Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Technical Annex-1 Report-60TA1: ERAMMP Integrated Modelling Platform (IMP) Land Use Scenarios

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Approved by Bridget Emmett (UKCEH)
James Skates (Welsh Government)

Abbreviations Used in this Report

ABC	Agricultural Budgeting and Costing
BBS	Breeding Bird Survey
BEIS	UK Gov Dept for Business, Energy & Industrial Strategy
BPS	Basic Payment Scheme
BTO	British Trust for Ornithology
CARBINE	A forestry model
DA	Disadvantaged areas
DMU	Decision-Making Unit
EFT	ERAMMP Farm Type
EMEP4UK	An off-line atmospheric chemistry transport model
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
ESC	A forestry model
ESRC	Economic and Social Research Council
EUID	ERAMMP Unique ID
FARMSCOPER	An agricultural emissions model
FBS	Farm Business Survey
FBI	Farm Business Income
FC	Forestry Commission
FR	Forest Research
FTA	Free Trade Agreement
FTE	Full time equivalent
GHG	Green House Gas
GMEP	Glastir Monitoring and Evaluation Programme
HMT	Her Majesty's Treasury
IMP	Integrated Modelling Platform
LAM	Land Allocation Module
LFA	Less Favoured Areas
LULUCF	Land Use, Land-Use Change and Forestry
MULTIMOVE	A Package of niche models for British Vegetation
NARSES	National Ammonia Reduction Strategy Evaluation System
NFI	National Forest Inventory
NPV	Net Present Value
NRW	Natural Resources Wales
QA	Quality Assurance
RFT	Robust Farm Type
RIGOUR analysis	Repeatable, Independent, Grounded in reality, Objective, have Uncertainty managed, Robust with respect to the initial question
SAC	Special Area of Conservation
SDA	Severely disadvantaged areas
SFARMOD	Silsoe Whole Farm Model
SFS	Sustainable Farming Scheme
SRO	Senior Responsible Officer
SSSI	Site of Special Scientific Interest
TRQ	EU tariff-rate quota
UKCEH	UK Centre for Ecology and Hydrology
UKTAG	UK Technical Advisory Group
WCP	Woody Cover Product
WFD	Water Framework Directive
WG	Welsh Government
WTO	World Trade Organisation

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

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ERAMMP

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INTEGRATED MODELLING PLATFORM

Land Use Scenarios (T1)

UK Centre for Ecology & Hydrology

Cranfield University

ADAS

Forest Research

eftec

BTO

Menu

Scenario description (T1)

- FAPRI MFTA (Trading on world prices).
- Zero tariffs applied on imports to the UK from both the EU and the rest of the world.
- MFN tariffs applied to UK exports destined for the EU.
- No change in tariff structure for exports to the rest of the world.
- 8% trade facilitation costs on UK-EU27 trade.
- Scenario settings:

	Milk (p/litre)	Beef (£/kg LWT)	Lamb (£/kg LWT)
Baseline (2015)	35	1.85	1.68
T1	**31.6**	**1.02**	**1.19**

https://www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/FAPRI-UK%20Brexit%20Report%20-%20FINAL%20Clean.pdf

PART 1: Agriculture

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Background information

The agricultural models are applied to all full-time farms

	No.	Area (ha)
Full-time	7726	1010891
Spare / Part-time	12738	409150
Total	**20464**	**1420041**

Farm Business Income classes within T1:

As baseline farm type	As alternative farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture
<£6000 p.a.	>£6000 p.a.	Farm under pressure	Likely to change farm type through sale to another enterprise
£6K-£13K	Any amount	Farms staying the same	Able to continue but unlikely to be able to change farm type
>£13000	<£13K +FBI uplift+finance	Farms staying the same	Insufficient economic incentive to change farm type
>£13000	>=£13K +FBI uplift+finance	Farms changes type	Likely to be sufficient economic incentive to change farm type

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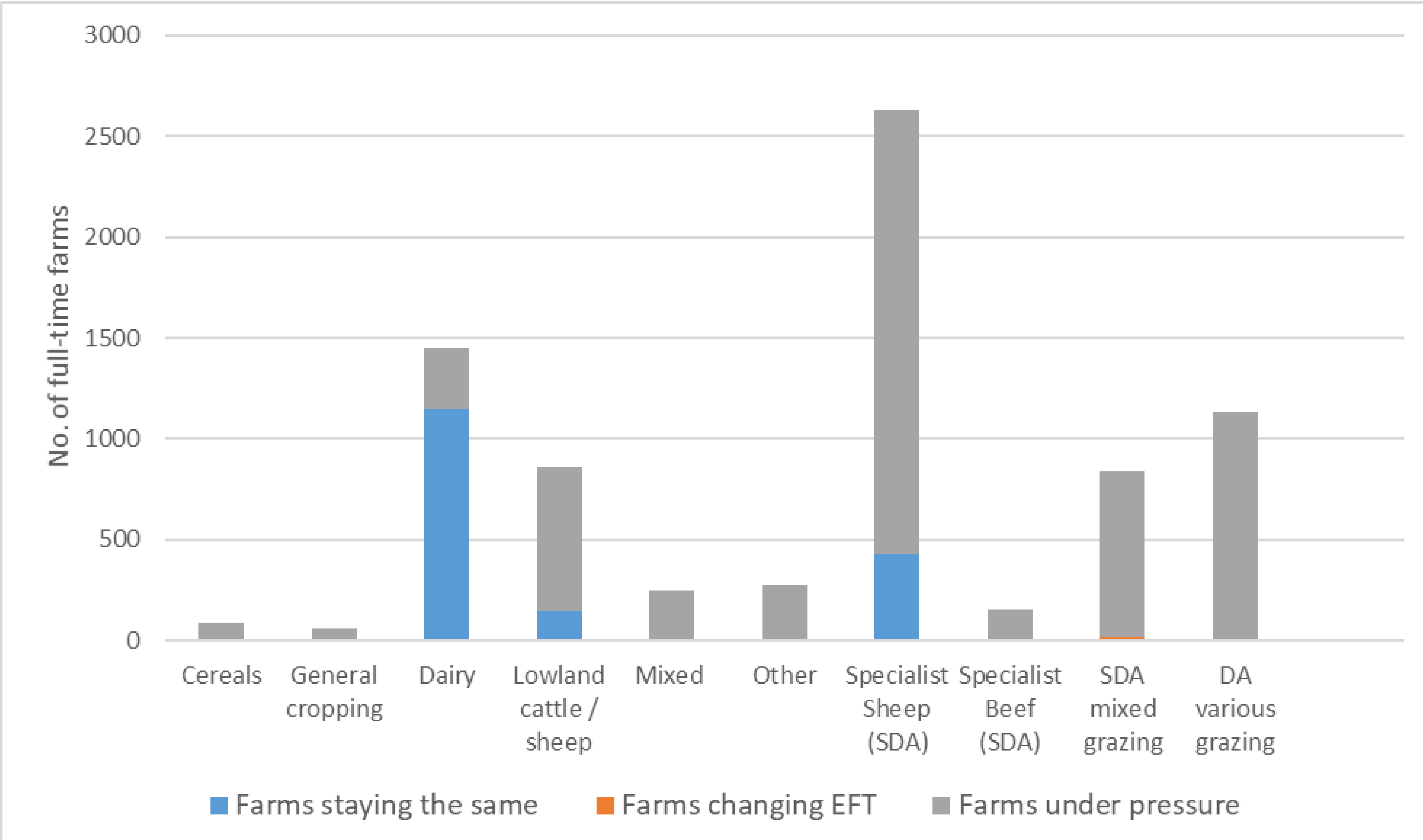
Simulated status of current Full-time farms under T1



Baseline number of full-time farms: 7726

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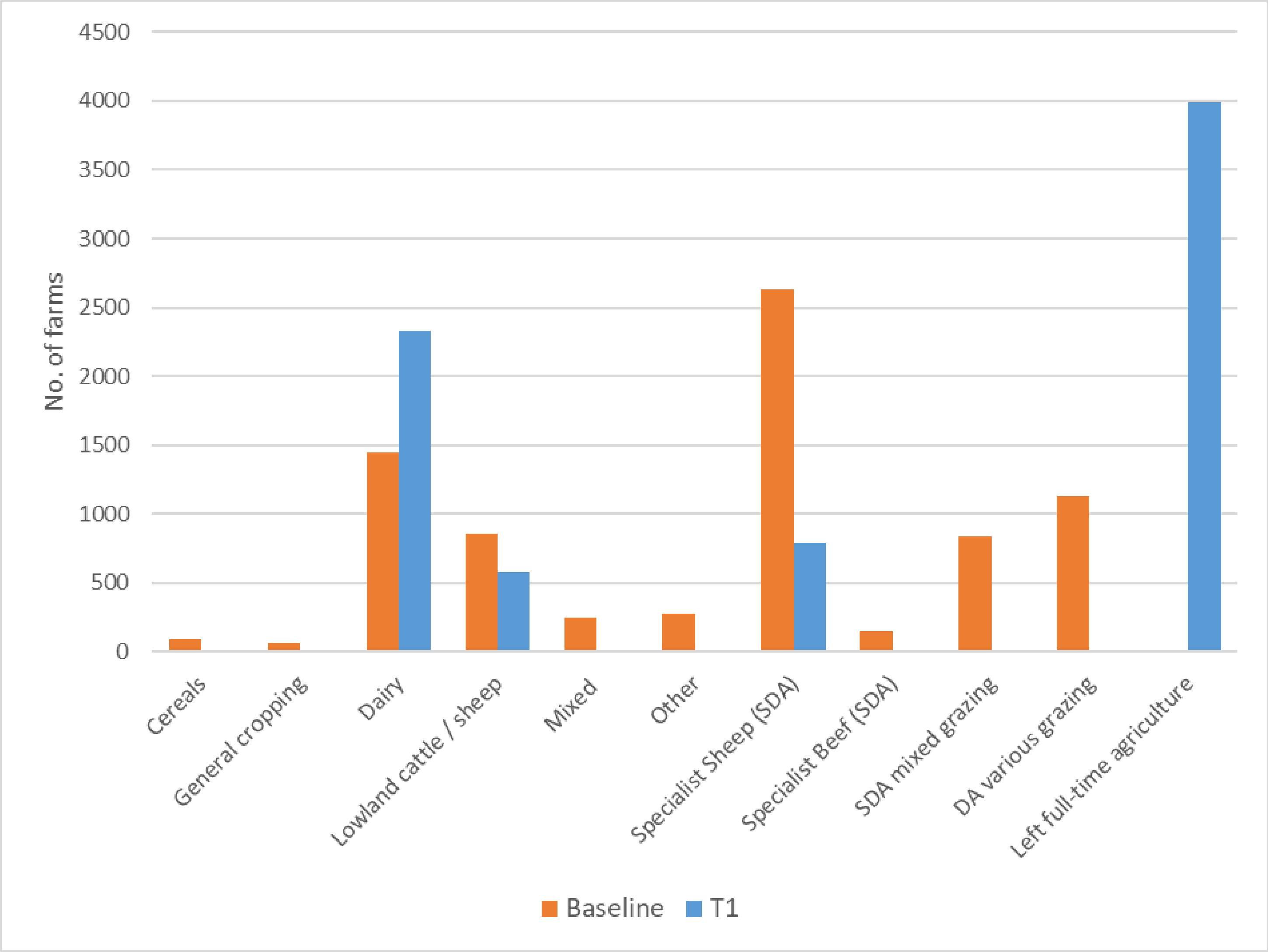
Farm numbers by farm-type (Baseline vs T1)



Total number of full-time farms: 7726 in Baseline; 3733 in T1

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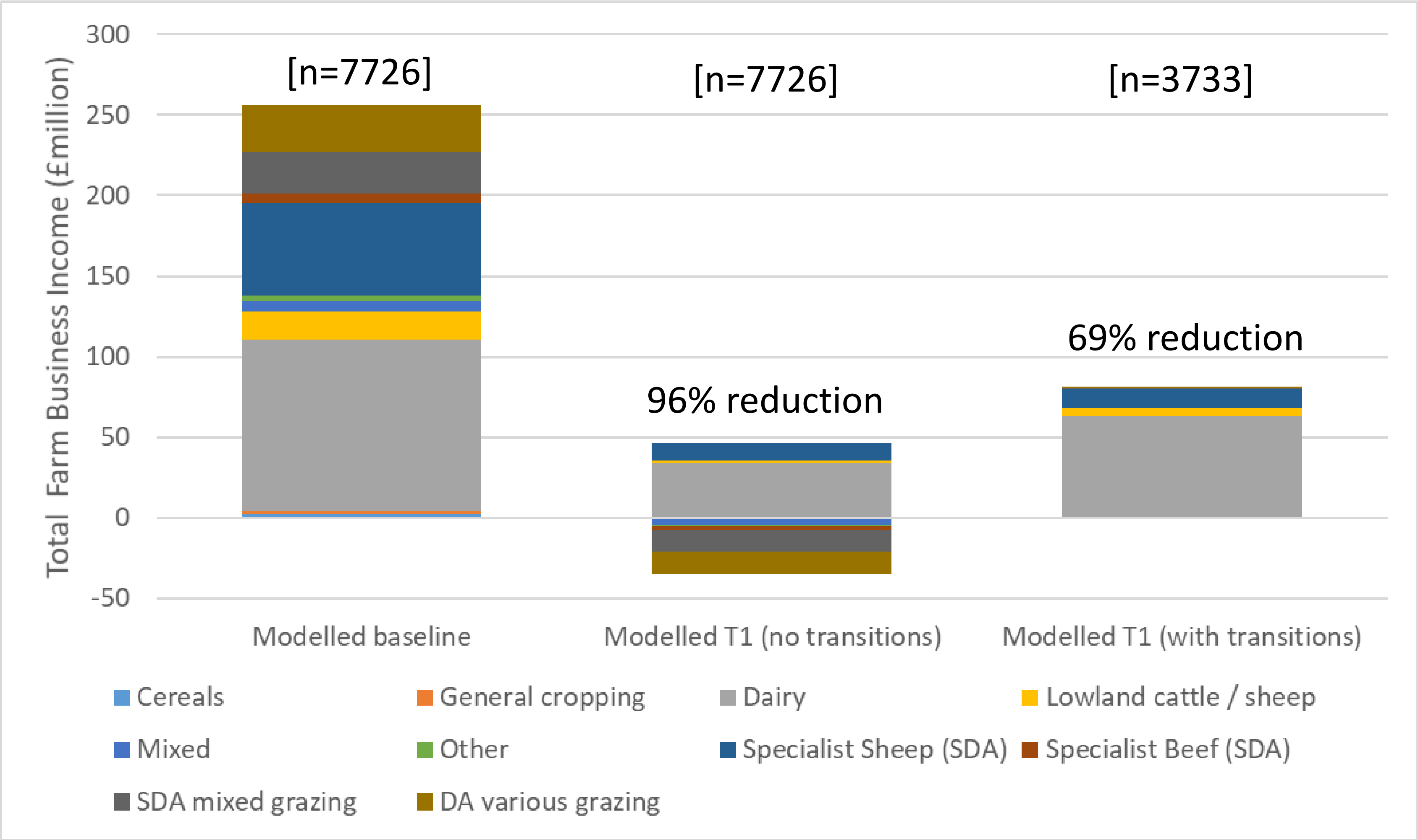
Total simulated Farm Business Income from full-time farms (T1)



Total number of full-time farms: 7726 in Baseline; 3733 in T1

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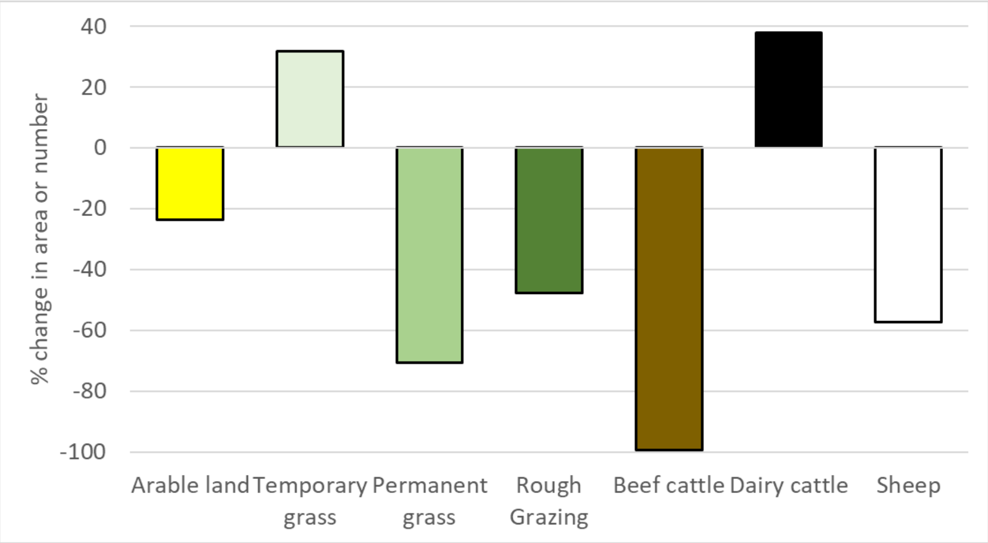
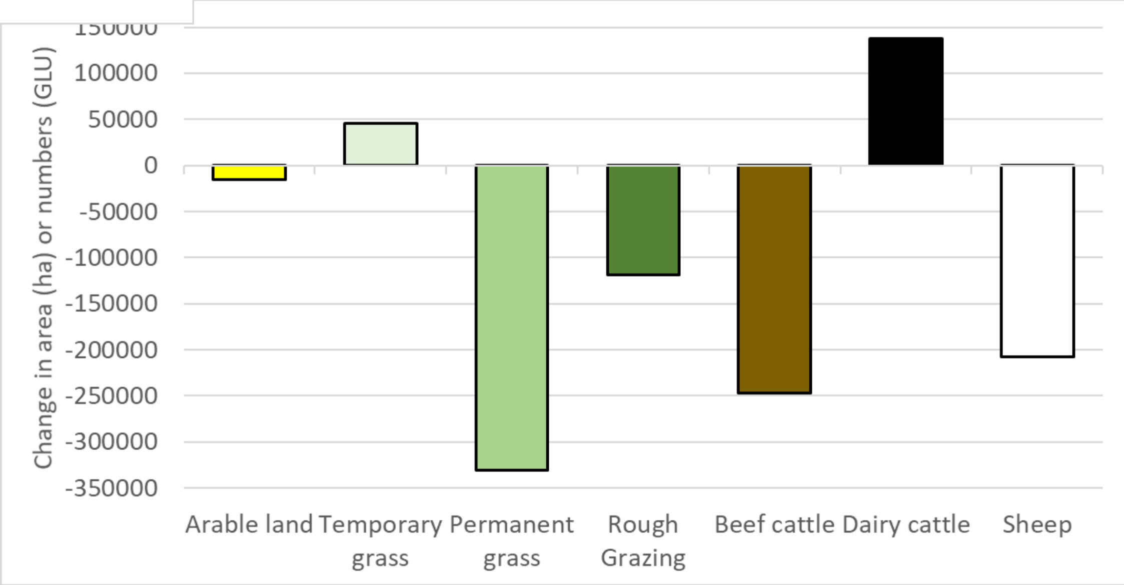
Change in simulated managed land use and livestock (T1)



Percentage change (relative to simulated baseline)

Absolute change in simulated areas (ha) and numbers (Grazing Livestock Units)



Simulated farms remaining in full-time agriculture: 3733

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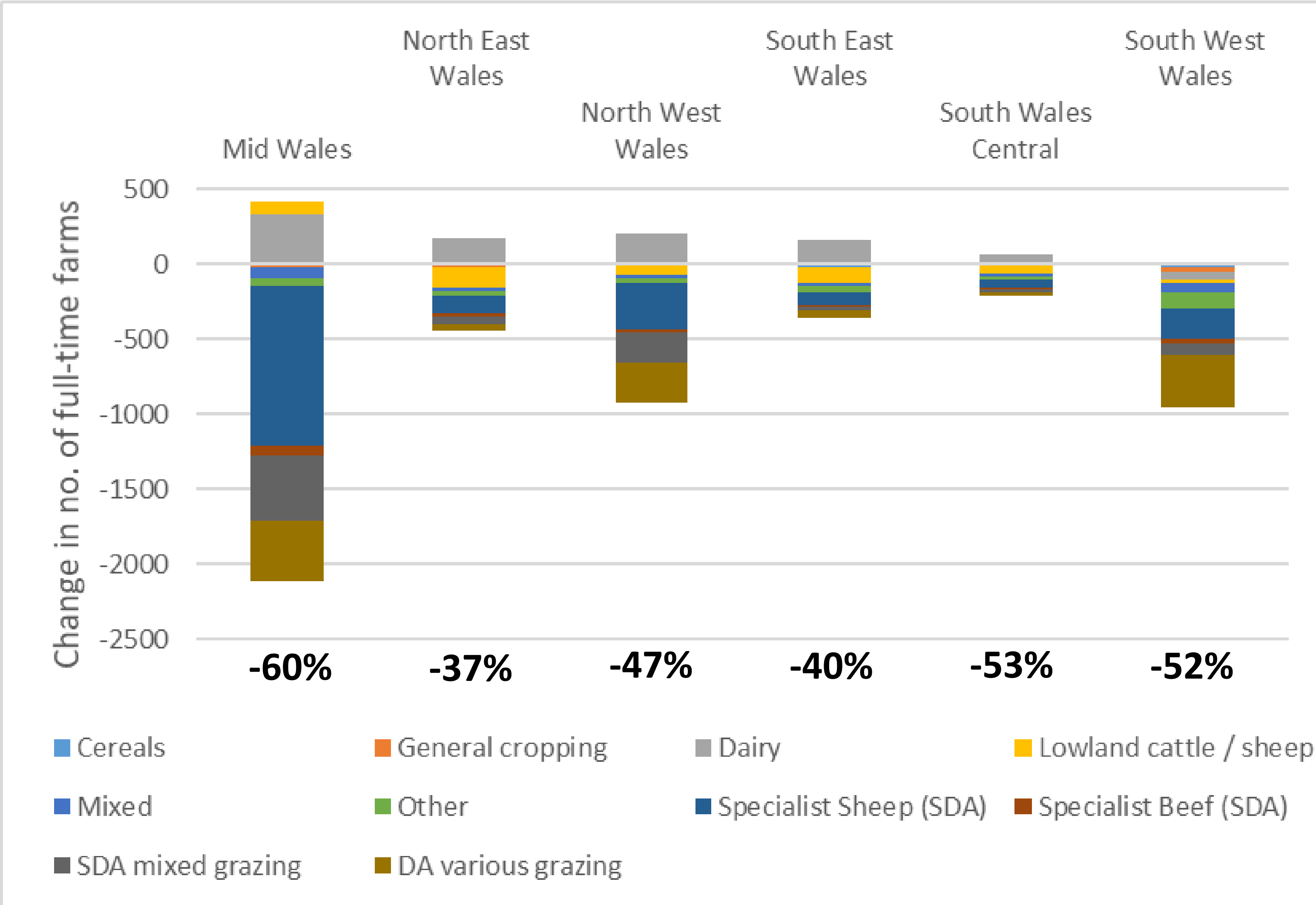
Change in farm numbers by farm-type (T1)



Simulated farms remaining in full-time agriculture: 3733

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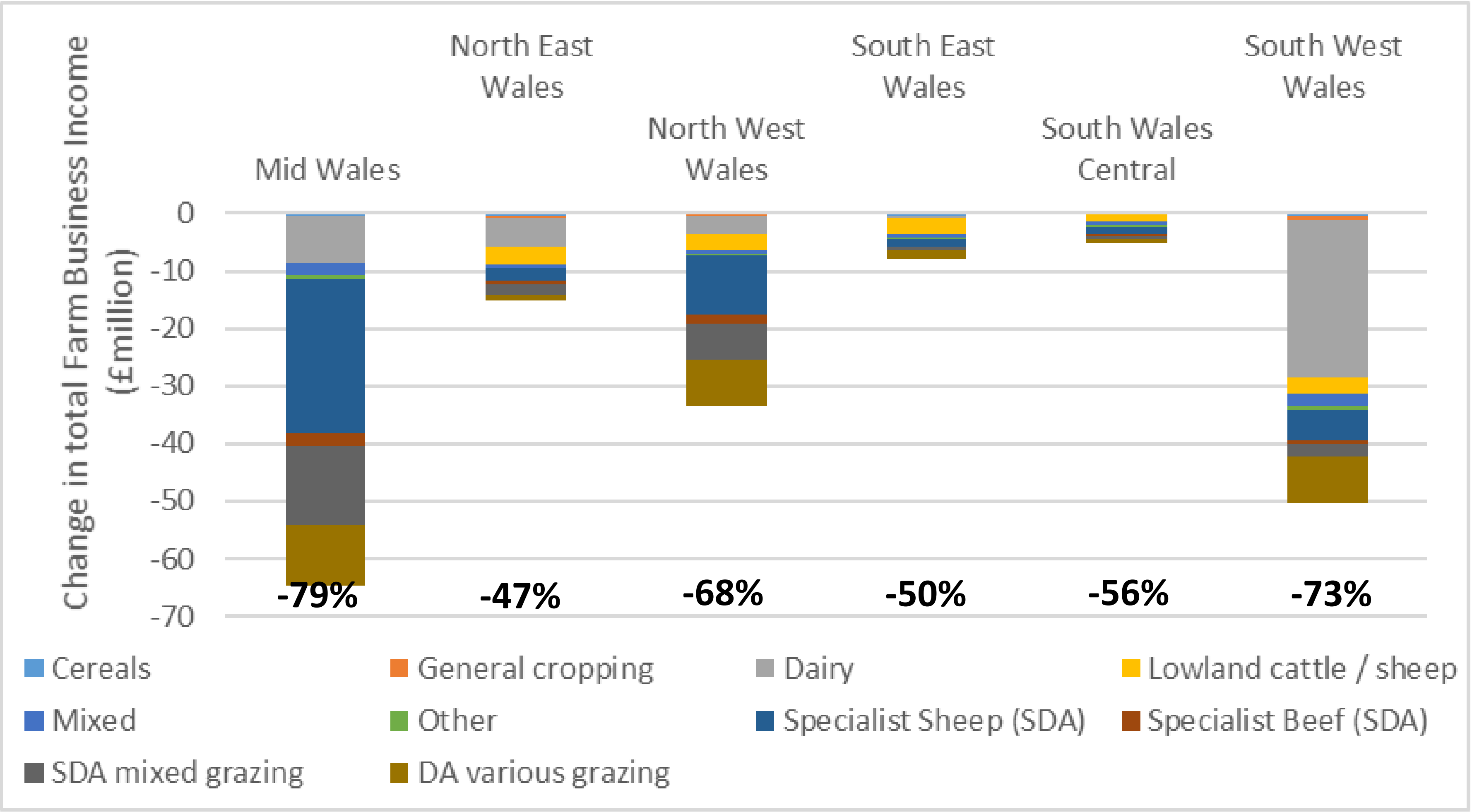
Change in total simulated Farm Business Income from remaining full-time farms (T1)



Simulated number remaining in full-time agriculture: 3733

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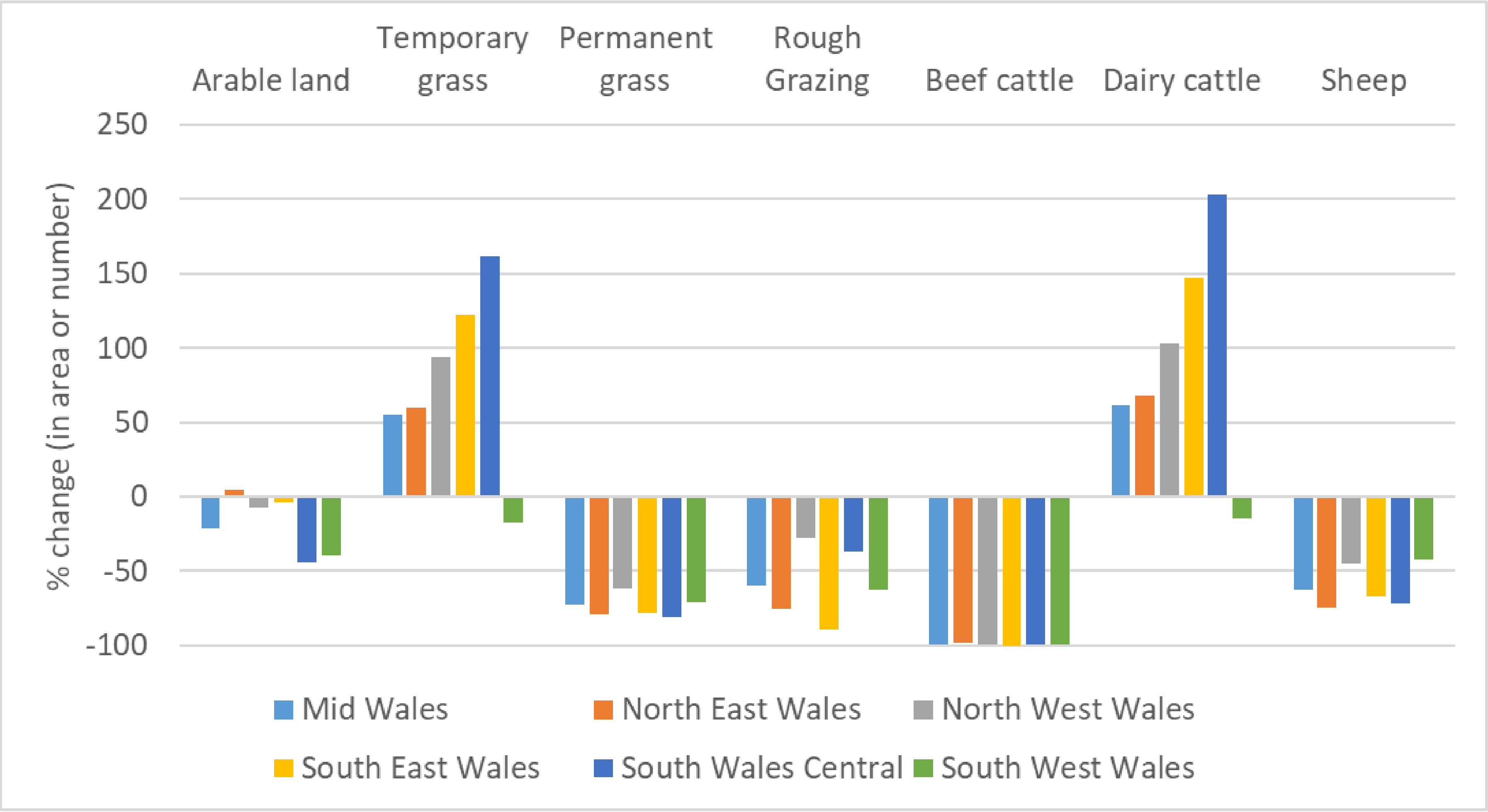
Regional change in land use and livestock (T1)



Simulated number remaining in full-time agriculture: 3733

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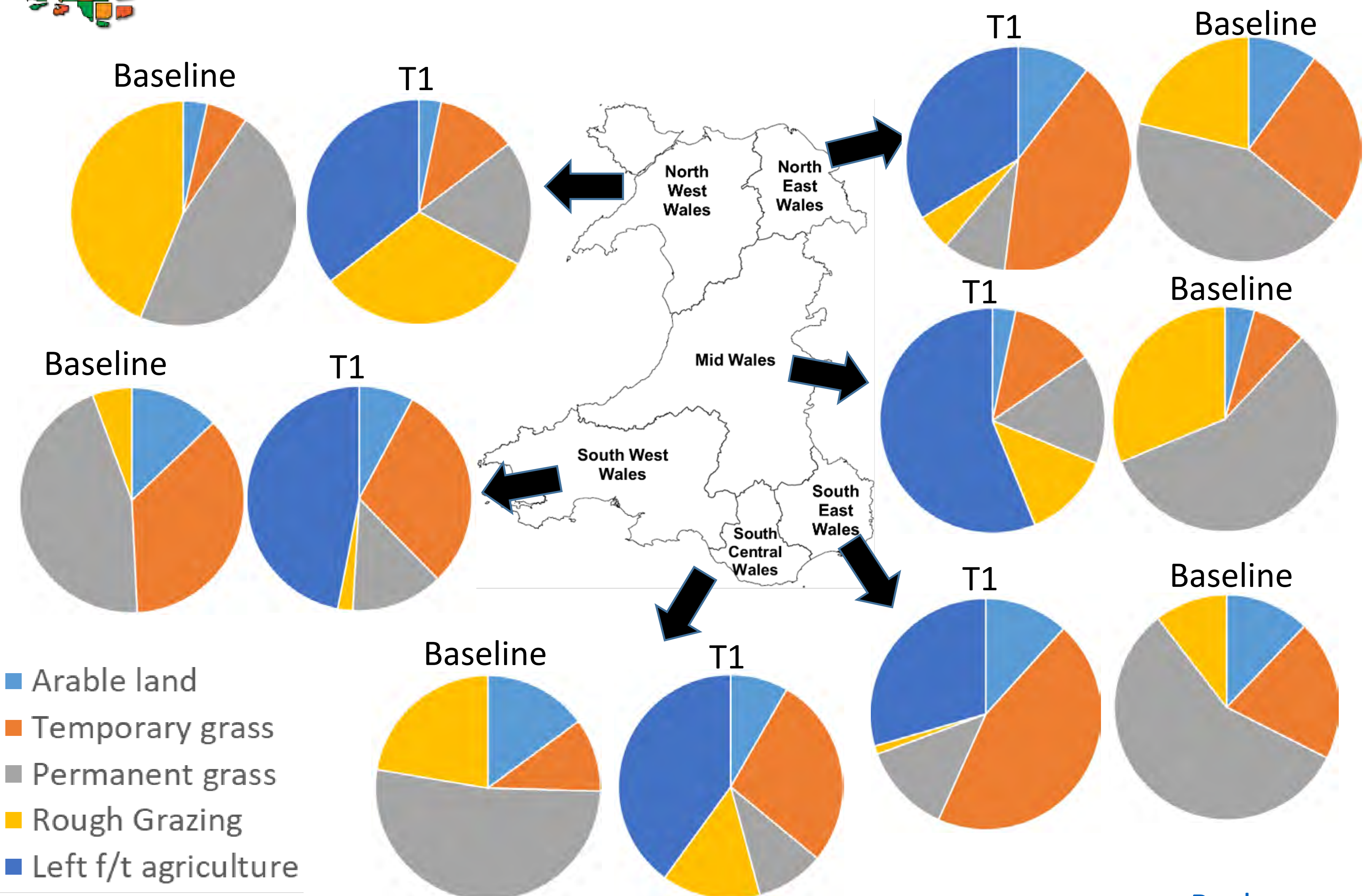
Regional land use proportions in T1



Simulated number remaining in full-time agriculture: 3733

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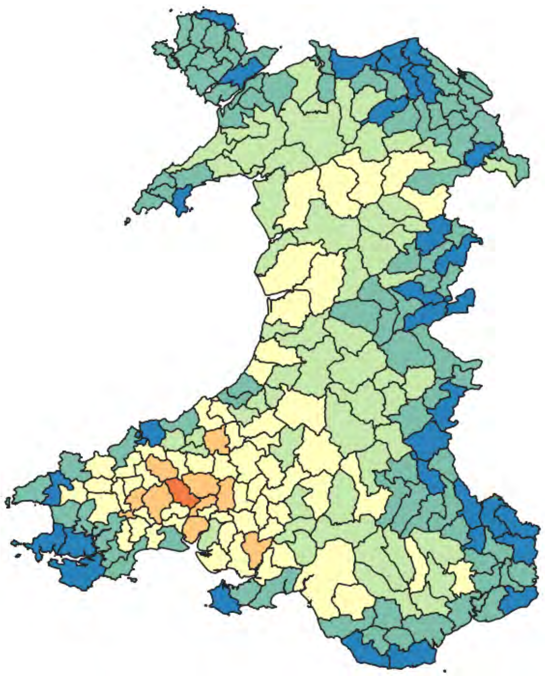
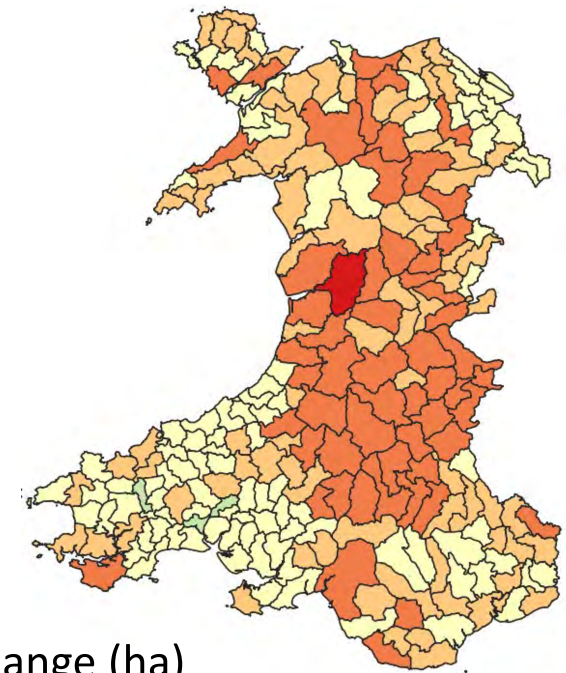
Simulated change in land use (T1)

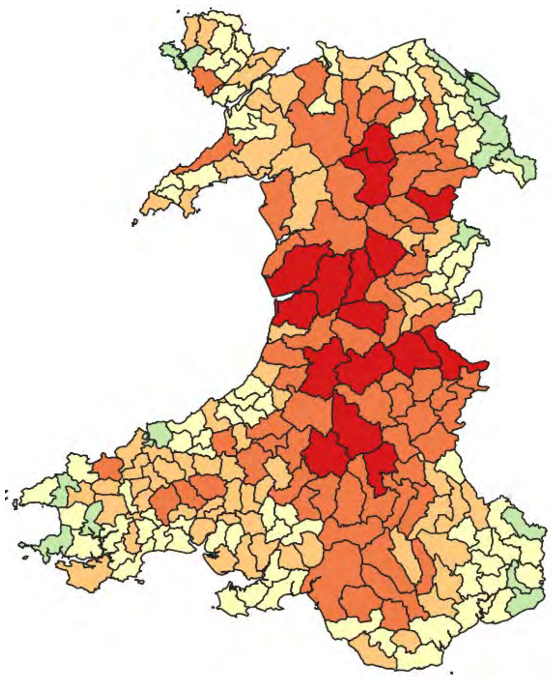
Change in cultivated / temporary grassland



Change in permanent grassland



Change in agricultural area



Change (ha)

- -8732 - -5000
- -5000 - -2000
- -2000 - -1000
- -1000 - -100
- -100 - 100
- 100 - 750
- 750 - 1931

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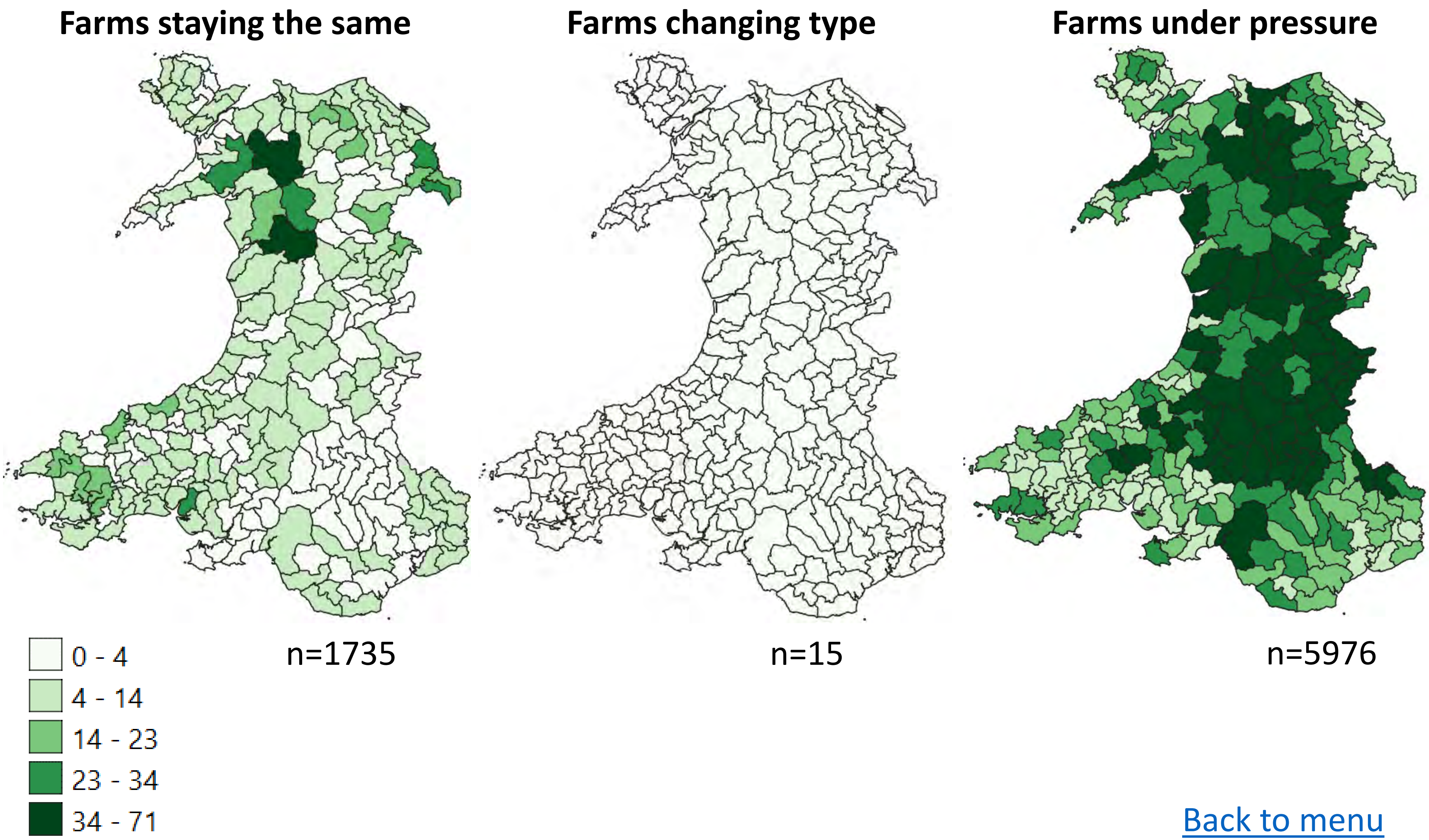
Simulated status of current full-time farms under T1



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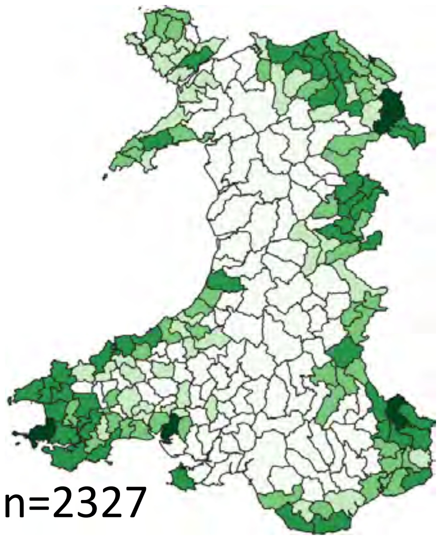
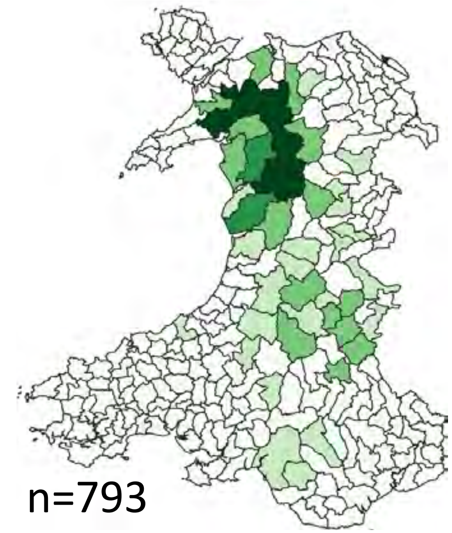
Simulated farm type numbers under T1

Dairy specialists



Beef specialists

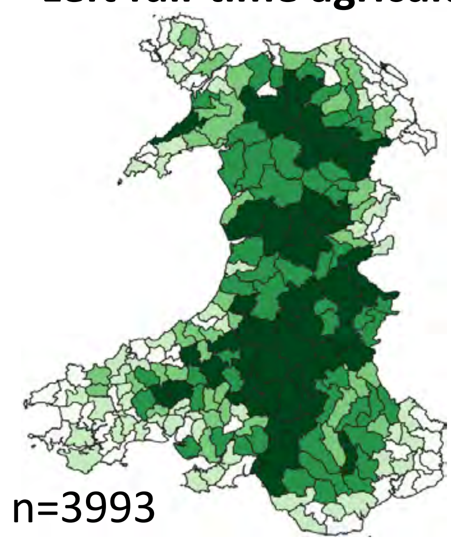
Sheep specialists



Mixed grazers

- 0 - 6
- 6 - 10
- 10 - 17
- 17 - 27
- 27 - 63

Left full-time agriculture



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Farms leaving full-time agriculture

Farm Business Income classes within T1:

As Baseline Farm type	As alternative Farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture

A farm that is unable to achieve a full-time annual FBI of £6,000 may:

- Implement cost savings and struggle on;
- Transition to part-time farming, to enable increased non-agricultural income though diversification and / or off-farm employment;
- Leave agriculture in the short-term;
- Leave agriculture in the longer-term (e.g. due to retirement / inter-generational change).

As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested

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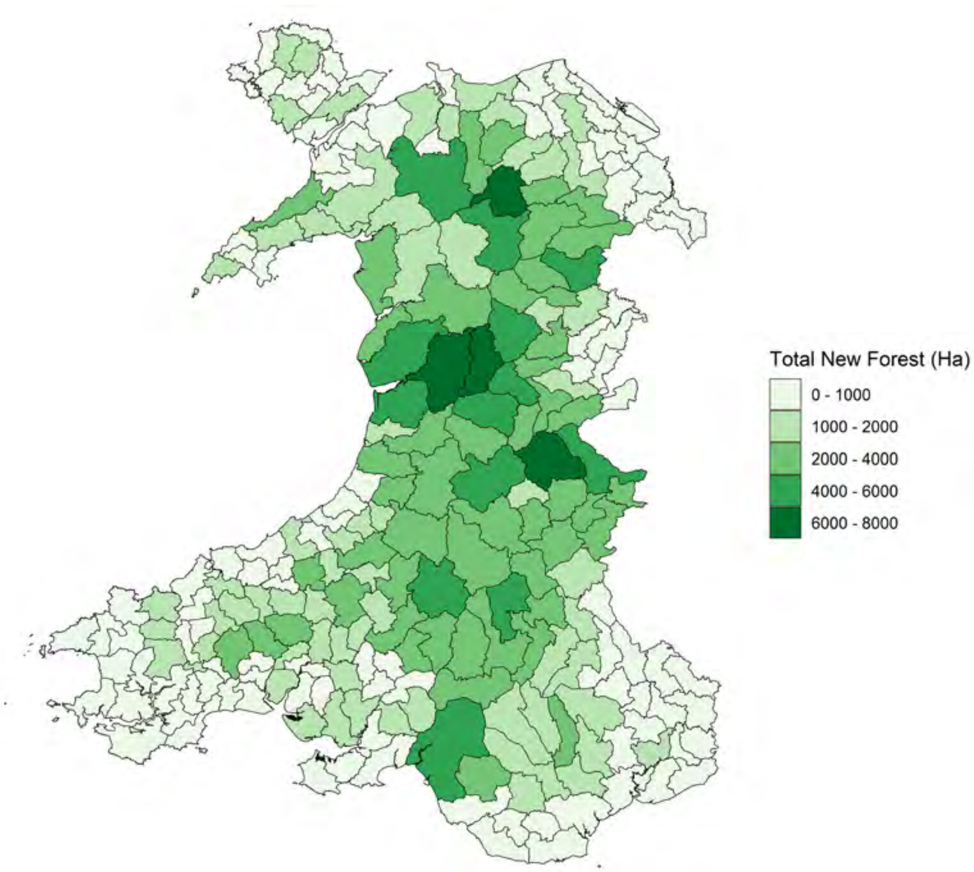
Simulated new woodland on farms leaving full-time agriculture (T1)



- Total new woodland area (ha) from afforestation and natural regeneration.
- Totals largely driven by afforestation: 278,215 ha.
- Afforestation will only occur on appropriate former agricultural land that will generate a positive net present value (NPV) from forestry.

Total area of new woodland: 373,315 ha (294% increase for modelled >1 FTE farms)

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PART 2: Biodiversity

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Biodiversity summary – Birds (T1)

- Increases and decreases in bird population sizes are an inevitable consequence of changes in land use.
- By **2050**, under the T1 scenario, we project substantially greater cover of coniferous woodland and secondary forest in some areas which were previously farmland.
- As a result, more bird species are simulated to decline than increase in overall population size.
- The majority of increases are for woodland species, whilst farmland & generalist species are projected to decrease.
- Greatest number of gains are simulated in Central and SW Wales, with losses most prevalent in the East and NW Wales.
- Note: This outcome is strongly dependant on a very large area of new woodland planting as modelled here, based on a planting on former agricultural land with net positive NPV.

Eaton, Mark, et al. "Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man." British Birds 108.12 (2015): 708-746.

Bladwell et al. "The state of birds in Wales 2018." (2018). The RSPB, BTO, NRW and WOS. RSPB Cymru, Cardiff

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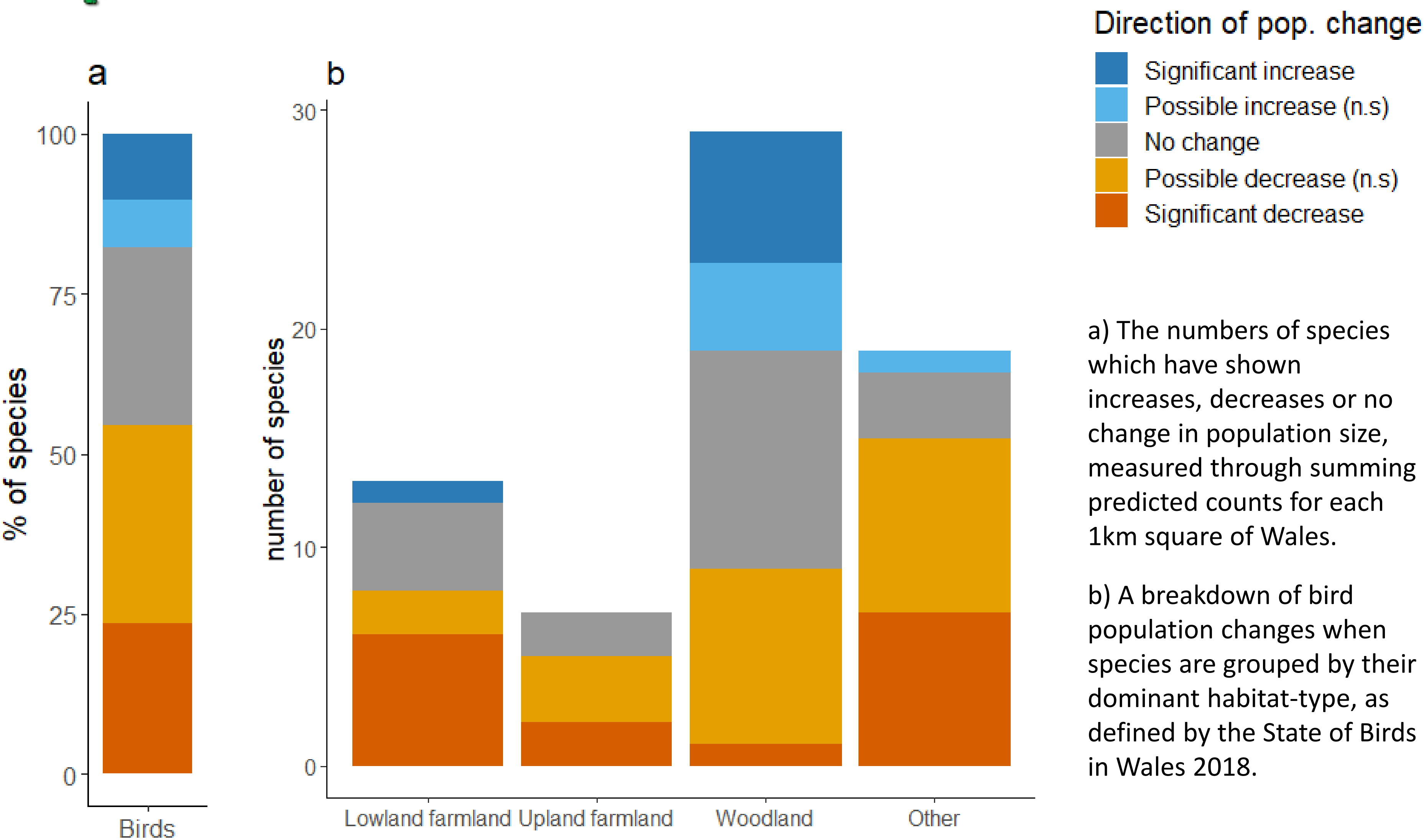
Overall bird population change in T1



a) The numbers of species which have shown increases, decreases or no change in population size, measured through summing predicted counts for each 1km square of Wales.

b) A breakdown of bird population changes when species are grouped by their dominant habitat-type, as defined by the State of Birds in Wales 2018.

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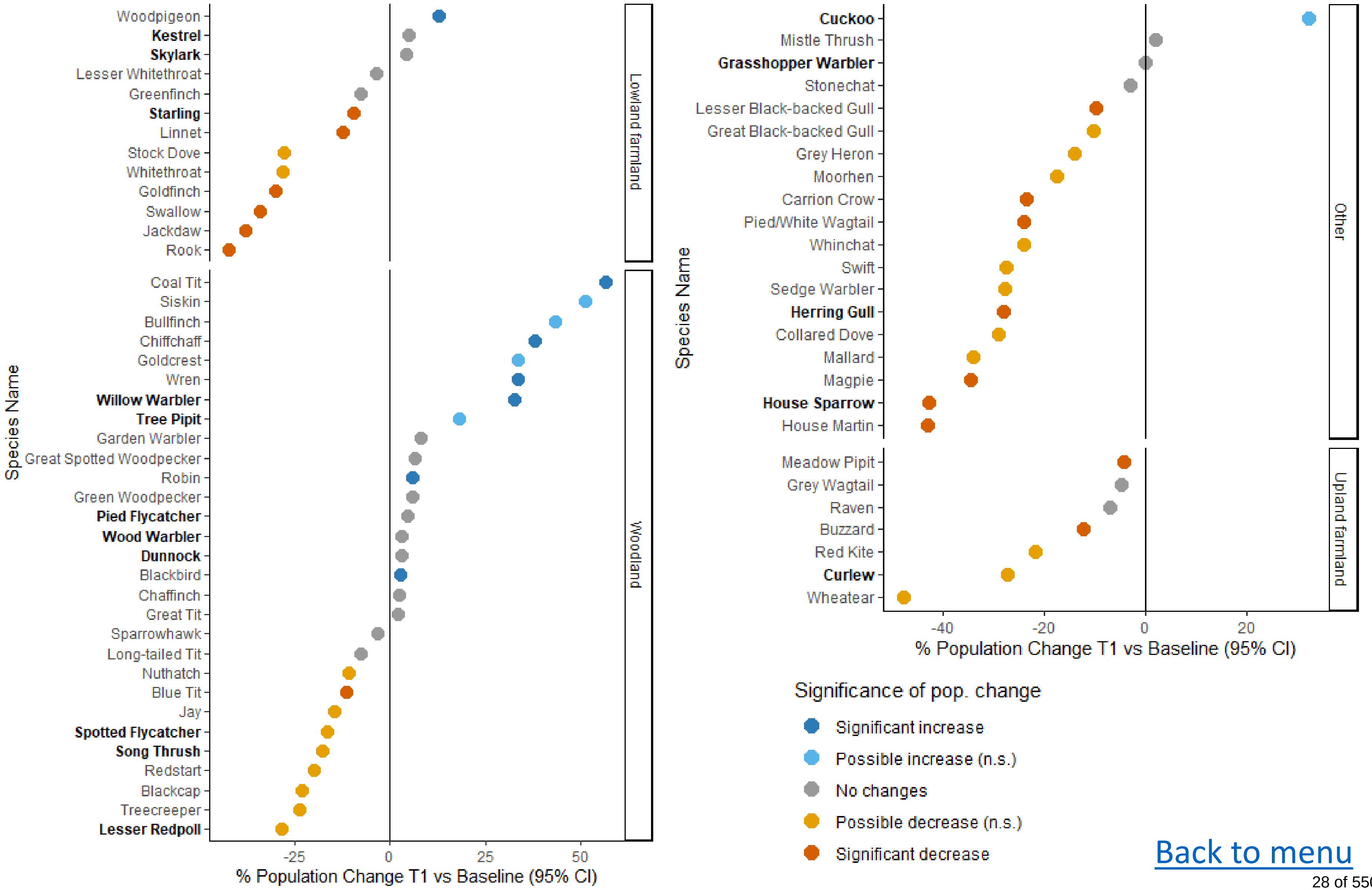
Population changes per bird species in T1



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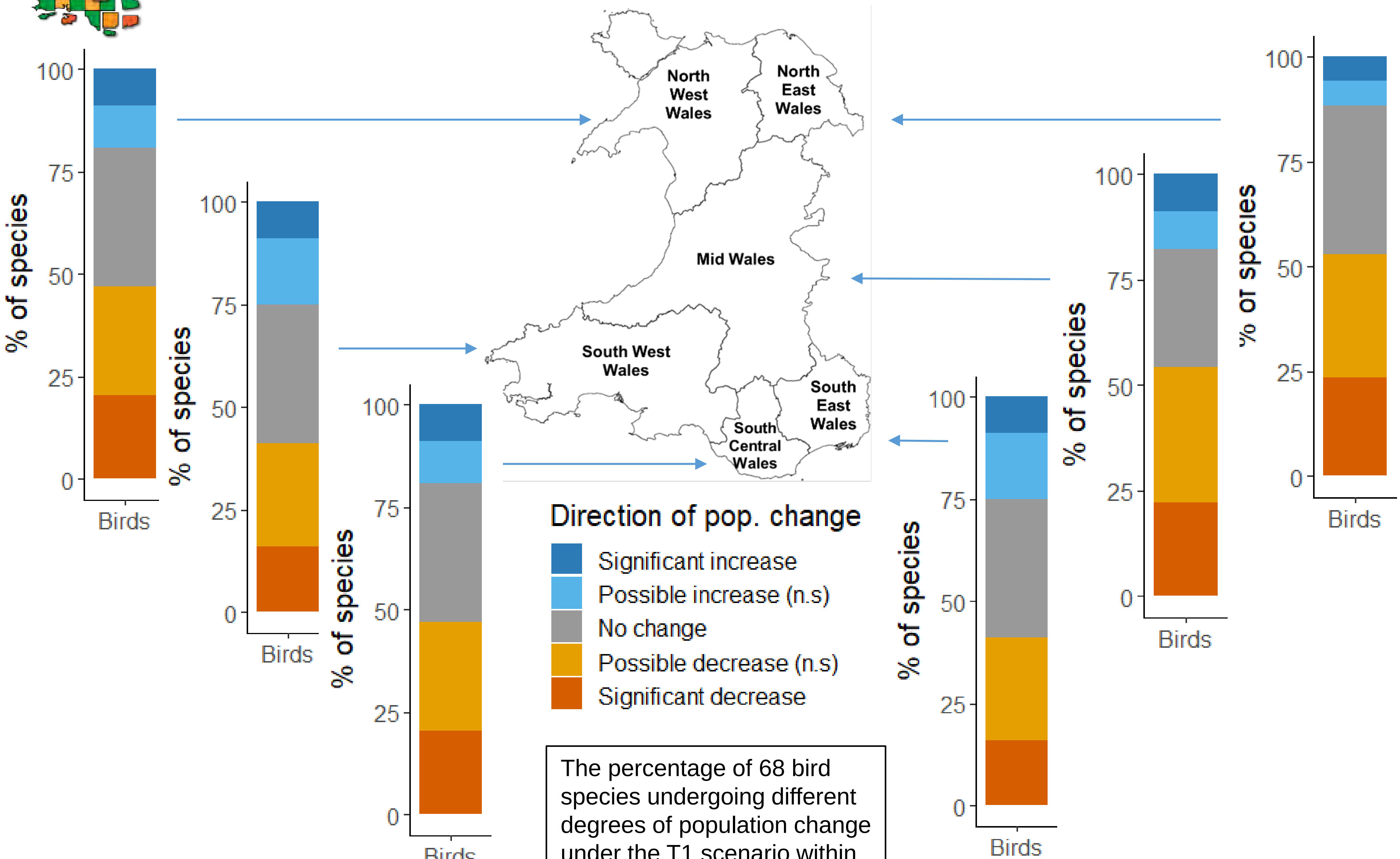
Regional bird population impacts in T1



The percentage of 68 bird species undergoing different degrees of population change under the T1 scenario within the six NRW regions.

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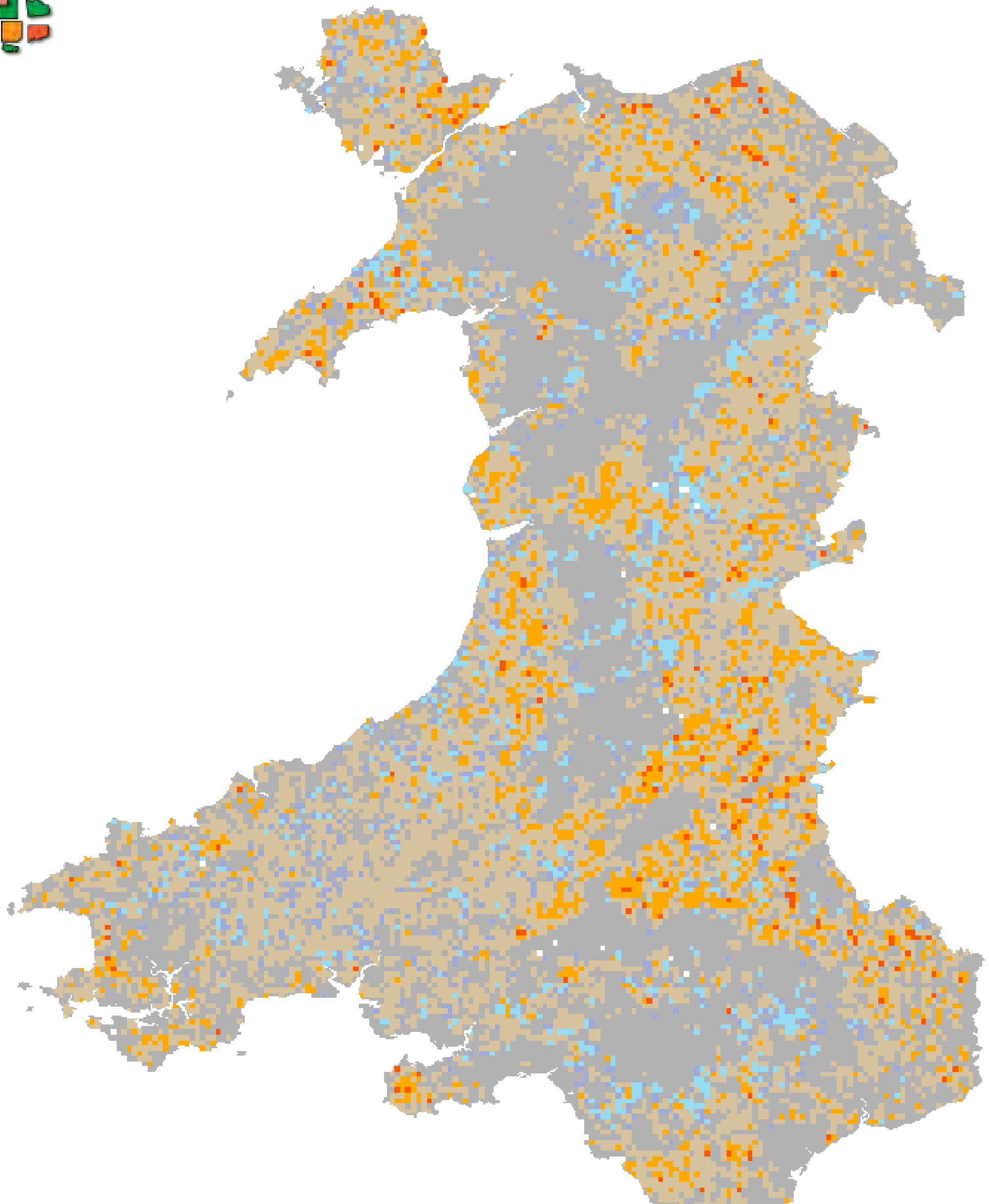
Local bird species change in T1



Ratio of species change

- +3 to +18
- +1 to +2
- 0
- -1 to -8
- -9 to -20
- -20 or greater

The ratio of 68 bird species undergoing significant increases *vs* decreases for each 1km square of Wales. Bolder colours are indicative of greater change. Note that under this metric, any square seeing large, but equal numbers of increases and decreases will be represented by grey colouration, identical to that of a square seeing no changes.

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Biodiversity summary – Plants (T1)

- Projected gains in woodland over 25 years result in expected increases in suitability of conditions for woodland specialist plants. Gain in temporary grass drives positive impacts on the small number of modelled arable specialists.
- Just over 50% of semi-natural habitat specialists are simulated to increase in suitable niche space, except for lowland heathland species. These patterns are similar across all regions except for South Central Wales where habitat suitability is expected to decrease or not change for semi-natural habitat specialist plants.
- Summary: Our modelling shows that ecological conditions across much of Wales are expected to be more favourable for the survival of many of these specialist plants.
- Note that realising the beneficial impact of these projected changes on survival, size and number of populations is likely to require management interventions to enhance natural dispersal or actively assist dispersal and establishment.

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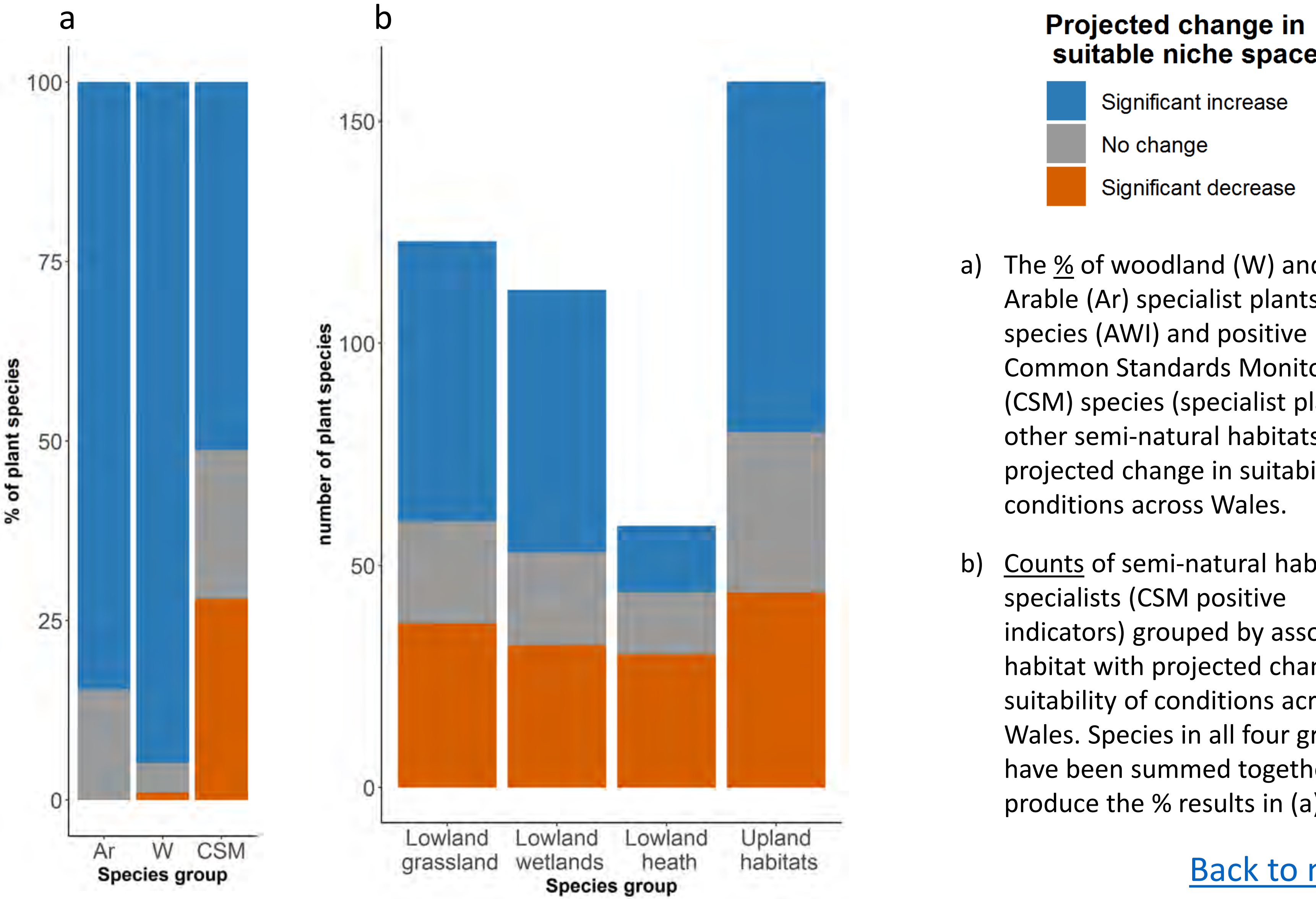
National change in habitat suitability for plants over 25 years (T1)



a) The <u>%</u> of woodland (W) and Arable (Ar) specialist plants species (AWI) and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales.

b) <u>Counts</u> of semi-natural habitat specialists (CSM positive indicators) grouped by associated habitat with projected change in suitability of conditions across Wales. Species in all four groups have been summed together to produce the % results in (a).

