Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Report-26: ‘Quick Start’ Agricultural Small Sectors Modelling

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Approved by Ken Stebbings
James Skates

Abbreviations Used in this Report

AHDB	Agriculture and Horticulture Development Board
DA	Disadvantaged Areas
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
FBS	Farm Business Survey
FTE	Full-Time Equivalent [worker]
GHG	Greenhouse Gas
GMEP	Glastir Monitoring & Evaluation Programme
IMP	Integrated Modelling Platform
JAS	June Agricultural Survey
LFA	Less Favourable Area
LPIS	Land Parcel Information System
LU	Livestock Units
MFT	Main Farm Type
MFTA	Multilateral Free Trade Agreement
NRW	Natural Resources Wales
QS	[ERAMMP] Quick Start
RFT	Robust Farm Type
SDA	Severely Disadvantaged Areas
SLR	Standard Labour Requirements
SO	Standard Output
SWG	The Sub-Working Group
UKCEH	UK Centre for Ecology & Hydrology
WTO	World Trade Organisation

Contents

Abbreviations and some of the technical terms used in this report are expanded in the project glossary: https://erammp.wales/en/glossary (English) and https://erammp.cymru/geirfa (Welsh)

1 Summary

The potential impact of Brexit on the farming sector and wider environment is just one of the many challenges facing the Welsh Government. There are a range of decision and modelling tools which can be used to explore potential outcomes and the areas at risk where the environmental regulatory floor needs to be enhanced or social transition programmes put in place.

To meet this challenge in Wales, a partnership between the Welsh Government, their stakeholders and a consortium of research organisations led by the UK Centre for Ecology and Hydrology (UKCEH) was formed. This partnership, called ERAMMP, (https://erammp.wales/en) combined expert knowledge and a range of decision and modelling tools to examine potential changes in agricultural land use that might result from Brexit, and to explore potential benefits of new land management options.

Brexit Trade Scenarios

Three Brexit trade scenarios were developed in Welsh Government by the Brexit Roundtable[1] convened by the Minister for Energy, Environment and Rural Affairs:

- EU Deal (EU based free trade agreement)
- No Deal (WTO rules apply)
- Multilateral Free Trade Agreements (MFTA)

The Evidence and Scenarios Roundtable Sub-Working Group translated the trade scenarios into potential shifts within and between the principal 'Grazing Livestock' sectors in Wales (Dairy, Beef and Sheep) and the principal 'Small Sectors' livestock producers (commercial pork and poultry) in response to changing market demand for dairy and meat products. The ERAMMP 'Quick Start' programme undertaken by the research consortium then converted the potential livestock shifts into the potential changes in agricultural land use needed to manage and support the livestock shifts.

The agricultural land use changes were mapped across Wales at field and farm scale and combined with other national data sources to drive a series of agricultural pollutant, woodland and ecological models exploring a range of potential "knock-on" consequences for environmental issues including woodland creation, agricultural pollutants, greenhouse gas (GHG) emissions, water quality, air quality and bird biodiversity.

In Phase 1 of the Quick Start programme, potential changes in the Grazing Livestock sector in Wales were analysed (Cosby et al. 2019-a,b). In this report, the analyses were extended to include the Small Sectors livestock producers (commercial pork and poultry) in Wales. The poultry and pork sectors occupy a relatively small land area within Wales, but modelling possible impacts is important as these sectors offer an opportunity for the Grazing Livestock sector to diversify, thereby impacting on communities and local economies. For that reason the Small Sectors results were derived by superimposing potential changes in the commercial pork and poultry sectors on the potential Grazing Livestock sector changes already derived in Quick Start Phase 1. Understanding the potential changes in the Grazing Livestock sectors

[1] https://gov.wales/evidence-and-scenario-sub-group-roundtable-wales-and-brexit

is therefore necessary for context and for understanding the potential Small Sectors changes presented in this report. Potential Grazing Livestock changes are summarized briefly below before presenting the summary of potential Small Sectors changes.

Potential changes in the Grazing Livestock sectors (dairy, beef, sheep)

The area potentially affected by the response of Grazing Livestock sectors to the Brexit scenarios is highly variable depending on the trade scenario, the current distribution of farming sectors and the agricultural quality of the land (Figure 1.1).

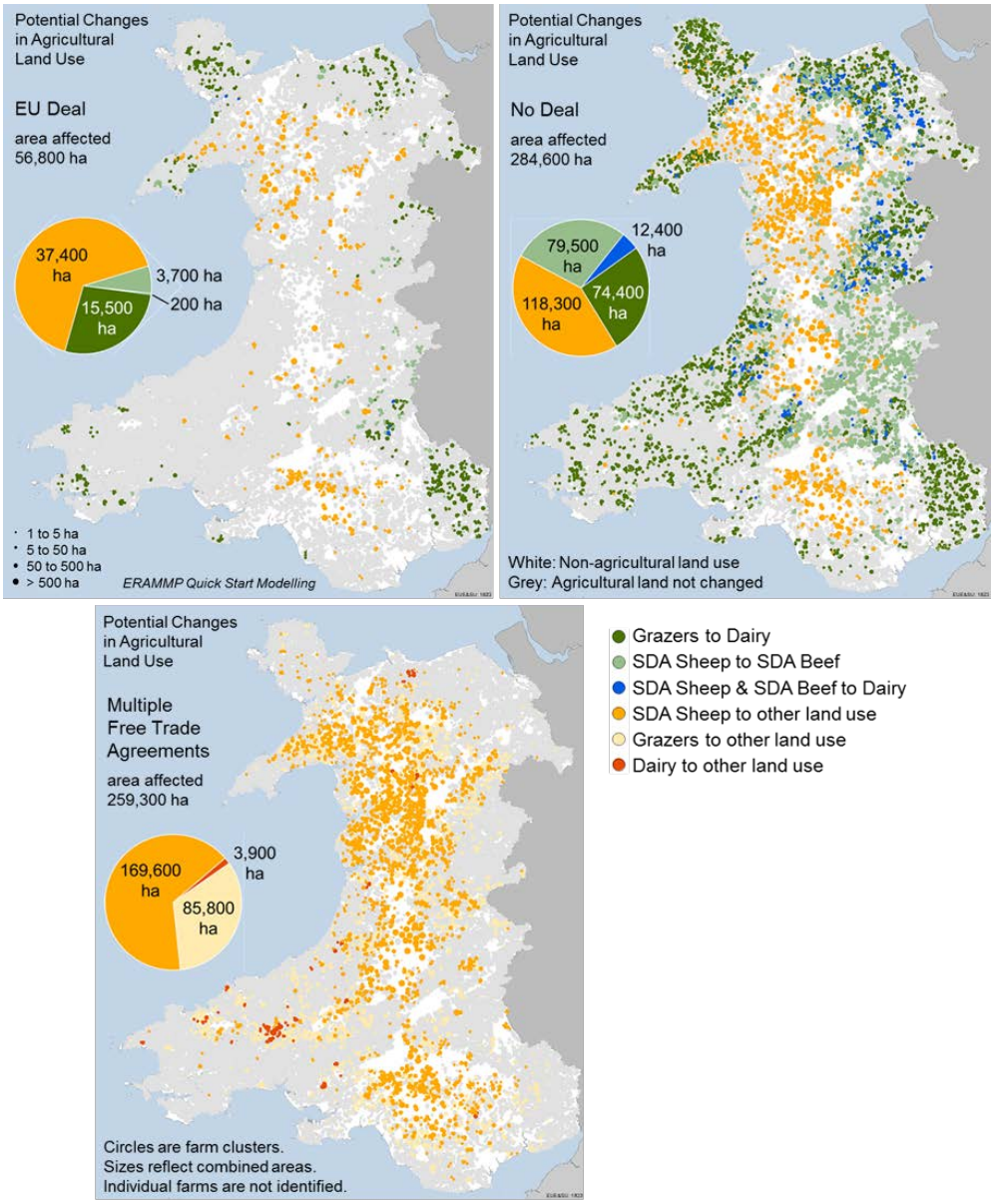


Figure 1.1. Potential Grazing Livestock sector land use change for the three Brexit trade scenarios. Circles are farm clusters. Individual farms cannot be identified.

Some key findings from the Phase 1 Grazing Livestock sector include:

- Potential change in animal numbers are between -36% (sheep sector; No Deal and MFTA) and +54% (Dairy; No Deal). The sheep sector is more negatively affected due to reliance on exports relative to the dairy and beef sectors.
- Total area potentially affected by the Brexit trade scenarios is 3 to 17% of current farmland depending on the scenario.
- Total area potentially changing to non-agricultural uses is 2 to 15% of current farmland depending on the trade scenario (with the sheep sector comprising 65 to 100% of this land). For the MFTA scenario, potential changes for all three livestock sectors is to non-agricultural use.

Potential changes in the commercial pork sector

Commercial pork units are defined as having 40 or more pigs (both finishing and breeding). Potential changes in the commercial pork sector in response to potential changes in market demand for pork products are: 8 new units in the EU scenario; 28 new units in the No Deal scenario; no new units in the MFTA scenario (Figure 1.2)

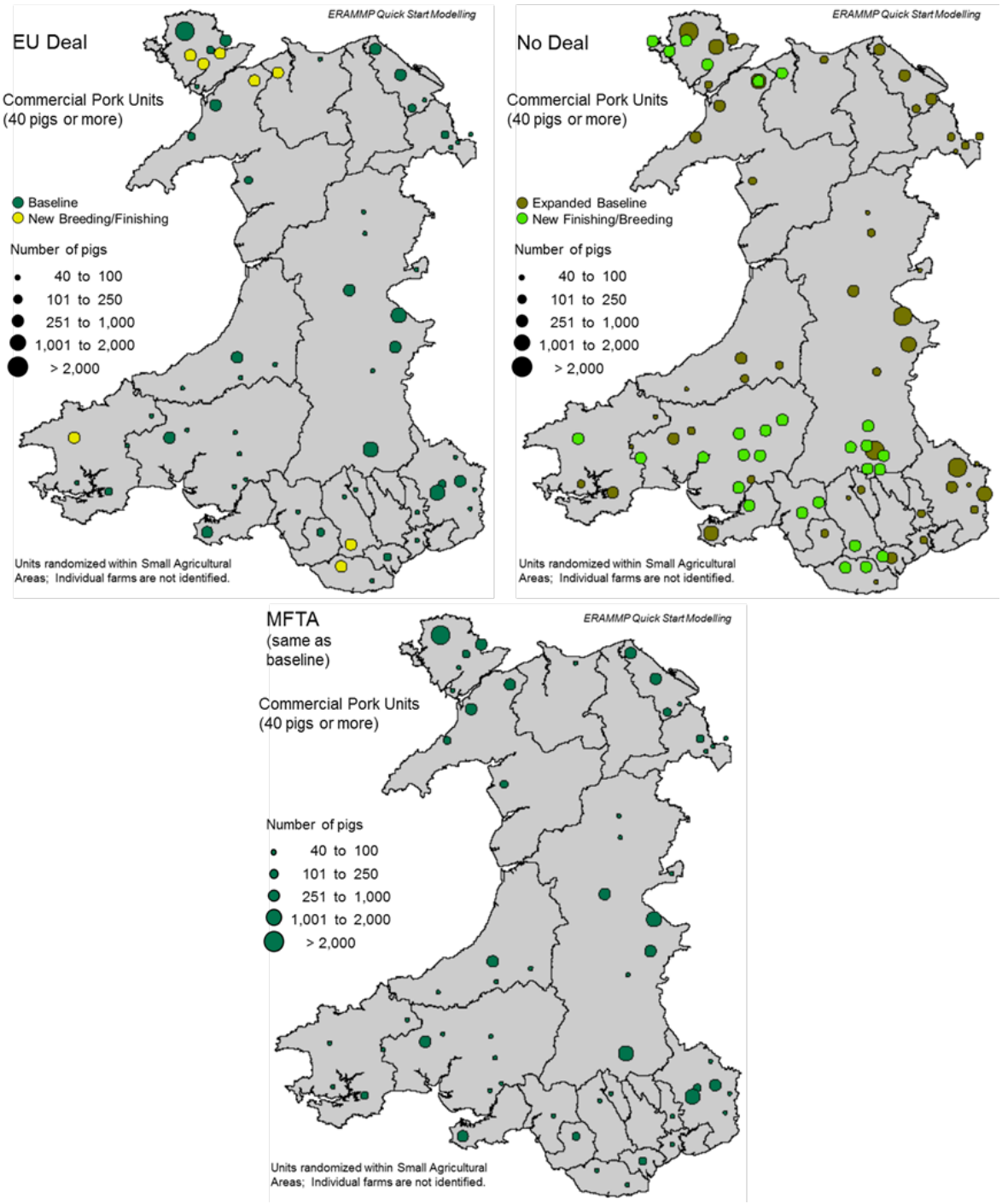


Figure 1.2. Potential changes in commercial pork units for the three Brexit trade scenarios. Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Potential changes in the commercial poultry sector

Commercial poultry units are defined as having 1,000 or more birds. Potential changes in the commercial poultry sector in response to potential changes in market

demand for poultry products are: 5 new broiler units and 26 new laying/breeding units in the EU scenario; 8 new broiler units and 42 new laying/breeding units in the No Deal scenario; and the removal of one broiler unit in the MFTA scenario (Figure 1.3).

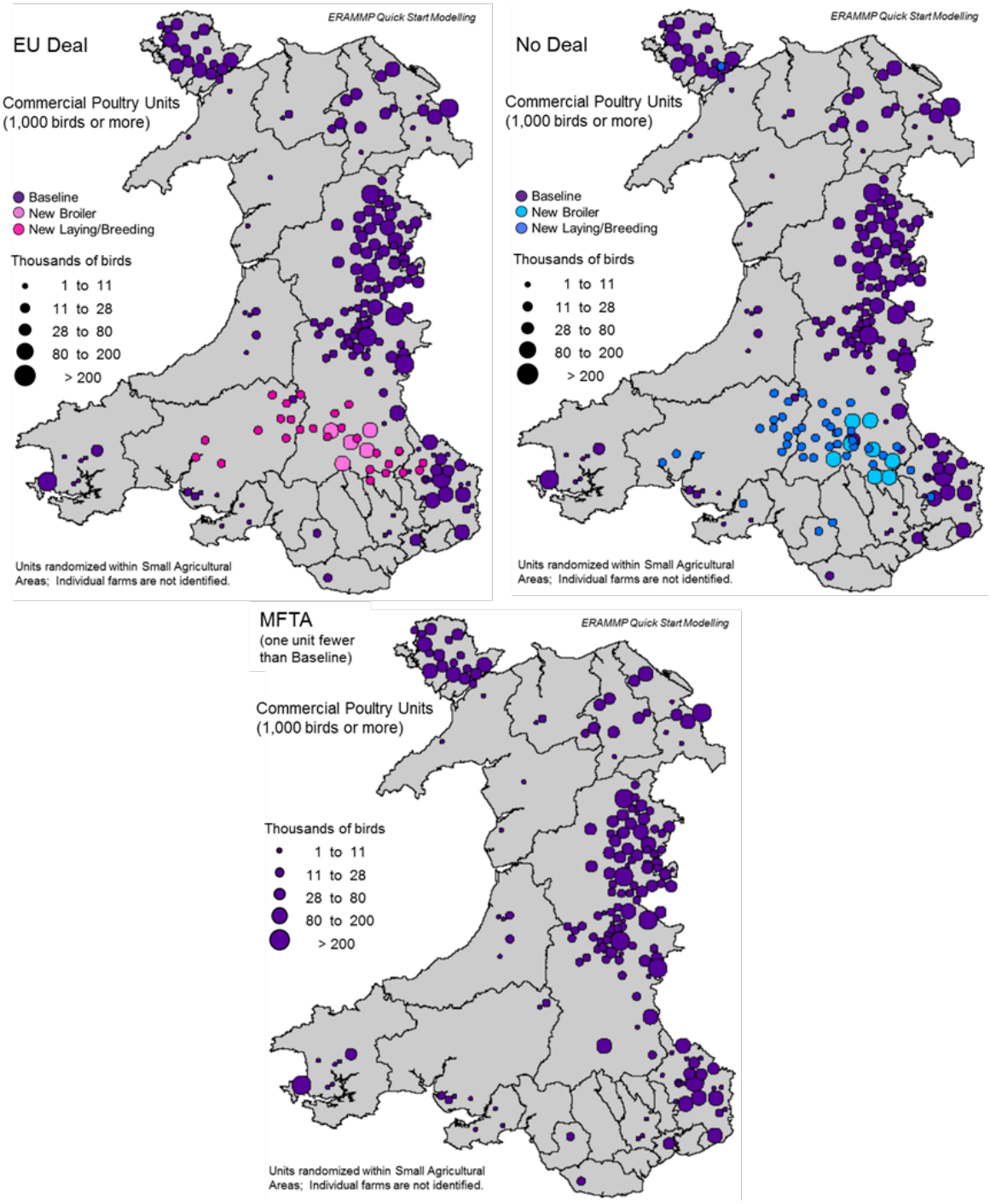


Figure 1.3. Potential changes in commercial poultry units for the three Brexit trade scenarios. Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Potential environmental impacts

Environmental effects resulting from Small Sectors responses to the Brexit trade scenarios have been explored in terms of magnitude and spatial distribution across

Wales for a number of environmental issues. These include issues of particular concern with respect to expansion of commercial pork and poultry units: climate mitigation (potential changes in greenhouse gas (GHG) emissions); Air quality (potential changes in ammonia emissions); and water quality (potential changes in nitrogen, phosphorous and sediment loads to waterbodies).

The locations and potential magnitudes of these effects need to be considered in the context of potential changes simultaneously occurring because of the Grazing Livestock sector responses to the same Brexit scenarios (see Figure 1.4 for one example).

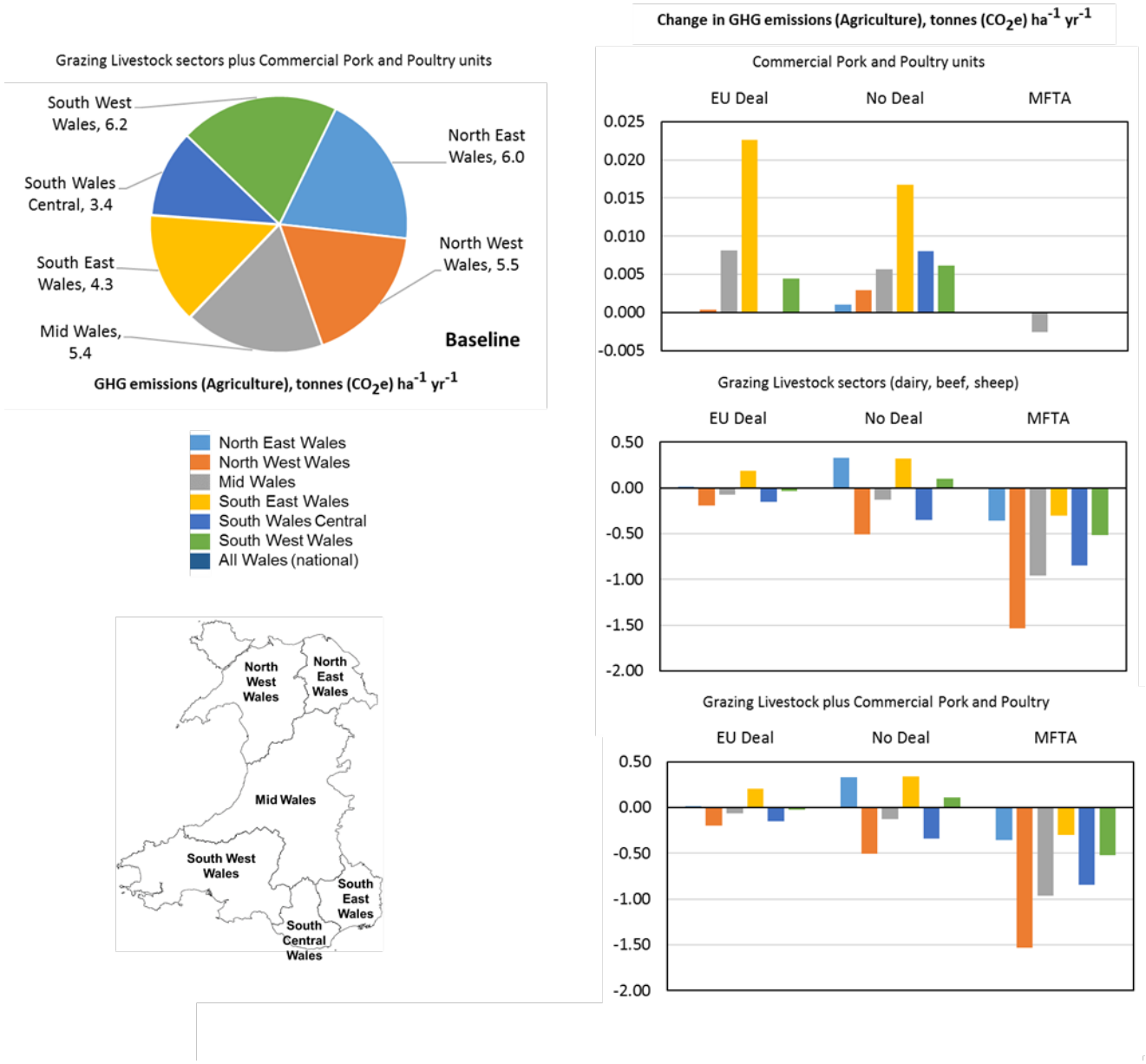


Figure 1.4. Baseline (pie chart) and potential changes in GHG emissions from agriculture in Wales for the three Brexit scenarios and 6 regions (bar charts). Potential change is shown for Commercial Pork and Poultry units (upper right; note different scale), the Grazing Livestock sectors (dairy, beef and sheep; middle right) and the combined sectors (lower right).

Key findings from the Small Sectors analyses include:

The potential installation of new commercial pork or poultry units on existing farms will result in increased GHG emissions and adverse effects on air and water quality.

In some cases, these effects will be additive with effects from potential changes in the Grazing Livestock sectors (e.g., expansion of Dairy). In other cases, the effects of potential Small Sectors changes will be in an opposite direction to those from the Grazing Livestock sector (e.g. Sheep sector taking land out of agriculture).

In either case, the relative magnitudes of potential changes from new commercial pork and poultry units must be considered relative to baseline (2017, pre-Brexit) conditions and relative to potential changes from the Grazing Livestock sectors (dairy, beef and sheep) for each of the three Brexit scenarios. Additionally, it is useful to examine these relative responses in a regional context because of the potential for adverse effects occurring at sub-national scales even if the average effects across all of Wales from new commercial pork and poultry units are small.

It should also be noted there will be important local (sub-regional scale) impacts as these pig and poultry units act as point sources of pollutants such as ammonia to adjacent designated sites and local water resources. National and regional data summaries do not adequately capture these impacts which can be most extreme when within 250m but also need to be considered within a 5km distance.

High level findings for each of the environmental issues associated with potential new commercial pork and poultry units in response to the Brexit scenario indicate:

- Climate mitigation - Expressed as a percentage of baseline GHG emissions, the potential Small Sectors increases are between 0% and 0.1% for all Wales depending on the scenario, with a maximum potential regional increase of more than 0.5% for the EU Deal in South East Wales.
- Air quality - Expressed as a percentage of baseline ammonia emissions, the potential Small Sectors increases are between 0% and 0.5% for all Wales depending on the scenario, with a maximum potential regional increase of 2% for the EU Deal in South East Wales.
- Water quality - Expressed as a percentage of baseline N load to waterbodies, the potential Small Sectors increases are between 0% and 0.3% for all Wales depending on the scenario, with maximum a potential regional increase of more than 1.1% for the EU Deal in South East Wales.
- Water quality - Expressed as a percentage of baseline P load to waterbodies, the potential Small Sectors increases are between 0% and 0.1% for all Wales depending on the scenario, with a maximum potential regional increase of more than 0.5% for the EU Deal in South East Wales.
- Water quality – Installation of a single average size commercial pork or poultry unit (the constraints of this analysis) are not expected to increase sediment runoff beyond that caused by existing farm activities.
- Potential agricultural labour requirements (as FTE) increase in the commercial pork sector between 13% and 139%, and increase in the commercial poultry sector between 19% and 32% (relative to baseline pork and poultry) for the EU Deal and No Deal scenarios, respectively.
- The potential increases in pork and poultry labour requirements, however, have to be considered in the context of large potential declines in labour requirements in the Grazing Livestock Sector (from -3% to -26% relative to the grazing livestock baseline depending on the scenario).

Issues to consider

Some specific issues which should be considered with respect to these Brexit trade scenario analyses include:

- Expert judgement and many assumptions have been taken in creating the Brexit trade scenarios and anticipated livestock sector responses. We are going into uncharted territory, expert knowledge will inevitably fall short, and unexpected and unpredictable outcomes may occur.
- The Small Sectors responses (commercial pork and poultry) have been added on top of the livestock grazing sector (sheep, beef and dairy) responses, but interactions between the two producer types have not been considered.
- Spatial patterns of the potential environmental impacts are highly variable largely because of the combined impact of the spatial distribution of environmental constraints (e.g. soil, climate) and their influence on current farming practices.

Finally it should be noted that, for transparency, effort has been made throughout this report to describe in detail the assumptions, limitations and uncertainties in the analyses. The language used throughout has been deliberately chosen to emphasise the highly speculative nature of the work. Predicting the behaviour and decision making of any sector has many pitfalls, especially when no comparable situation has been experienced before.

Recommendations from the Quick Start Project

1. WG should ensure the limitations and assumptions for the work are always included in any presentations and future uses of the work and data protection considered for all maps and results released.
2. WG should consult with the ERAMMP team on the best use of the Quick Start approach versus the Integrated Modelling Platform (IMP) for any future scenario work required.
3. WG should consult with the ERAMMP team as to additional environmental impacts and public goods which should be considered in any Quick Start work going forward.
4. WG should ensure future work takes into account displacement or leakage of environmental impacts within Wales, UK and globally to ensure compliance with the Well Being of Future Generations Goal of ‘A Globally Responsible Wales’.
5. WG should ensure biodiversity impacts at both local and national scale are given due consideration in future work.

2 Background and Approach

2.1 Potential Brexit effects on agriculture in Wales

This report provides a synthesis of rapid modelling work ("Quick Start") carried out by ERAMMP for the Welsh Government to provide early insight into the questions:

- What are the potential changes to the Welsh livestock sectors under three different Brexit trade scenarios?
- Where will these most likely occur across the landscape of Wales, and what agricultural land use changes will these entail?
- What will be the consequences for a range of environmental issues including agricultural pollutants, GHG emissions, water quality and air quality?

This report focuses on Small Sectors livestock (commercial pork and poultry) and follows on from the Quick Start Phase 1 analysis for the Grazing Livestock sectors (dairy, sheep and beef).

The Quick Start work has involved close partnership between the ERAMMP team and the Welsh Government Evidence and Scenarios Roundtable Sub-Working Group. The **Sub-Working Group** (SWG) is part of the Brexit Roundtable Group, a forum set up by the Welsh Government Cabinet Secretary for Energy, Planning and Rural Affairs of Welsh Government and stakeholders across the portfolio to support a collective approach to Brexit in Wales.

ERAMMP is a partnership of 20 organisations, funded by Welsh Government and the UK Centre for Ecology & Hydrology, designed to deliver a programme of monitoring and modelling which collects data across the Welsh landscape and links observed changes to their impacts on a wide range of benefits including their economic consequences. The programme undertakes modelling for the EU exit process and for the design and evaluation of programmes delivering to Natural Resources Policy.

2.1.1 'Quick Start' approach

The aim of this work was to combine expert knowledge with decision support and modelling tools to identify potential changes in Wales' Small Sectors livestock producers (commercial pork and poultry) in response to three Brexit trade scenarios. The agricultural land use changes needed to support the new Small Sectors livestock activities for each scenario could then be mapped at field and farm scale across Wales and combined with other national data sources to drive agricultural and ecological models to provide estimates of impacts on a range of environmental goods and services (e.g. GHG emissions, air quality and diffuse pollution).

This Small Sectors analysis follows and builds on the recently completed ERAMMP Quick Start (QS) Phase 1 analysis of potential changes in Wales' Grazing Livestock sectors in response to the three Brexit scenarios (Cosby et al. 2019-a,b).

The Quick Start Small Sectors modelling approach consisted of three stages:

1. Develop scenarios of potential responses of Small Sectors commercial pork and poultry producers in Wales to different Brexit trade agreements, using market driven changes in demand pork and poultry products (informing the

potential Small Sectors responses with the results of the QS Phase 1 analyses of potential responses of the Grazing Livestock sectors)

2. Convert the potential Small Sectors commercial responses (pork and poultry) to spatially explicit national maps of potential agricultural land use changes, adding the potential Small Sectors land use changes to the potential land use changes derived for the Grazing Livestock sectors in QS Phase-1.
3. Estimate the potential environmental impacts on climate mitigation, air quality and water quality resulting from Small Sectors pork and poultry changes.

Key features of the Quick Start approach are:

- interactivity (input from Welsh Government at policy relevant stages)
- transparency (access to intermediate modelling results)
- adaptability (ability to add or modify assumptions and rule-based decisions)
- modularity (facility to add or modify environmental impact models)

Central to implementation was the UKCEH Land Use Change Toolbox (Appendix 3, Cosby et al. 2019-b), a GIS-based modelling and analysis package which integrated:

1. Anticipated changes in animal numbers in the Welsh livestock sectors in response to Brexit trade scenarios (provided by the Welsh Government Brexit Roundtable Sub-Working Group);
2. Field-scale national maps of current farm types in Wales (based on the Land Parcel Information System, LPIS);
3. Statistics describing current livestock farm characteristics and practices in Wales (from the 2017 June Agricultural Survey, JAS)
4. Rule-based decision trees specifying the type, likelihood and location of livestock farm changes that potentially could occur in response to Brexit trade scenarios (based on criteria developed and agreed with Welsh Government).

The outputs of the Toolbox were spatially explicit maps (and national/regional summaries) of potential livestock and agricultural land use changes across Wales in response to the Brexit scenarios. The land use change maps were provided to a suite of environmental impact models to examine the environmental consequences of the potential agricultural land use change. The land use change maps were also used by Welsh Government to compare with other spatially explicit datasets of interest (e.g., socioeconomic, employment, etc.).

2.1.2 Baseline agricultural sectors

The data from the 2017 June Agricultural Survey in Wales defined the baseline for Quick Start and were used to provide a comprehensive picture of current farm practice in Wales. Using the known characteristics of current farm types in Wales, rule-based decision-trees can be developed for specifying the land area requirements and farm properties needed to re-allocate livestock numbers in response to each Brexit trade scenario.

On the advice of the SWG, ‘Part Time Farms’ using less than 1 full-time equivalent worker (FTE) were not included in the Quick Start analyses. Even though Part Time Farms account for 37% of agricultural land in Wales, they manage only 10% of livestock LU’s, and contribute only 13% of economic value (as SO). The SWG did not

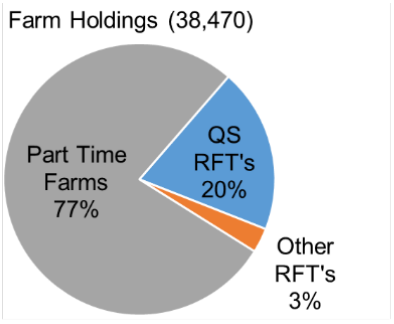
consider that Part Time Farms would be influenced in a predictable manner (if at all) by the Brexit trade scenarios.

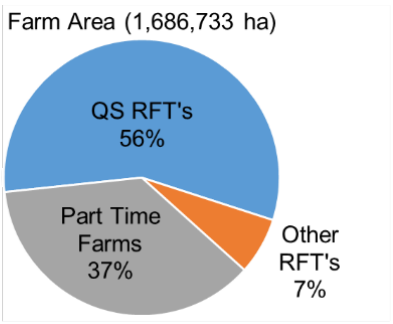
Robust Farm Type (RFT) categories were used to characterize the different agricultural sectors in Wales (Table 2.1.2.1). For each RFT category, summary statistics were derived describing land use practices, livestock distributions, stocking rates, supporting land use areas and livestock cohorts, and sizes of labour and capital requirements.

