10.6 or 10.6	86%	10.6	
l12	Other pigs 50 to 80 kg	P5	10.6	88%	10.6	
l13	Other pigs 20 to 50 kg	P3 or P4	7.7 or 7.7	88%	7.7	
l14	Other pigs <20kg	P1 or P2	1 or 4.2	71% or 82%	0.71 or 3.444	Use min, max or average

7 ANNEX B - UNIT COMPLIANCE COSTS, MULTIPLIERS AND SLR COEFFICIENTS

112. Estimated compliance costs depend upon estimated excess N per farm plus the unit costs of different mitigation actions.

113. Additional land is assumed to be rented, using reported current average short-term rental prices of c.£231ha for hill or upland sites and c.£325 for lowland sites (see farm-rent-land-values-2009-10-to-2016-17.ods)(live.com) (see also SCSI Teagasc Agricultural Land Market Review and Outlook 2023 for helpful commentary). Dairy rental land is slightly more costly at c.£363/ha but since land for slurry disposal need not be suitable for dairying per se, the lower lowland value is used.

114. Income foregone is assumed to be equivalent to Gross Margins taken mainly from Wales-Farm-Income-Booklet-2022-2023.pdf (aber.ac.uk). Specifically, depending on LFA status: Ewe Gross Margin = £38/hd to £79/hd; Suckler cow Gross Margin = £436/hd to £478/hd; Dairy cow Gross Margin = £1802/hd to £2075/hd. Per place poultry and pig Gross Margins of £2.50 and £20 are taken from the 53rd edition of the John Nix Pocketbook for Farm Management. All Gross margins are indicative, but this is particularly true of pig and poultry given the variation in production systems and cycle lengths. Moreover, no account is taken of the impact of loss of throughput on enterprise viability and fixed cost burdens.

115. Export tankering costs are assumed to be £5/t per 10km. This is derived from RHA estimates of haulage costs and maximum permitted slurry tanker sizes in the UK. Moreover, the N content of slurry is assumed to be 2.5%, meaning that 1t N = 40t slurry (approximately four tanker loads).

116. Physically transporting slurry incurs a cost. Costs may also be incurred from spreading on the receiving land, but since these would have been incurred to approximately the same degree on the home farm anyway they do not count as additional. Strictly, this also applies to the time taken to load and unload a tanker since, again, this would be required for spreading on the home farm. Hence the relevant additional cost is limited to actual tanker haulage.[12]

117. Data on slurry tankering costs do not appear to have been gathered through any systematic surveys. Nonetheless, typical costs can be estimated from published industry standards. This does, however, require some further assumptions regarding typical haulage distances and, more importantly, time.

118. The IMP cite a haulage cost of £1.25/t for 10km. On rural roads, an average speed of 30km/hr implies a round-trip travel time of 40 minutes for 10km. Longer distances and/or slower speeds would extend this. It is also assumed that an importing farm pays nothing for the nutrient value of slurry.

[12] Fealy et al. 2012. Modelling the Gross Cost of Transporting Pig Slurry to Tillage Spread Lands in a Post Transition Arrangement within the Nitrates Directive.https://t-stor.teagasc.ie/bitstream/handle/11019/680/gross%20cost.pdf?sequence=1

119. The Road Haulage Association (RHA) suggests that running a 44t lorry costs c.£70/hr + £0.51/km.[13] This would have an effective load carrying capacity of c.30t. Hence, a 40-minute round trip would incur unit costs of c.£1.68/t. However, slurry tankers are generally smaller. In particular, legal tanker sizes are effectively limited to c.2500 gallons, or c.11t. Whilst running costs for these might be lower, the smaller tonnage denominator will outweigh any savings to raise the unit cost to c.£4.57/t.

120. Agricultural benchmark references suggest a similar order of magnitude of hourly costs. For example, Nix cites a contractor cost of £67/hr for tanker spreading (£60/hr by farmer) whilst ABC cite £55 to £75/hr.[14] Similarly, published contractor price lists suggest £75/hr.[15] These suggest lower-bound unit costs for 10km of c.£3.35/t to c.£4.57/t for an 11t tanker.