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% change in habitat suitability per plant species in T1 (Examples)

Woodland specialists for Wales [1]

Species name	% change in suitability
Carex sylvatica	19
Allium ursinum	17
Sanicula europaea	15
Veronica montana	14
Moehringia trinervia	13
Galium odoratum	13
Lonicera periclymenum	11
Acer campestre	10
Hyacinthoides non-scripta	5
Anemone nemorosa	3
Adoxa moschatellina	2

Arable specialists [2]

Species name	% change in suitability
Polygonum aviculare	5.9
Lamium purpureum	2.1
Spergula arvensis	1.8
Euphorbia helioscopia	1.2
Papaver rhoeas	1.0

Excerpts from lists of species with projected change in suitability of ecological conditions across Wales. Click here to view the modelled niche of each species in Britain.

Semi-natural habitat specialists (CSM +ve indicators)

Species name	% change in suitability
Blechnum spicant	2.2
Dryopteris filix-mas	7.7
Carex caryophyllea	-1.2
Carex echinata	-0.4
Conopodium majus	-1.3
Festuca ovina	-0.9
Filipendula ulmaria	0.5
Lathyrus pratensis	-1.6
Mercurialis perennis	5.9
Molinia caerulea	0.2
Ranunculus flammula	-0.5
Primula veris	2.3
Vaccinium oxycoccos	0.6
Thalictrum alpinum	0.0
Polystichum lonchitis	0.0
Potentilla crantzii	0.0
Dryas octopetala	0.0

[1] Glaves D et al. (2009) A Survey of the Coverage, Use and Application of Ancient Woodland Indicator Lists in the UK. Appendix 1. Hallam Environmental Consultants, Sheffield.

[2] Walker, K.J. (2018) Vascular plant 'axiophyte' scores for Great Britain, derived from the assessments of the vice-county recorders of the Botanical Society of Britain and Ireland (May 2016). NERC Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/af2ac4af-12c6-4152-8ed7-e886ed19622b

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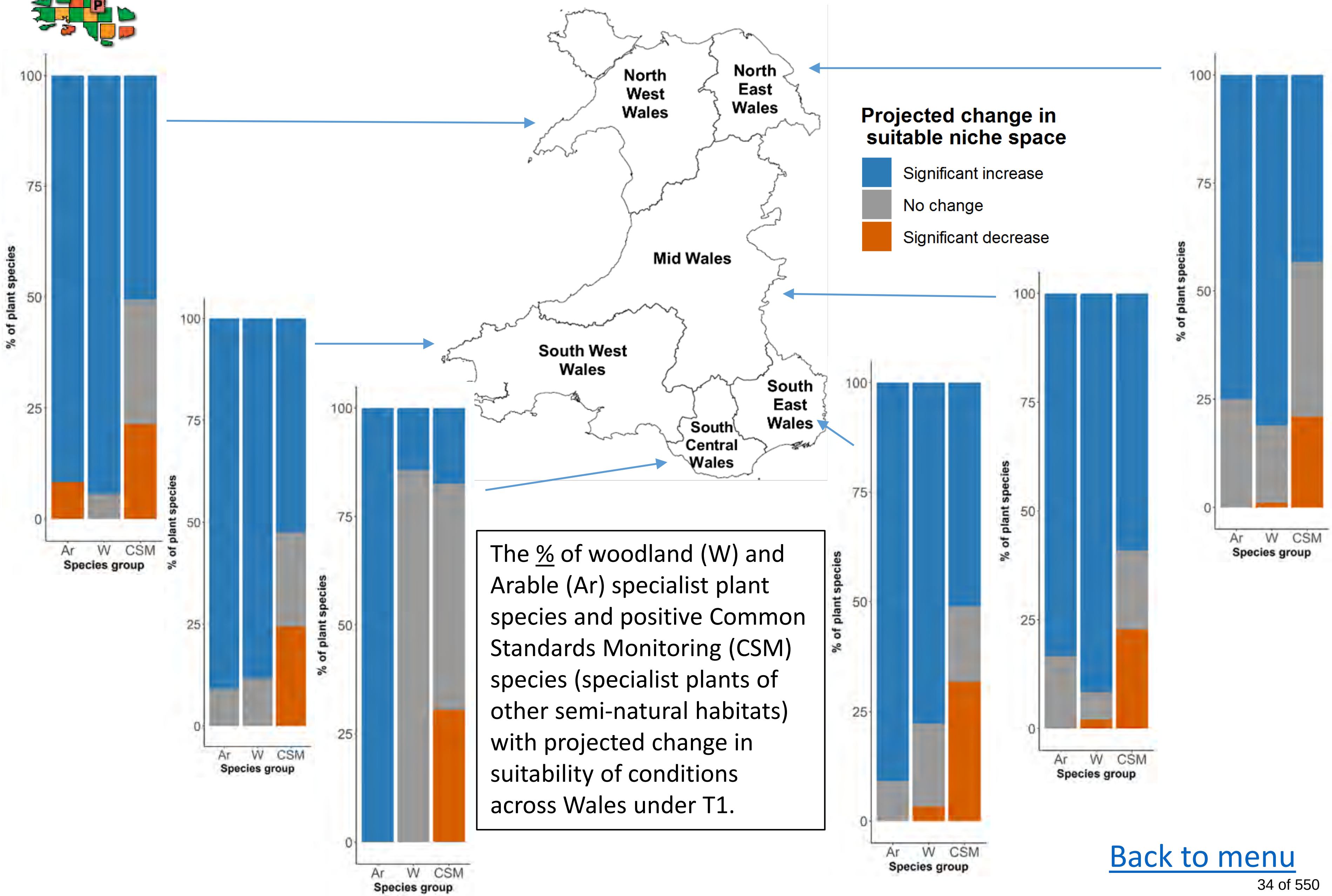
Regional impacts on plant species (T1)



The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales under T1.

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Woodland habitat connectivity: Background information

- Woodland connectivity was modelled using a simple approach based on the distance species can travel (dispersal distance) and minimum habitat area requirements (patch size).
- Land within the dispersal distance of more than one patch could connect those patches if trees were planted.
- We identified a range of parameter combinations from the literature and applied these for Wales, broken down into NRW Area Statement regions.
- Baseline woodland was assigned using NFI data, combined with LCM2017, and data on woody linear features.

Dispersal distance/ patch size	**100m: snails**	**200m: woodland specialist plants**	**500m: invertebrates**	**1km: max. for snakes; amphibians; moths**	**2km: max. for woodland flora/fauna**
1 ha: low area requirements	not modelled	modelled	modelled	not modelled	not modelled
10 ha: high area requirements	not modelled	modelled	modelled	not modelled	not modelled
40 ha: NE recommended minimum size for wildlife site	not modelled	modelled	modelled	not modelled	modelled

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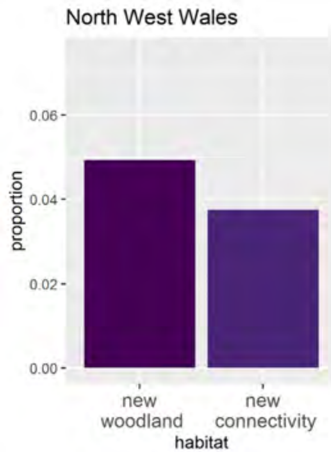
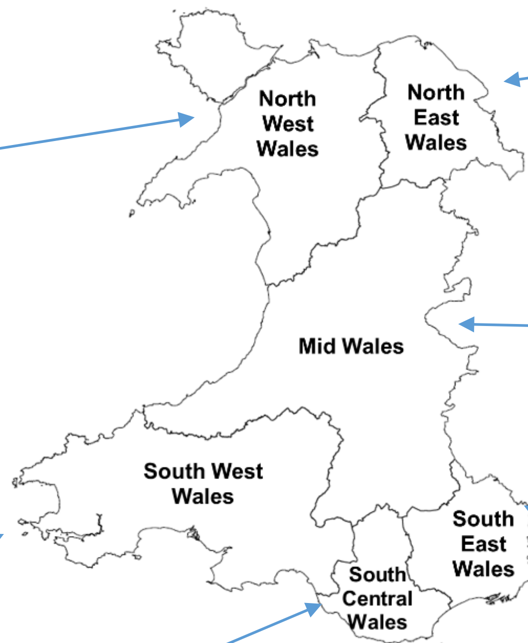
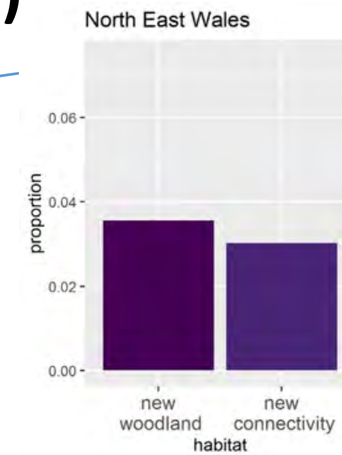
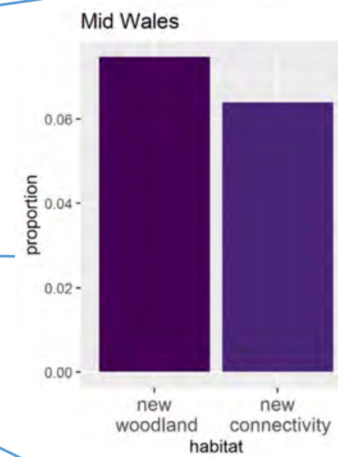
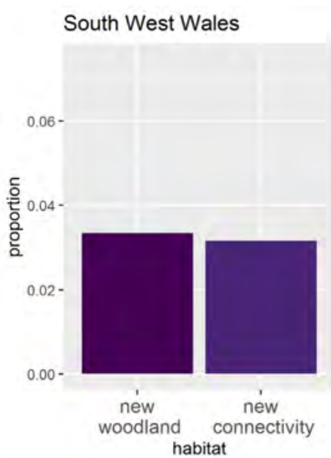
Woodland habitat connectivity: Regional variation in opportunity and predicted change (T1)

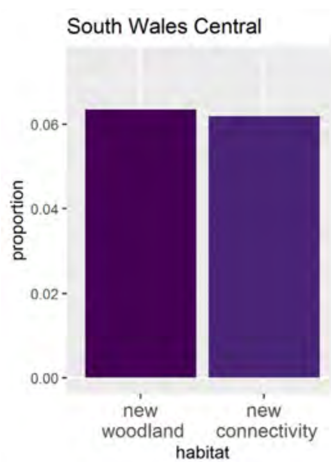


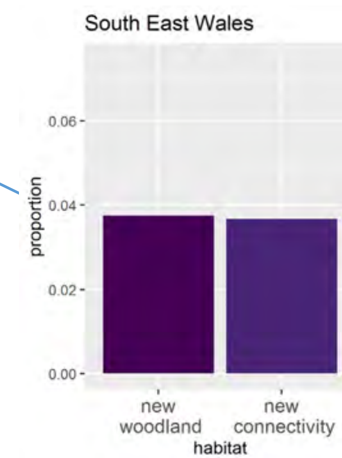












Most of the new woodland increases connectivity for at least one of our species type groups

- Total area new habitat woodland (ha)
- Total area providing increased connectivity

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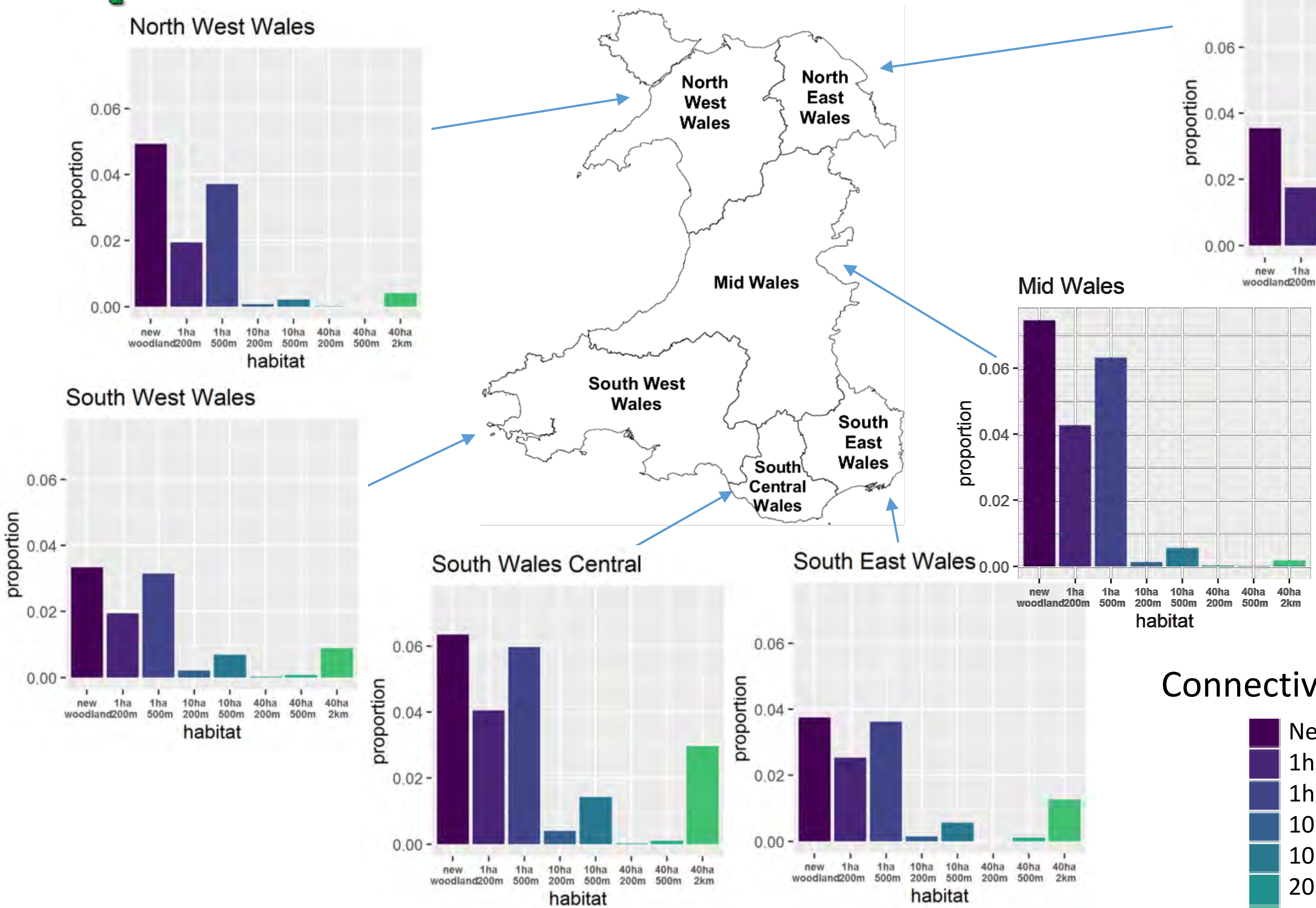
Breakdown of woodland connectivity type in NRW regions (T1)



Connectivity increase:

- New woodland habitat
- 1ha 200m
- 1ha 500m
- 10ha 200m
- 10ha 500m
- 20ha 200m
- 40ha 500m
- 40ha 2km

PART 3: Ecosystem Services

3a: Carbon

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Carbon summary: Stocks and GHG emissions (T1)

(Note: Negative numbers indicate sequestration or avoided emissions)	**Increased emissions or losses of carbon by the year:**		
Inventory category:	**2025**	**2050**	**2100**
Losses from carbon stocks in Land use change and forestry + harvested wood products (4 A,B,C & G) (KtCO2eq)	6,109	-105,617	-178,602
Additional emissions from wetlands (4D) flux (KtCO2eq)	-605	-3,628	-9,674
Additional agricultural GHG flux (KtCO2eq)	-5,019	-30,113	-80,303
TOTAL	486	-139,359	-268,578

- Overall, a **large net increase in C stocks by 2100**, alongside **reduced GHG emissions** is simulated for the T1 scenario, creating **net reduction in atmospheric GHGs**.
- Modelled sequestration in new woodland soils, vegetation and harvested wood products exceeds the reduction in greenhouse gas emissions associated with changes in livestock and nutrient inputs and avoided peatland emissions. This outcome is strongly dependant on the very large area of new woodland planting as modelled here, based on planting on former agricultural land with net positive NPV.

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Carbon stock and change in LULUCF categories (T1)

LULUCF category	Baseline	Change to 2100
Cropland and Grassland (4B +4C)(Kt) C	173,399	Loss of: 3,154 (Kt) Gain of: 657 (Kt)
Forest Land (4A) (Kt)C	Baseline woodland C data are not available	Gain of: 39,984 (Kt)
Harvested Wood products (4G) (Kt) C		Gain of: 11,223 (Kt)

- Carbon in cropland and grassland systems (LULUCF category 4B and 4C) is simulated to be lost in the T1 scenario, due to transitions from permanent and rough grassland into arable/grass rotation.
- Some gains in carbon in cropland and grassland systems are also simulated related to land going out of agriculture.
- Large gains in C storage are simulated for forest land and harvested wood products related to agricultural land that is converted to woodland. Note: this outcome is strongly dependant on the very large area of new woodland planting as modelled here, based on planting on former agricultural land with net positive NPV. Note also that data are not available to account for C storage in existing woodland.

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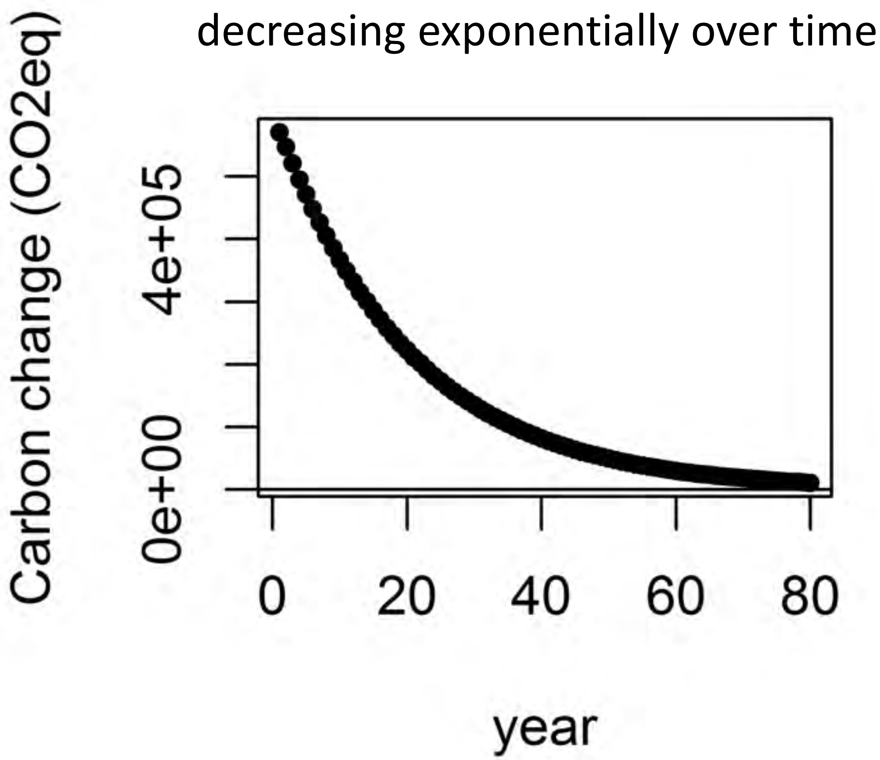
Agricultural carbon stock over time (T1)

Rate of C emissions from soils and vegetation at agricultural sites: Initially high losses in C stock, decreasing exponentially over time



(Plot for agricultural land staying in agriculture)

- Carbon stock in croplands and grasslands (LULUCF 4B + 4C) is simulated to decrease, rapidly at first with high initial emissions, but slowing over time, approaching a new equilibrium by 2100.
- Total losses to 2100 on this agricultural land account for almost 2% of total IMP modelled C stocks in agricultural vegetation and soils.

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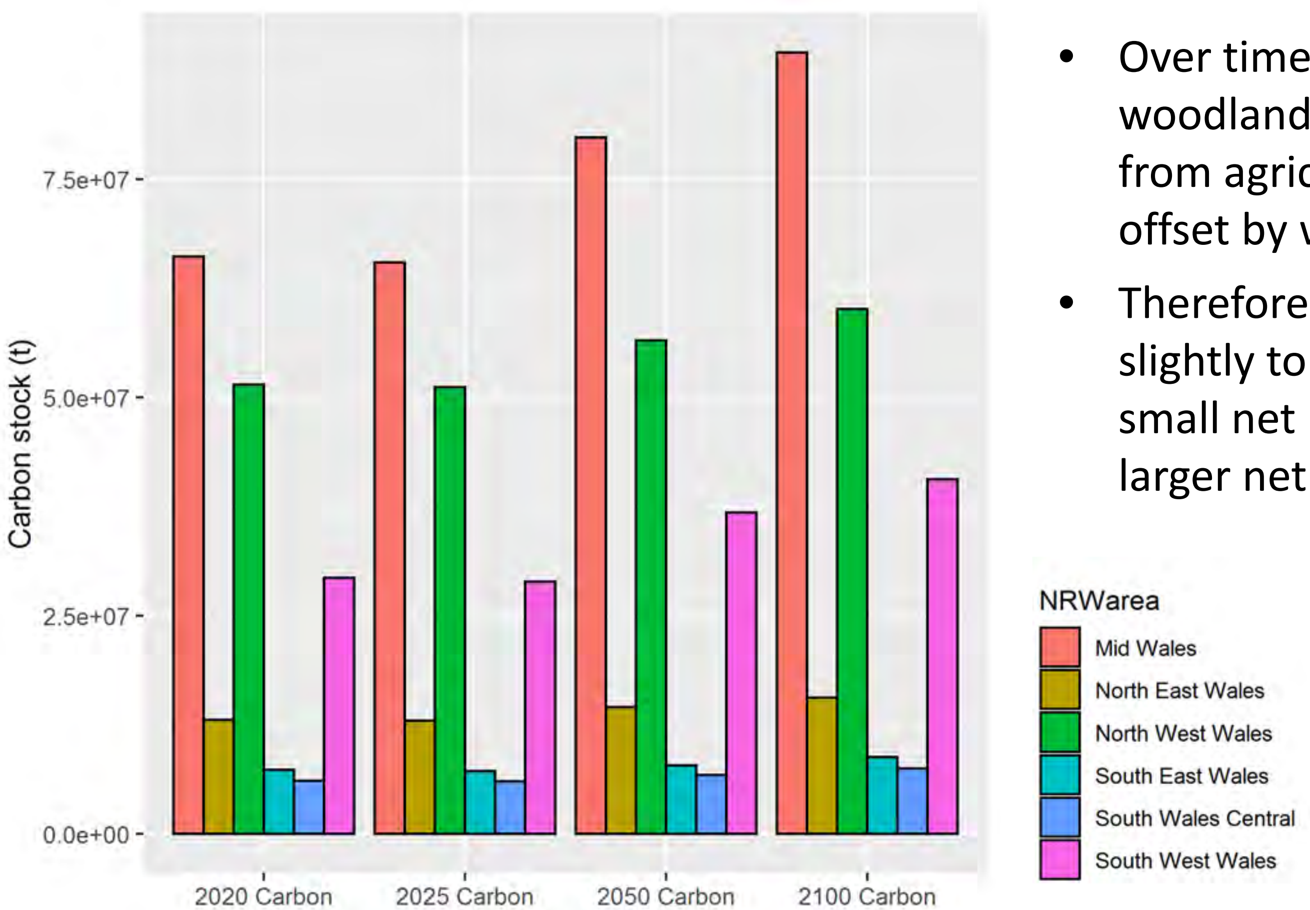
Total carbon stock over time (T1)

Total C stock for all modelled land in: 2020, 2025, 2050 and 2100



- Carbon stock in woodland systems increases slowly over time, with initial losses at some sites due to soil disturbance.
- Over time, initial losses from woodland disturbance and losses from agricultural changes are offset by woodland sequestration.
- Therefore, total C stock decreases slightly to 2025, followed by a small net increase by 2050 and a larger net increase by 2100.

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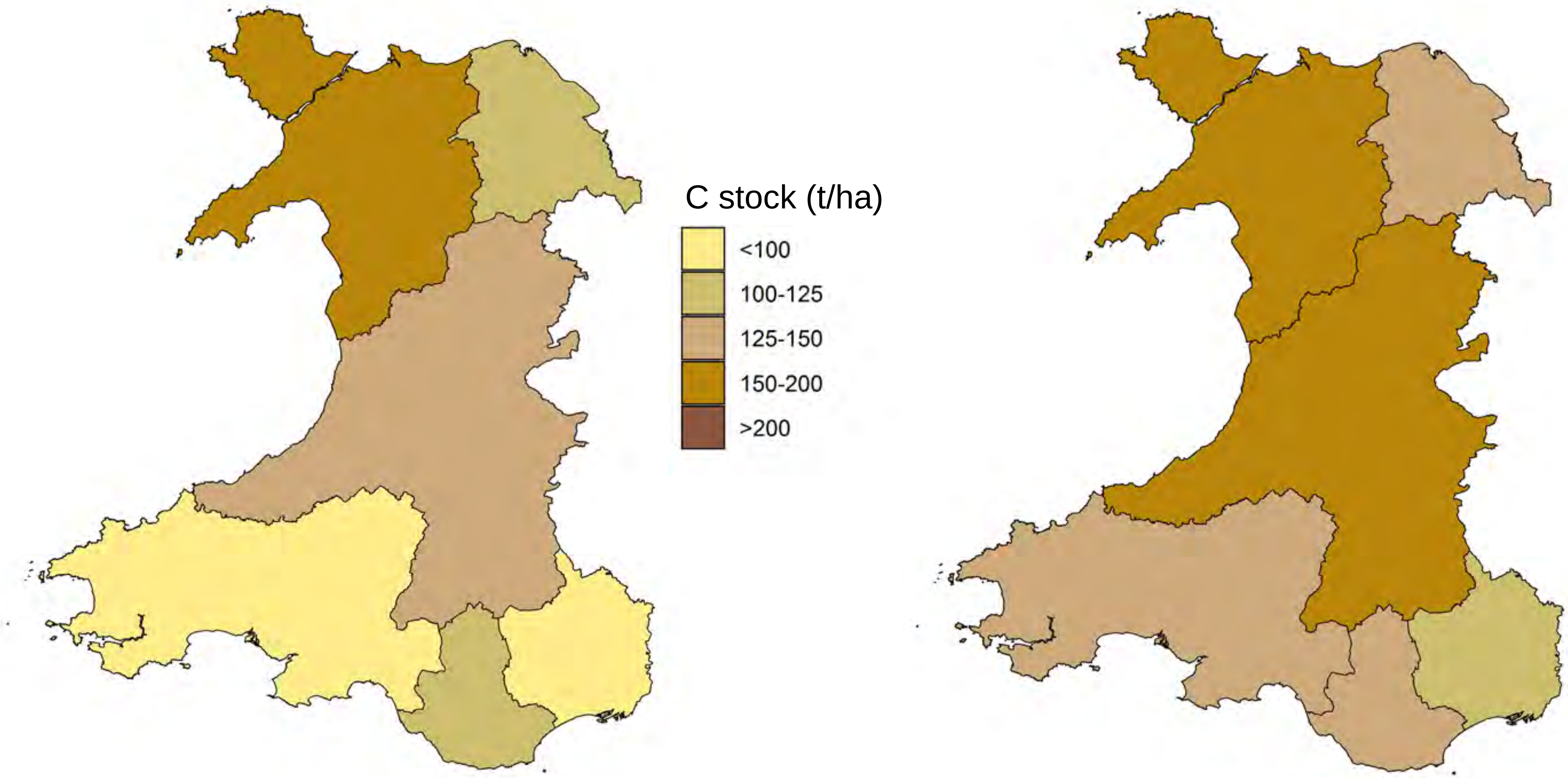
Carbon stock for NRW regions (T1)

Baseline (2020) **T1 scenario (2100)**



Data are for LULUCF categories 4 A,B,C &G
and are displayed per ha of land modelled

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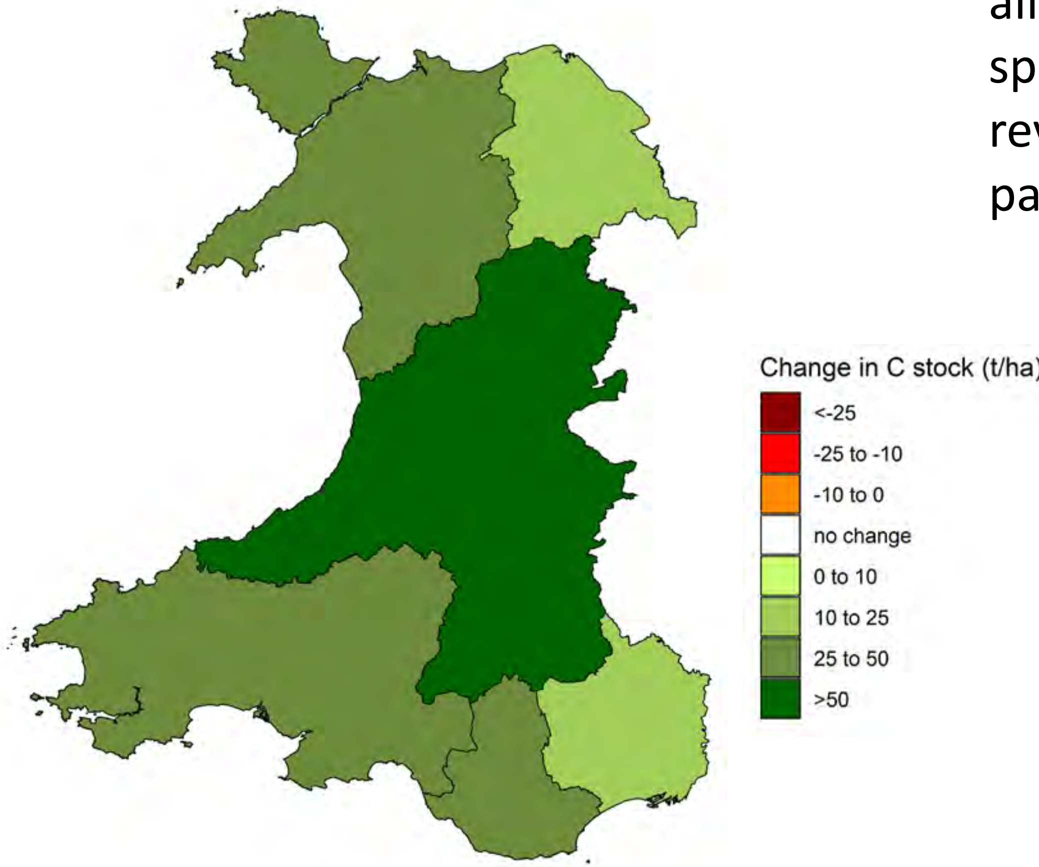
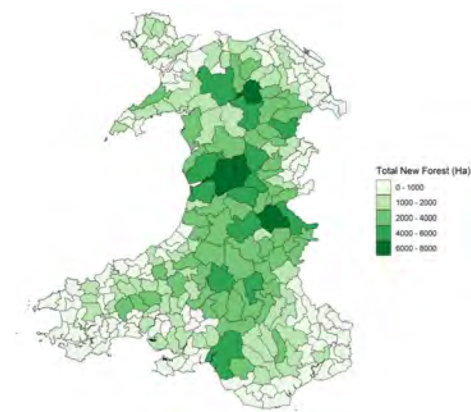
Carbon change for T1 scenario

Carbon change 2020-2100 (tC/ha)



Data are for LULUCF categories 4 A,B,C &G and are displayed per ha of land modelled

A net carbon increase is simulated for all NRW regions, however, the finer spatial detail in the maps that follow reveal that this net increase masks a pattern of increase/decrease



New woodland is the main control on change in carbon

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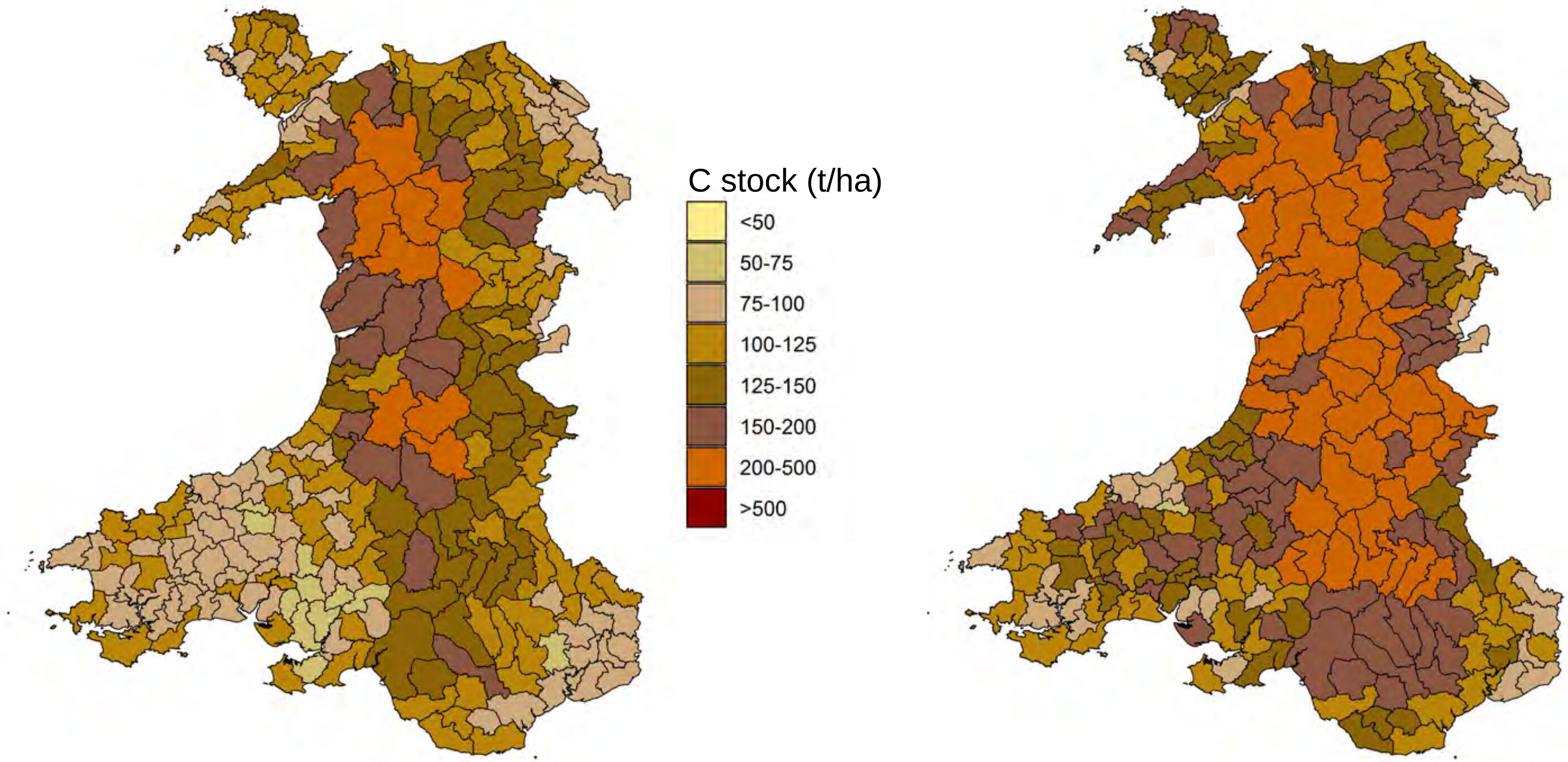
Carbon stock for small agricultural areas (T1)

Baseline (2020)

T1 scenario (2100)



Data are for LULUCF categories 4 A,B,C &G
and are displayed per ha of land modelled

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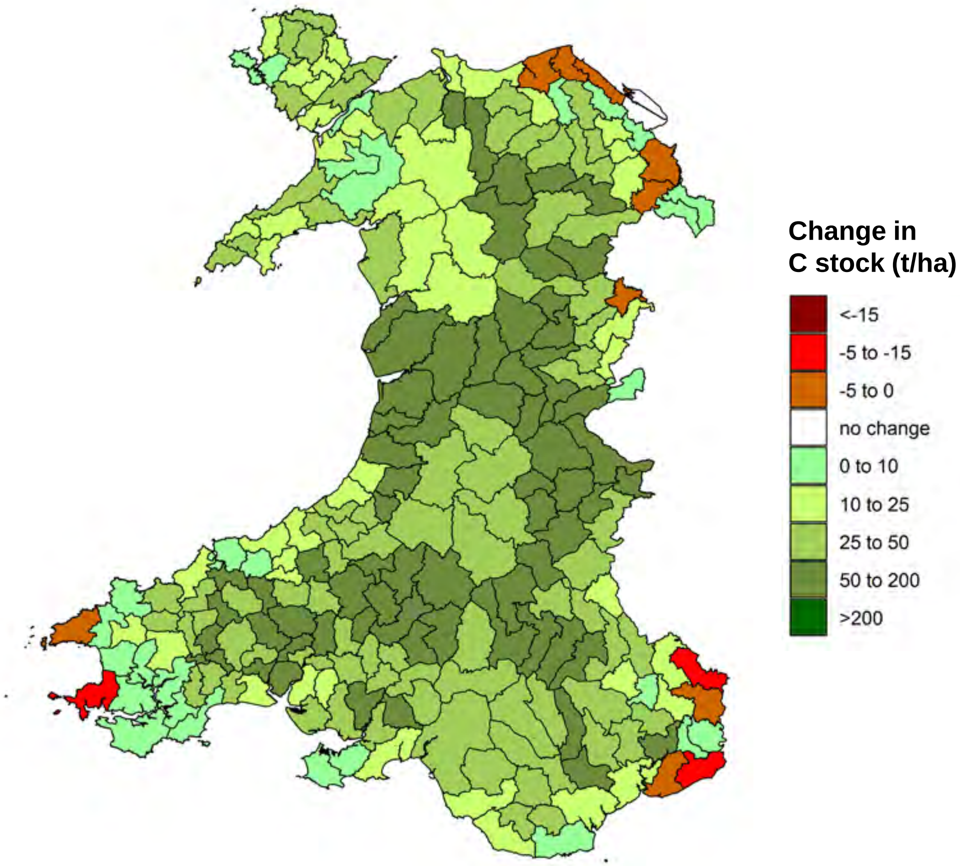
Carbon change for small agricultural areas (T1)

Map: tC/ha change 2020-2100



Data are for LULUCF categories 4 A,B,C &G and are displayed per ha of land modelled

- Carbon stocks are simulated to increase in some areas and decrease in others.
- Areas of decrease reflect reduction in areas of permanent and rough grass, and increase in arable-grass rotation.
- Areas of large increase reflect new woodland (see slide 38), largely due to the significant C storage potential of biomass and harvested wood products.
- Some increase may also be attributed to sequestration on land reverting to short vegetation.

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GHG emissions: Peat and agriculture (T1)

This table compares total agricultural emissions and wetland emissions for farms modelled by IMP:

LULUCF category	Baseline	T1 scenario
Wetlands (4D) flux (KtCO2eq/yr)	873	753
Agricultural GHG flux (KtCO2eq/yr)	4,816	3,812

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Agricultural GHG emissions are simulated to reduce, reflecting the decrease in beef cattle and sheep, which is not offset by the increase in dairy.
- GHG emissions from wetlands are also simulated to reduce, reflecting the halving of arable land use on peat.

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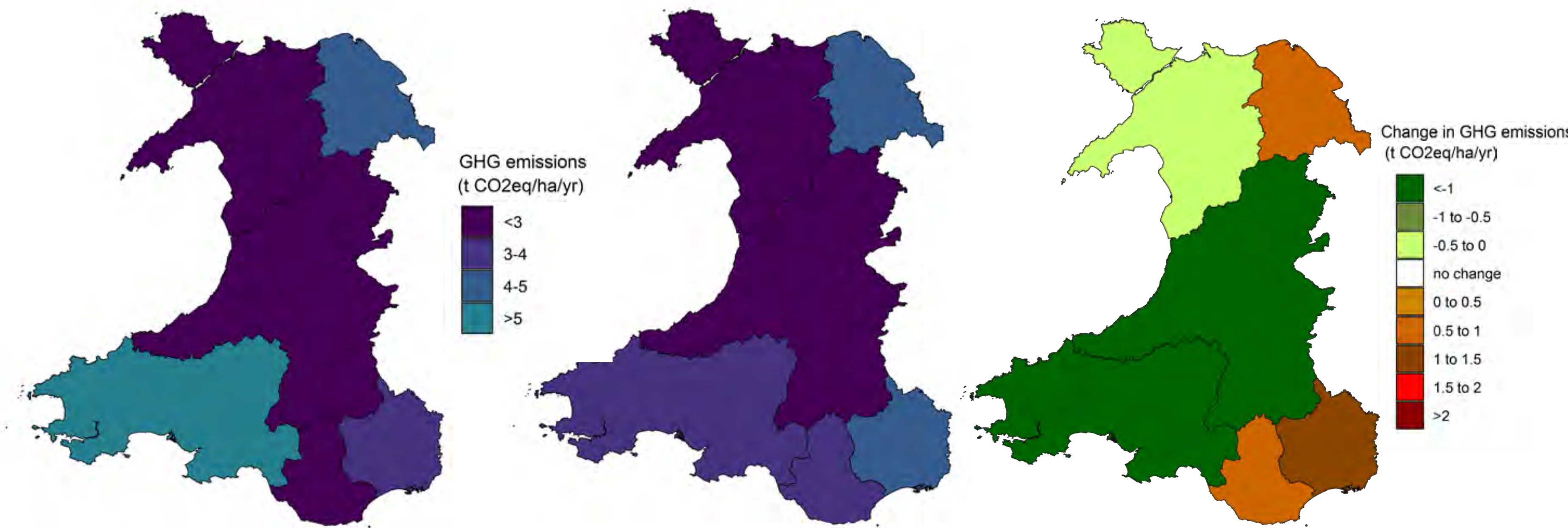
GHG emissions for NRW regions (livestock and management) (T1)

Baseline | **T1 scenario** | **Change**



- Data are displayed per ha of land modelled, and reflect patterns of livestock, land use and management.
- Reductions reflect land being simulated to go out of agricultural use in North West, Central and South West Wales.
- Increases reflect simulated increases in intensity with greater areas of conversion to arable/temporary grassland.

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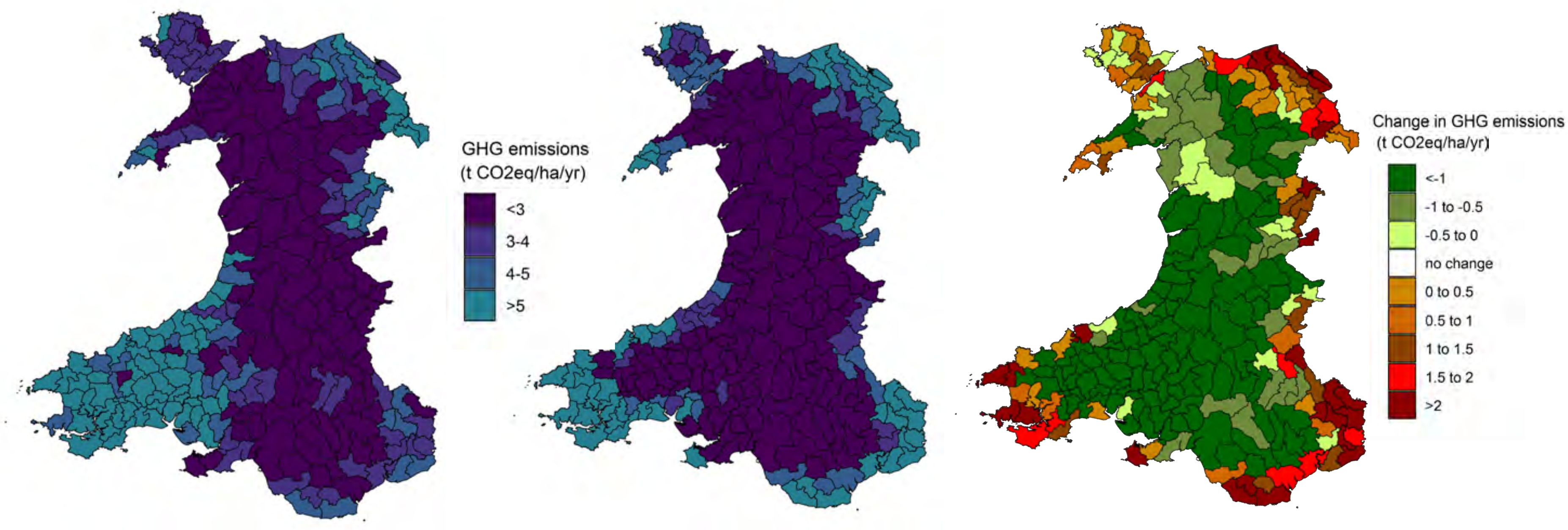
GHG emissions for small agricultural areas (livestock and management) (T1)

Baseline | **T1 scenario** | **Change**



- The finer scale data reveal the greater magnitude of local changes.
- Reductions reflect land going out of agricultural use across much of Wales.
- Increases in lowland and coastal areas reflect increased intensity with greater areas of conversion to arable/temporary grassland.

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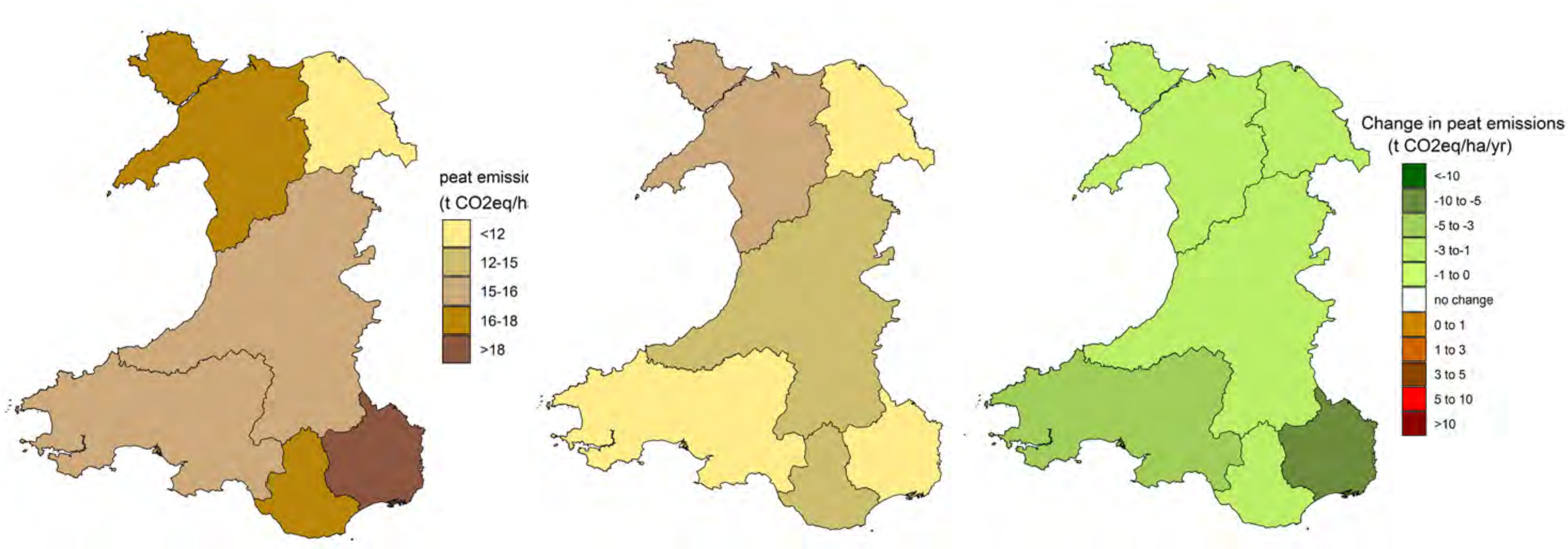
GHG emissions for NRW regions (peat) (T1)

Baseline **T1 scenario** **Change**



- Data are displayed per ha of peat modelled, and reflect land use and inferred management.
- Emissions are simulated to reduce in all areas under the T1 scenario, due to land on peat coming out of agricultural use.

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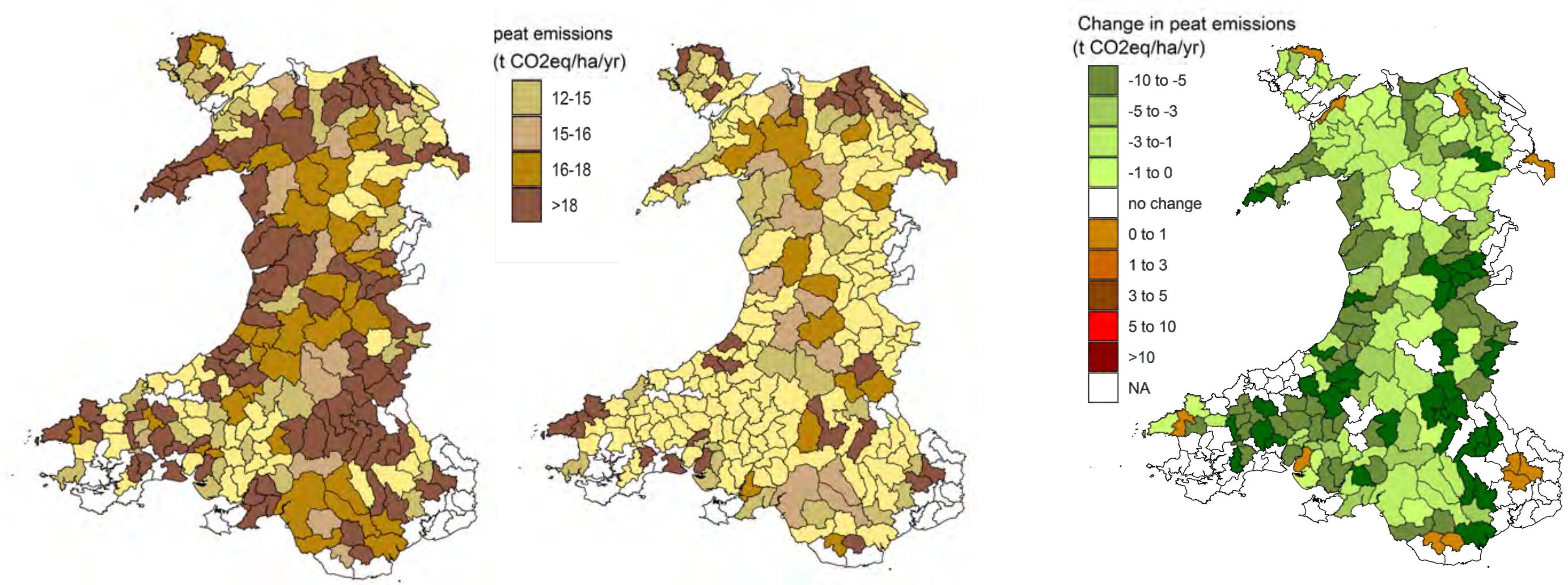
GHG emissions for small agricultural areas (peat) (T1)

Baseline **T1 scenario** **Change**



- Emissions are projected to reduce to 2100 in most areas, but increase in a few areas due to conversion from permanent grass to grass/arable rotation.
- Some small agricultural areas do not contain peat, or do not experience predicted land use change on peat.

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PART 3b: Water quality

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Water Quality: Background information 1

- Water quality impacts must be considered for WFD catchments, therefore, loads calculated at the DMU level **(in kg/ha)** must be processed to in-stream loads, by aggregating at the catchment level.
- We also add in non-agricultural sources of pollutants, as well as estimates of pollutants for farms not modelled by the IMP (<1FTE).
- We then account for flow (and nutrient) accumulation to downstream catchments, and account for stream flow to calculate concentration for N and P.
- Data for N and P are processed to units reflecting the relevant thresholds: **annual average concentration for P and 95th percentile for N**.
- Data on sediments are calculated as **annual average loads**. River sediment concentrations are controlled by event driven inputs and in-river processes occurring over a range of timescales, so it is hard to measure average concentrations using infrequent grab samples and difficult to predict these from annual average inputs to watercourses as predicted by the IMP.

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Water Quality: Background information 2

- The water quality analyses are based on the scenario being applied to farms >1FTE only. Farms <1FTE are modelled as not responding to the scenario.
- We assume afforestation or reversion to short vegetation or natural woodland on the "non-economically viable" farms.
- Changes in water quality are not modelled for lakes, but these may be important for recreation, and associated businesses in Wales.
- Data outputs relate to a new long-term average reflecting land use and management for the scenario: we do not account for time lags in the nitrogen system.
- Predicted loads are based on average climate data (1961-1990).
- Data reflect average losses rather than those that might occur once in several years due to an intense rainfall event causing significant erosion (particularly important for sediment and P).
- Some measures might change soil P status or soil organic N supply, which happen over a period of 10+ years to reach a new equilibrium. Our scenario outputs assume these changes have already occurred.

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Water Quality for Wales: Change in N, P and sediment load (T1)

This table compares total agricultural loading for farms modelled by the IMP:

	Farms <1FTE	Baseline	T1 scenario	Change	% change	Glastir impacts
Nitrate kt NO3 N	4.13	30.11	22.36	-7.75	-26%	-1%
Phosphorus kt P	0.18	0.72	0.41	-0.31	-43%	-0.9%
Sediment kt Z	68	194	106	-88.01	-45%	-0.1%

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Major reductions are simulated in all pollutants for the T1 scenario.
- This reflects an assumption that large areas no longer viable as farms go to non-agricultural use.
- Glastir impacts, modelled from 2016 uptake data, are shown for comparison.

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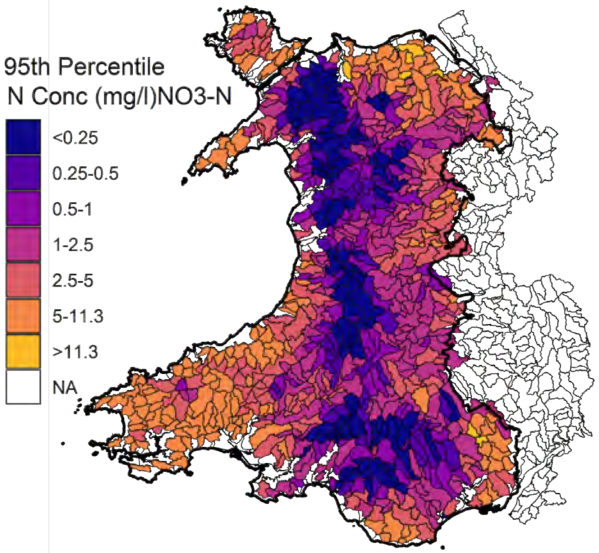
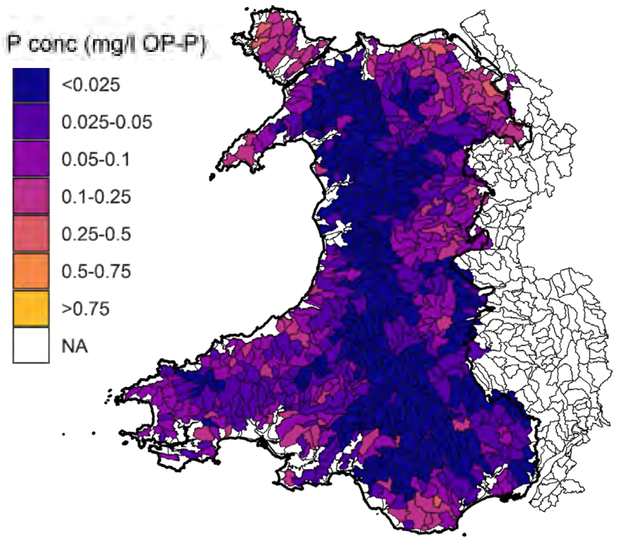
N, P and sediment load for baseline and T1

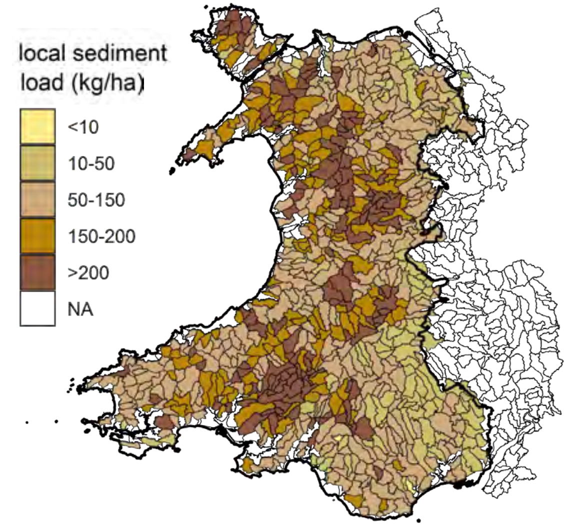
Baseline N



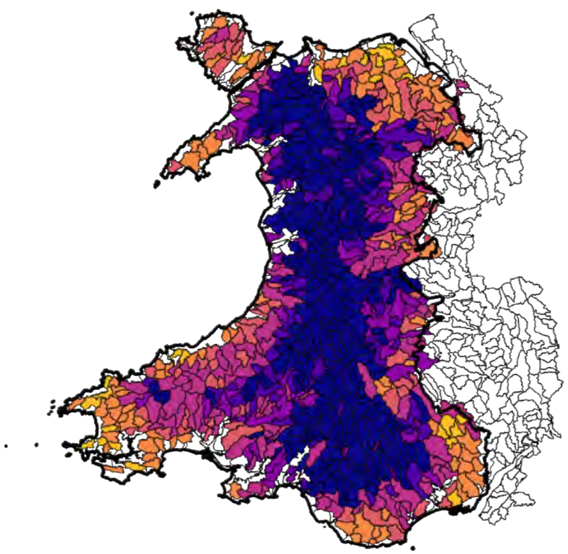
Baseline P



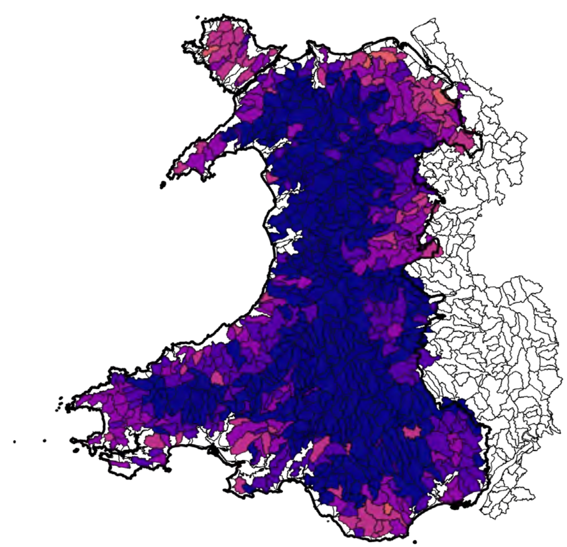
Baseline Sediment



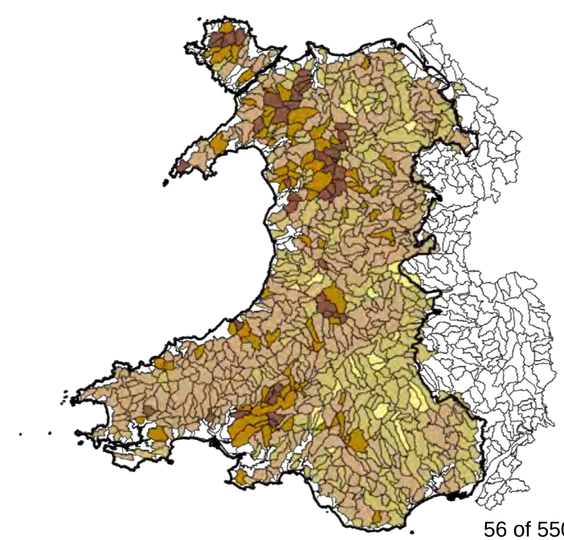
T1 scenario N



T1 scenario P

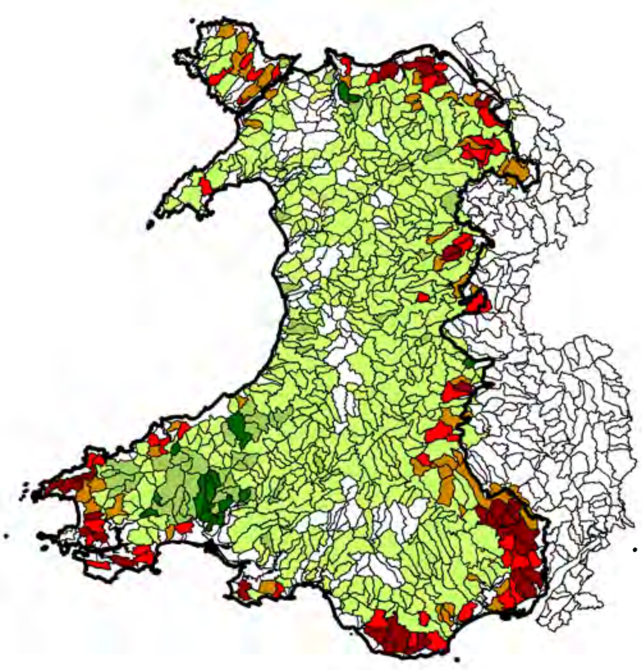


T1 scenario Sediment



Change in N, P and sediment load (T1)

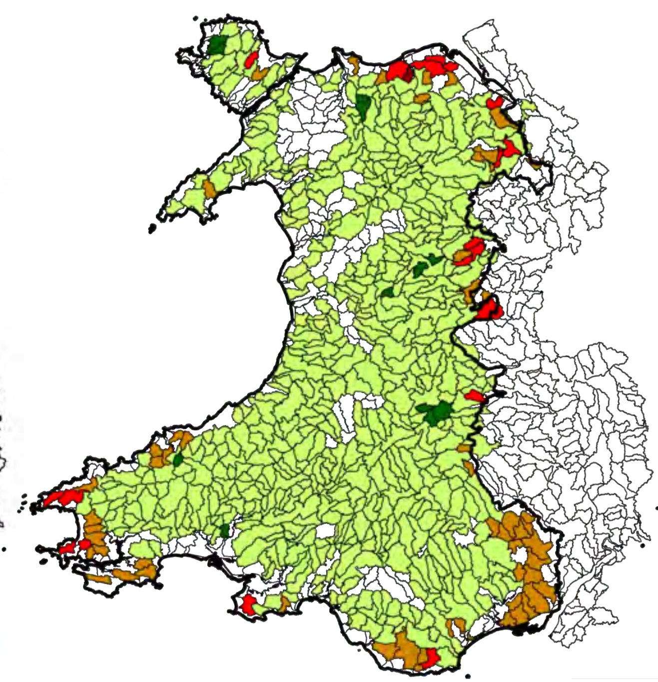
N change



Change in 95th Percentile N Conc (mg/l)NO3-N

- <- 5
- -5 to -2.5
- -2.5 to
- no change
- 0 to 2.5
- 2.5 to 7.5
- >7.5
- NA

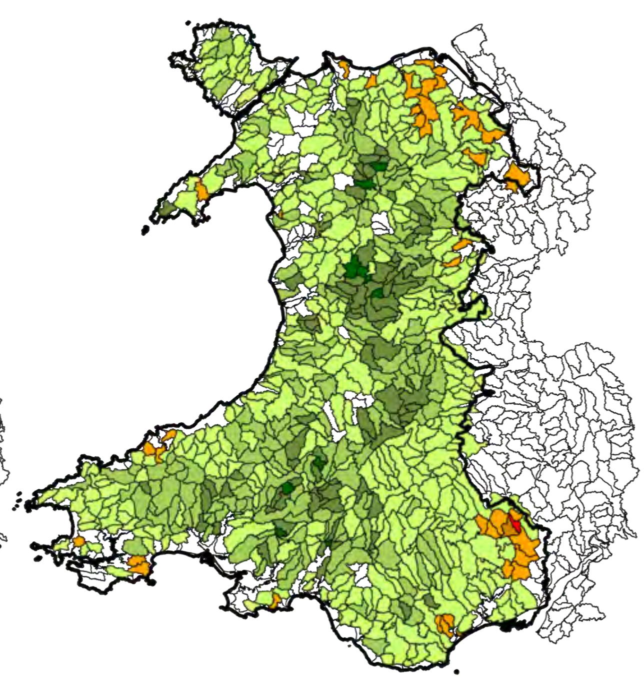
P change



Change in P conc (mg/l OP-P)

- <- 0.05
- -0.05 to 0
- no change
- 0 to 0.01
- 0.01 to 0.05
- >0.05
- NA

Sediment change



Change in local sediment load (t/ha)

- <-200
- -200 to -100
- -100 to -50
- -50 to 0
- no change
- 0 to 10
- 10 to 25
- 25 to 50
- >50
- NA

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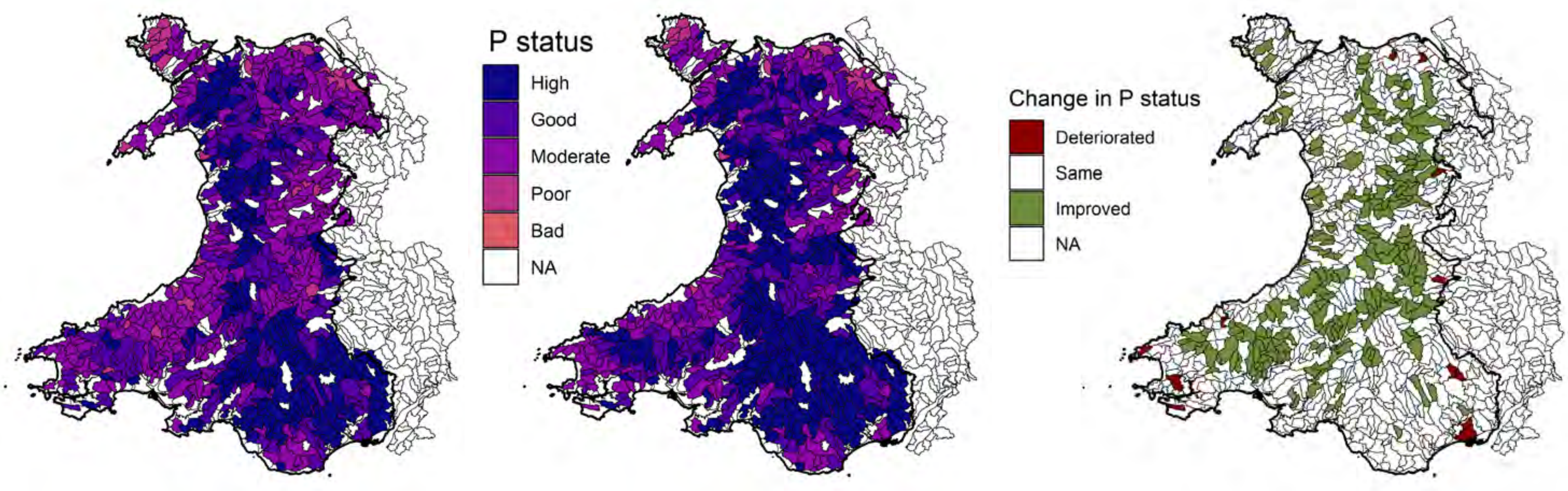
WFD P status (T1)

Baseline **T1 scenario** **Change**



- WFD P status is projected to improve under the T1 scenario in several catchments, reflecting farms assumed to leave full-time agriculture.
- WFD P status is projected to deteriorate in some catchments where arable-grass rotations increase.

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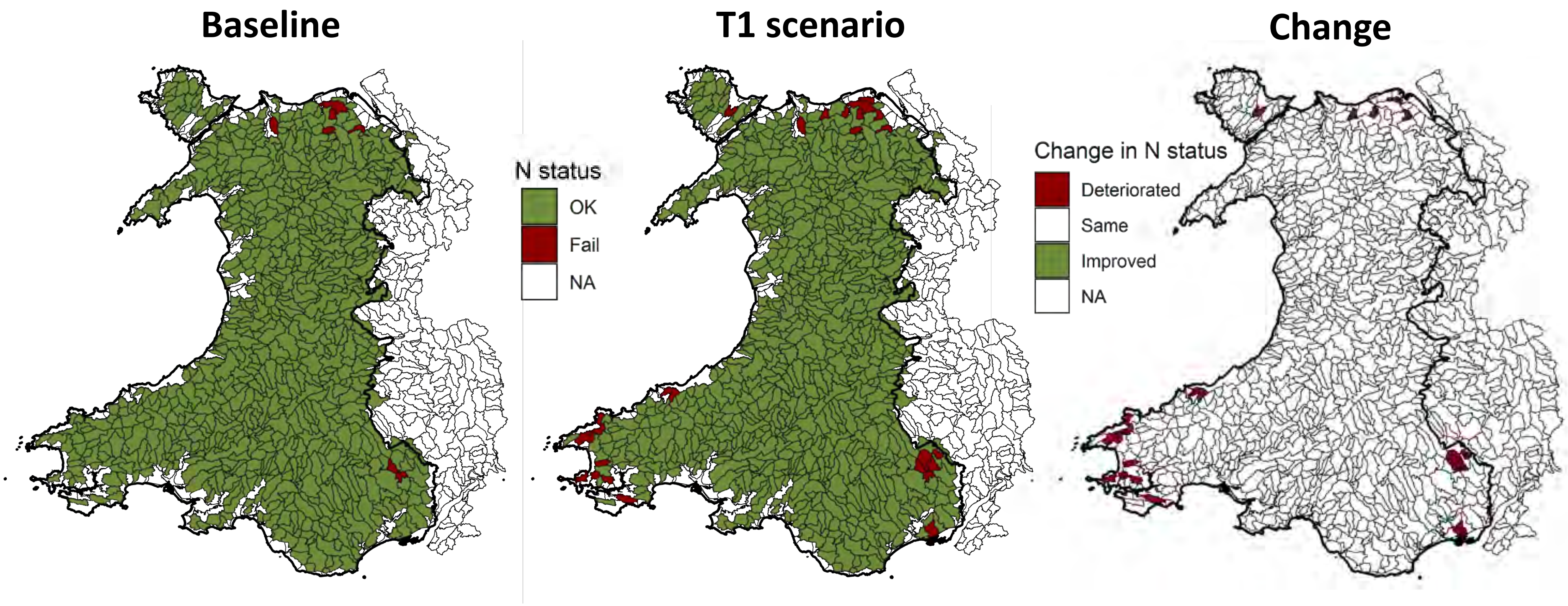
Drinking water N status (T1)



- Drinking water N status is projected to be largely unaffected by the T1 scenario, but worsens in key areas coinciding with increased arable-grass rotations.
- This deterioration of status is in spite of the modelled 26% reduction in total agricultural load from farms modelled by the IMP.