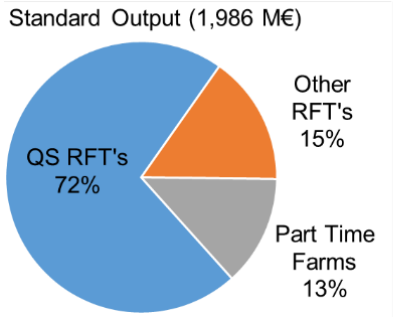
Table 2.1.2.1. Robust Farm Type (RFT) categories in Wales.

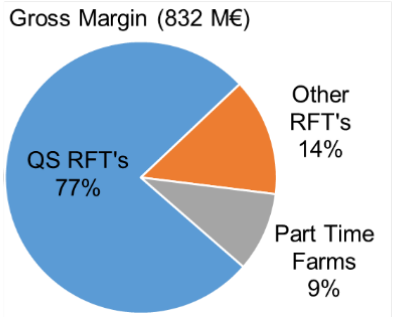
RFT	Category	Deriving 2/3 of Standard Output (SO) from:
1	Cereals	Cereals, combinable crops and set-aside
2	General cropping	Arable crops including field scale vegetables
3	Horticulture	Fruit, nursery stock, glasshouse, market garden vegetables
4	Specialist pigs	Pigs
5	Specialist poultry	Poultry
6	Dairy	Dairy cows
7	LFA grazing	Cattle, sheep & other grazing livestock (> 50% of area in LFA)
8	Lowland grazing	Cattle, sheep & other grazing livestock (< 50% of area in LFA)
9	Mixed	Mixed crop-livestock farms, mixed pig-poultry farms
10	Non classifiable	None of the above (e.g., fallow or buildings and other areas)

In Quick Start Phase 1, the focus was on Livestock Grazers (RFT's 6, 7 and 8; called the QS RFT's). The QS RFT's comprise 20% of farm holdings in Wales, control 56% of agricultural land, manage 87% of livestock (as LU's), contribute 72% of economic value (as SO), and account for 76% of labour FTE's (Figures 2.1.2.1 and 2.1.2.2). Commercial pork and poultry units are included in "Other RFT's".









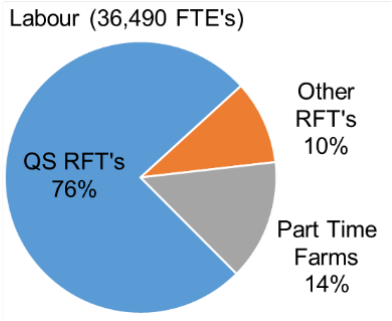


Figure 2.1.2.1. Distribution of baseline (2017) farm enterprise measures in Wales comparing Part Time Farms (< 1 FTE), Quick Start (QS) Livestock RFT's (6,7,8; Part Time Farms excluded) and all Other RFT's (1,2,3,4,5,9,10; Part Time Farms excluded). Data from 2017 June Agricultural Survey for Wales.

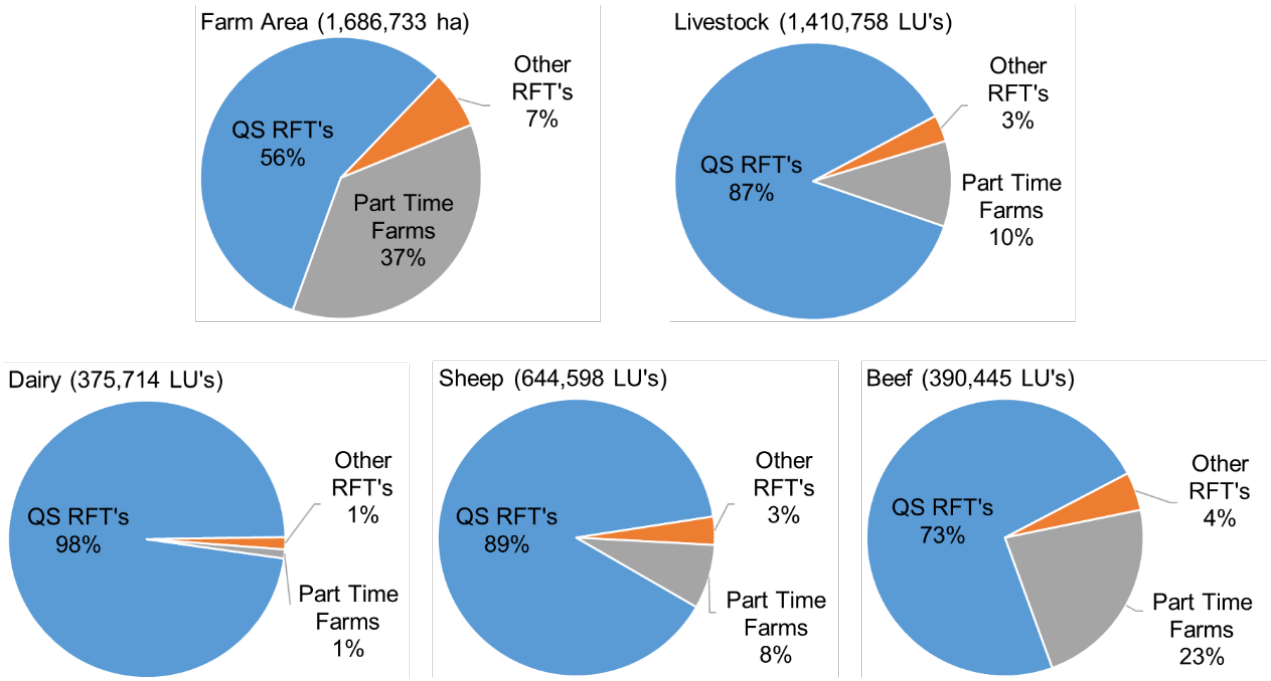


Figure 2.1.2.2. Distribution of baseline (2017) farmland and livestock in Wales comparing Part Time Farms (< 1 FTE), Quick Start (QS) Livestock RFT's (6,7,8; Part Time Farms excluded) and all Other RFT's (1,2,3,4,5,9,10; Part Time Farms excluded). Data from 2017 June Agricultural Survey for Wales.

2.1.3 Brexit trade scenarios

The Brexit trade scenario work here is based on "Summary of the EU Exit Scenario Planning Workshop" published in 2018 by the Evidence and Scenarios Roundtable Sub-Working Group (https://gweddill.gov.wales/docs/drah/publications/180219-summary-of-eu-exit-scenario-planning-workshops-en.pdf). The purpose of the Sub-Working Group (SWG) report was to "draw together evidence and expert opinion around five possible scenarios for the UK leaving the EU. The report uses scenario planning as a tool to analyse the potential impacts on the agricultural, fishing, forestry and environment sectors, it explores some of the interdependencies to understand some of the complex changes that may be ahead".

Three basic trade scenarios were identified by the SWG, with additional variables of public funding and workforce constraints (therefore five scenarios in total), to help draw out the Welsh implications of EU Exit. The work was designed to test particular trade and market vulnerabilities in key sectors including fisheries, farming and timber while drawing out interdependencies across sectors and the wider impacts on the environment and communities.

For the purpose of their report, the SWG simplified the analysis on each sector to reflect three possible trading scenarios (which were analysed in this project):

- **EU Deal:** EU-UK FTA trading environment. Trade with the EU-27, non-tariff barriers are in place increasing transaction costs. This scenario is closest to business as usual. The EU will still want to access some UK goods, services and markets.
- **No Deal:** Trade under World Trade Organisation (WTO) rules. The UK-EU trade relationship is the same as with rest of the world. This scenario would be a major change for existing business models, causing economic disruption.
- **Multilateral Free Trade Agreements (MFTA):** UK Government aspiration: FTAs with the EU-27 (and other nations also having FTAs with the EU-27), and new FTAs with countries not previously traded with. This scenario assumes a broadly similar EU trade relationship as currently in place, enabling potential impacts of greater world market exposure to be examined.

The SWG report summarised the pressures and directions of change (expansion or contraction of markets) anticipated for each agricultural sector for each Brexit scenario. However, the SWG report did not speculate on the possible scales of the changes to the farming sectors or the magnitude of the interactions between the sectors. The SWG general consensus was that impacts from the three Brexit scenarios would be different for each sector and that this would be reflected in geographical differences across Wales, but the pattern and extent of impacts was unknown.

2.2 Potential Livestock sector responses

Stage 1. Develop scenarios of potential responses of Small Sectors commercial pork and poultry producers in Wales to different Brexit trade agreements, using market driven changes in demand pork and poultry products (informing the potential Small Sectors responses with the results of the QS Phase 1 analyses of potential responses of the Grazing Livestock sectors)

2.2.1 Grazing Livestock sectors (dairy, beef and sheep)

Among the Key Findings of the SWG report are the following related to the Grazing Livestock sectors (from the Phase 1 Quick Start Report; Cosby et al., 2019-a,b):

- "The ***sheep*** sector faces severe challenges as it relies on export to balance seasonal production and to achieve carcass balance. The pressures from geographical constraints and workforce availability in abattoirs and processing mean lamb markets are likely to struggle in all scenarios."
- "The ***dairy*** and poultry sectors are most robust because of their focus on UK internal markets and lower reliance on export."
- "***Beef*** remains viable with a buoyant dairy industry to supply calves, with a better carcass balance and a lower dependency on export."

To examine the potential geographic extent and pattern of sheep, dairy and beef sector responses to the Brexit scenarios, the qualitative directions of change indicated in the SWG report were converted into estimates of changes in the numbers of animals needed on Welsh farms under each Brexit scenario to meet the new market demands. Using expert judgement and cross-checking with stakeholder groups, the SWG developed projections of market demand for meat and dairy

products for each Brexit scenario and extrapolated these to estimated changes in animal numbers in the Sheep, Dairy and Beef sectors in Wales (Stebbings, 2018).

The SWG livestock sector analysis drew on the FAPRI-UK modelling work published (https://www.afbini.gov.uk/publications/afbi-report-post-brexit-trade-agreements-uk-agriculture) by the Agri-Food and Biosciences Institute (AFBI) and the analysis of changes to farm business income post-Brexit modelled in Agriculture and Horticulture Development Board (AHDB) reports (https://ahdb.org.uk/brexit).

The estimated changes in animal numbers for each Brexit trade scenario can be compared to baseline animal numbers in 2017 as a measure of the potential impacts of Brexit scenario Wales' grazing livestock sectors (Table 2.2.1.1).

Table 2.2.1.1 Changes in grazing livestock in Wales (relative to 2017) anticipated for the Sheep, Dairy and Beef sectors in response to the three Brexit trade scenarios.

Brexit Roundtable SWG	EU Deal	No Deal	MFTA
Grazing Livestock Sectors, Change in Numbers			
Dairy Herd	42,749	238,402	-13,774
Beef Herd	-1,658	23,164	-130,723
Sheep Flock	-301,124	-3,011,242	-3,011,242
Grazing Livestock Sectors, % Change in Numbers			
Dairy Herd	9.5	53	-3.1
Beef Herd	-0.2	3.4	-19
Sheep Flock	-3.0	-30	-30

2.2.2 Small Sectors (commercial pork and poultry)

This report expands the Phase-1 Quick Start analyses to examine the potential geographic extent and pattern of commercial pork and poultry sector responses to the Brexit scenarios. Using expert judgement and cross-checking with stakeholder groups, the SWG developed projections of market demand for pork and poultry products for each Brexit scenario and extrapolated these to estimated changes in animal numbers in the small livestock sectors in Wales (Stebbings, 2019).

Key Findings of the SWG report related to the Small Sectors livestock producers include:

- Poultry production, both meat and eggs, can be expanded rapidly with the short life cycles of the birds, but both systems require substantial capital investment for sheds and tight margins may be a barrier to expansion.
- Wales has 3.6% of UK broiler chickens, there could be an expansion with increasing Welsh/UK self-sufficiency and if the demand for poultry meat continues to increase. Poultry meat consumption trend over the last 10 years has been an increase of 2% per annum.

- Wales has 5.3% of UK egg laying chickens, the number has been stable for the last few years but consumer demand is continuing to increase with a push towards free range production. Egg consumption per capita has increased over the last 10 years from 166 to 196 eggs/head, 1.8% per annum.
- There will be an opportunity to increase the pork sector within Wales under all trading scenarios.
- Pig farming in Wales has some disadvantages, such as distance from arable feed crops, distance from consumer and soil/climatic conditions which rule out low capital outdoor systems. However, there are opportunities to develop more mixed farm types in Wales, utilise human food waste streams and develop short food chains supplying Welsh pork to Welsh consumers.

The SWG Small Sectors analysis drew on the FAPRI-UK modelling work published (https://www.afbini.gov.uk/publications/afbi-report-post-brexit-trade-agreements-uk-agriculture) by the Agri-Food and Biosciences Institute (AFBI) and the analysis of changes to farm business income post-Brexit modelled in Agriculture and Horticulture Development Board (AHDB) reports (https://ahdb.org.uk/brexit).

The estimated changes in pork and poultry numbers for each Brexit trade scenario can be compared to baseline animal numbers in 2017 as a measure of the potential impacts of Brexit scenario Wales' Small Sectors livestock (Table 2.2.2.1).

Table 2.2.2.1. Changes in Small Sectors livestock in Wales (relative to 2017) anticipated for the commercial pork and poultry sectors in response to the three Brexit trade scenarios.

Brexit Roundtable SWG	**Potential Change in Animal Numbers**		
	EU Deal	**No Deal**	**MFTA**
Broiler Birds	+ 639,657	+ 1,039,443	- 99,946
Laying/Breeding/Other Birds	+ 599,056	+ 973,465	- 35,178
Breeding pigs	+ 352	+ 3,515	0
Finishing pigs	+ 2,100	+ 21,000	0
Brexit Roundtable SWG	**Potential % Change in Animal Numbers**		
	EU Deal	**No Deal**	**MFTA**
Broiler Birds	+ 16	+ 26	- 2.5
Laying/Breeding/Other Birds	+ 16	+ 26	- 0.9
Breeding pigs	+ 10	+ 100	0
Finishing pigs	+ 10	+ 100	0

Note that there are no changes in pig numbers projected by SWG for the MFTA scenario. Also, the changes in poultry numbers projected for MFTA are a small percentage of baseline numbers (-2%). Small Sectors results will still be presented in this report for the MFTA scenario, but they will be driven primarily by the effects of Grazing Livestock land use changes (presented in Quick Start Phase 1 report).

2.3 Assigning agricultural land use changes

Stage 2. Convert the potential Small Sectors commercial responses (pork and poultry) to spatially explicit national maps of potential agricultural land use changes, adding the potential Small Sectors land use changes to the potential land use changes derived for the Grazing Livestock sectors in QS Phase-1.

A simple approach for assigning and mapping potential agricultural land use change was required in Quick Start so that the outputs could be interpreted and easily communicated to ministers and policymakers. A conceptual approach and general rules using RFT's were developed in conjunction with the SWG to constrain and define the potential types of livestock sector changes that might occur in response to the Brexit scenarios. The assumptions and rules in this approach are easily stated and readily changed to examine alternate potential responses of livestock sectors.

2.3.1 Linking land use to livestock numbers

To convert anticipated changes in animal numbers required under each Brexit trade scenario into agricultural land use changes across Wales, we used Robust Farm Type (RFT) categories to characterize the different agricultural sectors in Wales (Table 2.3.1.1). Summary statistics can be derived for each RFT category describing land use practices, livestock distributions, stocking rates, supporting land use areas and livestock cohorts, and sizes of labour and capital requirements. This project used data from the 2017 June Agricultural Survey to define Welsh RFT's.

Using the known characteristics of current RFT's, a rule-base can be developed for specifying the land area requirements and farm properties needed to re-allocate livestock numbers in response to each Brexit trade scenario. For instance, to accommodate an increase in the Welsh poultry flock, the characteristics of existing commercial vs small-sale broiler and egg producers can be derived from statistics for existing poultry producers (RFT-5). These can be used to calculate the number of additional commercial poultry units needed to accommodate the additional birds required for a Brexit scenario. RFT-4 characteristics can similarly be used to calculate the requirements for additional commercial pork units for each scenario.

Table 2.3.1.1. Robust Farm Type (RFT) categories in Wales used to allocate agricultural land use changes in response to Brexit trade scenarios.

Robust Farm Types in Wales			
Category	**Description**	**Category**	**Description**
RFT-1	Cereals	RFT-6	Dairy
RFT-2	General Cropping	RFT-7	LFA Grazing Livestock
RFT-3	Horticulture	RFT-8	Lowland Grazing Livestock
RFT-4	Specialist Pigs	RFT-9	Mixed
RFT-5	Specialist Poultry	RFT-10	Non Classifiable

Due to the large area and number of farms included in the LFA grazing category (RFT-7), this category was sub-divided using Main Farm Type (MFT) categories

which differentiate the LFA (Less Favourable Area) into Disadvantaged Areas (DA) and Severely Disadvantaged Areas (SDA) and identify sheep specialists, beef specialists and mixed grazers in each area (Table 2.3.1.2). A similar mapping into Lowland, DA and SDA was done for dairy (RFT-6). This differentiation on the landscape of Wales provides finer spatial resolution for mapping potential agricultural land use change aligned to the livestock sectors.

Table 2.3.1.2. Baseline (2017) agricultural areas for the four livestock sectors (Dairy, Sheep, Beef and Grazers) modelled in Quick Start. The livestock sectors are based on Robust and Main Farm type classifications (RFT's 6, 7 and 8; LFA divided into SDA and DA by MFT; full time farms >1 FTE labour).Based on 2017 June Agricultural Survey data.

	MFT	RFT-6 Dairy (ha)	RFT-7 LFA Grazing (ha)	RFT-8 Lowland Grazing (ha)	Total Areas (ha)
Dairy					178,638
RFT 6A	SDA Dairy	25,896			
RFT 6B	DA Dairy	75,206			
RFT 6C	Lowland Dairy	77,536			
Sheep					437,236
RFT 7A	SDA Sheep		437,236		
Beef					21,259
RFT 7B	SDA Beef		21,259		
Grazers					318,229
RFT 7C	SDA Grazing		135,080		
RFT 7D	DA Grazing		117,635		
RFT 8	Lowland Grazing			65,514	
All QS Farms					955,363
Total		178,638	711,210	65,514	

To simplify presentation and align the outputs with the SWG focus on the four livestock sectors (dairy, sheep, beef and grazers), the three groups of dairy (Lowland, DA and SDA) were combined into a single category called "Dairy", and three groups of grazers (Lowland, DA and SDA) were combined into a single category called "Grazers". The agricultural areas associated with the final Quick Start RFT categories are summarized by the grey entries in Table 2.3.1.2.

The geographical locations of RFT's across Wales were derived from the Land Parcel Information System (LPIS). This spatially explicit field scale database was linked to the June Agricultural Survey (JAS) to identify the locations and areas of individual farms (holdings) and the current RFT category for each.

2.3.2 Land use by Small Sectors commercial units

Commercial pork and poultry units require very little land (compared to grazing livestock herds). In this Small Sectors analysis, an expansion of the poultry flock or

pig herd in a Brexit scenario is modelled by: 1) by adding additional commercial units to existing pork or poultry farms; and/or 2) adding commercial units to existing non-pork or non-poultry farms. In both cases the land required for the additional commercial units is assumed to be negligible and assumed not to displace any current agricultural activity on farms potentially installing a new commercial unit.

The effects of new or expanded commercial units will be manifest as additional environmental stressors added to the farm installing the new unit. In particular, ammonia and GHG emissions from the new commercial unit will be added to the whole farm emissions from existing activity (dependent on RFT). Animal manure from the new commercial units will be assumed to be added to the fields of the farm installing the unit, adding to diffuse pollution from existing agricultural activities for that RFT.

The procedure for identifying the new national distribution of Small Sectors commercial producers under a Brexit trade scenario is through a rule-driven iterative process of distributing commercial producer units amongst existing RFT's until the total animal numbers in the national poultry flock or pork herd reach the size required by market demand in the Brexit scenario under consideration.

2.4 Evaluating environmental impacts

Stage 3. Estimate the potential environmental impacts on climate mitigation, air quality and water quality resulting from Small Sectors pork and poultry changes.

2.4.1 Spatially explicit impact models

The spatial changes in agricultural land use from potential change in farm enterprise in response to a Brexit scenario were passed to the ERAMMP impacts modelling team for application in a series of environmental impact models. The impact models used were well-tested models which have previously been developed and applied at the national scale. In Phase 1 of Quick Start the following impact models were used:

- **Farmscoper** developed by ADAS for agricultural pollutants (greenhouse gas emissions, diffuse pollution to water bodies and air ammonia emissions).
- **Carbine** developed by FR for carbon sequestration in woodlands and greenhouse gas emissions from forest management.
- **ESC** developed by FR for woodland species selection and estimation of woodland recreation and ecosystem services
- Bird abundance and diversity developed by BTO.

In this Small Sectors analysis the only impact model required was Farmscoper, used to assess the effects of the changes in agricultural emissions and diffuse pollution from changing numbers of commercial pork or poultry units across Wales.

2.4.2 Farmscoper

Farmscoper (Farm Scale Optimisation of Pollutant Emission Reductions; Gooday et al., 2014) is a pollutant modelling framework that allows for the assessment of the impacts of multiple mitigation methods on multiple pollutants at both farm and catchment scale. Within this project, the following pollutants were considered: Nitrate, Phosphorus, Sediment, Ammonia, Nitrous Oxide, and Methane.

Farmscoper functions as a decision support tool that can be used to assess diffuse agricultural pollutant loads on a farm and quantify the impacts of farm mitigation methods on these pollutants. The farm systems within the tool can be customised to reflect management and environmental conditions representative of farming across England and Wales. The tool contains over 100 mitigation methods, including many of those in the latest Defra Mitigation Method User Guide.

Both the PSYCHIC (Davidson et al. 2008) and NEAPN (Lord & Anthony 2000) source models and Farmscoper itself have been used for policy appraisal in England and Wales, with Farmscoper recently used in the assessment of the Glastir scheme (Emmett et al., 2017). The database of export coefficients that drive Farmscoper was produced by applying these source models to every 1km2 in England and Wales, with the results summarised by 6 climate zones and 3 soil types. Note that Farmscoper predicts long term annual average pollutant loads based on 1971-2000 climate data.

With the exception of Specialist Pork and Specialist Poultry farms, the crop areas and livestock numbers for these farm systems were derived from the 2017 June Agricultural Survey data. For the Specialist Pork and Specialist Poultry farms, the area of the farm was irrelevant to how the outputs were used, so they were simply given sufficient land area to allow the manure generated by the livestock on the farm to be applied at a realistic rate (150 kg N ha-1). Crop specific fertiliser application rates were taken from the 2017 British Survey of Fertiliser Practice, using the rates for Great Britain disaggregated by farm type group. Where possible, other farm management data were based upon Welsh information (e.g. the Second Welsh Farm Practice survey undertaken as part of the Glastir Monitoring and Evaluation Project; Emmett et al., 2017), supplemented by data available for England and Wales.

2.5 Primary assumptions and uncertainties

Many unknowns and uncertainties surround the Brexit scenario questions resulting in a series of assumptions which had to be drawn for the work to proceed. These assumptions relate to the series of steps taken in creating the three Brexit trade scenarios, generating the anticipated responses of the livestock sectors in Wales, and translating the sector responses to spatially explicit agricultural land use change data which could be used to drive the Quick Start environmental impact models.

There were also issues involved in producing outputs which are accessible, informative and highlight important issues concerning interpretation of maps and units, while protecting personal privacy and respecting data protection agreements.

2.5.1 Brexit scenarios and livestock sector responses

Readers are referred to the SWG livestock sector reports (Stebbings, 2018, 2019) for a thorough discussion of assumptions and uncertainties inherent in the development of the three Brexit trade-scenarios and their effects on livestock sectors in Wales.

2.5.2 Assigning land use changes

Using average farm characteristics and practices

In Quick Start, the area of land required to convert between farm types in order to match anticipated changes in livestock numbers for a Brexit trade scenario was

calculated based on the average characteristics (e.g., land use patterns) and average practices (e.g., stocking densities) for each Robust Farm Type. While using averages is a straightforward method of deriving a first estimate of national capacity for agricultural change, it is useful to consider whether estimates based on averages are likely to be un-biased.

For instance, In the face of declining livestock numbers (in a given Brexit scenario) it may be the case that farms with stocking densities greater than average could adapt to the declining demand by reducing stocking numbers, while farms with stocking densities less than the average have less flexibility and would be more likely change to other (non-agricultural) land uses. If the threshold stocking density to remain in agriculture (not a characteristic that can be derived from available JAS data) is greater than the average for a farm type, there will be more farms likely to leave agriculture than to remain (fewer farms have stocking flexibility). As a result, estimates of agricultural area being changed to other (non-agricultural) uses based on average practices (as in this study) are likely to be underestimates.

Making land use change decisions

The rule-based decision trees for assigning agricultural land use changes were based on a limited set of assumptions concerning the current characteristics of Small Sectors farms in Wales (as outlined in section 2.1.2). The limitation was intentional in order to provide transparent and easily understandable criteria of agricultural land use change. As implemented, the livestock sector changes were determined based solely on the current agricultural capacities and practices of livestock farms in Wales (e.g. what are the current capabilities of livestock farms to respond to trade scenario pressures).

With agreement from Welsh Government, and in order to complete this initial rapid assessment of potential for change, two obvious and important factors potentially affecting changes in farm enterprises were not included in the Quick Start decision-tree analyses:

- Socioeconomic factors, which strongly affect likelihood of change, were not taken into account except for exclusion of Part Time Farms (<1 FTE) from the analyses (the implicit assumption being that Part Time Farms would be unlikely to respond other than randomly to socio-economic drivers, thus increasing the variability of potential response, but not affecting overall capacity for response);
- Human behavioural factors, which also strongly affect likelihood of change through farmer choice, were not taken into account (the implicit assumption being that famer choice will create random variation in the pattern of change but not affect overall capacity for response).

2.5.3 Evaluating environmental impacts

Farmscoper

For water borne pollutants, Farmscoper incorporates outputs from a suite of models including the phosphorus and sediment model PSYCHIC (Davison et al. 2008) and the nitrate model NEAPN (Lord & Anthony 2000). Modelled pollutant loads from these source models compare favourably with available water quality datasets such as those from the Harmonised Monitoring Scheme (Defra Project WQ0223; with

adjustments made to account for inputs from non-agricultural sectors such as sewage treatment works).

Gaseous emissions are derived from the methodologies used in the national inventories for ammonia (NARSES; Webb and Misselbrook, 2004) and nitrous oxide and methane (IPCC; Baggottt et al., 2006), except that indirect emissions of nitrous oxide are calculated from the modelled nitrate losses rather than using the inventory approach. With the exception of these indirect emissions, the gaseous emissions are not affected by the physical environment (i.e. climate and soil type).

3 Methods

3.1 Assigning potential Small Sectors changes

3.1.1 Geographical focus

In discussion with the SWG, the locations for placement of new commercial pork or poultry units was constrained to fall within transportation corridors lying 20 miles either side of the A55, A40 and M4 highways in Wales (Figure 3.1.1.1). The focus on transportation corridors was for supply of feed and access to existing specialist abattoirs and meat processing plants. Constraining new commercial units to the transportation corridor had the additional effect (desired by the SWG) of limiting the placement of new commercial units in central Wales. Powys and bordering English counties already have a high concentration of intensive poultry and pork units and are facing pressure to limit further expansion (Stebbings et al., 2019)

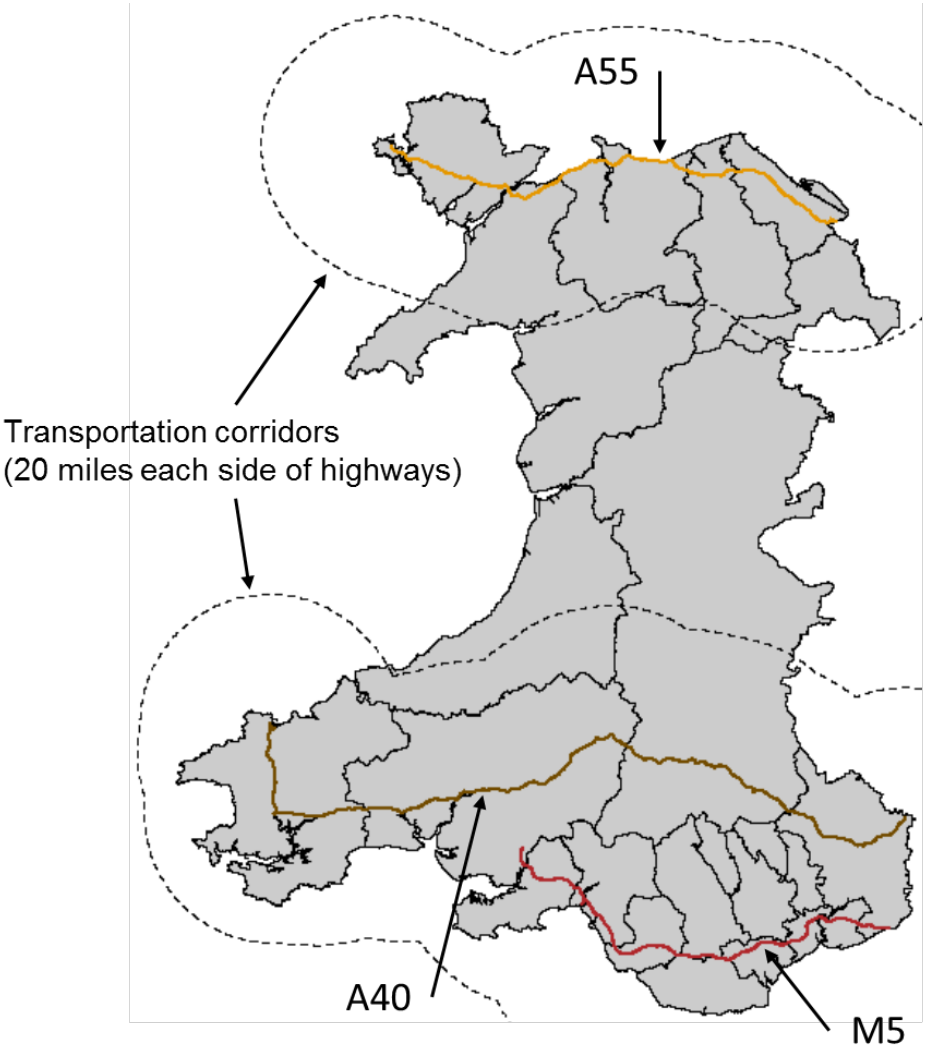


Figure 3.1.1.1. Candidate farms for new pork or poultry commercial units were selected from transportation corridors extending 20 miles from either side of the A55, A40 and M5 in Wales.

3.1.2 Commercial pork sector

"Wales is a very small producer of pig meat, supplying only 0.29% of total UK production…. As Wales is only about 5% self-sufficient in pig meat, there is an opportunity to exploit short food chains and offer quality niche products to Welsh consumers. Wales has some disadvantages: distance from pig abattoir/meat processing plants, higher delivery cost of pig feed and the Welsh climate with heavy soils rule out low capital outdoor pig systems…. There will be opportunities to increase pig meat production but Welsh farms may be slow to react….. "
(Stebbings, 2019)

The pork sector in Wales is small with 3,515 breeding pigs and 21,000 finishing (or fattening) pigs in the baseline year (Table 3.1.2.1). More than 70% of the pork herd is found in commercial pork units (defined as units with 40 or more pigs). Commercial units usually maintain a mix of finishing and breeding pigs. The baseline (2017) spatial distribution of the 57 commercial pork units in Wales reflects the dependence of the sector on transportation within Wales and the current close linkages to the meat sector across the border in England (Figure 3.1.2.1)

The three Brexit scenarios developed by the SWG provided potential responses in numbers of finishing and breeding pigs in commercial units for each scenario (Table 3.1.2.1; and see section 2.2.2). The SWG also specified the number of pigs per unit for each scenario, allowing the number of new commercial units needed in each scenario to be calculated. For the EU Deal and MFTA, baseline pigs per unit was used. For the No Deal scenario, pigs per unit was increased for both existing and new farms to allow expansion of existing capacity as well as expansion to new units.

Table 3.1.2.1. Characteristics of commercial pork units and non-commercial pork farms in Wales for the baseline year (June Agricultural Survey for Wales, 2017) and for potential responses to the three Brexit scenarios (based on SWG guidance). Numbers of commercial units and non-commercial farms are rounded up to integers.