121. These estimates are broadly consistent with sewage sludge transportation costs of c.£1.80/t to c.£5.50/t for 10km reported by water companies.[16]

122. The actual distance and speed of tankering will vary across different farms, as will the distance required to haul slurry. Equally, individual farmers may be able to negotiate better contractor costs or deploy their own equipment more efficiently. Nevertheless, indicative average unit costs of £5/t based on the above estimates can be used to illustrate potential aggregate costs of widespread disposal of slurry disposal off-farm.

123. Multiplier coefficients are taken from Thomson et al. (2021), which disaggregates UK and all-agriculture value to Wales and specific enterprises. The values used are shown in Table A1 below. Income multipliers are taken as a proxy for GVA in this context. Backward (Leontief) and forward (Ghosh) multipliers are applied separately to estimated changes in farm output, but should not be summed since double counting may be incurred. Employment effects are calculated from estimated changes in Standard Labour Requirements (SLR)[17] at the farm-level based on the estimated changes in livestock headcounts. Whilst the latter are direct for destocking, for renting-in land they are indirect via displacement of previous activity which is unknown and therefore must be assumed. For illustrative purposes, it is assumed to be cattle and sheep grazing at an intensity of 1 GLU/ha. In-turn, this can be used to estimate changes to Gross Margin, output and labour usage following the same approach as for destocking. Multiplier effects cannot easily be calculated for exporting excess N.

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[13] RHA 2024 Cost tables 2024 https://www.rha.uk.net/Portals/0/Membership/Annual%20Cost%20and%20Pay%20Surveys/Cost%20Tables%202024.pdf?ver=2023-12-15-110223-900&timestamp=1702638149055

[14] John Nix Pocketbook 53rd Edition; Agricultural and Budgeting Cost Book 97th edition.

[15] NAAC. Contracting Prices Survey 2024. https://www.naac.co.uk/pricesguide/

[16] Anglian Water. 2019. Sludge transport adjustment claim. https://www.anglianwater.co.uk/siteassets/household/about-us/sludge-transport-cost-adjustment-claim.pdf

[17] https://www.ruralbusinessresearch.co.uk/wp-content/uploads/2023/05/Labour-Use-in-Agriculture.pdf and https://assets.publishing.service.gov.uk/media/641073c8e90e076cd09acda9/fbs-uk-farmclassification-2014-14mar23.pdf

Table A1: Multiplier coefficient values used

Category	Income	Employment	Output Backward	Output Forward
Cattle	1.29	1.21	1.7	1.88
Sheep	1.16	1.21	1.69	1.83
Pigs	7.54	1.17	1.05	1.83
Poultry	1.83	1.17	1.46	1.84
Dairy	1.35	1.22	1.71	2.19

Source: Thomson et al. (2021) Evaluating the significance of agri-supply chains in rural economies: Inter-industry dependency insights from disaggregating UK Input-Output tables. SRUC Report to DEFRA

124. Table A2 shows the SLR coefficients used, with a standard nominal working year of 1900 hours.

Table A2: SLR coefficient values (hrs/hd) used; 1900 hours for an indicative FTE

Category	Hours	Category	Hours	Category	Hours	Category	Hours
Dairy cows	42	Ewes & rams (nLFA)	5.2	Sows	28	Table fowl	0.09
Beef cows	26	Ewes & rams (LFA)	3.7	Other pigs	2.3	Laying hen	0.36
Other cattle	12	Other sheep (nLFA)	2.9	Piglets	0.2	Growing pullets	0.24
		Other sheep (LFA)	3.1			Other poultry	0.10

Source: https://assets.publishing.service.gov.uk/media/641073c8e90e076cd09acda9/fbs-uk-farmclassification-2014-14mar23.pdf

125. The key for downstream elements of the supply chain shows a number of different dairy processing categories. These are:

* Key dairy processing plant - likely to be buying directly from the Welsh milk field
¥ Artisan cheese and yoghurt makers - likely to be supplied from local Welsh milk field
¤ Dairy vending machines and producer retailers – likely to be supplied from local Welsh milk field
§ Large food companies – using milk byproducts from manufacturing, likely to be sourced from multiple locations
∞ Other dairy processing units - milk likely to be sourced from multiple locations