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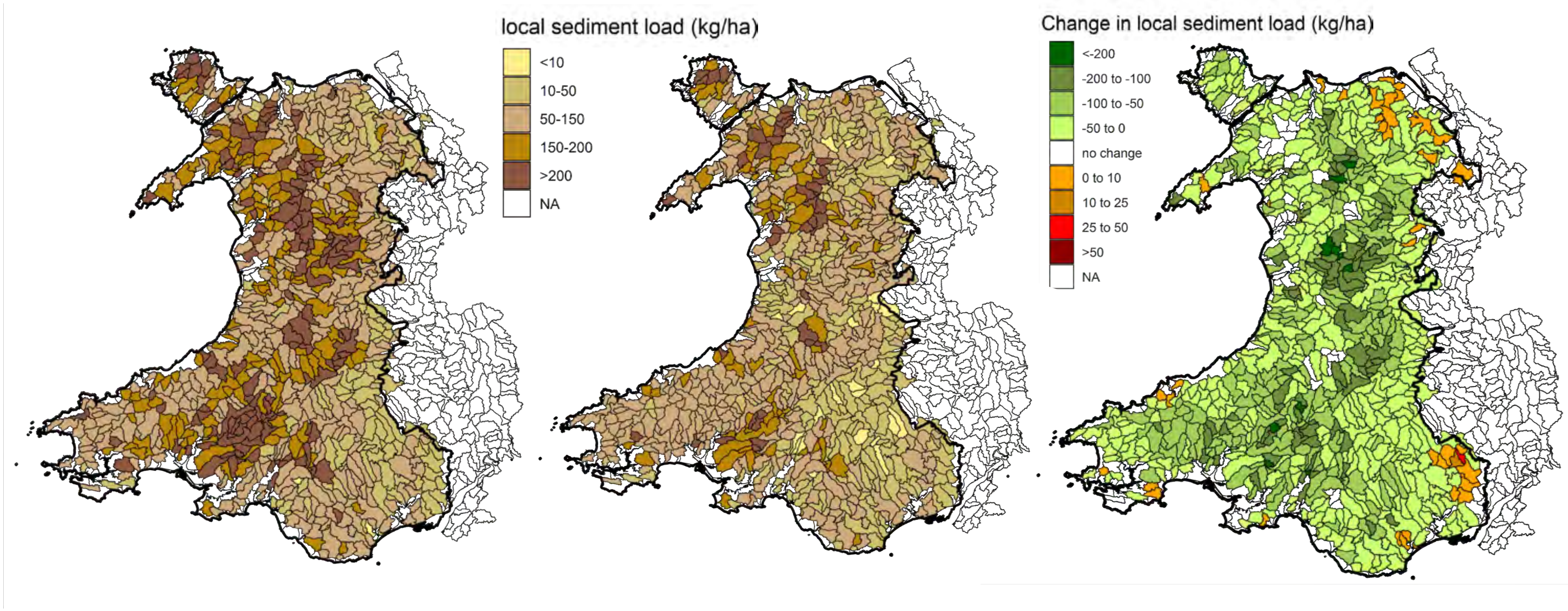
Change in sediment load (T1)

Baseline **T1 scenario** **Change**



- An increase in sediment loading is simulated in key areas coinciding with areas with increased arable-grass rotation, and a decrease for most other catchments in Wales.

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PART 3c: Air quality

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Air quality for Wales (T1)

This table shows changes in PM2.5 concentration and life years lost under the T1 scenario:

Average Change in PM2.5 Concentration	Life Years Lost (LYL)
-0.11	-211.1

- PM2.5 concentrations are projected to reduce on average for Wales, as a result of increased woodland planting and changes in NH3 emissions.
- This leads to a net health benefit of a reduction in 211.1 Life Years Lost.
- BUT spatial patterns vary …

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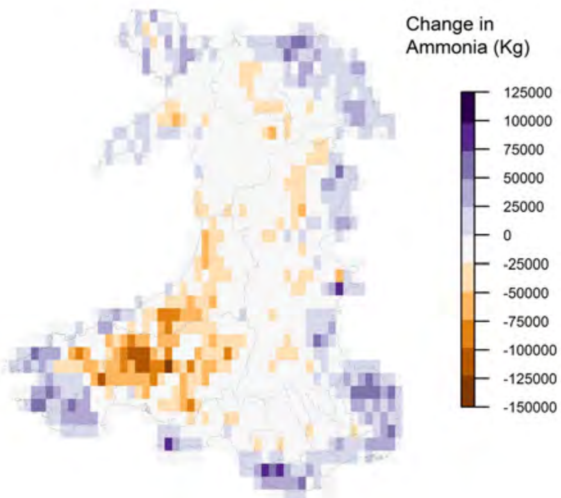
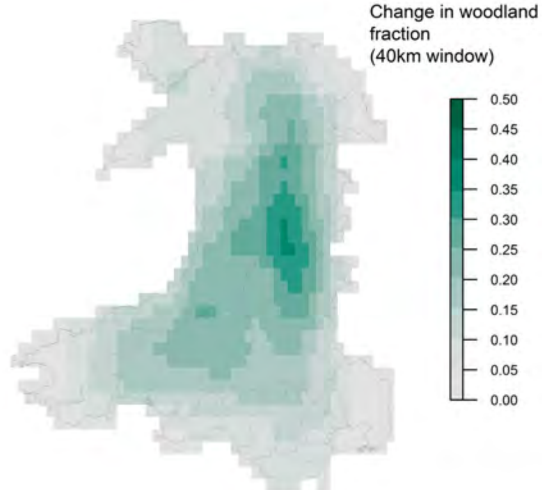
Health outcome from change in air quality (T1)

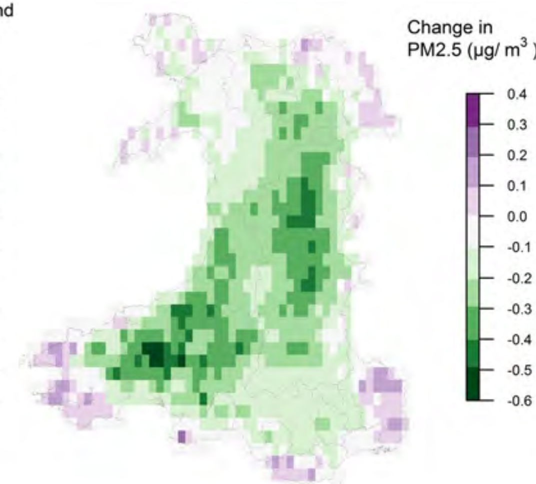
NH3 emissions



New woodland

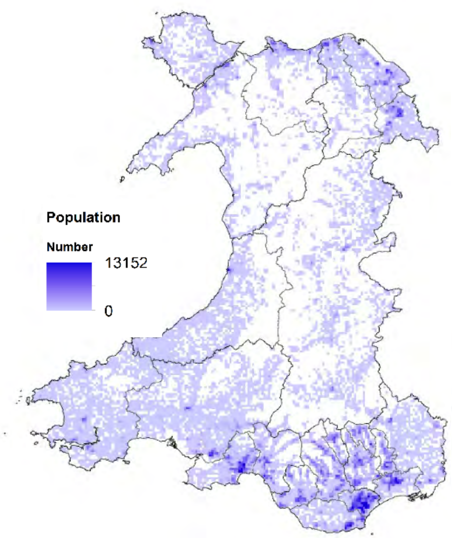


PM2.5 change

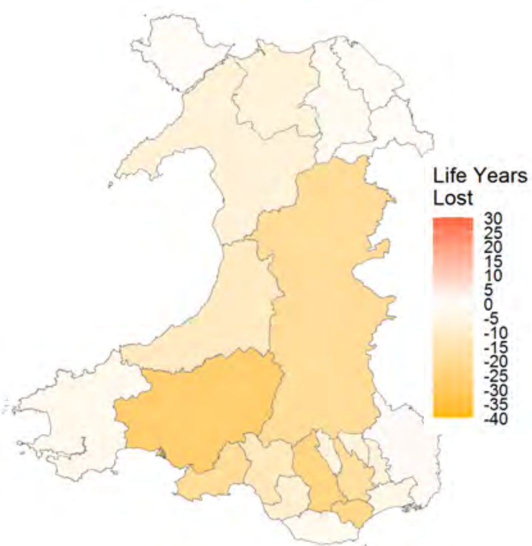


- Change in PM2.5 is a function of new woodland & change in NH3 emissions.
- Reductions in PM2.5 where there is new woodland AND reduced NH3.
- Increases in PM2.5 where NH3 emissions increase (mainly from dairy).

Population



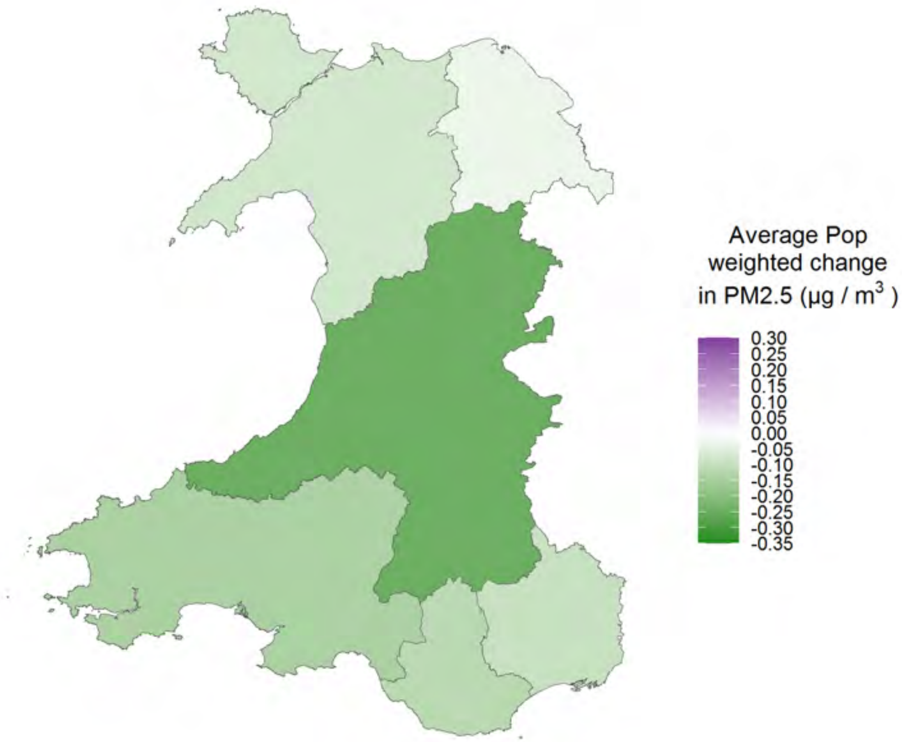
Avoided 'Life Years Lost'



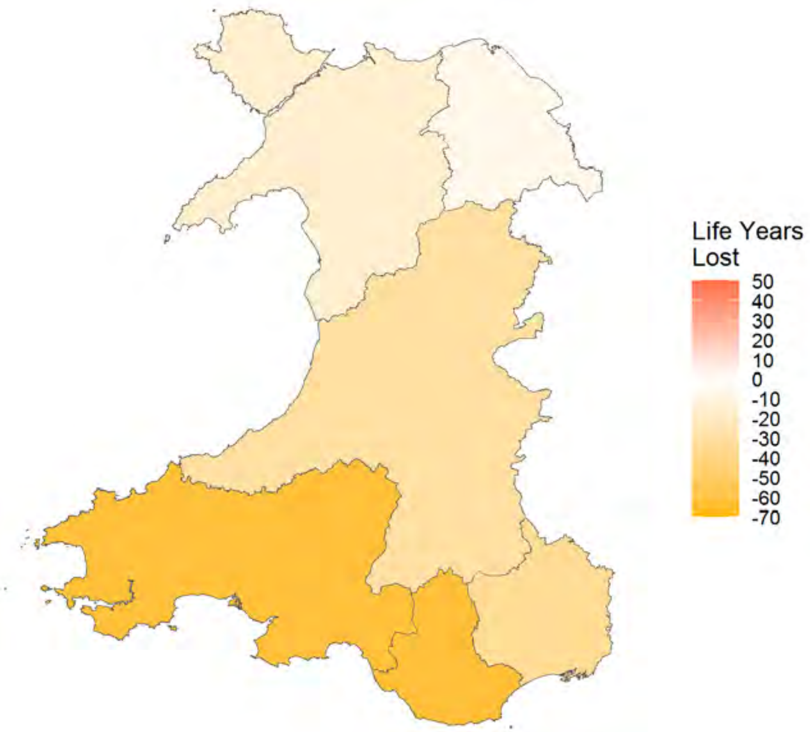
- Health outcomes are a function of change in exposure of the population.
- **Net positive benefit in most areas *except Monmouthshire*.**

Air quality for NRW regions in T1

Average change in PM2.5 concentration



Avoided Life Years Lost (total)



Greatest benefits are in parts of Mid to South Wales

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PART 4: Valuation

Valuation results: Background information

- Price year: 2020
- Present values: 75 year time horizon
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g. 3.5% declining discount rate/ health discount rate for air quality):
  - Values are based on BIES (2018) guidance on carbon values for appraisals by Government.
  - This was prior to the release of updated values in September 2021.
  - The 2018 values do not fully reflect the requirements of the Paris Agreement 2016, the domestic net zero target, and other recent policy developments.
- Results given to 3 significant figures.

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Summary of public goods values (T1)

Benefits	Physical measure	Units	Present value, 75 yrs, £	Type of value
Air Quality	Decrease of 211 years	Life Years Lost each year	£ 302m	Reduction in costs of health impacts from air pollution
Water Quality	28 Deteriorate, 200 Improve	Expected changes in WFD status due to changes in P	£ 66m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Decrease of 256m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	£ 18,060m	Benefit of Benefit of reducing atmospheric GHG concentrations from non-traded sources

- The figures are an estimate of the value of the increase in wellbeing to people over 75 years under this scenario.
- Figures indicate order of magnitude of values of expected changes in the Welsh Environment.

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Breakdown of public goods values (T1)

Benefits	Present value, £m			Type of value
	5 yrs	25 yrs	75 yrs	
Air Quality	£ 50m	£ 94m	£ 302m	Reduction in costs of health impacts from air pollution
Water Quality	£ 11m	£ 40m	£ 66m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs:				Benefit of reducing GHG sources:
Agriculture	£ 349m	£ 1,804m	£ 5,187m	Agricultural sources (livestock and inputs)
Land use	-£423m	£ 6,026m	£ 12,249m	LULUCF sources (soils, vegetation and harvested wood products)
Wetlands	£ 42m	£ 217m	£ 624m	Wetland sources (peatlands)
TOTAL	- £ 32m	£ 8,047m	£ 18,060m	Benefit of reducing carbon emissions from non-traded sources

- All figures are based on simplifying assumptions of change over time.

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Public Goods Values for different time horizons (T1)

- Relative value of air quality are simulated to increase over time as trees mature.
- All water quality improvements are due to reduced phosphate levels, and outweigh deteriorations (mainly caused by increased nitrates).
- Carbon values are negative in the short-term, due to emissions from soil disturbance (e.g. for tree planting); subsequent sequestration shifts this to a positive impact.

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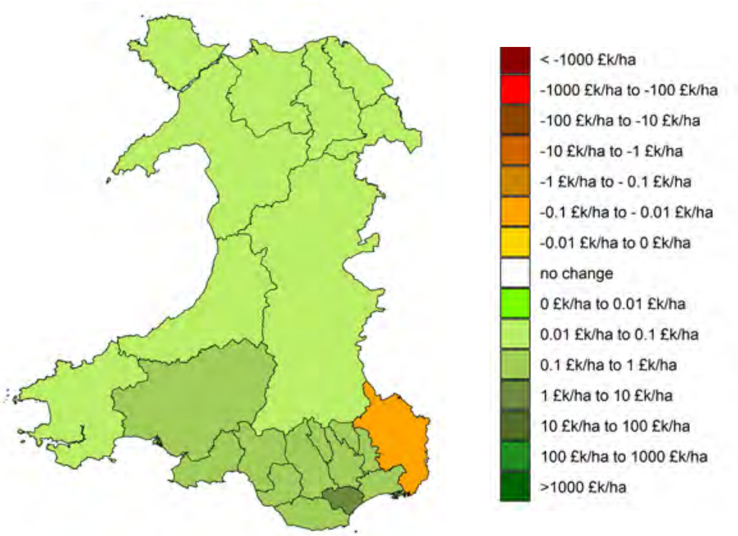
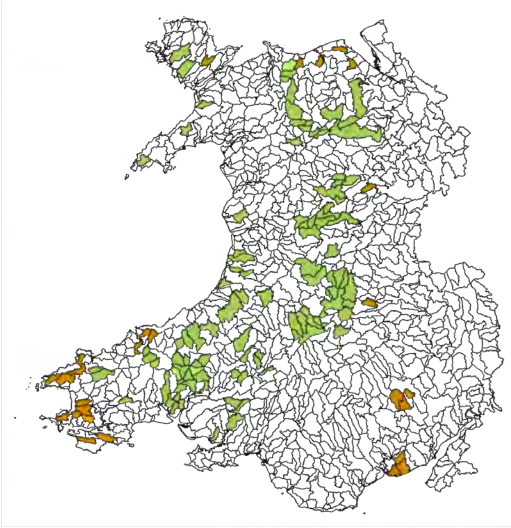
Spatial distribution of values (T1) (finest resolution)

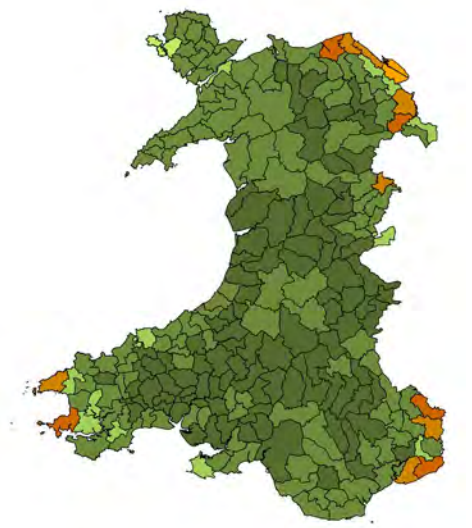
Reduction in costs of air pollution



Value of change in status of freshwater bodies



Value of change in LULUCF carbon stock in vegetation and soils



- The greatest per ha values for the T1 scenario comes from LULUCF carbon, due to the large area of new woodland and associated C sequestration.
- The LULUCF gains are strongly dependant on a very large area of new woodland planting as modelled here, based on a planting on former agricultural land with net positive NPV.

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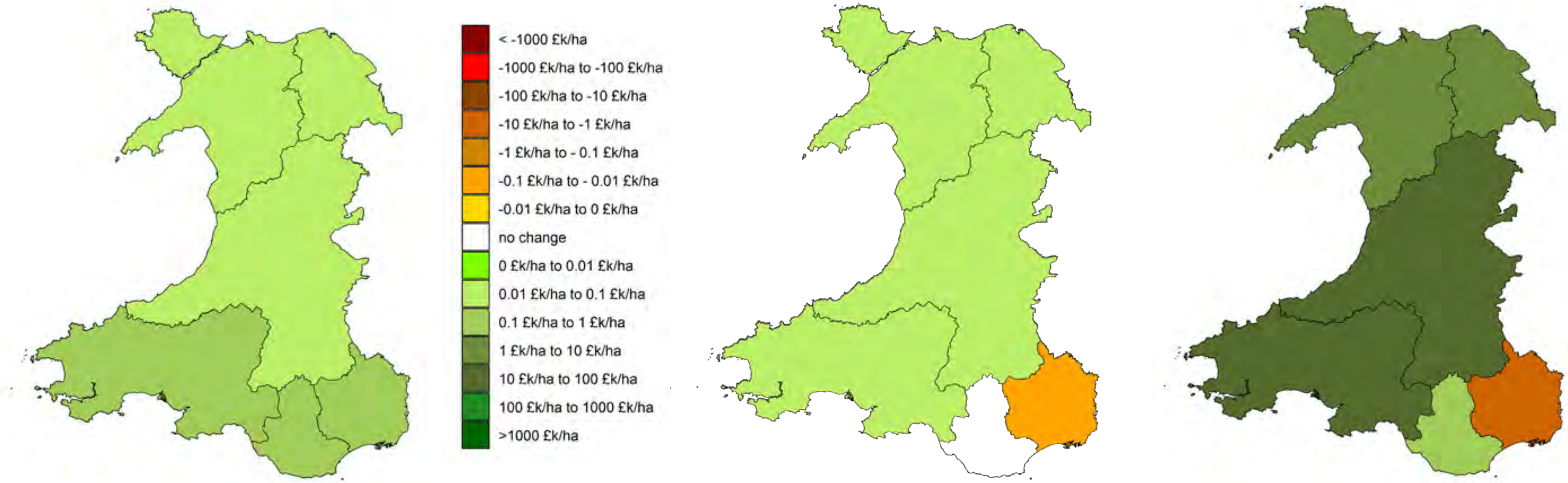
Spatial distribution of values (T1) (NRW regions)

Reduction in costs of air pollution

Value of change in status of freshwater bodies

Value of combined change in GHG and carbon balance



- The greatest per ha value for the T1 scenario comes from carbon and GHGs due to reductions in agricultural emissions, and the large area of new woodland and associated C sequestration (see next slide for breakdown).

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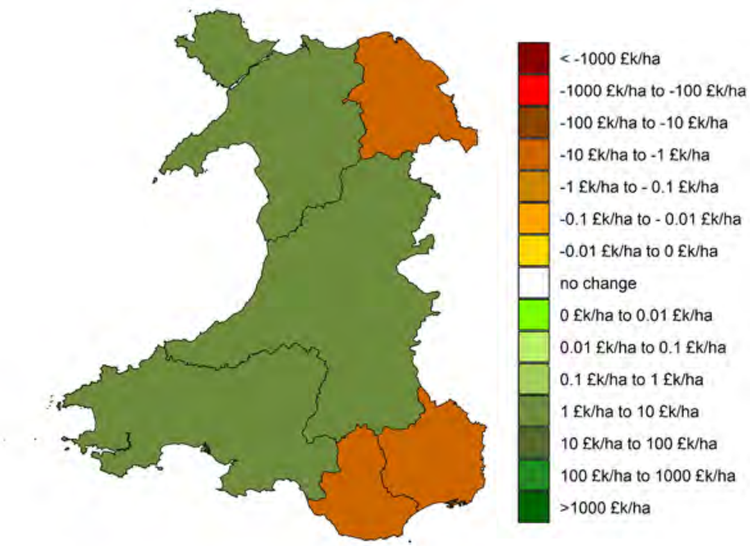
Breakdown of values for Carbon and GHGs (T1) (NRW regions)

Value of change in agricultural GHG emissions



Value of change in wetland (peat) GHG emissions

Value of change in LULUCF carbon stock in vegetation and soils

- The change is mostly attributed to change in LULUCF C stock and GHG emissions, which increase in some regions and decrease in others.
- The LULUCF gains are strongly dependant on a very large area of new woodland planting as modelled here, based on a planting on former agricultural land with net positive NPV.

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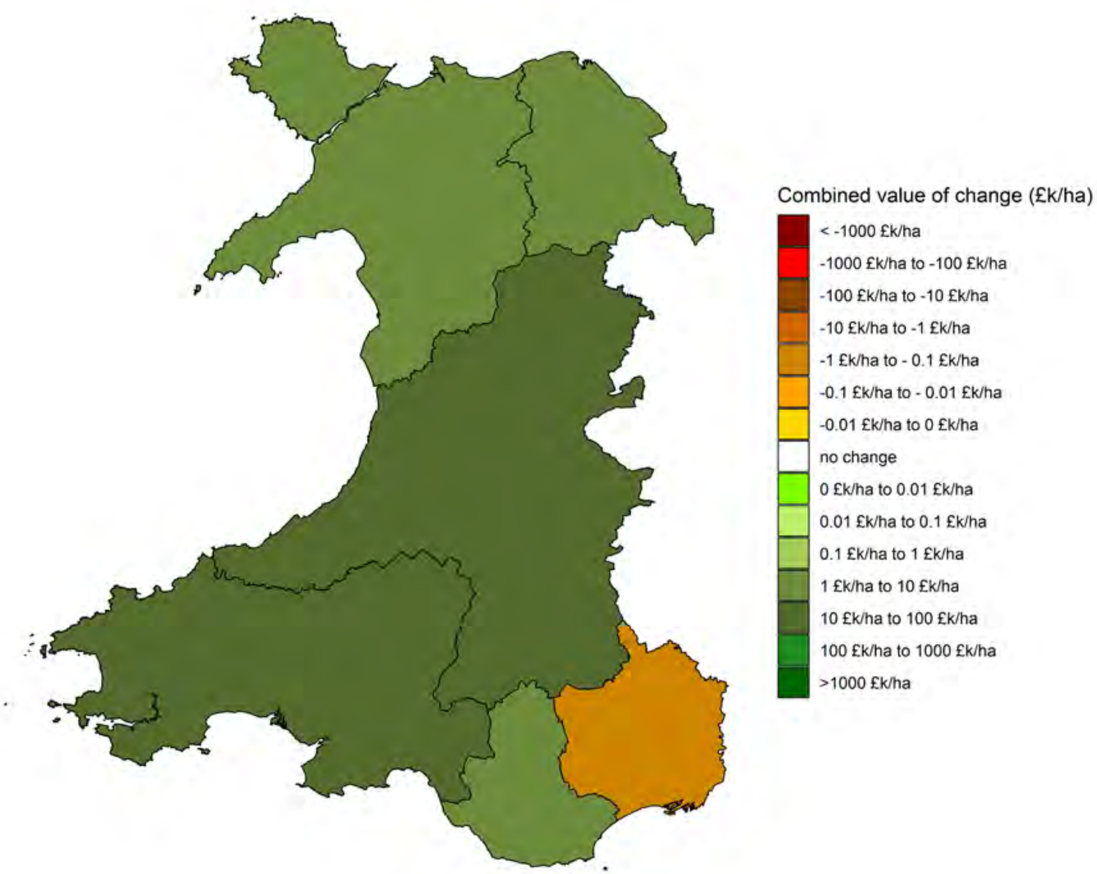
Sum of public goods values (T1) (NRW regions)

Sum of public goods values for all 3 benefits (air quality, water quality and carbon & GHGs):



- Most regions are simulated to experience net benefits.
- Benefits are mostly attributed to change in GHGs and LULUCF carbon stocks.
- Net costs are modelled for South East Wales, which reflect increased agricultural emissions and deterioration of water quality.

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PART 5: Conclusion

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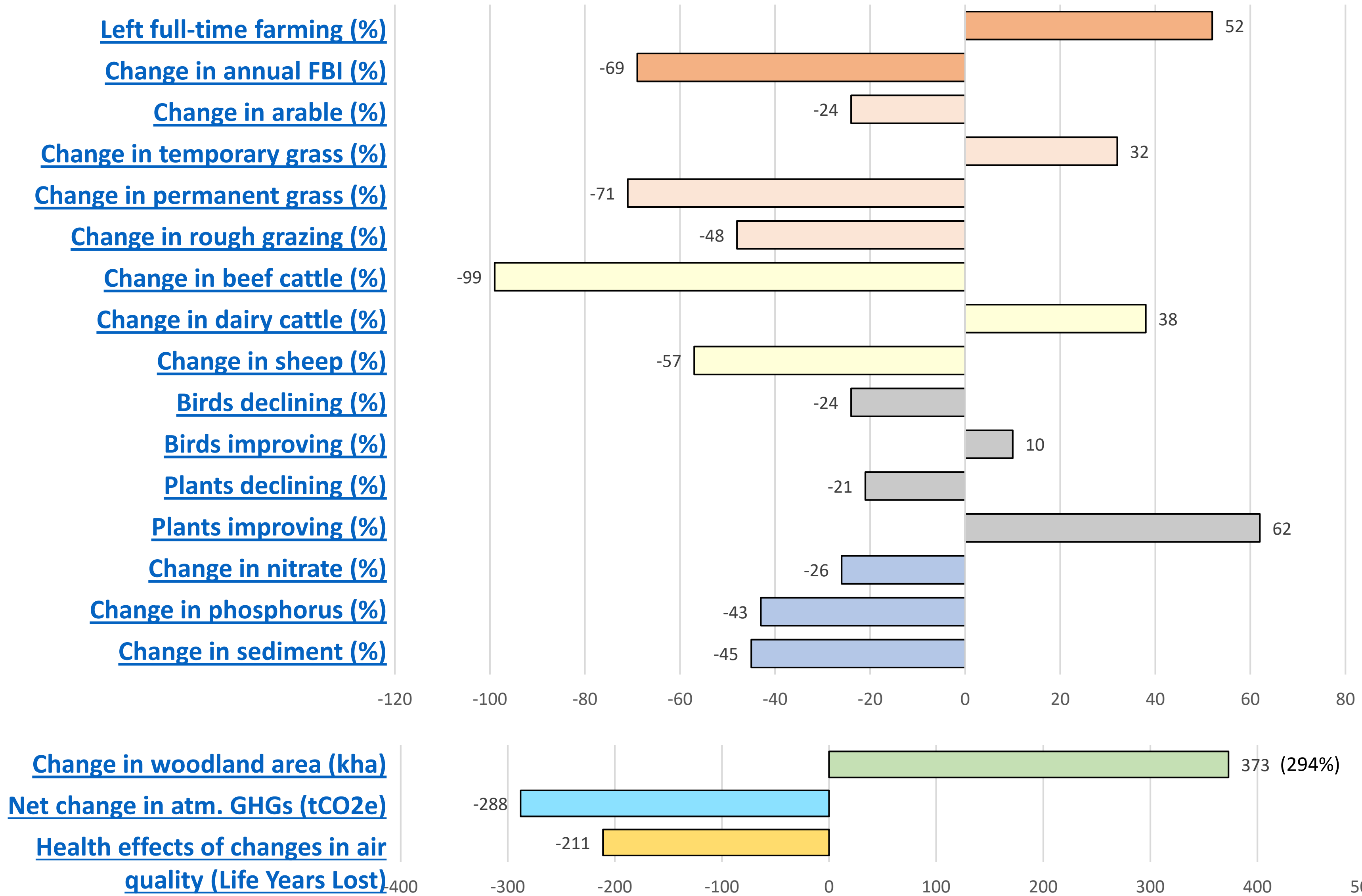
Summary of Impacts 1 (T1)



Summary of Impacts 2 (T1)

Impacts	Physical measure	Units	Present value, 75 yrs, £	Type of value
Agricultural Income	52%	Farms at risk of leaving full time agriculture	- £176 m	Total farm business income (per year)
Air Quality	Decrease of 211 years	Life Years Lost each year	£ 302m	Reduction in costs of health impacts from air pollution
Water Quality	4% Deteriorate, 28% Improve	% of waterbodies with change in WFD status due to changes in N, P	£ 66m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Decrease of 256m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	£ 18,060m	Benefit of reducing carbon emissions from non-traded sources
Biodiversity	24% Decline, 10% Improve	Bird species	N/A	Percentage of species with significant increase or decrease
	21% Decline, 62% Improve	Plant species	N/A	Percentage of groups with significant increase or decrease

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Final Considerations

- This slide pack shows results from applying the Integrated Modelling Platform to one (out of six) trade scenarios.
- The scenarios were provided by Welsh Government based on a series of internal and external workshops as changes in farm-gate (output) prices and input costs.
- All scenarios were applied to a baseline that includes CAP Pillar 1 payments.
- The economic accounts presented are partial and based solely on the components explicitly mentioned. Other significant aspects (e.g. recreation) are not valued here.
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses.
- The IMP is applied to only full-time farms (> 1 FTE labour).
- A farm that is categorised as under pressure is based on being unable to achieve a full-time annual FBI of £6,000. As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.
- The IMP has been developed following Aqua book guidelines. All the assumptions underlying the IMP are fully documented and have been signed-off by Welsh Government.

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PART 6: Glossary and Context

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Glossary: Key Acronyms (I)

- FAPRI: Food and Agricultural Policy Research Institute
  - FAPRI-UK Model was used to underpin assessments of the impacts of Brexit on the UK agricultural sector. More information: (Web-link)
  - Macro-economic model of the UK in a global context. Used to identify impacts of global trade. The FAPRI-UK model (created and maintained by staff in AFBI-Economics) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with sub-models covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) model run by FAPRI at the University of Missouri.
- MFTA: Multi-lateral free trade agreement
  - Free trade agreement between three or more countries without discrimination between those involved.

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Glossary: Key Acronyms (II)

- LULUCF: Land use, land-use change, and forestry
  - Standardised approach to the greenhouse gas inventory that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.
  - Used in this project to quantify impacts of land use change on carbon.
- MFN: Most Favoured Nation
  - World Trade Organisation (WTO) terminology. Under the WTO agreements, countries cannot normally discriminate between their trading partners. As such countries must treat all other WTO members as they would their "Most Favoured Nation". More information: (Web-link)
  - Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

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Glossary: Key Acronyms (III)

- WFD: Water Framework Directive
  - EU directive targeted at improving water quality and integrated catchment management.
- UKTAG: UK Technical Advisory Group (on the WFD)
  - The UKTAG is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies.
- LFA: Less-favoured area
  - Term used to describe an area with natural handicaps (lack of water, climate, short crop season and tendencies of depopulation), or that is mountainous or hilly, as defined by its altitude and slope.
- SDA / DA: Severely Disadvantaged Areas / Disadvantaged Areas
  - Sub-classes of LFA separating out the most severely disadvantaged areas for the purposes of basic payment scheme (BPS) grant payments.

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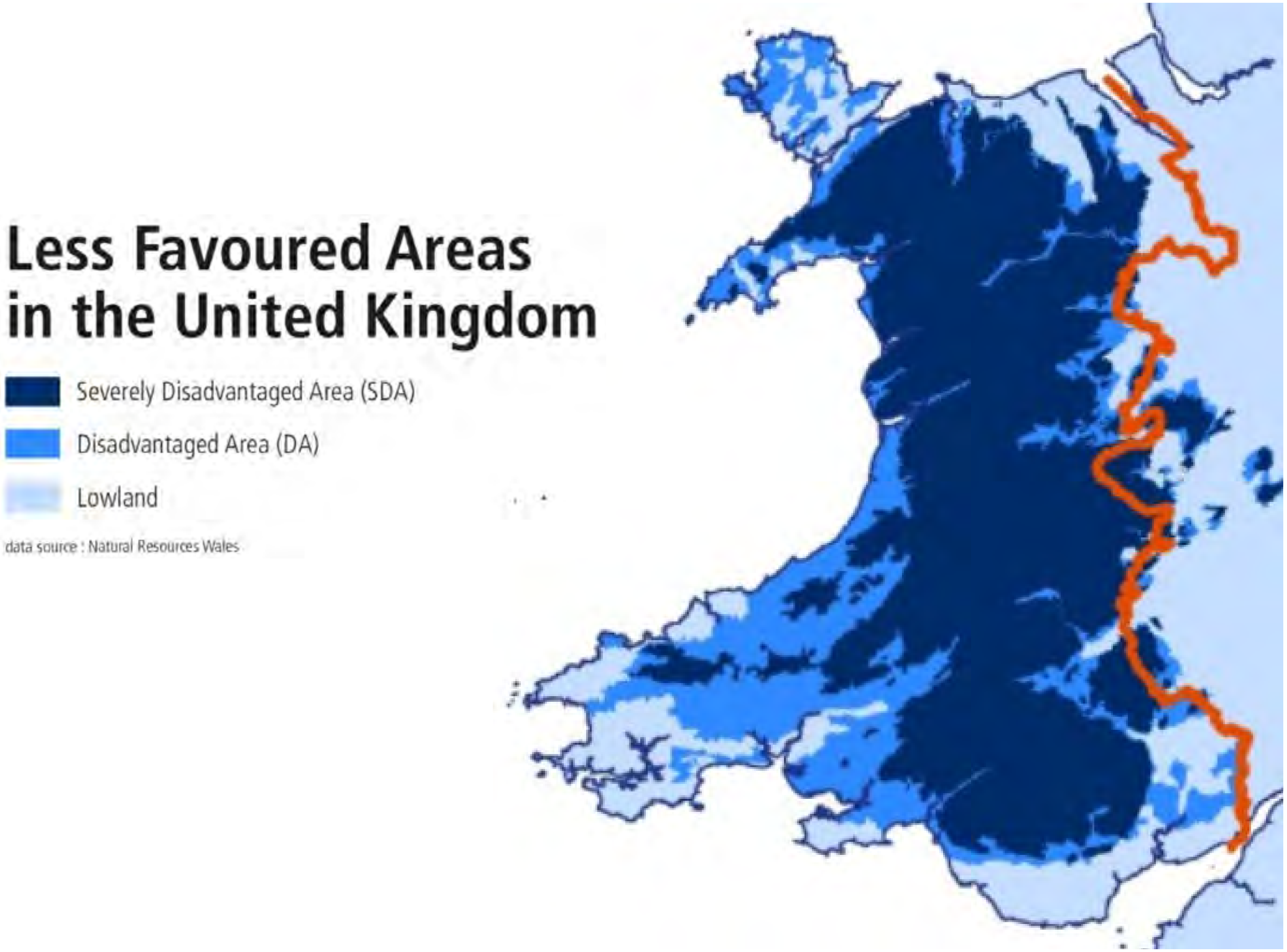
Severely Disadvantaged Areas/ Disadvantaged Areas in Wales



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Glossary: Key Acronyms (IV)

- RFT : Robust Farm Type
  - Robust farm type (used in previous Welsh Farm Practice Surveys).
  - Classes: Cereals; General Cropping; Horticulture; Specialist Pigs; Dairy; LFA Grazing Livestock; Lowland Grazing Livestock and Mixed.
- EFT: ERAMMP Farm Type
  - ERAMMP farm type (used within the IMP) is based on the RFT with additional detail on less favoured areas.
  - Classes: Cereals, General cropping, Dairy, Lowland cattle / sheep, Mixed , Specialist Sheep (SDA), Specialist Beef (SDA), DA various grazing, SDA mixed grazing .
- SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation: Names and acronyms for models within the IMP (see slide 79)

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Glossary: Key Acronyms (V)

- ERAMMP – Environment and Rural Affairs Mapping and Modelling Project.
  - Consortium Project led by the UK Centre for Ecology & Hydrology (UKCEH) and funded by the Welsh Government (WG).
  - Consortium members involved in these slide packs include Cranfield University, ADAS, the British Trust for Ornithology (BTO), eftec, Forest Research (FR) and UKCEH.
- IMP – Integrated Modelling Platform
  - The modelling platform used to produce the results shown in this slide pack. The platform combines the following models which pass data to one another as large multi-parameter data cubes:
    - SFARMOD: Whole farm model
    - ESC: Tree species suitability
    - CARBINE: Forest products, carbon and forest net present value
    - LAM: Land allocation model
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - Woodland habitat connectivity model
    - Ecosystem service models for carbon and water quality
    - EMEP4UK Emulator: health impacts of air pollution
    - Valuation: monetary and non-monetary valuation of public goods

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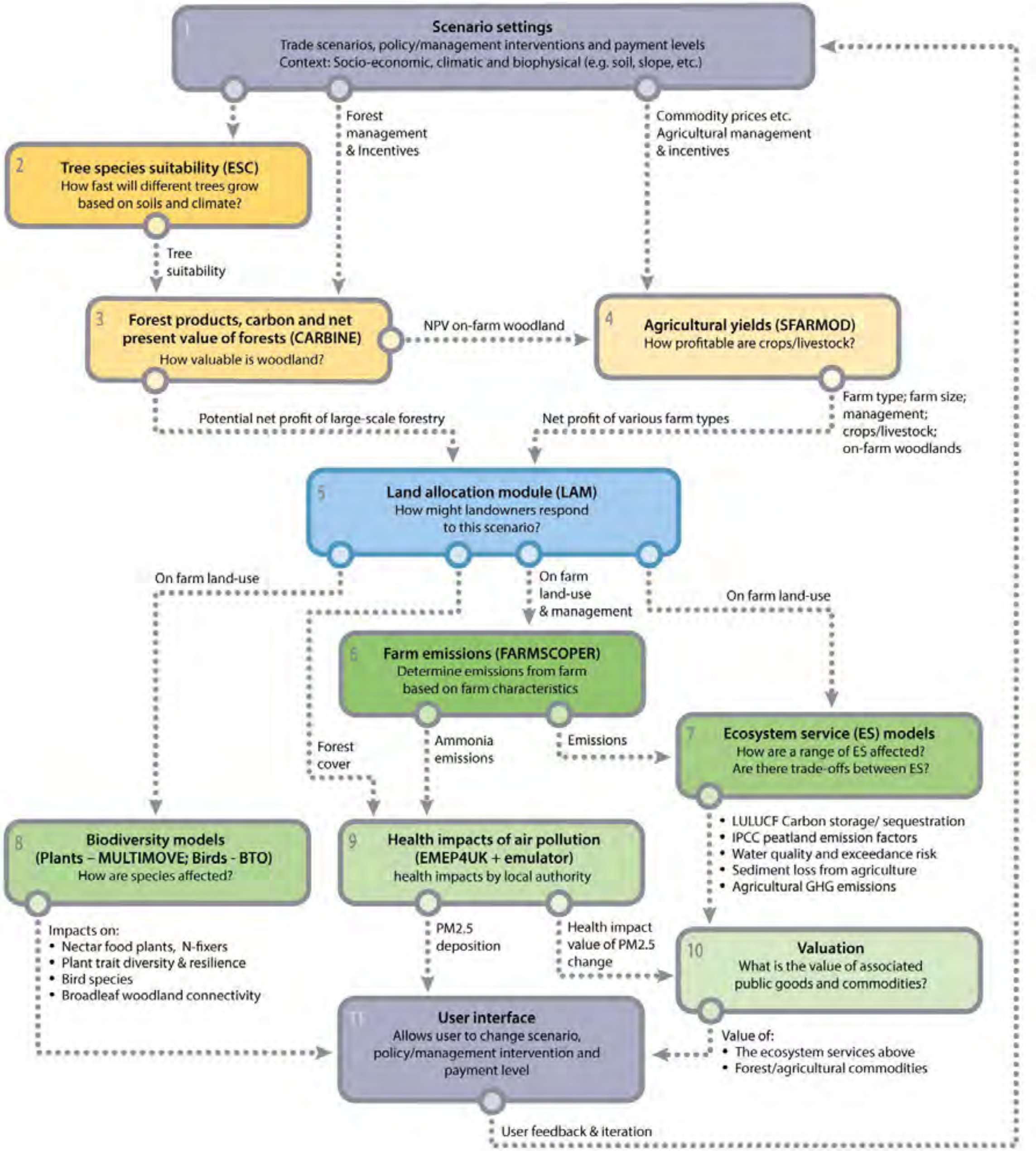
Integrated Modelling Platform schematic



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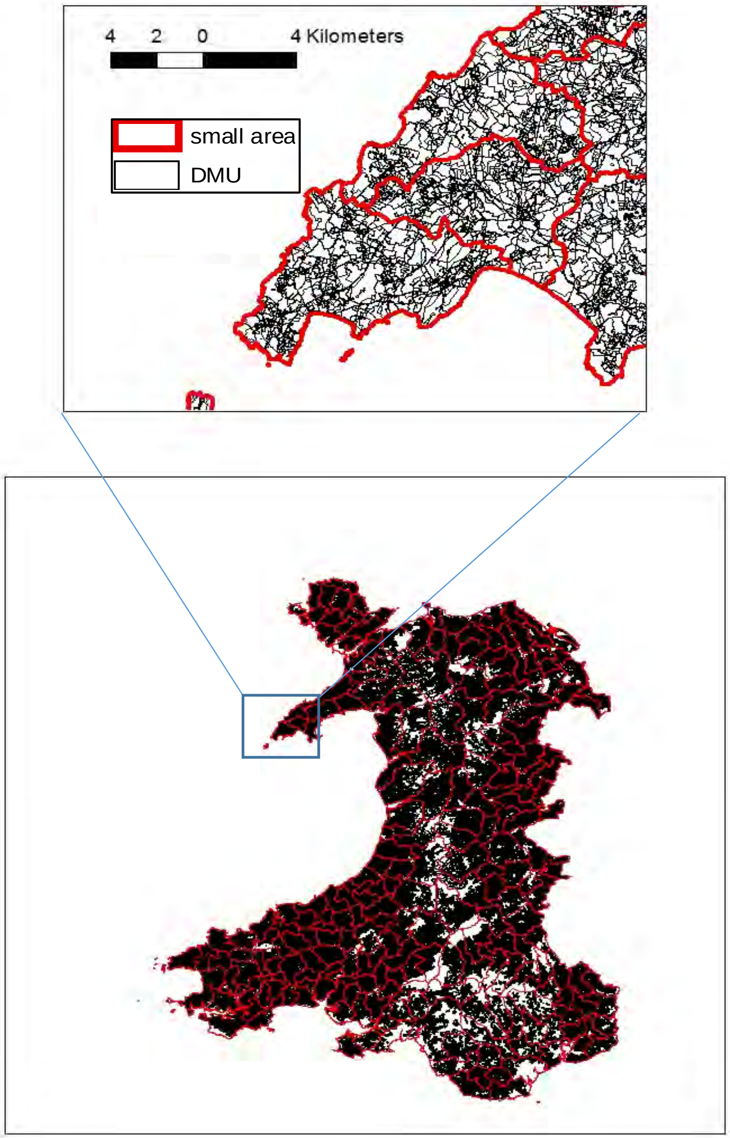
IMP modelling scales



- The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
- The finest spatial resolution used by Sfarmod and the Land Allocation Module (LAM) for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
- A DMU is defined as a managerially homogenous cluster of soil type, rainfall and land cover.
- Results in the slide pack are aggregated to small agricultural areas as findings are more robust at this level.

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2: ERAMMP_IMP_LandUseScenarios_T2_Slidepack

Funded by:

Llywodraeth Cymru
Welsh Government

Canolfan Ecoleg a Hydroleg y DU
UK Centre for Ecology & Hydrology

INTEGRATED MODELLING PLATFORM

Land Use Scenarios (T2)

UK Centre for Ecology & Hydrology

Cranfield University

ADAS

Forest Research

eftec

BTO

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Scenario description (T2)

- Assumptions as FAPRI scenario 1 (Bespoke FTA with the EU).
- As ambitions of UK Government White paper.
- UK forms a new customs arrangement with the EU.
- Tariff and quota free access for UK exports to and from EU.
- Tariff and quota free access for imports into the UK from the EU.
- Tariffs and other trade arrangements for UK imports and exports with the rest of the world countries are unchanged compared to the Baseline.
- Scenario settings:

	Milk (p/litre)	Beef (£/kg LWT)	Lamb (£/kg LWT)
Baseline (2015)	35	1.85	1.68
T2	**35.4**	**1.80**	**1.66**

https://www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/FAPRI-UK%20Brexit%20Report%20-%20FINAL%20Clean.pdf

PART 1: Agriculture

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Background information

The agricultural models are applied to all full-time farms

	No.	Area (ha)
Full-time	7726	1010891
Spare / Part-time	12738	409150
Total	**20464**	**1420041**

Farm Business Income classes within T2:

As baseline farm type	As alternative farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture
<£6000 p.a.	>£6000 p.a.	Farm under pressure	Likely to change farm type through sale to another enterprise
£6K-£13K	Any amount	Farms staying the same	Able to continue but unlikely to be able to change farm type
>£13000	<£13K +FBI uplift+finance	Farms staying the same	Insufficient economic incentive to change farm type
>£13000	>=£13K +FBI uplift+finance	Farms changes type	Likely to be sufficient economic incentive to change farm type

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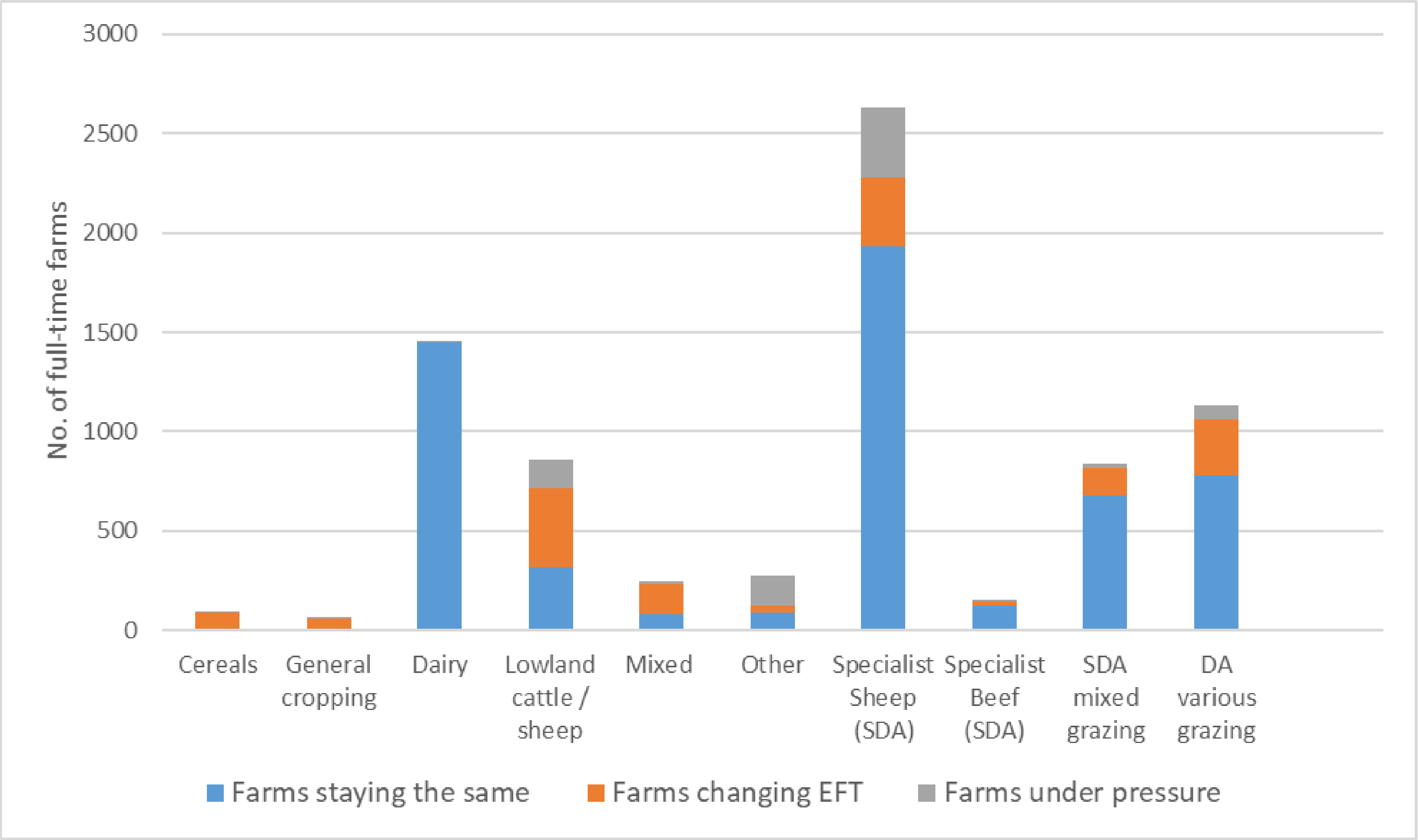
Simulated status of current Full-time farms under T2



Baseline number of simulated full-time farms: 7726

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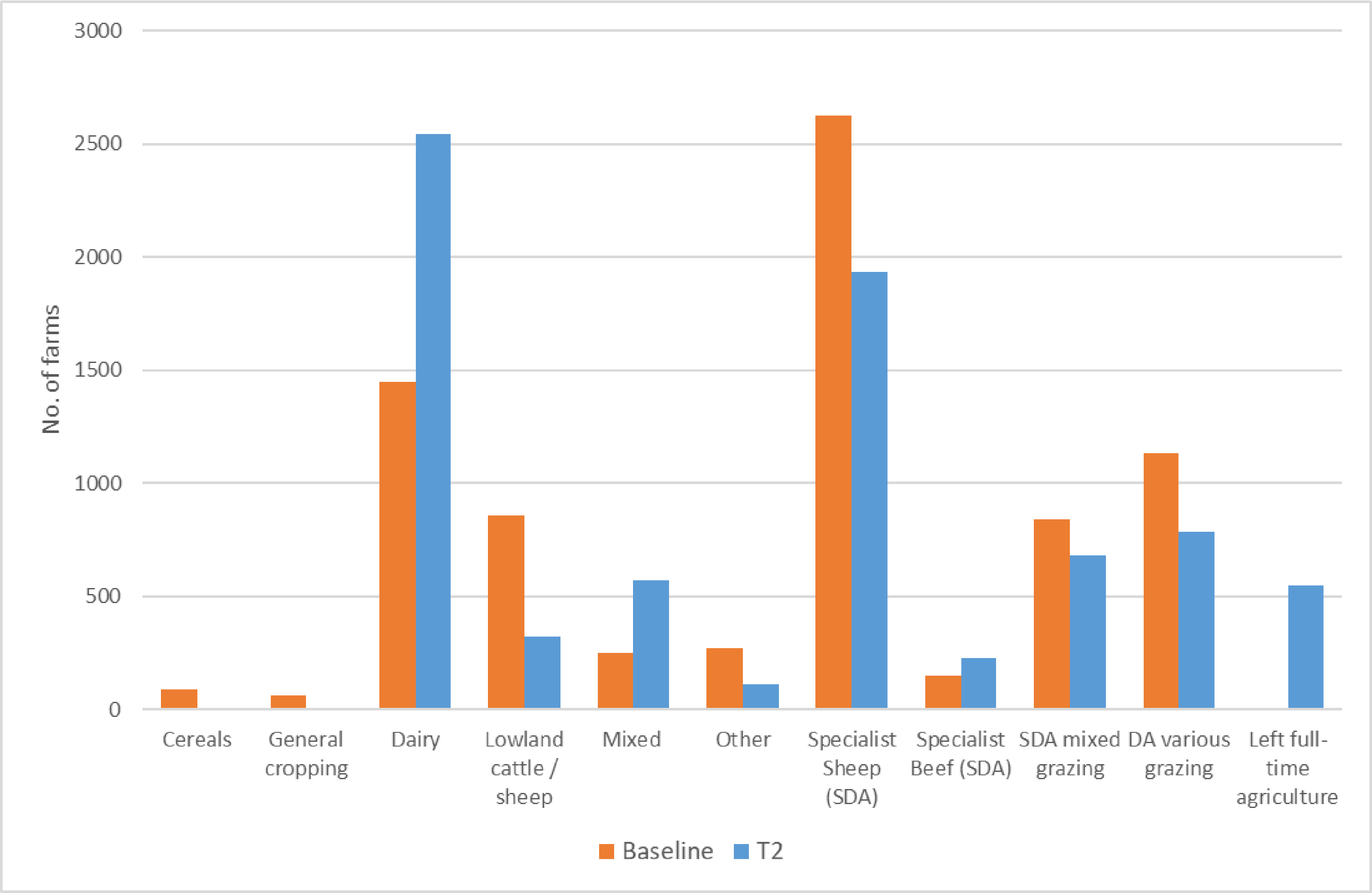
Farm numbers by farm-type (Baseline vs T2)



Total number of simulated full-time farms: 7726 in Baseline; 7117 in T2

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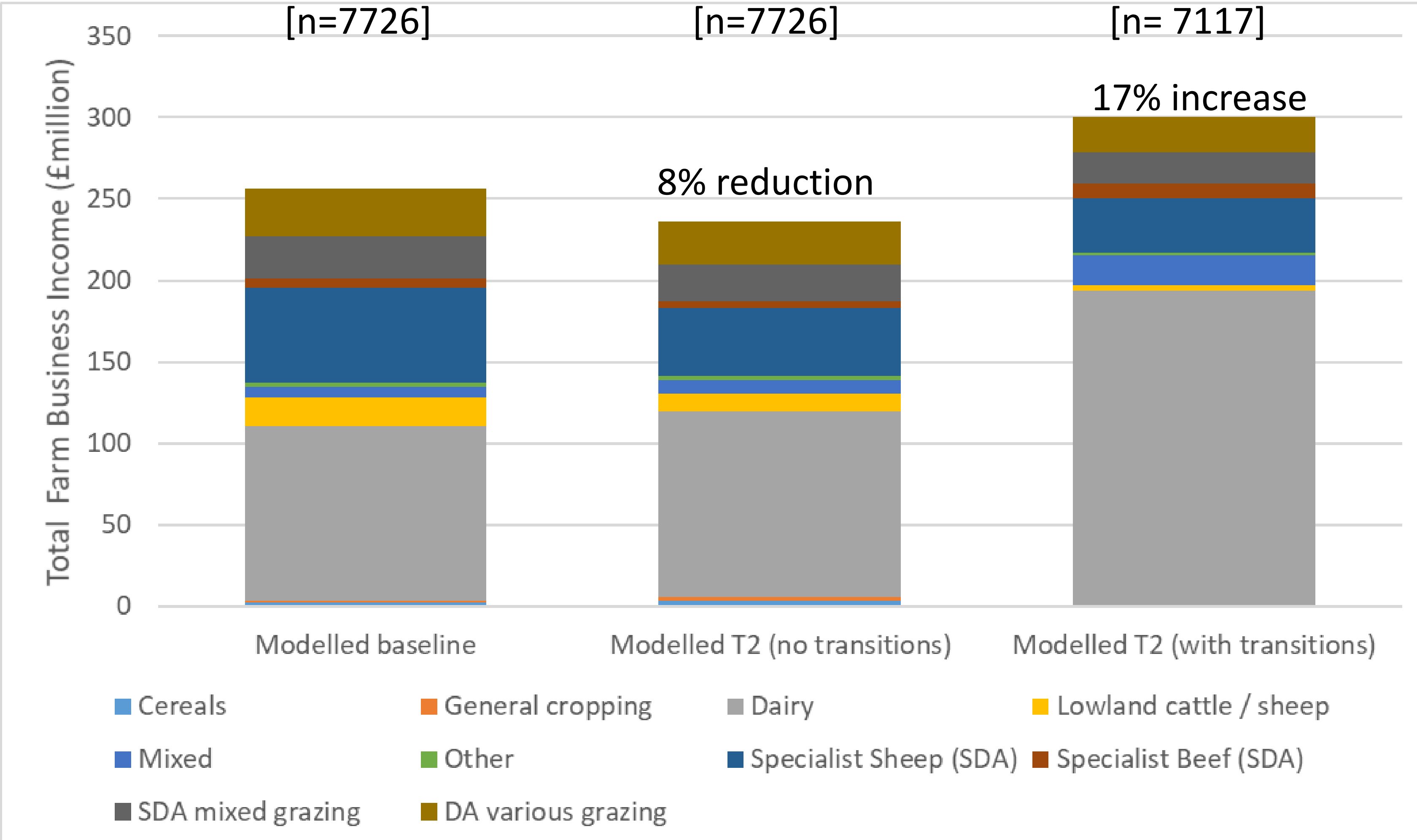
Total simulated Farm Business Income from full-time farms (T2)



Total number of full-time farms: 7726 in Baseline; 7117 in T2

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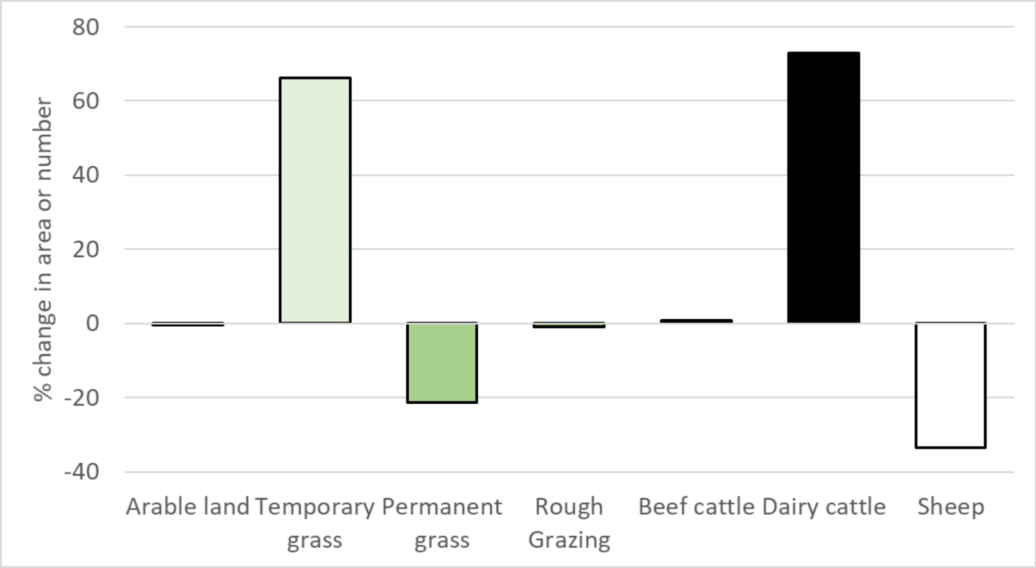
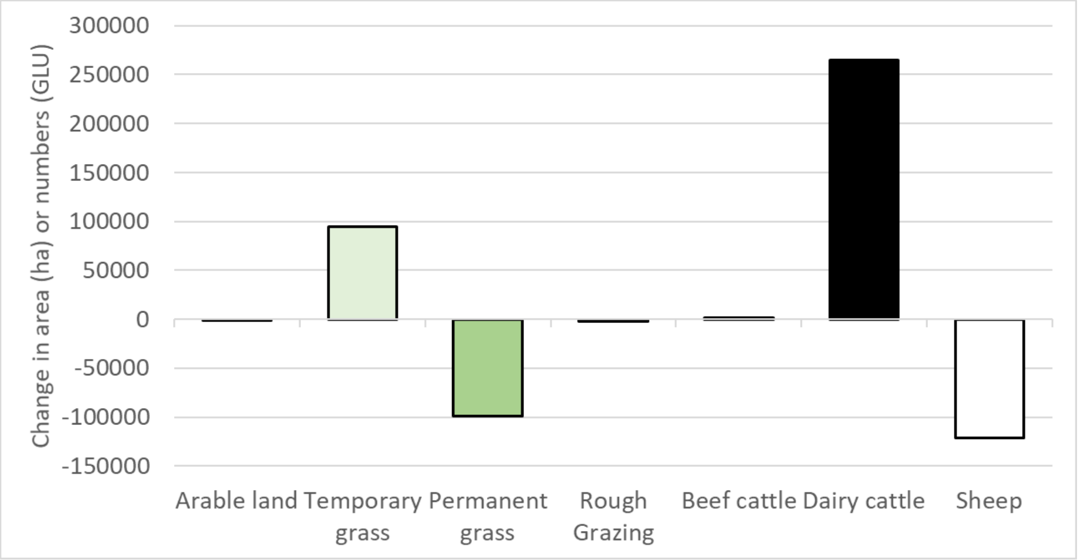
Change in simulated managed land use and stock (T2)



Percentage change (relative to simulated baseline)

Absolute change in simulated areas (ha) and numbers (Grazing Livestock Units)



Simulated farms remaining in full-time agriculture: 7117

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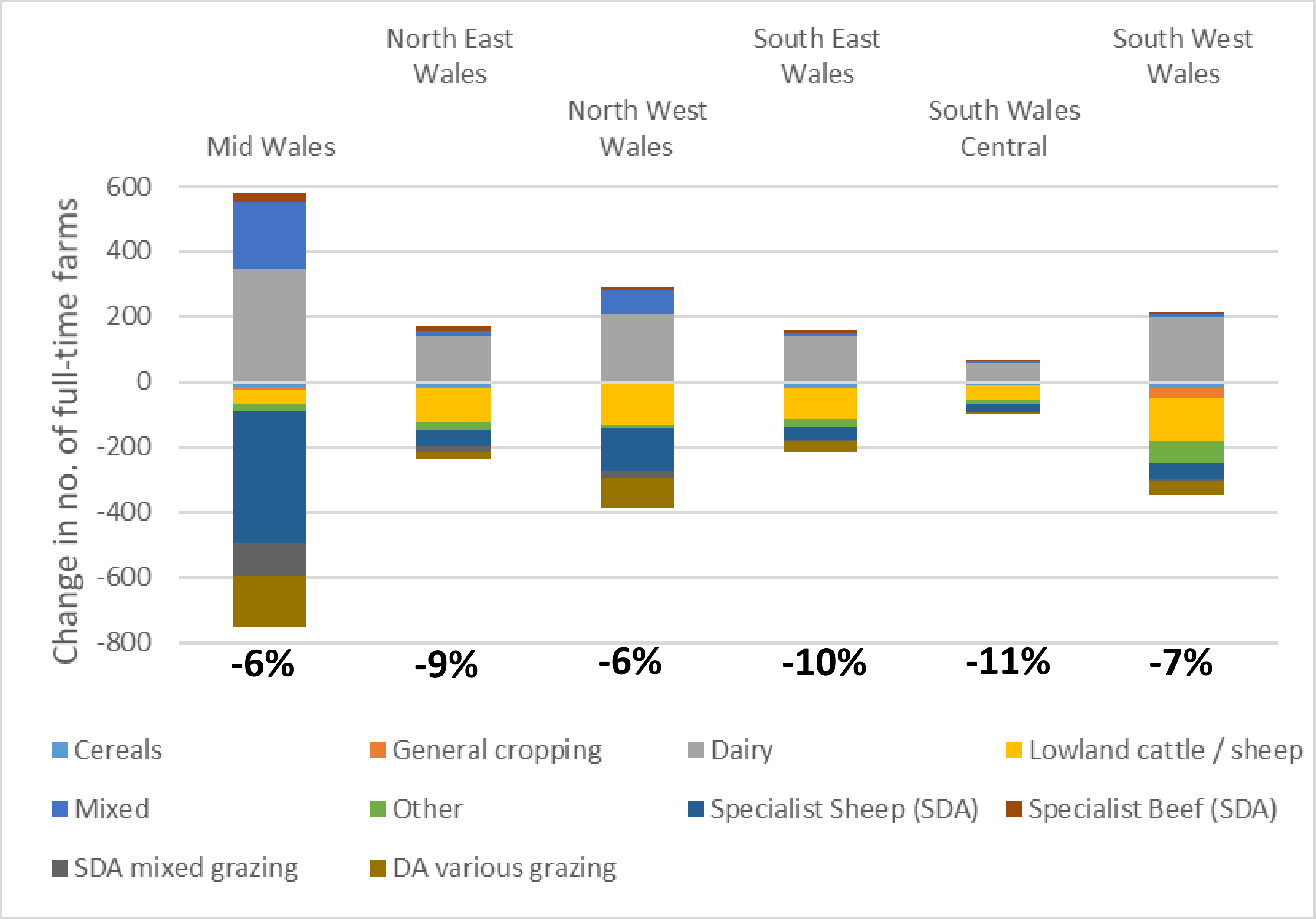
Change in farm numbers by farm-type (T2)