Potential Commercial Pork Response to Brexit Scenarios	Baseline (2017)	EU Deal	No Deal	MFTA
All Pork in Wales				
Breeding pigs	3,515	3,866	7,030	3,515
Finishing pigs	21,000	23,097	42,004	21,000
Total Pork Herd	24,515	26,963	49,035	24,515
Commercial Pork Units (40 or more pigs)				
Number of units	57	65	85	57
number of pigs	17,569	20,017	42,089	17,569
Pigs per unit (average)	308	308	500	308
Non-commercial Pork Farms (fewer than 40 pigs)				
Number of farms	1,338	1,338	1,338	1,338
Number of pigs	6,946	6,946	6,946	6,946
Pigs per farm (average)	5	5	5	5

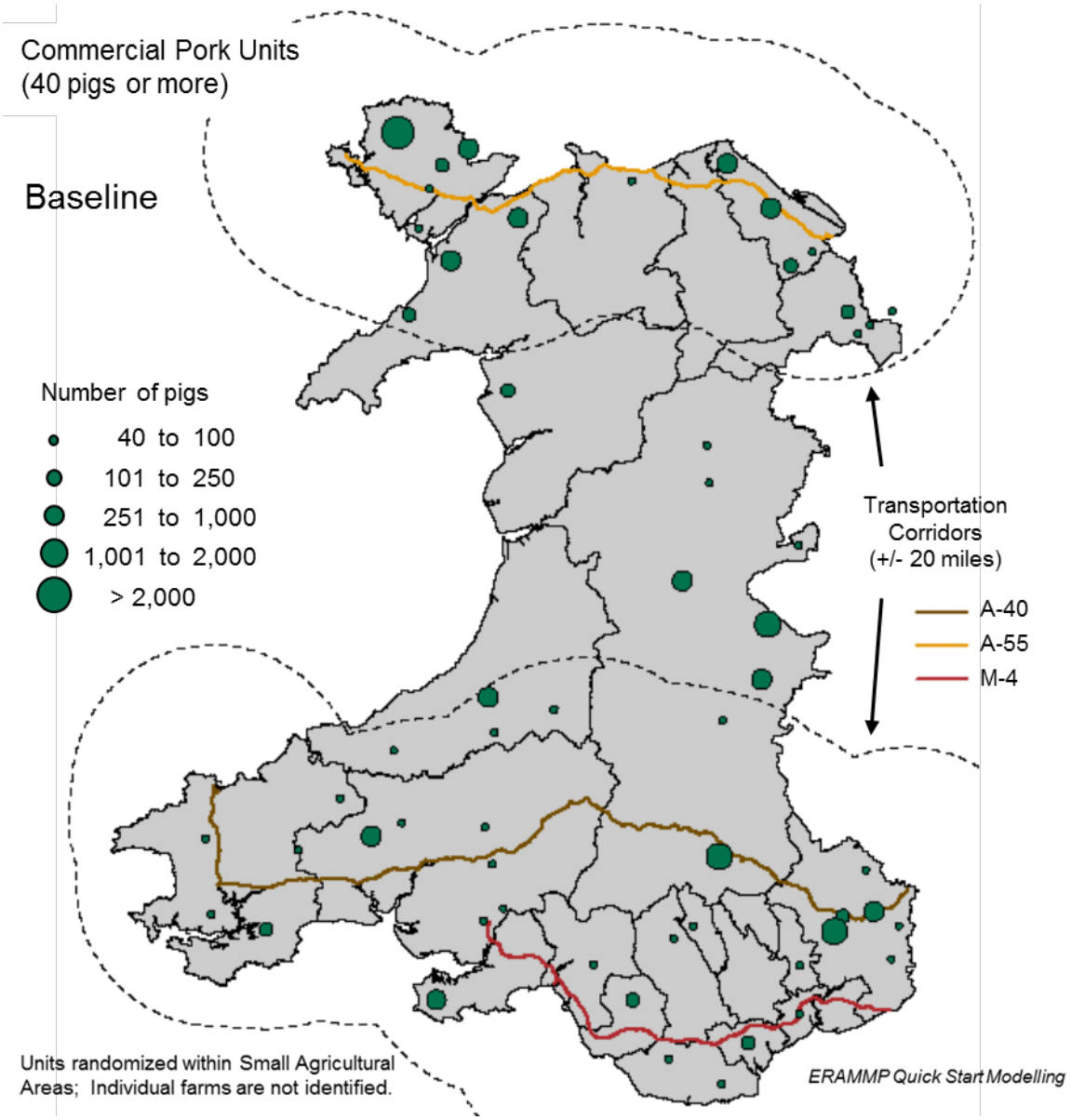


Figure 3.1.2.1. Baseline (2017) distribution of 57 commercial pork units in Wales (units with 40 or more pigs). Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Guidance for potential change

The following guidance for potential expansion of the Welsh commercial pork sector in the three Brexit scenarios were agreed in discussions with the SWG.

- All part time and spare time farms in Wales, defined as farms with < 1 FTE standard labour requirement were excluded from the analyses.
- Existing commercial pork units are defined as RFT-4 farms with 40 or more pigs in the June Agricultural Survey for Wales, 2017 (the baseline).

- The target for each scenario is to add commercial pork units to existing non-pork farms until the new total number of pigs in Wales for each scenario is reached.
- All new commercial pork units will use the average stocking density (308 pigs/unit) of existing commercial pork units in the June Agricultural Survey for Wales, 2017.
- For the EU and MFTA scenarios, existing commercial pork units remain in operation and their stocking densities (pigs/unit) remain at their individual baseline farm values.
- For the No Deal scenario, individual stocking density on each existing commercial pork unit will increase in the ratio 500/308, and all new commercial pork units will use a stocking density of 500 pigs/unit.
- Non-commercial pork farms (< 40 pigs) remain unchanged for all scenarios.
- Candidate farms for new commercial pork units will be drawn from a transportation corridor defined as the combined corridors extending 20 miles from either side of the A55, A40 and M5 in Wales (Figure 2.1.4.1).
- Candidate farms for new commercial pork units must also be within 20 km of an existing commercial pork unit.
- Candidate farms for new commercial pork units will be selected from existing SDA Beef specialists, SDA Sheep specialists, SDA mixed grazers and DA various grazers (all sub categories of RFT-7 LFA grazers).
- Farms already selected for change in Quick Start Phase 1 are excluded from selection as a candidate farm in this Small Sectors analysis.
- Candidate farms will be priority ranked using a combination of linear distances to the nearest road (A55, A40 or M5) and to the nearest commercial pork or poultry unit.
- Farms for addition of a commercial pork unit will be selected from the ranked list of candidate farms until the required new number of pigs for each scenario is reached.

3.1.3 Commercial poultry sector

"Poultry is geographically small but is economically large. It is made up of two distinct sectors; egg producers and meat producers……. There has been considerable Welsh investment in new poultry sheds for free range eggs and broiler production, primarily along the English border….. . The expansion of larger units in mid-Wales has occurred because there are good road links to the rest of the UK and growth has been encouraged due to limited opportunities for other types of farm diversification in an area dominated by beef and sheep farms…. Other features of the sector are that producers generally have aligned supply contracts with processors and retailers, margins per unit output are small but set up costs are high…. Poultry production, both meat and eggs, can be expanded rapidly with the short life cycles of the birds, but both systems require substantial capital investment for sheds and tight margins may be a barrier to expansion." (Stebbings, 2019).

Commercial poultry units are defined as units with 1,000 birds or more. Commercial poultry units in Wales specialise in either meat or egg production. Poultry breeding flocks (supporting the industry generally) are associated with the egg producing units. In this analysis, these two components of the commercial poultry industry are analysed separately: Broiler units and Laying/Breeding/Other units. There are 156 commercial Laying/Breeding/Other units and 29 commercial Broiler units in the baseline (2017) poultry sector in Wales (Table 3.1.3.1). The baseline spatial distribution of the 185 commercial poultry units of both types in Wales reflects the dependence of the poultry sector on transportation within Wales and the current close linkages to the poultry sector across the border in England (Figure 3.1.3.1).

The three Brexit scenarios developed by the SWG provided potential responses for the numbers of birds in commercial Broiler and Laying/Breeding/Other units for each scenario (Table 3.1.3.1; and see section 2.2.2). The numbers of birds per unit was assumed to remain constant at baseline values for the scenarios (no expansion of existing units), allowing the number of new commercial units of each type needed in each scenario to be calculated (Table 3.1.3.1).

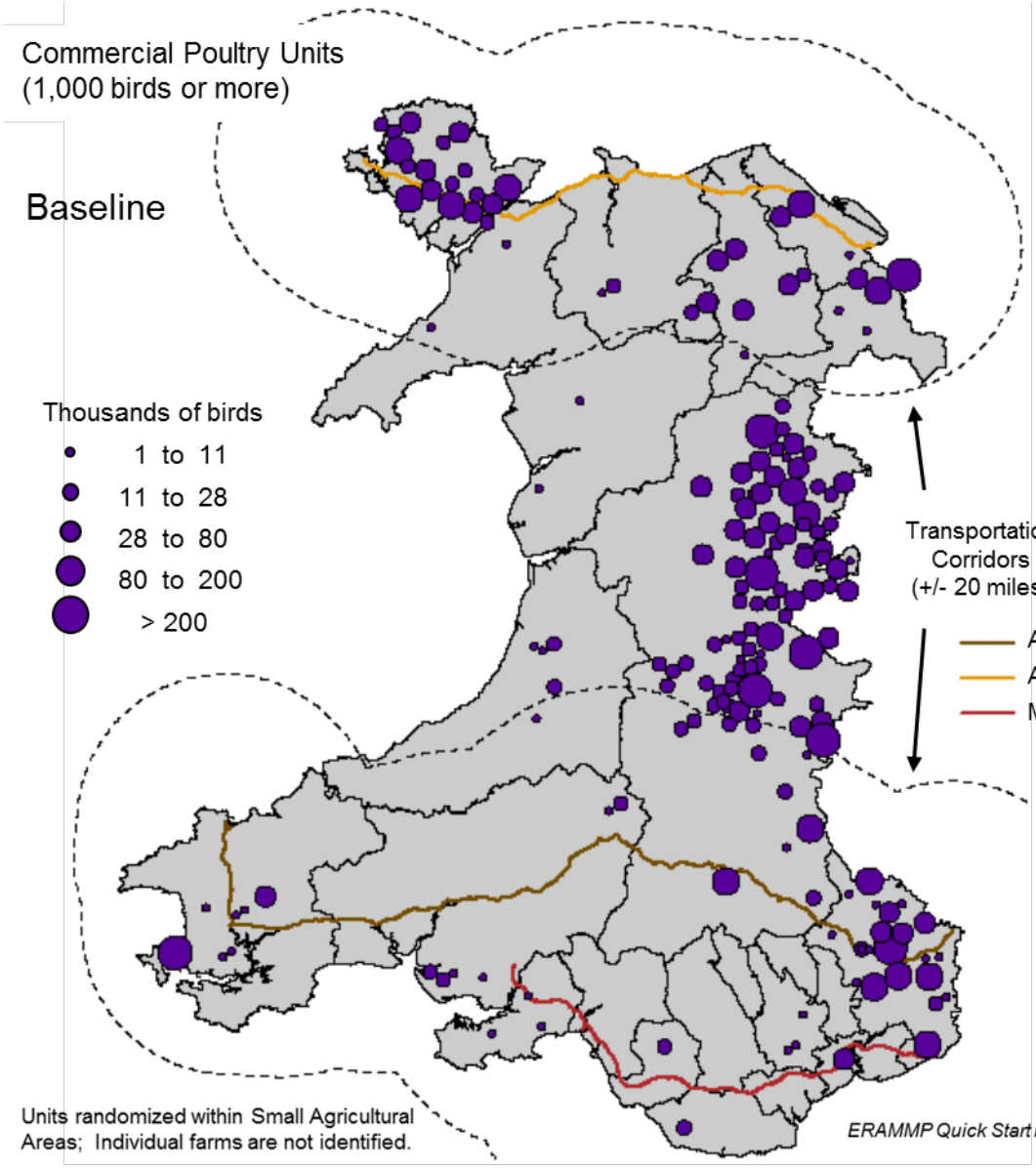


Figure 3.1.3.1. Baseline (2017) distribution of 185 commercial poultry units in Wales (units with 1,000 or more birds; Broiler & Laying/Breeding included). Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Table 3.1.3.1. Characteristics of commercial poultry units and non-commercial poultry farms in Wales for the baseline year (June Agricultural Survey for Wales, 2017) and for potential responses to the three Brexit scenarios (based on SWG guidance). Numbers of commercial units and non-commercial farms are rounded up to integers.

Potential Commercial Poultry Responses to Brexit Scenarios	Baseline (2017)	EU Deal	No Deal	MFTA
All Poultry in Wales				
Broiler birds	3,997,857	4,637,179	5,036,755	3,897,963
Laying / Breeding / Other birds	3,744,098	4,341,998	4,716,827	3,701,828
Total Poultry Flock	7,741,955	8,979,177	9,753,582	7,599,791
Commercial poultry units (1,000 or more birds)				
Broiler units	29	34	37	28
Number of birds	3,995,763	4,635,085	5,034,661	3,853,599
Birds per unit (average)	137,785	137,785	137,785	137,785
Commercial poultry units (1,000 or more birds)				
Laying / Breeding / Other units	156	182	198	156
Number of birds	3,629,238	4,227,138	4,601,967	3,586,968
Birds per unit (average)	23,264	23,264	23,264	23,264
Non-commercial poultry farms (fewer than 1,000 birds)				
Number of farms	5,959	5,959	5,959	5,959
Number of birds	116,954	116,954	116,954	116,954
Birds per farm (average)	20	20	20	20

Guidance for potential change

The following guidance for potential expansion of the Welsh commercial poultry sector in the three Brexit scenarios were agreed in discussions with the SWG.

- All part time and spare time farms, defined as farms with < 1 FTE standard labour requirement were excluded from the analyses.
- Existing commercial poultry units are defined as RFT-5 farms with 1,000 or more birds in the June Agricultural Survey for Wales, 2017 (the baseline).
- The target for each scenario is to add commercial poultry units to existing non-poultry farms until the new total number of birds in Wales for each scenario is reached.

- All new commercial poultry units will all use the average stocking density (137,785 broiler birds/unit; 23,264 laying birds/unit) of existing commercial poultry units in the June Agricultural Survey for Wales, 2017.
- For the EU Deal and No Deal scenarios, existing commercial poultry units remain in operation and their stocking densities (birds/unit) remain at their individual baseline farm values.
- For the MFTA scenario, Commercial units are closed to meet the reduction in poultry flock.
- Non-commercial poultry farms (< 1,000 birds) remain unchanged for all scenarios.
- Candidate farms for new commercial poultry units will be drawn from a transportation corridor defined as the combined corridors extending 20 miles from either side of the A55, A40 and M5 in Wales (Figure 2.1.4.1).
- Candidate farms for new commercial poultry units must also be within 20 km of an existing commercial poultry unit.
- Candidate farms for new commercial pork units will be selected from existing SDA Beef specialists, SDA Sheep specialists, SDA mixed grazers and DA various grazers (all sub categories of RFT-7 LFA grazers).
- Farms already selected for change in Quick Start Phase 1 are excluded from selection as a candidate farm in this Small Sectors analysis.
- Candidate farms will be priority ranked using a combination of linear distances to the nearest road (A55, A40 or M5) and to the nearest commercial pork or poultry unit.
- Farms for addition of a commercial poultry unit will be selected from the ranked list of candidate farms until the required new number of birds for each scenario is reached.

3.1.4 Rule-based decision tree

Once the relevant candidate farms have been identified and characterised, a rule-based decision tree can be developed to select farms with the potential to adopt commercial pork or poultry units. The decision tree is based on current (baseline) characteristics and farm practices of commercial pork and poultry farms. Future changes in assumptions concerning Small Sectors responses can easily be included in modified rule bases and the decision tree re-constructed and re-run.

The guidance provided by SWG was converted to a rule-based decision tree for selecting farms that potentially would adopt commercial pork or poultry units in response to the Brexit trade scenarios. All new commercial units placed on selected farms will use the average stocking densities of existing commercial pork or poultry units (same density for all new units).

The first steps in the decision process remove farm types that cannot accommodate commercial units (either because of physical restrictions or on the basis of guidance from SWG). This process produces a “Potential Farm Conversion List” resulting from application of the rules in the orange-green decision workflow in Figure 3.1.4.1.

Farms on the Potential Farm Conversion list are then ranked in priority order for adopting a commercial pork or poultry unit following the rules in the blue decision

workflow in Figure 3.1.4.1. Final selection of farms with potential for adoption of commercial units is from the priority ordered potential list using the rules in the red-yellow workflow in Figure 3.1.4.1.

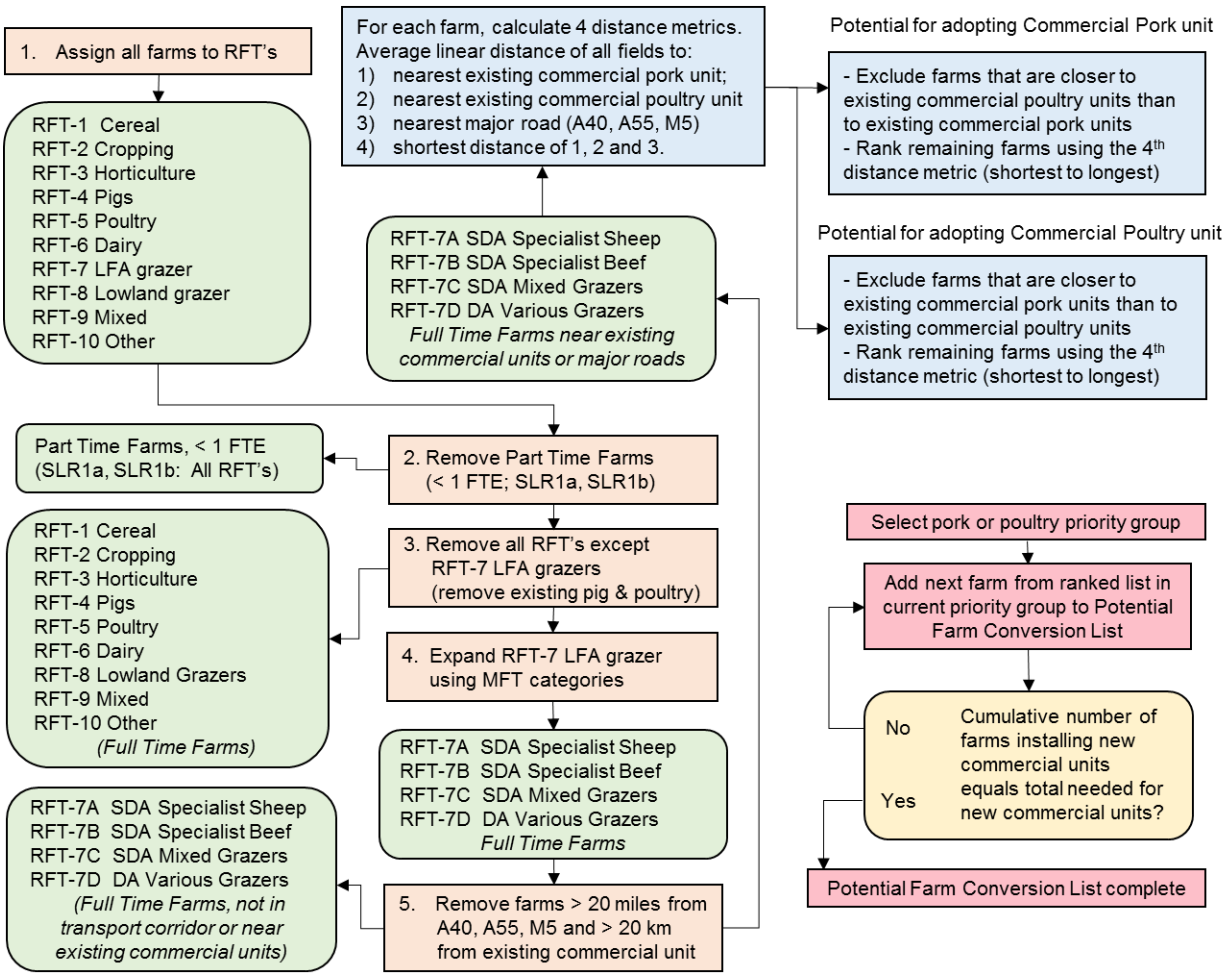


Figure 3.1.4.1. Rule-based decision tree for selecting farms with potential for adopting new commercial pork or poultry units.

3.2 Coupling to potential Grazing Livestock responses

It was decided with SWG that the analysis of potential responses of the Small Sectors in Wales (commercial pork and poultry units) to the Brexit scenarios would be superimposed on the potential Grazing Livestock sectors results of Quick Start Phase 1. The poultry and pork sectors occupy a relatively small land area within Wales but modelling possible impacts and interactions with the changing Grazing Livestock sectors is important as commercial pork and poultry units offer an opportunity for the Grazing Livestock sectors to diversify. For that reason, the Small Sectors results were derived by locating new commercial pork and poultry units based on potential Grazing Livestock changes in each scenario, and adding environmental effects resulting from the potential changes in commercial pork and poultry sectors to the potential Grazing Livestock sector environmental effects.

Therefore, in presenting results for the Small Sectors analyses, it is important to consider the results already obtained for the Grazing Livestock sectors. The Grazing Livestock results provide context and perspective for the Small Sectors results.

This section of the methods shows an extract of results from the Quick Start Phase 1 report to establish the necessary context and perspective. The results section of this report will present an "update" of these Phase 1 Grazing Livestock results (with potential Small Sectors responses added), and an analysis of the differences in potential responses which can be attributed to the Small Sectors alone.

For the remainder of this report, analyses and results from the Quick Start Phase 1 Report will only be cited once here (Cosby et al., 2019-a,b), and the reader is encouraged to access the Phase 1 Report for further details if necessary.

3.2.1 Grazing Livestock land use changes

Potential Grazing Livestock land use changes are summarized below for the three Brexit scenarios.

Total agricultural land area potentially affected is greatest for the No Deal trade scenario (17%) followed closely by the MFTA scenario (15%) with smallest potential change for the EU Deal trade scenario (Table 3.2.1.1). The scenario with most potential for conversion between livestock sectors is No Deal with 10% of livestock land potentially changing enterprise (and 7% potentially changing to non-agricultural use). The scenario with most potential for agricultural land changing to other, non-agricultural use is MFTA with 15% of current farmland moving to other uses (and no farms moving to new enterprises).

Table 3.2.1.1. Potential Grazing Livestock land use conversions under the three Brexit trade scenarios, the total areas affected (ha), and the proportion each represents of baseline (2017) farmland of all types in Wales (1,686,733 ha).

	EU Deal (ha)	No Deal (ha)	MFTA (ha)
Potential Conversions			
Grazers to Dairy	15,489	74,373	
SDA Beef to Dairy	146	1,775	
SDA Sheep to Dairy	40	10,638	
SDA Sheep to SDA Beef	3,674	79,547	
SDA Sheep to non-agricultural uses	37,430	118,258	169,550
Dairy to non-agricultural uses			3,939
Grazers to non-agricultural uses			85,803
Area Totals			
Total Area changed to new sector (% of baseline farmland)	19,348 (1.1%)	166,334 (9.9%)	0 (0%)
Total Area changed to non-agricultural uses (% of baseline farmland)	37,430 (2.2%)	118,258 (7.0%)	259,292 (15.4%)

Total Area affected by Brexit scenario (% of baseline farmland)	56,779 (3.4%)	284,592 (16.9%)	259,292 (15.4%)

The potential Grazing Livestock sector agricultural land use conversions vary in magnitude and location across Wales under the three different Brexit trade scenarios (Figure 3.2.1.1). Total agricultural land area potentially affected ranges from 56,779 to 284,592 ha depending on the scenario.

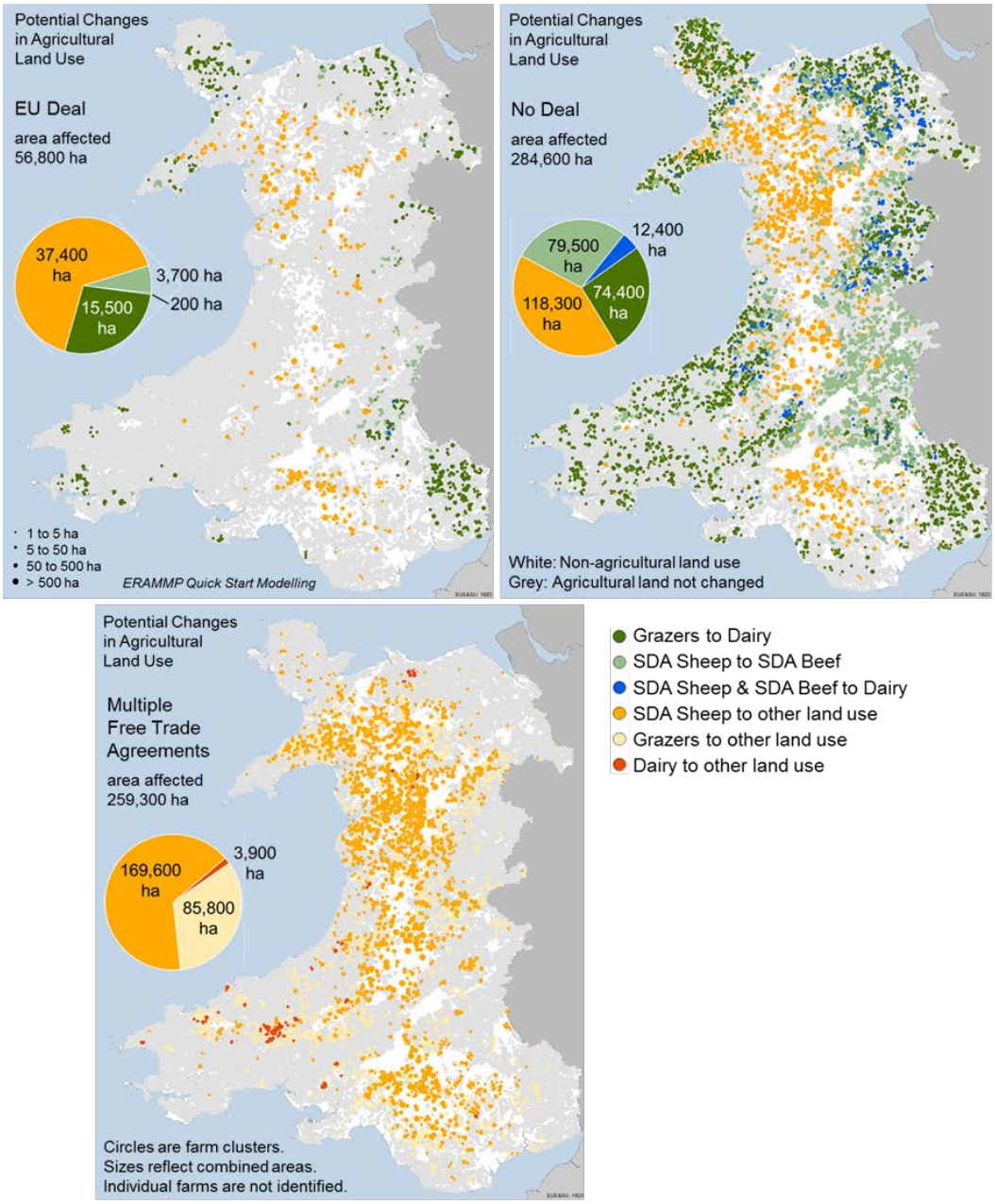


Figure 3.2.1.1. Potential Grazing Livestock land use change for three Brexit trade scenarios.

For all three Brexit trade scenarios, the sheep sector makes up the majority of farmland with potential for changing to other (non-agricultural) uses (100% in the EU Deal and No Deal scenarios, and 65% in the MFTA (Table 3.2.1.2).

Table 3.2.1.2. Area of farmland in different Grazing Livestock sectors potentially changing to non-agricultural land uses for each of the three Brexit trade scenarios.

Agricultural Land Potentially Changing to Non-agricultural uses: ha (% total)			
Sector	**EU Deal**	**No Deal**	**MFTA**
Sheep	37,430 (100%)	118,258 (100%)	169,550 (65%)
Beef	0	0	85,803 (33%)
Dairy	0	0	3,939 (2%)
Total	37,430	118,258	259,292

3.2.2 Grazing Livestock environmental impacts

Potential environmental impacts of the Grazing Livestock land use changes are shown below for the three Brexit scenarios.

Climate mitigation - greenhouse gas emissions

Outputs from Farmscoper modelling provide information regarding the potential change in agricultural greenhouse gas (GHG) emissions at national and regional scales (Figure 3.2.2.1).

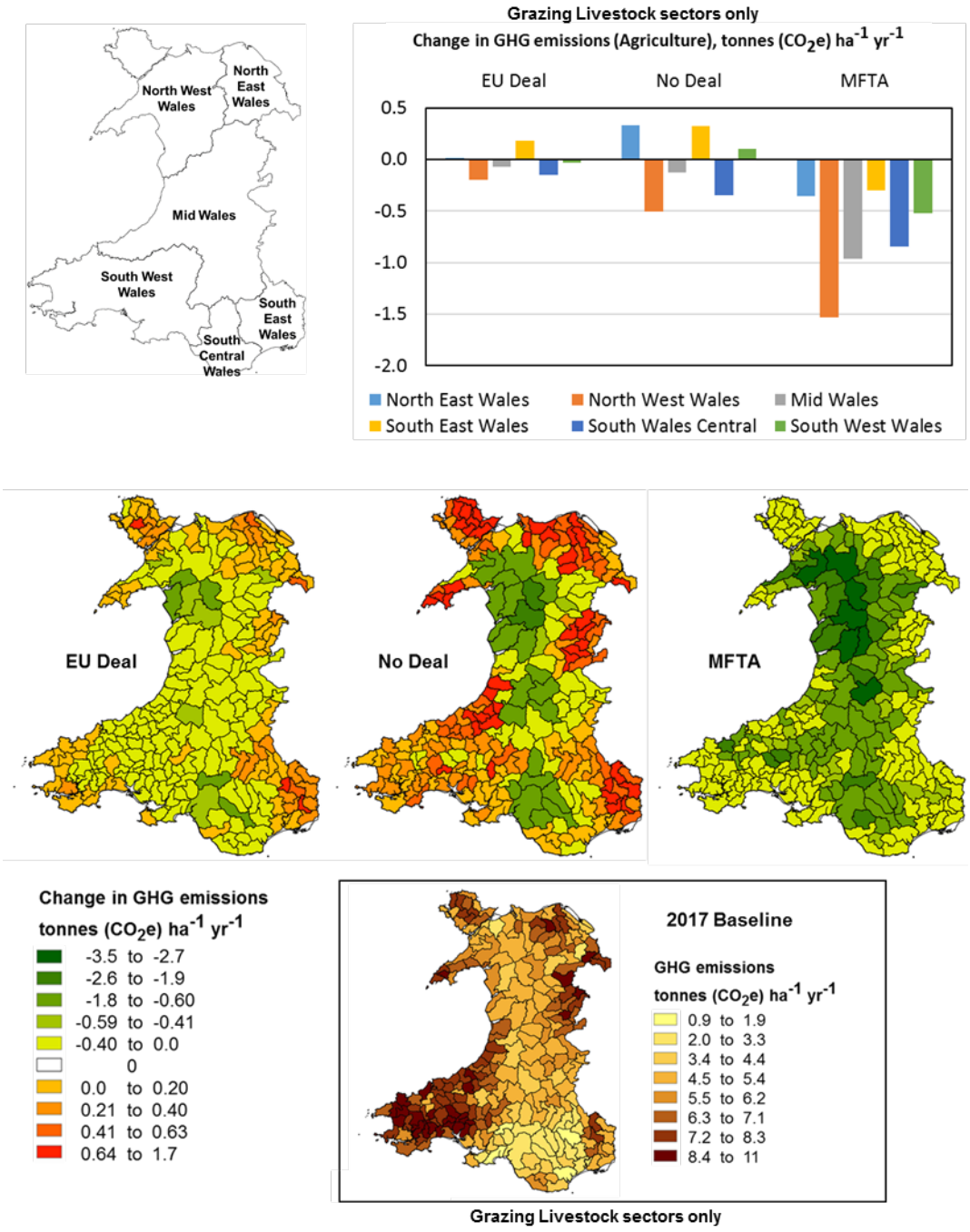


Figure 3.2.2.1. Spatial patterns of potential changes in agricultural GHG emissions across Wales for the Brexit trade scenarios. The results are for potential land use changes by the Grazing Livestock sectors only. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Air quality – ammonia emissions

Outputs from Farmscoper modelling provide information regarding the potential change in ammonia emissions at national and regional scales (Figure 3.2.2.2). Ammonia is an important precursor for formation of particulates (e.g. PM2.5's) and also a contributor to nitrogen enrichment (eutrophication) of the wider countryside.