Simulated farms remaining in full-time agriculture: 7117

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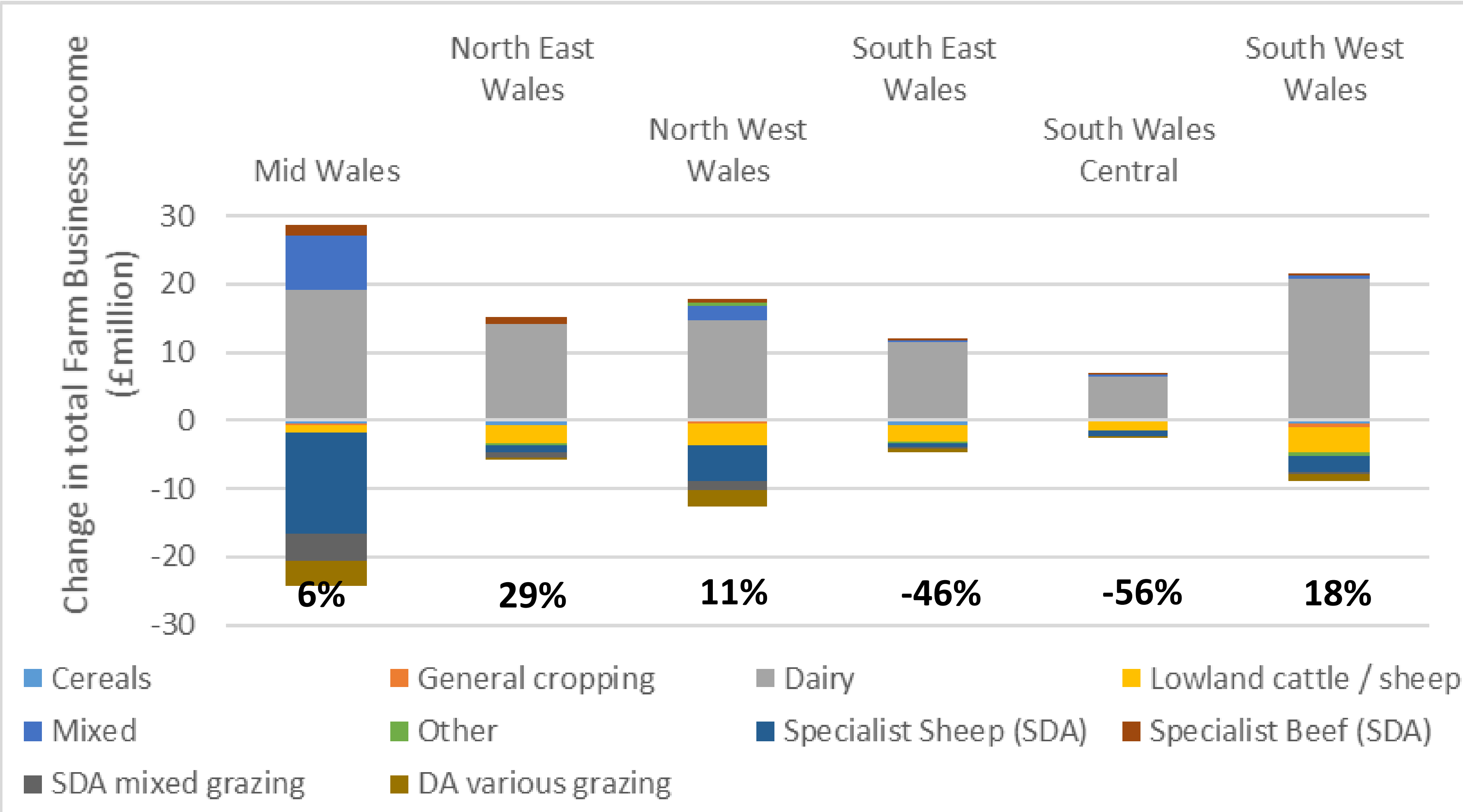
Change in total simulated Farm Business Income from remaining full-time farms (T2)



Simulated number remaining in full-time agriculture: 7117

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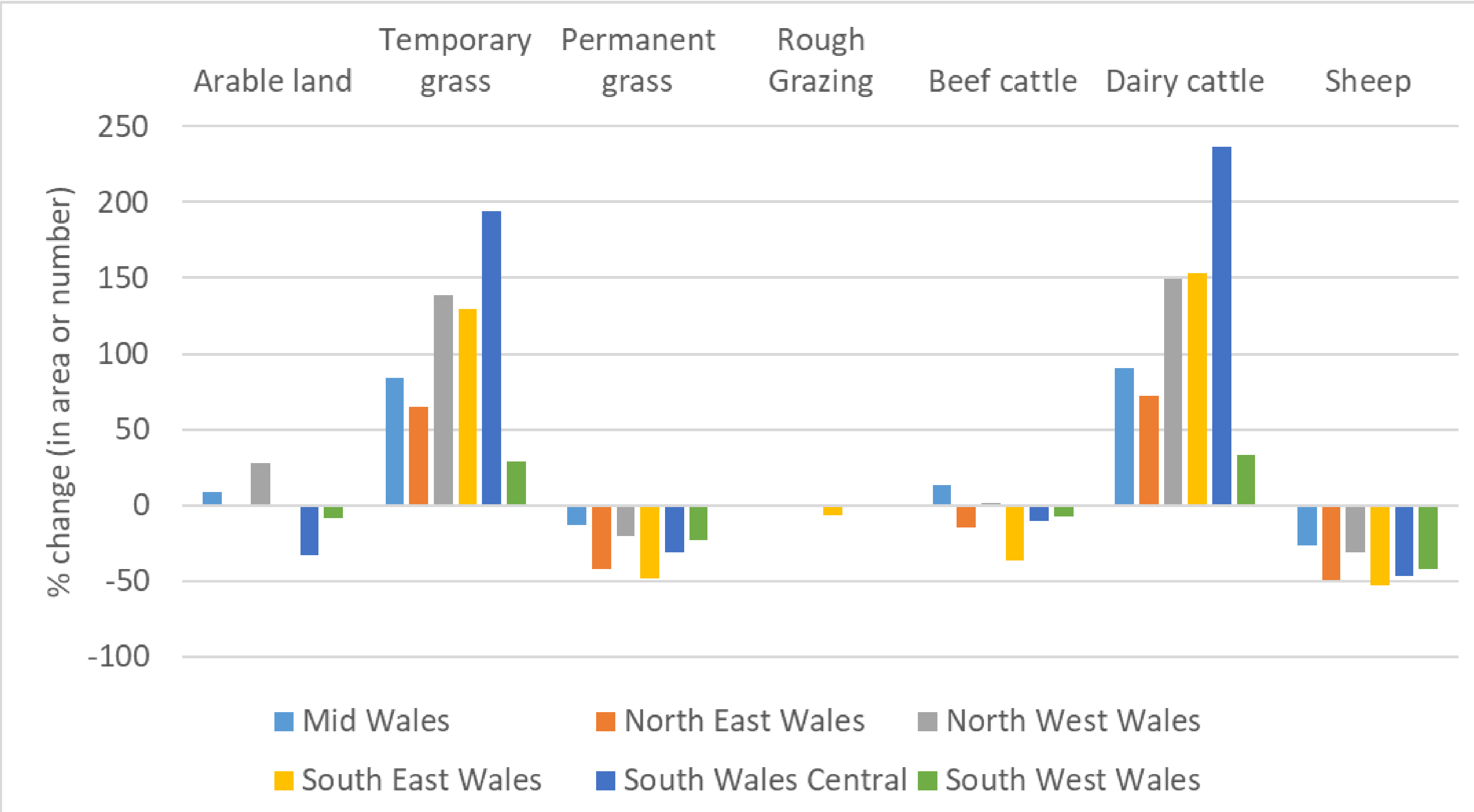
Regional change in land use and livestock (T2)



Simulated number remaining in full-time agriculture: 7117

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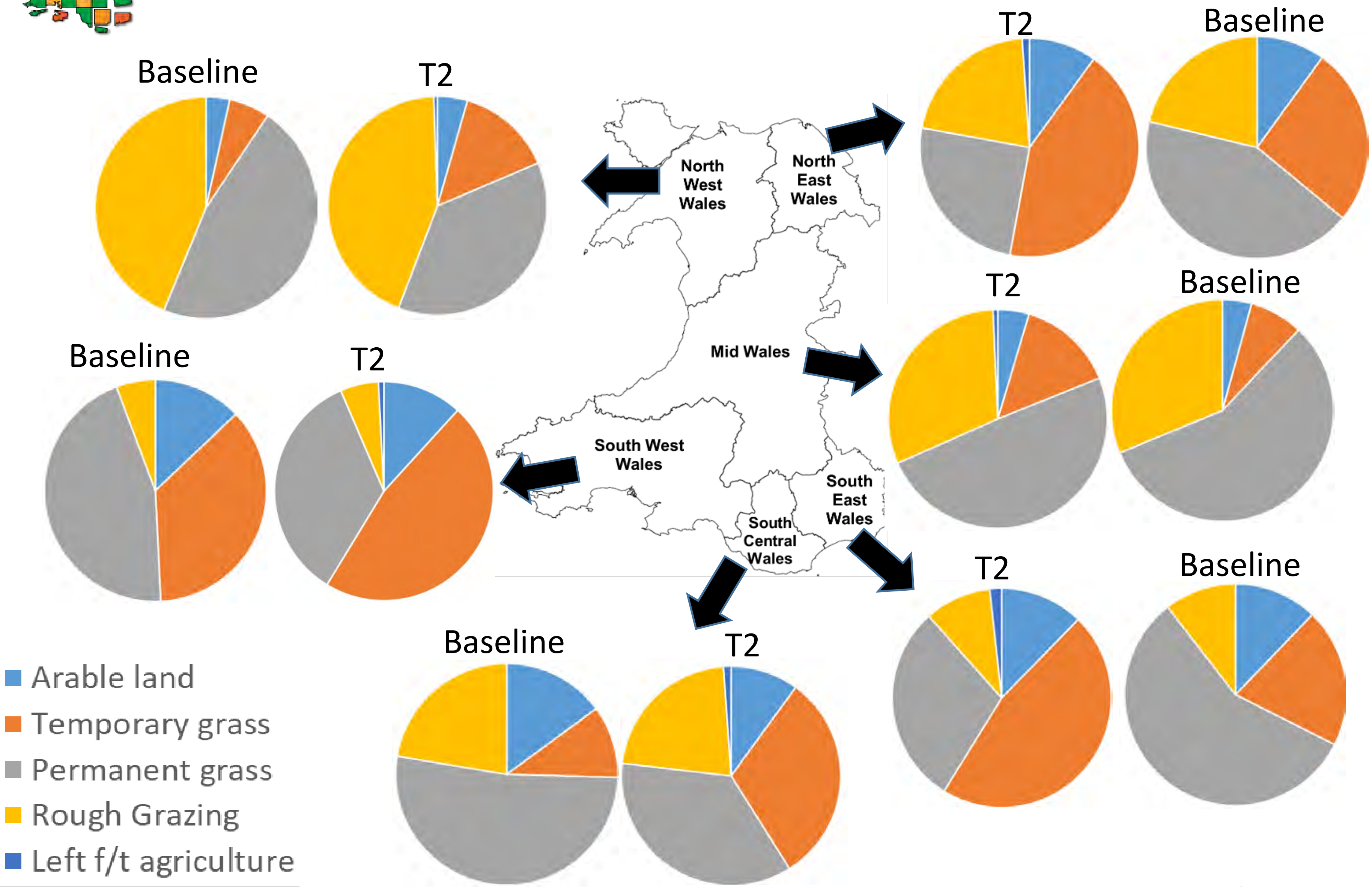
Regional land use proportions in T2



Simulated number remaining in full-time agriculture: 7117

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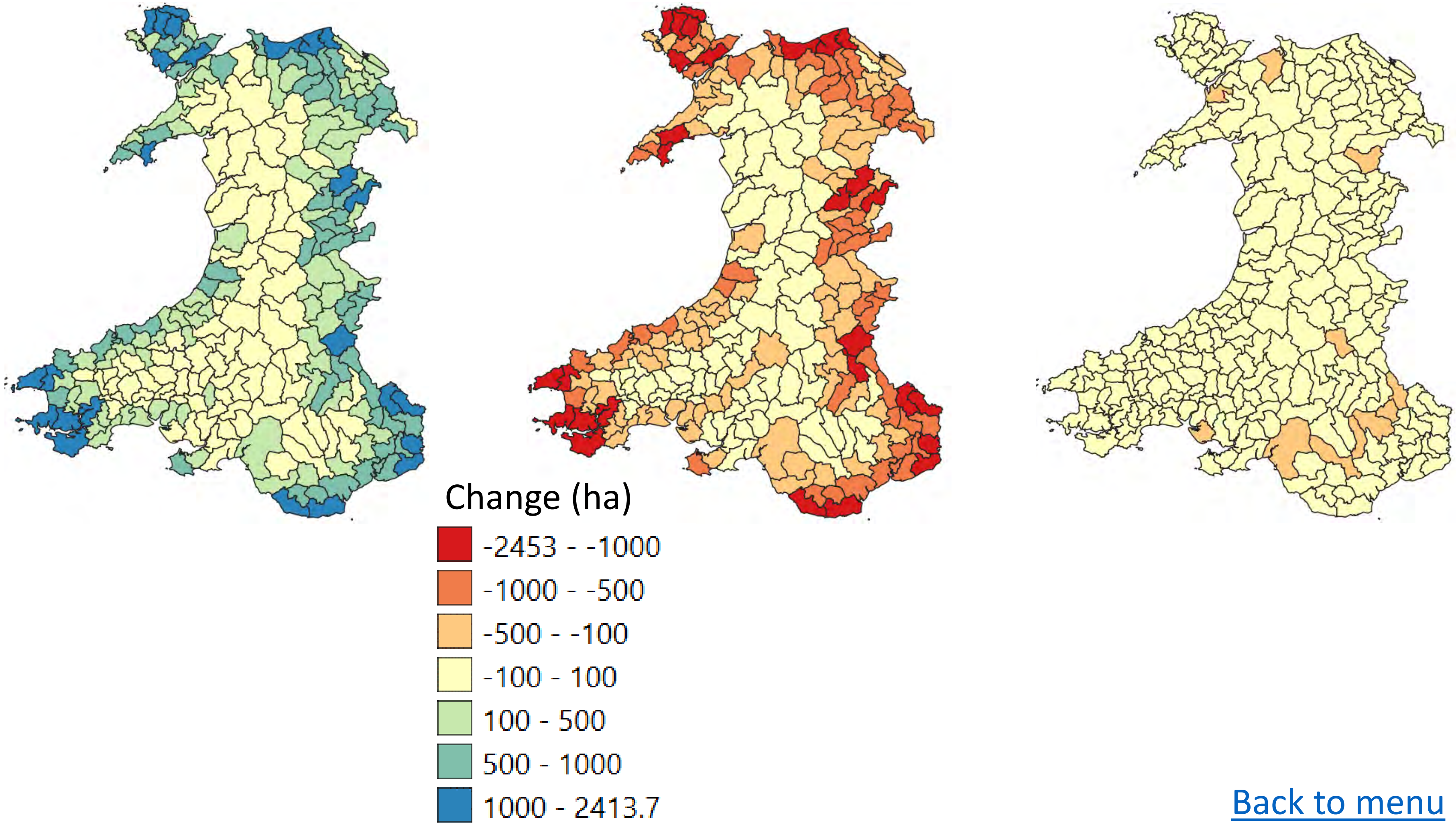
Simulated change in land use (T2)

Change in cultivated / temporary grassland | **Change in permanent grassland** | **Change in agricultural area**



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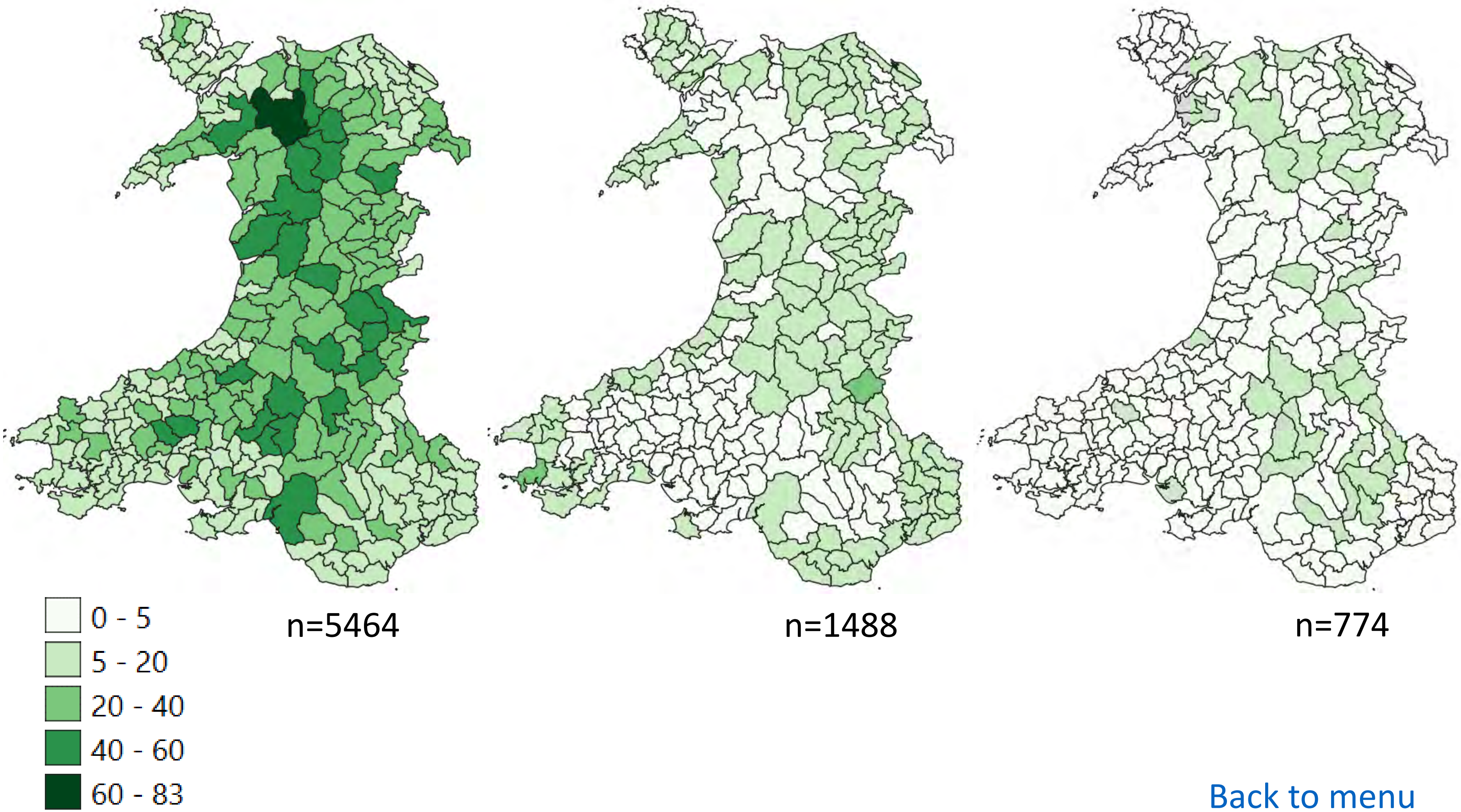
Simulated status of current full-time farms under T2

Farms staying the same | **Farms changing type** | **Farms under pressure**



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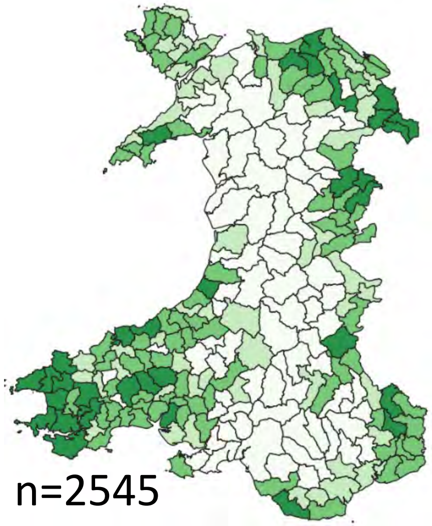
Simulated farm type numbers under T2

Dairy specialists

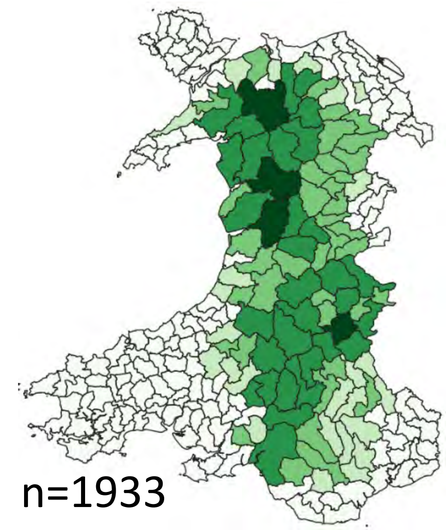


n=2545

Beef specialists

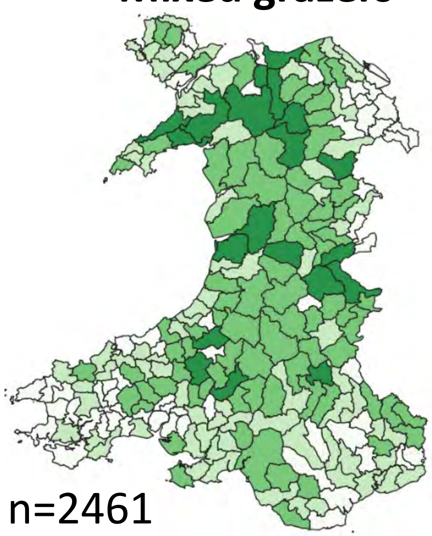
n=224

Sheep specialists



n=1933

Mixed grazers



n=2461

- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 56

Left full-time agriculture

n=549

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Farms leaving full-time agriculture

Farm Business Income classes within T2:

As Baseline Farm type	As alternative Farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture

A farm that is unable to achieve a full-time annual FBI of £6,000 may:

- Implement cost savings and struggle on;
- Transition to part-time farming, to enable increased non-agricultural income though diversification and / or off-farm employment;
- Leave agriculture in the short-term
- Leave agriculture in the longer-term (e.g. due to retirement / inter-generational change)

As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested

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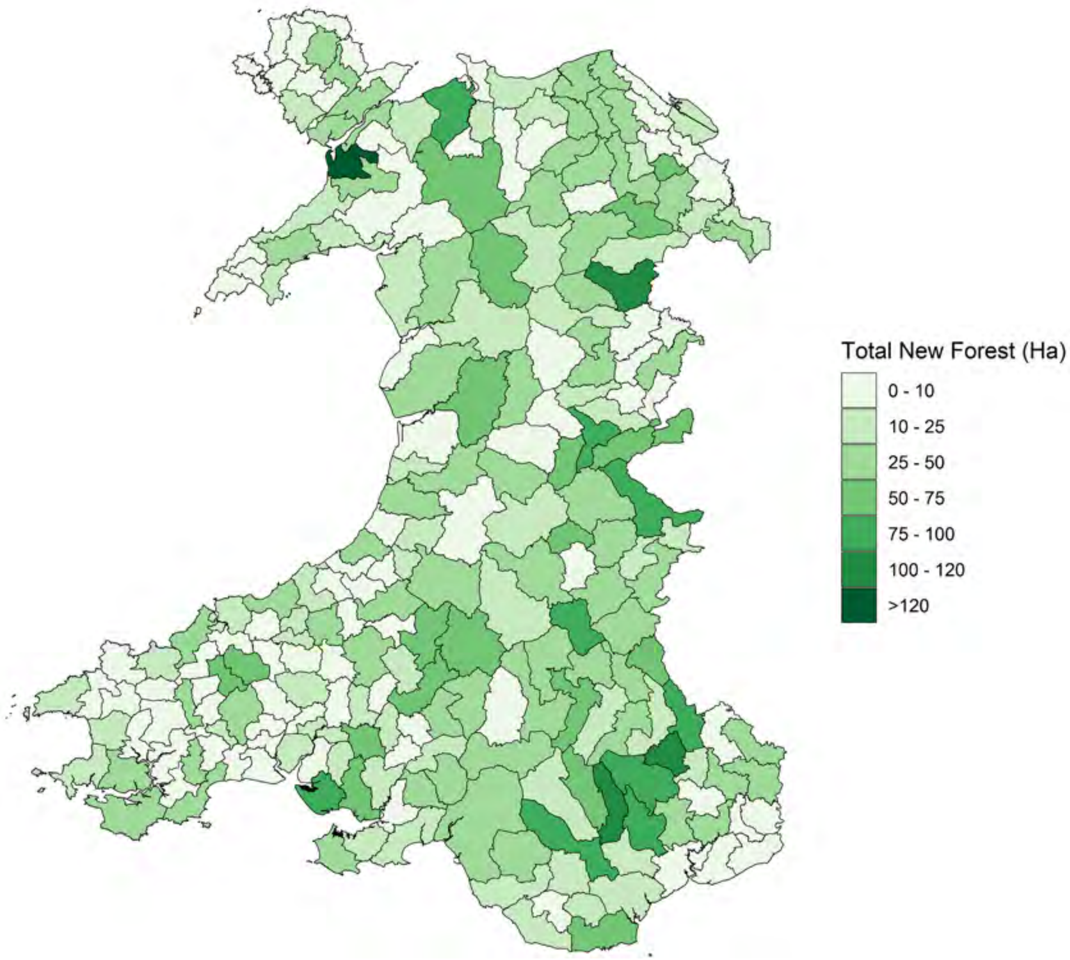
Simulated new woodland on farms leaving full-time agriculture (T2)



Total area of new woodland: 6,060 ha (5% increase for modelled >1 FTE farms)

- Total new woodland area (ha) from afforestation and natural regeneration.
- Totals largely driven by afforestation: 4,679 ha.
- Afforestation will only occur on appropriate former agricultural land that will generate a positive net present value (NPV) from forestry.

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PART 2: Biodiversity

Biodiversity summary – Birds (T2)

- Increases and decreases in bird population sizes are an inevitable consequence of changes in land use.
- By **2050**, under the T2 scenario, increases in the cover of maize, rotational grass and coniferous woodland are simulated.
- The vast majority of species are simulated to slightly decrease in population size under this scenario. Most changes are non-significant.
- Declines are simulated to be similar across Wales, though more species are in the category of "possible decline" in the East Wales.

Eaton, Mark, et al. "Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man." British Birds 108.12 (2015): 708-746.

Bladwell et al. "The state of birds in Wales 2018." (2018). The RSPB, BTO, NRW and WOS. RSPB Cymru, Cardiff

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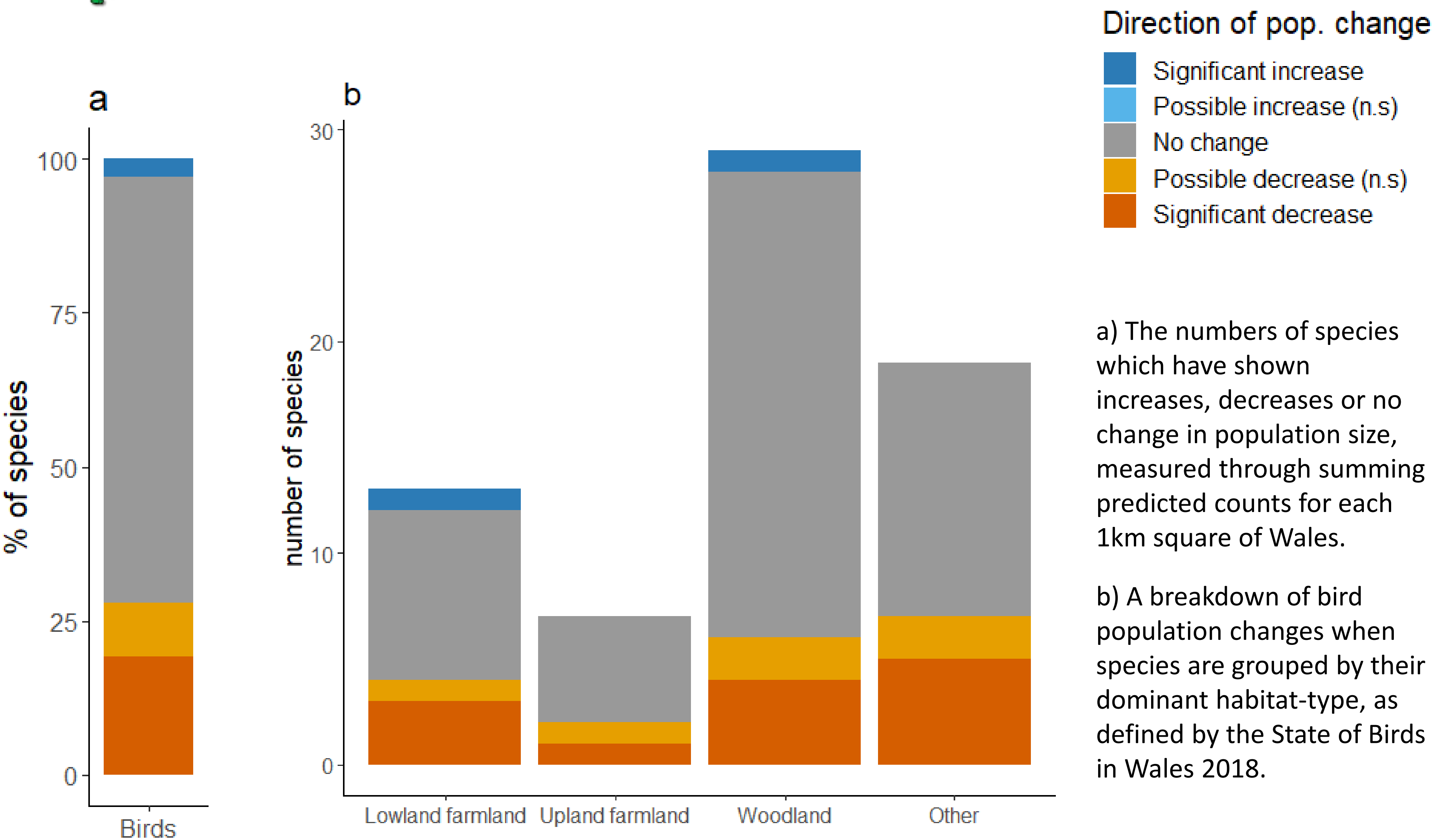
Overall bird population change in T2



a) The numbers of species which have shown increases, decreases or no change in population size, measured through summing predicted counts for each 1km square of Wales.

b) A breakdown of bird population changes when species are grouped by their dominant habitat-type, as defined by the State of Birds in Wales 2018.

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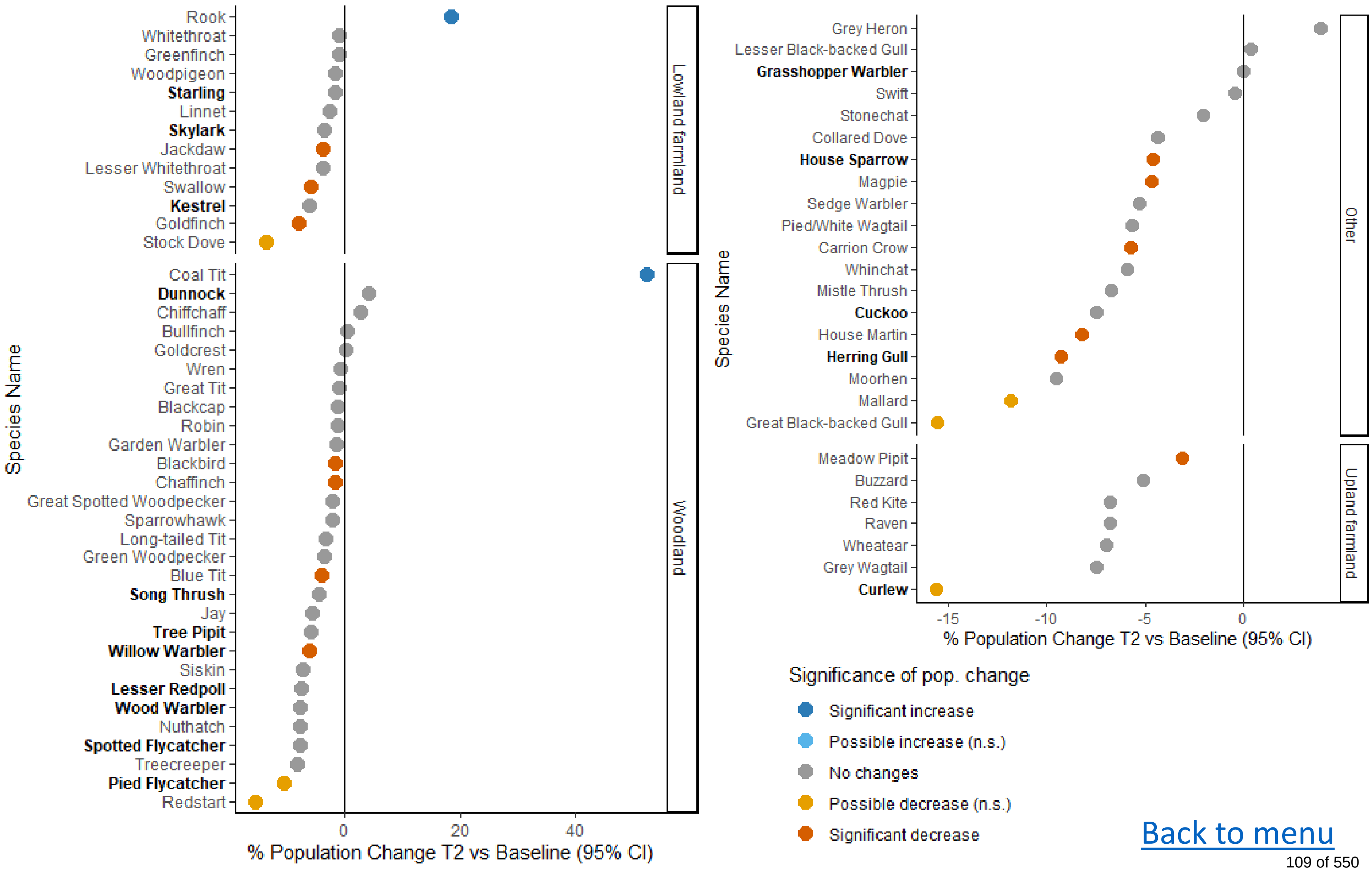
Population changes per bird species in T2



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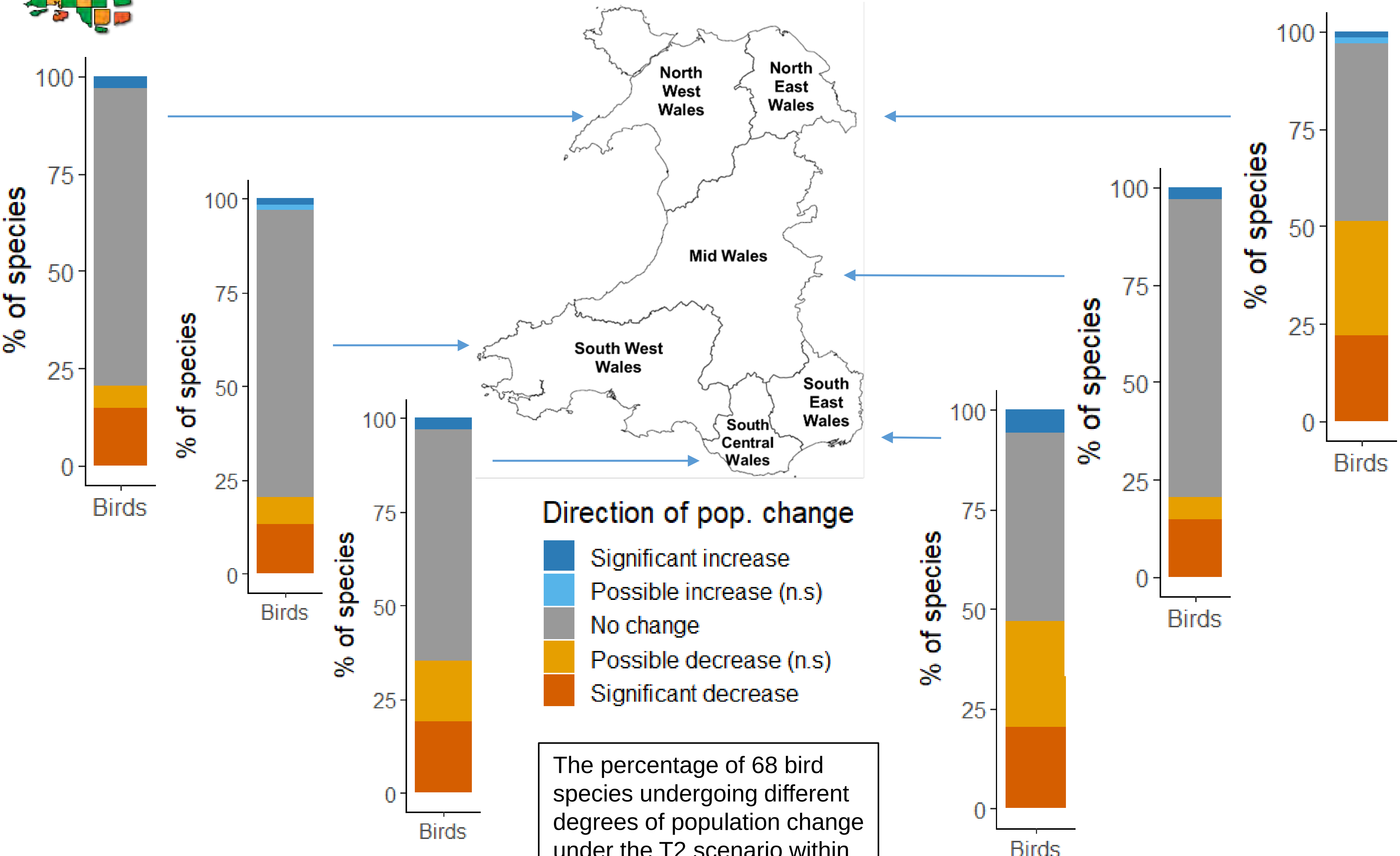
Regional bird population impacts in T2



The percentage of 68 bird species undergoing different degrees of population change under the T2 scenario within the six NRW regions.

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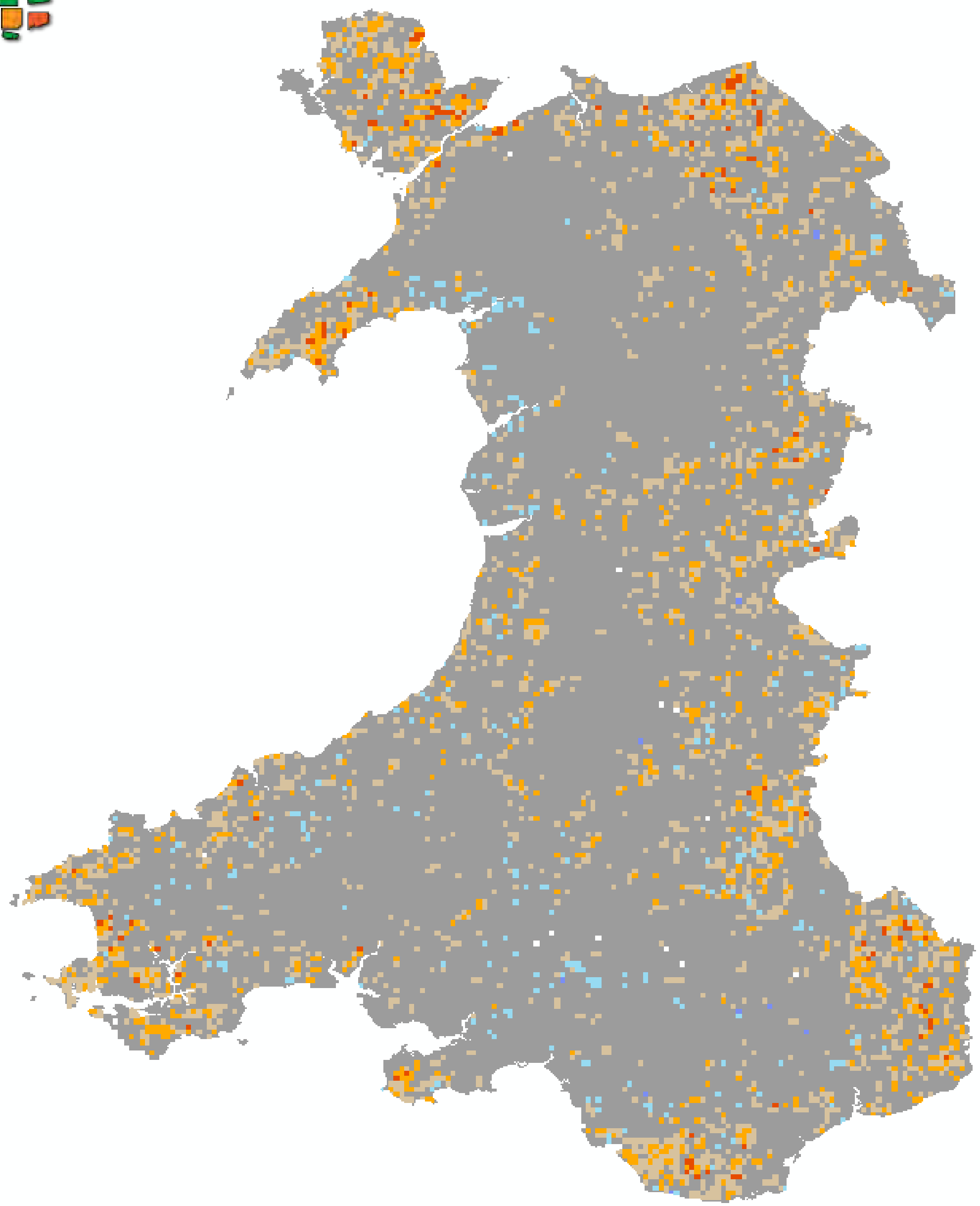
Local bird species change in T2



Ratio of species change

- +3 to +18
- +1 to +2
- 0
- -1 to -8
- -9 to -20
- -20 or greater

The ratio of 68 bird species undergoing significant increases *vs* decreases for each 1km square of Wales. Bolder colours are indicative of greater change. Note that under this metric, any square seeing large, but equal numbers of increases and decreases will be represented by grey colouration, identical to that of a square seeing no changes.

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Biodiversity summary – Plants (T2)

- Overall simulated transitions between farm types are small in this scenario with minimal movement of land out of agriculture or turnover between sectors. The shift is toward temporary grass and dairy and away from sheep and permanent grass; on balance a small intensification trajectory.
- The tendency toward stability or intensification results in either no change or decreases in suitable niche space for woodland and semi-natural habitat specialists. The small number of modelled arable specialists also largely remain stable reflecting minor change in arable land under the scenario. These patterns are similar across all regions except for South Central Wales where no change is estimated across all three groups.
- Summary: Our modelling shows that the suitability of ecological conditions across much of Wales are expected to remain largely stable or decline for the majority of specialist plants.

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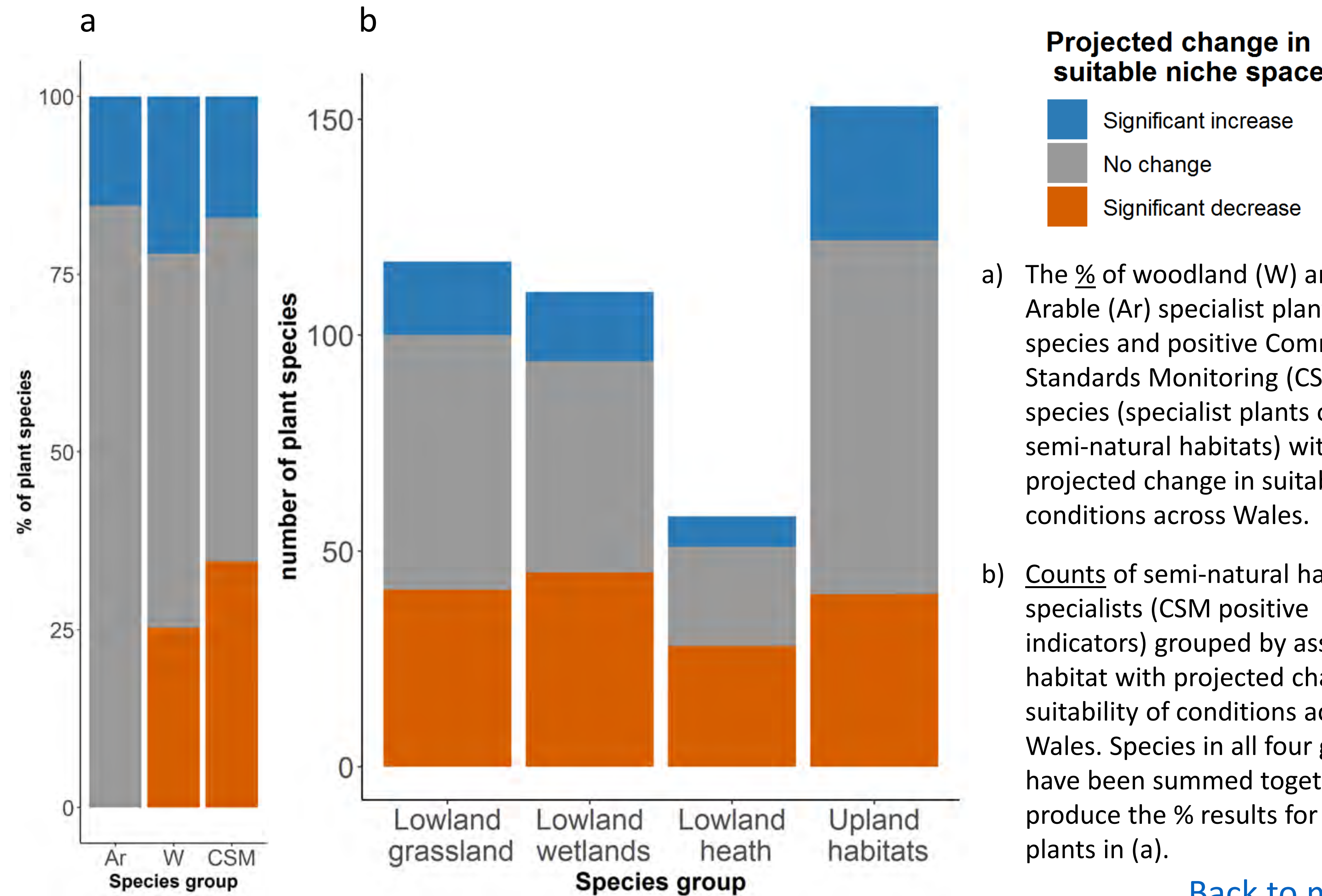
National change in habitat suitability for plants over 25 years (T2)



a) The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales.

b) Counts of semi-natural habitat specialists (CSM positive indicators) grouped by associated habitat with projected change in suitability of conditions across Wales. Species in all four groups have been summed together to produce the % results for CSM plants in (a).

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% change in habitat suitability per plant species in T2 (Examples)

Woodland specialists for Wales [1]

Latin	% change in suitability	Sig change
Oxalis acetosella	2.0	+
Sorbus aucuparia	1.5	+
Ilex aquifolium	1.3	+
Potentilla sterilis	0.4	ns
Campanula latifolia	0.3	ns
Luzula sylvatica	0.2	ns
Allium ursinum	-0.1	-

Arable specialists [2]

Latin	% change in suitability	Sig change
Veronica arvensis	0.1	+
Anthemis cotula	0.0	ns
Anagallis arvensis	0.0	ns
Geranium molle	0.0	ns
Lamium purpureum	0.0	ns
Papaver rhoeas	0.0	ns
Polygonum aviculare	0.1	ns

Excerpts from lists of species with projected change in suitability of ecological conditions across Wales. Click here to view the modelled niche of each species in Britain.

Semi-natural habitat specialists (CSM +ve indicators)

Latin	% change in suitability	Sig change
Angelica sylvestris	0.2	+
Pimpinella saxifraga	0.3	+
Euphrasia officinalis agg.	0.3	+
Festuca rubra	-4.4	-
Leucanthemum vulgare	-4.3	-
Festuca ovina	-3.7	-
Agrostis capillaris	-3.7	-
Galium saxatile	-2.0	-
Galium palustre	-0.2	ns
Veronica officinalis	-0.2	ns
Epilobium palustre	-0.1	ns
Briza media	0.0	ns
Betonica officinalis	0.0	ns
Molinia caerulea	0.2	ns
Silene dioica	0.3	ns

[1] Glaves D et al. (2009) A Survey of the Coverage, Use and Application of Ancient Woodland Indicator Lists in the UK. Appendix 1. Hallam Environmental Consultants, Sheffield.
[2] Walker, K.J. (2018) Vascular plant 'axiophyte' scores for Great Britain, derived from the assessments of the vice-county recorders of the Botanical Society of Britain and Ireland (May 2016). NERC Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/af2ac4af-12c6-4152-8ed7-e886ed19622b

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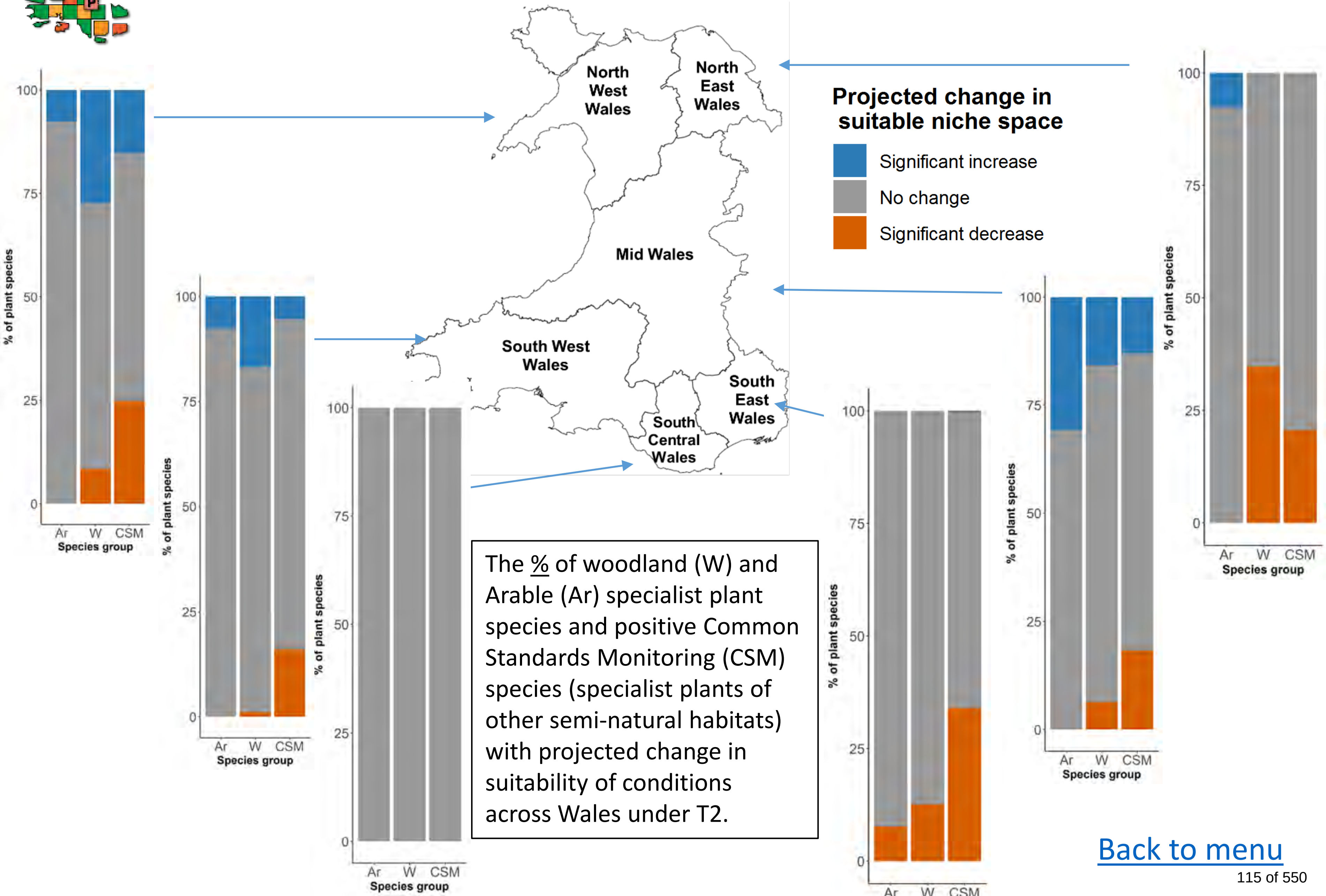
Regional impacts on plant species in T2



The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales under T2.

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Woodland habitat connectivity: Background information

- Woodland connectivity was modelled using a simple approach based on the distance species can travel (dispersal distance) and minimum habitat area requirements (patch size).
- Land within the dispersal distance of more than one patch could connect those patches if trees were planted.
- We identified a range of parameter combinations from the literature and applied these for Wales, broken down into NRW Area Statement regions.
- Baseline woodland was assigned using NFI data, combined with LCM2017, and data on woody linear features.

Dispersal distance/ patch size	**100m: snails**	**200m: woodland specialist plants**	**500m: invertebrates**	**1km: max. for snakes; amphibians; moths**	**2km: max. for woodland flora/fauna**
1 ha: low area requirements	not modelled	modelled	modelled	not modelled	not modelled
10 ha: high area requirements	not modelled	modelled	modelled	not modelled	not modelled
40 ha: NE recommended minimum size for wildlife site	not modelled	modelled	modelled	not modelled	modelled

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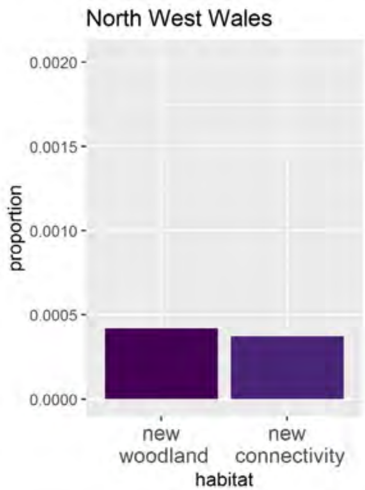
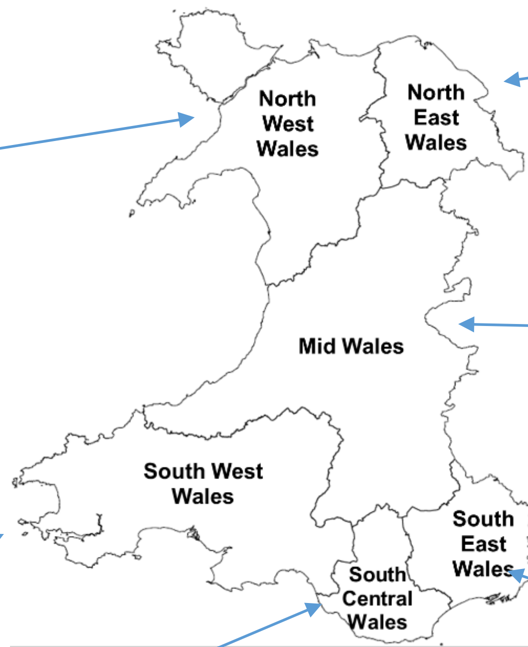
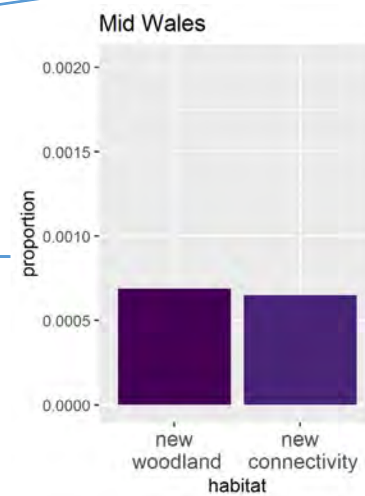
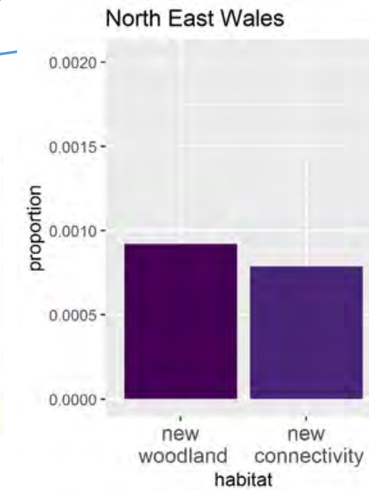
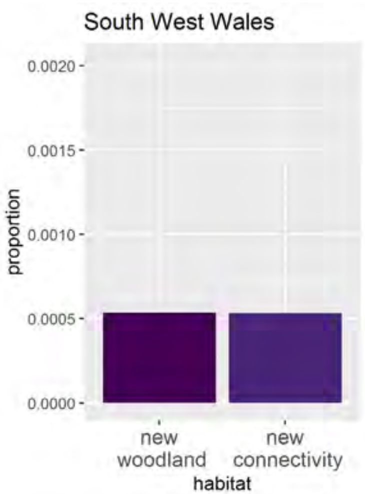
Woodland habitat connectivity: Regional variation in opportunity and predicted change (T2)

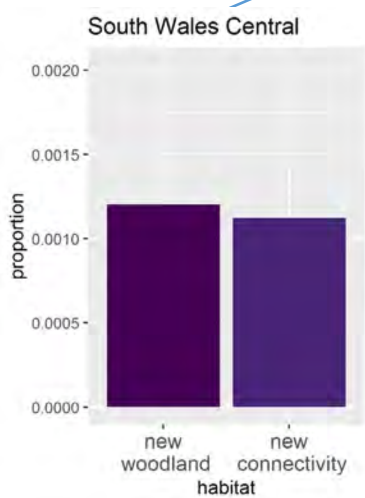




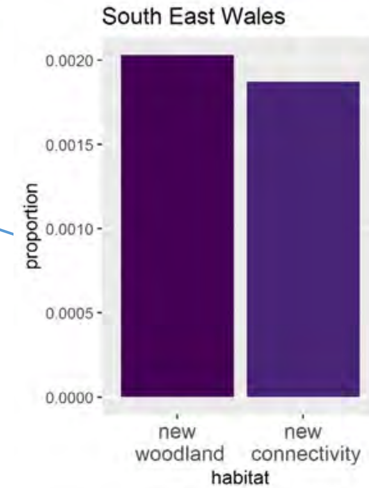








Most of the new woodland increases connectivity for at least one of our species type groups



- Total area new habitat woodland (ha)
- Total area providing increased connectivity

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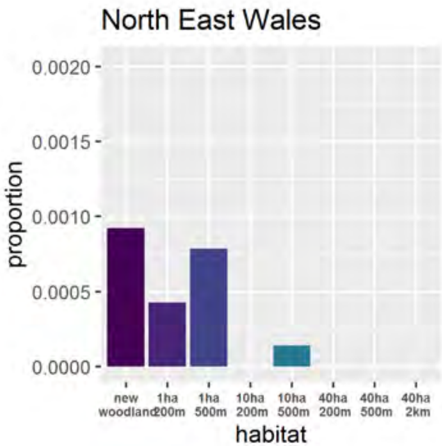
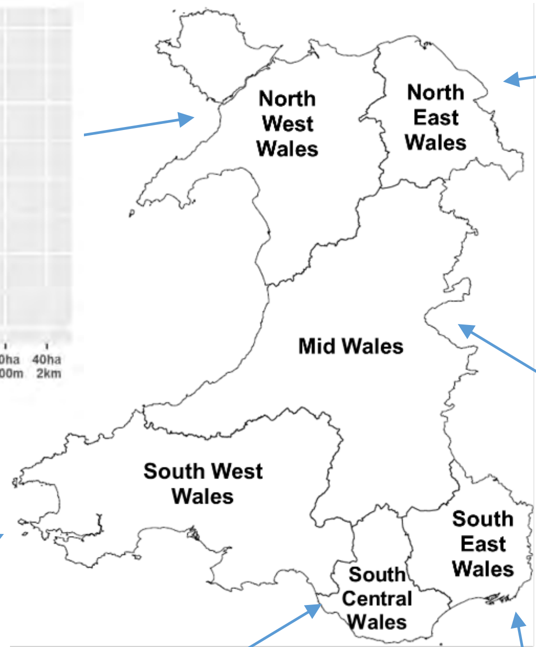
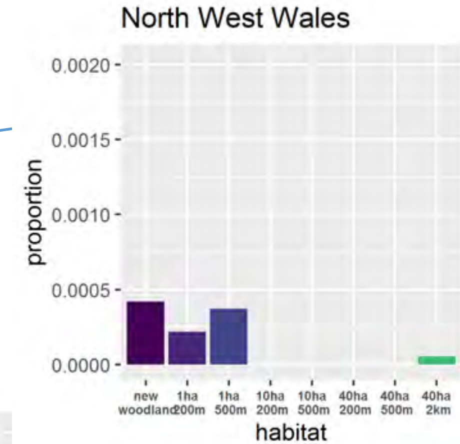
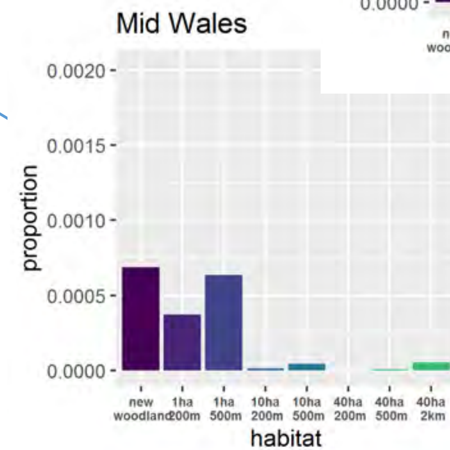
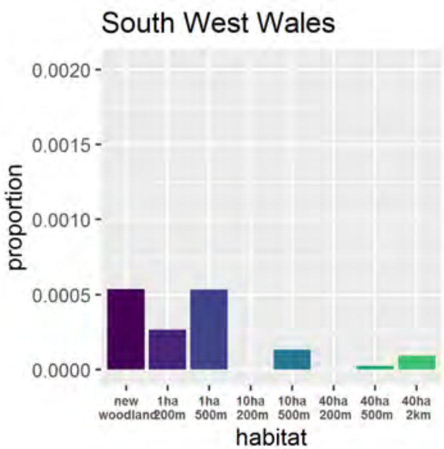
Breakdown of woodland connectivity type in NRW regions (T2)

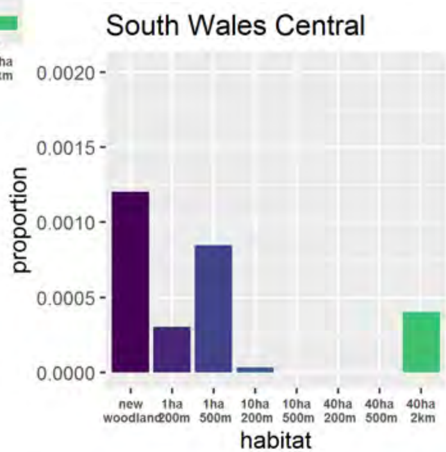


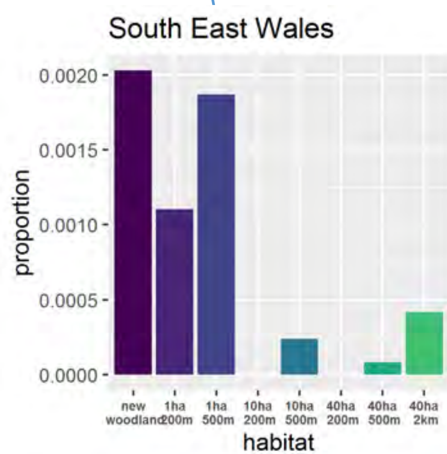












Connectivity increase:

- New woodland habitat
- 1ha 200m
- 1ha 500m
- 10ha 200m
- 10ha 500m
- 20ha 200m
- 40ha 500m
- 40ha 2km

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PART 3: Ecosystem Services

3a: Carbon

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Carbon summary: Stocks and GHG emissions (T2)

(Note: Negative numbers indicate sequestration or avoided emissions)	**Increased emissions or losses of carbon by the year:**		
Inventory category:	**2025**	**2050**	**2100**
Losses from carbon stocks in Land use change and forestry + harvested wood products (4 A,B,C & G) (KtCO2eq)	2,960	8,269	9,668
Additional emissions from wetlands (4D) flux (KtCO2eq)	-6	-34	-91
Additional agricultural GHG flux (KtCO2eq)	7,137	42,823	114,196
TOTAL	10,091	51,058	123,772

- Overall, a **net decrease in C stocks by 2100**, alongside **increased GHG emissions** is simulated for the T2 scenario, creating **net increase in atmospheric GHGs**.
- Modelled increases in greenhouse gas emissions associated with changes in livestock and nutrient inputs dominate the overall C budget, greatly exceeding the predicted emissions from vegetation and soils associated with agricultural land use change (LULUCF 4 A,B,C & G).

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Carbon stock and change in LULUCF categories (T2)

LULUCF category	Baseline	Change to 2100
Cropland and Grassland (4B +4C)(Kt) C	173,399	Loss of: 3,532(Kt) Gain of: 20 (Kt)
Forest Land (4A) (Kt)C	Baseline woodland C data are not available	Gain of: 667 (Kt)
Harvested Wood products (4G) (Kt) C		Gain of: 210 (Kt)

- Carbon in cropland and grassland systems (LULUCF category 4B and 4C) is simulated to be lost in the T2 scenario due to transitions from permanent and rough grassland into arable/grass rotation.
- Small gains in carbon in cropland and grassland systems are also simulated related to land going out of agriculture.
- Some gains in C storage are simulated for forest land and harvested wood products related to agricultural land that is converted to woodland. Note, this outcome is strongly dependant on the small area of new woodland planting as modelled here, based on planting on former agricultural land with net positive NPV. Note also that data are not available to account for C storage in existing woodland.

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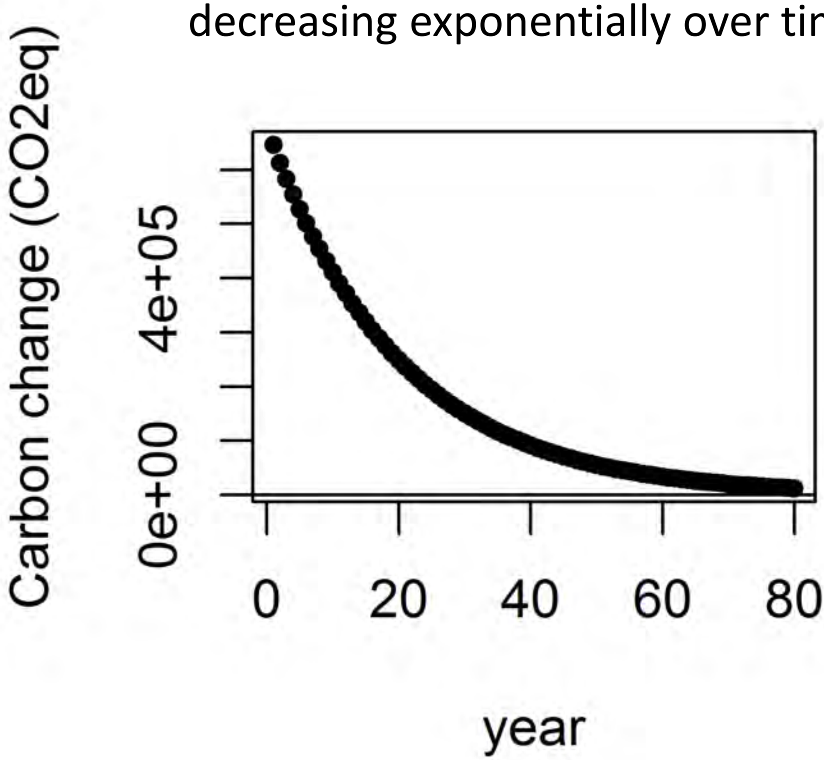
Agricultural carbon stock over time (T2)

Rate of C emissions from soils and vegetation at agricultural sites:
Initially high losses in C stock, decreasing exponentially over time



(Plot for agricultural land staying in agriculture)

- Carbon stock in croplands and grasslands (LULUCF 4B + 4C) is simulated to decrease, rapidly at first with high initial emissions, but slowing over time, approaching a new equilibrium by 2100.
- Total losses to 2100 account for around 2% of total IMP modelled C stocks in agricultural vegetation and soils.

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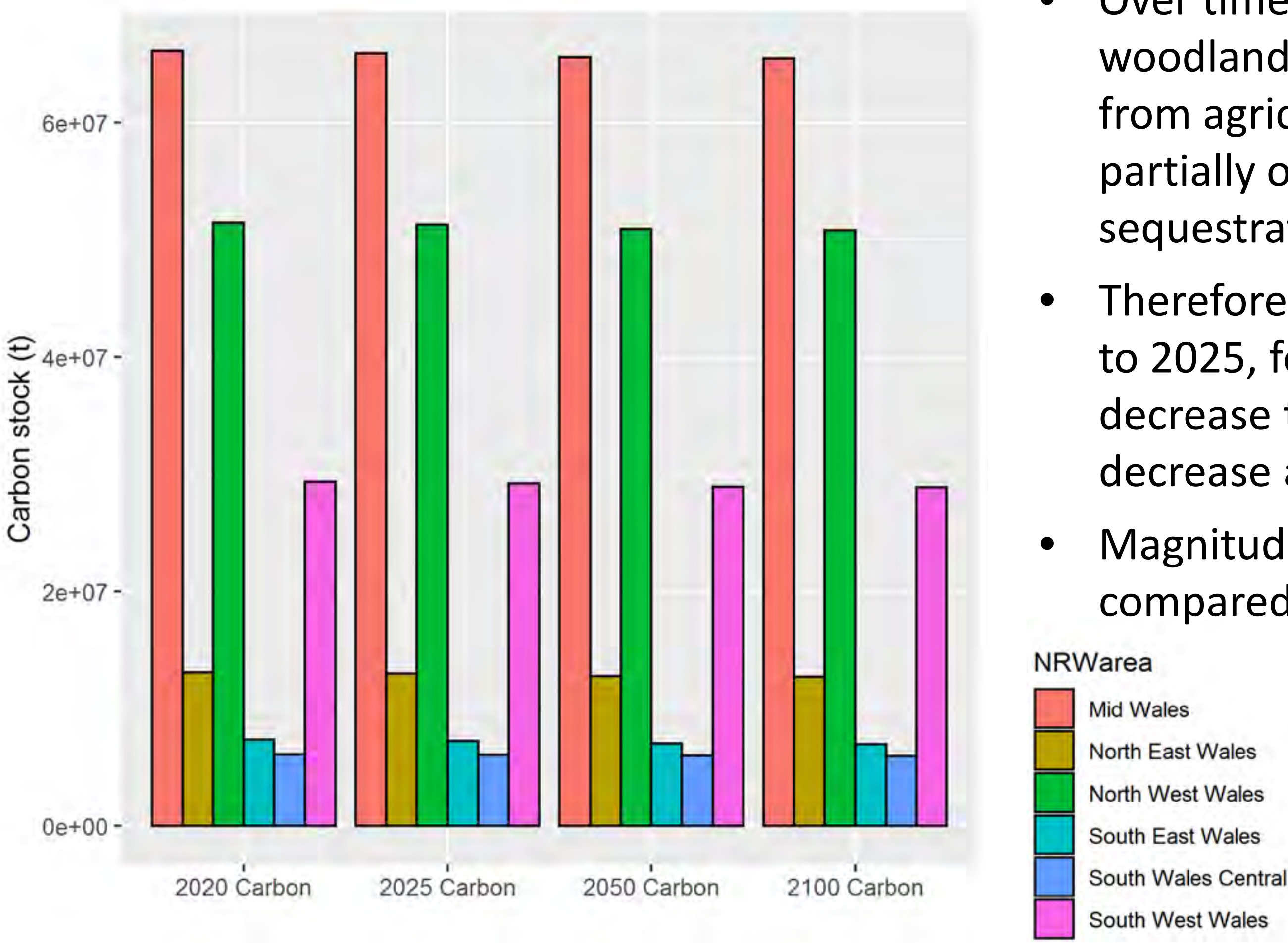
Total carbon stock over time (T2)

Total C stock for all modelled land in: 2020, 2025, 2050 and 2100



- Carbon stock in woodland systems increases slowly over time, with initial losses at some sites due to soil disturbance.
- Over time, initial losses from woodland disturbance and losses from agricultural changes are partially offset by woodland sequestration.
- Therefore, total C stock decreases to 2025, followed by a slower decrease to 2050 and slower decrease again through to 2100.
- Magnitude of change is very small compared to total stocks.