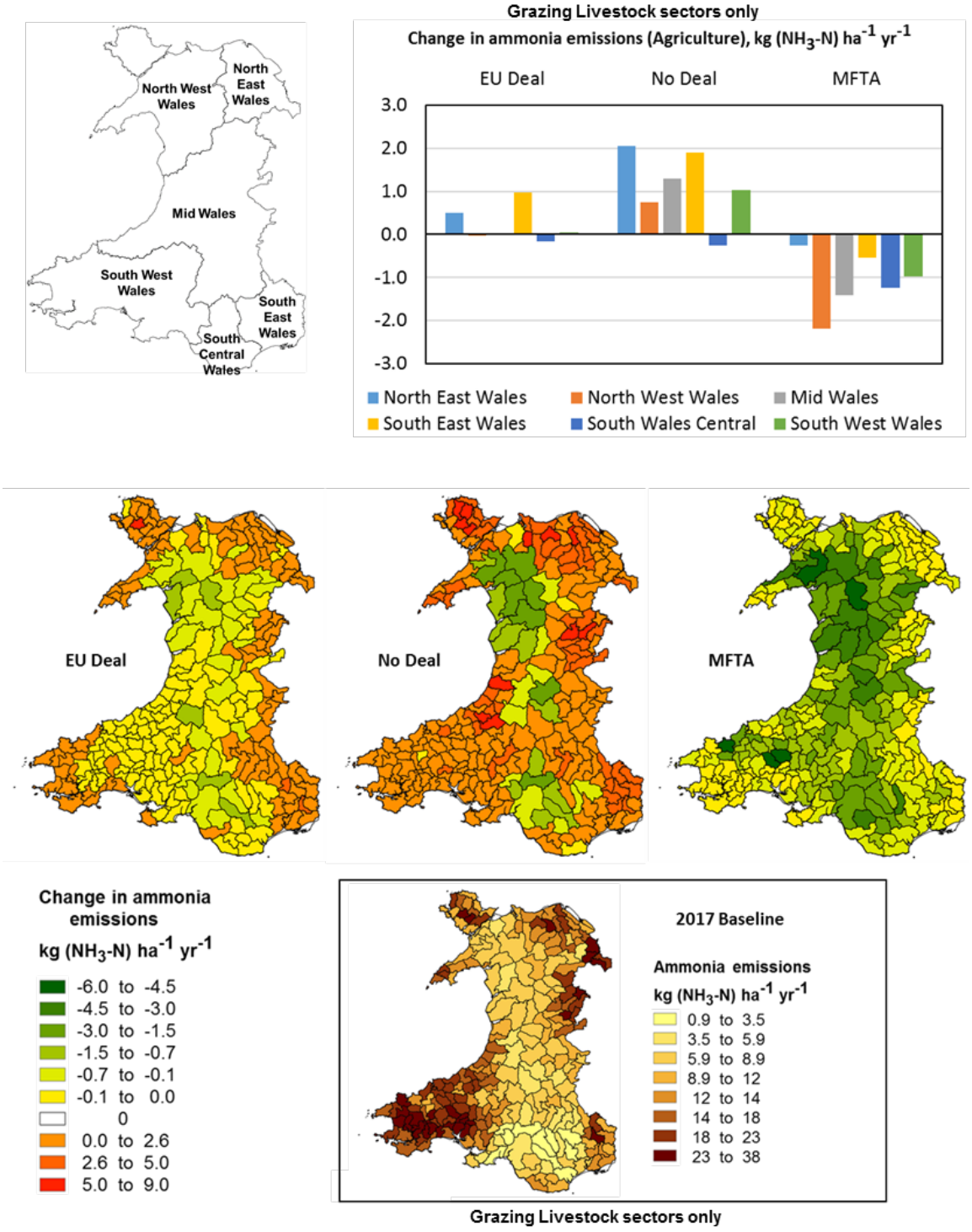


Figure 3.2.2.2. Spatial patterns of potential changes in agricultural ammonia emissions across Wales for the Brexit trade scenarios. The results are for potential land use changes by the Grazing Livestock sectors only. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Water quality – nitrogen load to water bodies

Outputs from Farmscoper modelling provide information regarding the potential change in nitrate nitrogen load to water bodies at national and regional scales (Figure 3.2.2.3).

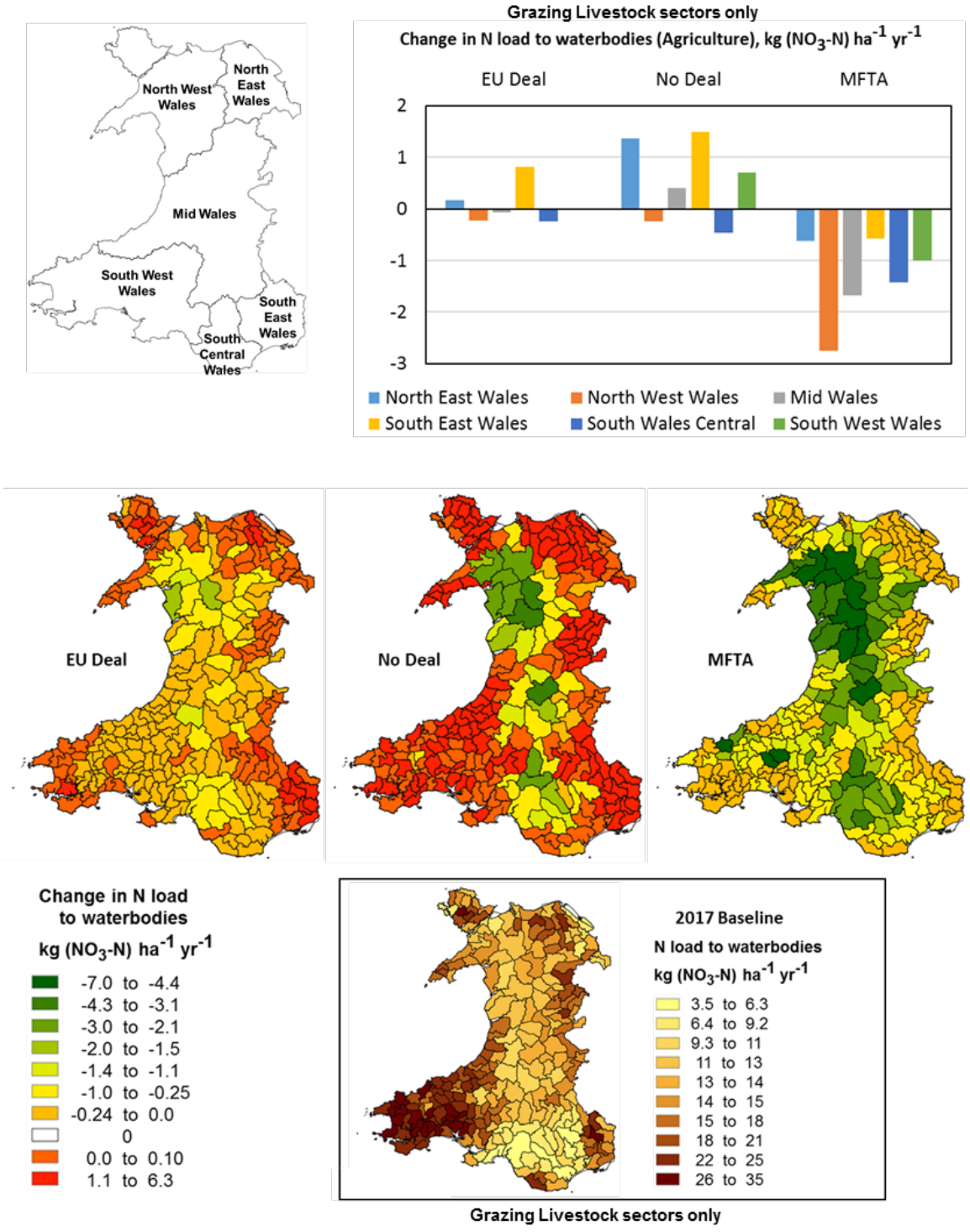


Figure 3.2.2.3. Spatial patterns of potential changes in agricultural nitrogen loads to waterbodies across Wales for the Brexit trade scenarios. The results are for potential land use changes by the Grazing Livestock sectors only. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Water quality – phosphorous load to water bodies

Outputs from Farmscoper modelling provide information regarding the potential change in total phosphorous load to water bodies at national and regional scales (Figure 3.2.2.4).

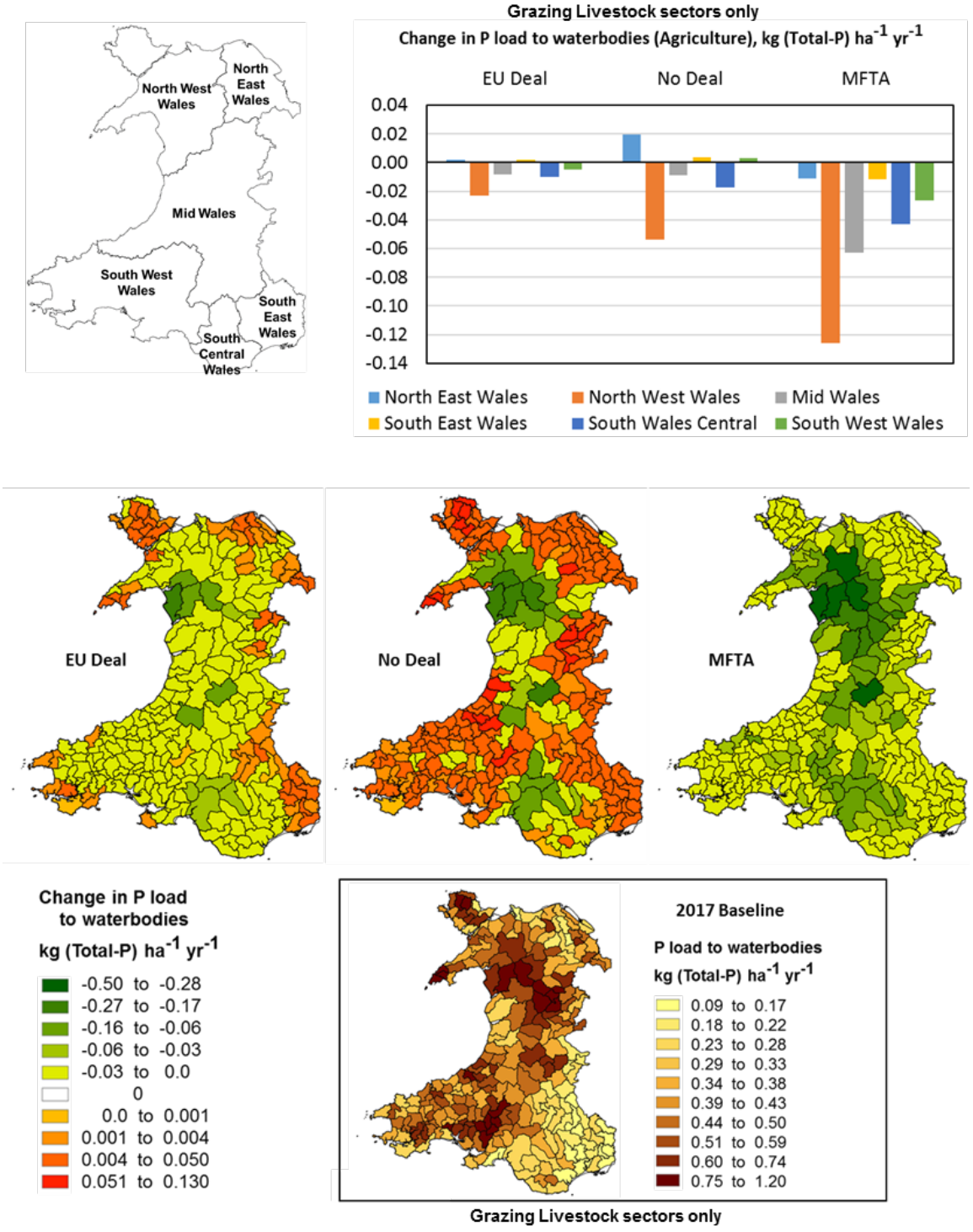


Figure 3.2.2.4. Spatial patterns of potential changes in agricultural phosphorous loads to waterbodies across Wales for the Brexit trade scenarios. The results are for potential land use changes by the Grazing Livestock sectors only. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Water quality – sediment load to water bodies

Outputs from Farmscoper modelling provide information regarding the potential change in total sediment load (suspended solids) to water bodies at national and regional scales (Figure 3.2.2.5).

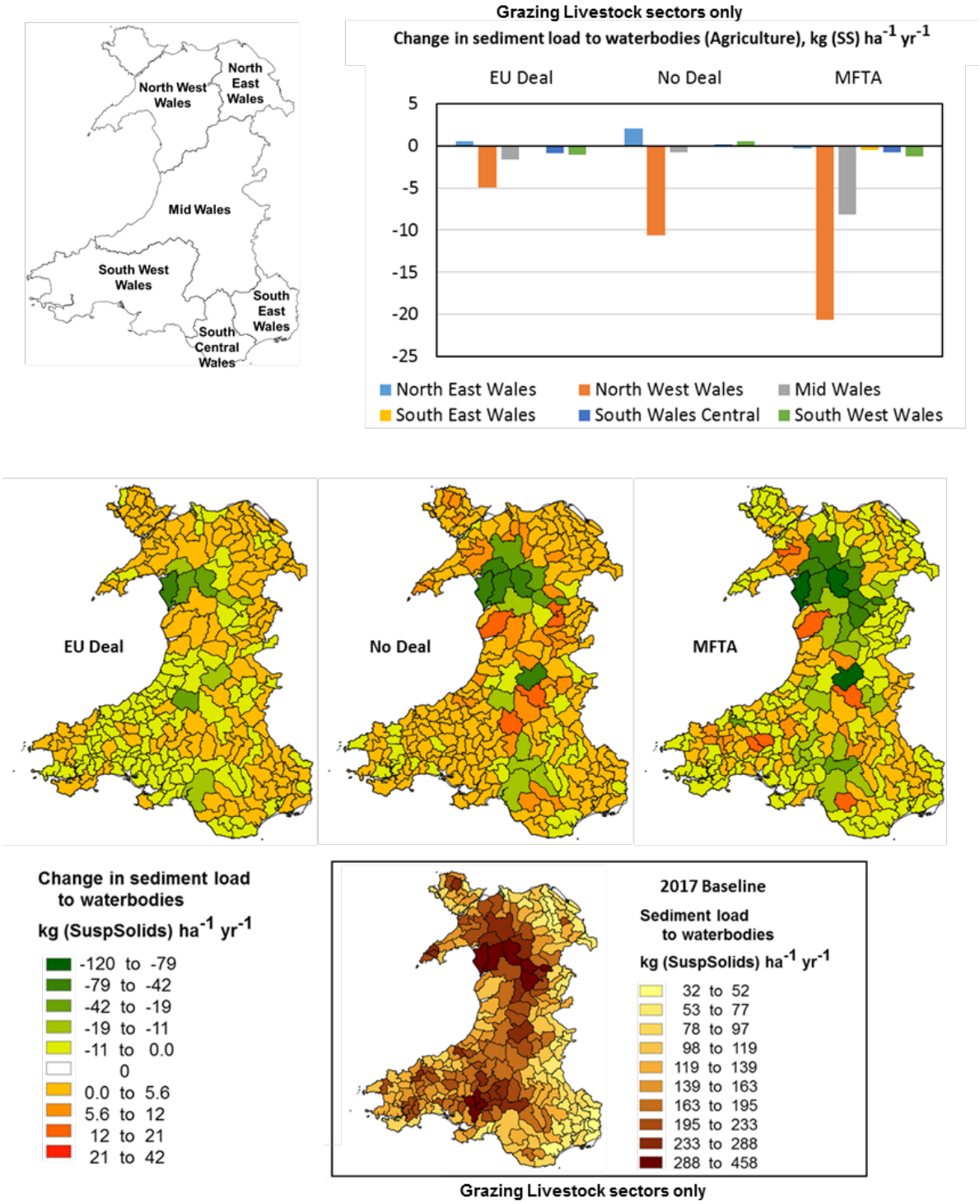


Figure 3.2.2.5. Spatial patterns of potential changes in agricultural sediment loads to waterbodies (suspended solids) across Wales for the Brexit trade scenarios. The results are for potential land use changes by the Grazing Livestock sectors only. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

4 Results

4.1 Potential new commercial pork units

The rule-based decision tree for installation of new commercial Small Sectors units on existing farms (section 3.1.4) was combined with the potential number of additional animals required for the Brexit scenarios for the pork sector (section 3.1.2) to identify potential farms for installation of new commercial pork units.

Potential market demand for pork under the EU Deal scenario requires 8 potential new commercial pork units (308 pigs/unit) in Wales, in addition to the 57 baseline commercial pork units in Wales (Table 3.1.2.1). The potential new commercial pork units would be located in both transportation corridors (Figure 4.1.1).

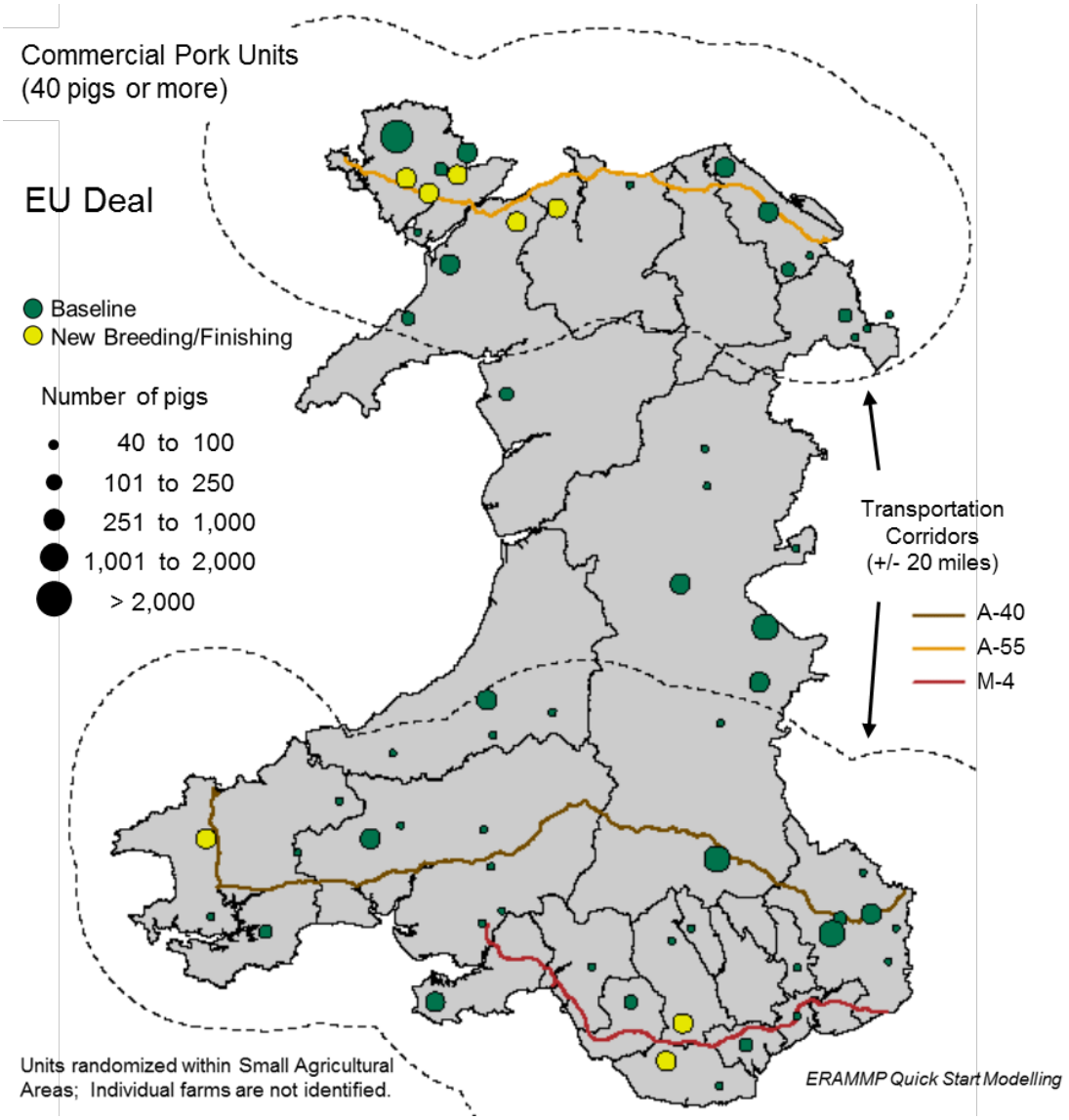


Figure 4.1.1. Potential new commercial pork units in Wales for the EU Deal scenario, shown with the existing baseline commercial pork units which remained in business but did not expand in the EU scenario. Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Following the guidance of the SWG, the response of the commercial pork sector to the No Deal scenario involved both expansion of existing commercial units and addition of new units. Potential market demand for pork under the No Deal scenario requires 28 potential new commercial pork units (500 pigs/unit) in Wales, in addition to potential expansion of the 57 baseline commercial pork units in Wales (increasing pig numbers in each baseline unit by 62%) (Table 3.1.2.1).

The potential new commercial pork units would be located mostly in the southern transportation corridor (Figure 4.1.2).

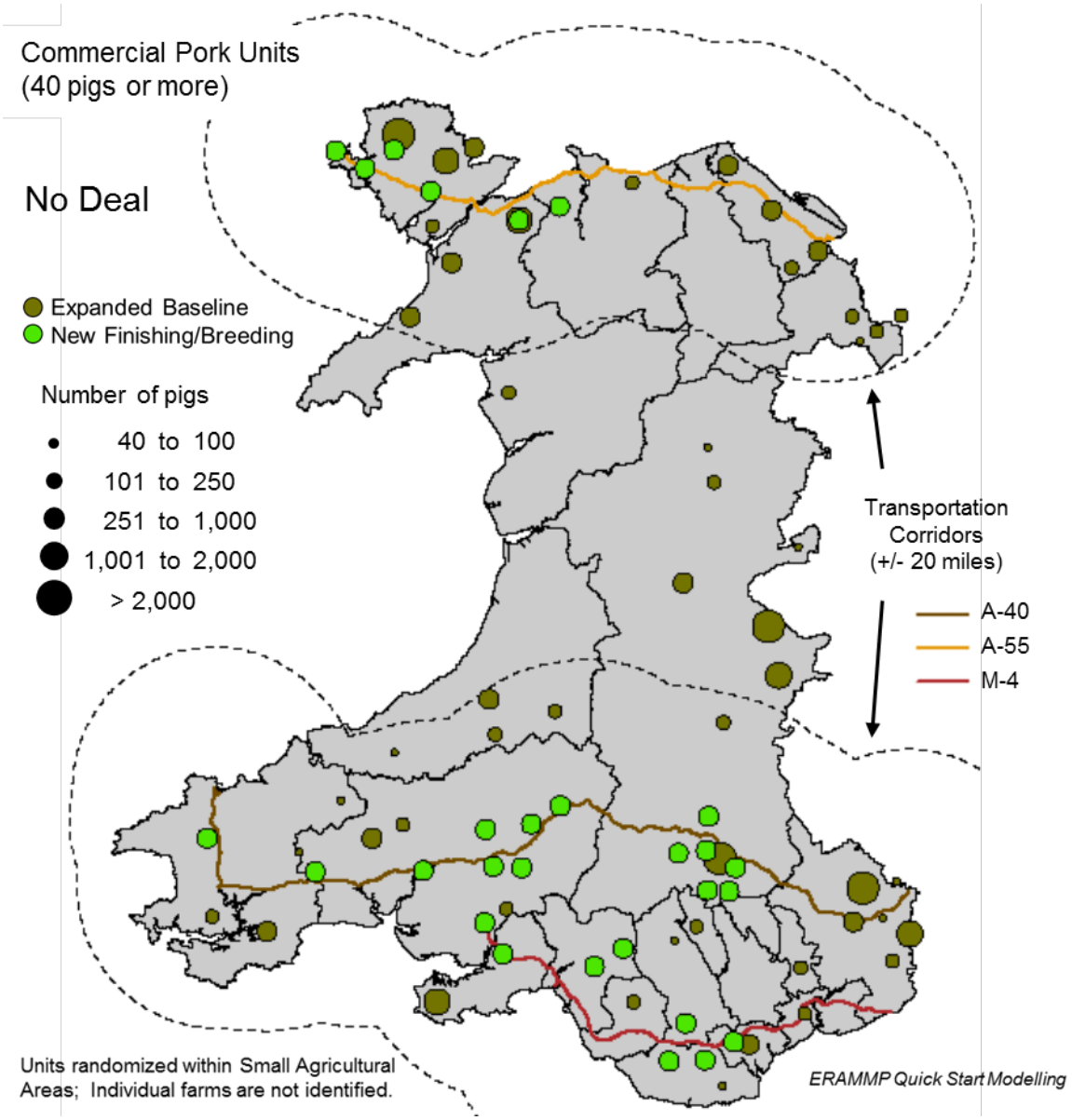


Figure 4.1.2. Potential new commercial pork units in Wales for the No Deal scenario, shown with the existing baseline commercial pork units which remained in business with potential expansion of 62% in the No Deal scenario. Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Potential market demand for pork under the MFTA scenario remained the same as the baseline demand (Table 3.1.2.1). Therefore, no new commercial pork units were

required and the distribution of commercial pork units under the MFTA scenario remains the same as the baseline distribution (Figure 4.1.3).

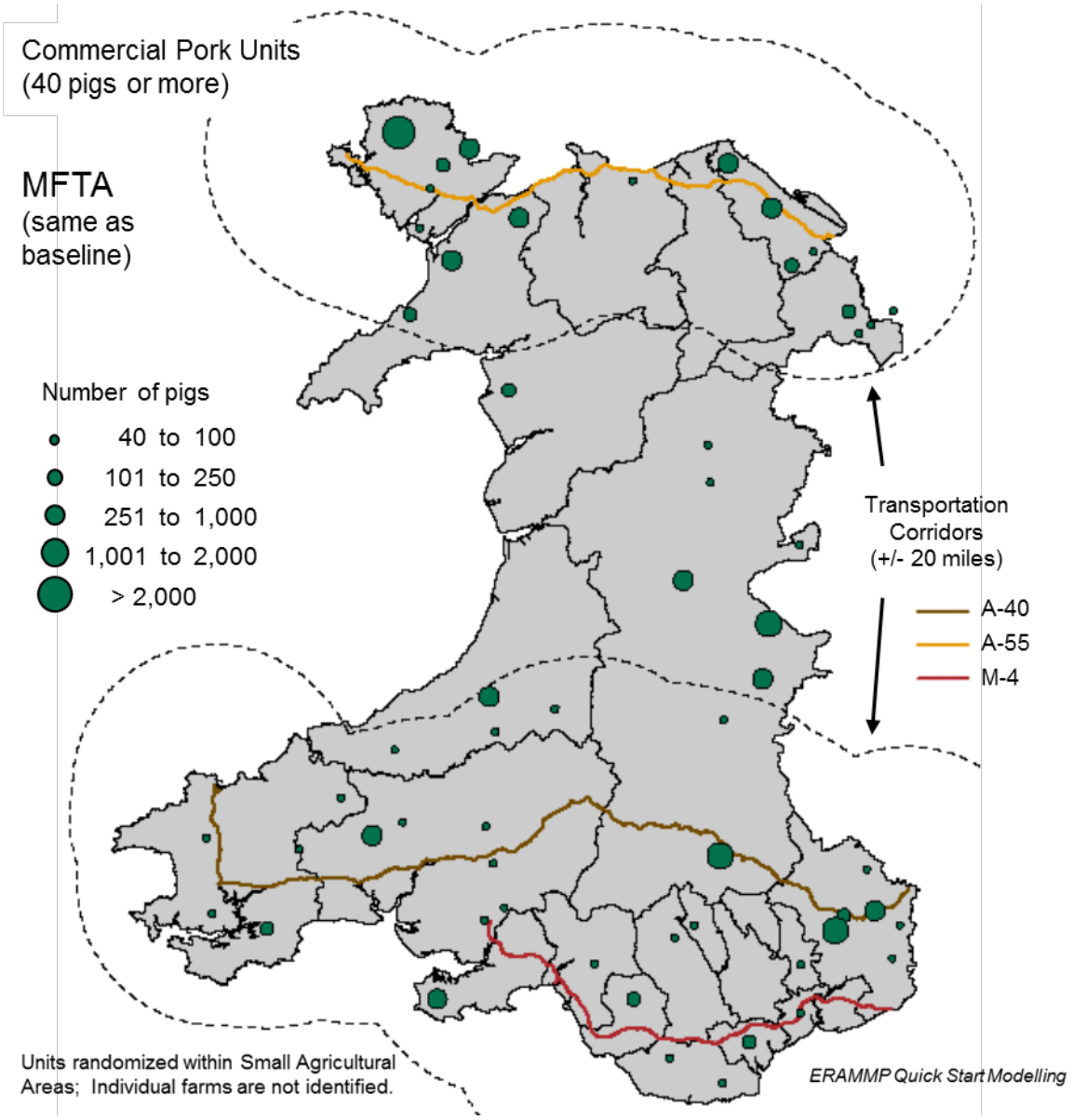


Figure 4.1.3. Potential distribution of commercial pork units in Wales for the MFTA scenario is the same as the existing baseline distribution because there is no potential change in pork numbers under the scenario. Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

4.2 Potential new commercial poultry units

The rule-based decision tree for installation of new commercial Small Sectors units on existing farms (section 3.1.4) was combined with the potential number of additional animals required for the Brexit scenarios for the poultry sector (section 3.1.3) to identify potential farms for installation of new commercial poultry units. The

procedure was applied for the EU Deal and No Deal scenarios. The MFTA scenario required no new commercial poultry units.

Potential market demand for poultry (eggs and meat) under the EU Deal scenario requires 26 potential new commercial laying/breeding units (23k birds/unit) and 5 potential new broiler units (138k birds/unit) in Wales, in addition to the 185 baseline commercial poultry units in Wales (Table 3.1.3.1). The potential new commercial poultry units would be located mostly in the southern transportation corridor (Figure 4.2.1). There was no potential expansion of the existing baseline poultry units.

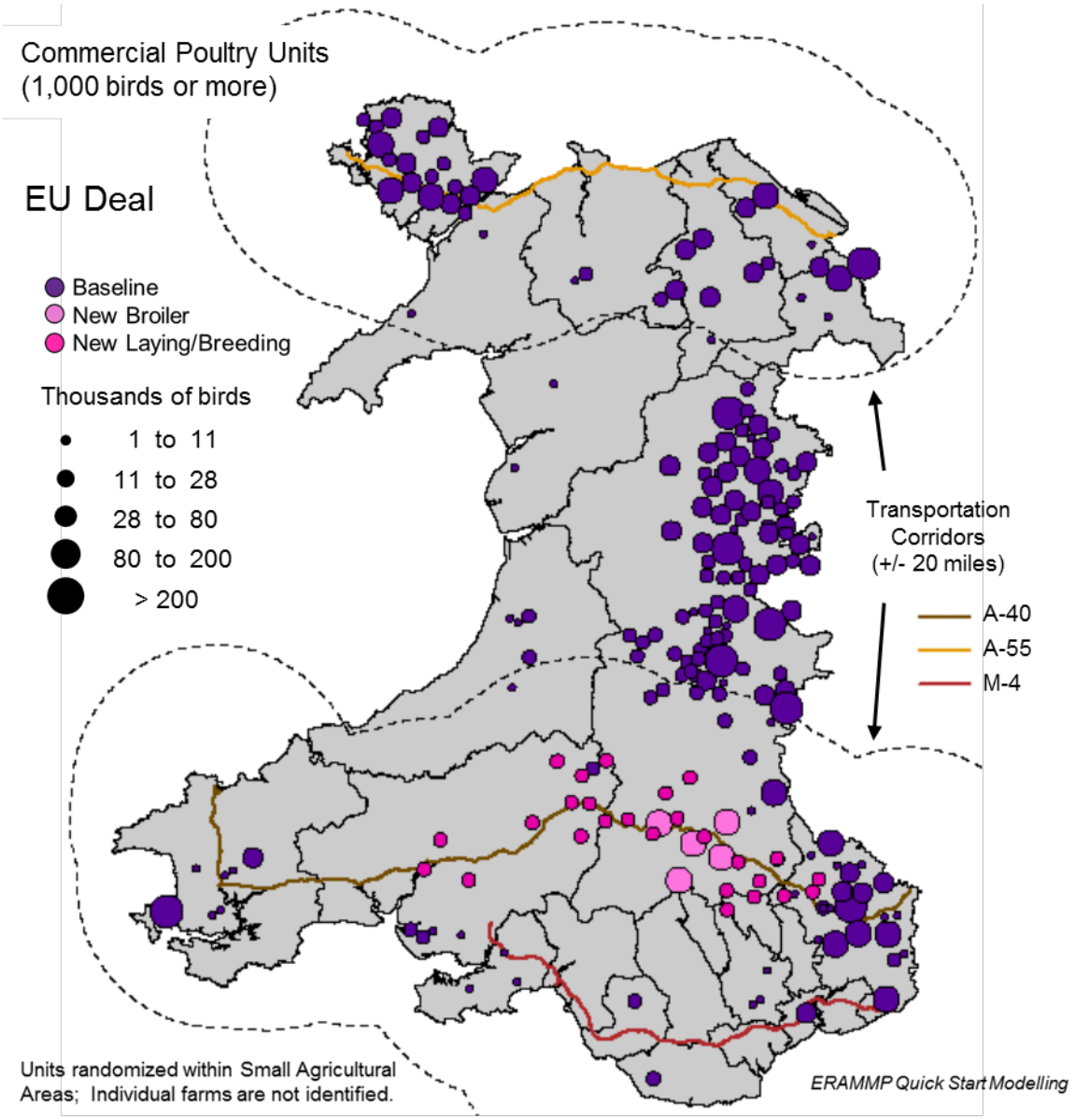


Figure 4.2.1. Potential new commercial poultry units in Wales for the EU Deal scenario with the baseline commercial poultry units. Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Potential market demand for poultry (eggs and meat) under the No Deal scenario requires 42 potential new commercial laying/breeding units (23k birds/unit) and 8

potential new broiler units (138k birds/unit) in Wales, in addition to the 185 baseline commercial poultry units in Wales (Table 3.1.3.1). The potential new commercial poultry units would be located mostly in the southern transportation corridor (Figure 4.2.2). There was no potential expansion of the existing baseline poultry units.

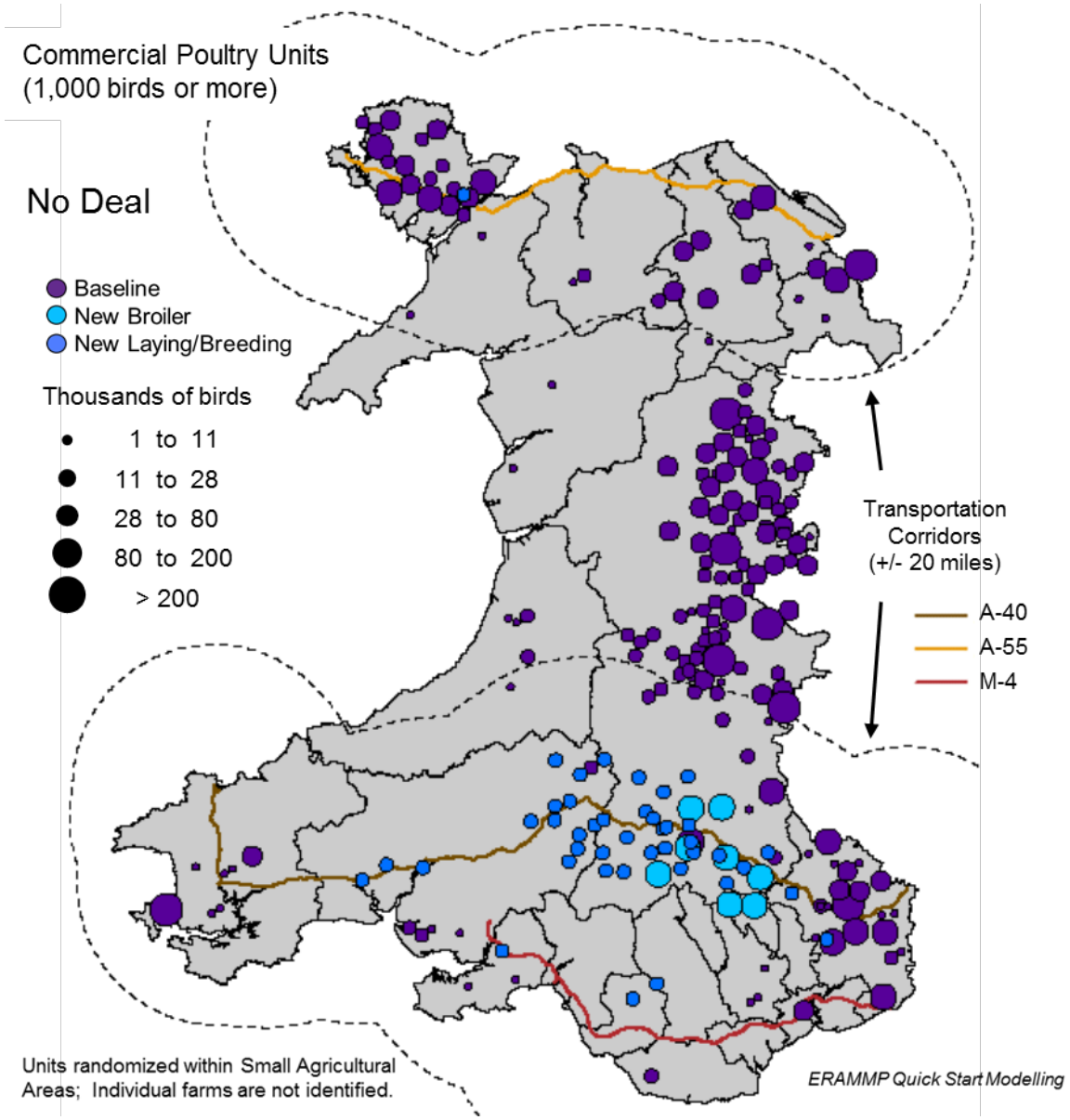


Figure 4.2.2. Potential new commercial poultry units in Wales for the No Deal scenario with the baseline commercial poultry units. Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

Potential market demand for poultry under the MFTA scenario remained essentially the same as the baseline demand (Table 3.1.2.1) requiring only 2% fewer birds than the baseline. The decrease in bird numbers was achieved by the removal of a single commercial broiler unit of intermediate size (out of the185 commercial poultry units in the baseline). Therefore, the distribution of commercial poultry units in the MFTA

scenario remains essentially the same as the baseline distribution (Figure 4.2.3). The location of the single unit potentially removed is not disclosed for data security considerations.

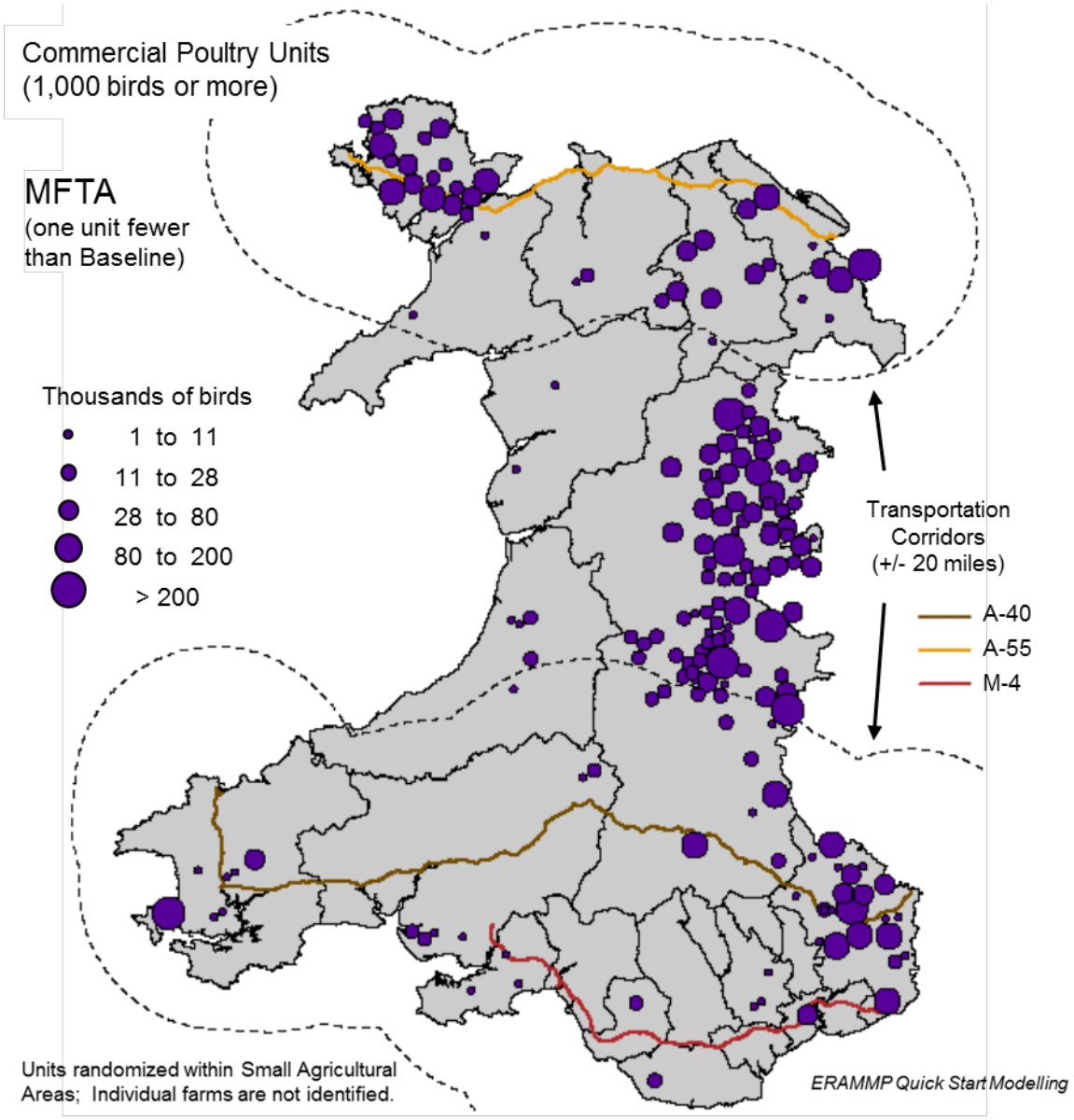


Figure 4.2.3. Potential distribution of commercial poultry units in Wales for the MFTA scenario is the same as the baseline distribution but with one intermediate sized commercial unit removed (not indicated for data security considerations). Locations of each commercial unit have been randomized within the Small Agricultural Area in which the unit occurs.

4.3 Potential environmental impacts in Wales

Spatial patterns of Small Sectors change and impacts that are produced in this analysis (new commercial pork and poultry units) have been superimposed on the Grazing Livestock results of Quick Start Phase 1. For each Brexit scenario, the spatially explicit changes in agricultural land use arising from potential Small Sectors responses (and the spatially explicit knock-on environmental impacts presented in this section) have been added to the spatial changes potentially occurring as a result of the responses of the Grazing Livestock sector. The results of this section present potential combined responses, which are separated into components in Section 4.4.

It should be noted there will be important local (sub-regional scale) impacts as these pig and poultry units act as point sources of pollutants such as ammonia to adjacent designated sites and local water resources. National and regional data summaries do not adequately capture these impacts which can be most extreme when within 250m but also need to be considered within a 5km distance (NRW 2020).

Climate mitigation - greenhouse gas emissions

Outputs from Farmscoper modelling provide information regarding the potential change in agricultural greenhouse gas (GHG) emissions at national and regional scales (Figure 4.3.1) resulting from installation of new commercial pork and poultry units on existing farms. Potential new emissions from the installed pork and poultry units are shown in the figure added to potential emissions from the Grazing Livestock sectors (dairy, sheep and beef) for each scenario.

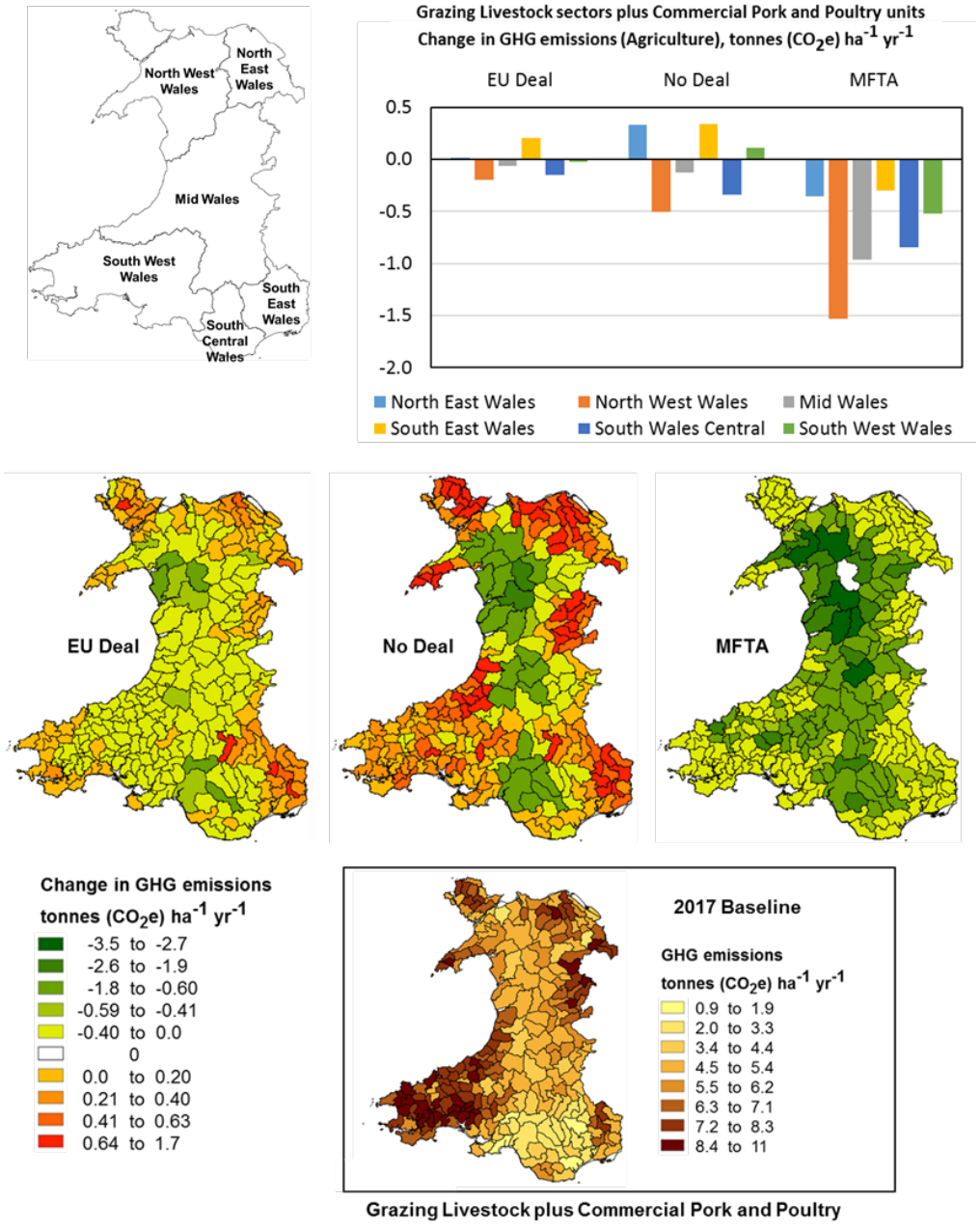


Figure 4.3.1. Spatial patterns of potential changes in agricultural GHG emissions across Wales for the Brexit trade scenarios. The results are for combined potential land use changes by the Grazing Livestock sectors and Commercial Pork and Poultry units. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Air quality – ammonia emissions

Outputs from Farmscoper modelling provide information regarding the potential change in agricultural ammonia emissions at national and regional scales (Figure 4.3.2) resulting from installation of new commercial pork and poultry units on existing farms. Potential new emissions from the installed pork and poultry units are shown in the figure added to potential emissions from the Grazing Livestock sectors (dairy, sheep and beef) for each scenario.

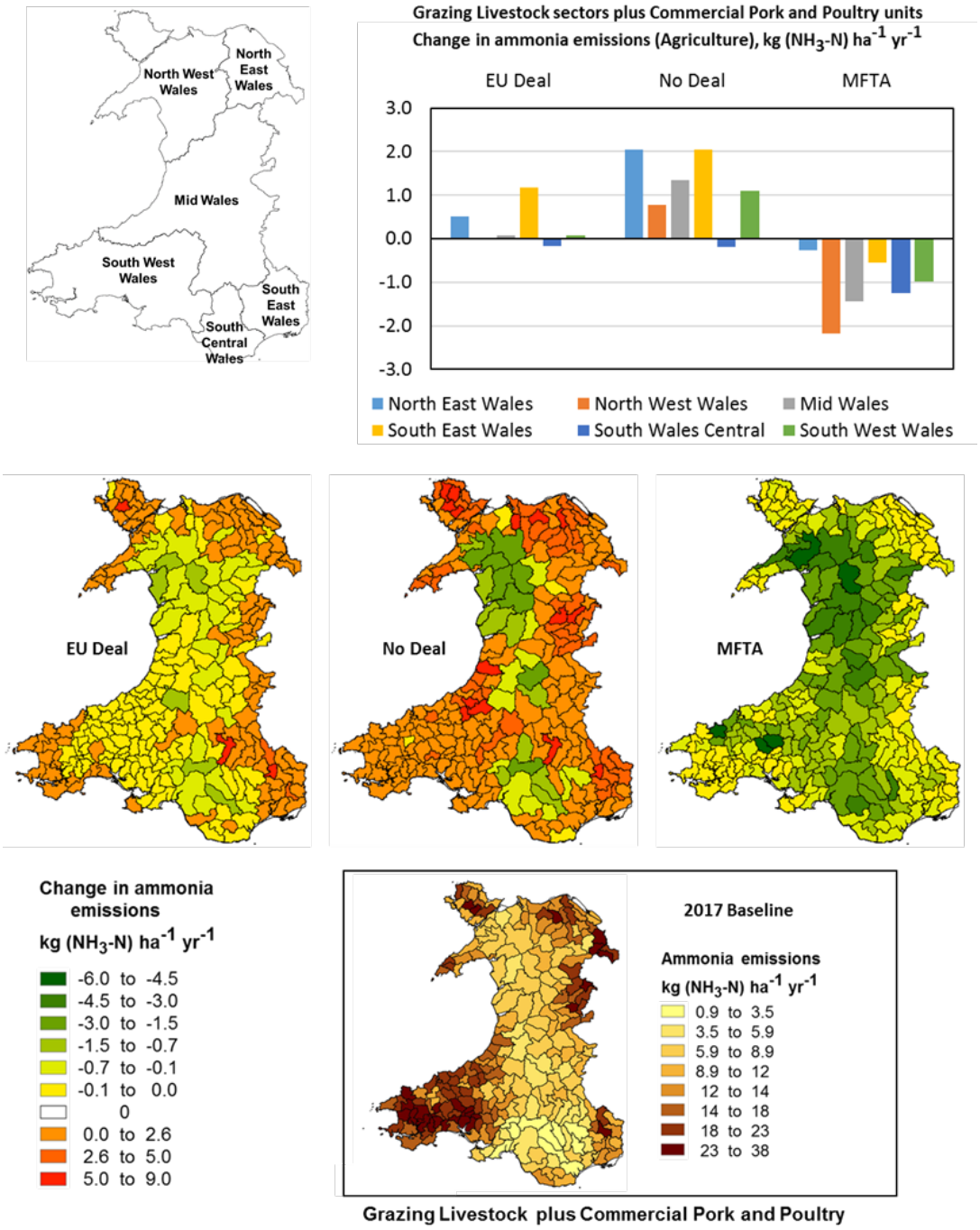


Figure 4.3.2. Spatial patterns of potential changes in agricultural ammonia emissions across Wales for the Brexit trade scenarios. The results are for combined potential land use changes by the Grazing Livestock sectors and Commercial Pork and Poultry units. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Water Quality – nitrogen load to waterbodies

Outputs from Farmscoper modelling provide information regarding the potential change in nitrogen loads to waterbodies at national and regional scales (Figure 4.3.3) resulting from installation of new commercial pork and poultry units on existing farms. Potential new loads from the installed pork and poultry units are shown in the figure added to potential loads from the Grazing Livestock sectors (dairy, sheep and beef) for each scenario.

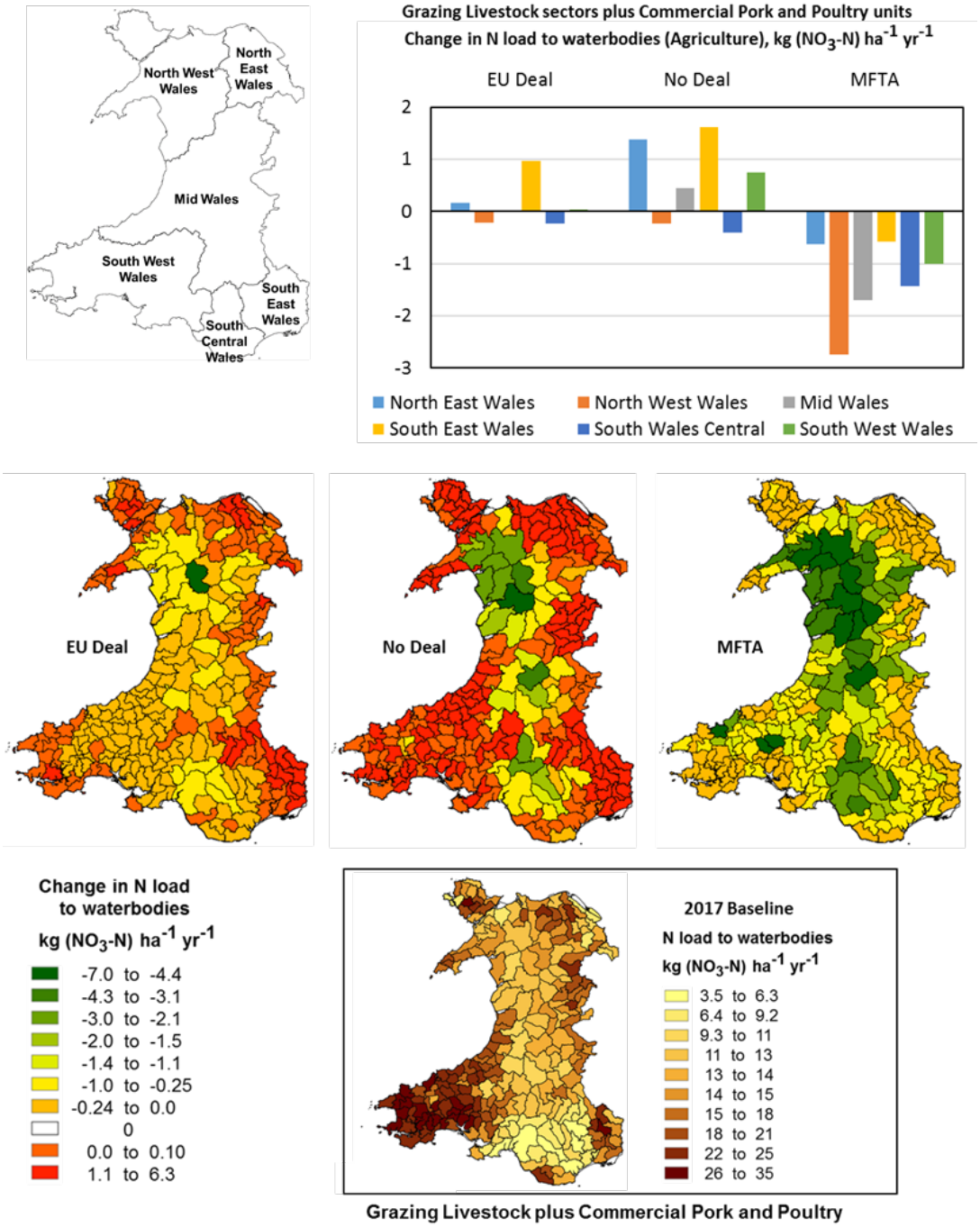


Figure 4.3.3. Spatial patterns of potential changes in agricultural nitrate nitrogen loads to waterbodies across Wales for the Brexit trade scenarios. The results are for combined potential land use changes by the Grazing Livestock sectors and Commercial Pork and Poultry units. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Water Quality – phosphorous load to waterbodies

Outputs from Farmscoper modelling provide information regarding the potential change in phosphorous loads to waterbodies at national and regional scales (Figure 4.3.4) resulting from installation of new commercial pork and poultry units on existing farms. Potential new loads from the installed pork and poultry units are shown in the figure added to potential loads from the Grazing Livestock sectors (dairy, sheep and beef) for each scenario.

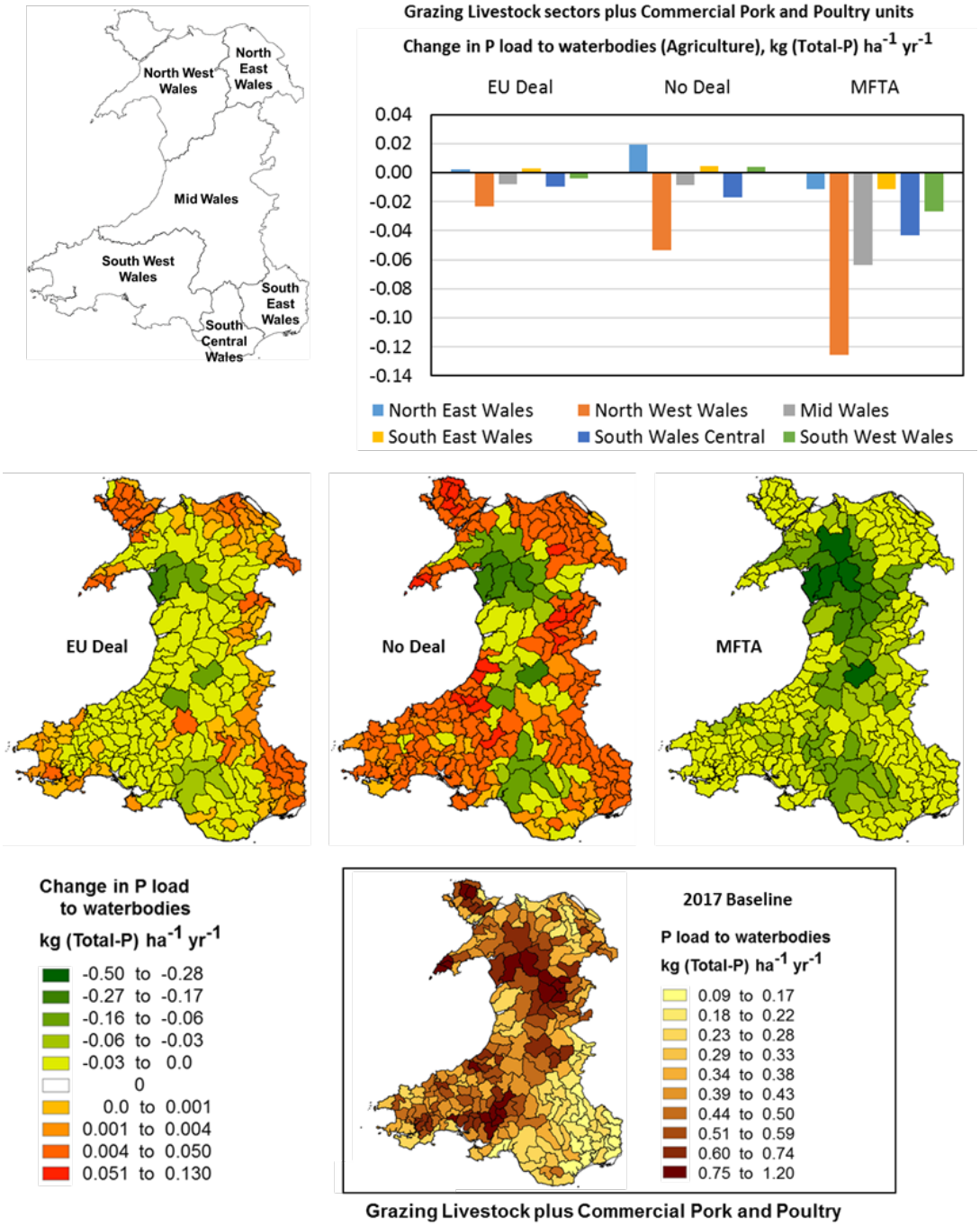


Figure 4.3.4. Spatial patterns of potential changes in agricultural total phosphorous loads to waterbodies across Wales for the Brexit trade scenarios. The results are for combined potential land use changes by the Grazing Livestock sectors and Commercial Pork and Poultry units. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

Water Quality – sediment load to waterbodies

Outputs from Farmscoper modelling provide information regarding the potential change in sediment loads to waterbodies at national and regional scales (Figure 4.3.5) resulting from installation of new commercial pork and poultry units on existing farms. Potential new loads from the installed pork and poultry units are shown in the figure added to potential loads from the Grazing Livestock sectors (dairy, sheep and beef) for each scenario.

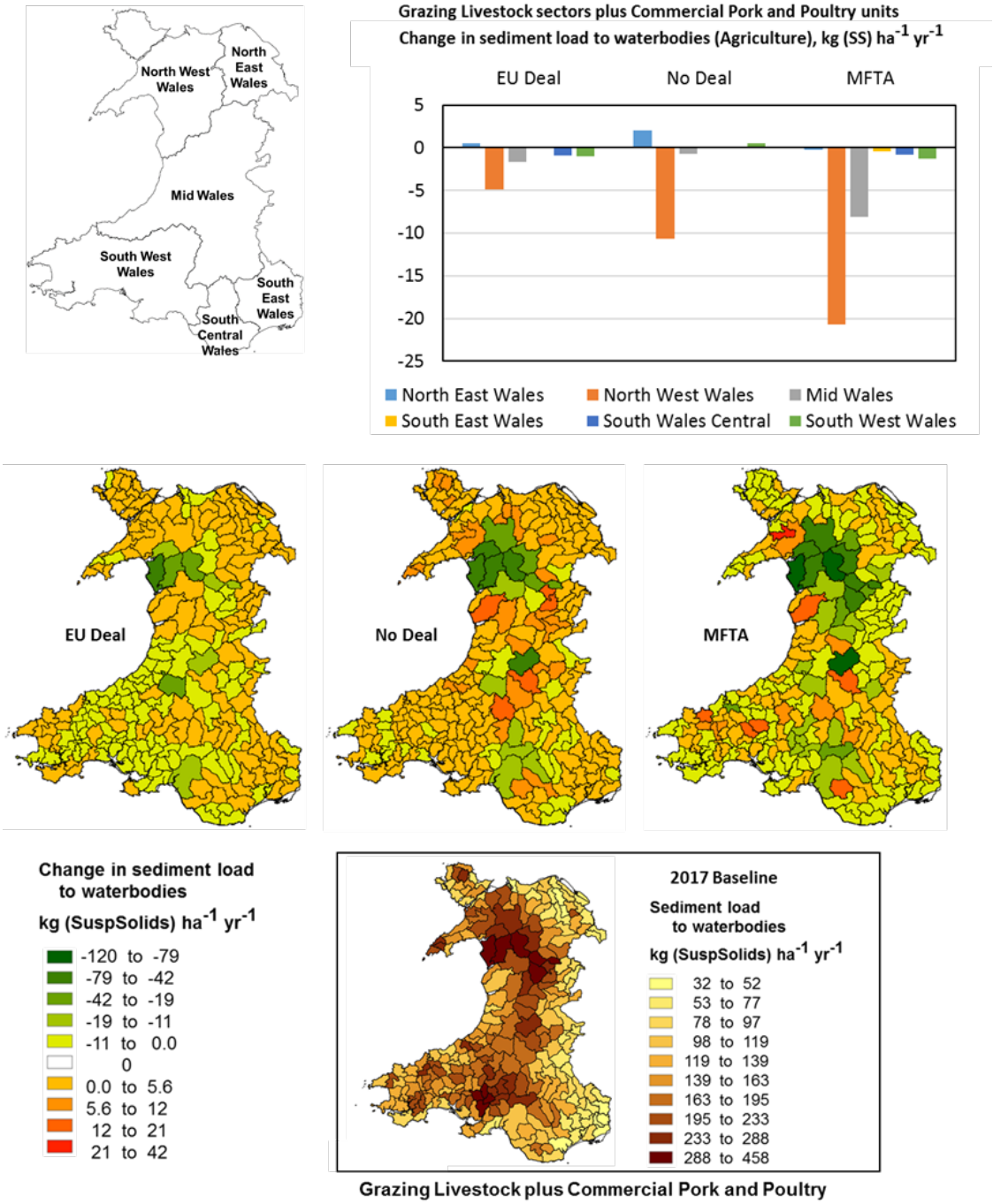


Figure 4.3.5. Spatial patterns of potential changes in agricultural sediment loads to waterbodies (suspended solids) across Wales for the Brexit trade scenarios. The results are for combined potential land use changes by the Grazing Livestock sectors and Commercial Pork and Poultry units. Upper bar chart summarizes potential change for 6 regions in Wales. Lower maps aggregate potential change to Wales Small Agricultural Areas, each of which contains 100 to 200 farms.