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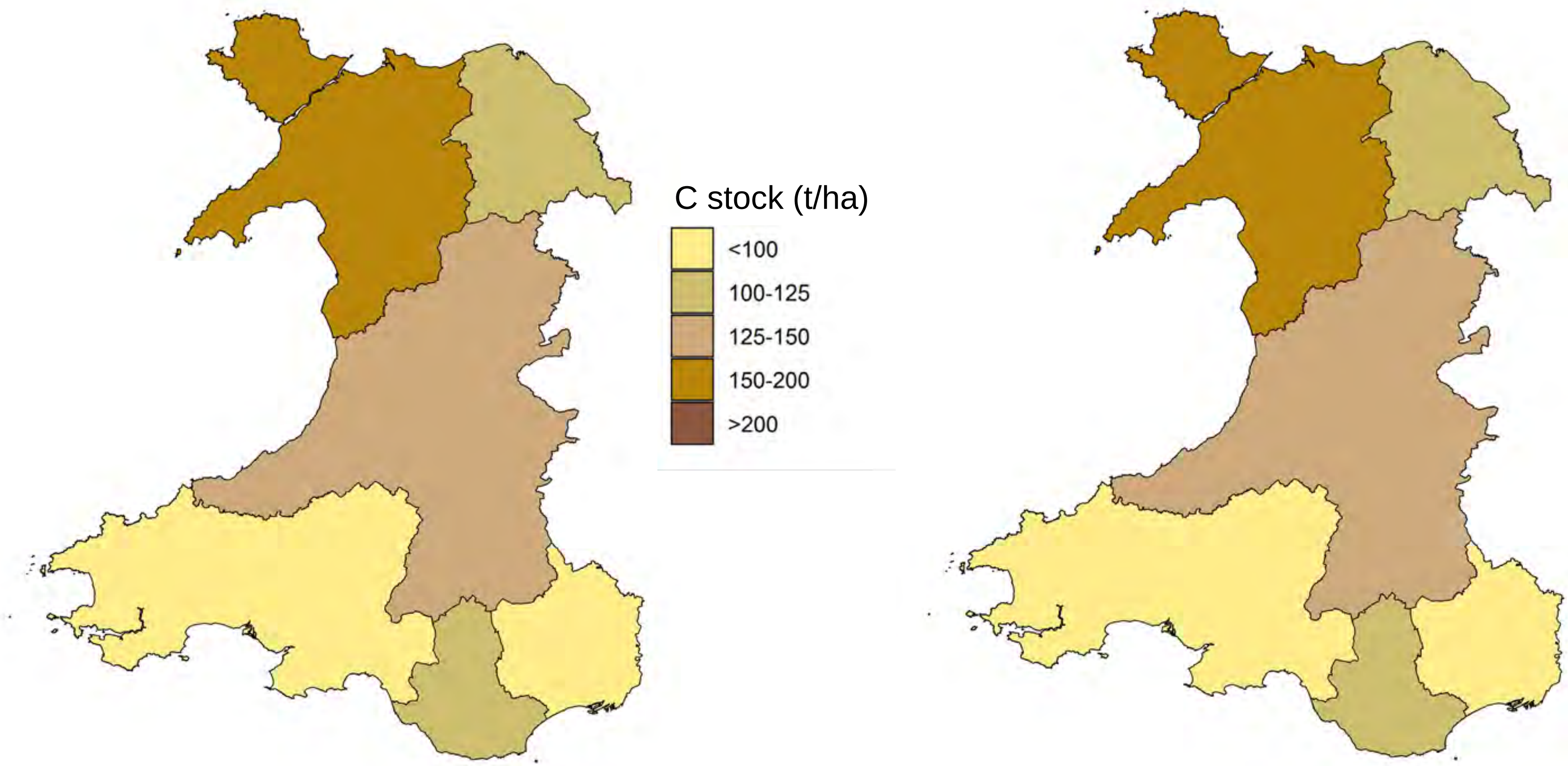
Carbon stock for NRW regions (T2)

Baseline (2020) | T2 scenario (2100)



Data are for LULUCF categories 4 A,B,C &G
and are displayed per ha of land modelled

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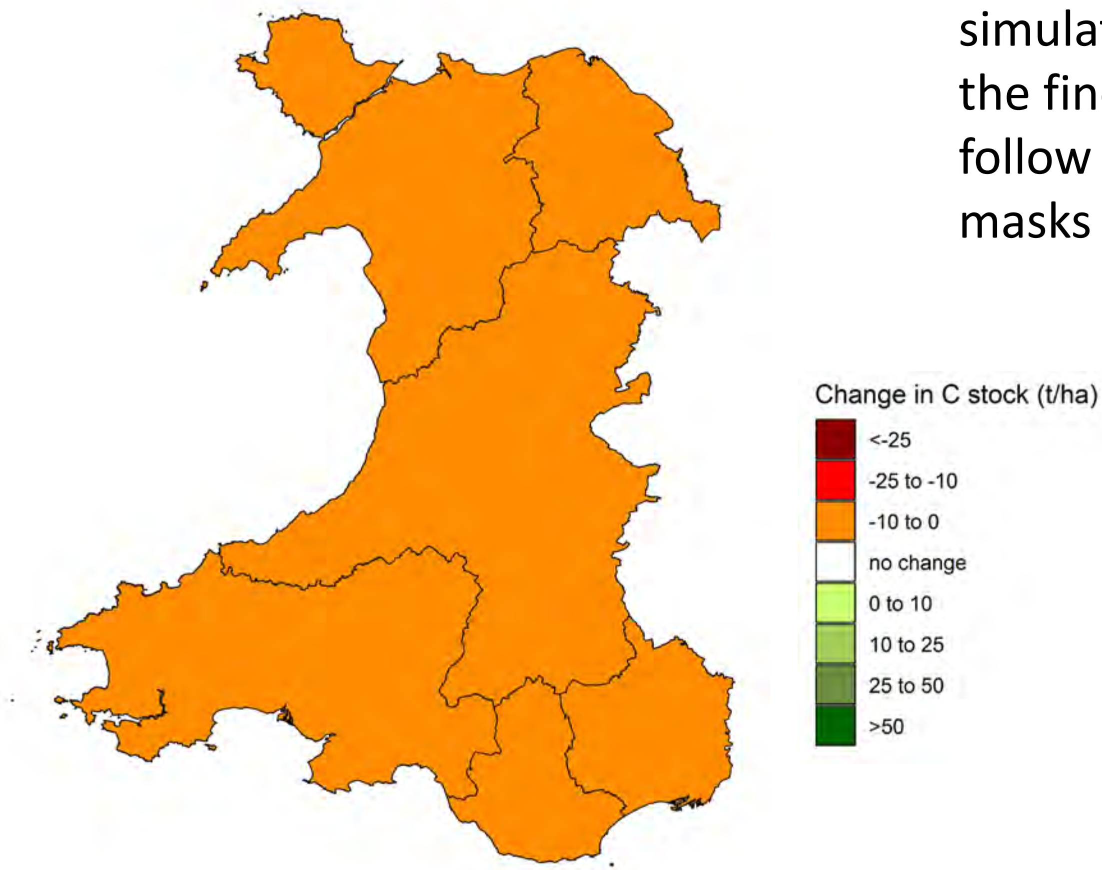
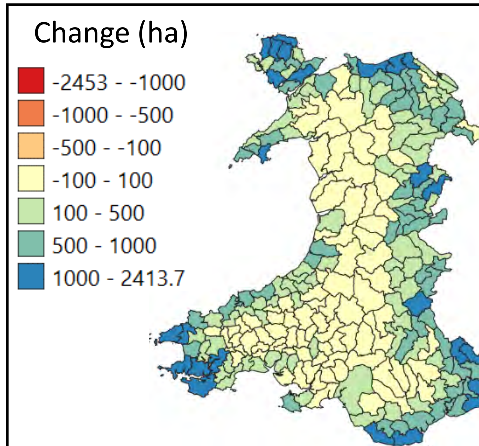
Carbon change for T2 scenario

Carbon change 2020-2100 (tC/ha)



A small reduction in C stocks is simulated in all NRW regions, however, the finer spatial detail in the maps that follow reveal that this net decrease masks a pattern of increase/decrease



Increase in arable-grass rotation is the main driver of change

Data are for LULUCF categories 4 A,B,C &G and are displayed per ha of land modelled

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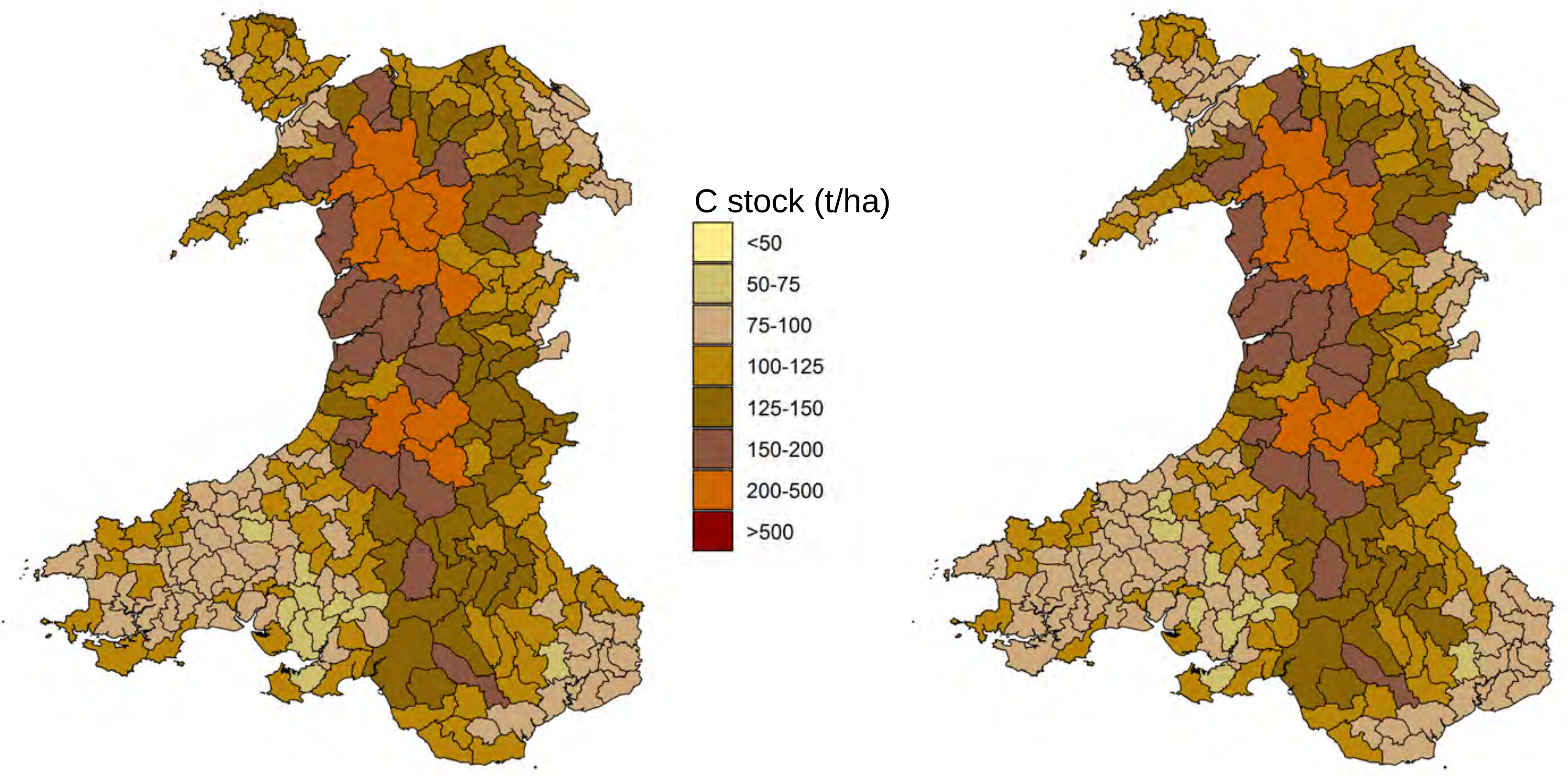
Carbon stock for small agricultural areas (T2)

Baseline (2020)

T2 scenario (2100)



Data are for LULUCF categories 4 A,B,C &G
and are displayed per ha of land modelled

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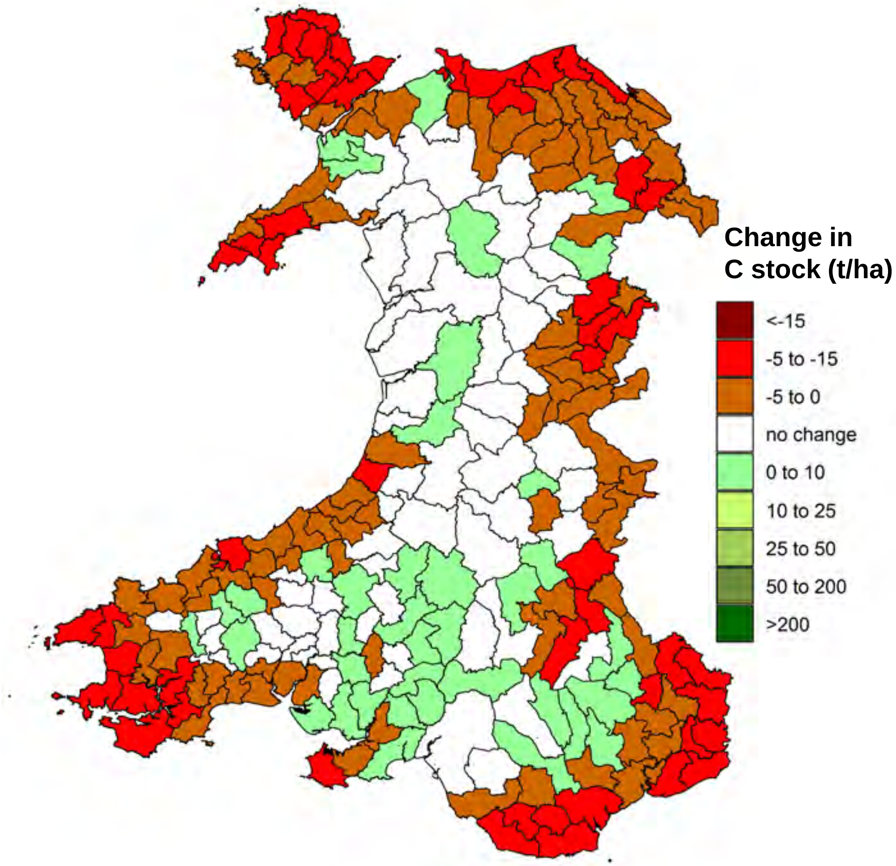
Carbon change for small agricultural areas (T2)

Map: tC/ha change 2020-2100



Data are for LULUCF categories 4 A,B,C &G and are displayed per ha of land modelled

- Carbon stocks are simulated to increase in some areas and decrease in others, whilst some have no change.
- Areas of decrease reflect reductions in areas of permanent and rough grass, and increases in arable-grass rotation.
- Areas of increase reflect new woodland (see slide 38), largely due to the significant C storage potential of biomass and harvested wood products.
- Some increase may also be attributed to sequestration on land reverting to short vegetation.

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GHG emissions: Peat and agriculture (T2)

This table compares total agricultural emissions and wetland emissions for farms modelled by IMP:

LULUCF category	Baseline	T2 scenario
Wetlands (4D) flux (KtCO2eq/yr)	873	872
Agricultural GHG flux (KtCO2eq/yr)	4,816	6,243

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Agricultural GHG emissions are simulated to increase reflecting the large increases in dairy and arable/grass rotations, which are not offset by smaller decreases in sheep.
- GHG emissions from wetlands are simulated to decrease slightly, reflecting the small area of land that comes out of agriculture on peat.

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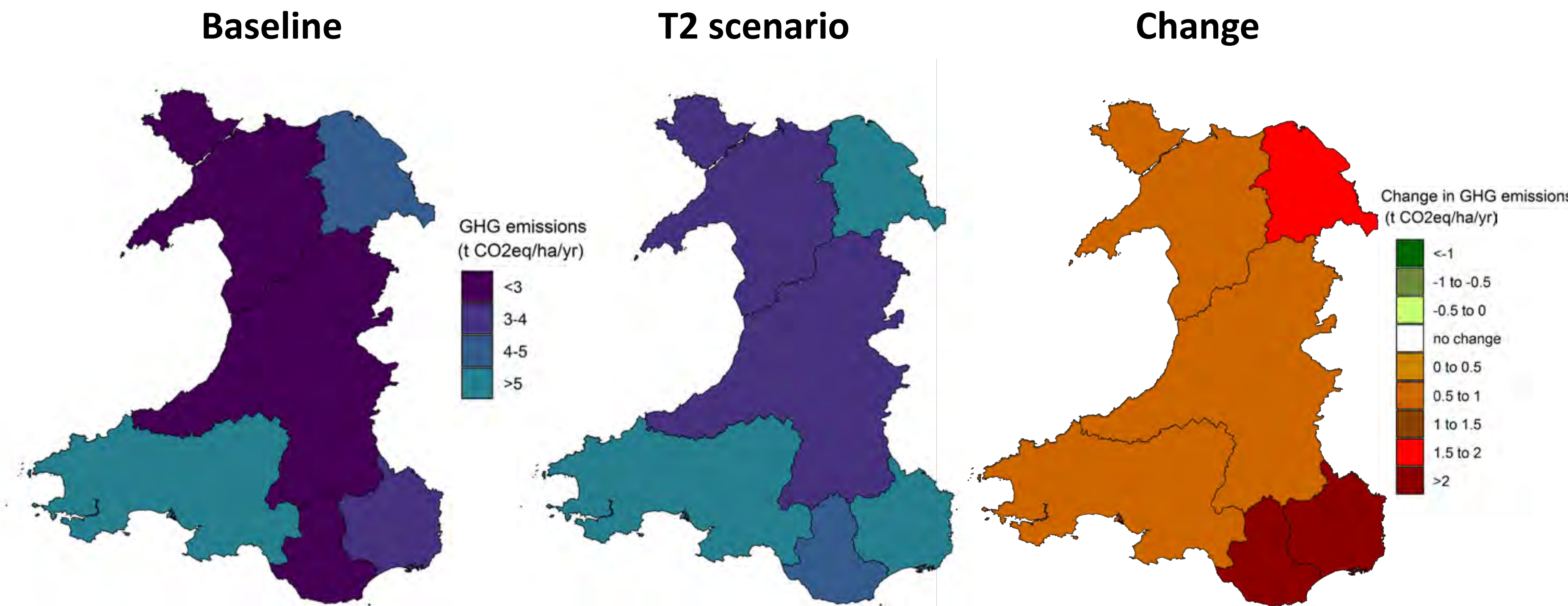
GHG emissions for NRW regions (livestock and management) (T2)



- Data are displayed per ha of land modelled, and reflect patterns of livestock, land use and management.
- Increases reflect increased intensity with greater areas of conversion to arable/temporary grassland.
- None of the regions experience net reduction, but some areas of reduction become apparent when data are explored at finer scale.

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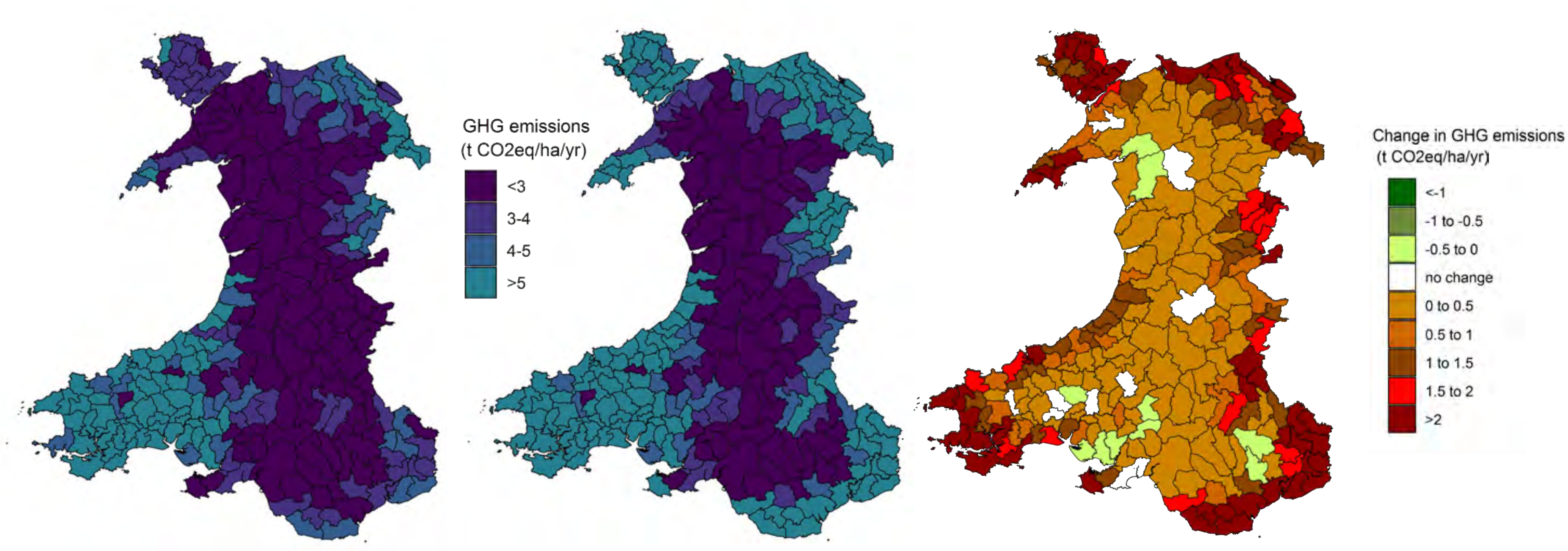
GHG emissions for small agricultural areas (livestock and management) (T2)

Baseline | **T2 scenario** | **Change**



- The finer scale data reveal the greater magnitude of local changes.
- Reductions reflect land coming out of agricultural use.
- Increases reflect increased intensity with greater areas of conversion to arable/temporary grassland.

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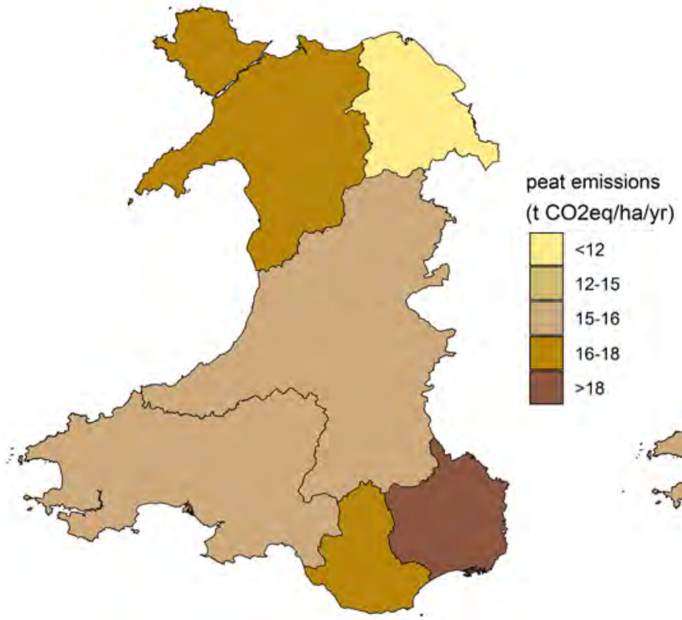
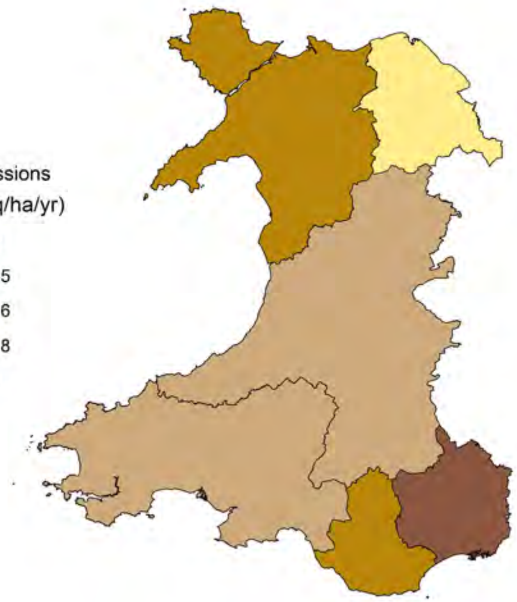
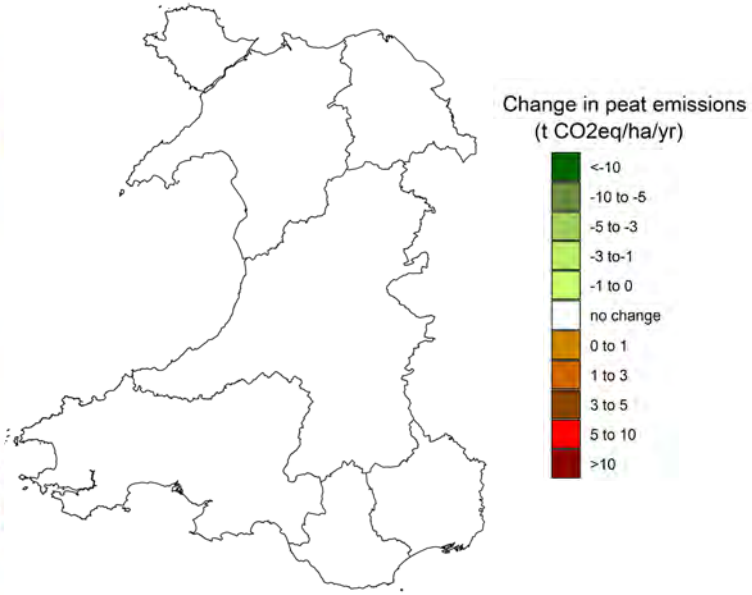
GHG emissions for NRW regions (peat) (T2)

Baseline | **T2 scenario** | **Change**







- Data are displayed per ha of peat modelled, and reflect land use and inferred management.
- Emissions do not change noticeably at the scale of NRW regions, due to the limited area of simulated land use change on peat.

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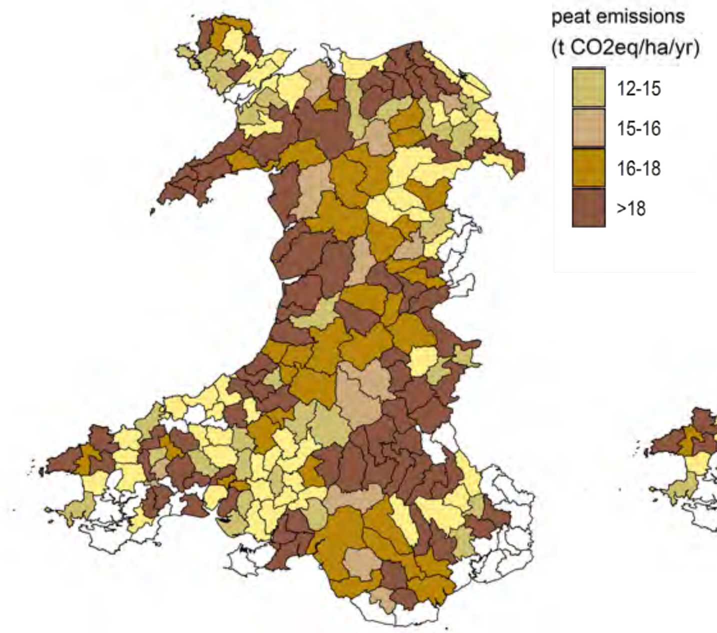
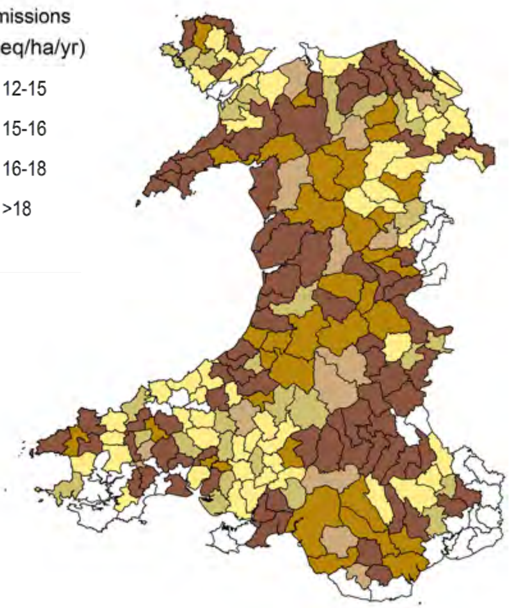
GHG emissions for small agricultural areas (peat) (T2)

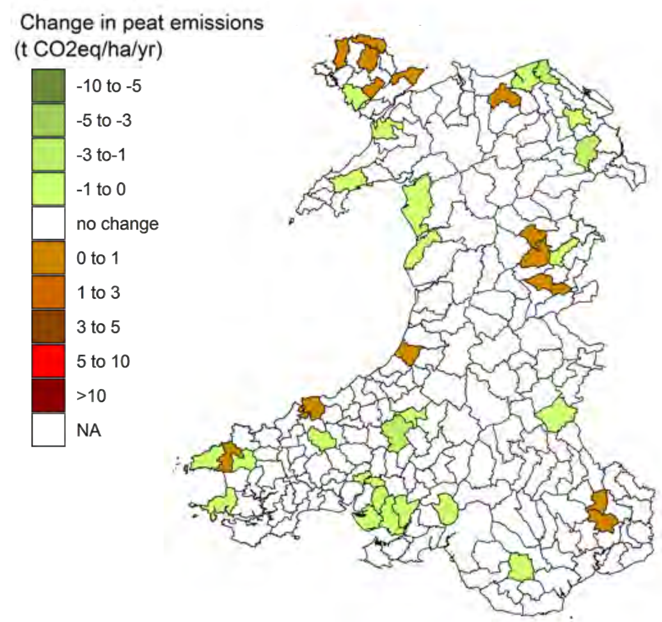
Baseline



T2 scenario



Change



- Emissions are projected to change very little to 2100.
- Changes in some areas mostly reflect reduced emissions due to recovery on land going out of agricultural use.
- Some small agricultural areas do not contain peat, or do not experience predicted land use change on peat.

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PART 3b: Water quality

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Water Quality: Background information 1

- Water quality impacts must be considered for WFD catchments, therefore, loads calculated at the DMU level **(in kg/ha)** must be processed to in-stream loads, by aggregating at the catchment level.
- We also add in non-agricultural sources of pollutants, as well as estimates of pollutants for farms not modelled by the IMP (<1FTE).
- We then account for flow (and nutrient) accumulation to downstream catchments, and account for stream flow to calculate concentration for N and P.
- Data for N and P are processed to units reflecting the relevant thresholds: **annual average concentration for P and 95th percentile for N**.
- Data on sediments are calculated as **annual average loads**. River sediment concentrations are controlled by event driven inputs and in-river processes occurring over a range of timescales, so it is hard to measure average concentrations using infrequent grab samples and difficult to predict these from annual average inputs to watercourses as predicted by the IMP.

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Water Quality: Background information 2

- The water quality analyses are based on the scenario being applied to farms >1FTE only. Farms <1FTE are modelled as not responding to the scenario.
- We assume afforestation or reversion to short vegetation or natural woodland on the "non-economically viable" farms.
- Changes in water quality are not modelled for lakes, but these may be important for recreation, and associated businesses in Wales.
- Data outputs relate to a new long-term average reflecting land use and management for the scenario: we do not account for time lags in the nitrogen system.
- Predicted loads are based on average climate data (1961-1990).
- Data reflect average losses rather than those that might occur once in several years due to an intense rainfall event causing significant erosion (particularly important for sediment and P).
- Some measures might change soil P status or soil organic N supply, which happen over a period of 10+ years to reach a new equilibrium. Our scenario outputs assume these changes have already occurred.

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Water Quality for Wales: Change in N, P and sediment load (T2)

This table compares total agricultural loading for farms modelled by the IMP:

	Farms <1FTE	Baseline	T2 scenario	Change	% change	Glastir impacts
Nitrate kt NO3 N	4.13	30.11	38.00	7.89	26%	-1%
Phosphorus kt P	0.18	0.72	0.80	0.08	11%	-0.9%
Sediment kt Z	68	194	194	-0.37	0%	-0.1%

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Increases are simulated for N and P and decreases for sediment under T2.
- This reflects the increase in dairy and increased nutrient inputs, set against a contraction of permanent grass and sheep.
- Glastir impacts, modelled from 2016 uptake data, are shown for comparison.

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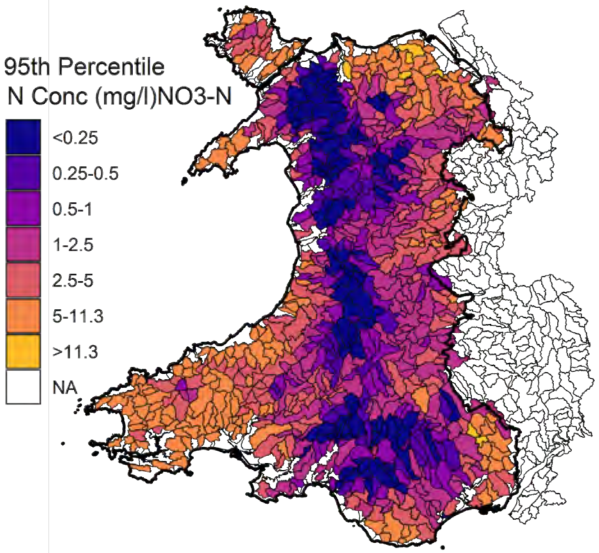
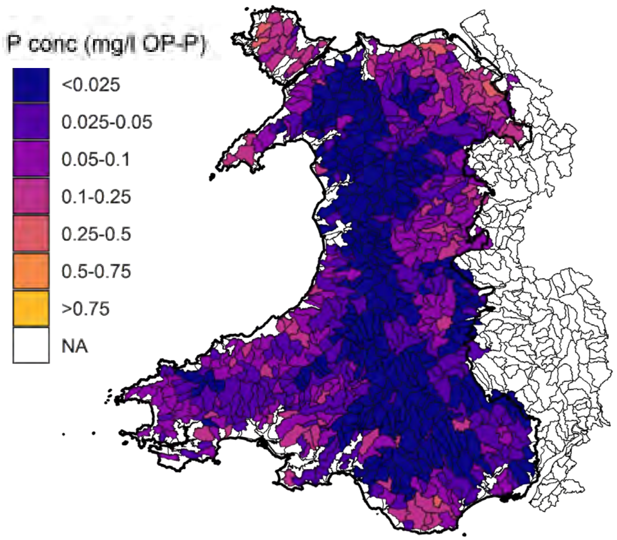
N, P and sediment load for baseline and T2

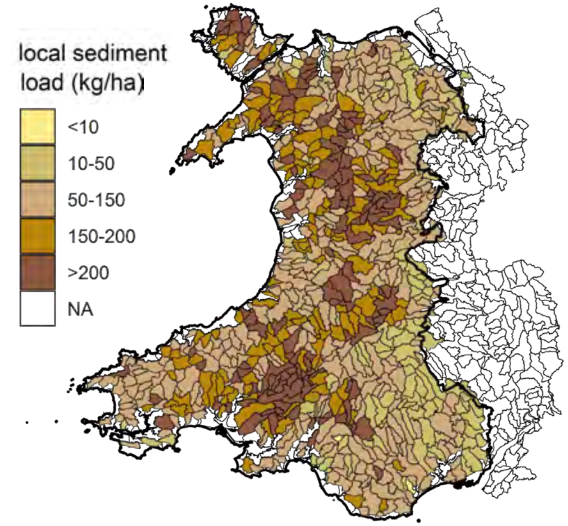
Baseline N



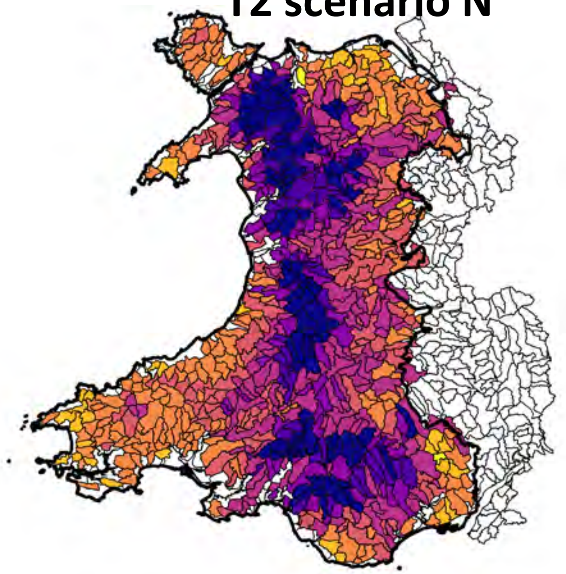
Baseline P



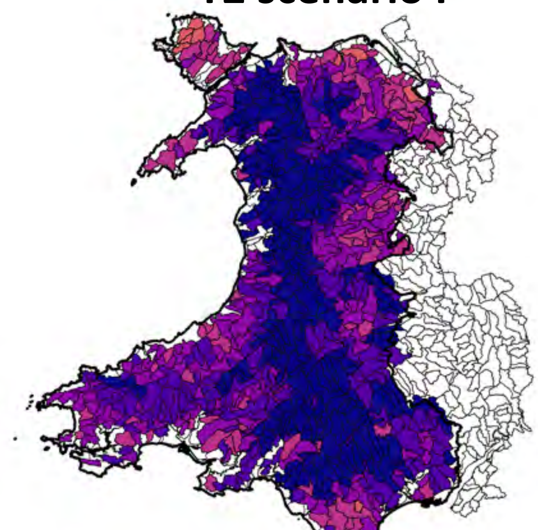
Baseline Sediment



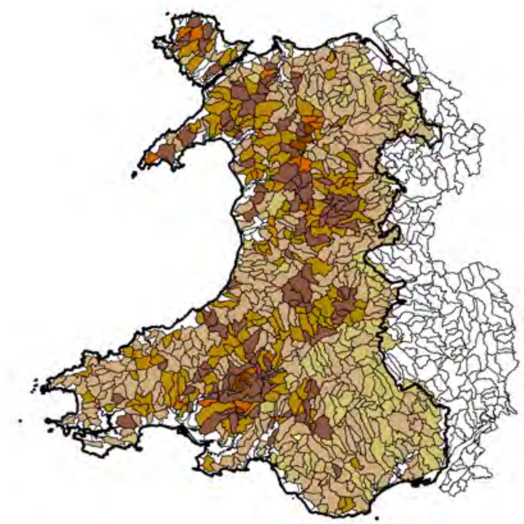
T2 scenario N



T2 scenario P

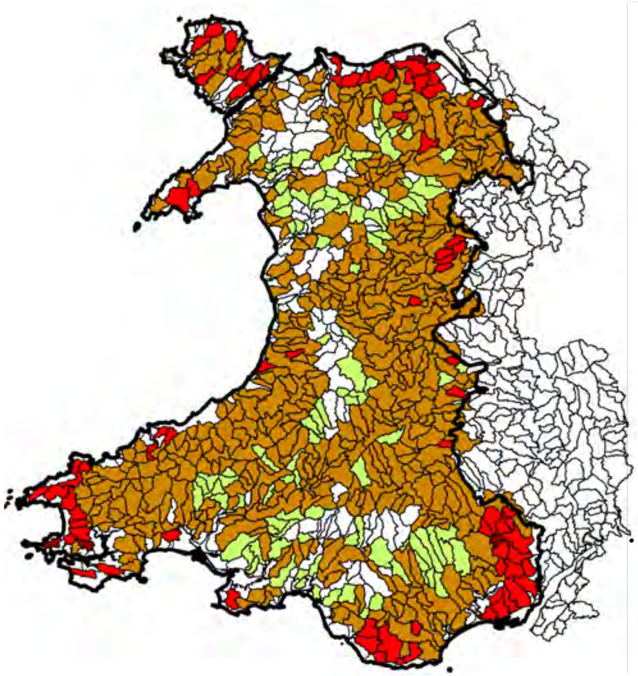


T2 scenario Sediment



Change in N, P and sediment load (T2)

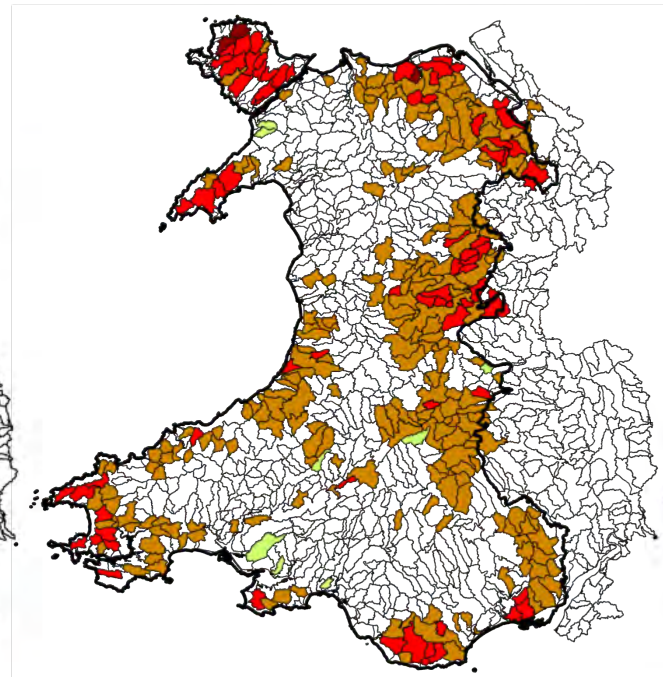
N change



Change in 95th Percentile N Conc (mg/l)NO3-N

- <- 5
- -5 to -2.5
- -2.5 to
- no change
- 0 to 2.5
- 2.5 to 7.5
- >7.5
- NA

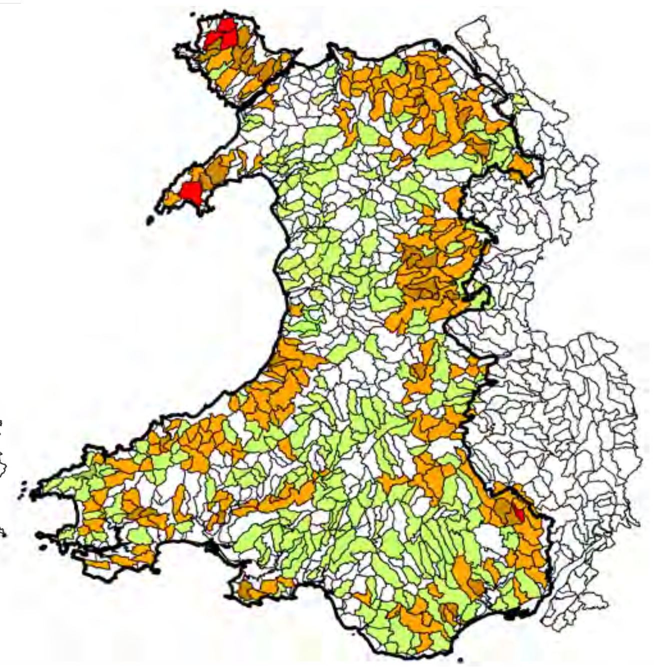
P change



Change in P conc (mg/l OP-P)

- <- 0.05
- -0.05 to 0
- no change
- 0 to 0.01
- 0.01 to 0.05
- >0.05
- NA

Sediment change



Change in local sediment load (t/ha)

- <-200
- -200 to -100
- -100 to -50
- -50 to 0
- no change
- 0 to 10
- 10 to 25
- 25 to 50
- >50
- NA

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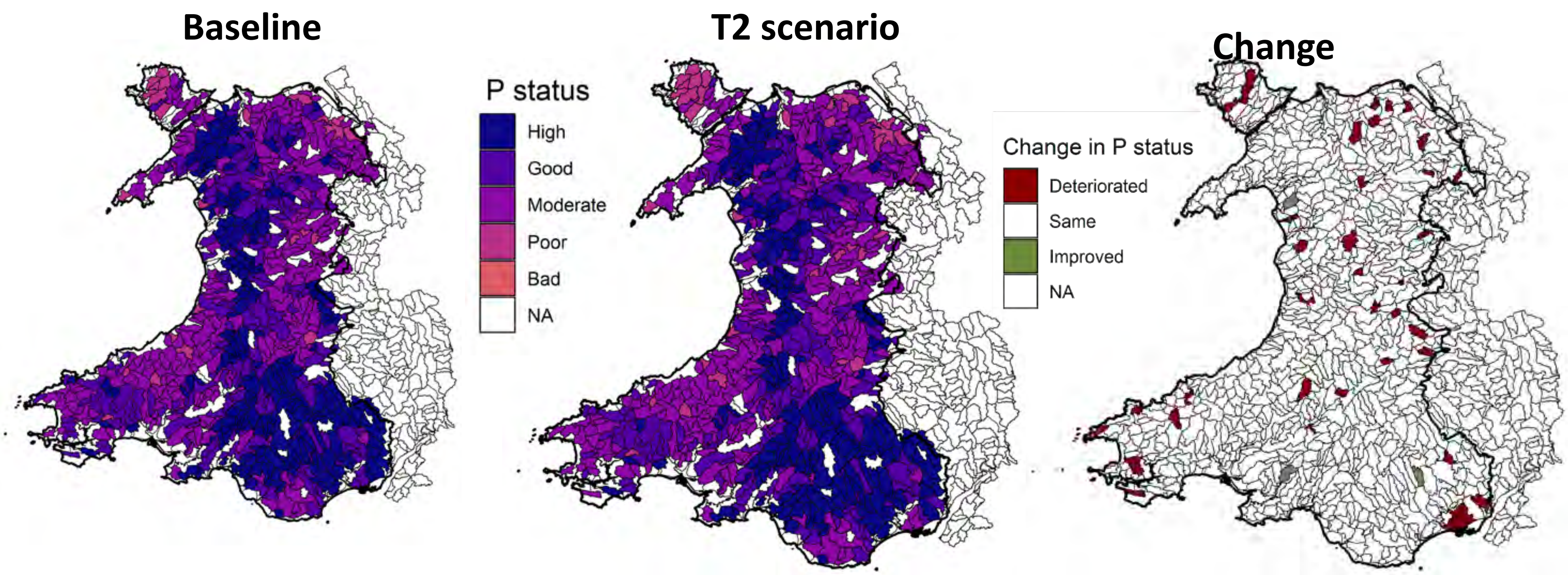
WFD P status (T2)



- WFD P status is projected to deteriorate under the T2 scenario in several catchments, reflecting increased agricultural intensity (dairy).
- WFD P status is projected to improve in some catchments where land transitions to non-agricultural uses, including woodland.
- The pattern of status change reflects the spatial pattern of thresholds as well as the changes in loading.

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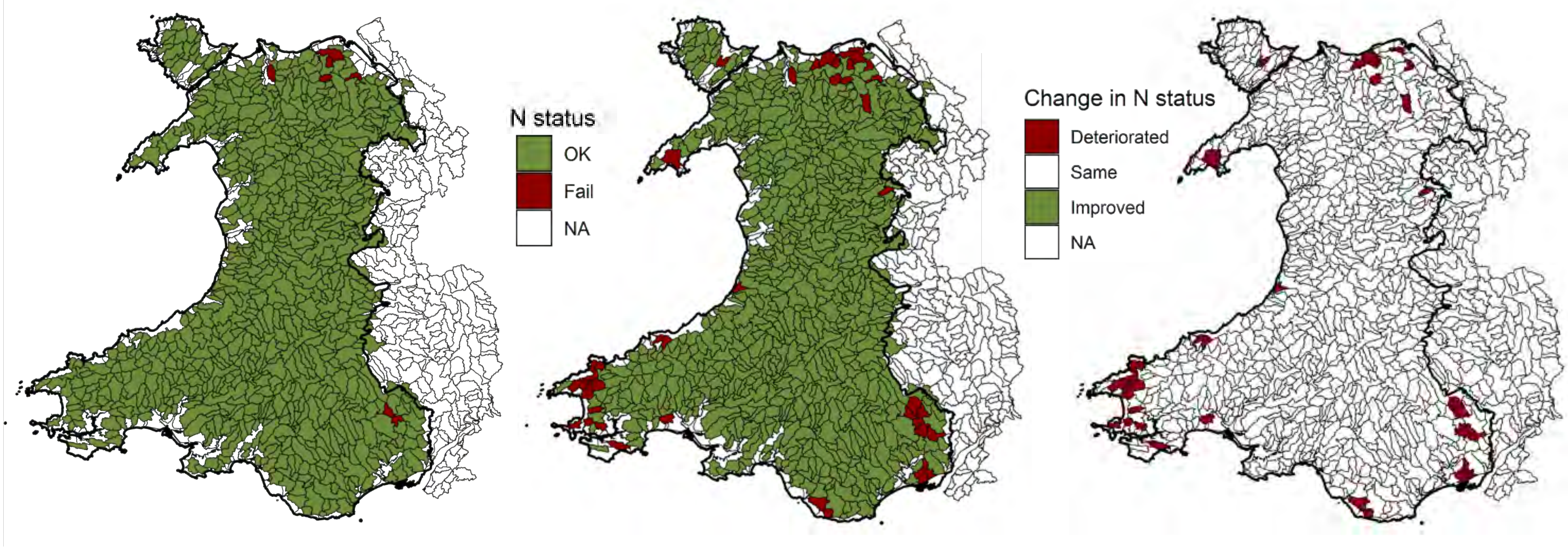
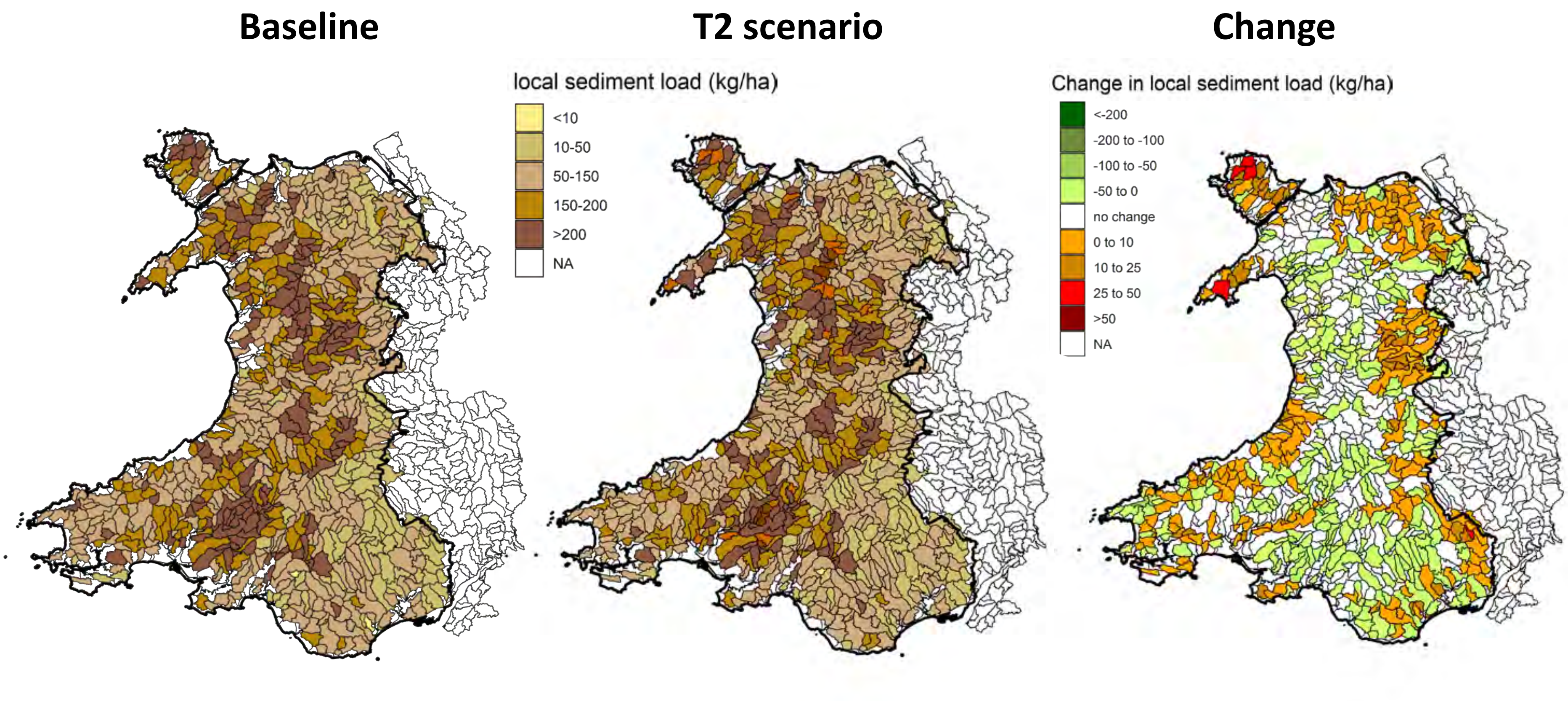
Drinking water N status (T2)

Baseline **T2 scenario** **Change**



- Drinking water N status is projected to deteriorate in key areas coinciding with expansion of dairy.
- The spatial pattern also reflects baseline concentrations in relation to the drinking water quality threshold.

Change in sediment load (T2)



- An increase in sediment loading is simulated for areas where dairy expands, whilst a reduction is simulated for many catchments that show a reduction in sheep numbers.

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PART 3c: Air quality

Air quality – Wales overview (T2)

This table shows changes in PM2.5 concentration and life years lost under the T2 scenario:

Average Change in PM2.5 Concentration	Life Years Lost (LYL)
+0.04	+59.5

- PM2.5 concentrations are simulated to slightly increase on average for Wales, as a result of increased NH3 emissions and only small increases in woodland planting.
- This leads to a net health dis-benefit of an increases in 59.5 Life Years Lost.
- BUT spatial patterns vary …

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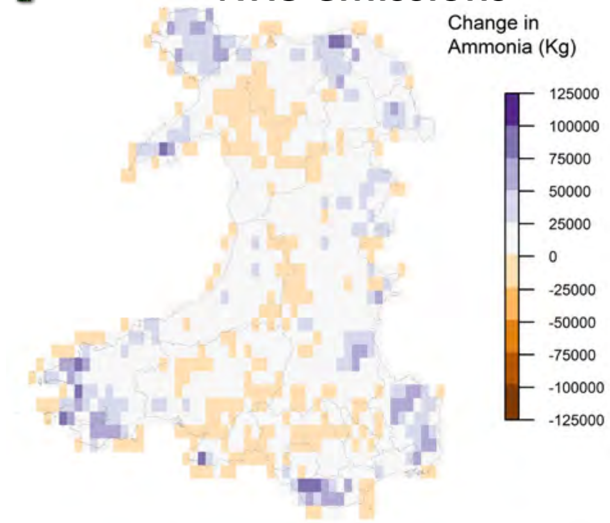
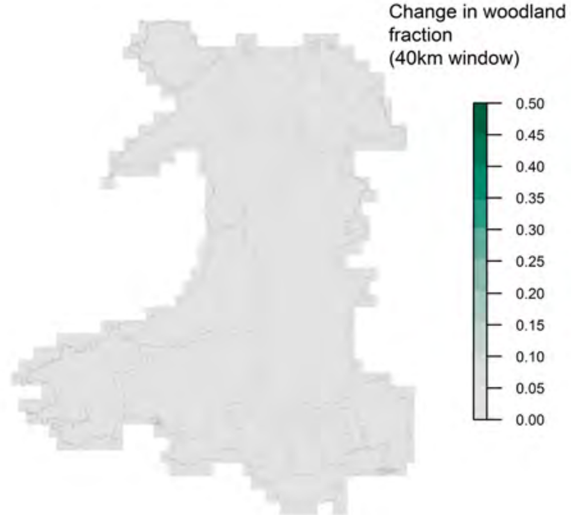
Health outcome from change in air quality (T2)

NH3 emissions



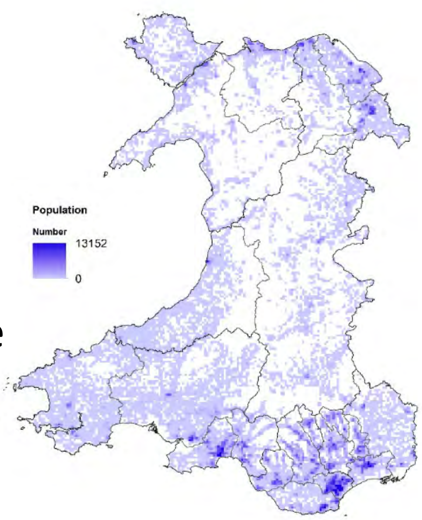
New woodland



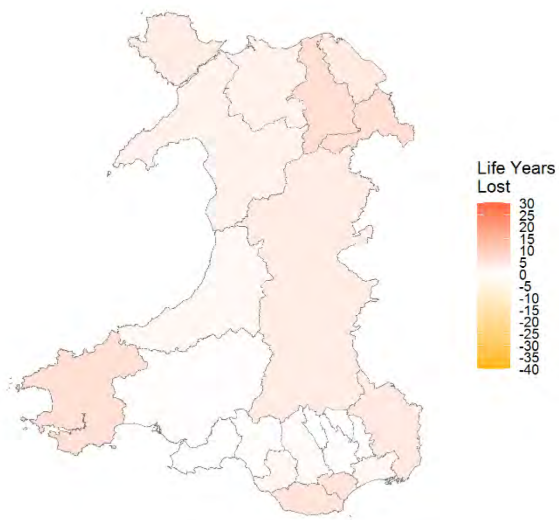
PM2.5 change

- Change in PM2.5 is a function of change in NH3 emissions and the small increase in new woodland planted.
- Increases in PM2.5 are simulated where NH3 emissions increase (mainly from dairy).

Population



Avoided 'Life Years Lost'



- Health outcomes are a function of change in exposure of the population
- **Net negative benefit in most areas, *except* Blaenau Gwent**

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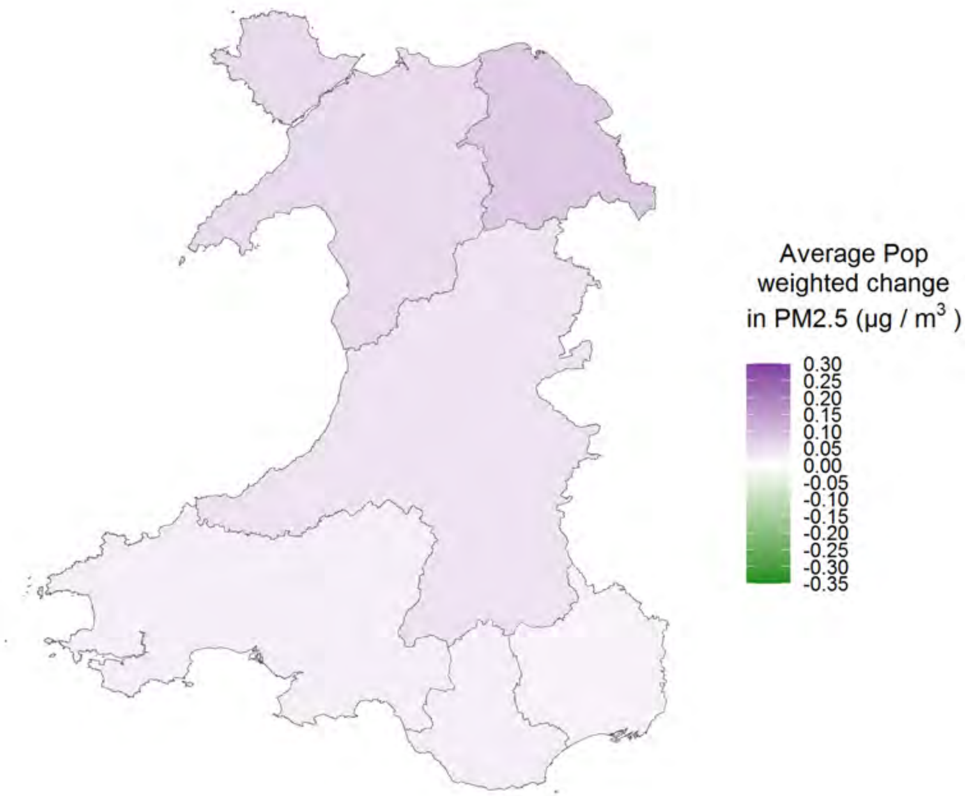
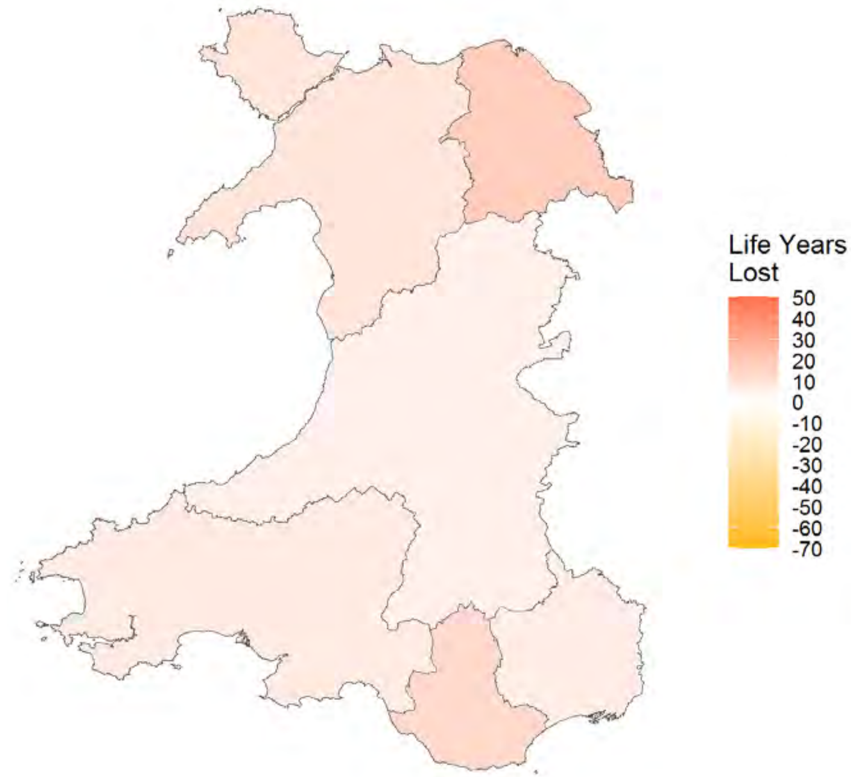
Air quality for NRW regions (T2)

Average change in PM2.5 concentration



Avoided Life Years Lost (total)



Greatest dis-benefits are in parts of North and South Wales.

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PART 4: Valuation

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Valuation results: Background information

- Price year: 2020
- Present values: 75 year time horizon
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g. 3.5% declining discount rate/ health discount rate for air quality):
  - Values are based on BIES (2018) guidance on carbon values for appraisals by Government.
  - This was prior to the release of updated values in September 2021.
  - The 2018 values do not fully reflect the requirements of the Paris Agreement 2016, the domestic net zero target, and other recent policy developments.
- Results given to 3 significant figures.

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Summary of public goods values (T2)

Benefits	Physical measure	Units	Present value, 75 yrs, £	Type of value
Air Quality	Increase of 60 years	Life Years Lost each year	- £ 85m	Reduction in costs of health impacts from air pollution
Water Quality	65 Deteriorate, 3 Improve	Expected changes in WFD status due to changes in P	- £ 33m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 117m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 8,074m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- The figures are an estimate of the value of the increase in wellbeing to people over 75 years under this scenario.
- Figures indicate order of magnitude of values of expected changes in the Welsh Environment.

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Breakdown of public goods values (T2)

Benefits	Present value, £m			Type of value
	5 yrs	25 yrs	75 yrs	
Air Quality	- £ 4m	- £ 27m	- £ 85m	Reduction in costs of health impacts from air pollution
Water Quality	- £ 5m	- £ 20m	- £ 33m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs:				Benefit of reducing GHG sources:
Agriculture	- £ 497m	- £ 2,565m	- £ 7,376m	Agricultural sources (livestock and inputs)
Land use	- £ 206m	- £545m	- £704m	LULUCF sources (soils, vegetation and harvested wood products)
Wetlands	£ 0.4m	£ 2m	£ 6m	Wetland sources (peatlands)
Total GHGs	- £ 703m	- £ 3,108m	- £ 8,074m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- All figures are based on simplifying assumptions of change over time.

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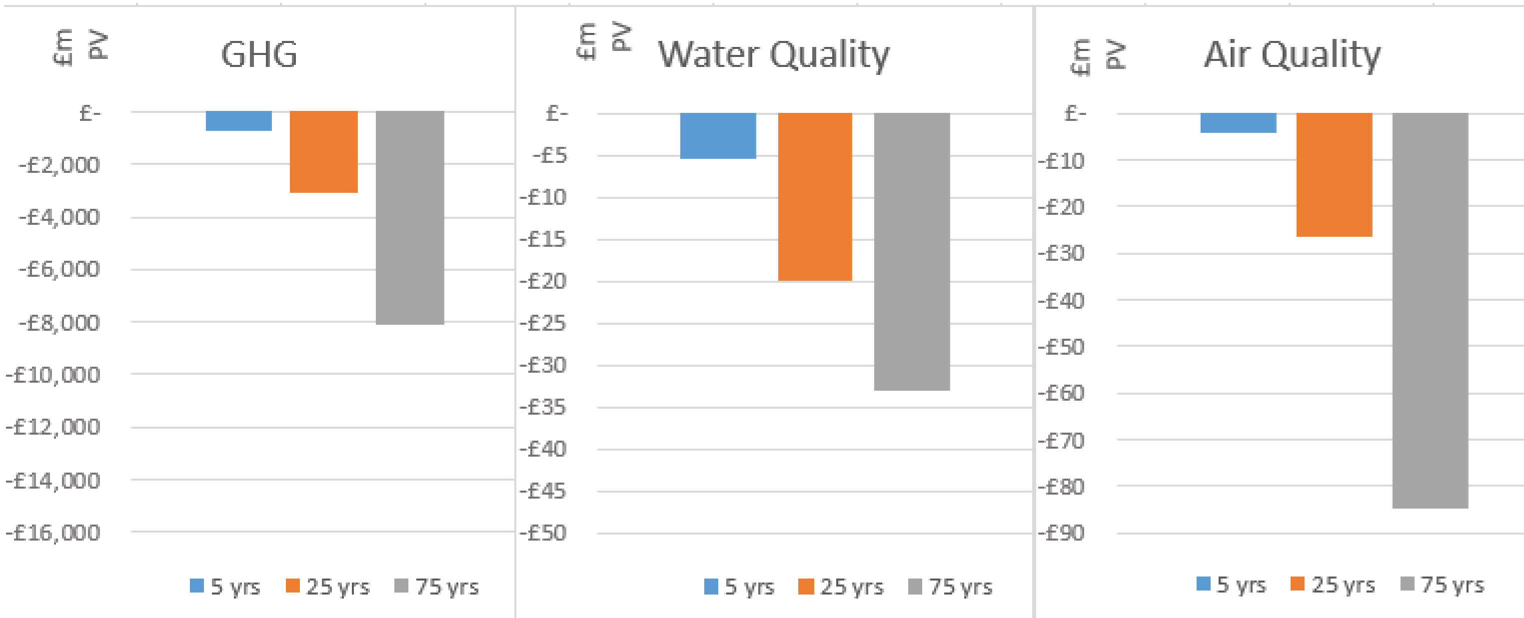
Public Goods Values for different time horizons (T2)



- A sustained loss of value of all three ecosystem services is simulated under the T2 scenario.
- The changes reflect increased agricultural intensity in some area as dairy expands, and limited new woodland planting.