4.4 Potential impacts: Small Sectors vs Grazing Livestock

The quick start analysis of Small Sectors responses to Brexit was implemented by adding the potential responses of the Small Sectors in Wales (commercial pork and poultry units) to the potential responses of the larger Grazing Livestock sectors in Wales (dairy, beef and sheep). This section decomposes the individual contributions of each group of sectors (large and small) to the overall potential responses to the Brexit scenarios presented in the previous section (4.3).

As can be seen below, the potential responses and environmental effects of changes in commercial pork and poultry units are generally much smaller than (and not as widespread as) those from the Grazing Livestock sectors.

Key findings

The potential installation of new commercial pork or poultry units on existing farms will result in increased GHG emissions and adverse effects on air and water quality. In some cases, these effects will be additive with effects from potential changes in the Grazing Livestock sectors (e.g., expansion of Dairy). In other cases, the effects of potential Small Sectors changes will be in an opposite direction to those from the Grazing Livestock sector (e.g. Dairy or Sheep sectors taking land out of agriculture).

In either case, the relative magnitudes of potential changes from new commercial pork and poultry units must be considered relative to baseline (2017, pre-Brexit) conditions and relative to potential changes from the Grazing Livestock sectors (dairy, beef and sheep) for each of the three Brexit scenarios. Additionally, it is useful to examine these relative responses in a regional context because of the potential for adverse local effects occurring even if the average effects across all of Wales from new commercial pork and poultry units are small.

High level findings for each of the environmental issues associated with potential new commercial pork and poultry units in response to the Brexit scenario indicate (see below for details):

- Climate mitigation - Expressed as a percentage of baseline GHG emissions, the potential Small Sectors increases are between 0% and 0.1% for all Wales depending on the scenario, with a maximum potential regional increase of more than 0.5% for the EU Deal in South East Wales.
- Air quality - Expressed as a percentage of baseline ammonia emissions, the potential Small Sectors increases are between 0% and 0.5% for all Wales depending on the scenario, with a maximum potential regional increase of 2% for the EU Deal in South East Wales.
- Water quality - Expressed as a percentage of baseline N load to waterbodies, the potential Small Sectors increases are between 0% and 0.3% for all Wales depending on the scenario, with maximum a potential regional increase of more than 1.1% for the EU Deal in South East Wales.
- Water quality - Expressed as a percentage of baseline P load to waterbodies, the potential Small Sectors increases are between 0% and 0.1% for all Wales depending on the scenario, with a maximum potential regional increase of more than 0.5% for the EU Deal in South East Wales.
- Water quality – Installation of a single average size commercial pork or poultry unit (the constraints of this analysis) are not expected to increase sediment runoff beyond that caused by existing farm activities.

Climate mitigation - greenhouse gas emissions

Potential changes in agricultural greenhouse gas (GHG) emissions from commercial pork and poultry units are generally smaller (by one to two orders of magnitude) than potential changes from the Grazing Livestock Sector, at both regional and national sales. In some regions and scenarios the direction of change for Small Sectors response is opposite that of Grazing Livestock (Table 4.4.1).

Table 4.4.1. Baseline and potential GHG emissions from agriculture in Wales for the three Brexit scenarios. Regional and national results are given for Commercial Pork and Poultry units, the Grazing Livestock sectors and the combined sectors. Change from the baseline is given in the last three columns.

	GHG emissions (Agriculture), tonnes (CO_2e) ha^{-1} yr^{-1}				**Change from baseline**		
	Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	6.0	6.0	6.0	6.0	0.000	0.001	0.000
North West Wales	5.5	5.5	5.5	5.5	0.000	0.003	0.000
Mid Wales	5.4	5.5	5.5	5.4	0.008	0.006	-0.003
South East Wales	4.3	4.4	4.3	4.3	0.023	0.017	0.000
South Wales Central	3.4	3.4	3.4	3.4	0.000	0.008	0.000
South West Wales	6.2	6.2	6.2	6.2	0.004	0.006	0.000
All Wales	5.5	5.5	5.5	5.5	0.006	0.006	-0.001
	Grazing Livestock sectors (Dairy, Beef and Sheep)						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	6.0	6.1	6.4	5.7	0.02	0.33	-0.35
North West Wales	5.5	5.3	5.0	4.0	-0.20	-0.50	-1.53
Mid Wales	5.4	5.4	5.3	4.5	-0.07	-0.13	-0.96
South East Wales	4.3	4.5	4.7	4.0	0.18	0.32	-0.30
South Wales Central	3.4	3.2	3.1	2.6	-0.15	-0.35	-0.84
South West Wales	6.2	6.2	6.3	5.7	-0.03	0.10	-0.52
All Wales	5.5	5.4	5.4	4.6	-0.07	-0.10	-0.87
	Grazing Livestock sectors plus Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	6.0	6.1	6.4	5.7	0.02	0.33	-0.35
North West Wales	5.5	5.3	5.0	4.0	-0.19	-0.50	-1.53
Mid Wales	5.4	5.4	5.3	4.5	-0.06	-0.12	-0.96
South East Wales	4.3	4.5	4.7	4.0	0.21	0.34	-0.30
South Wales Central	3.4	3.2	3.1	2.6	-0.15	-0.34	-0.84
South West Wales	6.2	6.2	6.3	5.7	-0.03	0.11	-0.52
All Wales	5.5	5.4	5.4	4.6	-0.06	-0.09	-0.87
GHG emission (Agriculture): Emissions of CH_4 and N_20 from livestock, fertiliser and soil (as CO_2e).							

Potential increases in Small Sectors GHG emissions are largest in South East Wales for both the EU Deal and No Deal scenarios, while potential changes in Grazing Livestock GHG emissions are largest in North West Wales, South Wales Central and Mid Wales (decreases for all three Brexit scenarios) (Figure 4.4.1).

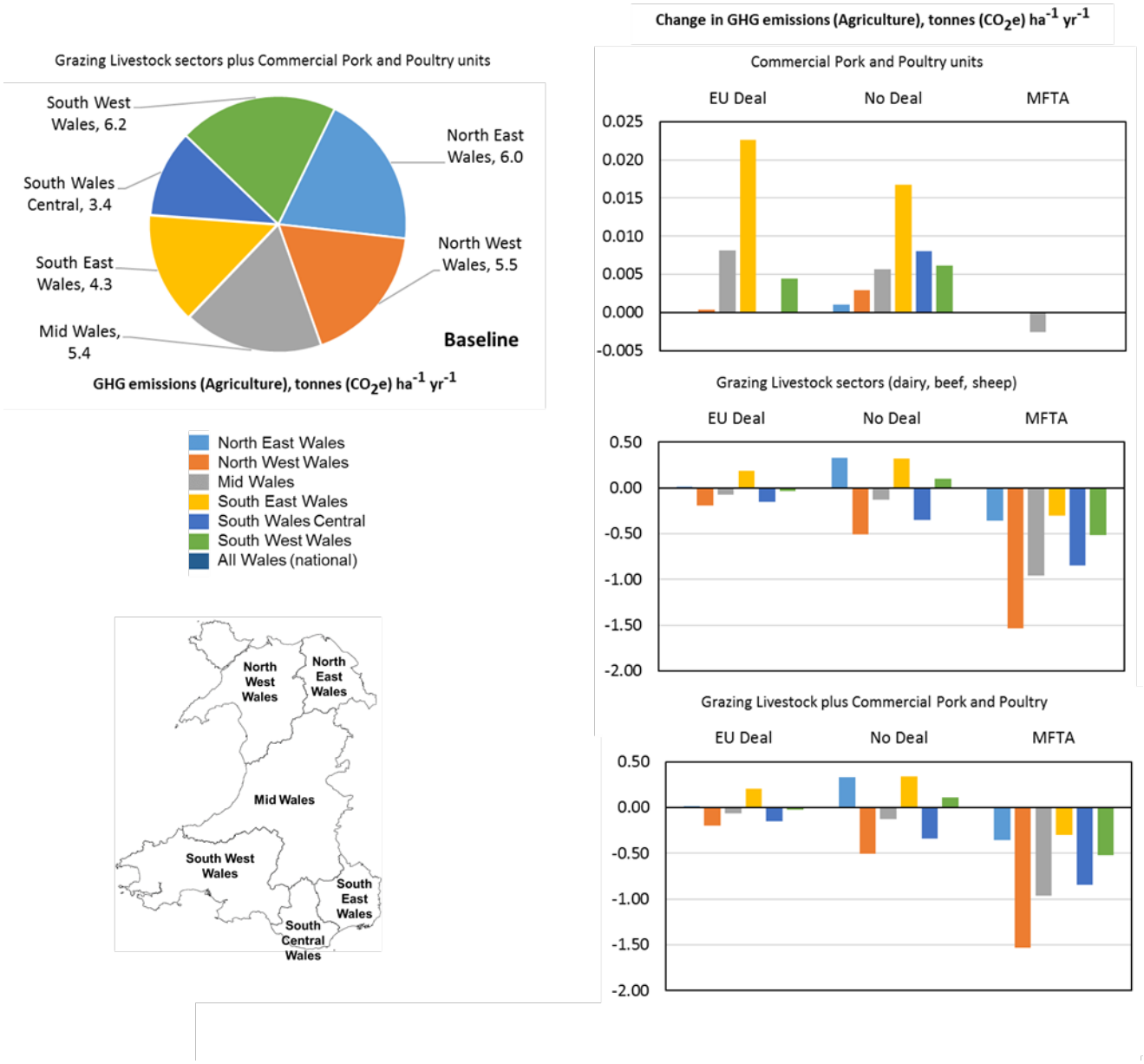


Figure 4.4.1. Baseline (pie chart) and potential changes in GHG emissions from agriculture in Wales for the three Brexit scenarios and 6 regions (bar charts). Potential change is shown for Commercial Pork and Poultry units (upper right; note different scale), the Grazing Livestock sectors (dairy, beef and sheep; middle right) and the combined sectors (lower right).

Expressed as a percentage of baseline GHG emissions, the potential Small Sectors increases are between 0% and 0.1% for all Wales depending on the scenario, with a maximum potential regional increase of more than 0.5% for the EU Deal in South East Wales (Table 4.4.2 and Figure 4.4.2).

Table 4.4.2. Potential regional and national changes in GHG emissions from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline, partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Potential Change (%) in GHG Emissions Relative to Baseline						
	Grazing Livestock Sectors (Dairy, Beef and Sheep)			Commercial Pork and Poultry units		
NRW areas	EU Deal	No Deal	MFTA	EU Deal	No Deal	MFTA
North East Wales	0.2	5.4	-5.6	0.0	0.0	0.0
North West Wales	-3.5	-9.5	-30.7	0.0	0.1	0.0
Mid Wales	-1.3	-2.4	-18.0	0.1	0.1	0.0
South East Wales	4.3	7.2	-6.5	0.5	0.4	0.0
South Wales Central	-4.5	-10.7	-27.7	0.0	0.2	0.0
South West Wales	-0.5	1.7	-8.2	0.1	0.1	0.0
All Wales	-1.2	-1.8	-16.2	0.1	0.1	0.0
GHG emission (Agriculture): Emissions of CH_4 and N_20 from livestock, fertiliser and soil (as CO_2e).						

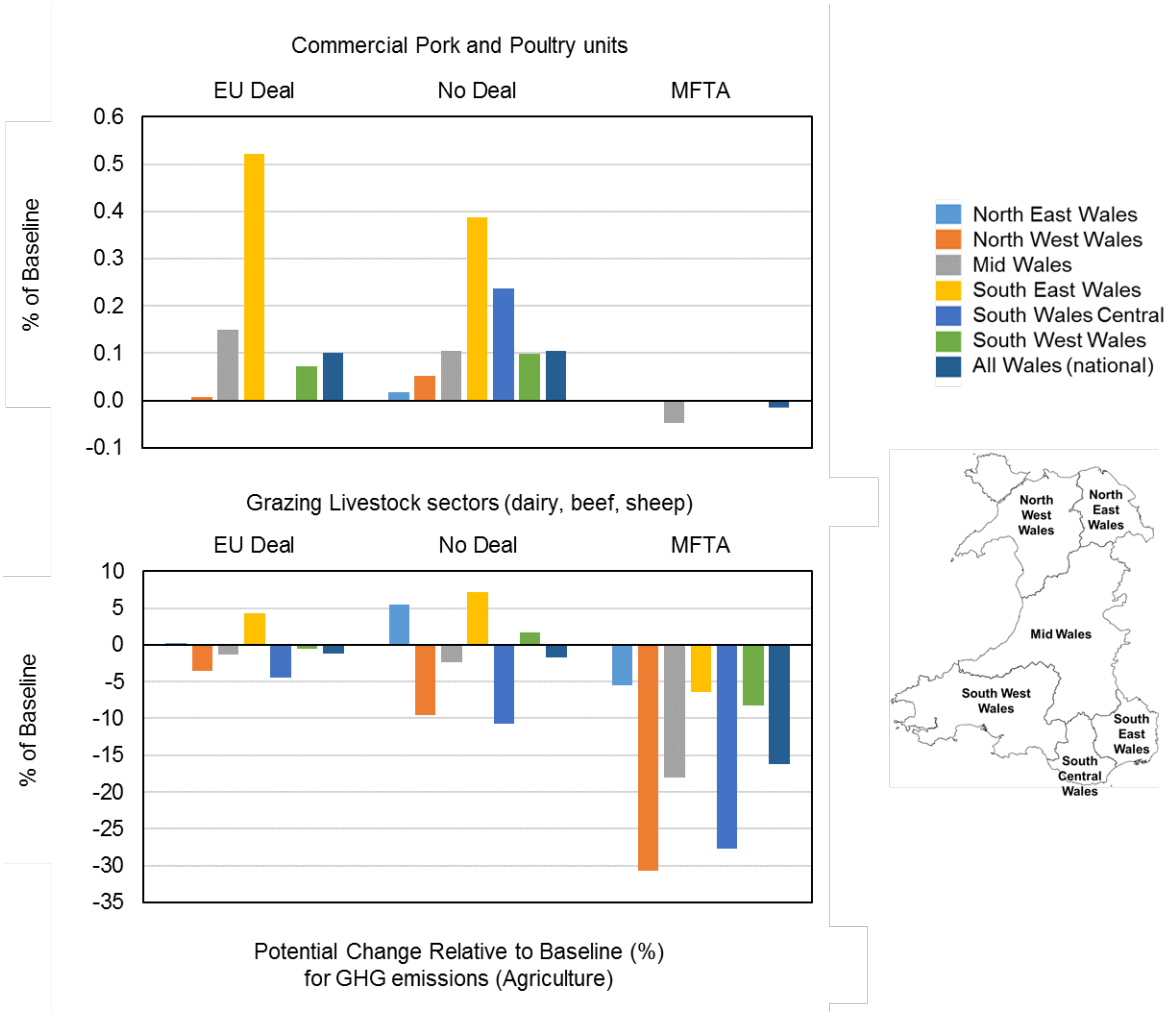


Figure 4.4.2. Potential regional and national changes in GHG emissions from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline (note different scales), partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Air Quality - ammonia emissions

Potential changes in ammonia emissions from commercial pork and poultry units are generally smaller (by one order of magnitude) than potential changes from the Grazing Livestock Sector, at both regional and national sales. In some regions and scenarios the direction of change for Small Sectors response is opposite that of Grazing Livestock (Table 4.4.3).

Table 4.4.3. Baseline and potential ammonia emissions from agriculture in Wales for the three Brexit scenarios. Regional and national results are given for Commercial Pork and Poultry units, the Grazing Livestock sectors and the combined sectors. Change from the baseline is given in the last three columns.

	Ammonia emissions (Agriculture), kg (NH_3-N) ha^{-1} yr^{-1}				**Change from baseline**		
	Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	14.4	14.4	14.4	14.4	0.000	0.008	0.000
North West Wales	9.7	9.7	9.7	9.7	0.003	0.025	0.000
Mid Wales	9.7	9.8	9.8	9.7	0.070	0.049	-0.024
South East Wales	9.8	10.0	9.9	9.8	0.196	0.143	0.000
South Wales Central	6.3	6.3	6.4	6.3	0.000	0.069	0.000
South West Wales	15.0	15.0	15.0	15.0	0.039	0.053	0.000
All Wales	11.1	11.2	11.2	11.1	0.048	0.049	-0.008
	Grazing Livestock sectors (Dairy, Beef and Sheep)						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	14.4	14.8	16.7	13.8	0.38	2.32	-0.55
North West Wales	9.7	9.7	10.5	7.5	-0.03	0.75	-2.19
Mid Wales	9.7	9.8	11.0	8.3	0.01	1.30	-1.41
South East Wales	9.8	10.8	11.7	9.2	0.98	1.90	-0.55
South Wales Central	6.3	6.1	6.1	5.1	-0.17	-0.25	-1.25
South West Wales	15.0	15.0	16.0	14.0	0.05	1.04	-0.98
All Wales	11.1	11.2	12.3	9.8	0.10	1.16	-1.33
	Grazing Livestock sectors plus Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	14.4	14.8	16.7	13.8	0.38	2.32	-0.55
North West Wales	9.7	9.7	10.5	7.5	-0.03	0.77	-2.19
Mid Wales	9.7	9.8	11.1	8.3	0.08	1.35	-1.43
South East Wales	9.8	11.0	11.8	9.2	1.18	2.04	-0.55
South Wales Central	6.3	6.1	6.1	5.1	-0.17	-0.18	-1.25
South West Wales	15.0	15.0	16.1	14.0	0.08	1.09	-0.98
All Wales	11.1	11.3	12.3	9.8	0.15	1.21	-1.34
Ammonia emissions (Agriculture): Atmospheric emissions of NH_3 from agricultural activities.							

Potential increases in Small Sectors ammonia emissions are largest in South East Wales for both the EU Deal and No Deal scenarios. Potential changes in Grazing Livestock ammonia emissions are largest in North East and South East Wales for the EU Deal and No Deal scenarios (increases) and for North West, Mid, and South Central Wales for the MFTA scenario (all regions decrease) (Figure 4.4.3).

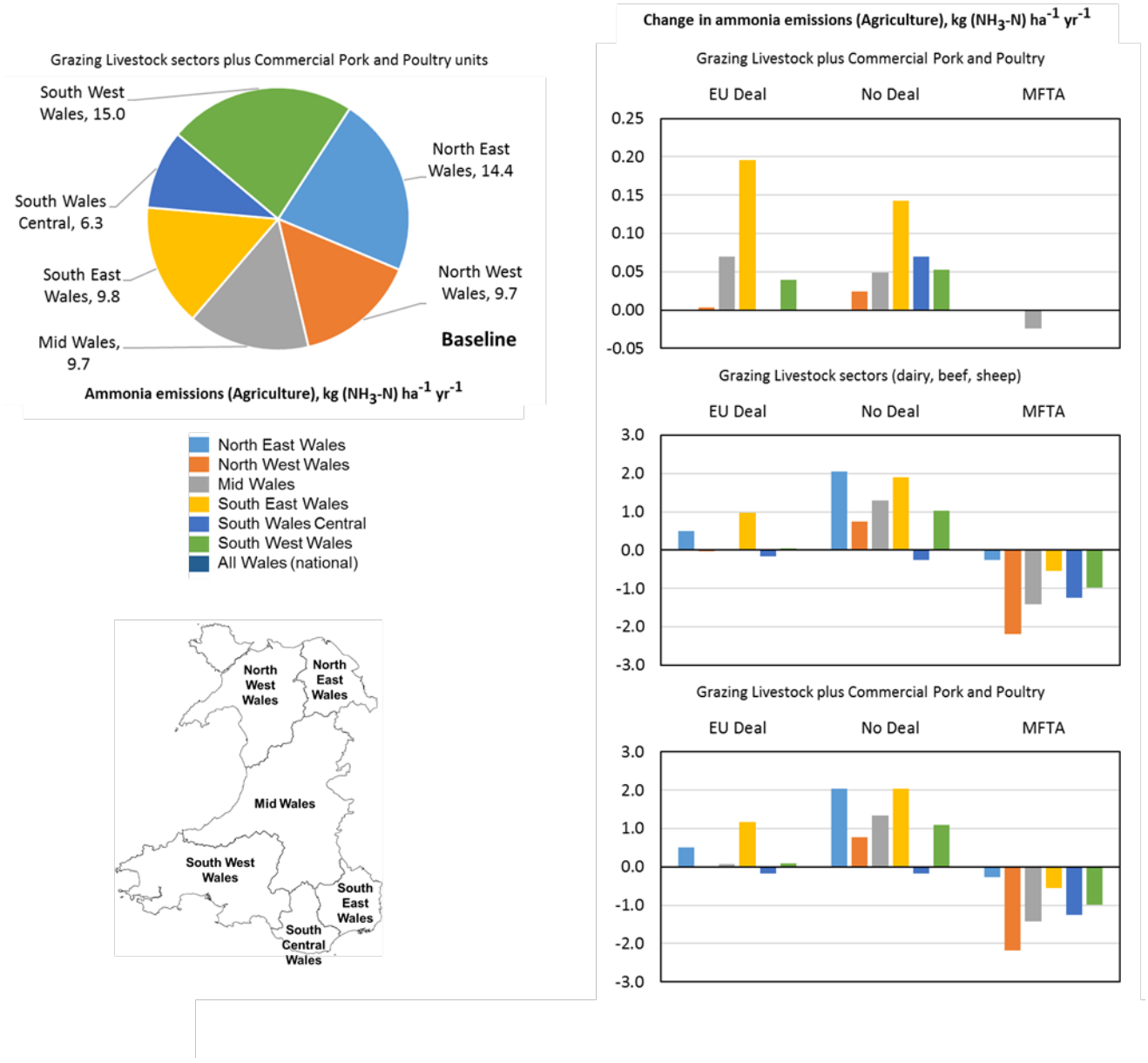


Figure 4.4.3. Baseline (pie chart) and potential changes in ammonia emissions from agriculture in Wales for the three Brexit scenarios and 6 regions (bar charts). Potential change is shown for Commercial Pork and Poultry units (upper right; note different scale), the Grazing Livestock sectors (dairy, beef and sheep; middle right) and the combined sectors (lower right).

Expressed as a percentage of baseline ammonia emissions, the potential Small Sectors increases are between 0% and 0.5% for all Wales depending on the scenario, with a maximum potential regional increase of 2% for the EU Deal in South East Wales (Table 4.4.4 and Figure 4.4.4).

Table 4.4.4. Potential regional and national changes in ammonia emissions from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline, partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Potential Change (%) in Ammonia Emissions Relative to Baseline						
	Grazing Livestock Sectors (Dairy, Beef and Sheep)			Commercial Pork and Poultry units		
NRW areas	EU Deal	No Deal	MFTA	EU Deal	No Deal	MFTA
North East Wales	2.6	15.7	-3.3	0.0	0.1	0.0
North West Wales	-0.3	7.7	-20.9	0.0	0.3	0.0
Mid Wales	0.1	13.3	-12.8	0.7	0.5	-0.2
South East Wales	10.0	17.6	-4.7	2.0	1.5	0.0
South Wales Central	-2.7	-4.1	-20.6	0.0	1.1	0.0
South West Wales	0.3	6.9	-6.2	0.3	0.4	0.0
All Wales	0.9	10.3	-10.8	0.4	0.4	-0.1
Ammonia emissions (Agriculture): Atmospheric emissions of NH_3 from agricultural activities.						

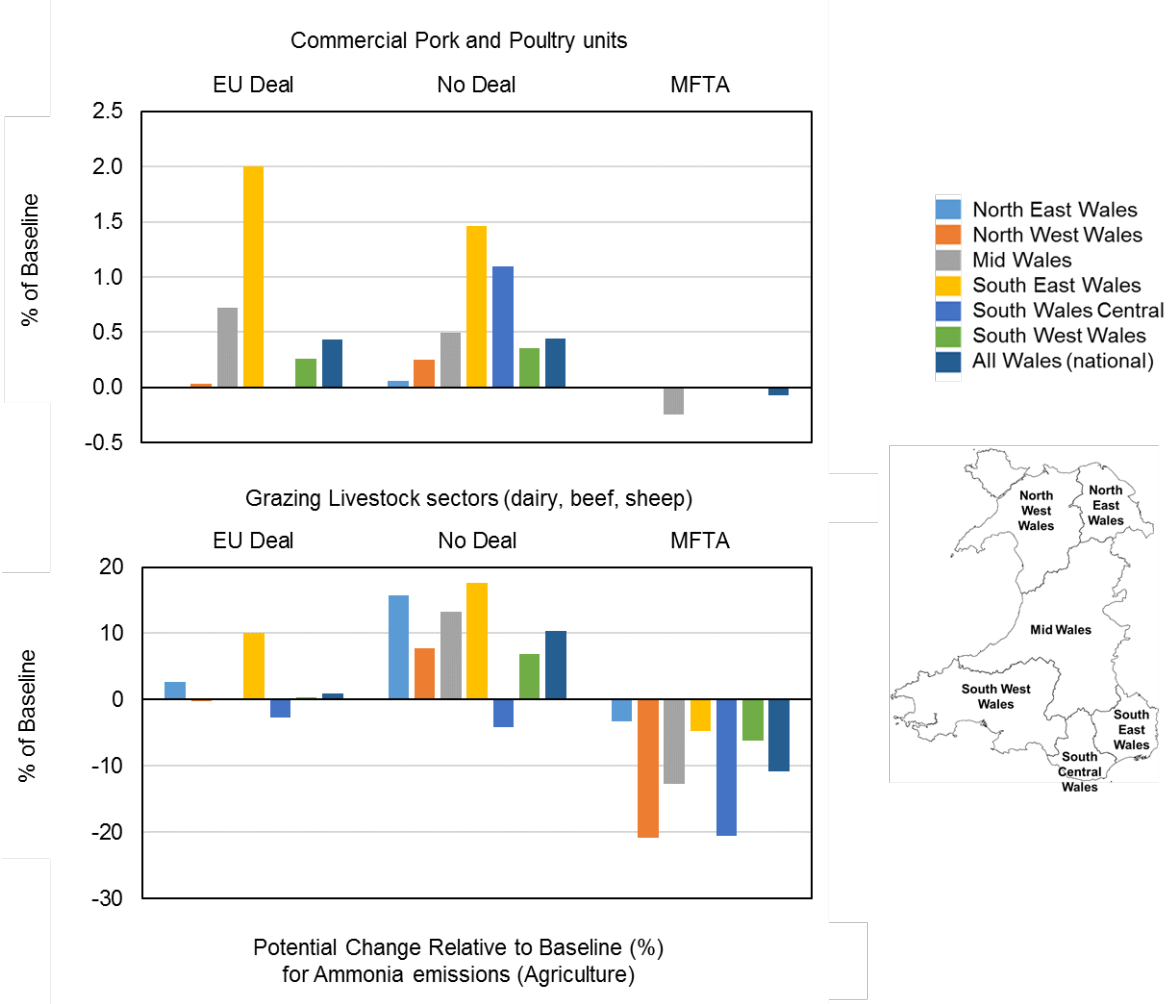


Figure 4.4.4. Potential regional and national changes in ammonia emissions from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline (note different scales), partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Water Quality – nitrogen load to waterbodies

Potential changes in nitrogen load to waterbodies from commercial pork and poultry units are generally smaller (by one order of magnitude) than potential changes from the Grazing Livestock Sector, at both regional and national sales. In some regions and scenarios the direction of change for Small Sectors response is opposite that of Grazing Livestock (Table 4.4.5).

Table 4.4.5. Baseline and potential nitrate nitrogen loads to waterbodies from agriculture in Wales for the three Brexit scenarios. Regional and national results are given for Commercial Pork and Poultry units, the Grazing Livestock sectors and the combined sectors. Change from the baseline is given in the last three columns.

	N load to waterbodies (Agriculture), kg (NO_3-N) ha^{-1} yr^{-1}				**Change from baseline**		
	Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	14.3	14.3	14.3	14.3	0.000	0.004	0.000
North West Wales	14.0	14.0	14.0	14.0	0.002	0.014	0.000
Mid Wales	14.1	14.2	14.2	14.1	0.055	0.038	-0.014
South East Wales	13.1	13.2	13.2	13.1	0.153	0.109	0.000
South Wales Central	9.8	9.8	9.8	9.8	0.000	0.053	0.000
South West Wales	18.3	18.3	18.3	18.3	0.028	0.037	0.000
All Wales	14.7	14.8	14.8	14.7	0.037	0.036	-0.005
	Grazing Livestock sectors (Dairy, Beef and Sheep)						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	14.3	14.5	15.7	13.7	0.16	1.37	-0.62
North West Wales	14.0	13.7	13.7	11.2	-0.22	-0.24	-2.74
Mid Wales	14.1	14.0	14.5	12.4	-0.07	0.41	-1.68
South East Wales	13.1	13.9	14.6	12.5	0.82	1.50	-0.57
South Wales Central	9.8	9.6	9.3	8.4	-0.24	-0.45	-1.43
South West Wales	18.3	18.3	19.0	17.3	0.00	0.70	-1.00
All Wales	14.7	14.7	15.2	13.2	-0.01	0.45	-1.56
	Grazing Livestock sectors plus Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	14.3	14.5	15.7	13.7	0.16	1.38	-0.62
North West Wales	14.0	13.7	13.7	11.2	-0.22	-0.23	-2.74
Mid Wales	14.1	14.1	14.6	12.4	-0.02	0.44	-1.70
South East Wales	13.1	14.1	14.7	12.5	0.97	1.61	-0.57
South Wales Central	9.8	9.6	9.4	8.4	-0.24	-0.40	-1.43
South West Wales	18.3	18.3	19.0	17.3	0.03	0.74	-1.00
All Wales	14.7	14.7	15.2	13.2	0.03	0.49	-1.56

N load to waterbodies (Agriculture): Runoff of NO_3-N from fertilizer and manure.

Potential increases in Small Sectors N load to waterbodies are largest in South East Wales for both the EU Deal and No Deal scenarios. Potential changes in Grazing Livestock N loads to waterbodies show the largest increases in South East and South Central Wales (for the EU Deal and No Deal scenarios) while all regions show potential decreases for the MFTA scenario (Figure 4.4.5).

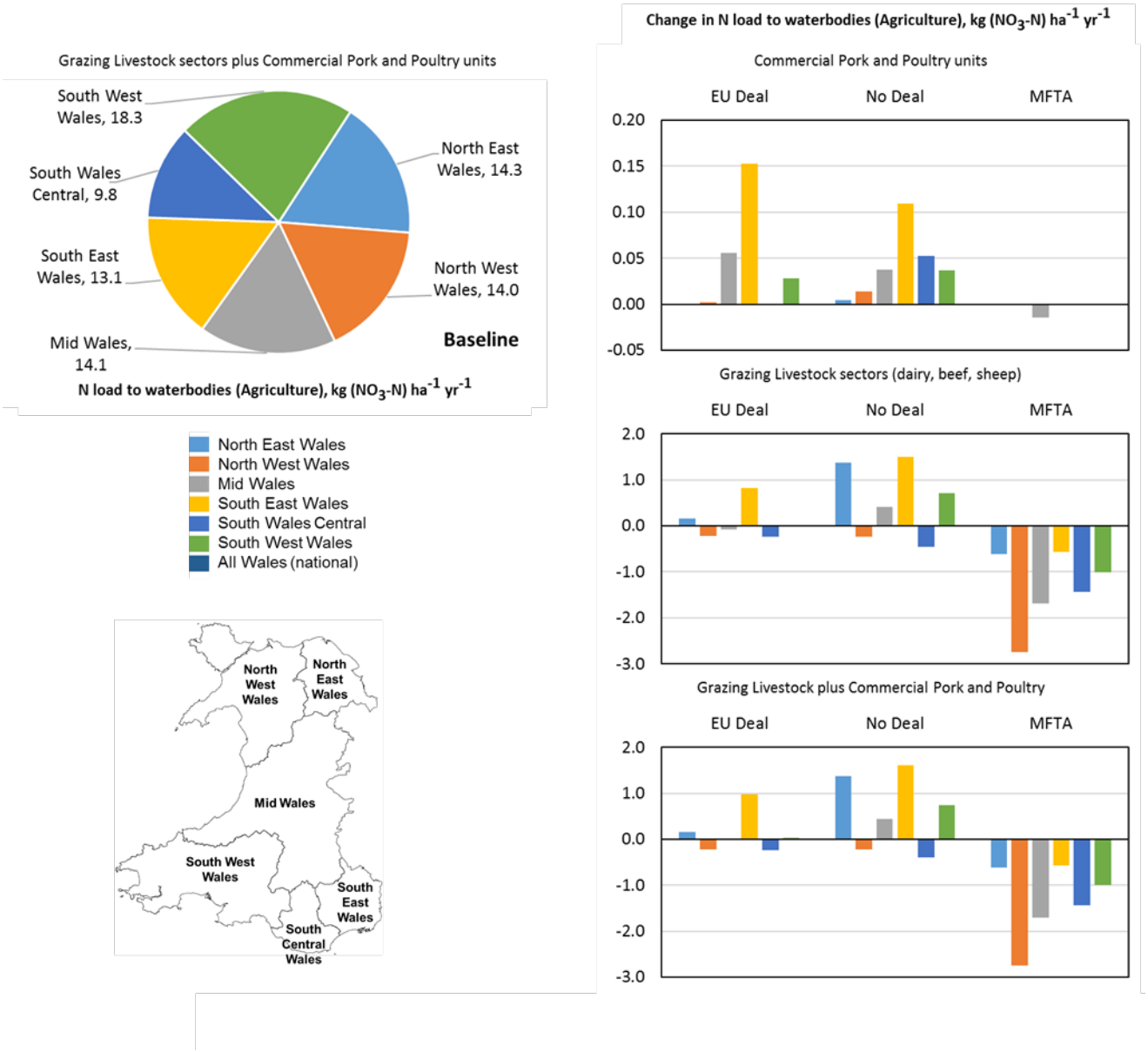


Figure 4.4.5. Baseline (pie chart) and potential changes in nitrogen loads to waterbodies from agriculture in Wales for the three Brexit scenarios and 6 regions (bar charts). Potential change is shown for Commercial Pork and Poultry units (upper right; note different scale), the Grazing Livestock sectors (dairy, beef and sheep; middle right) and the combined sectors (lower right).

Expressed as a percentage of baseline N load to waterbodies, the potential Small Sectors increases are between 0% and 0.3% for all Wales depending on the scenario, with maximum a potential regional increase of more than 1.1% for the EU Deal in South East Wales (Table 4.4.6 and Figure 4.4.6).

Table 4.4.6. Potential regional and national changes in nitrate nitrogen loads to waterbodies from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline, partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Potential change in N load to waterbodies (Agriculture) relative to baseline (%)						
	Grazing Livestock Sectors (Dairy, Beef and Sheep)			Commercial Pork and Poultry units		
NRW areas	EU Deal	No Deal	MFTA	EU Deal	No Deal	MFTA
North East Wales	1.1	9.5	-4.0	0.0	0.0	0.0
North West Wales	-1.6	-1.8	-20.0	0.0	0.1	0.0
Mid Wales	-0.5	2.9	-11.6	0.4	0.3	-0.1
South East Wales	6.3	10.8	-3.9	1.2	0.8	0.0
South Wales Central	-2.4	-4.8	-15.3	0.0	0.5	0.0
South West Wales	0.0	3.9	-5.3	0.2	0.2	0.0
All Wales	-0.1	3.1	-10.3	0.3	0.2	0.0
N load to waterbodies (Agriculture): Runoff of NO_3-N from fertilizer and manure.						

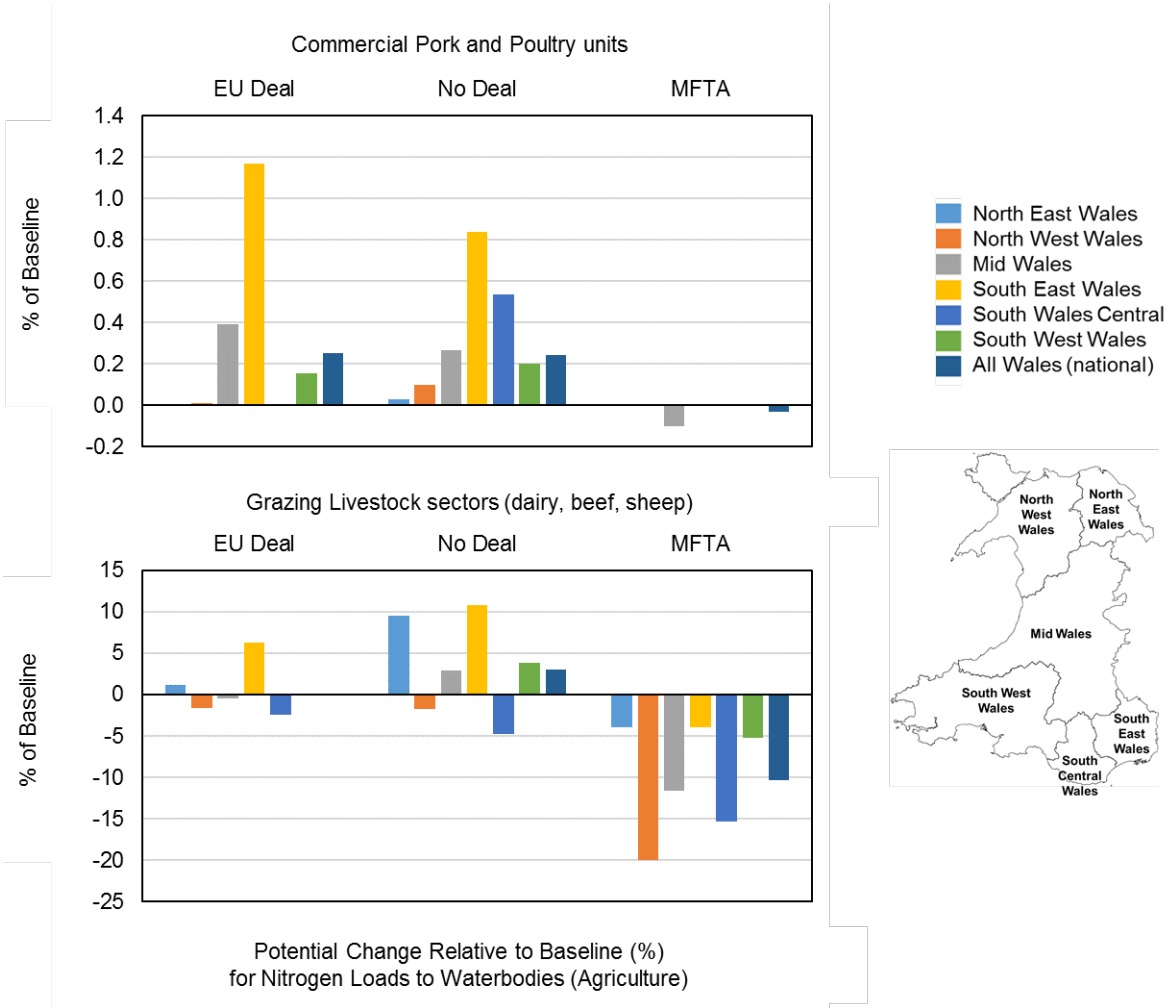


Figure 4.4.6. Potential regional and national changes in nitrogen loads to waterbodies from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline (note different scales), partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Water Quality – phosphorous load to waterbodies

Potential changes in phosphorous load to waterbodies from commercial pork and poultry units are generally smaller (by one to two orders of magnitude) than potential changes from the Grazing Livestock Sector, at both regional and national sales. In some regions and scenarios the direction of change for Small Sectors response is opposite that of Grazing Livestock (Table 4.4.7).

Table 4.4.7. Baseline and potential total phosphorous loads to waterbodies from agriculture in Wales for the three Brexit scenarios. Regional and national results are given for Commercial Pork and Poultry units, the Grazing Livestock sectors and the combined sectors. Change from the baseline is given in the last three columns.

	P load to waterbodies (Agriculture), kg (Total-P) ha^{-1} yr^{-1}				**Change from baseline**		
	Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	0.35	0.35	0.35	0.35	0.000	0.000	0.000
North West Wales	0.53	0.53	0.53	0.53	0.000	0.000	0.000
Mid Wales	0.44	0.44	0.44	0.44	0.000	0.000	0.000
South East Wales	0.20	0.20	0.20	0.20	0.001	0.001	0.000
South Wales Central	0.27	0.27	0.27	0.27	0.000	0.001	0.000
South West Wales	0.45	0.45	0.45	0.45	0.000	0.001	0.000
All Wales	0.43	0.43	0.43	0.43	0.000	0.000	0.000
	Grazing Livestock sectors (Dairy, Beef and Sheep)						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	0.35	0.35	0.37	0.34	0.002	0.019	-0.011
North West Wales	0.53	0.51	0.48	0.41	-0.023	-0.054	-0.126
Mid Wales	0.44	0.43	0.43	0.38	-0.008	-0.009	-0.063
South East Wales	0.20	0.20	0.20	0.19	0.002	0.004	-0.012
South Wales Central	0.27	0.26	0.25	0.23	-0.010	-0.017	-0.043
South West Wales	0.45	0.44	0.45	0.42	-0.005	0.003	-0.027
All Wales	0.43	0.42	0.41	0.37	-0.009	-0.013	-0.058
	Grazing Livestock sectors plus Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	0.35	0.35	0.37	0.34	0.002	0.019	-0.011
North West Wales	0.53	0.51	0.48	0.41	-0.023	-0.053	-0.126
Mid Wales	0.44	0.43	0.43	0.38	-0.008	-0.009	-0.063
South East Wales	0.20	0.20	0.20	0.19	0.003	0.004	-0.012
South Wales Central	0.27	0.26	0.25	0.23	-0.010	-0.017	-0.043
South West Wales	0.45	0.44	0.45	0.42	-0.004	0.004	-0.027
All Wales	0.43	0.42	0.41	0.37	-0.009	-0.012	-0.059
P load to waterbodies (Agriculture): Runoff of Total P from fertilizer and manure.							

Potential increases in Small Sectors P load to waterbodies are largest in South East and South West Wales for the EU Deal scenario, and in South East, South West and South Central Wales for the No Deal scenario. Potential changes in Grazing Livestock P loads to waterbodies are decreases under all three scenarios, with the largest decreases in North West Wales (for the No Deal and MFTA scenarios). (Figure 4.4.7).

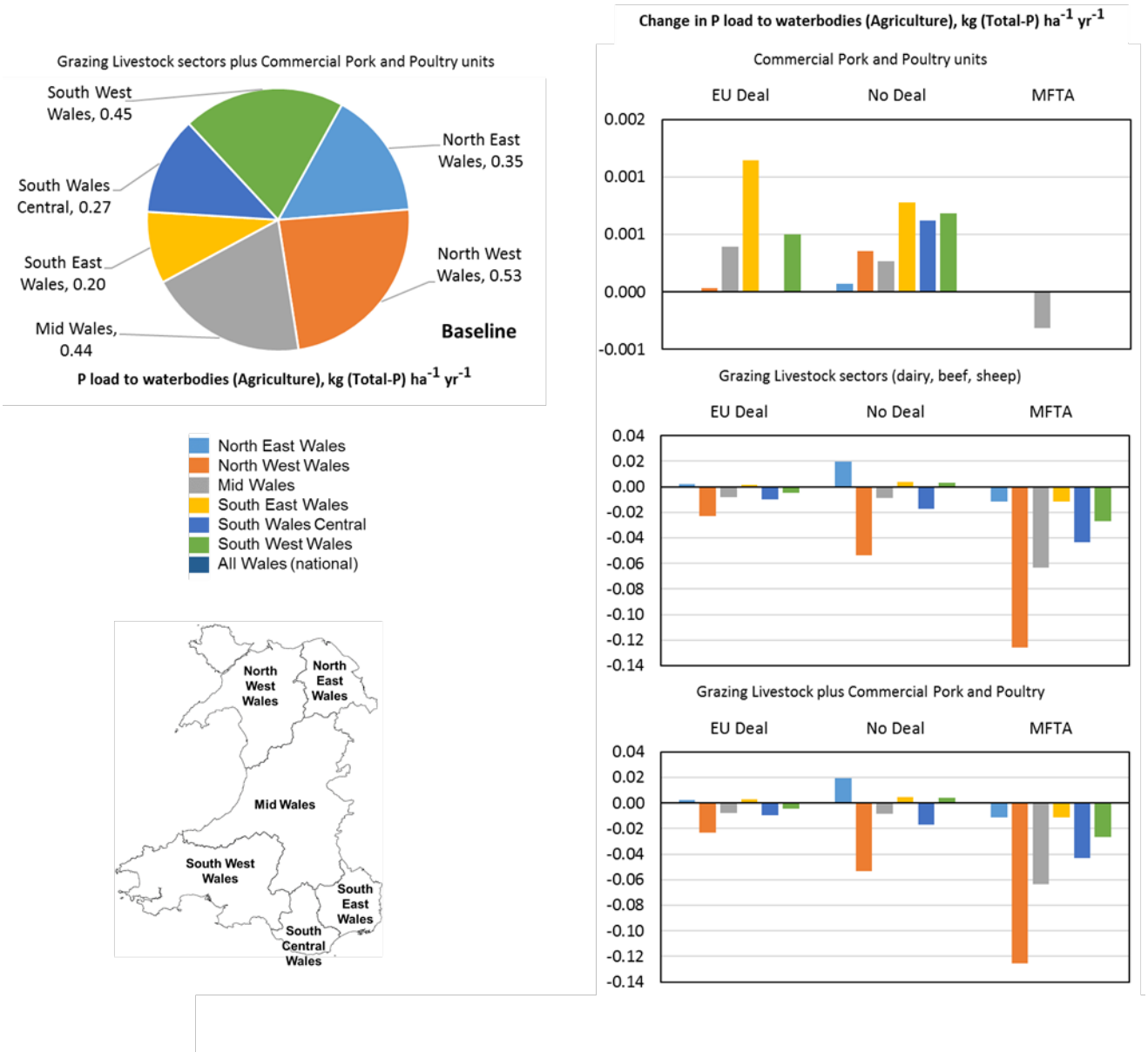


Figure 4.4.7. Baseline (pie chart) and potential changes in phosphorous loads to waterbodies from agriculture in Wales for the three Brexit scenarios and 6 regions (bar charts). Potential change is shown for Commercial Pork and Poultry units (upper right; note different scale), the Grazing Livestock sectors (dairy, beef and sheep; middle right) and the combined sectors (lower right).

Expressed as a percentage of baseline P load to waterbodies, the potential Small Sectors increases are between 0% and 0.1% for all Wales depending on the scenario, with a maximum potential regional increase of more than 0.5% for the EU Deal in South East Wales (Table 4.4.8 and Figure 4.4.8).

Table 4.4.8. Potential regional and national changes in total phosphorous loads to waterbodies from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline, partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Potential change in P load to waterbodies (Agriculture) relative to baseline (%)						
	Grazing Livestock Sectors (Dairy, Beef and Sheep)			Commercial Pork and Poultry units		
NRW areas	EU Deal	No Deal	MFTA	EU Deal	No Deal	MFTA
North East Wales	0.6	5.5	-3.1	0.0	0.0	0.0
North West Wales	-4.3	-10.5	-26.3	0.0	0.1	0.0
Mid Wales	-1.9	-2.1	-14.7	0.1	0.1	-0.1
South East Wales	0.9	1.8	-5.7	0.6	0.4	0.0
South Wales Central	-3.6	-6.7	-17.0	0.0	0.2	0.0
South West Wales	-1.1	0.7	-5.9	0.1	0.2	0.0
All Wales	-2.1	-3.1	-14.2	0.1	0.1	0.0
P load to waterbodies (Agriculture): Runoff of Total P from fertilizer and manure.						

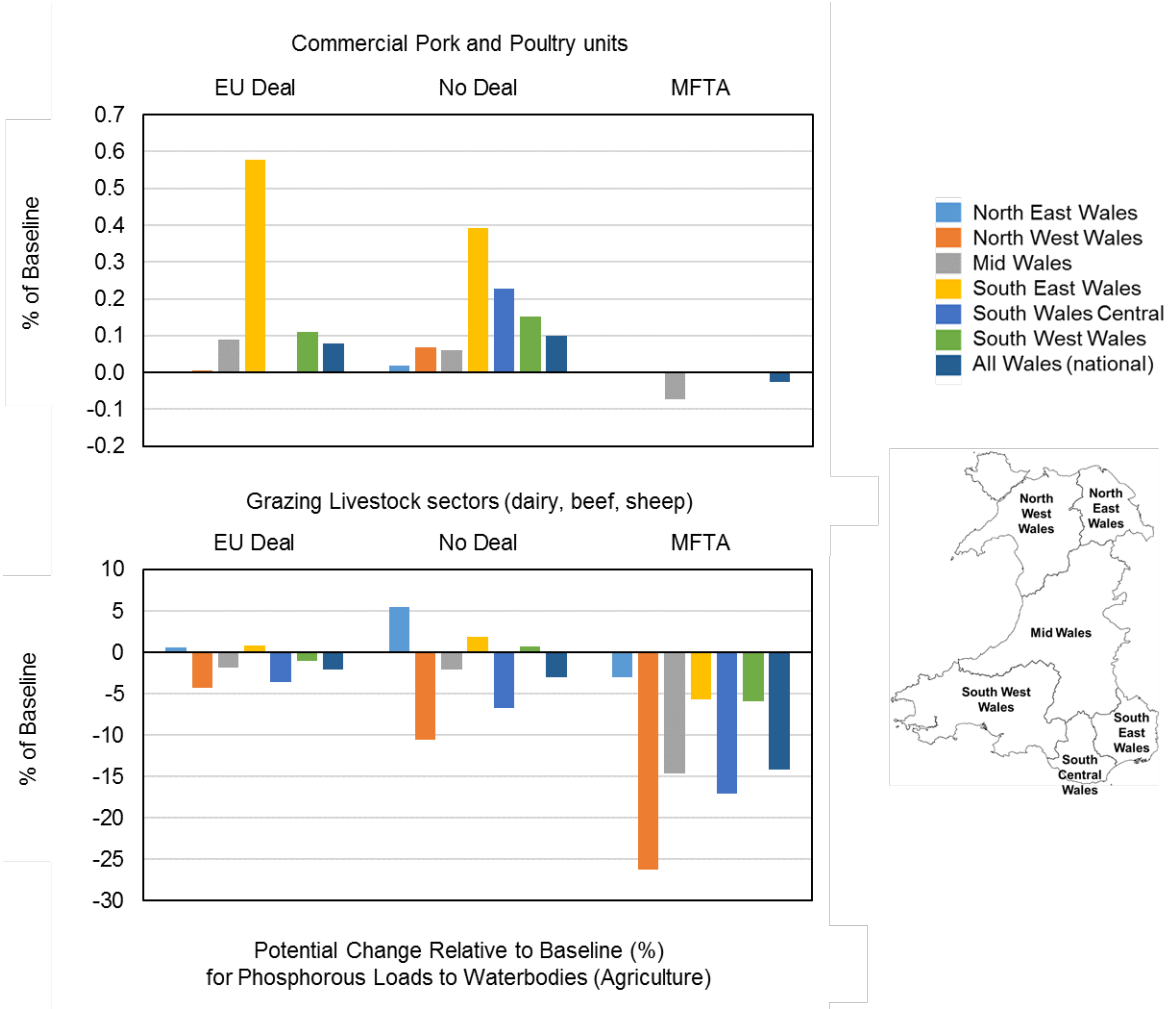


Figure 4.4.8. Potential regional and national changes in phosphorous loads to waterbodies from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline (note different scales), partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Water Quality – sediment load to waterbodies

Potential changes in sediment load (suspended solids) to waterbodies from new commercial pork and poultry units are zero for all scenarios (Table 4.4.9). This results from the assumption that installation of commercial pig or poultry units on an existing farm does not alter the activities on the farm except for additional manure being spread and air borne emissions. Emissions do not affect soil erosion, and the additional manure is assumed to be applied using on-going fertilization practices on the farm, so no additional soil disturbances are calculated.

Table 4.4.9. Baseline and potential sediment loads to waterbodies from agriculture in Wales for the three Brexit scenarios. Regional and national results are given for Commercial Pork and Poultry units, the Grazing Livestock sectors and the combined sectors. Change from the baseline is given in the last three columns.

	Sediment load to waterbodies (Agriculture), kg (SuspSolids) ha^{-1} yr^{-1}				**Change from baseline**		
	Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	95	95	95	95	0.00	0.00	0.00
North West Wales	199	199	199	199	0.00	0.00	0.00
Mid Wales	162	162	162	162	0.00	0.00	0.00
South East Wales	81	81	81	81	0.00	0.00	0.00
South Wales Central	117	117	117	117	0.00	0.00	0.00
South West Wales	169	169	169	169	0.00	0.00	0.00
All Wales	157	157	157	157	0.00	0.00	0.00
	Grazing Livestock sectors (Dairy, Beef and Sheep)						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	95	96	97	95	0.5	2.0	-0.3
North West Wales	199	194	188	178	-4.9	-10.6	-20.7
Mid Wales	162	160	161	154	-1.7	-0.8	-8.1
South East Wales	81	81	81	81	-0.1	0.1	-0.4
South Wales Central	117	116	117	116	-0.9	0.1	-0.8
South West Wales	169	168	169	168	-1.0	0.6	-1.3
All Wales	157	155	155	149	-1.9	-2.2	-7.5
	Grazing Livestock sectors plus Commercial Pork and Poultry units						
NRW areas	**Baseline**	**EU Deal**	**No Deal**	**MFTA**	**EU Deal**	**No Deal**	**MFTA**
North East Wales	95	96	97	95	0.5	2.0	-0.3
North West Wales	199	194	188	178	-4.9	-10.6	-20.7
Mid Wales	162	160	161	154	-1.7	-0.8	-8.1
South East Wales	81	81	81	81	-0.1	0.1	-0.4
South Wales Central	117	116	117	116	-0.9	0.1	-0.8
South West Wales	169	168	169	168	-1.0	0.6	-1.3
All Wales	157	155	155	149	-1.9	-2.2	-7.5
Sediment load to waterbodies (Agriculture): Runoff of suspended solids from agricultural activities.							

There are no potential changes in sediment loads to waterbodies from the Small Sectors. Potential changes in Grazing Livestock sediment loads to waterbodies remain essentially constant or decline under all scenarios, with the largest decreases in North West Wales for all three scenarios. (Figure 4.4.9).

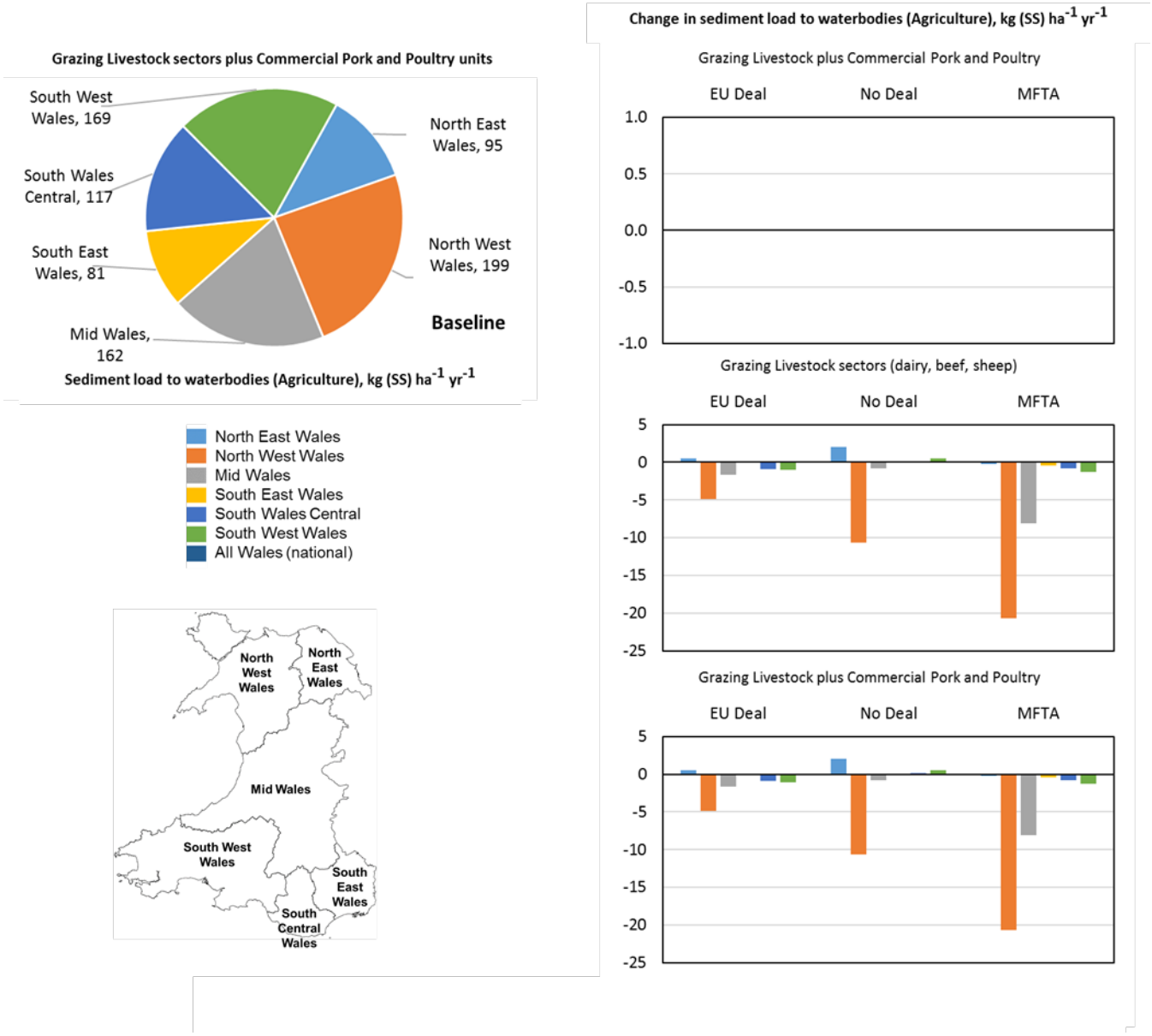


Figure 4.4.9. Baseline (pie chart) and potential changes in sediment loads to waterbodies from agriculture in Wales for the three Brexit scenarios and 6 regions (bar charts). Potential change is shown for Commercial Pork and Poultry units (upper right; note different scale), the Grazing Livestock sectors (dairy, beef and sheep; middle right) and the combined sectors (lower right).

Expressed as a percentage of baseline sediment load to waterbodies, the potential Grazing Livestock sector decreases are between 1% and 5% for all Wales depending on the scenario, with maximum a potential regional decrease of more than 10% for the MFTA Deal in North West Wales (Table 4.4.10 and Figure 4.4.10).

Table 4.4.10. Potential regional and national changes in sediment loads to waterbodies from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline, partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

Potential change in Sediment load to waterbodies (Agriculture) relative to baseline (%)						
	Grazing Livestock Sectors (Dairy, Beef and Sheep)			Commercial Pork and Poultry units		
NRW areas	EU Deal	No Deal	MFTA	EU Deal	No Deal	MFTA
North East Wales	0.5	2.1	-0.3	0.0	0.0	0.0
North West Wales	-2.5	-5.5	-11.0	0.0	0.0	0.0
Mid Wales	-1.0	-0.5	-5.0	0.0	0.0	0.0
South East Wales	-0.1	0.1	-0.5	0.0	0.0	0.0
South Wales Central	-0.8	0.1	-0.7	0.0	0.0	0.0
South West Wales	-0.6	0.3	-0.8	0.0	0.0	0.0
All Wales	-1.2	-1.4	-4.9	0.0	0.0	0.0
Sediment load to waterbodies (Agriculture): Runoff of suspended solids from agricultural activities.						

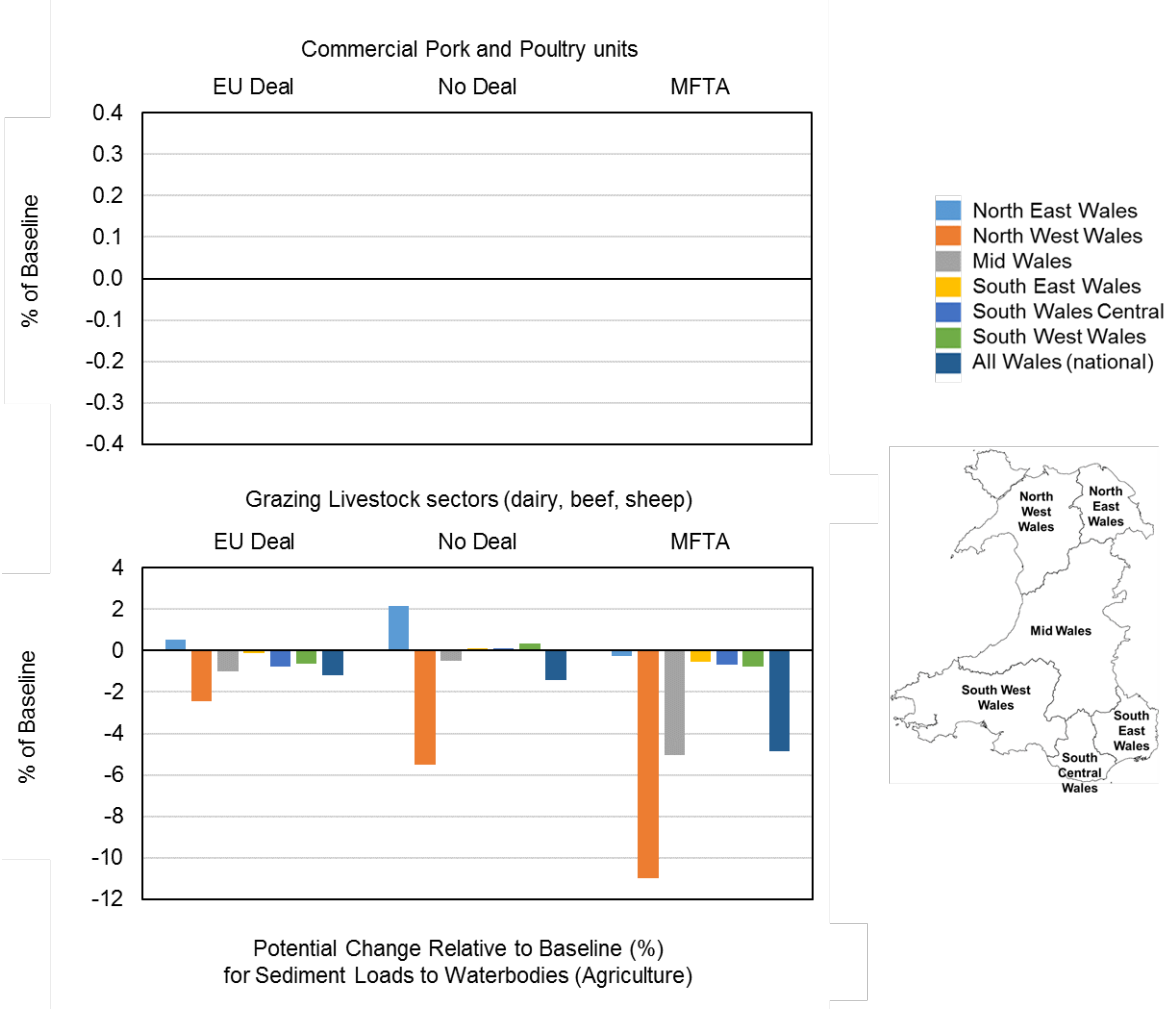


Figure 4.4.10. Potential regional and national changes in sediment loads to waterbodies from agriculture in Wales for the three Brexit scenarios, expressed as percent of baseline (note different scales), partitioned between the Grazing Livestock sectors (dairy, sheep, beef) and Commercial Pork and Poultry units.