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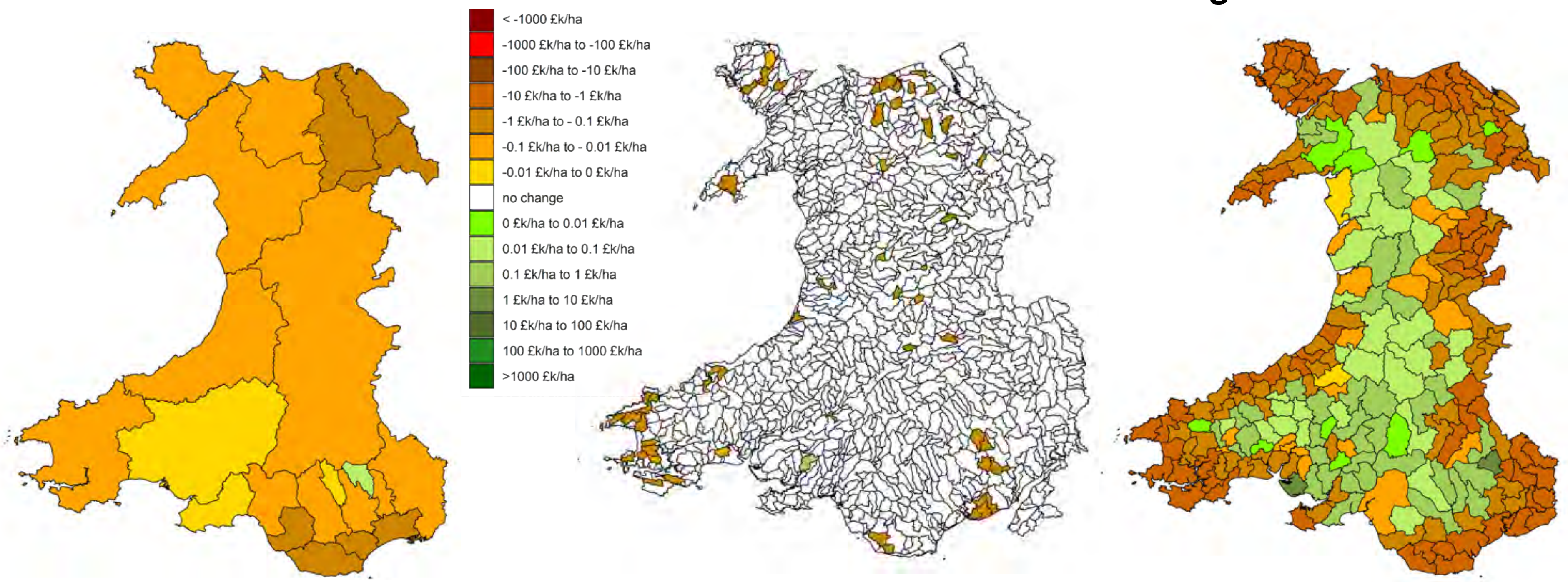
Spatial distribution of values (T2) (finest resolution)



- Costs are simulated in some regions for all three services.
- Benefits are simulated for all services in some regions, particularly for carbon, which reflects land going to non-agricultural uses.

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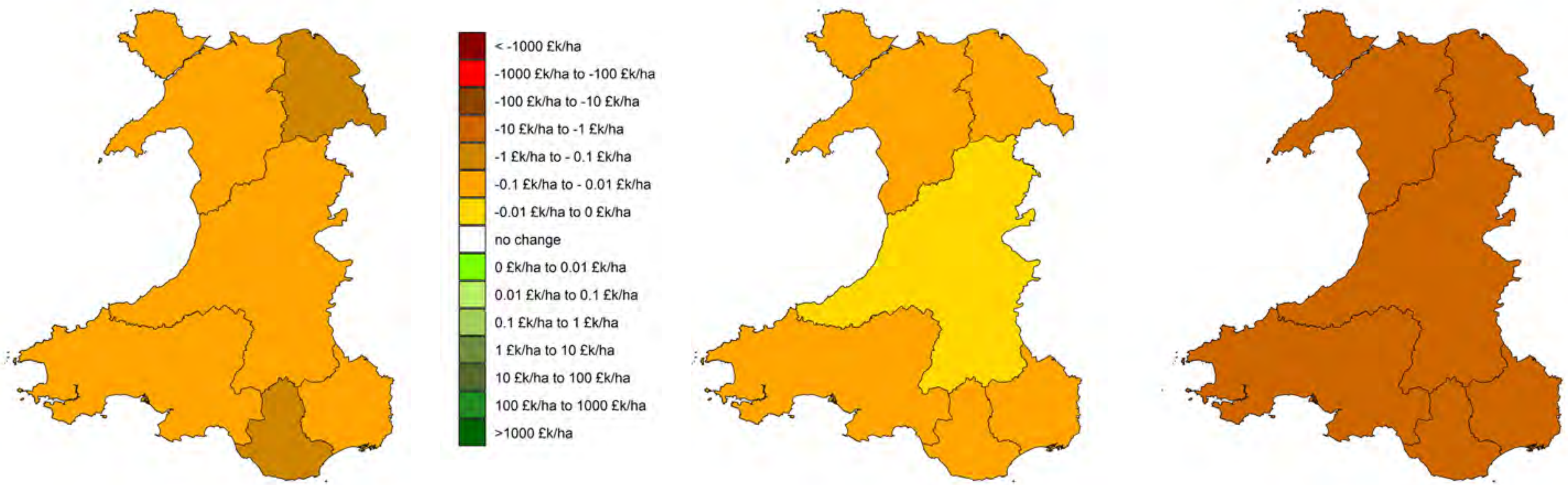
Spatial distribution of values (T2) (NRW regions)

Reduction in costs of air pollution

Value of change in status of freshwater bodies

Value of combined change in GHG and carbon balance



- The greatest per ha cost for the T2 scenario comes from carbon and GHGs due to increased agricultural emissions and some LULUCF losses (see next slide).

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Breakdown of values for Carbon and GHGs (T2) (NRW regions)

Value of change in agricultural GHG emissions

Value of change in wetland (peat) GHG emissions

Value of change in LULUCF carbon stock in vegetation and soils

- Costs are simulated for all regions in both increased agricultural emissions and LULUCF losses.
- Very small benefits for peatland GHGs are simulated in most regions, except for South West Wales, where small costs were simulated.

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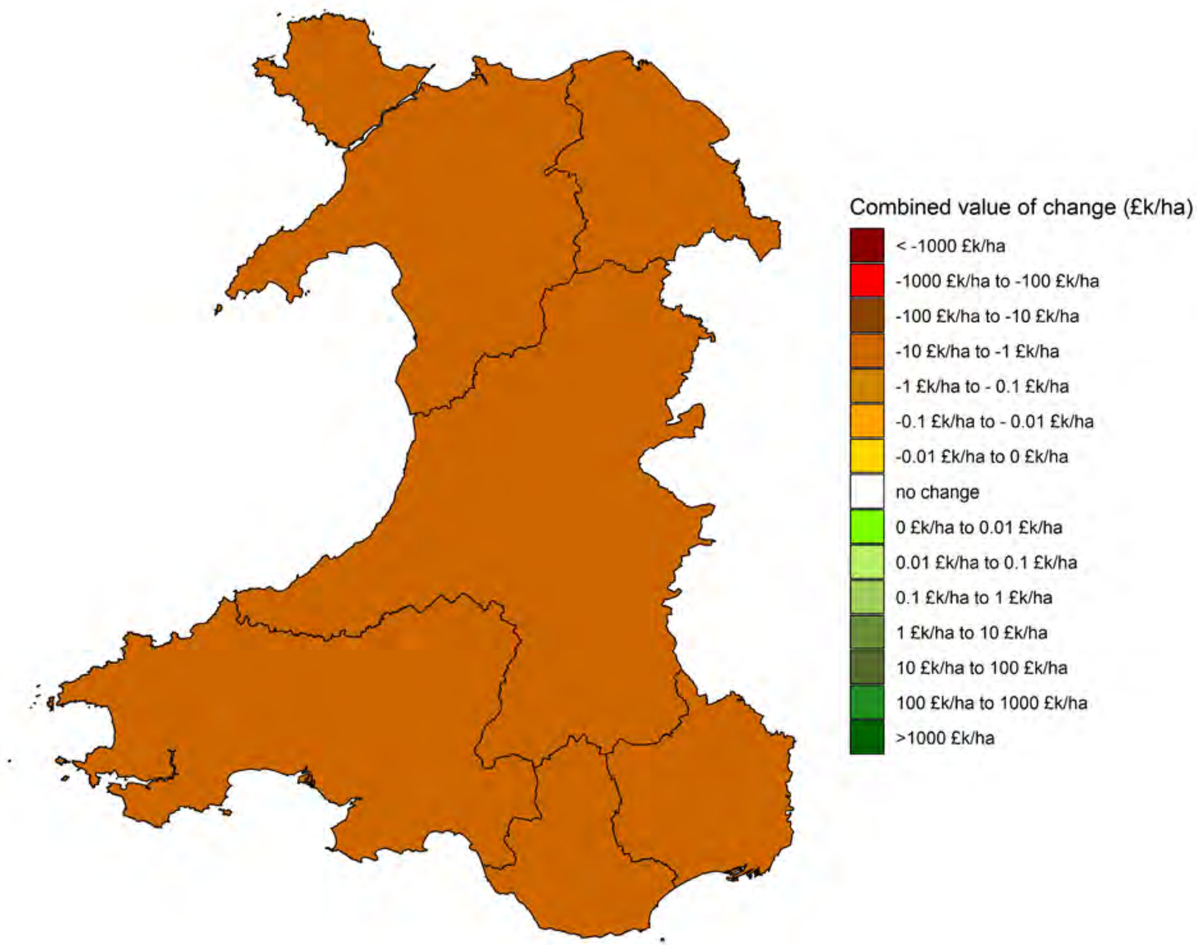
Sum of public goods values (T2) (NRW regions)

Sum of public goods values for all 3 benefits (air quality, water quality and carbon & GHG):



- Net costs are modelled for all regions, which are uniformly distributed when considered at this resolution.

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PART 5: Conclusion

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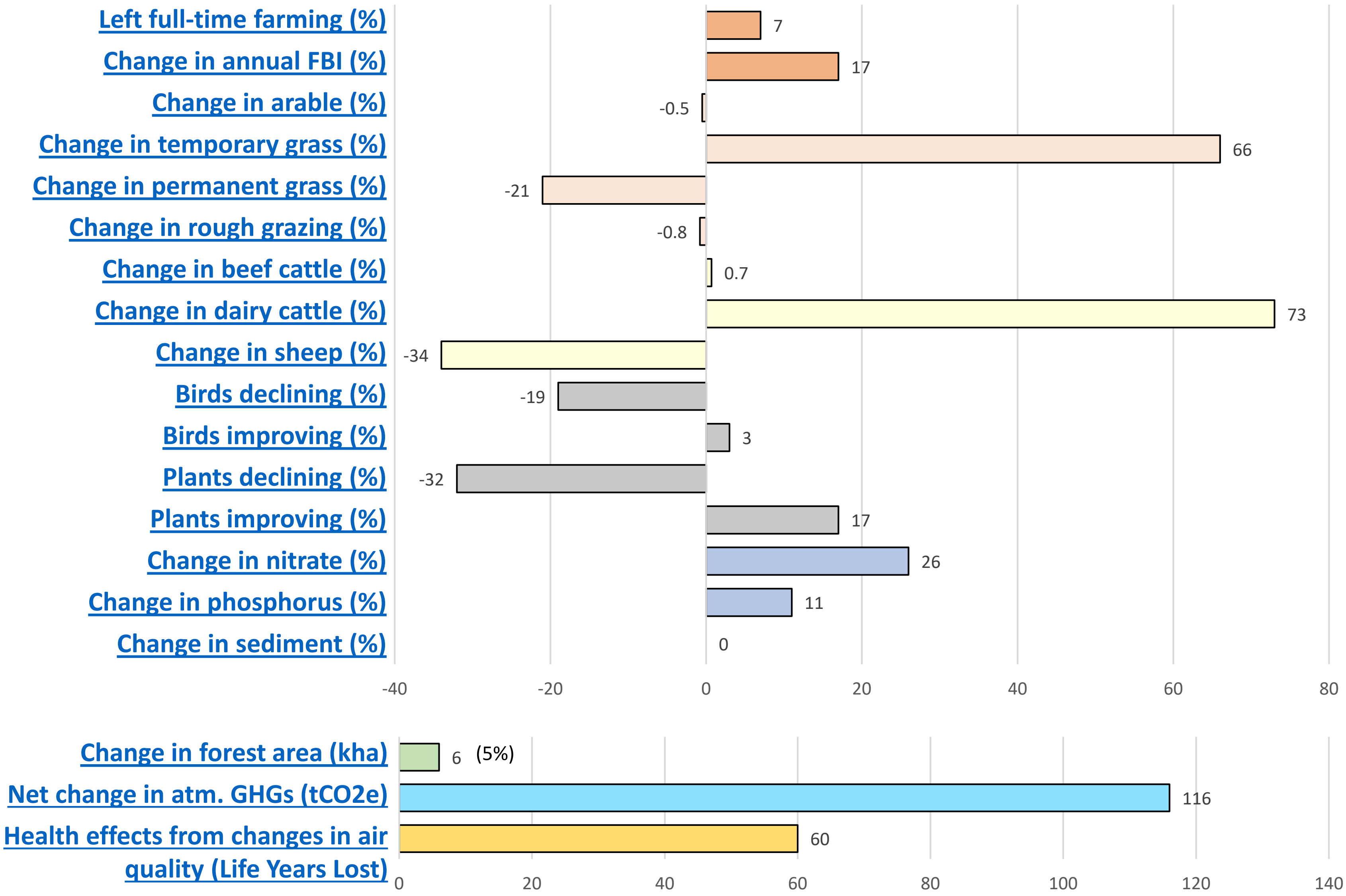
Summary of Impacts 1 (T2)



Summary of Impacts 2 (T2)

Impacts	Physical measure	Units	Present value, 75 yrs, £	Type of value
Agricultural Income	7%	Farms at risk of leaving full time agriculture	+43M	Total farm business income (per year
Air Quality	Increase of 60 years	Life Years Lost each year	- £ 85m	Reduction in costs of health impacts from air pollution
Water Quality	9% Deteriorate, 0.4% Improve	% of waterbodies with change in WFD status due to changes in N, P	- £ 33m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 117m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 8,074m	Benefit of reducing atmospheric GHG concentrations from non-traded sources
Biodiversity	19% Decline, 3% Improve	Bird species	N/A	Percentage of species with significant increase or decrease
	32% Decline, 17% Improve	Plant species	N/A	Percentage of groups with significant increase or decrease

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Final Considerations

- This slide pack shows results from applying the Integrated Modelling Platform to one (out of six) trade scenarios.
- The scenarios were provided by Welsh Government based on a series of internal and external workshops as changes in farm gate (output) prices and input costs.
- All scenarios were applied to a baseline that includes CAP Pillar 1 payments.
- The economic accounts presented are partial and based solely on the components explicitly mentioned. Other significant aspects (e.g. recreation) are not valued here.
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses.
- The IMP is applied to only full-time farms (> 1 FTE labour).
- A farm that is categorised as under pressure is based on being unable to achieve a full-time annual FBI of £6,000. As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.
- The IMP has been developed following Aqua book guidelines. All the assumptions underlying the IMP are fully documented and have been signed-off by Welsh Government.

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PART 6: Glossary and Context

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Glossary: Key Acronyms (I)

- FAPRI: Food and Agricultural Policy Research Institute
  - FAPRI-UK Model was used to underpin assessments of the impacts of Brexit on the UK agricultural sector. More information: (Web-link)
  - Macro-economic model of the UK in a global context. Used to identify impacts of global trade. The FAPRI-UK model (created and maintained by staff in AFBI-Economics) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with submodels covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) model run by FAPRI at the University of Missouri.
- MFTA: Multi-lateral free trade agreement
  - Free trade agreement between three or more countries without discrimination between those involved.

Glossary: Key Acronyms (II)

- LULUCF: Land use, land-use change, and forestry
  - Standardised approach to the greenhouse gas inventory that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.
  - Used in this project to quantify impacts of land use change on carbon.
- MFN: Most Favoured Nation
  - World Trade Organisation (WTO) terminology. Under the WTO agreements, countries cannot normally discriminate between their trading partners. As such countries must treat all other WTO members as they would their "Most Favoured Nation". More information: (Web-link)
  - Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

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Glossary: Key Acronyms (III)

- WFD: Water Framework Directive
  - EU directive targeted at improving water quality and integrated catchment management.
- UKTAG: UK Technical Advisory Group (on the WFD)
  - The UKTAG is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies.
- LFA: Less-favoured area
  - Term used to describe an area with natural handicaps (lack of water, climate, short crop season and tendencies of depopulation), or that is mountainous or hilly, as defined by its altitude and slope.
- SDA / DA: Severely Disadvantaged Areas / Disadvantaged Areas
  - Sub-classes of LFA separating out the most severely disadvantaged areas for the purposes of basic payment scheme (BPS) grant payments.

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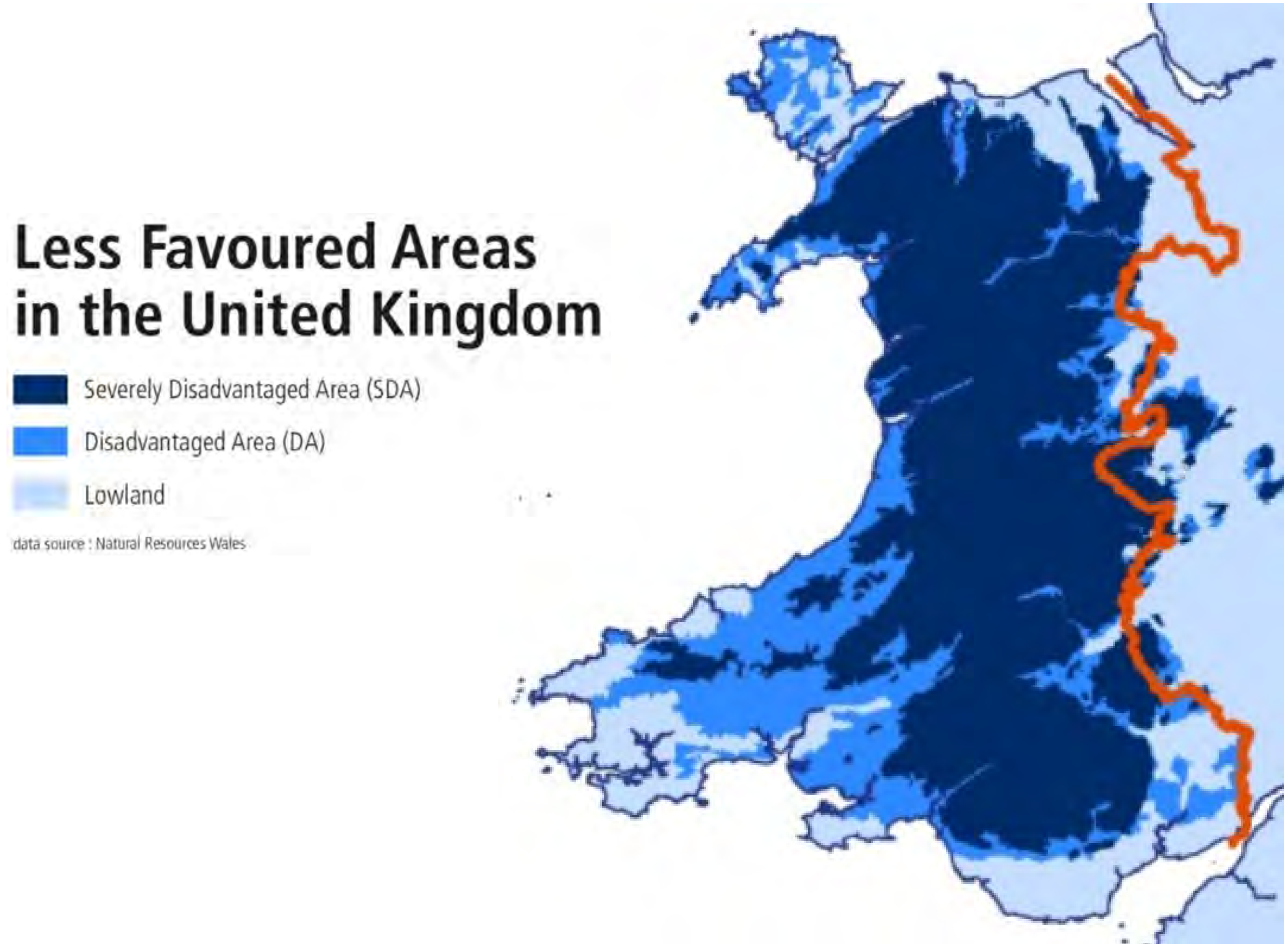
Severely Disadvantaged Areas/ Disadvantaged Areas in Wales



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Glossary: Key Acronyms (IV)

- RFT : Robust Farm Type
  - Robust farm type (used in previous Welsh Farm Practice Surveys).
  - Classes: Cereals; General Cropping; Horticulture; Specialist Pigs; Dairy; LFA Grazing Livestock; Lowland Grazing Livestock and Mixed.
- EFT: ERAMMP Farm Type
  - ERAMMP farm type (used within the IMP) is based on the RFT with additional detail on less favoured areas.
  - Classes: Cereals, General cropping, Dairy, Lowland cattle / sheep, Mixed , Specialist Sheep (SDA), Specialist Beef (SDA), DA various grazing, SDA mixed grazing .
- SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation: Names and acronyms for models within the IMP (see slide 79)

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Glossary: Key Acronyms (V)

- ERAMMP – Environment and Rural Affairs Mapping and Modelling Project.
  - Consortium Project led by the UK Centre for Ecology & Hydrology (UKCEH) and funded by the Welsh Government (WG).
  - Consortium members involved in these slide packs include Cranfield University, ADAS, the British Trust for Ornithology (BTO), eftec, Forest Research (FR) and UKCEH.
- IMP – Integrated Modelling Platform
  - The modelling platform used to produce the results shown in this slide pack. The platform combines the following models which pass data to one another as large multi-parameter data cubes:
    - SFARMOD: Whole farm model
    - ESC: Tree species suitability
    - CARBINE: Forest products, carbon and forest net present value
    - LAM: Land allocation model
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - Woodland habitat connectivity model
    - Ecosystem service models for carbon and water quality
    - EMEP4UK Emulator: health impacts of air pollution
    - Valuation: monetary and non-monetary valuation of public goods

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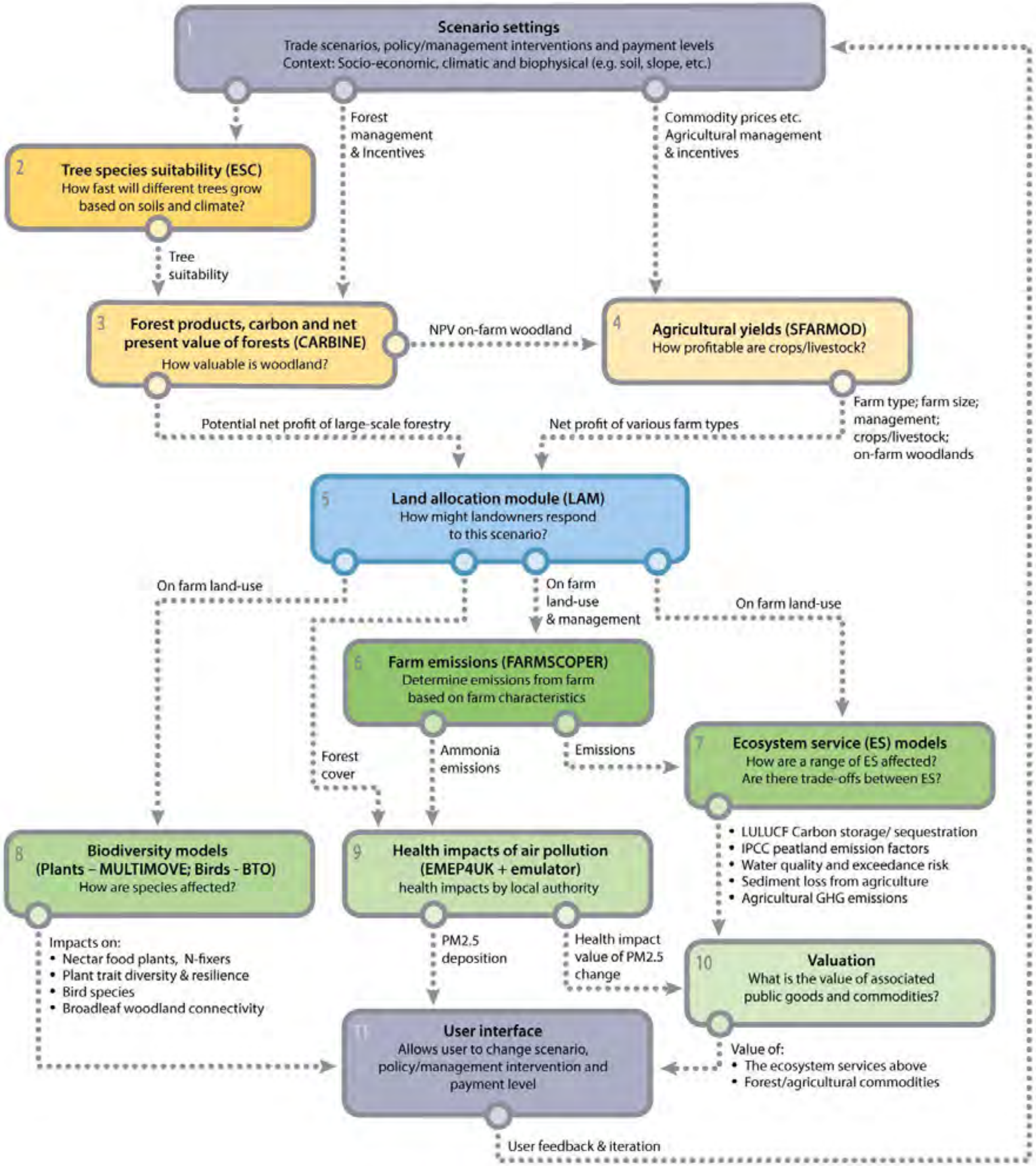
Integrated Modelling Platform schematic



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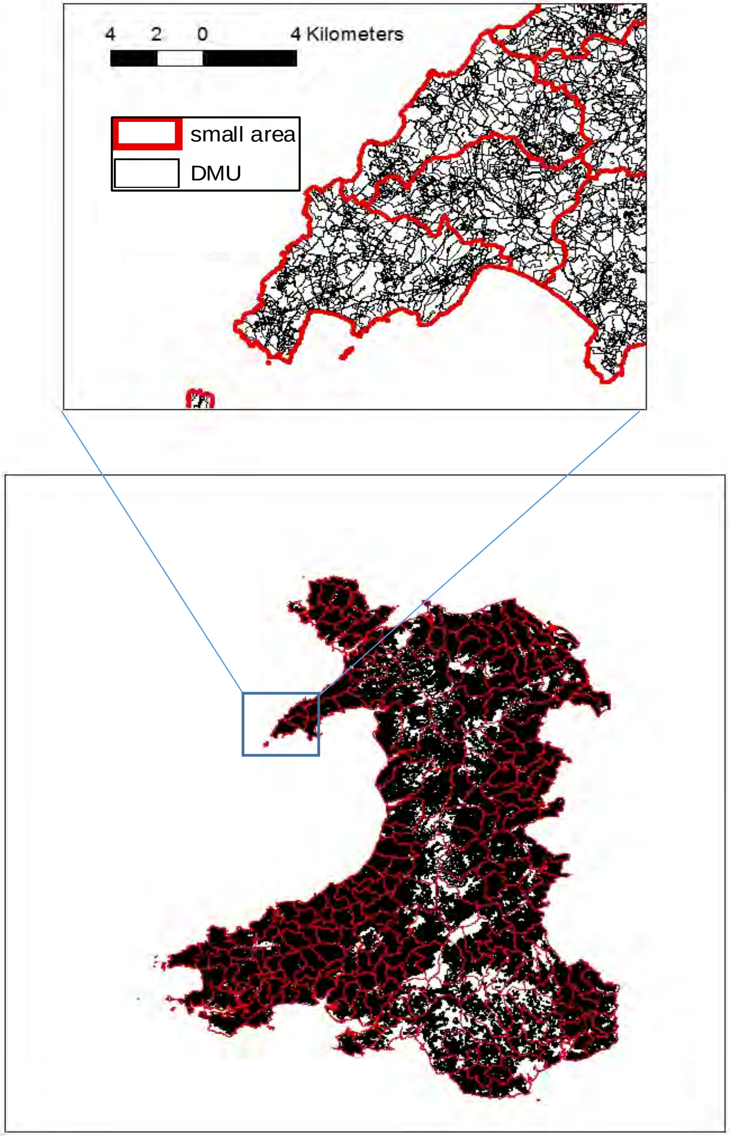
IMP modelling scales



- The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
- The finest spatial resolution used by Sfarmod and the Land Allocation Module (LAM) for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
- A DMU is defined as a managerially homogenous cluster of soil type, rainfall and land cover.
- Results in the slide pack are aggregated to small agricultural areas as findings are more robust at this level.

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3: ERAMMP_IMP_LandUseScenarios_T3_Slidepack

Funded by:

Llywodraeth Cymru
Welsh Government

Canolfan Ecoleg a Hydroleg y DU
UK Centre for Ecology & Hydrology

INTEGRATED MODELLING PLATFORM

Land Use Scenarios (T3)

UK Centre for Ecology & Hydrology

Cranfield University

ADAS

Forest Research

eftec

BTO

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Scenario description (T3)

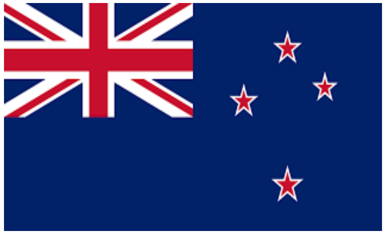
- Free trade agreements with EU, USA, Australia and New Zealand.
- WG held a stakeholder workshop to discuss and quantify changes in farm-gate prices from current figures for milk, lamb and beef:
  - Increase for milk due to increased home consumption, but held back by competition from traded commodities (butter/cheese) from the FTAs
  - Beef and lamb come under pressure from both Aus and NZ, and beef from USA.
- Scenario settings:

	Milk (p/litre)	Beef (£/kg LWT)	Lamb (£/kg LWT)
Baseline (2015)	35	1.85	1.68
T3	**36.8**	**1.48**	**1.43**

EU


USA


AUS


NZ


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PART 1: Agriculture

Background information

	No.	Area (ha)
Full-time	7726	1010891
Spare / Part-time	12738	409150
Total	**20464**	**1420041**

The agricultural models are applied to all full-time farms

Farm Business Income classes within T3:

As baseline farm type	As alternative farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture
<£6000 p.a.	>£6000 p.a.	Farm under pressure	Likely to change farm type through sale to another enterprise
£6K-£13K	Any ammount	Farms staying the same	Able to continue but unlikely to be able to change farm type
>£13000	<£13K +FBI uplift+finance	Farms staying the same	Insufficient economic incentive to change farm type
>£13000	>=£13K +FBI uplift+finance	Farms changes type	Likely to be sufficient economic incentive to change farm type

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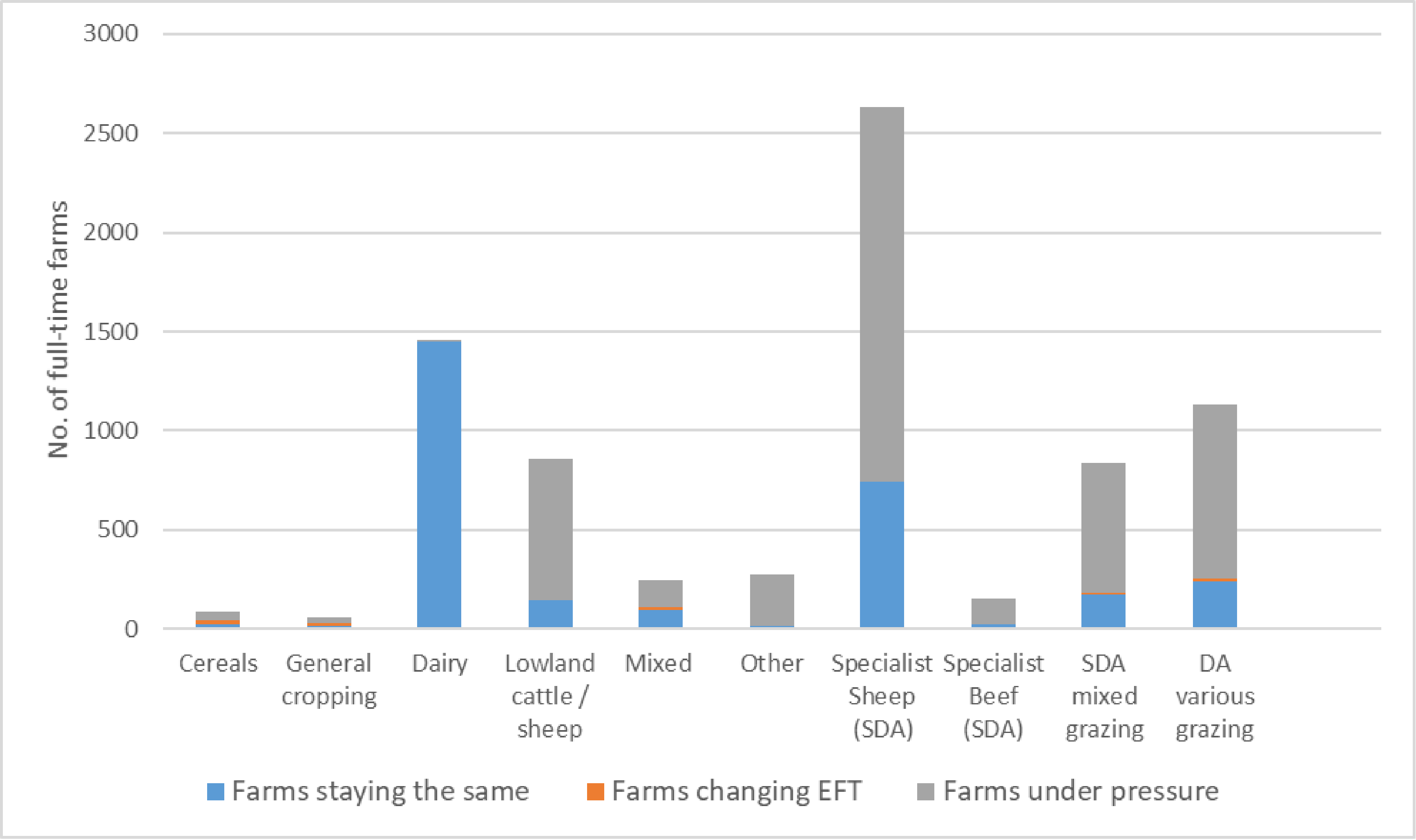
Simulated status of current full-time farms under T3



Baseline number of simulated full-time farms: 7726

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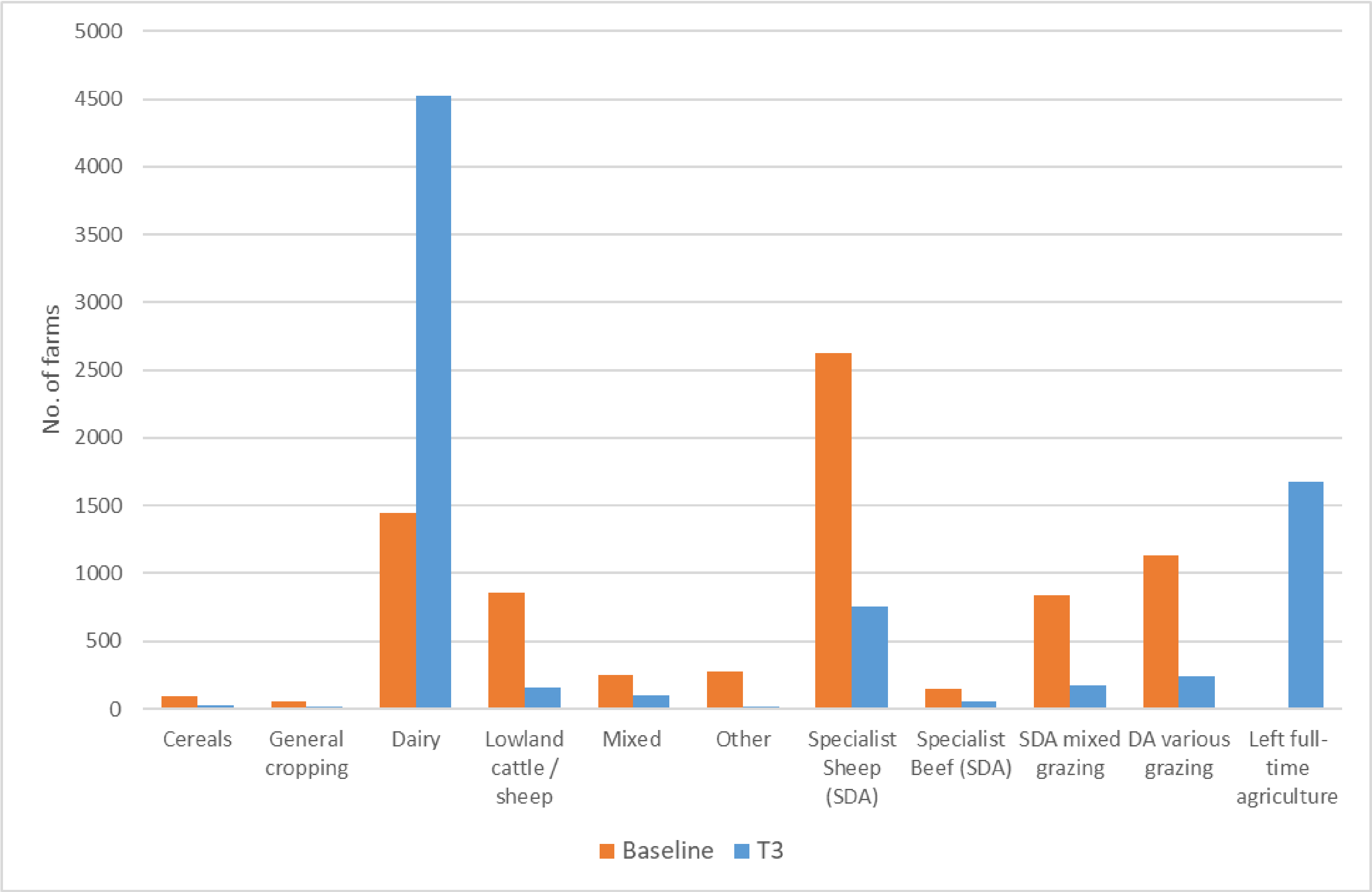
Farm numbers by farm-type (Baseline vs T3)



Total number of simulated full-time farms: 7726 in Baseline; 6052 in T3

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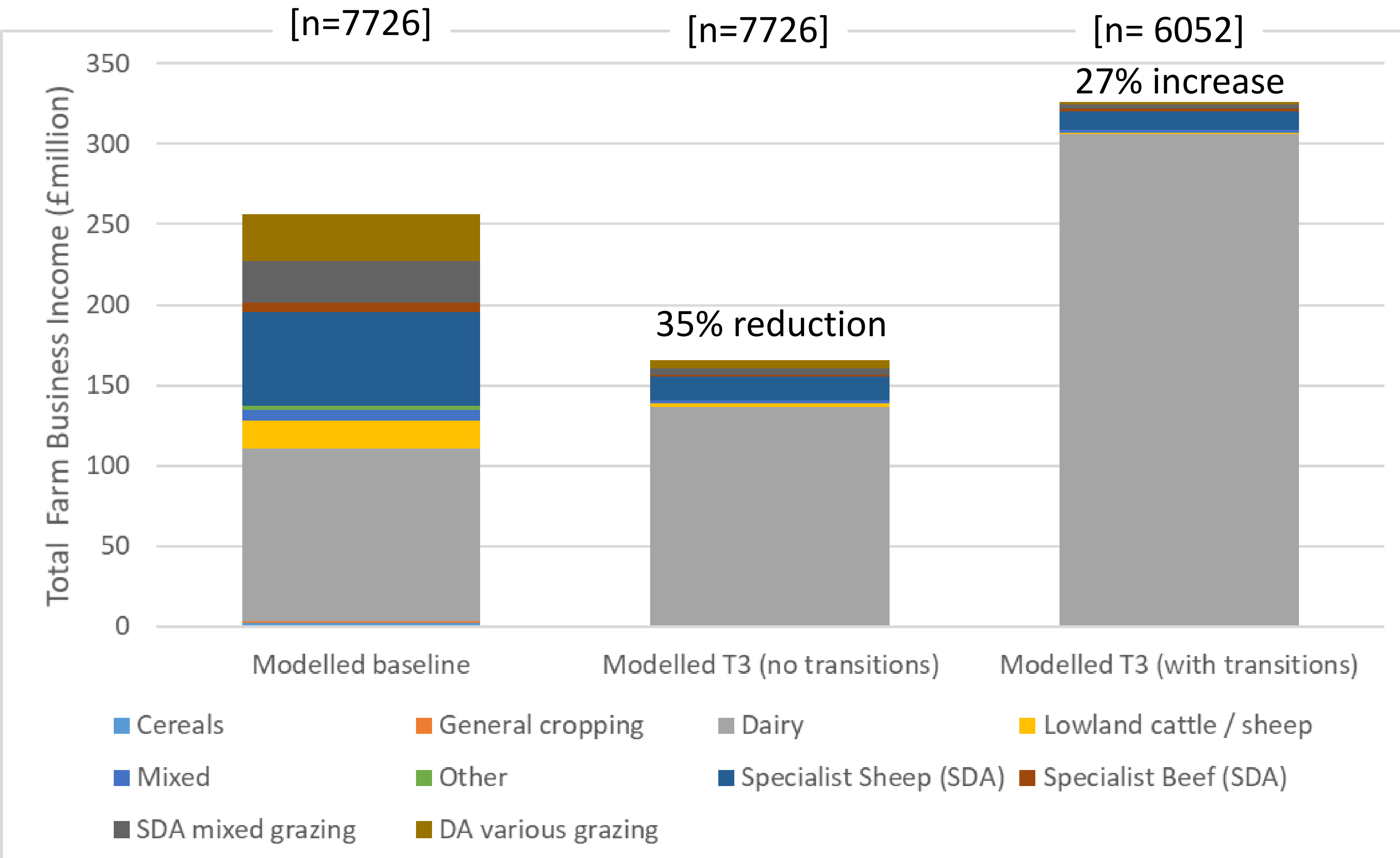
Total simulated Farm Business Income from full-time farms (T3)



Total number of simulated full-time farms: 7726 in Baseline; 6052 in T3

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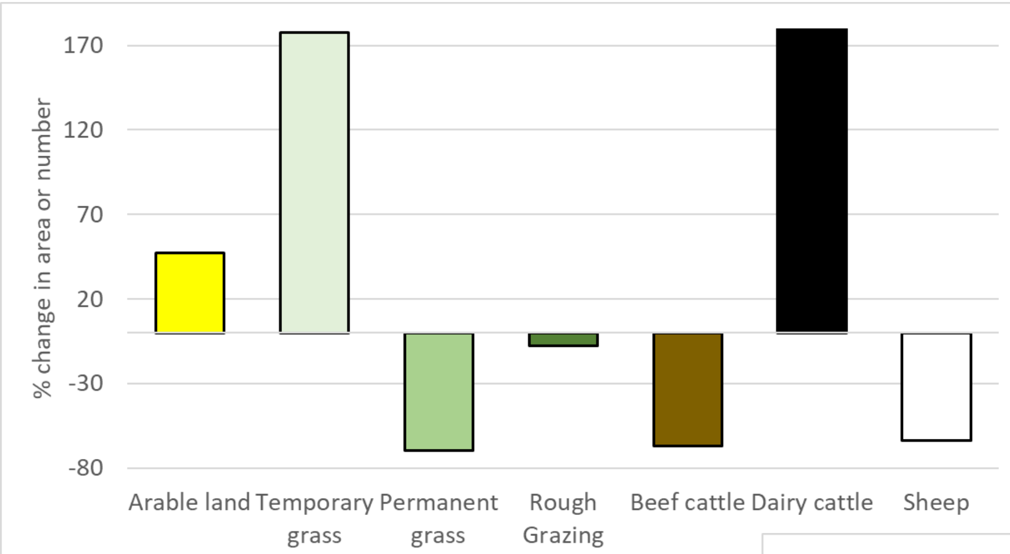
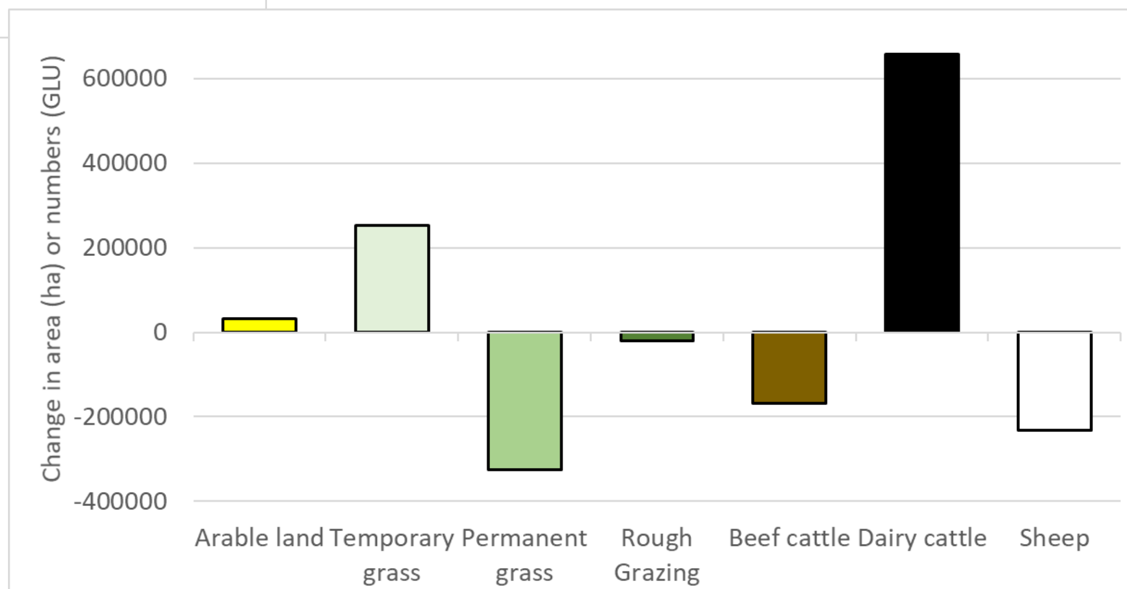
Change in simulated managed land use and stock (T3)



Percentage change (relative to simulated baseline)

Absolute change in simulated areas (ha) and numbers (Grazing Livestock Units)



Simulated farms remaining in full-time agriculture: 6052

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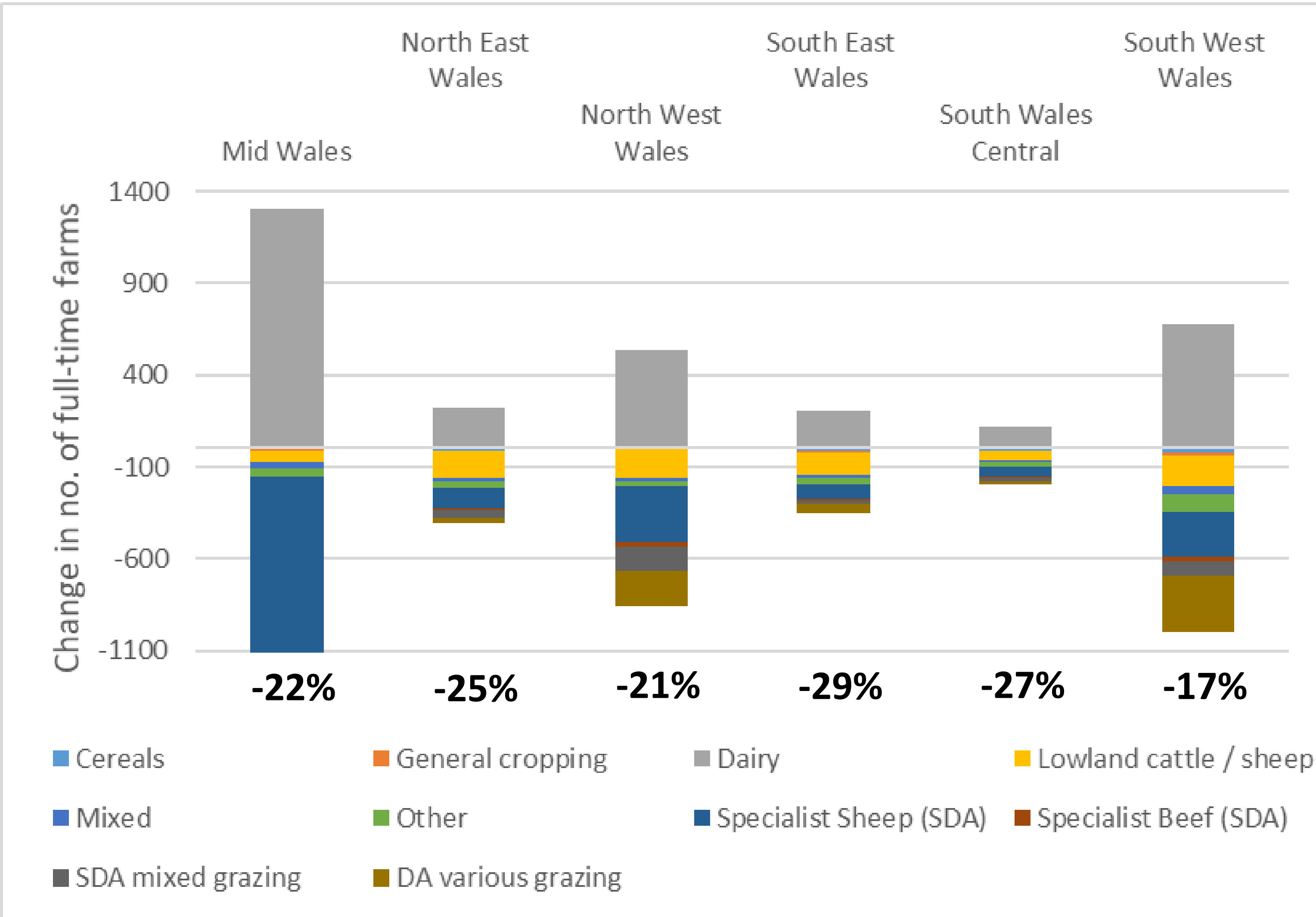
Change in farm numbers by farm-type (T3)



Simulated farms remaining in full-time agriculture: 6052

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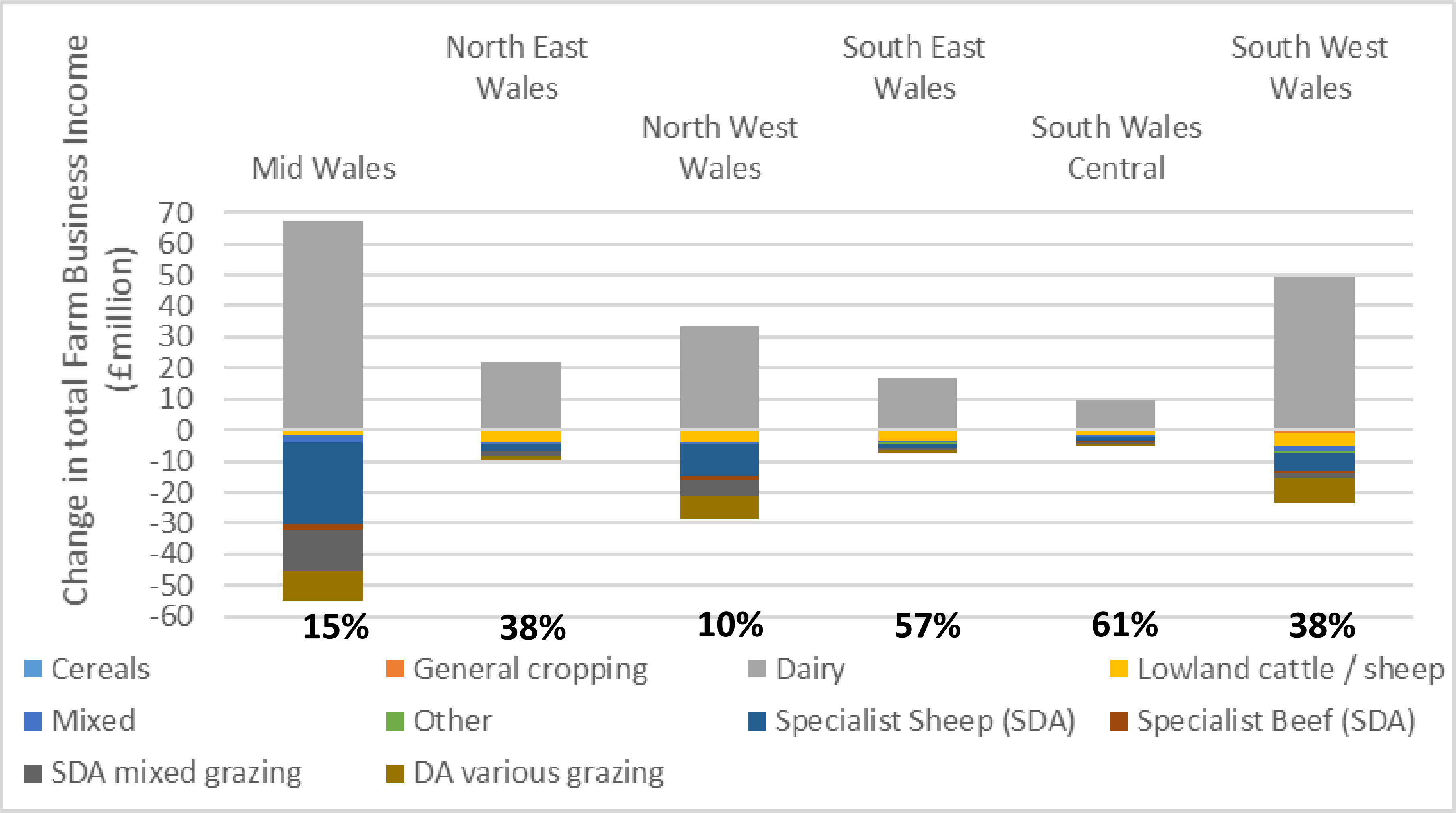
Change in total simulated Farm Business Income from remaining full-time farms (T3)



Simulated number remaining in full-time agriculture: 6052

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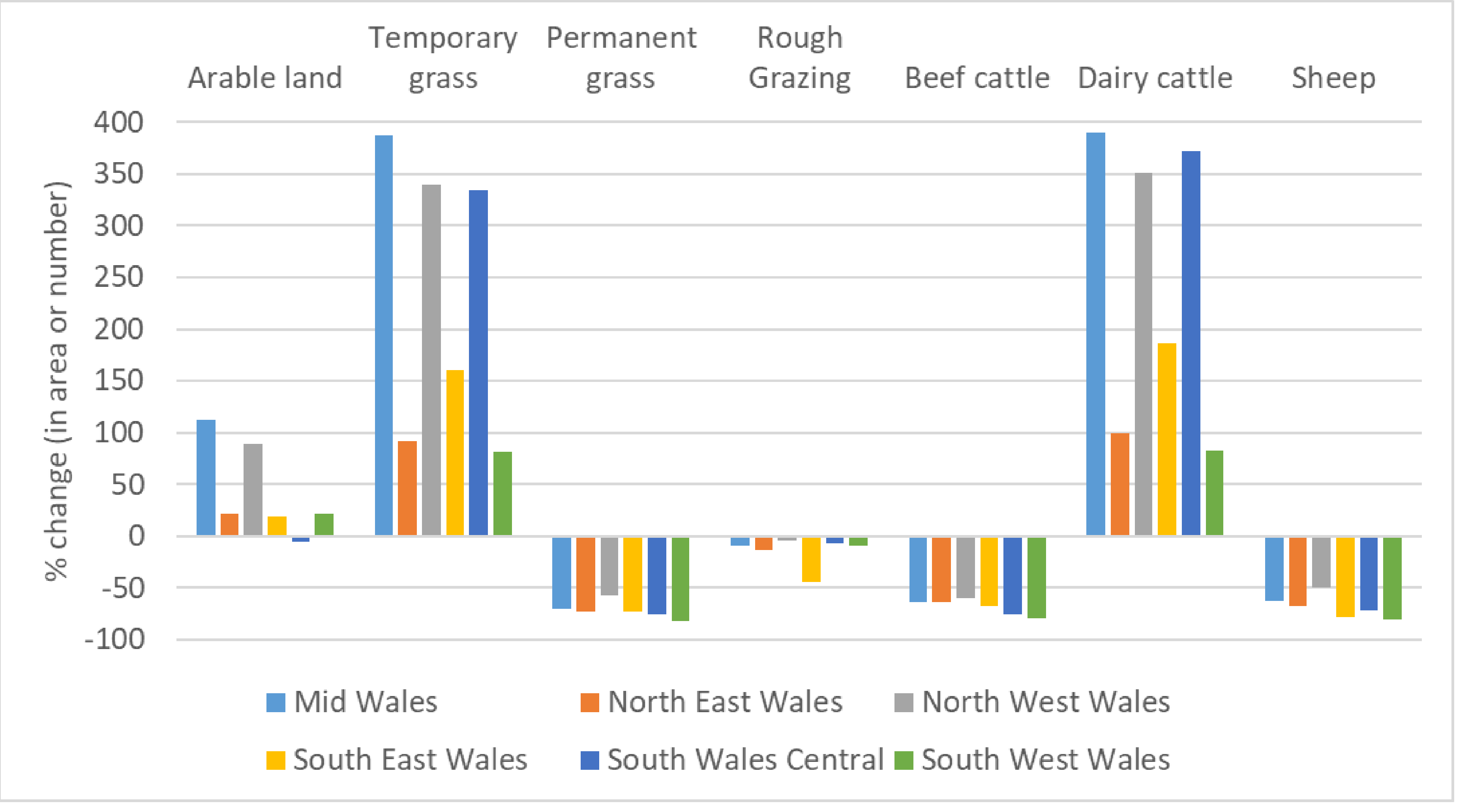
Regional change in land use and livestock (T3)



Simulated number remaining in full-time agriculture: 6052

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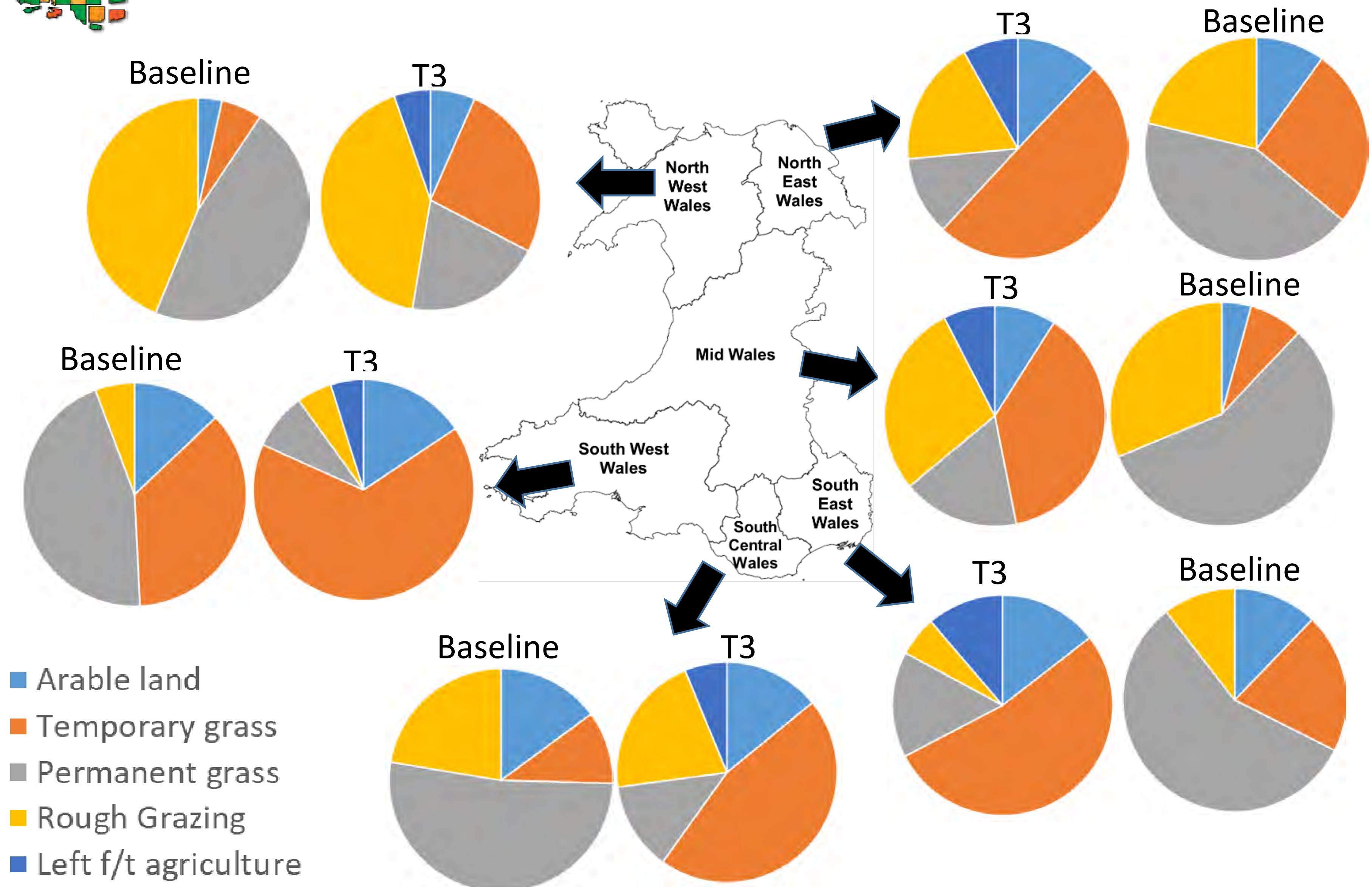
Regional land use proportions in T3



Simulated number remaining in full-time agriculture: 6052

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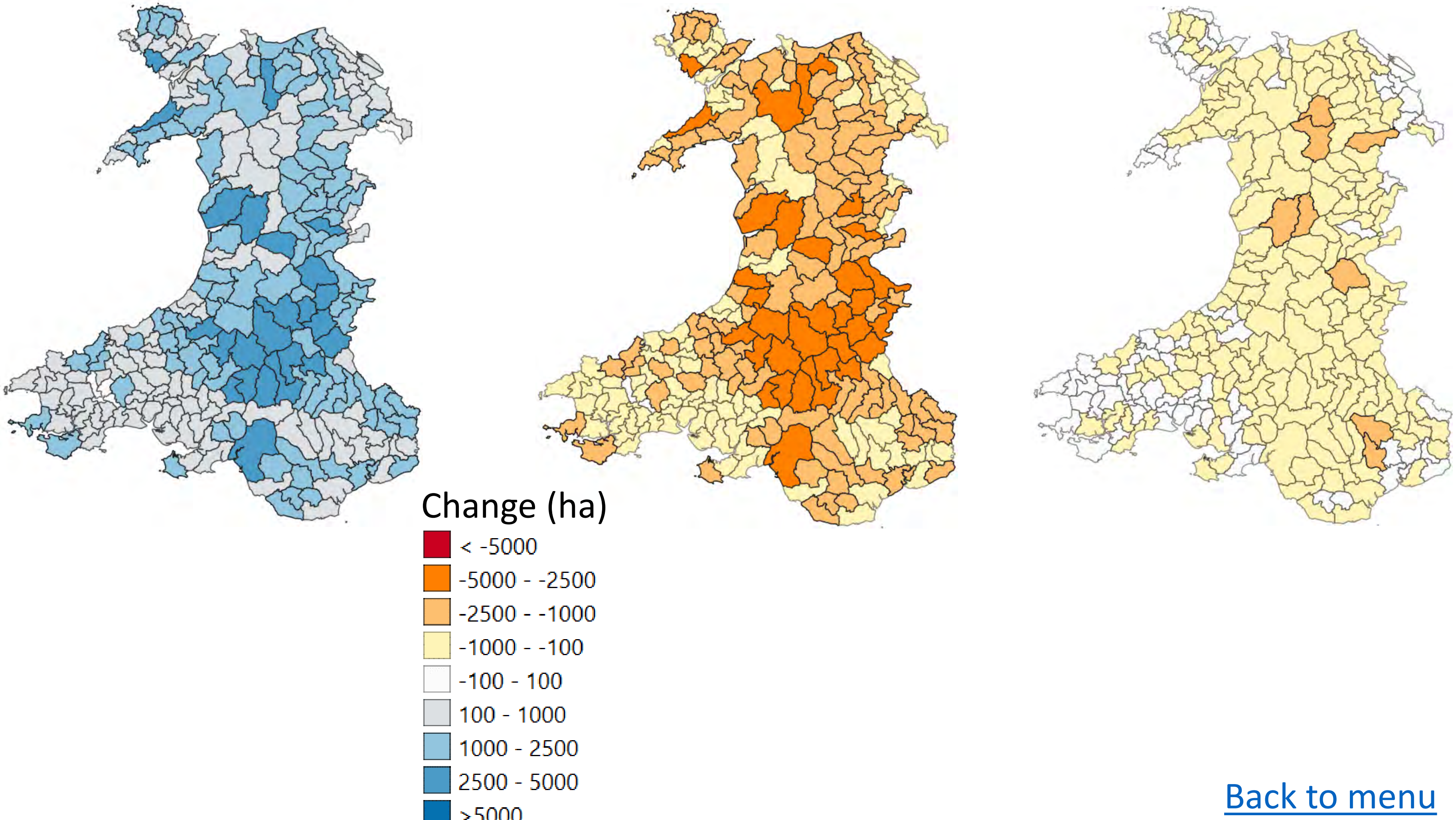
Simulated change in land use (T3)

Change in cultivated / temporary grassland

Change in permanent grassland

Change in agricultural area



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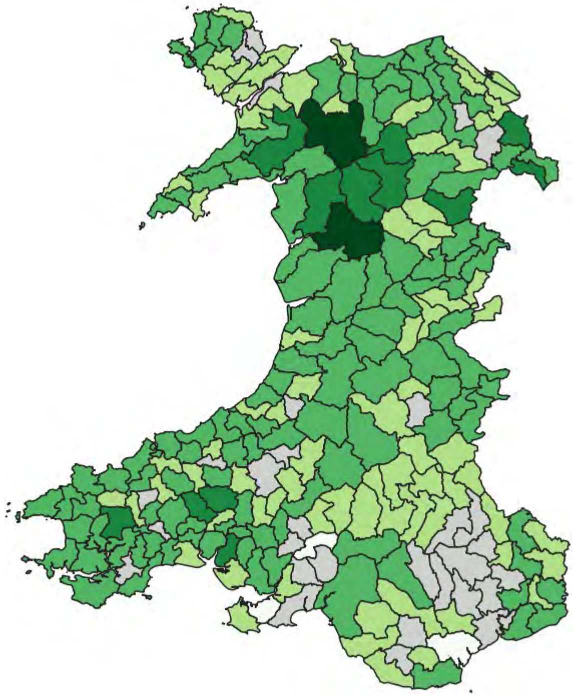
Simulated status of current full-time farms under T3

Farms staying the same

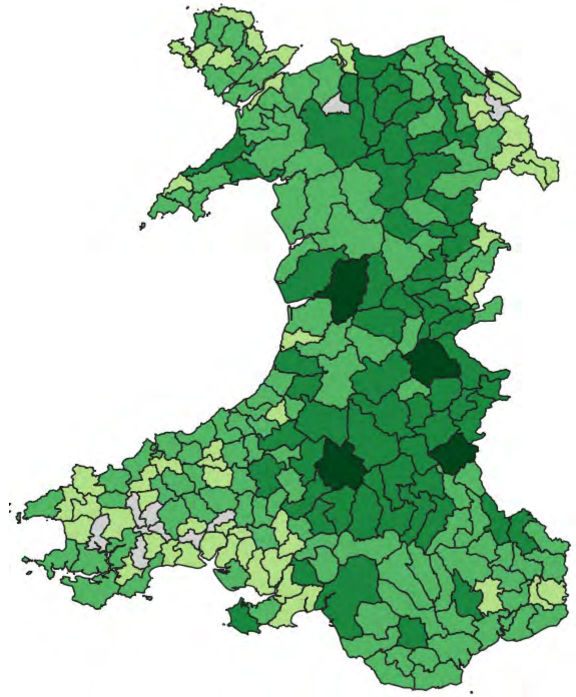


n=2916

Farms changing type

n=69

Farms under pressure



n=4741

- 0
- 1 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- > 50

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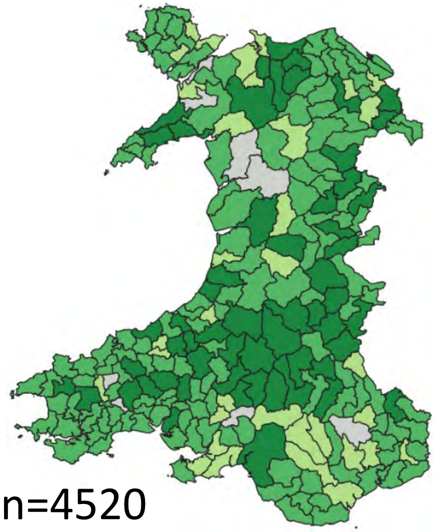
Simulated farm type numbers under T3

Dairy specialists

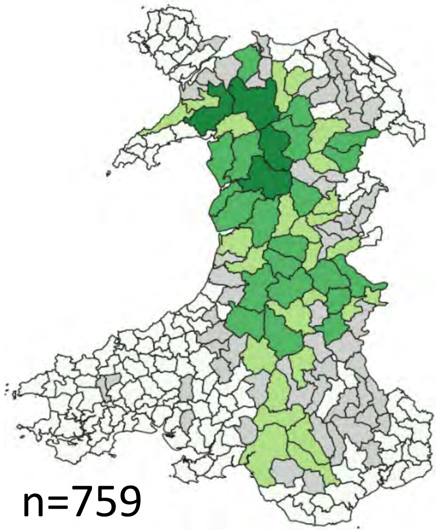


n=4520

Beef specialists

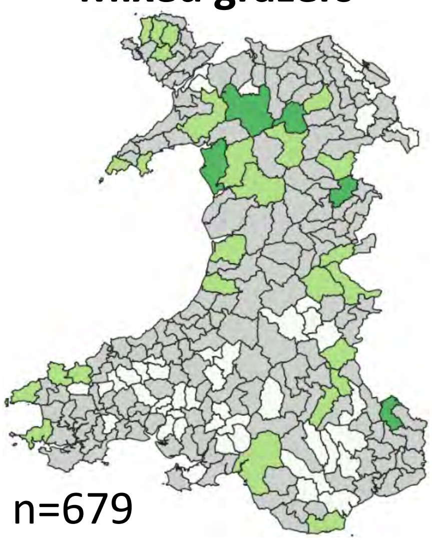
n=51

Sheep specialists



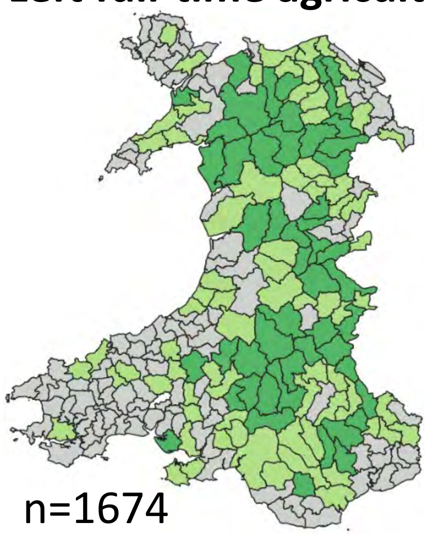
n=759

Mixed grazers



n=679

Left full-time agriculture



n=1674

- 0
- 1 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- > 50

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Farms leaving full-time agriculture

Farm Business Income classes within T3:

As Baseline Farm type	As alternative Farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture

A farm that is unable to achieve a full-time annual FBI of £6,000 may:

- Implement cost savings and struggle on;
- Transition to part-time farming, to enable increased non-agricultural income though diversification and / or off-farm employment;
- Leave agriculture in the short-term;
- Leave agriculture in the longer-term (e.g. due to retirement / inter-generational change).

As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.

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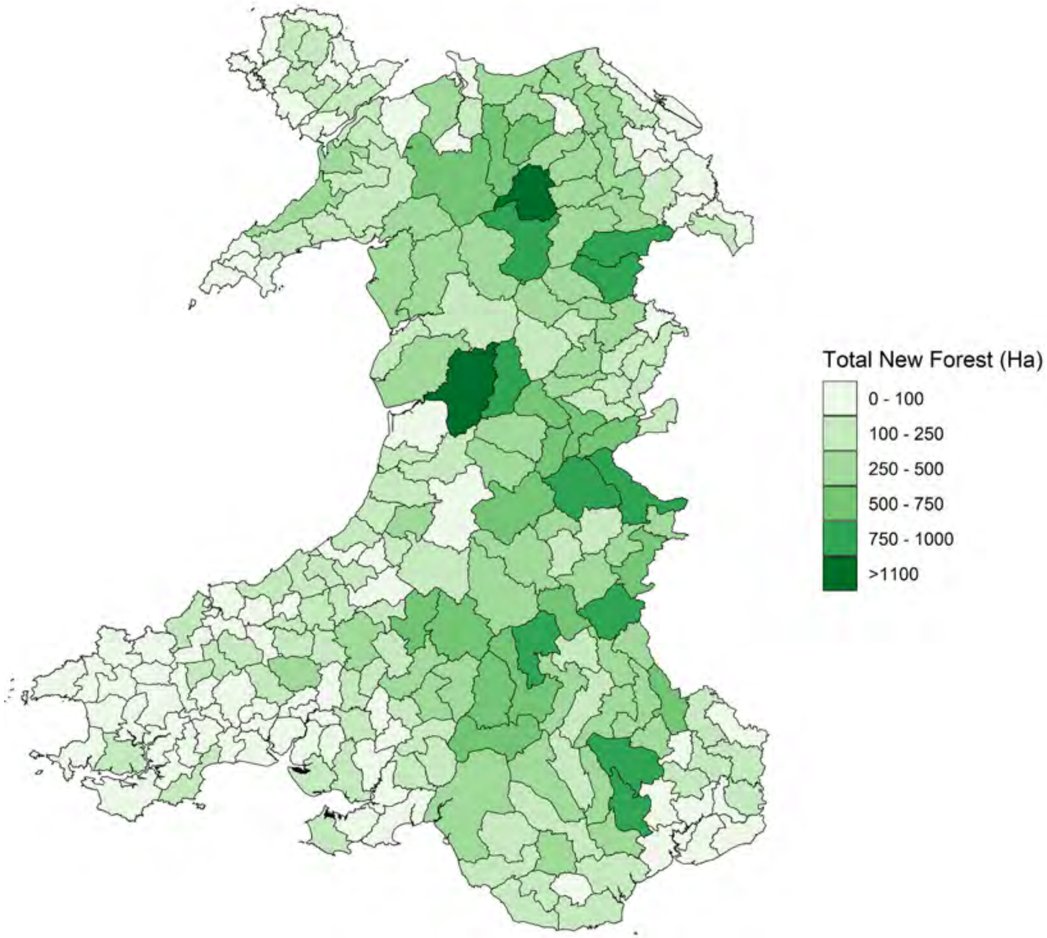
Simulated new woodland on farms leaving full-time agriculture (T3)



Total area of new forest: 53,995 ha
(32% increase for modelled >1 FTE farms)

- Total new forest area (ha) from afforestation and natural regeneration.
- Totals largely driven by afforestation: 41,045 ha.
- Afforestation will only occur on abandoned land that will generate a positive net present value (NPV) from forestry.

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PART 2: Biodiversity

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Biodiversity summary – Birds (T3)

- Increases and decreases in bird population sizes are an inevitable consequence of changes in land use.
- By **2050**, under the T3 scenario, increases in the cover of maize, rotational grass and coniferous woodland are simulated.
- Overall, a greater number of species are simulated to decline in the T3 scenario than increase in population size.
- Woodland species are simulated to perform better under this scenario, with declines more common in farmland and generalist species.
- Local changes are fairly patchy, with the greatest impacts found in the East and Mid-Wales.

Eaton, Mark, et al. "Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man." British Birds 108.12 (2015): 708-746.

Bladwell et al. "The state of birds in Wales 2018." (2018). The RSPB, BTO, NRW and WOS. RSPB Cymru, Cardiff

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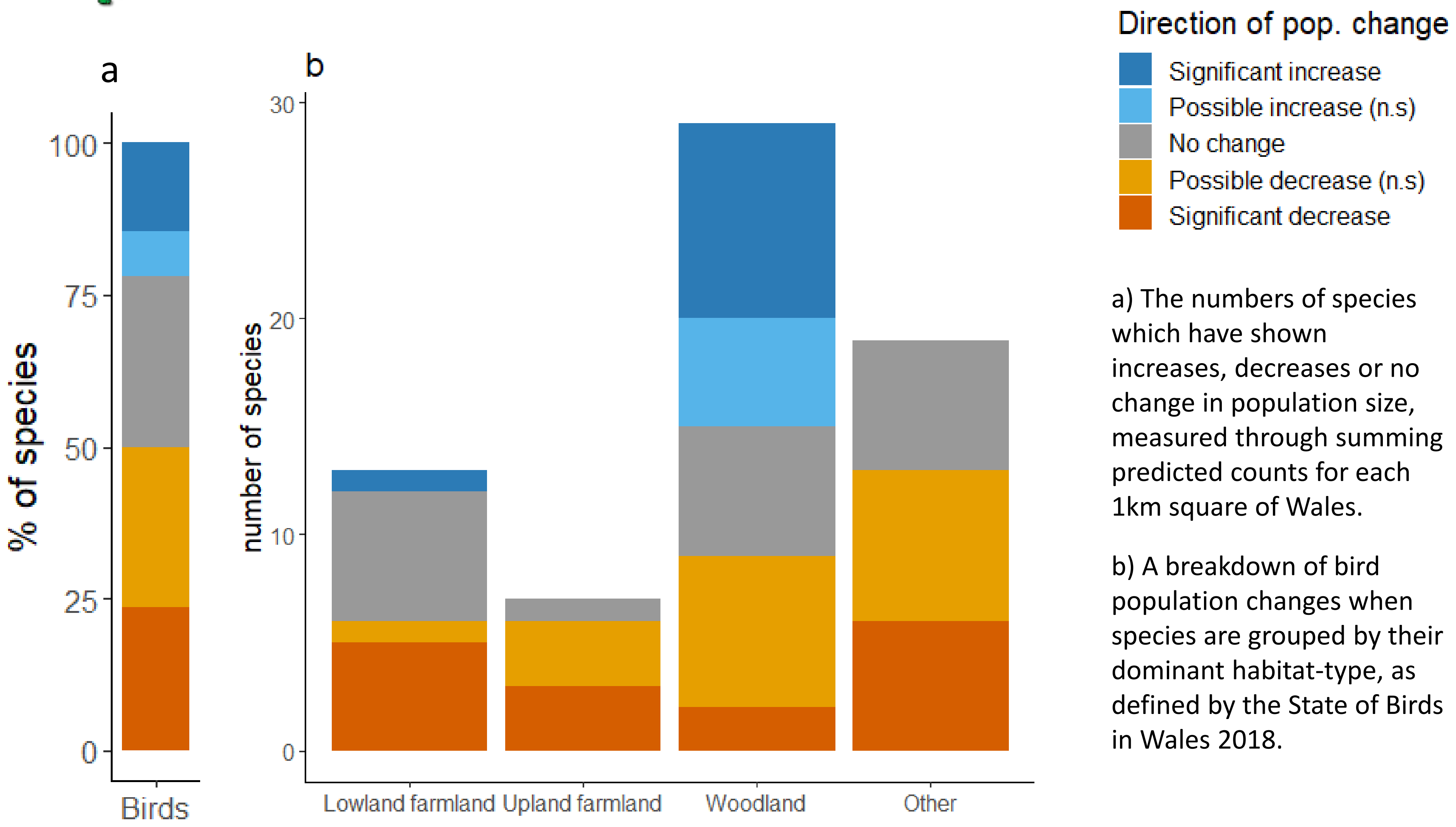
Overall bird population change in T3



a) The numbers of species which have shown increases, decreases or no change in population size, measured through summing predicted counts for each 1km square of Wales.

b) A breakdown of bird population changes when species are grouped by their dominant habitat-type, as defined by the State of Birds in Wales 2018.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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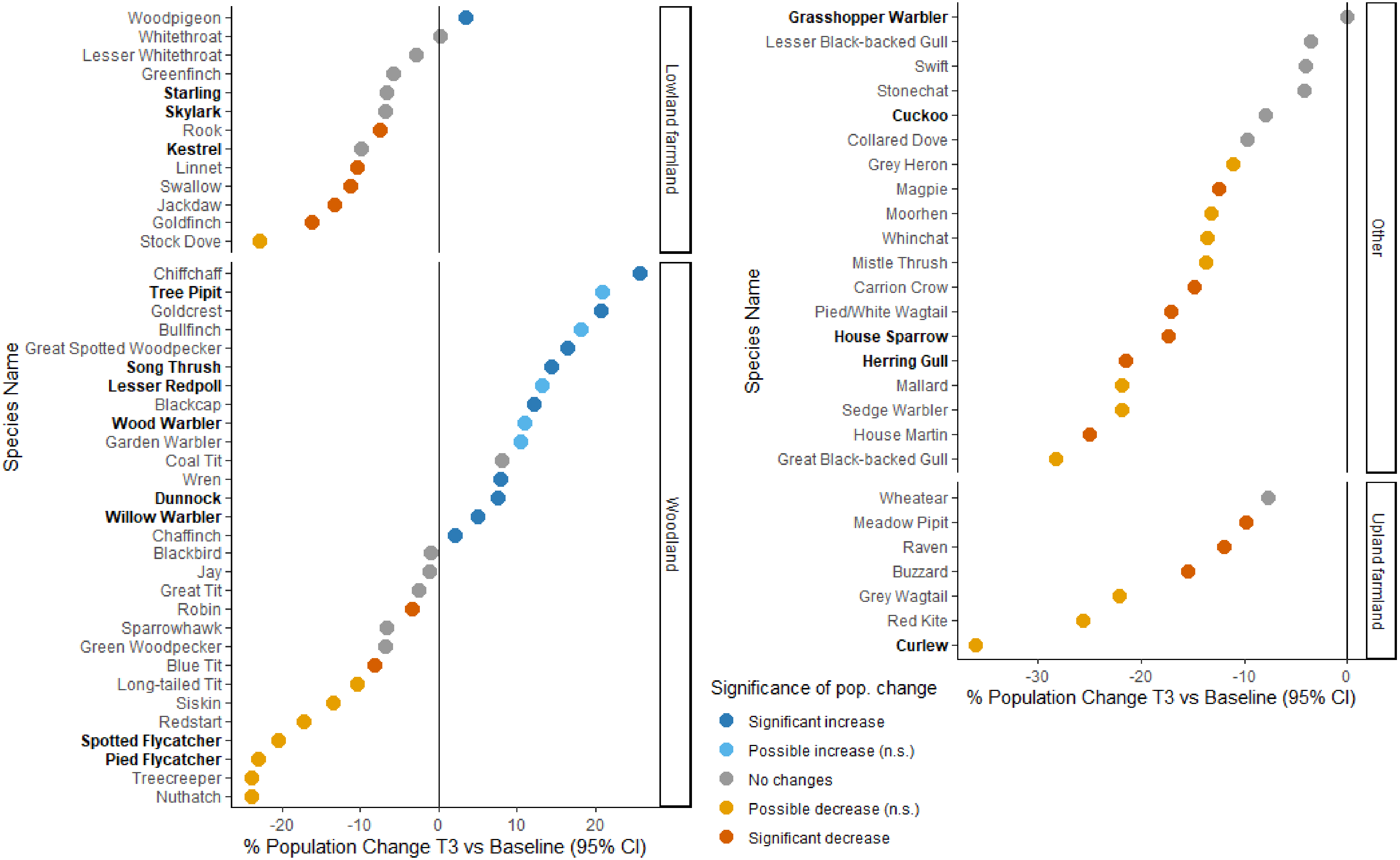
Population changes per bird species in T3



- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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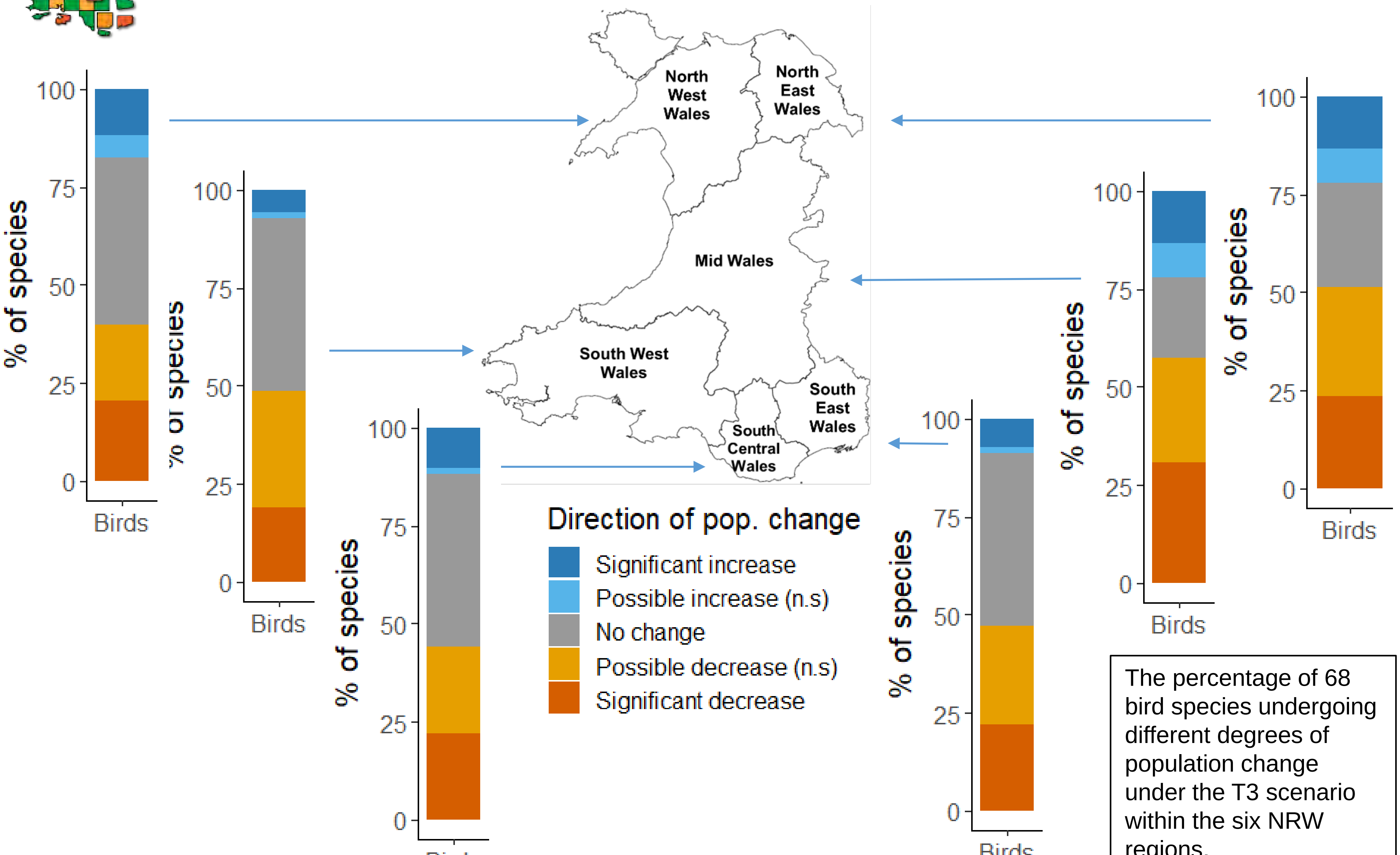
Regional bird population impacts in T3



The percentage of 68 bird species undergoing different degrees of population change under the T3 scenario within the six NRW regions.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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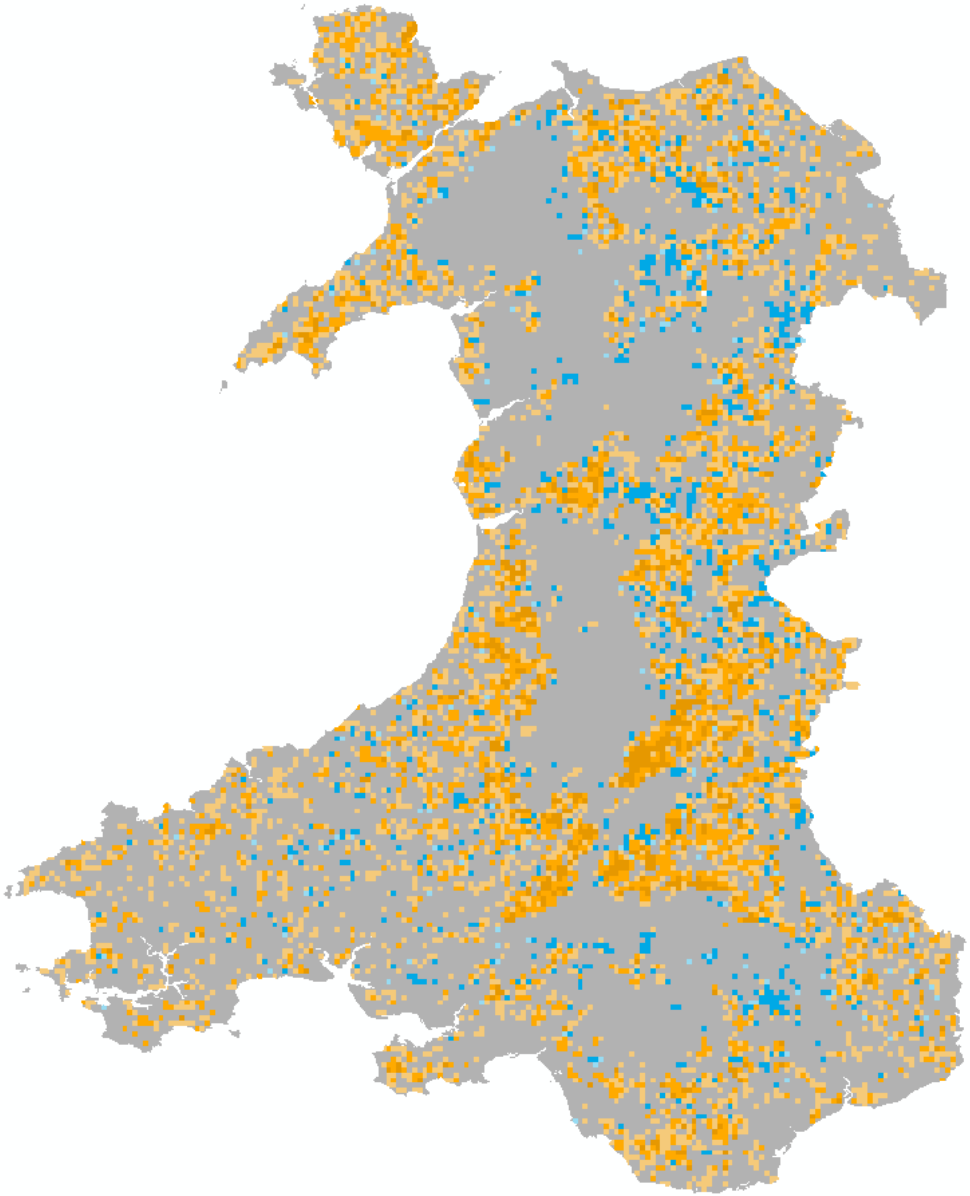
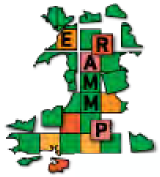
Local bird species change in T3





Ratio of species change

- +3 to +18
- +1 to +2
- 0
- -1 to -8
- -9 to -20
- -20 or greater

The ratio of 68 bird species undergoing significant increases *vs* decreases for each 1km square of Wales. Bolder colours are indicative of greater change. Note that under this metric, any square seeing large, but equal numbers of increases and decreases will be represented by grey colouration, identical to that of a square seeing no changes.

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Biodiversity summary – Plants (T3)

- Overall, simulated shifts between agricultural sectors appear to be intermediate between T1 and T2. The shift is toward temporary grass and dairy and away from sheep and permanent grass; on balance an intensification trajectory but accompanied by potential movement out of agriculture in the SDA areas indicating a shift in land use to new forestry and natural succession but where the size of this shift is not as great, in terms of area, as T1.
- The results is a degree of polarisation. Woodland and semi-natural habitat specialists are simulated to increase if shade-tolerant, while grassland, wetland and heathland specialists see reduced suitable niche space in areas that shift from permanent to more intensive temporary grassland. These patterns are broadly similar across all regions, except for South Central Wales very little change is estimated across all three groups.
- Summary: Our modelling shows that the suitability of ecological conditions across much of Wales increases or decreases depending on the balance between intensification and reduced agricultural activity.

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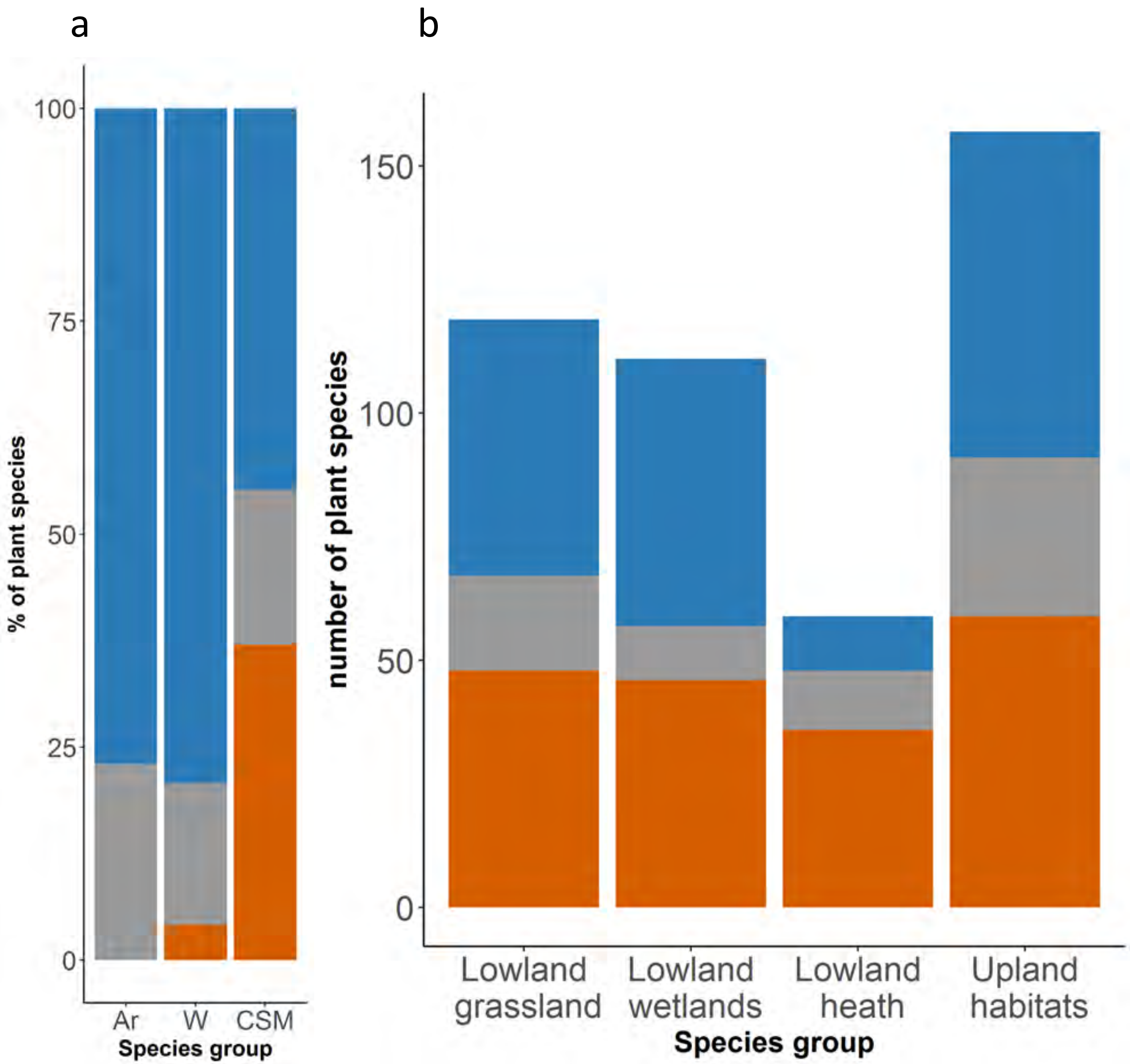
National change in habitat suitability for plants over 25 years (T3)



a) The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales.

b) Counts of semi-natural habitat specialists (CSM positive indicators) grouped by associated habitat with projected change in suitability of conditions across Wales. Species in all four groups have been summed together to produce the % results for CSM plants in (a).

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% change in habitat suitability per plant species in T3 (Examples)

Woodland specialists for Wales [1]

Latin	% change in suitability	Sig change
Sorbus aucuparia	1.4	+
Ilex aquifolium	1.3	+
Campanula latifolia	0.7	+
Oxalis acetosella	0.6	ns
Allium ursinum	0.5	+
Luzula sylvatica	0.0	ns
Potentilla sterilis	-0.3	ns

Arable specialists [2]

Latin	% change in suitability	Sig change
Polygonum aviculare	1.3	+
Veronica arvensis	0.7	+
Geranium molle	0.3	+
Anagallis arvensis	0.2	+
Lamium purpureum	0.2	+
Papaver rhoeas	0.0	+
Anthemis cotula	0.0	ns

Excerpts from lists of species with projected change in suitability of ecological conditions across Wales. Click here to view the modelled niche of each species in Britain.

Semi-natural habitat specialists (CSM +ve indicators)

Latin	% change in suitability	Sig change
Agrostis capillaris	-12.5	-
Festuca rubra	-8.1	-
Leucanthemum vulgare	-7.7	-
Galium saxatile	-5.2	-
Festuca ovina	-3.7	-
Festuca ovina	-3.7	-
Veronica officinalis	-0.8	-
Euphrasia officinalis agg.	-0.6	-
Briza media	-0.5	-
Angelica sylvestris	-0.4	-
Molinia caerulea	-0.4	-
Epilobium palustre	-0.4	-
Pimpinella saxifraga	-0.2	ns
Betonica officinalis	0.0	ns
Silene dioica	0.1	ns

[1] Glaves D et al. (2009) A Survey of the Coverage, Use and Application of Ancient Woodland Indicator Lists in the UK. Appendix 1. Hallam Environmental Consultants, Sheffield.
[2] Walker, K.J. (2018) Vascular plant 'axiophyte' scores for Great Britain, derived from the assessments of the vice-county recorders of the Botanical Society of Britain and Ireland (May 2016). NERC Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/af2ac4af-12c6-4152-8ed7-e886ed19622b

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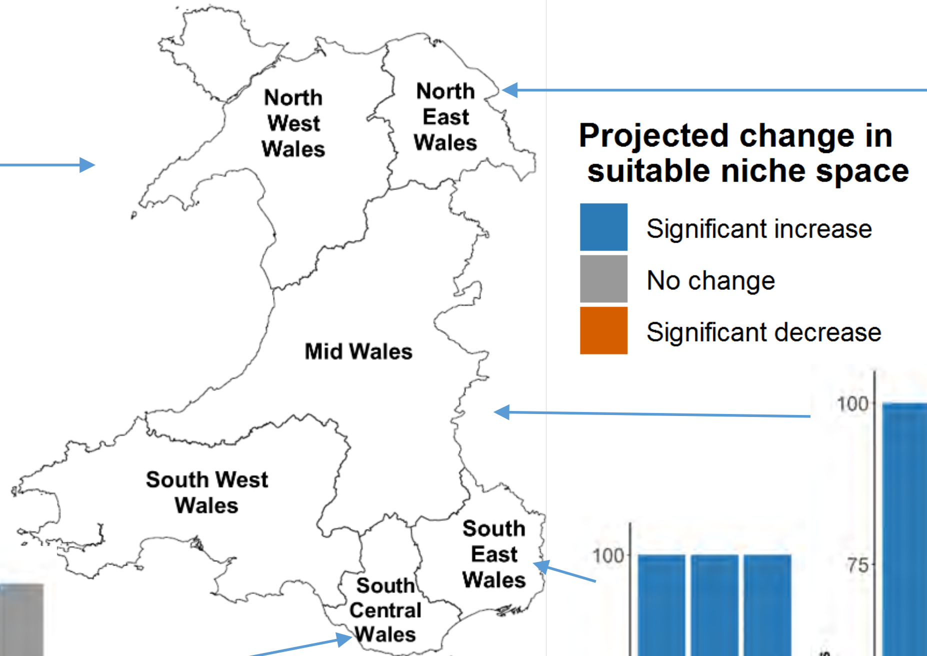
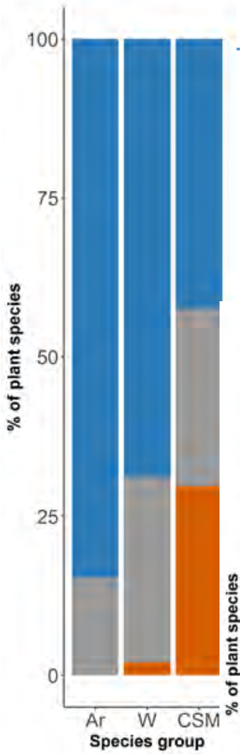
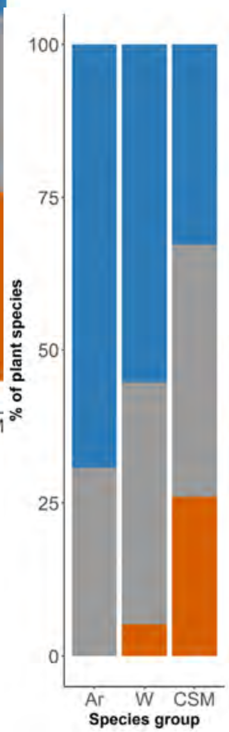
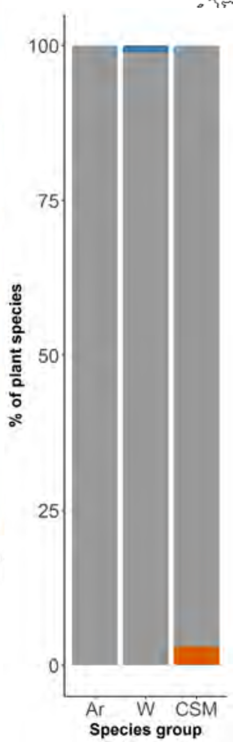
Regional impacts on plant species in T3

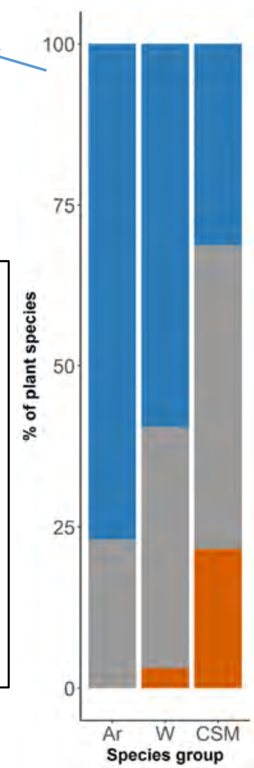


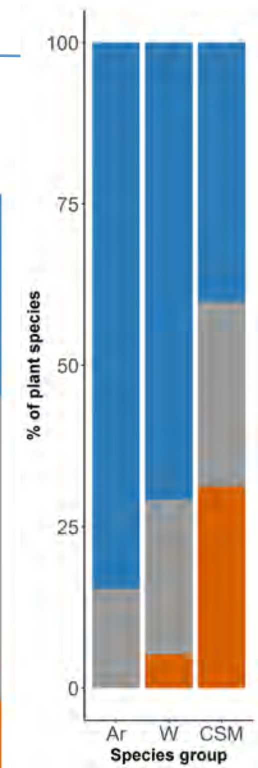


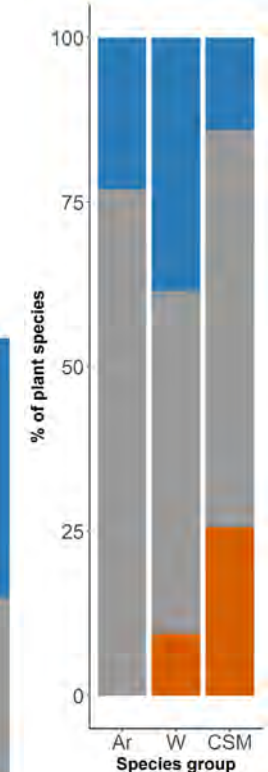




The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales under T3.







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Woodland habitat connectivity: Background information

- Woodland connectivity was modelled using a simple approach based on the distance species can travel (dispersal distance) and minimum habitat area requirements (patch size).
- Land within the dispersal distance of more than one patch could connect those patches if trees were planted.
- We identified a range of parameter combinations from the literature and applied these for Wales, broken down into NRW Area Statement regions.
- Baseline woodland was assigned using NFI data, combined with LCM2017, and data on woody linear features.

Dispersal distance/ patch size	100m: snails	200m: woodland specialist plants	500m: invertebrates	1km: max. for snakes; amphibians; moths	2km: max. for woodland flora/fauna
1 ha: low area requirements	not modelled	modelled	modelled	not modelled	not modelled
10 ha: high area requirements	not modelled	modelled	modelled	not modelled	not modelled
40 ha: NE recommended minimum size for wildlife site	not modelled	modelled	modelled	not modelled	modelled

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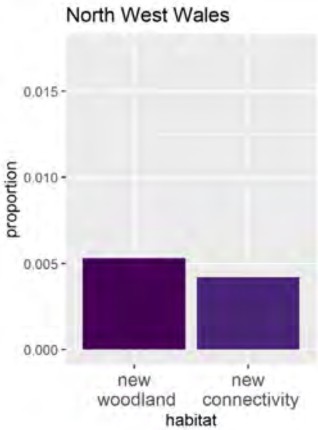
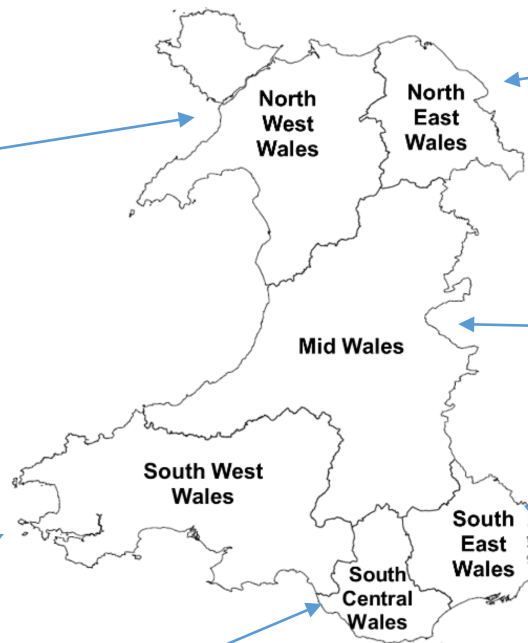
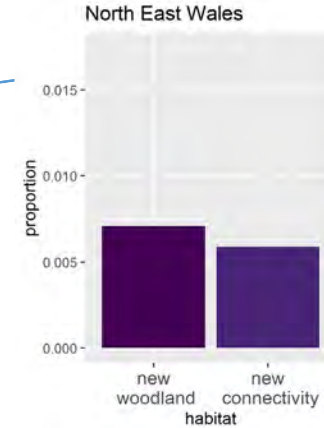
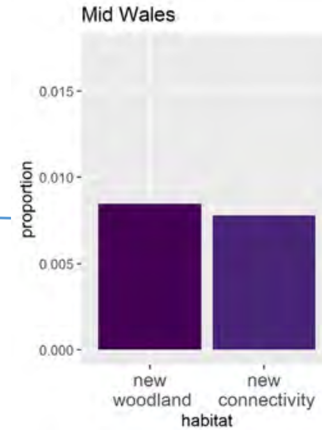
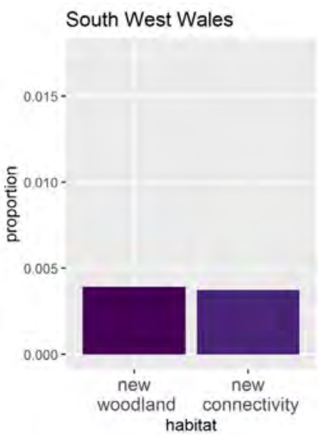
Woodland habitat connectivity: Regional variation in opportunity and predicted change (T3)

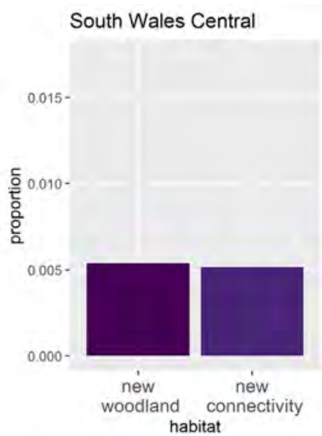


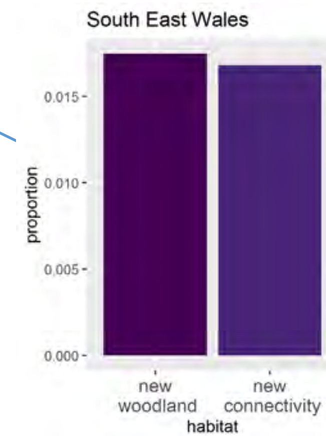












Most of the new woodland increases connectivity for at least one of our species type groups

- Total area new habitat woodland (ha)
- Total area providing increased connectivity

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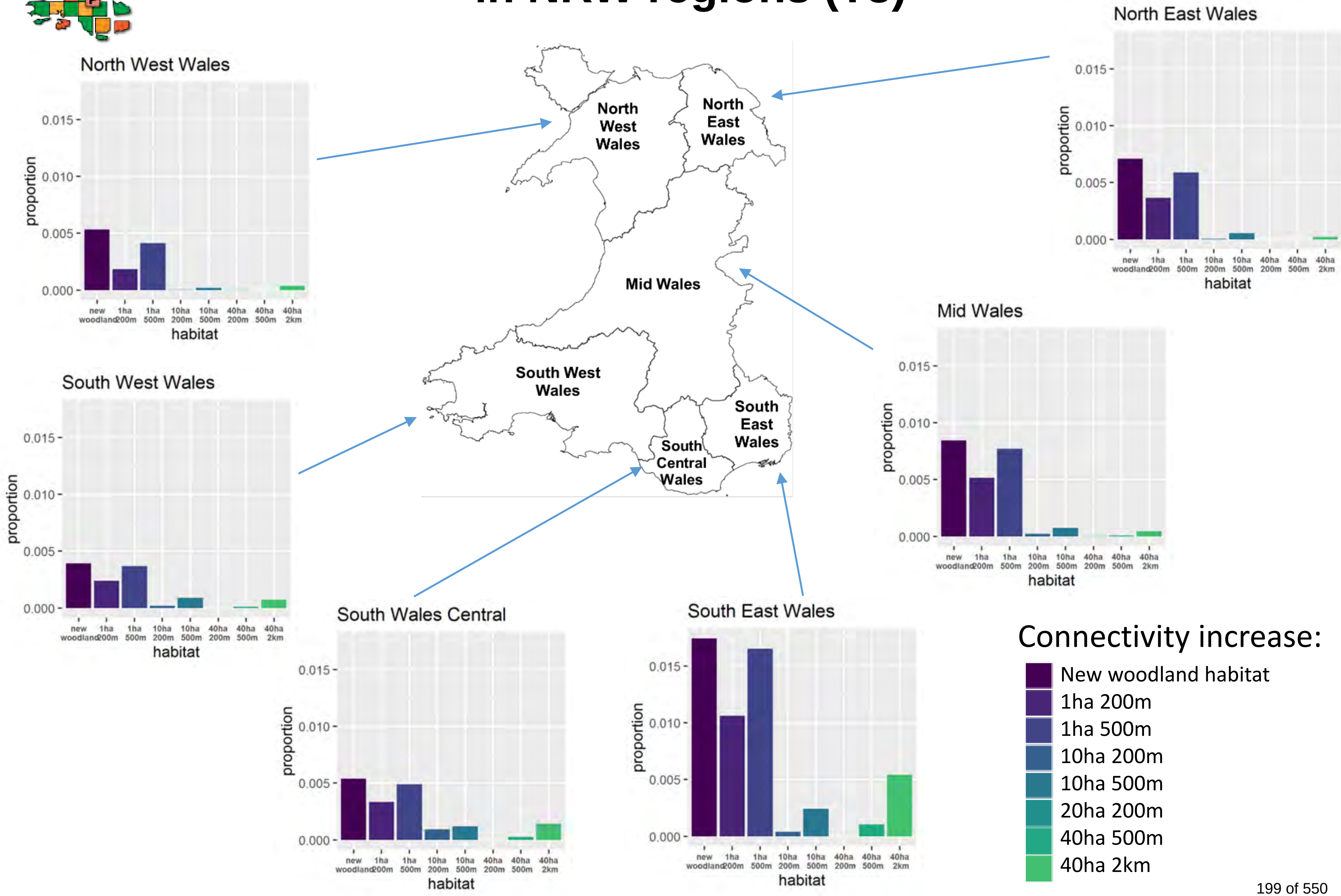
Breakdown of woodland connectivity type in NRW regions (T3)



PART 3: Ecosystem Services

3a: Carbon

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Carbon summary: Stocks and GHG emissions (T3)

(Note: Negative numbers indicate sequestration or avoided emissions)	**Increased emissions or losses of carbon by the year:**		
Inventory category:	**2025**	**2050**	**2100**
Losses from carbon stocks in Land use change and forestry + harvested wood products (4 A, B, C & G) (KtCO2eq)	8,644	12,330	8,795
Additional emissions from wetlands (4D) flux (KtCO2eq)	-47	-282	-753
Additional agricultural GHG flux (KtCO2eq)	14,359	86,152	229,738
TOTAL	22,955	98,200	237,781

- Overall, a **reduction in C stocks by 2100**, alongside **an increase in agricultural GHG emissions** is simulated for the T3 scenario, creating **net increase in atmospheric GHGs**.
- Modelled increase in GHG emissions associated with changes in livestock and nutrient inputs dominates the overall C budget, and the small reduction in emissions from wetlands does little to offset this.
- For agricultural land use change and forestry (LULUCF 4 A, B, C & G), it is interesting to note that net C sequestration from 2050-2100 offsets some of the losses between 2020-2050.

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Carbon stock and change in LULUCF categories (T3)

This table compares Carbon stock and change in the LULUCF categories:

LULUCF category	Baseline	Change to 2100
Cropland and Grassland (4B + 4C)(Kt) C	173,399	Loss of: 10,123 (Kt) Gain of: 107 (Kt)
Forest Land (4A) (Kt)C	Baseline woodland C data are not available	Gain of: 5,855 (Kt)
Harvested Wood products (4G) (Kt) C		Gain of: 1,763 (Kt)

- Carbon in cropland and grassland systems (LULUCF category 4B and 4C) is simulated to reduce in T3, due to conversion of grassland to arable/grass rotation.
- Slight simulated gains in carbon under LULUCF 4B + 4C are due to land going out of agriculture.
- Some gains in C storage are simulated for forest land and harvested wood products related to agricultural land that is converted to woodland. Note, this outcome is strongly dependant on the small area of new woodland planting as modelled here, based on planting on former agricultural land with net positive NPV. Note also that data are not available to account for C storage in existing woodland.

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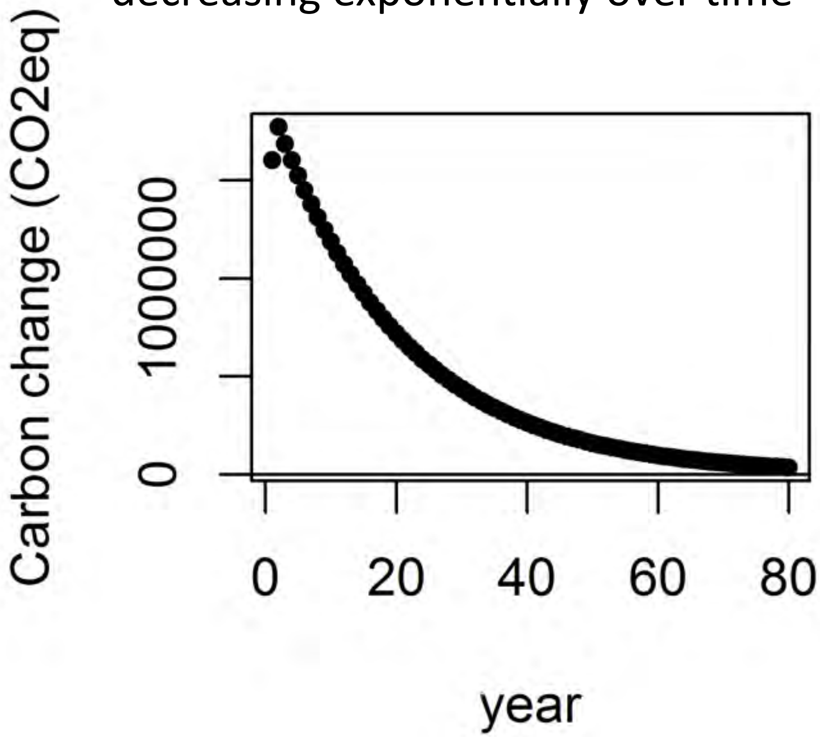
Agricultural carbon stock for Wales (T3)

Rate of C emissions from soils and vegetation at agricultural sites:
Initially high losses in C stock, decreasing exponentially over time



(Plot for agricultural land staying in agriculture)

- Carbon stock in croplands and grasslands (LULUCF 4B + 4C) are simulated to decrease, rapidly at first with high initial emissions, but slowing over time, approaching a new equilibrium by 2100.
- Total losses to 2100 on this agricultural land account for around 6% of total IMP modelled C stocks in agricultural vegetation and soils.

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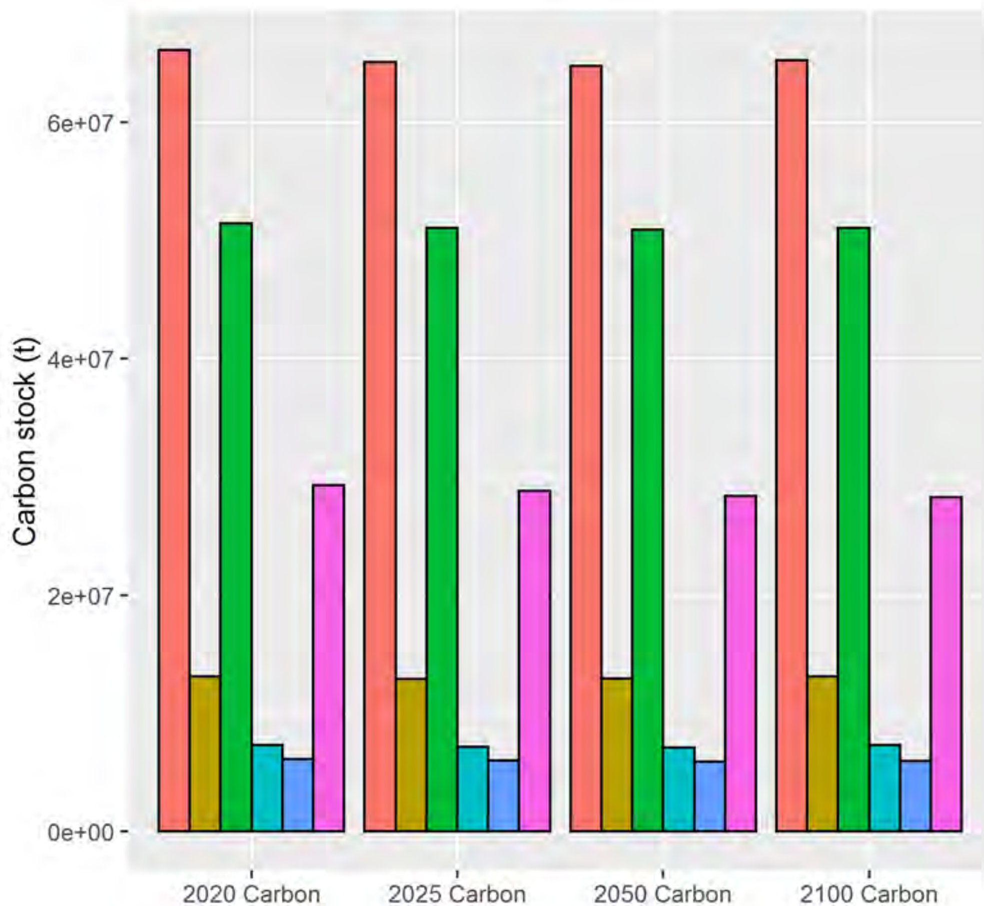
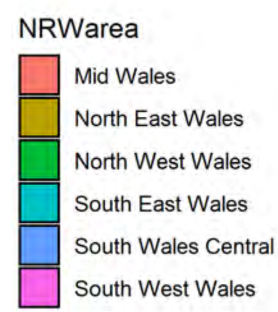
Total carbon stock over time (T3)

Total C stock for all modelled land in: 2020, 2025, 2050 and 2100



- Carbon stock in woodland systems increases slowly over time, with initial losses at some sites due to soil disturbance.
- Over time, initial rapid losses from agricultural changes slow down and woodland sequestration rates increase, hence losses are partially offset by woodland sequestration.
- Therefore, total C stock decreases to 2025, with further decreases to 2050, followed by a small increase from 2050 to 2100.



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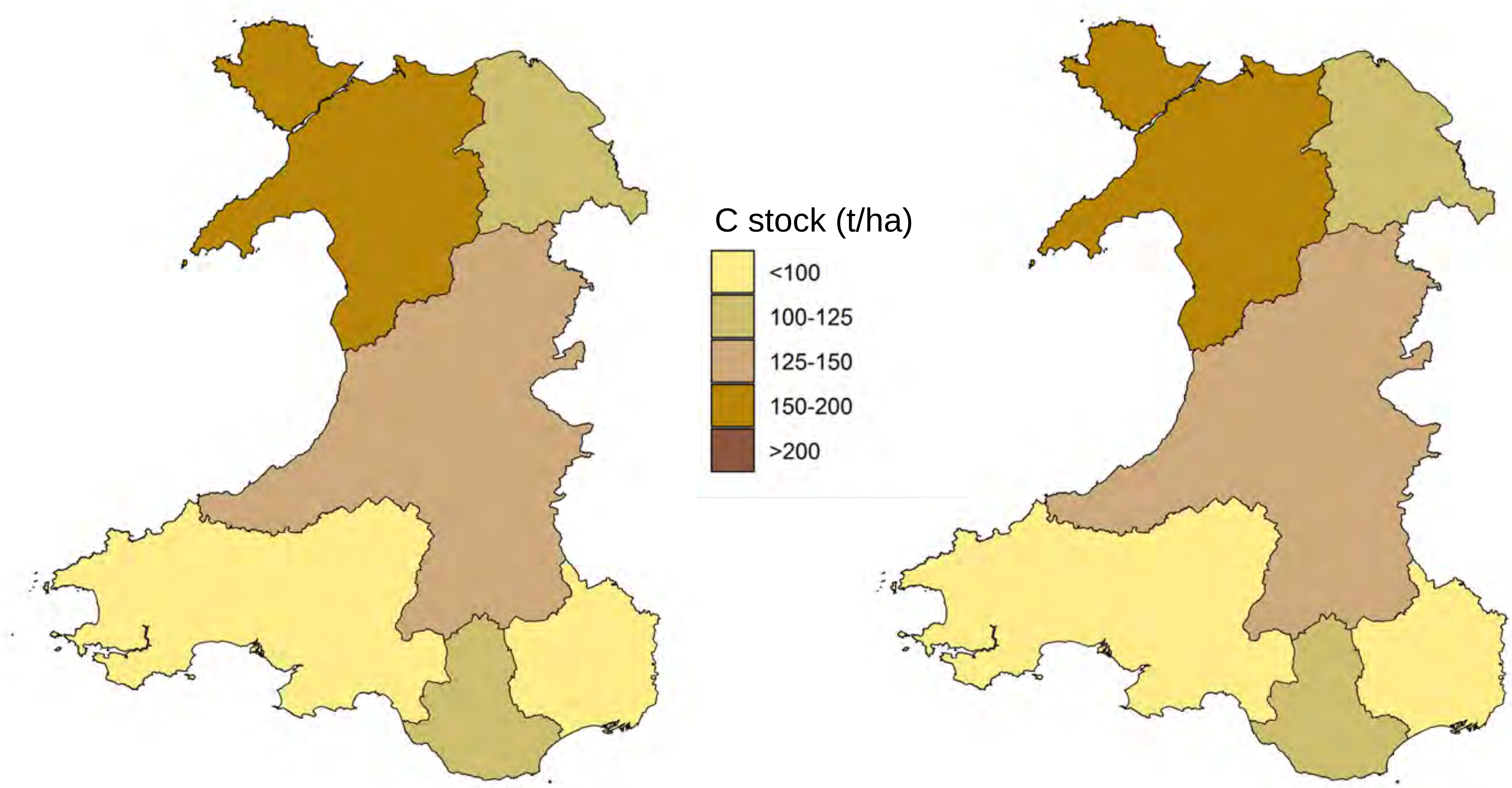
Carbon stock for NRW regions (T3)

Baseline (2020) | **T3 scenario (2100)**



Data are for LULUCF categories 4 A, B, C & G
and are displayed per ha of land modelled

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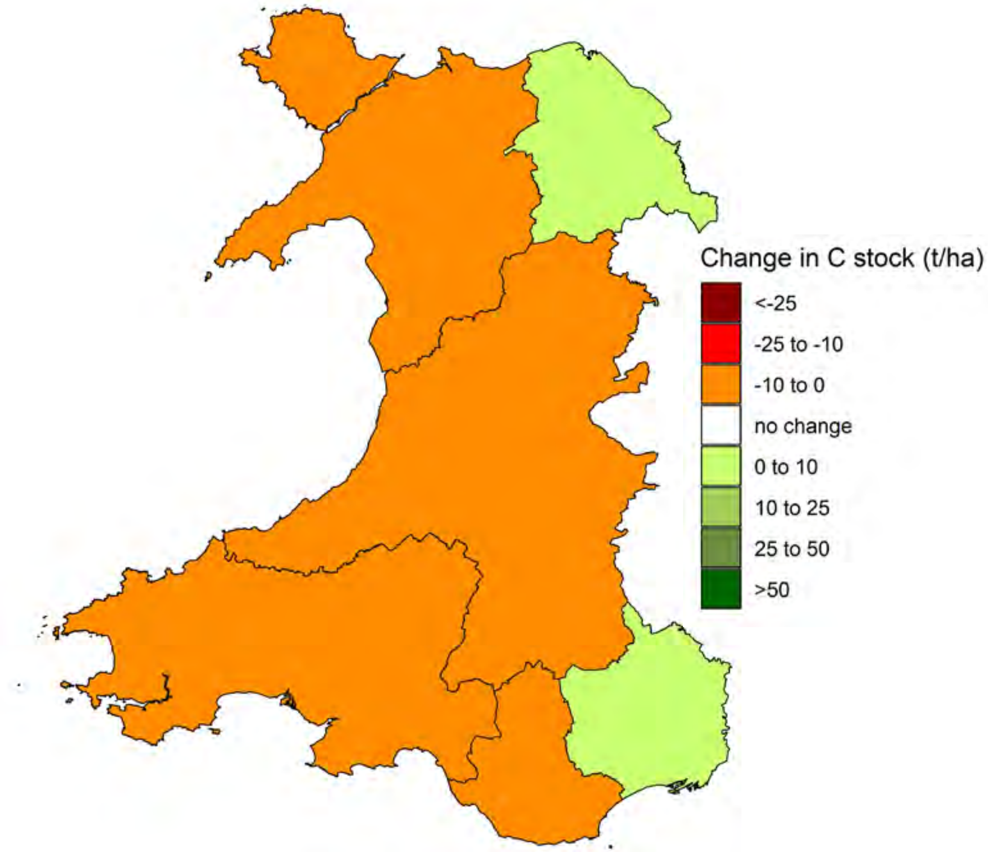
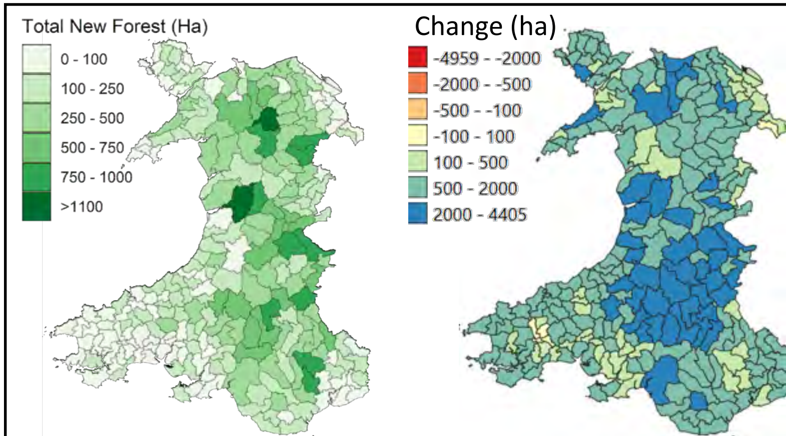
Carbon change for T3 scenario

Carbon change 2020-2100 (tC/ha)



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

Small increases or decreases are simulated in the NRW regions. However, the finer spatial detail in the maps that follow reveal some areas of greater change.



Increase in arable/grass rotation and area of new woodland must be considered together to understand the change in carbon

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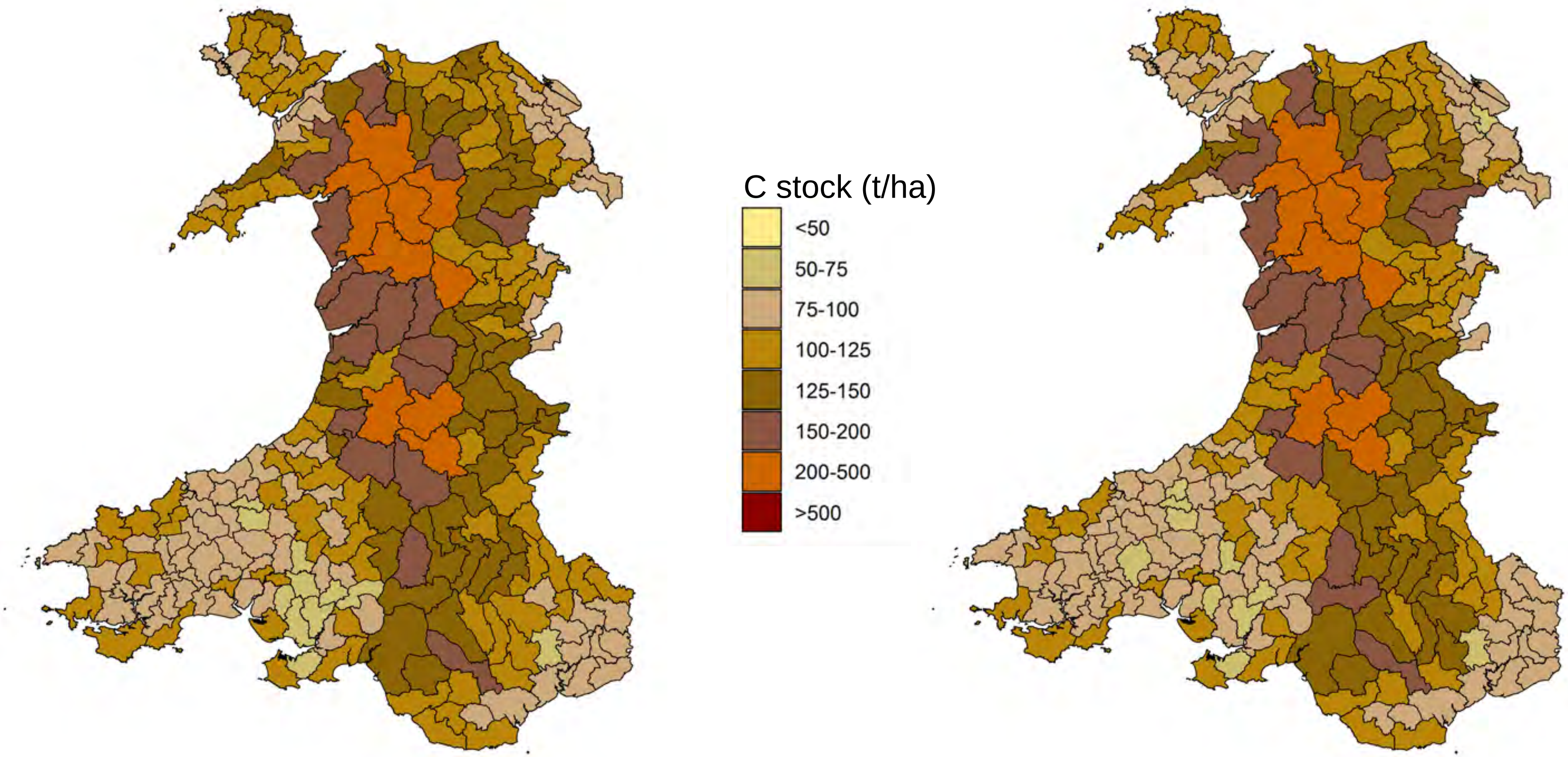
Carbon stock for small agricultural areas (T3)

Baseline (2020) | T3 scenario (2100)



Data are for LULUCF categories 4 A, B, C & G
and are displayed per ha of land modelled

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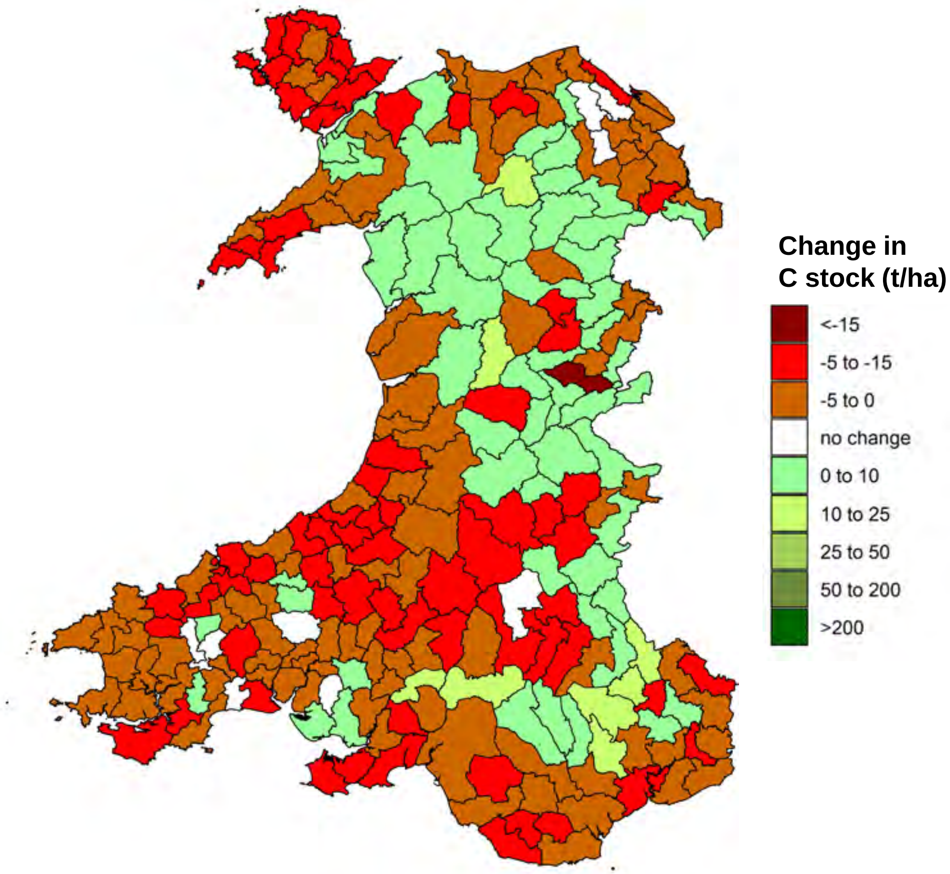
Carbon change for small agricultural areas (T3)

Map: tC/ha change 2020-2100



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

- Carbon stocks are simulated to increase in some areas and decrease in others.
- Areas of decrease reflect the large increase in land under arable-grass rotation.
- Areas of increase reflect new woodland (see slide 38), largely due to the significant C storage potential of biomass and harvested wood products.
- Some increase may also be attributed to sequestration on land reverting to short vegetation.

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GHG emissions: Peat and agriculture (T3)

This table compares total agricultural emissions and wetland emissions for farms modelled by IMP:

LULUCF category	Baseline	Scenario
Wetlands (4D) flux (KtCO2eq/yr)	873	864
Agricultural GHG flux (KtCO2eq/yr)	4,816	7,687

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Agricultural GHG emissions are simulated to increase reflecting large increases in dairy cattle, which are not offset by reductions in sheep and beef.
- GHG emissions from wetlands are simulated to reduce slightly, reflecting a small area of peat modelled as coming out of agricultural use.

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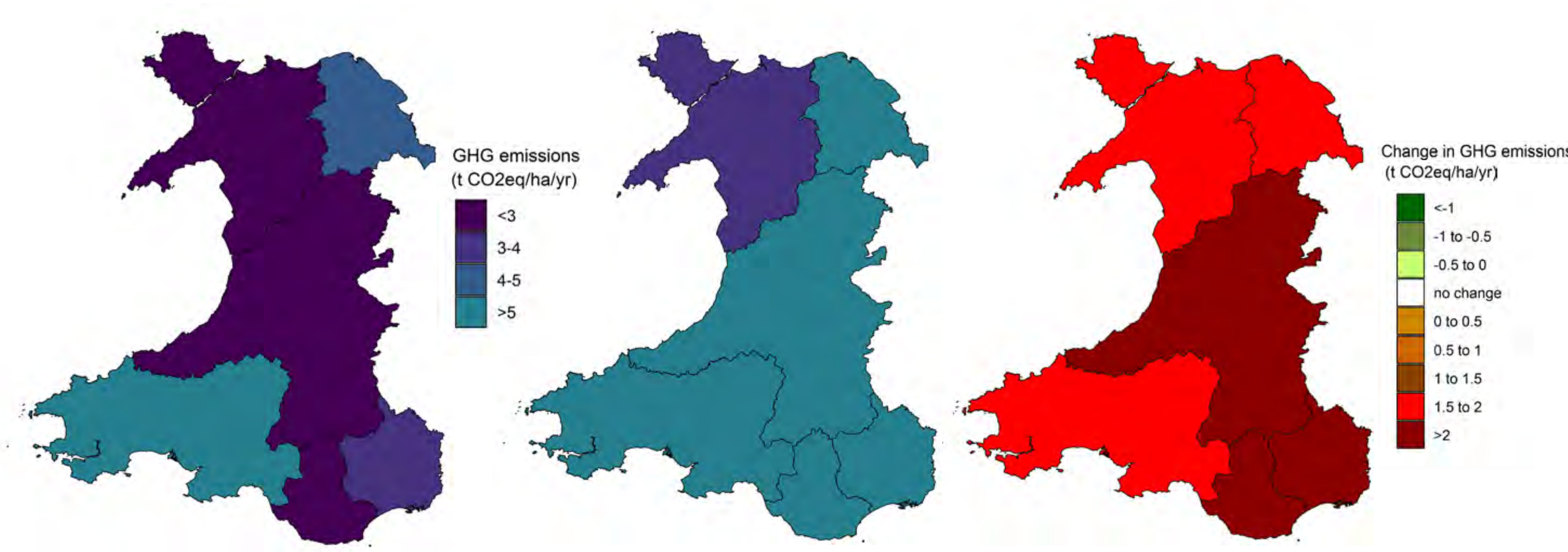
GHG emissions for NRW regions (livestock and management) (T3)

Baseline T3 scenario Change



- Data are displayed per ha of land modelled, and reflect patterns of livestock, land use and management.
- Increases reflect increased agricultural intensity due to the expansion of dairy simulated for all NRW regions.