5 Further Discussion

5.1 Estimating Brexit effects on farm labour in Wales

The potential changes in the Grazing Livestock sectors and the Small Sectors in response to the three Brexit scenarios have been analysed above with respect to potential effects on environmental issues related to climate mitigation, air quality and diffuse pollution. However, the potential changes in these sectors are also expected to affect socio-economic aspects of agriculture in Wales. One indicator of these societal effects is the potential change in agricultural jobs under each Brexit scenario. The Quick Start results above can be used to provide a high-level estimate of the potential effects of the Brexit scenarios on agricultural labour in Wales using agricultural Standard Labour Requirements (SLR's).

This analysis of potential Brexit effects on agricultural labour in Wales is included in this report as Further Discussion (rather than being included in the Results section), because these analyses were not a primary objective of the Quick Start Project. It is important to note that the Quick Start approach was not intended for detailed socio-economic analyses. Quick Start was developed to examine current physical and management characteristics of farms in Wales and how these constrain and shape potential responses to different Brexit trade scenarios.

Nonetheless, applying the same aggregate labour statistics as used in the Farm Business Surveys in Wales (see https://www.aber.ac.uk/en/ibers/research-and-enterprise/fbs/), the potential changes in animal numbers and agricultural land use generated in the Quick Start analyses can be translated to high-level estimates of potential changes in agricultural labour.

Standard Labour Requirements, FTEs and Jobs

Information about individual labour usage by different enterprises on each farm is not always available and can vary across farms, for example depending on the extent to which the farmer chose to substitute machinery for labour. Standard figures are therefore used for the labour requirements associated with different livestock and crop types. Standard Labour Requirements (SLR) represent the notional amount of labour required by a holding to carry out all of its agricultural activity and is also used as a measure of farm size.

Standard Labour Requirements are derived at an aggregate level for each agricultural activity. The total SLR for each farm is calculated by multiplying its crop areas and livestock numbers by the appropriate SLR coefficients and then summing the results for all agricultural activity on that farm. In Welsh farm statistics, one SLR equals one full time effort (FTE) of 1,900 working hours per year. The SLR coefficients are based on values agreed in 2010 (FBS 2014).

The total farm FTE is only a notional measure of farm labour, and is usually numerically smaller than total farm jobs due to the fact that jobs totals are usually expressed as headcounts (i.e. a part-time worker employed for a year would equate to less than one FTE but would contribute one full headcount to a jobs total). Potential net changes in farm labour expressed as FTE's will usually translate into larger net changes in farm jobs, if both full and part time employees are counted.

SLR coefficients are used in the June Agricultural Survey (JAS) for Wales to derive the labour size of holdings reported in the survey results. The 2017 JAS forms the

baseline for the Quick Start analyses. In keeping with the approach used in Quick Start, labour requirements aggregated to Robust Farm Type (RFT) are used to characterize baseline farm labour and farm area in Wales. This baseline is in turn used to estimate the potential effects of the Brexit trade scenarios on future agricultural farm labour and farm area in Wales.

5.2 Baseline agricultural labour in Wales

The data from the 2017 June Agricultural Survey in Wales defined the baseline for Quick Start and were used to provide a comprehensive picture of current farm practice in Wales. On the advice of the SWG, 'Part Time Farms' using less than 1 full-time equivalent worker (FTE) were not included in the Quick Start analyses. Even though Part Time Farms account for 37% of agricultural land in Wales, they manage only 10% of livestock LU's, and contribute only 13% of economic value (as Standard Output). The SWG did not consider that Part Time Farms would be influenced in a predictable manner (if at all) by the Brexit trade scenarios. The quick Start analyses only considered "Full Time Farms" utilizing 1 or more FTE per farm.

The largest amount of agricultural labour on full time farms in Wales (as measured by FTE) is in the LFA grazing sector (62 % of total farm labour), followed by the dairy sector (24 % of total farm labour) (Table 5.2.1).These two RFT's also manage the majority of agricultural land on full time farms in Wales (69% and 17% respectively). Both facts were underlying reasons for focussing on the Grazing Livestock sectors in Quick Start Phase 1.

Table 5.2.1. Farm labour and farm area characteristics for full time (> 1 FTE) farms in Wales, disaggregated by Robust Farm Type (RFT). From the 2017 June Agricultural Survey for Wales.

Labour Size (FTE) and Area Size (ha) of Full Time Farms in Wales June Agricultural Survey Wales, 2017				
Type	**Description**	**Number of Farms**	**Total Agricultural Labour (FTE)**	**Total Agricultural Area (ha)**
RFT-1	Cereals	108	309	28,725
RFT-2	General Cropping	68	285	10,286
RFT-3	Horticulture	71	533	2,426
RFT-4	Pigs			
RFT-5	Poultry			
RFT-6	Dairy	1,502	7,201	178,638
RFT-7	LFA Grazing	5,282	18,446	711,210
RFT-8	Lowland Grazing	744	1,995	65,514
RFT-9	Mixed Crops-Animals	270	1,019	38,209
RFT-10	Others	498	1,063	31,359
Total for Full Time Farms in Wales		8,543	30,851	1,066,367
Part Time farms with < 1 FTE per farm not included. Pigs and Poultry analysed elsewhere.				

Due to the large area and number of farms included in the LFA grazing category (RFT-7), this category was sub-divided using Main Farm Type (MFT) categories to separate the LFA (Less Favourable Area) into Disadvantaged Areas (DA) and Severely Disadvantaged Areas (SDA), and to identify sheep specialists, beef specialists and mixed grazers in each area (see section 2.3.1). This separation on the landscape of Wales provides finer spatial resolution for mapping potential agricultural land use change, and allows finer resolution in analysing farm labour requirements in the Grazing Livestock sectors.

The spatially expanded Full Time RFT's were then combined into the Grazing Livestock sectors of interest to SWG: Dairy, SDA Beef, SDA Sheep and Grazers. These categories comprise the "Quick Start Robust Farm Types" (QS RFT's). The national and regional farm labour and farm area characteristics of the QS RFT's are shown in Figure 5.2.1.

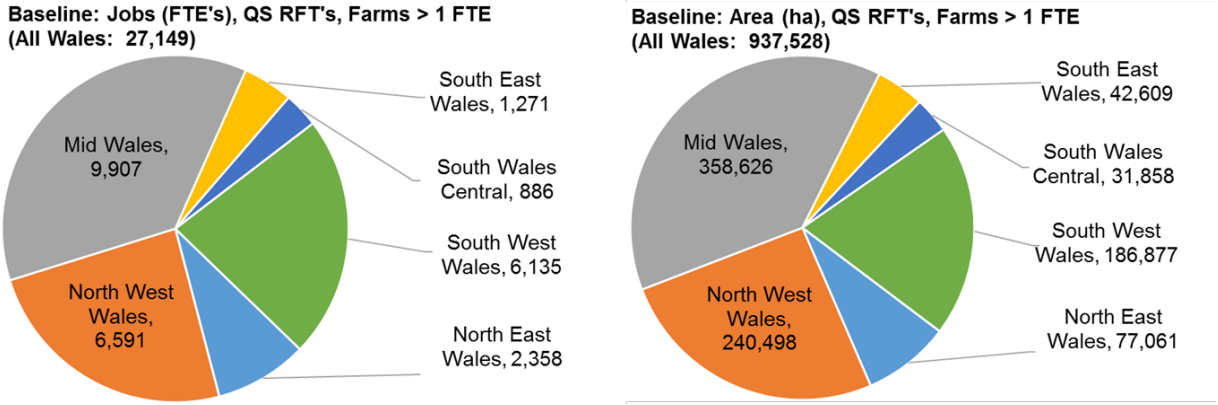


Figure 5.2.1. National and regional baseline farm labour and farm area characteristics for the Grazing Livestock sectors in Wales. From the 2017 June Agricultural Survey for Wales.

The national and regional farm labour and farm area characteristics of the QS RFT's can be broken down into the four Grazing Livestock sectors: dairy, beef, sheep and grazers (Tables 5.2.2 and 5.2.3). This format will be used in the analysis of potential changes in agricultural labour in Wales as a result of the Brexit scenarios.

Table 5.2.2. National and regional baseline farm labour characteristics for full time (> 1 FTE) Grazing Livestock animal sectors (RFT's 6, 7 and 8) in Wales. From the 2017 June Agricultural Survey for Wales.

Baseline	Total Agricultural Labour (FTE) Quick Start Full Time Grazing Livestock Sectors				
	Dairy	Grazers	SDA Beef	SDA Sheep	Total
North East Wales	1,009	795	48	507	2,358
North West Wales	802	2,286	114	3,389	6,591
Mid Wales	1,393	2,892	156	5,466	9,907
South East Wales	437	632	16	186	1,271

South Wales Central	162	342	23	360	886
South West Wales	3,509	1,666	42	918	6,135
All Wales	7,312	8,613	398	10,826	27,149
Part Time farms with < 1 FTE per farm are not included.					

Table 5.2.3. National and regional baseline farm area characteristics for full time (> 1 FTE) Grazing Livestock animal sectors (RFT's 6, 7 and 8) in Wales. From the 2017 June Agricultural Survey for Wales.

Baseline	**Total Agricultural Area (ha) Quick Start Full Time Grazing Livestock Sectors**				
	Dairy	**Grazers**	**SDA Beef**	**SDA Sheep**	**Total**
North East Wales	25,019	29,887	3,126	19,029	77,061
North West Wales	19,895	85,904	7,465	127,234	240,498
Mid Wales	34,560	108,655	10,240	205,170	358,626
South East Wales	10,849	23,732	1,043	6,986	42,609
South Wales Central	4,018	12,837	1,507	13,496	31,858
South West Wales	87,041	62,584	2,776	34,475	186,877
All Wales	181,382	323,599	26,156	406,390	937,528
Part Time farms with < 1 FTE per farm are not included.					

5.3 Grazing Livestock sectors

Potential changes in farm labour for each scenario are estimated from potential net changes in agriculture land use for each Brexit scenario as determined in Quick Start Phase 1 (see section 3.2 for a summary).

Potential land taken out of agriculture (Figure 5.3.1) produces a reduction in farm labour required.

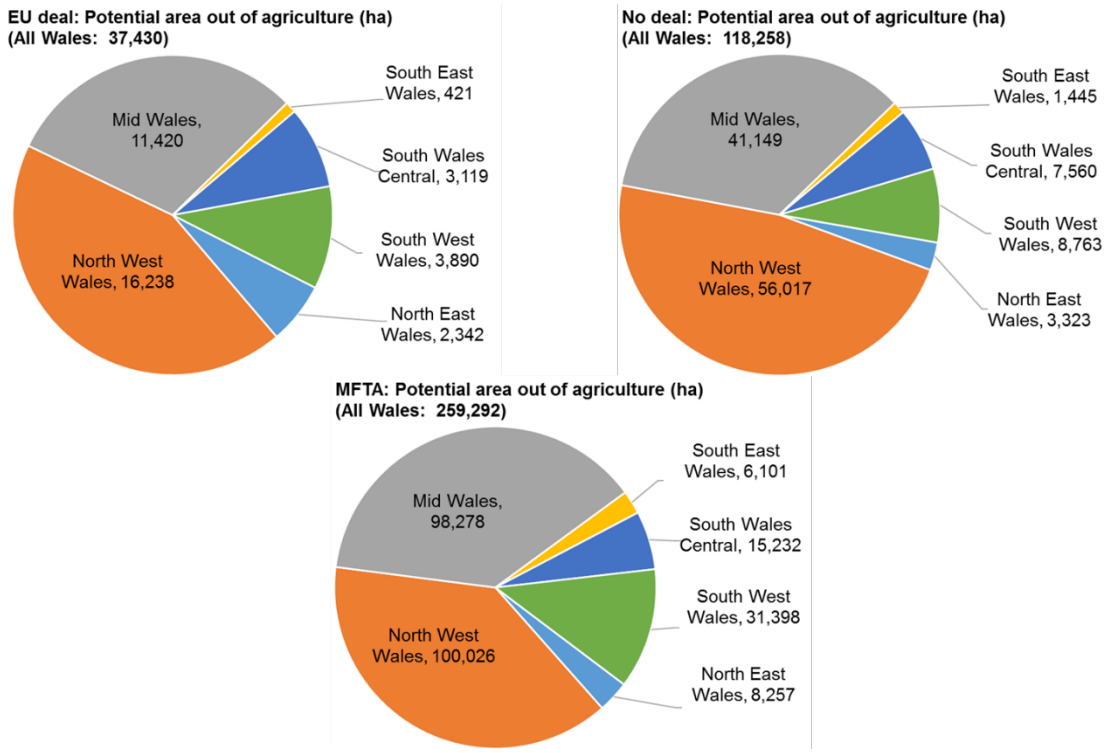


Figure 5.3.1.Potential changes in national and regional farm areas in the combined Grazing Livestock sectors resulting from changes to non-agricultural use for each Brexit scenario.

Potential Grazing Livestock changes between sectors or RFT's (e.g. Grazers changing to Dairy) also occur in the Brexit trade scenarios (Figure 5.3.2). The type of change, from labour intensive to less intensive (or vice versa) will determine if the potential land use change results in a larger or smaller farm labour requirement.

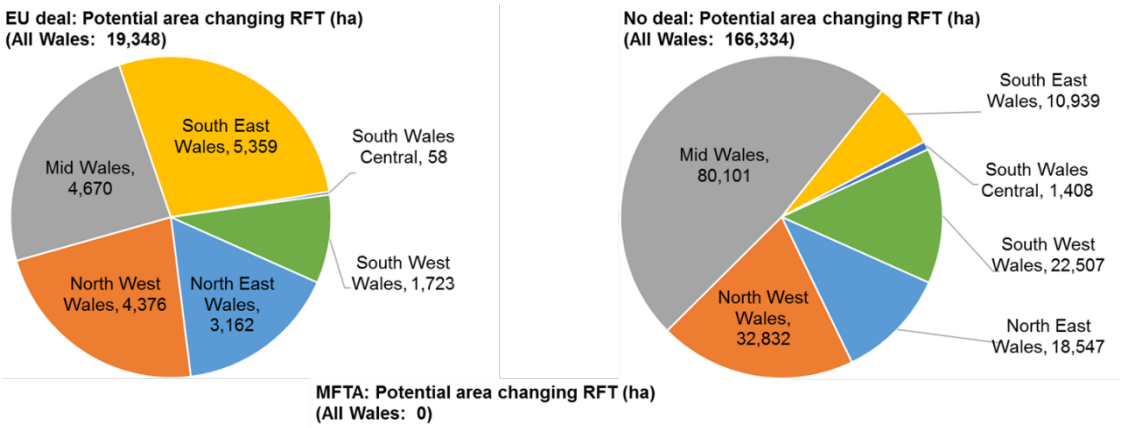


Figure 5.3.2.Potential changes in national and regional farm areas in the combined Grazing Livestock sectors resulting from changes between sectors (RFTs) for each Brexit scenario.

The potential land use changes in each Grazing Livestock sector (to another sector or to non-agricultural use) are combined and the baseline average FTE per hectare of land for farms in the appropriate sector(s) are used to calculate the potential gain or loss of farm labour resulting from the land use changes (Figure 5.3.3).

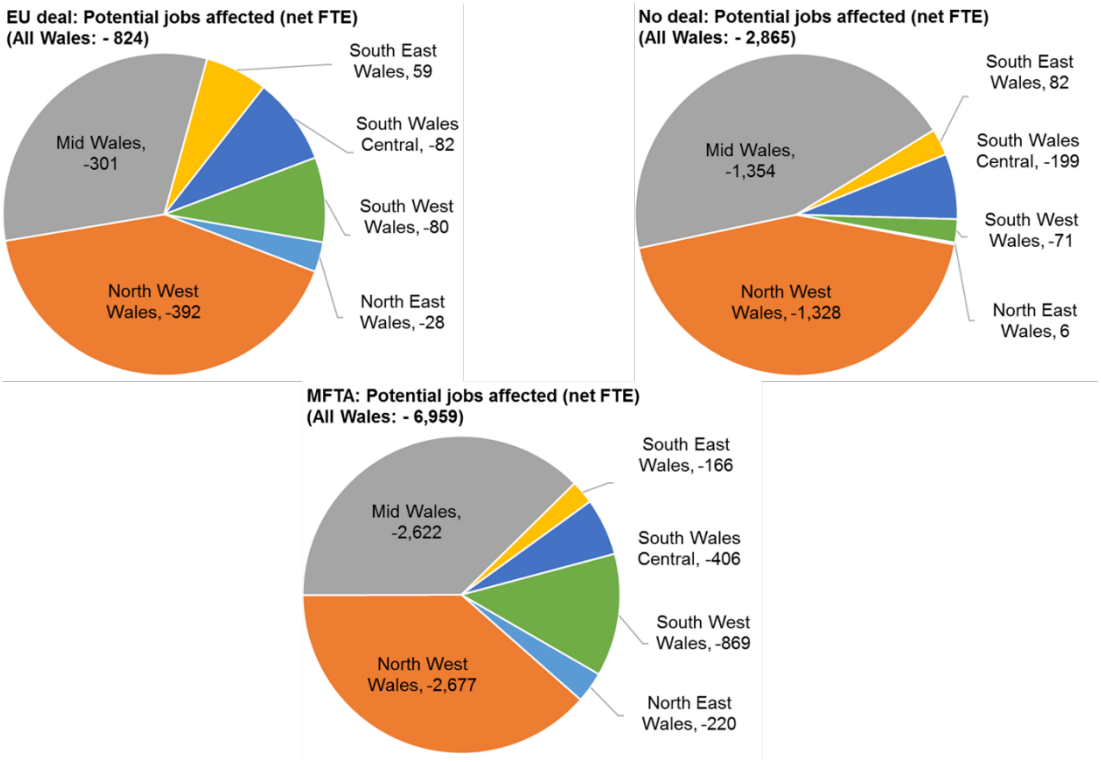


Figure 5.3.3.Potential changes in national and regional farm labour in the combined Grazing Livestock sectors resulting from sector land use changes for each Brexit scenario.

5.3.1 Potential farm area changes by sector

Potential net changes in agricultural land use in the Grazing Livestock sectors are negative (net land to non-agricultural uses) for all three Brexit Trade scenarios. Land out of agriculture is greatest for the MFTA scenario (nearly 260,000 ha), least for the EU Deal scenario (over 37,000 ha), with the No Deal scenario intermediate (over 118,000 ha lost). Spatially, the areas with greatest potential land are going to non-agricultural uses are North West Wales and Mid Wales for all three scenarios (Table 5.3.1.1).

Table 5.3.1.1 Potential national and regional net changes in farm area (ha) for the Grazing Livestock animal sectors in Wales in response to the three Brexit trade scenarios. Part Time farms (< 1 FTE per farm) are not included.

Potential Net Change in Agricultural Area (ha) Quick Start Full Time Grazing Livestock Sectors					
	EU Deal Scenario				
	Dairy	**Grazers**	**SDA Beef**	**SDA Sheep**	**Total**
North East Wales	2,791	-2,791	371	-2,713	-2,342
North West Wales	3,610	-3,552	737	-17,032	-16,238
Mid Wales	2,256	-2,128	2,350	-13,899	-11,420
South East Wales	5,236	-5,236	123	-544	-421
South Wales Central	58	-58	0	-3,119	-3,119
South West Wales	1,723	-1,723	0	-3,890	-3,890
All Wales	15,674	-15,489	3,581	-41,197	-37,430
	No Deal Scenario				
	Dairy	**Grazers**	**SDA Beef**	**SDA Sheep**	**Total**
North East Wales	12,156	-9,329	4,977	-11,127	-3,323
North West Wales	21,419	-18,856	10,131	-68,712	-56,017
Mid Wales	26,044	-20,022	51,047	-98,218	-41,149
South East Wales	9,758	-9,664	1,134	-2,673	-1,445
South Wales Central	718	-718	690	-8,250	-7,560
South West Wales	16,692	-15,785	5,362	-15,032	-8,763
All Wales	86,786	-74,373	73,341	-204,012	-118,258
	MFTA Scenario				
	Dairy	**Grazers**	**SDA Beef**	**SDA Sheep**	**Total**
North East Wales	0	-3,175	0	-5,082	-8,257
North West Wales	-952	-24,889	0	-74,185	-100,026
Mid Wales	-306	-31,200	0	-66,772	-98,278
South East Wales	-267	-3,696	0	-2,138	-6,101
South Wales Central	0	-5,401	0	-9,830	-15,232
South West Wales	-2,414	-17,442	0	-11,542	-31,398
All Wales	-3,939	-85,803	0	-169,550	-259,292
Part Time farms with < 1 FTE per farm are not included.					

5.3.2 Potential farm labour changes by sector

Potential net changes in agricultural labour in the Grazing Livestock sectors are negative (loss of FTE) for all three Brexit Trade scenarios. FTE losses are greatest for the MFTA scenario (over 6,900 FTE lost), least for the EU Deal scenario (over 800 FTE lost), with the No Deal scenario intermediate (over 2,800 FTE lost). Spatially, the areas with greatest potential FTE losses are North West Wales and Mid Wales for all three scenarios (Table 5.3.2.1).

Table 5.3.2.1. Potential national and regional net changes in farm labour (FTE) for the Grazing Livestock animal sectors in Wales in response to the three Brexit trade scenarios. Part Time farms (< 1 FTE per farm) are not included.

Potential Net Change in Agricultural Labour (FTE) Quick Start Full Time Grazing Livestock Sectors					
	EU Deal Scenario				
	Dairy	**Grazers**	**SDA Beef**	**SDA Sheep**	**Total**
North East Wales	113	-74	6	-72	-28
North West Wales	146	-95	11	-454	-392
Mid Wales	91	-57	35	-370	-301
South East Wales	211	-139	2	-14	59
South Wales Central	2	-2	0	-83	-82
South West Wales	69	-46	0	-104	-80
All Wales	632	-412	53	-1,097	-824
	No Deal Scenario				
	Dairy	**Grazers**	**SDA Beef**	**SDA Sheep**	**Total**
North East Wales	490	-248	60	-296	6
North West Wales	863	-502	140	-1,830	-1,328
Mid Wales	1,050	-533	744	-2,615	-1354
South East Wales	393	-257	17	-71	82
South Wales Central	29	-19	10	-220	-199
South West Wales	673	-420	77	-400	-71
All Wales	3,499	-1,980	1,048	-5,432	-2,865
	MFTA Scenario				
	Dairy	**Grazers**	**SDA Beef**	**SDA Sheep**	**Total**
North East Wales	0	-85	0	-135	-220
North West Wales	-38	-662	0	-1,976	-2,677
Mid Wales	-12	-830	0	-1,779	-2,622
South East Wales	-11	-98	0	-57	-166
South Wales Central	0	-144	0	-262	-406
South West Wales	-97	-464	0	-307	-869
All Wales	-159	-2,284	0	-4,517	-6,959
Part Time farms with < 1 FTE per farm are not included.					

5.4 Small Sectors

The pork sector in Wales is small with 3,515 breeding pigs and 21,000 finishing (or fattening) pigs in the baseline year. More than 70% of the pork herd is found in commercial pork units (defined as units with 40 or more pigs). Commercial units usually maintain a mix of finishing and breeding pigs. The baseline (2017) spatial distribution of the 57 commercial pork units in Wales reflects the dependence of the

sector on transportation within Wales and the current close linkages to the meat sector across the border in England (see section 3.1.2).

Commercial poultry units are defined as units with 1,000 birds or more. Commercial poultry units in Wales specialise in either meat or egg production. Poultry breeding flocks (supporting the industry generally) are associated with the egg producing units. In this analysis, these two components of the commercial poultry industry are analysed separately: Broiler units and Laying/Breeding/Other units. There are 156 commercial Laying/Breeding/Other units and 29 commercial Broiler units in the baseline (2017) poultry sector in Wales. The baseline spatial distribution of the 185 commercial poultry units of both types in Wales reflects the dependence of the poultry sector on transportation within Wales and the current close linkages to the poultry sector across the border in England (see section 3.1.3).

Estimating potential labour changes for the Small Sectors is straightforward. Each potential new commercial pork or poultry unit can be assigned a labour requirement based on the number of pigs or birds assumed for the new commercial unit and the average FTE/pig or FTE/bird in baseline commercial units. Potential installation of a new commercial pork or poultry unit on an existing farm is assumed not to change the normal farm land use or activity. Therefore only the increased labour FTE needed for the potential new commercial unit needs to be accounted.

Baseline animal numbers and labour requirements (needed to calculate average FTE/pig or FTE/bird) were taken from the June Agricultural Survey of Wales, 2017 (Table 5.4.1).

Table 5.4.1. Baseline labour characteristics for commercial pork and poultry units in Wales. From the June agricultural Survey, 2017.

Commercial Pork Units (40 or more pigs)		**Commercial Broiler Units (1,000 or more birds)**		**Commercial Laying / Breeding Units (1,000 or more birds)**	
Units	57	Units	29	Units	156
Total Pigs	17,569	Total Birds	3,995,763	Total Birds	3,629,239
Total FTE	120.5	Total FTE	116.7	Total FTE	597.9
FTE per 100 pigs	0.69	FTE per 10,000 birds	0.29	FTE per 10,000 birds	1.65
From the June Agricultural Survey, Wales, 2017.					

5.4.1 Potential farm labour changes for commercial pork

Estimated potential farm labour changes from the commercial pork sector for the Brexit scenarios would range from an increase of over 170 FTE in the No Deal scenario to no changes in FTE in the MFTA scenario (Table 5.4.1.1).

Table 5.4.1.1. Labour characteristics of commercial pork units for the baseline and for potential responses to each Brexit scenario (with the FTE labour requirement for each), and the potential net increases in commercial pork sector agricultural labour requirements.

Potential Pork Sector Responses to Brexit Scenarios Commercial pork units (40 or more pigs)				
	Baseline	**EU Deal**	**No Deal**	**MFTA**
Pork Units	57	65	85	57
Number of pigs	17,569	20,017	42,089	17,569
Total FTE	121	137	289	121
Potential new labour requirements (FTE)		**EU Deal**	**No Deal**	**MFTA**
Commercial Pork Units		16	168	0

5.4.2 Potential farm labour changes for commercial poultry

Estimated potential farm labour changes from the commercial poultry sector for the Brexit scenarios would range from an increase of over 750 FTE in the No Deal scenario to a loss of 4 FTE in the MFTA scenario (Table 5.4.2.1).

Table 5.4.2.1. Labour characteristics of commercial poultry units for the baseline and for potential responses to each Brexit scenario (with the FTE labour requirement for each), and the potential net increases in commercial poultry sector agricultural labour requirements.

Potential Poultry Sector Responses to Brexit Scenarios Commercial poultry units (1,000 or more birds)				
	Baseline	**EU Deal**	**No Deal**	**MFTA**
Broiler Units	29	34	37	28
Number of birds	3,995,763	4,635,085	5,034,661	3,853,599
Total FTE	117	135	147	113
Laying / Breeding Units	156	182	198	156
Number of birds	3,629,238	4,227,138	4,601,967	3,629,238
Total FTE	598	696	758	598
Potential new labour requirements (FTE)		**EU Deal**	**No Deal**	**MFTA**
Broiler Units		18	30	-4
Laying / Breeding Units		98	160	0
Commercial Poultry Sector		116	190	-4

The potential FTE increases in the commercial pork sector are 13% and 139%, and increases in the commercial poultry sector are 19% and 32% (relative to the baseline) for the EU Deal and No Deal scenarios, respectively. The combined potential increases in farm labour from potential commercial pork and poultry expansion range from 132 to 358 FTE's for the EU Deal and No Deal scenarios, respectively, with essentially no change for the MFTA scenario (Tables 5.4.1.1 and 5.4.2.1).

These potential increases in pork and poultry labour requirements, however, have to be considered in the context of the large potential declines in labour requirements in the Grazing Livestock Sector, ranging from loss of more than 800 FTE's to loss of nearly 7,000 FTE's, depending on the Brexit trade scenario (from 3% to 26% potential loss of FTE's in the Grazing Livestock Sectors; Tables 5.3.2.1 and 5.2.2)

6 Conclusions

The poultry and pork sectors occupy a relatively small land area within Wales, but modelling possible impacts is important as these sectors offer an opportunity for the Grazing Livestock sector to diversify, thereby impacting on communities and local economies.

Potential changes in the commercial pork sector in Wales in response to the Brexit scenarios are: 8 new units in the EU scenario; 28 new units in the No Deal scenario; no new units in the MFTA scenario. Commercial pork units are defined as having 40 or more pigs (both finishing and breeding).

Potential changes in the commercial poultry sector in Wales in response to the Brexit scenarios are: 5 new broiler units and 26 new laying/breeding units in the EU scenario; 8 new broiler units and 42 new laying/breeding units in the No Deal scenario; and the removal of one broiler unit in the MFTA scenario. Commercial poultry units are defined as having 1,000 or more birds.

The potential installation of new commercial pork or poultry units on existing farms will result in increased GHG emissions and adverse effects on air and water quality. In some cases, these effects will be additive with effects from potential changes in the Grazing Livestock sectors (e.g., a potential 15,500 ha expansion of Dairy in the EU scenario). In other cases, the effects of potential Small Sectors changes will be in an opposite direction to those from the Grazing Livestock sector (e.g. a potential 118,000 ha removed from agriculture in the No Deal scenario).

The Quick Start modelling work relied on close cooperation and joint working between the ERAMMP team, WG staff and the Evidence and Scenarios Roundtable Sub-Working Group. We would like to express our thanks to the WG staff and SWG for their contribution without which this report would not have been possible.

With respect to the Brexit scenarios work, the outputs have highlighted the highly variable magnitude of the potential risks and benefits which may arise from the different Brexit trade scenarios with respect to environmental outcomes. The application of the models, albeit with many brave assumptions also described the highly spatially variable nature of these potential outcomes. This information may be used to both highlight where the regulatory floor may need enhancing and / or transition schemes put in place to support communities heavily reliant on the agricultural livestock sector.

The large number of assumptions, limitations and uncertainties have been described in detail for transparency purposes and a language used throughout the report to emphasise the highly speculative nature of the work. Predicting the behaviour and decision making of any sector has many pitfalls, not least when no comparable situation has been experienced before.

Overall, despite these limitations the results provide a significant contribution to the debate concerning the trade-offs / risks and benefits we can all derive from the agriculture, woodland and recreation sectors. Some past assumptions of delivery of public goods by different sectors and where these occur in our Welsh landscape have perhaps been challenged through the work. We hope this report will contribute to an informed, collective discussion about how we all can all secure a more sustainable future for Wales' primary production industries and natural resources going forward.

7 Recommendations

A. WG should ensure the limitations and assumptions for the work are always included in any presentations and future uses of the work and data protection considered for all maps and results released.

B. WG should consult with the ERAMMP team on the best use of the Quick Start approach versus the Integrated Modelling Platform (IMP) for any future scenario work required.

C. WG should consult with the ERAMMP team as to additional environmental impacts and public goods which should be considered in any Quick Start work going forward.

D. WG should ensure future work takes into account displacement or leakage of environmental impacts within Wales, UK and globally to ensure compliance with the Well Being of Future Generations Goal of ‘A Globally Responsible Wales’.

E. WG should ensure biodiversity impacts at both local and national scale are given due consideration in future work.

8 References

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