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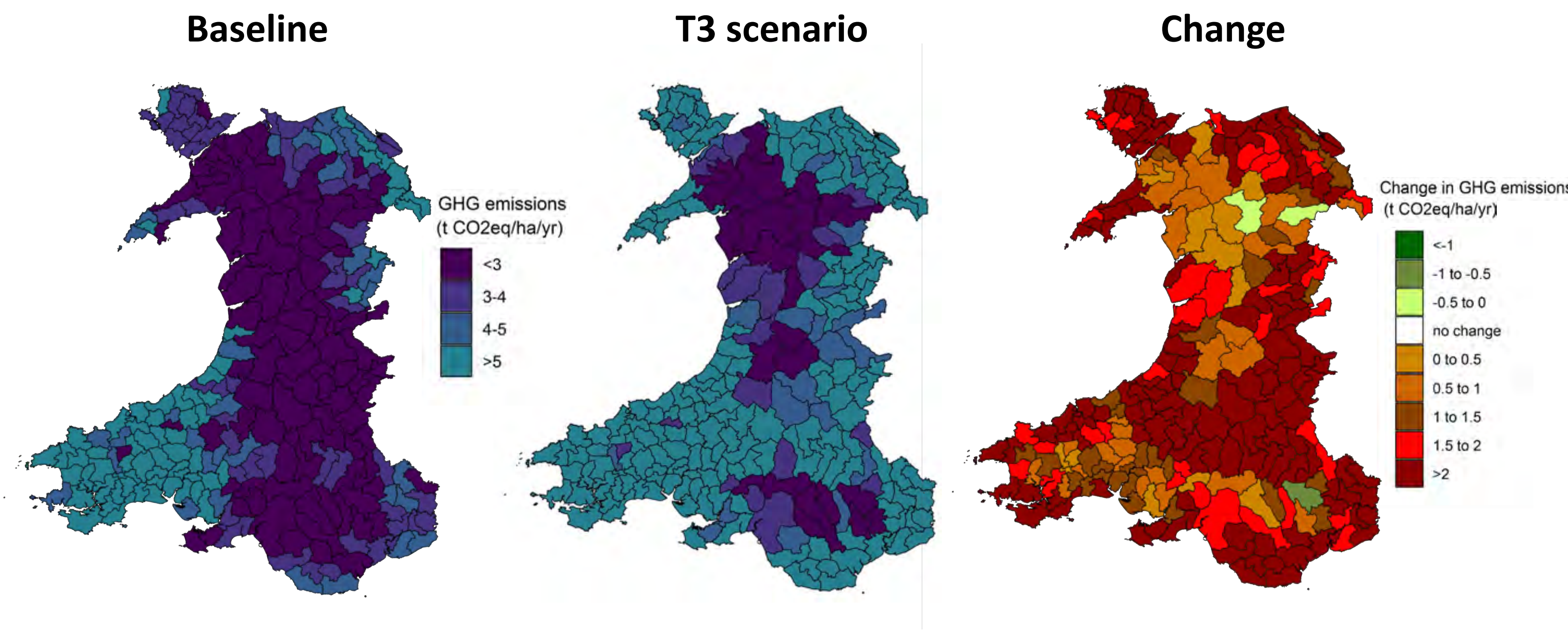
GHG emissions for small agricultural areas (livestock and management) (T3)



- The finer scale data reveal the greater magnitude of local changes.
- Increases in most areas reflect increased agricultural intensity due to the simulated expansion of dairy.
- Reductions in a few areas reflect land coming out of agricultural use.

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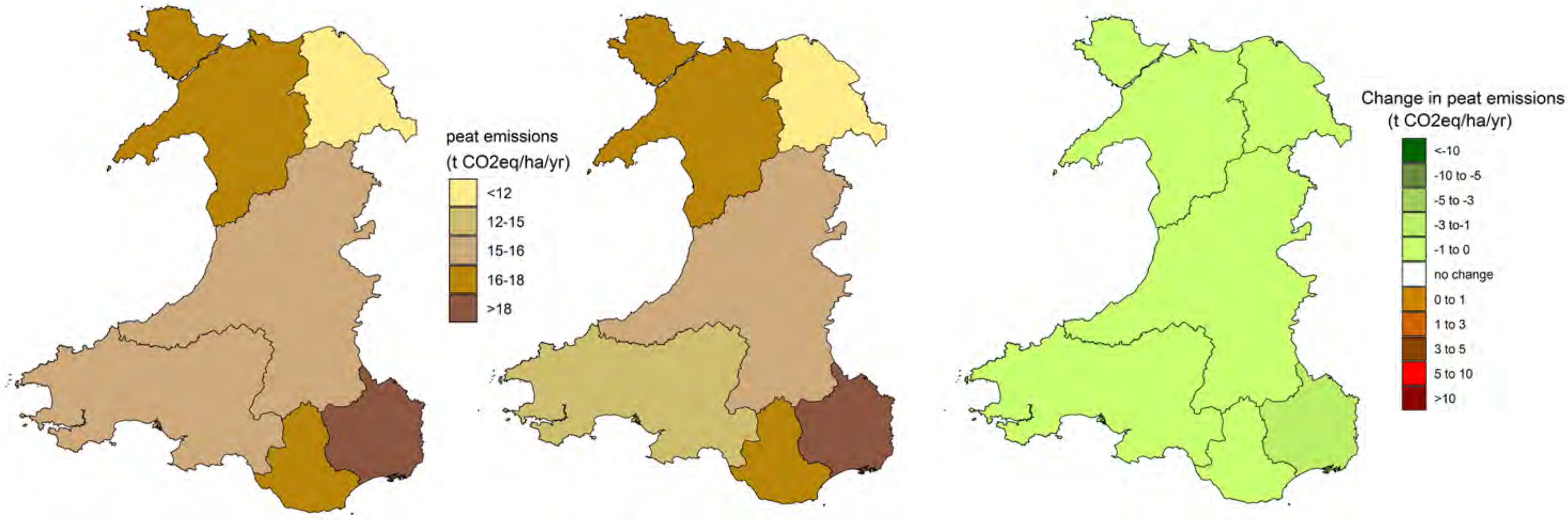
GHG emissions for NRW regions (peat) (T3)

Baseline **T3 scenario** **Change**



- Data are displayed per ha of peat modelled, and reflect land use and inferred management.
- Emissions are reduced slightly in all areas under the T3 scenario, due to land on peat modelled as coming out of agricultural use.

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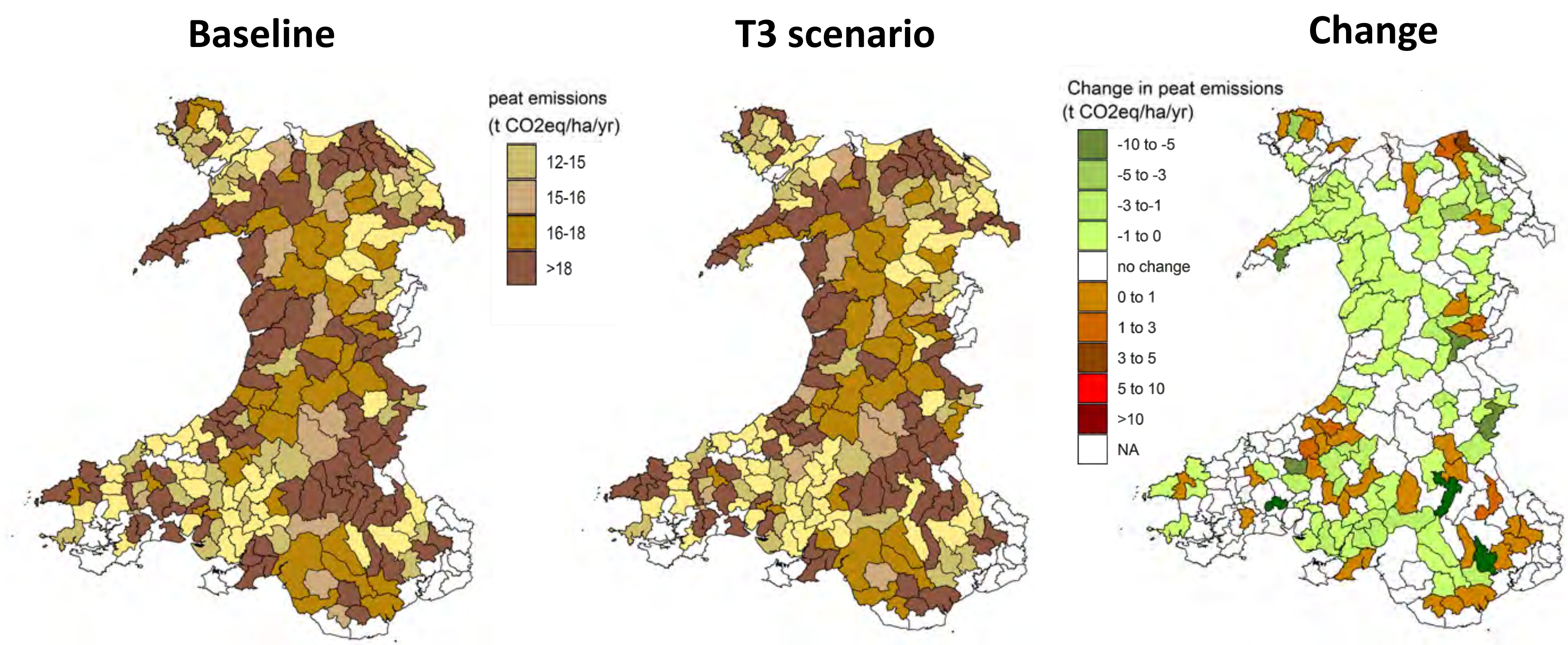
GHG emissions for small agricultural areas (peat) (T3)



- Emissions are simulated to decrease to 2100 in many areas, but increase in some areas where agricultural intensification is simulated to occur on peat.
- Some small agricultural areas do not contain peat, or do not experience predicted land use change on peat.

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PART 3b: Water quality

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Water Quality: Background information 1

- Water quality impacts must be considered for WFD catchments, therefore, loads calculated at the DMU level **(in kg/ha)** must be processed to in-stream loads, by aggregating at the catchment level.
- We also add in non-agricultural sources of pollutants, as well as estimates of pollutants for farms not modelled by the IMP (<1FTE).
- We then account for flow (and nutrient) accumulation to downstream catchments, and account for stream flow to calculate concentration for N and P.
- Data for N and P are processed to units reflecting the relevant thresholds: **annual average concentration for P and 95th percentile for N**.
- Data on sediments are calculated as **annual average loads**. River sediment concentrations are controlled by event driven inputs and in-river processes occurring over a range of timescales, so it is hard to measure average concentrations using infrequent grab samples and difficult to predict these from annual average inputs to watercourses as predicted by the IMP.

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Water Quality: Background information 2

- The water quality analyses are based on the scenario being applied to farms >1FTE only. Farms <1FTE are modelled as not responding to the scenario.
- We assume afforestation or reversion to short vegetation or natural woodland on the "non-economically viable" farms.
- Changes in water quality are not modelled for lakes, but these may be important for recreation, and associated businesses in Wales.
- Data outputs relate to a new long-term average reflecting land use and management for the scenario: we do not account for time lags in the nitrogen system.
- Predicted loads are based on average climate data (1961-1990).
- Data reflect average losses rather than those that might occur once in several years due to an intense rainfall event causing significant erosion (particularly important for sediment and P).
- Some measures might change soil P status or soil organic N supply, which happen over a period of 10+ years to reach a new equilibrium. Our scenario outputs assume these changes have already occurred.

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Water Quality for Wales: Change in N, P and sediment load (T3)

This table compares total agricultural loading for farms modelled by the IMP:

	Farms < 1FTE	Baseline	T3 scenario	Change	% change	Glastir impacts
Nitrate kt NO3 N	4.13	30.11	46.08	15.97	53%	-1%
Phosphorus kt P	0.18	0.72	0.86	0.14	20%	-0.9%
Sediment kt Z	68	194	206	11.62	6%	-0.1%

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Increases in all pollutants are simulated for the T3 scenario.
- This reflects the large simulated increases for dairy and to arable-grass rotation.
- Glastir impacts, modelled from 2016 uptake data, are shown for comparison.

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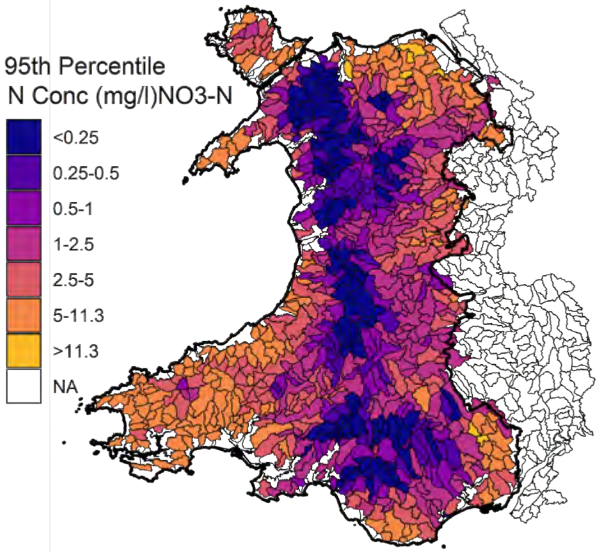
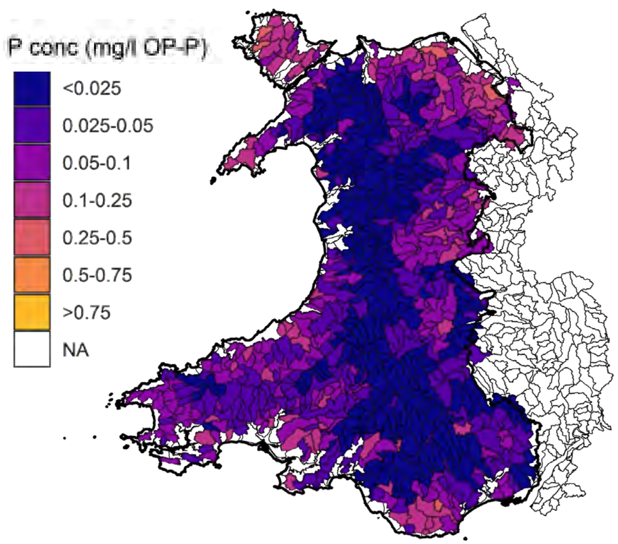
N, P and sediment load for baseline and T3

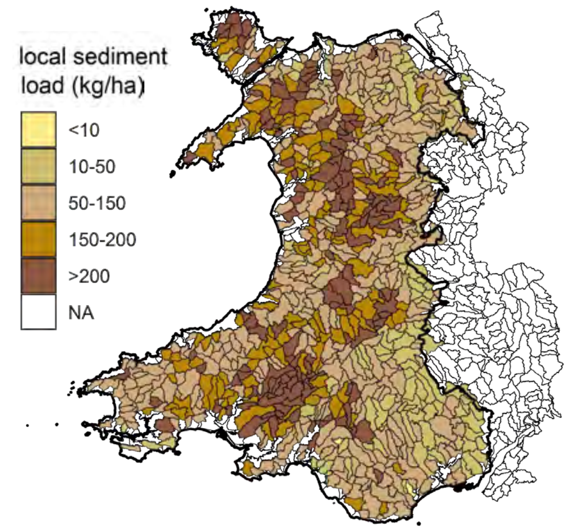
Baseline N



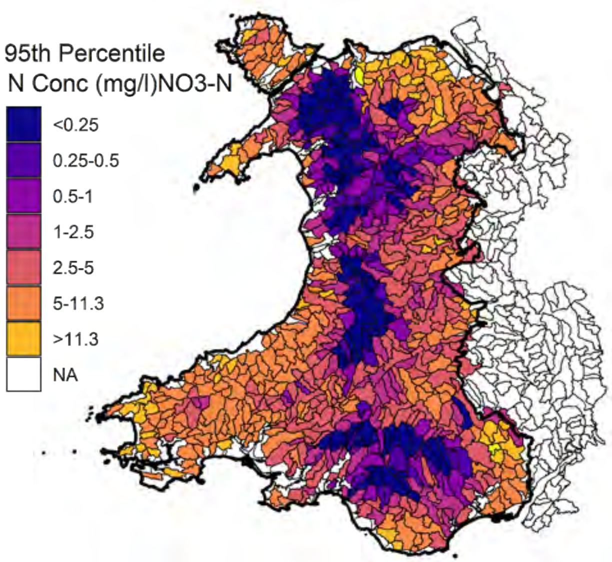
Baseline P



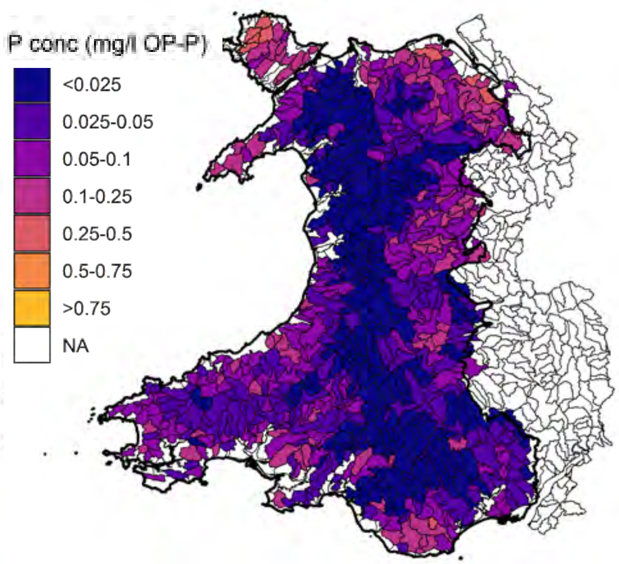
Baseline Sediment



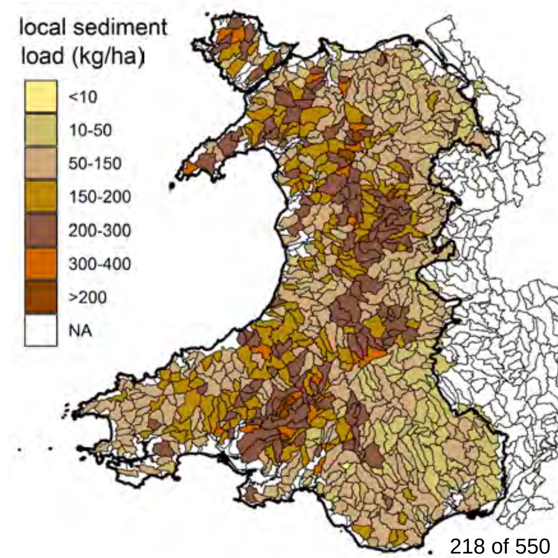
T3 scenario N



T3 scenario P

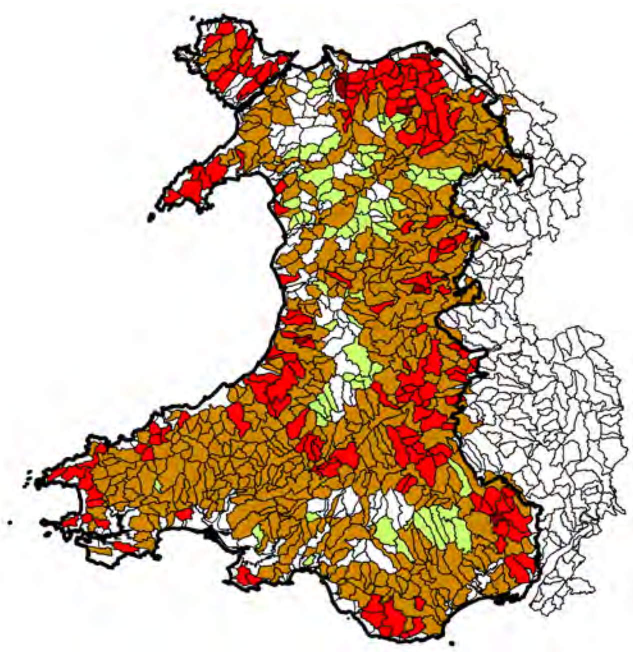


T3 scenario Sediment



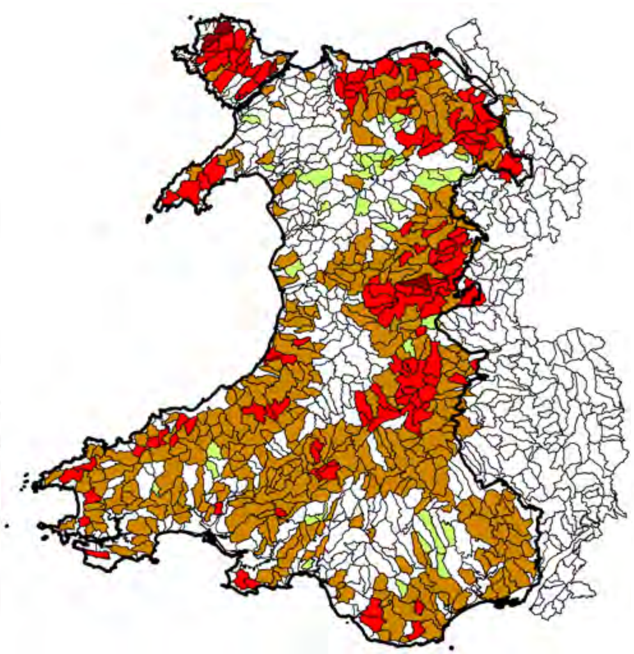
Change in N, P and sediment load (T3)

N change



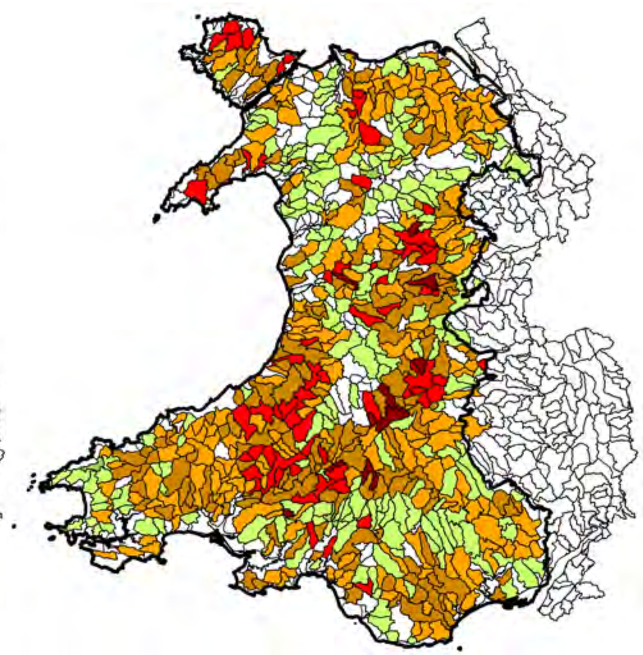
Change in 95th Percentile N Conc (mg/l)NO3-N
- <- 5
- -5 to -2.5
- -2.5 to
- no change
- 0 to 2.5
- 2.5 to 7.5
- >7.5
- NA

P change



Change in P conc (mg/l OP-P)
- <- 0.05
- -0.05 to 0
- no change
- 0 to 0.01
- 0.01 to 0.05
- >0.05
- NA

Sediment change



Change in local sediment load (t/ha)
- <-200
- -200 to -100
- -100 to -50
- -50 to 0
- no change
- 0 to 10
- 10 to 25
- 25 to 50
- >50
- NA

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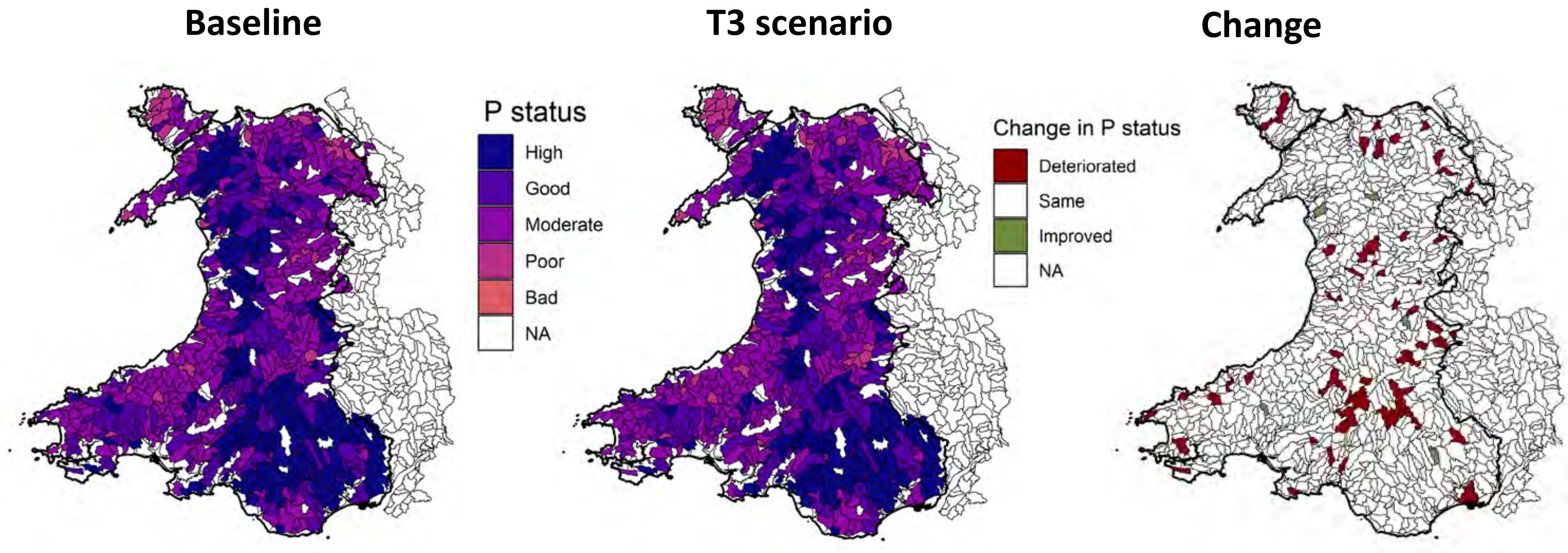
WFD P status (T3)



- WFD P status is simulated to deteriorate in some catchments under the T3 scenario where agricultural intensity increases.
- WFD P status is simulated to improve in a few catchments.
- Change in status may be modelled for very small changes in concentrations where baseline is close to a threshold.

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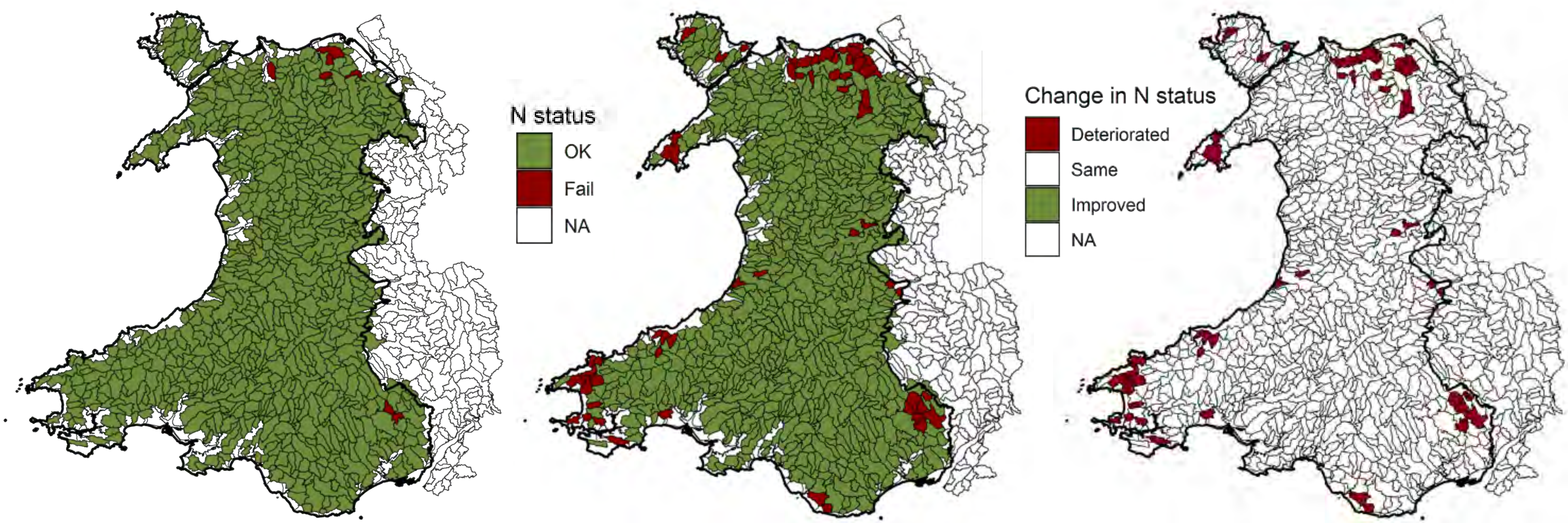
Drinking water N status (T3)

Baseline | T3 scenario | Change



- Drinking water N status is projected to change little under this scenario, but to deteriorate in key areas coinciding with increased agricultural intensity.
- No change in status was projected for most catchments, in spite of the 53% increase in total load from IMP modelled farms.

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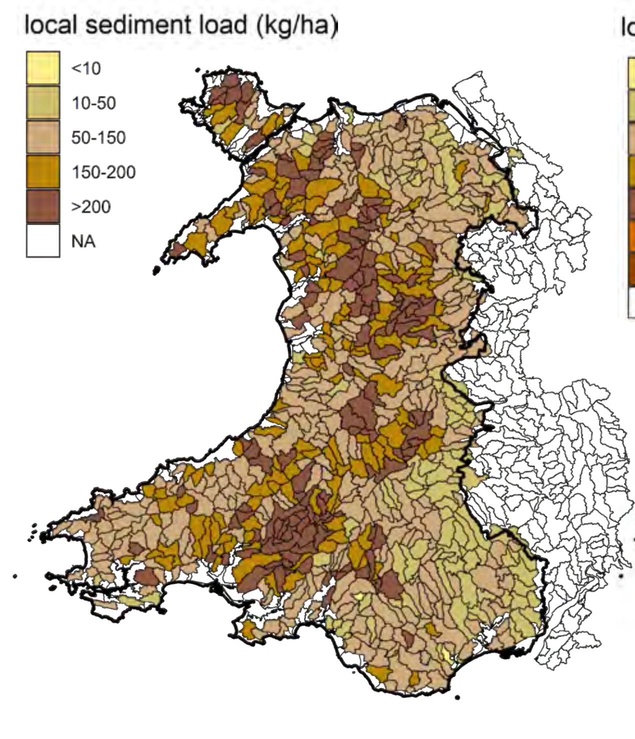
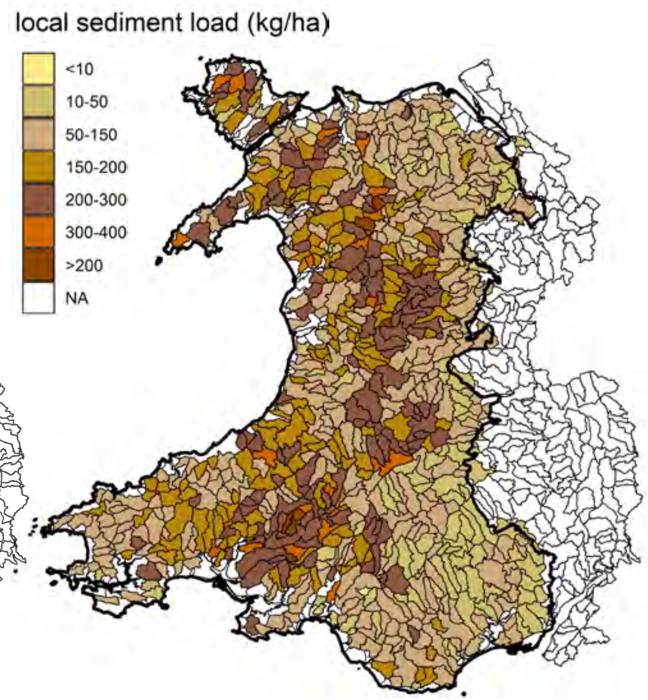
Change in sediment load (T3)

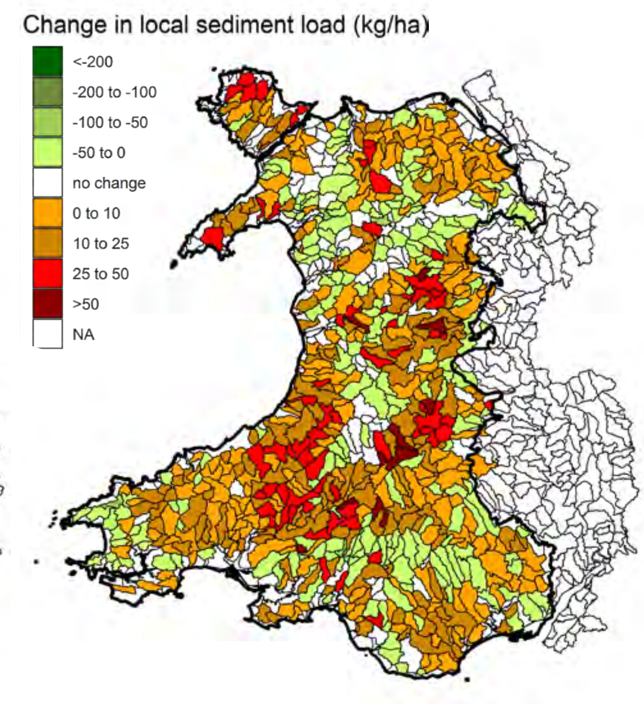
Baseline



T3 scenario



Change



- Increases in sediment loading are simulated, coinciding with areas with increased agricultural intensity.
- Small decreases are simulated in some WFD catchments reflecting land coming out of agricultural use.

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PART 3c: Air quality

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Air quality – Wales overview (T3)

This table shows changes in PM2.5 concentration and life years lost under the T3 scenario:

Average Change in PM2.5 Concentration	Life Years Lost (LYL)
+0.04	+58.6

- PM2.5 concentrations are simulated to increase on average for Wales, as a result of increases in NH3 emissions and only small areas of new woodland.
- This leads to a net health dis-benefit of +58.6 Life Years Lost.
- BUT spatial patterns vary …

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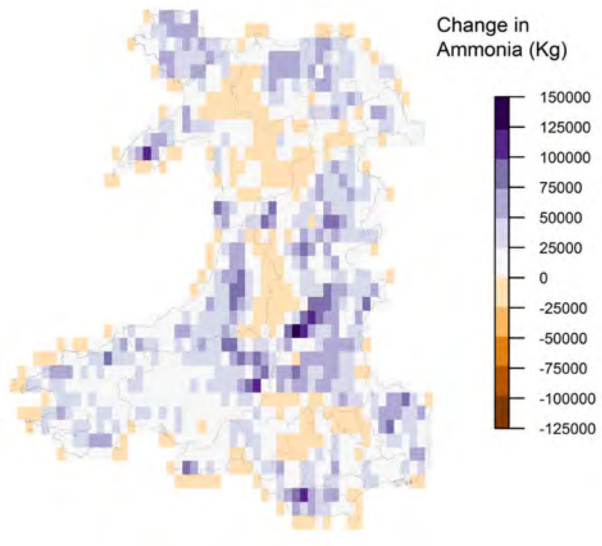
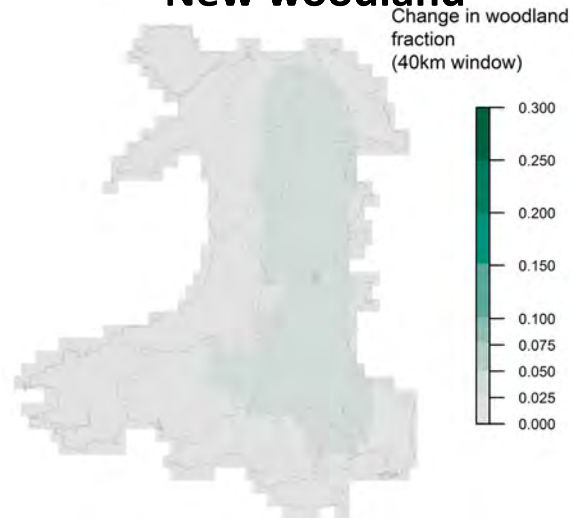
Health outcome from change in air quality (T3)

NH3 emissions



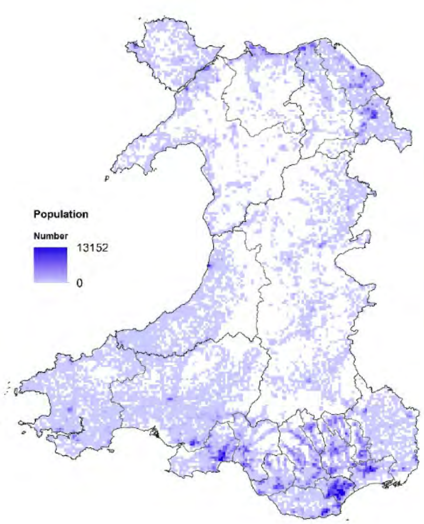
New woodland



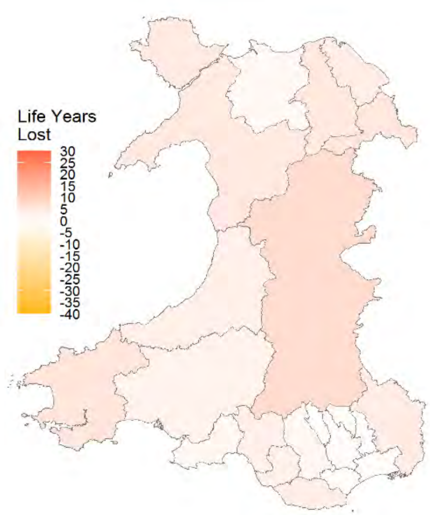
PM2.5 change

- Change in PM2.5 is a function of change in NH3 emissions and little new woodland planted.
- Increases in PM2.5 are simulated where NH3 emissions increase (mainly from dairy).

Population

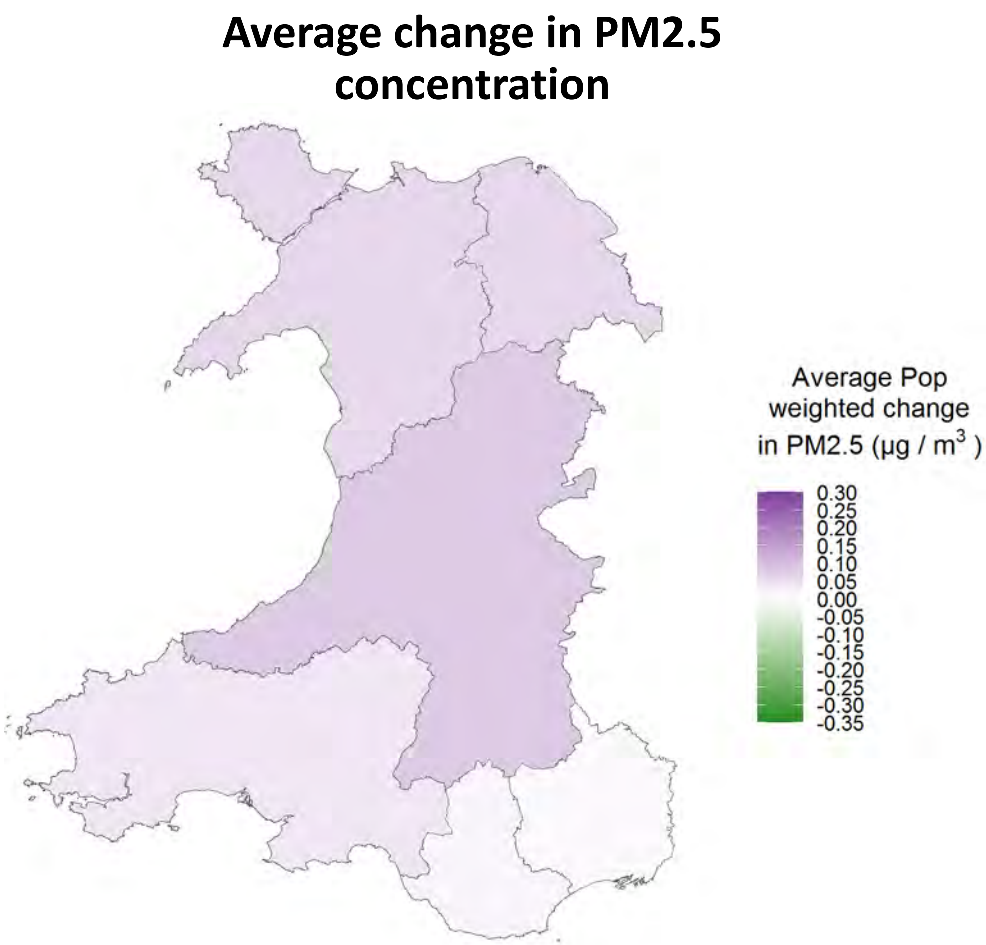


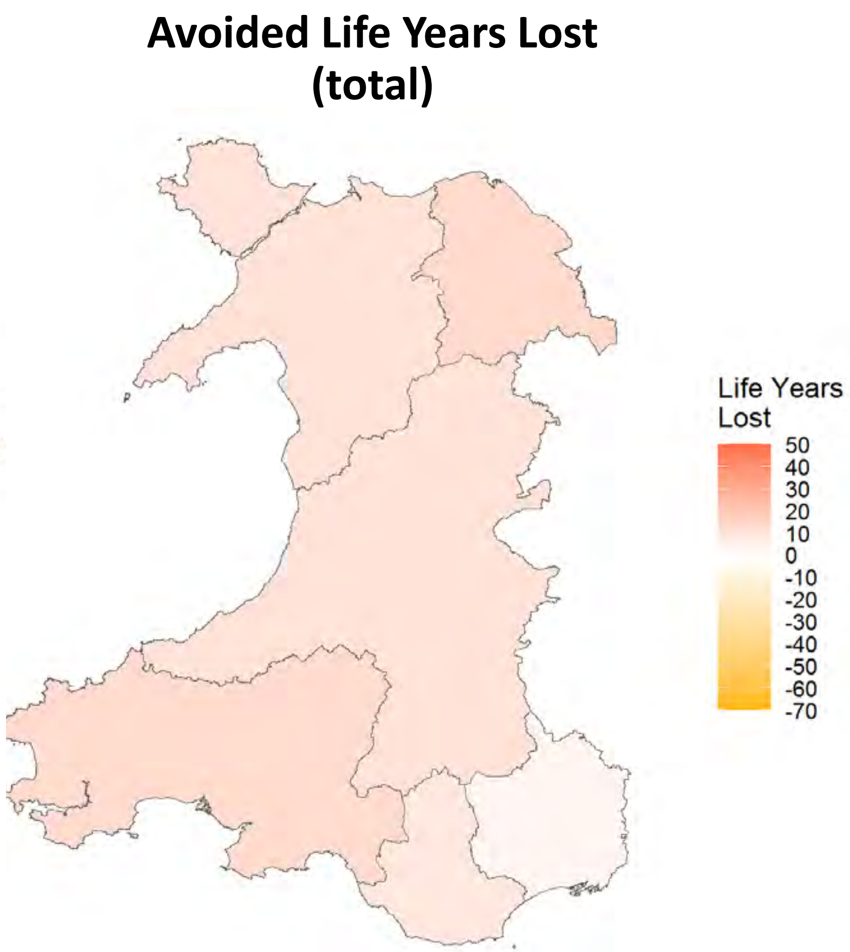
Avoided 'Life Years Lost'



- Health outcomes are a function of change in exposure of the population.
- **Net negative benefit in all areas, *except Blaenau Gwent, Torfaen & Merthyr Tydfil*.**

Air quality for NRW regions in T3





Greatest dis-benefits are in parts of North and South Wales.

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PART 4: Valuation

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Valuation results: Background information

- Price year: 2020
- Present values: 75 year time horizon
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g. 3.5% declining discount rate/ health discount rate for air quality):
  - Values are based on BIES (2018) guidance on carbon values for appraisals by Government.
  - This was prior to the release of updated values in September 2021.
  - The 2018 values do not fully reflect the requirements of the Paris Agreement 2016, the domestic net zero target, and other recent policy developments.
- Results given to 3 significant figures.

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Summary of public goods values (T3)

Benefits	Physical measure	Units	Present value, 75 yrs, £	Type of value
Air Quality	Increase of 59 years	Life Years Lost each year	- £ 85m	Reduction in costs of health impacts from air pollution
Water Quality	108 Deteriorate, 5 Improve	Expected changes in WFD status due to changes in P and N	- £ 47m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 224m tCO_2e	Net change in atmospheric TCO2eq over 75 years	- £ 15,509m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- The figures are an estimate of the value of the increase in wellbeing to people over 75 years under this scenario. Negative costs for air quality indicate increasing health care expenditure needed.
- Figures indicate order of magnitude of values of expected changes in the Welsh Environment.

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Breakdown of public goods values (T3)

Benefits	Present value, £m			Type of value
	5 yrs	25 yrs	75 yrs	
Air Quality	- £ 4m	- £ 26m	- £ 85m	Reduction in costs of health impacts from air pollution
Water Quality	- £ 8m	- £ 29m	- £ 47m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs:				Benefit of reducing GHG sources:
Agriculture	- £ 1,000m	- £ 5,161m	- £ 14,838m	Agricultural sources (livestock and inputs)
Land use	-£ 602m	-£ 905m	-£ 719m	LULUCF sources (soils, vegetation and harvested wood products)
Wetlands	£ 3m	£ 17m	£ 49m	Wetland sources (peatlands)
Total GHGs	- £ 1,598m	- £ 6,049m	- £ 15,509m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- All figures are based on simplifying assumptions of change over time.

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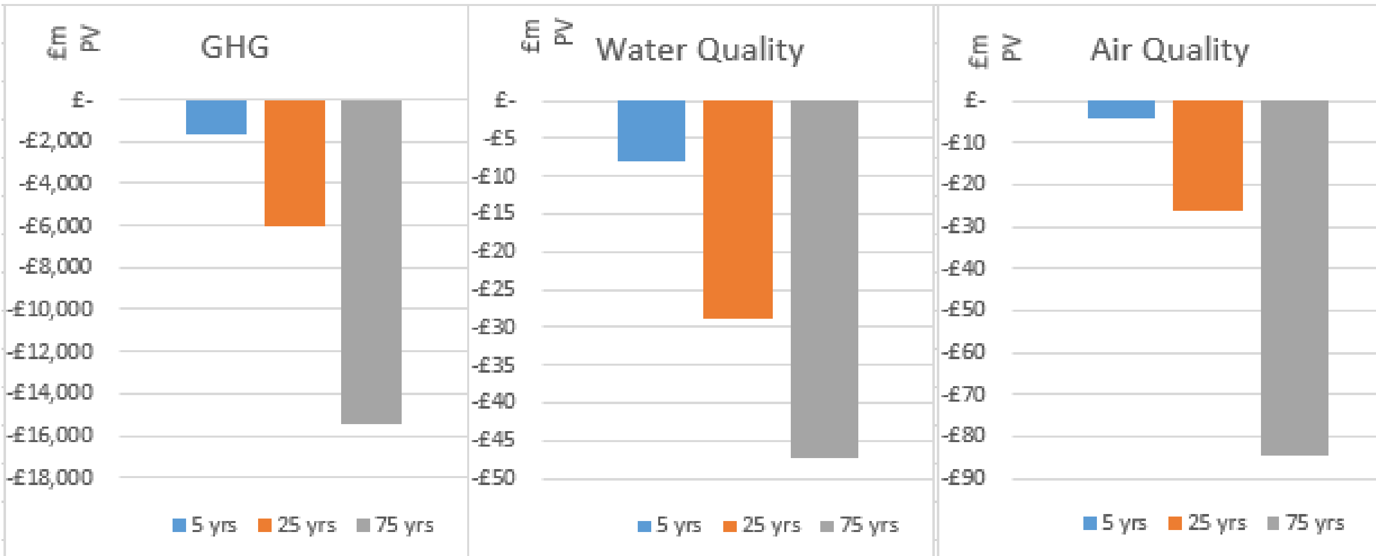
Public goods values for different time horizons (T3)



- A sustained loss of value of all three ecosystem services is simulated under the T3 scenario.
- The changes reflect increased agricultural intensity in some areas as dairy expands, and limited new woodland planting.

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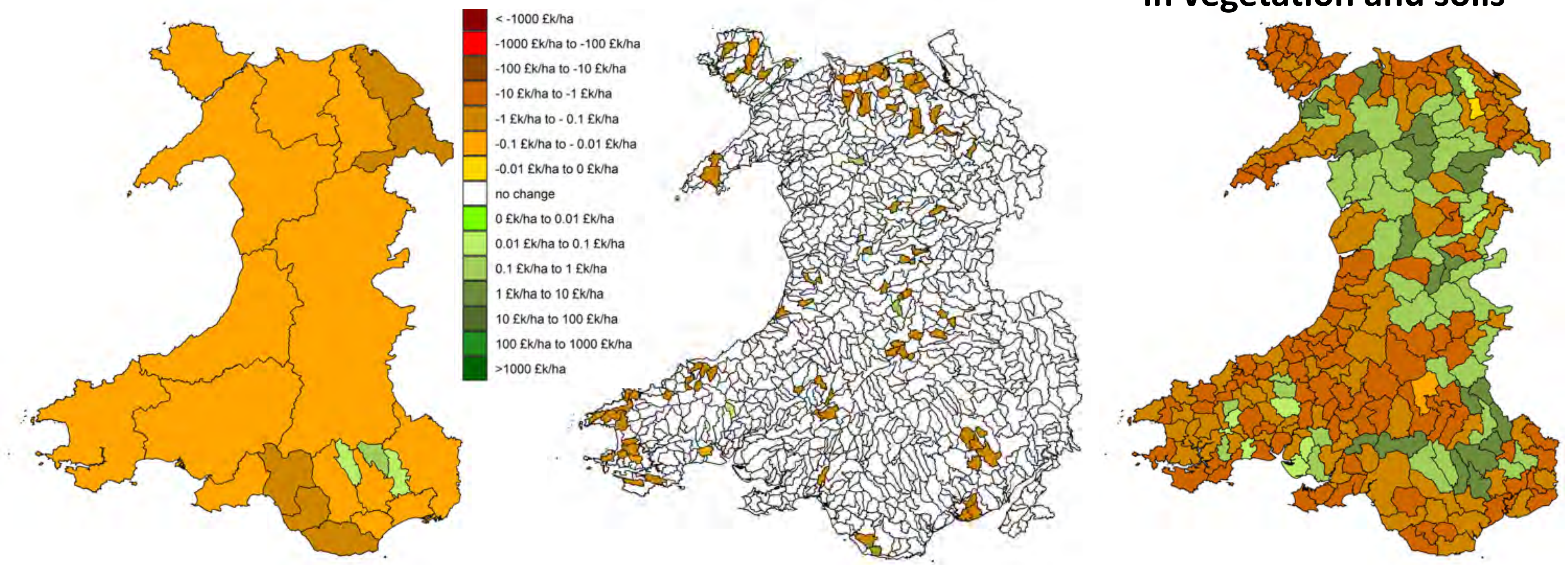
Spatial distribution of values (T3) (finest resolution)

Reduction in costs of air pollution

Value of change in status of freshwater bodies

Value of change in LULUCF carbon stock in vegetation and soils



- The greatest simulated costs for the T3 scenario come from LULUCF carbon losses, as well as deterioration in air and water quality.
- There are simulated improvements in air quality in some local authorities and from LULUCF carbon in many small agricultural areas.

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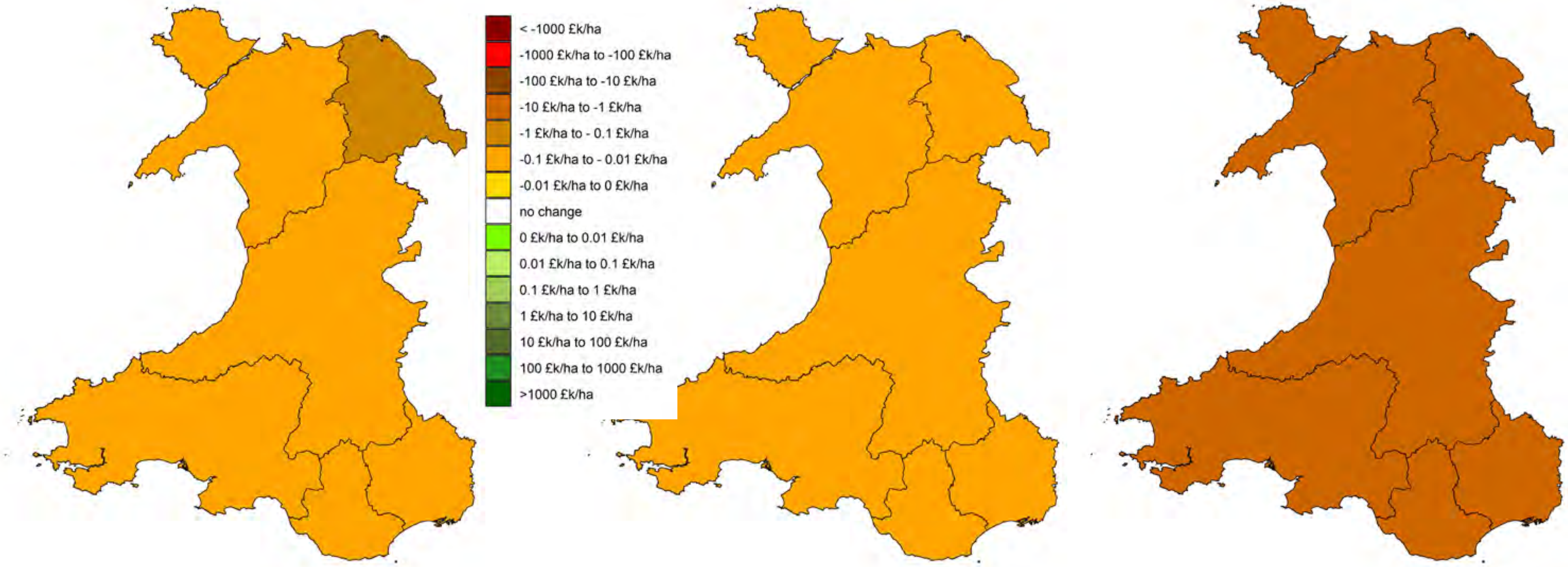
Spatial distribution of values (T3) (NRW regions)

Reduction in costs of air pollution

Value of change in status of freshwater bodies

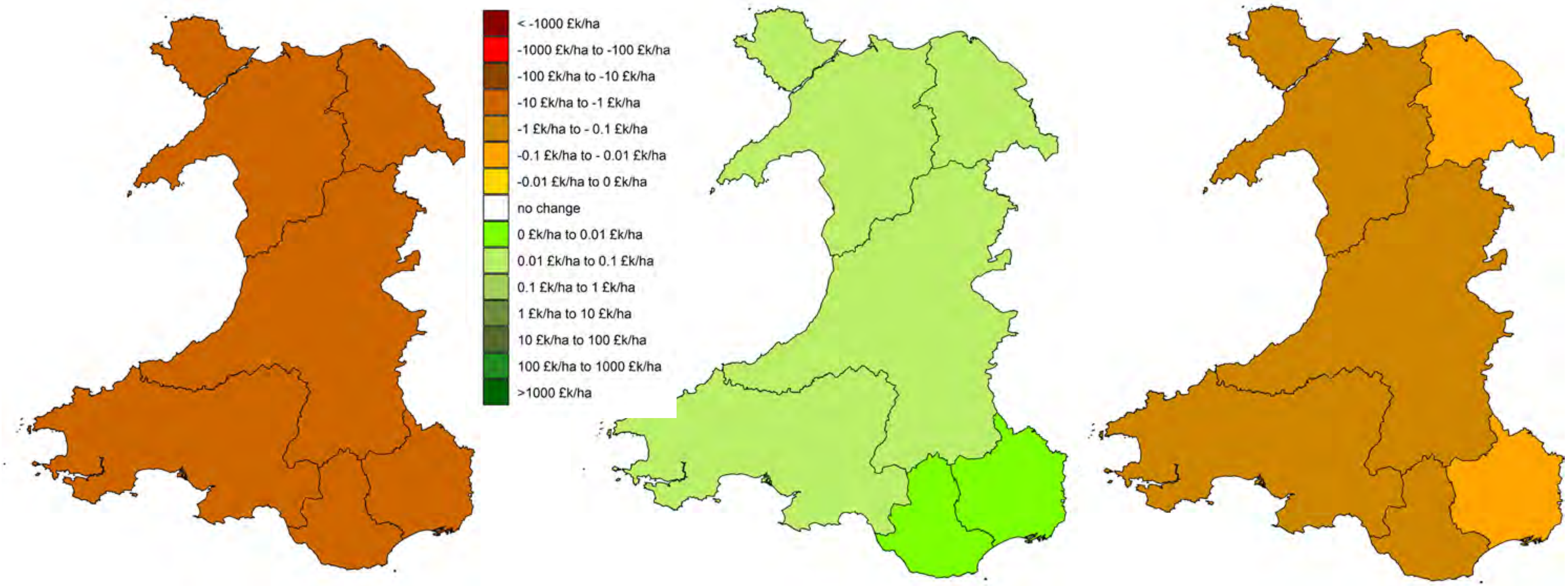
Value of combined change in GHG and carbon balance



- The greatest simulated costs for the T3 scenario come from GHG and LULUCF carbon losses, as well as the deterioration in air and water quality.
- The fine scale improvements for some local authorities and small agricultural areas are negated by deterioration in other areas when the data are aggregated to NRW regions.

Breakdown of values for Carbon and GHGs (T3) (NRW regions)

Value of change in agricultural GHG emissions | **Value of change in wetland (peat) GHG emissions** | **Value of change in LULUCF carbon stock in vegetation and soils**



- The change in carbon and GHGs is mostly attributed to an increase in GHG emissions, as well as the losses of LULUCF carbon. The small economic benefit for reduced peat GHGs partly reduces these costs.

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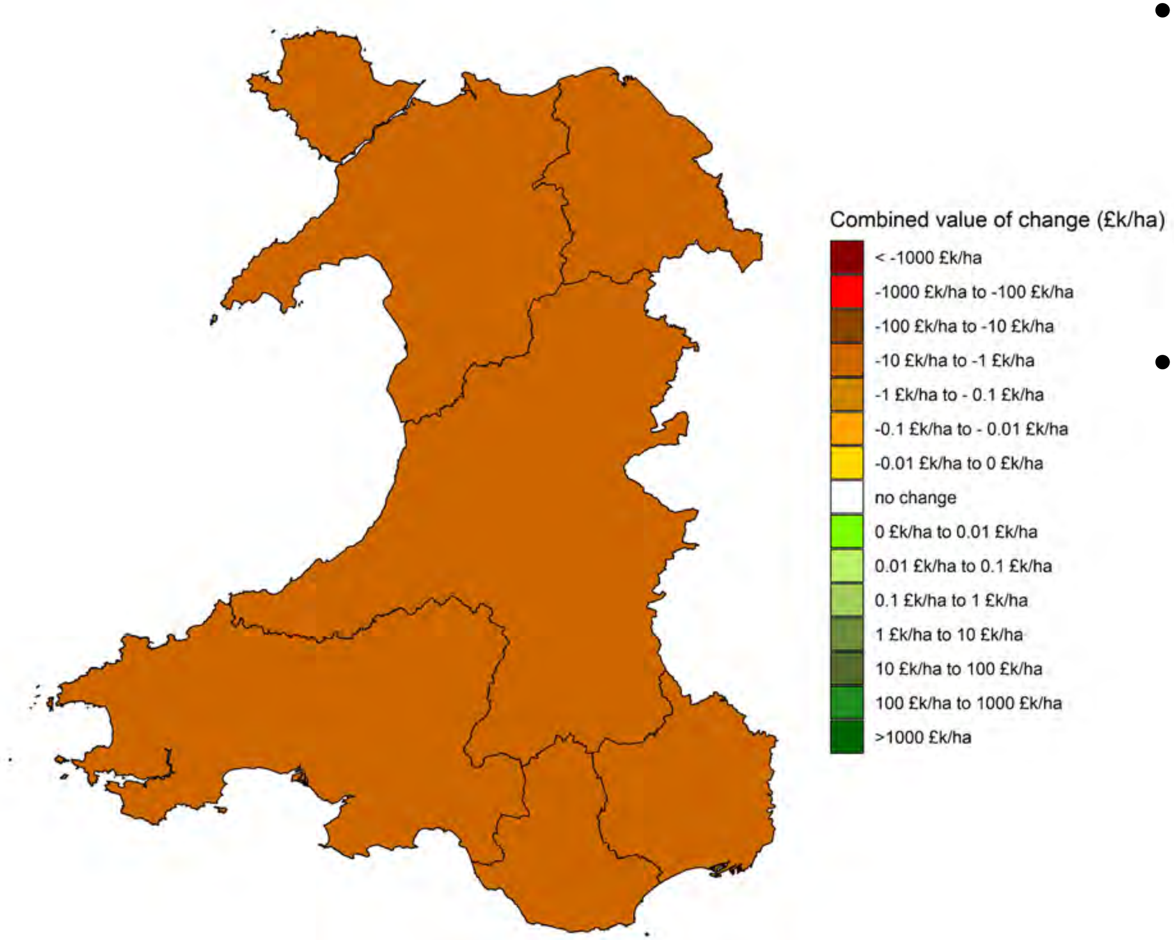
Sum of public goods values (T3) (NRW regions)

Sum of public goods values for all 3 benefits (air quality, water quality and carbon & GHGs):



- All regions are simulated to experience net costs in terms of deterioration of public goods under this scenario.
- This reflects the increased agricultural intensity with significant expansion of dairy and associated GHGs and ammonia, as well as the loss of carbon from conversion of land to arable-grass rotation.

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PART 5: Conclusion

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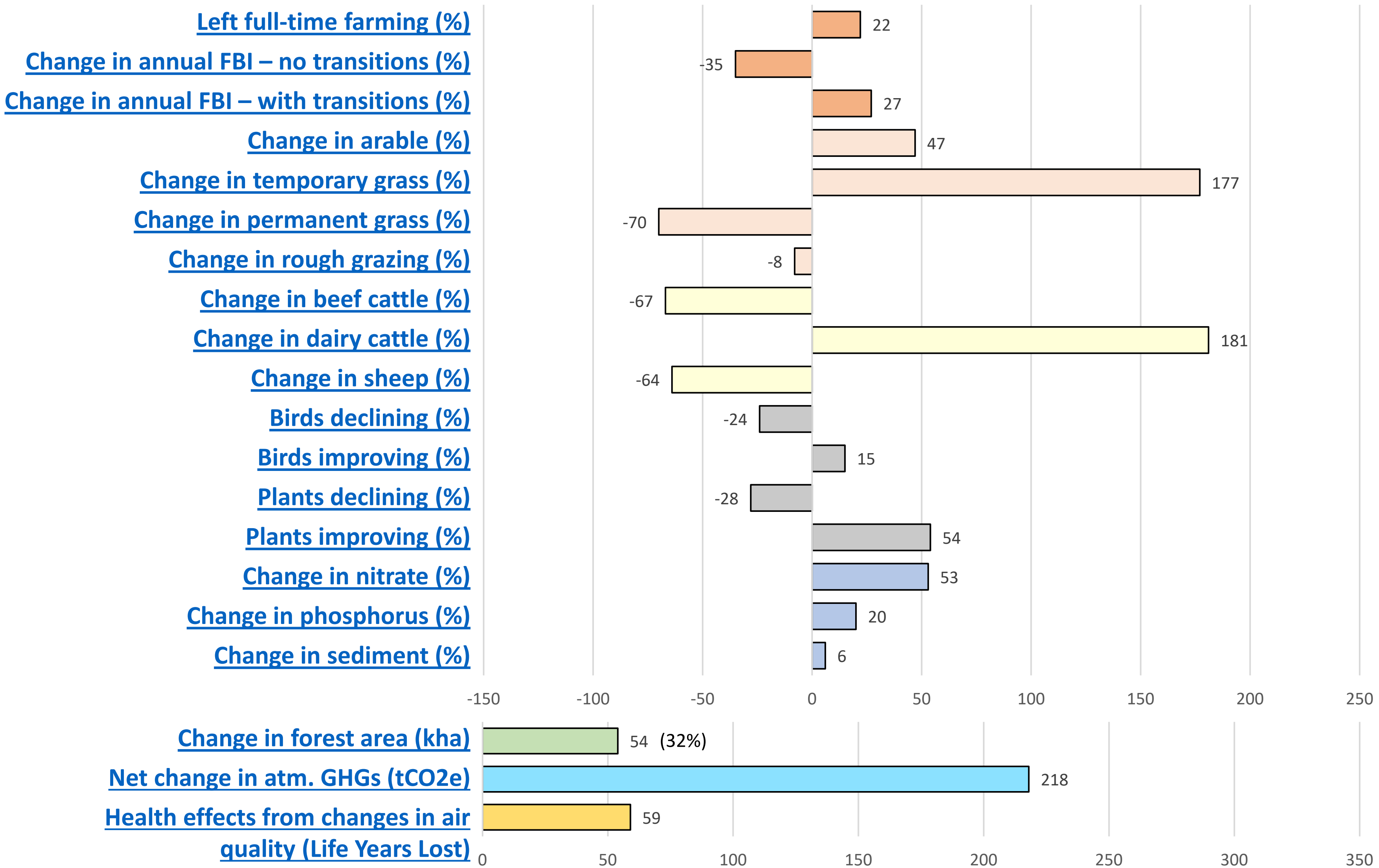
Summary of Impacts 1 (T3)



Summary of Impacts 2 (T3)

Impacts	Physical measure	Units	Present value, 75 yrs, £	Type of value
Agricultural Income	22%	Farms at risk of leaving full time agriculture	-91m (no EFT transitions) +70m (if EFT transition)	Total farm business income (per year)
Air Quality	Increase of 59 years	Life Years Lost each year	- £ 85m	Reduction in costs of health impacts from air pollution
Water Quality	108 Deteriorate, 5 Improve	Expected changes in WFD status due to changes in P and N	- £ 47m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 224m tCO_2e	Net change in atmospheric TCO2eq over 75 years	- £ 15,509m	Benefit of reducing atmospheric GHG concentrations from non-traded sources
Biodiversity	24% Decline, 15% Improve	Bird species	N/A	Percentage of species with significant increase or decrease
	28% Decline, 54% Improve	Plant species	N/A	Percentage of groups with significant increase or decrease

Final Considerations

- This slide pack shows results from applying the Integrated Modelling Platform to one (out of six) trade scenarios.
- The scenarios were provided by Welsh Government based on a series of internal and external workshops as changes in farm gate (output) prices and input costs.
- All scenarios were applied to a baseline that includes CAP Pillar 1 payments.
- The economic accounts presented are partial and based solely on the components explicitly mentioned. Other significant aspects (e.g. recreation) are not valued here.
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses.
- The IMP is applied to only full-time farms (> 1 FTE labour).
- A farm that is categorised as under pressure is based on being unable to achieve a full-time annual FBI of £6,000. As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.
- The IMP has been developed following Aqua book guidelines. All the assumptions underlying the IMP are fully documented and have been signed-off by Welsh Government.

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PART 6: Glossary and Context

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Glossary: Key Acronyms (I)

- FAPRI: Food and Agricultural Policy Research Institute
  - FAPRI-UK Model was used to underpin assessments of the impacts of Brexit on the UK agricultural sector. More information: (Web-link)
  - Macro-economic model of the UK in a global context. Used to identify impacts of global trade. The FAPRI-UK model (created and maintained by staff in AFBI-Economics) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with submodels covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) model run by FAPRI at the University of Missouri.
- MFTA: Multi-lateral free trade agreement
  - Free trade agreement between three or more countries without discrimination between those involved.

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Glossary: Key Acronyms (II)

- LULUCF: Land use, land-use change, and forestry
  - Standardised approach to the greenhouse gas inventory that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.
  - Used in this project to quantify impacts of land use change on carbon.
- MFN: Most Favoured Nation
  - World Trade Organisation (WTO) terminology. Under the WTO agreements, countries cannot normally discriminate between their trading partners. As such countries must treat all other WTO members as they would their "Most Favoured Nation". More information: (Web-link)
  - Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

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Glossary: Key Acronyms (III)

- WFD: Water Framework Directive
  - EU directive targeted at improving water quality and integrated catchment management.
- UKTAG: UK Technical Advisory Group (on the WFD)
  - The UKTAG is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies.
- LFA: Less-favoured area
  - Term used to describe an area with natural handicaps (lack of water, climate, short crop season and tendencies of depopulation), or that is mountainous or hilly, as defined by its altitude and slope.
- SDA / DA: Severely Disadvantaged Areas / Disadvantaged Areas
  - Sub-classes of LFA separating out the most severely disadvantaged areas for the purposes of basic payment scheme (BPS) grant payments.

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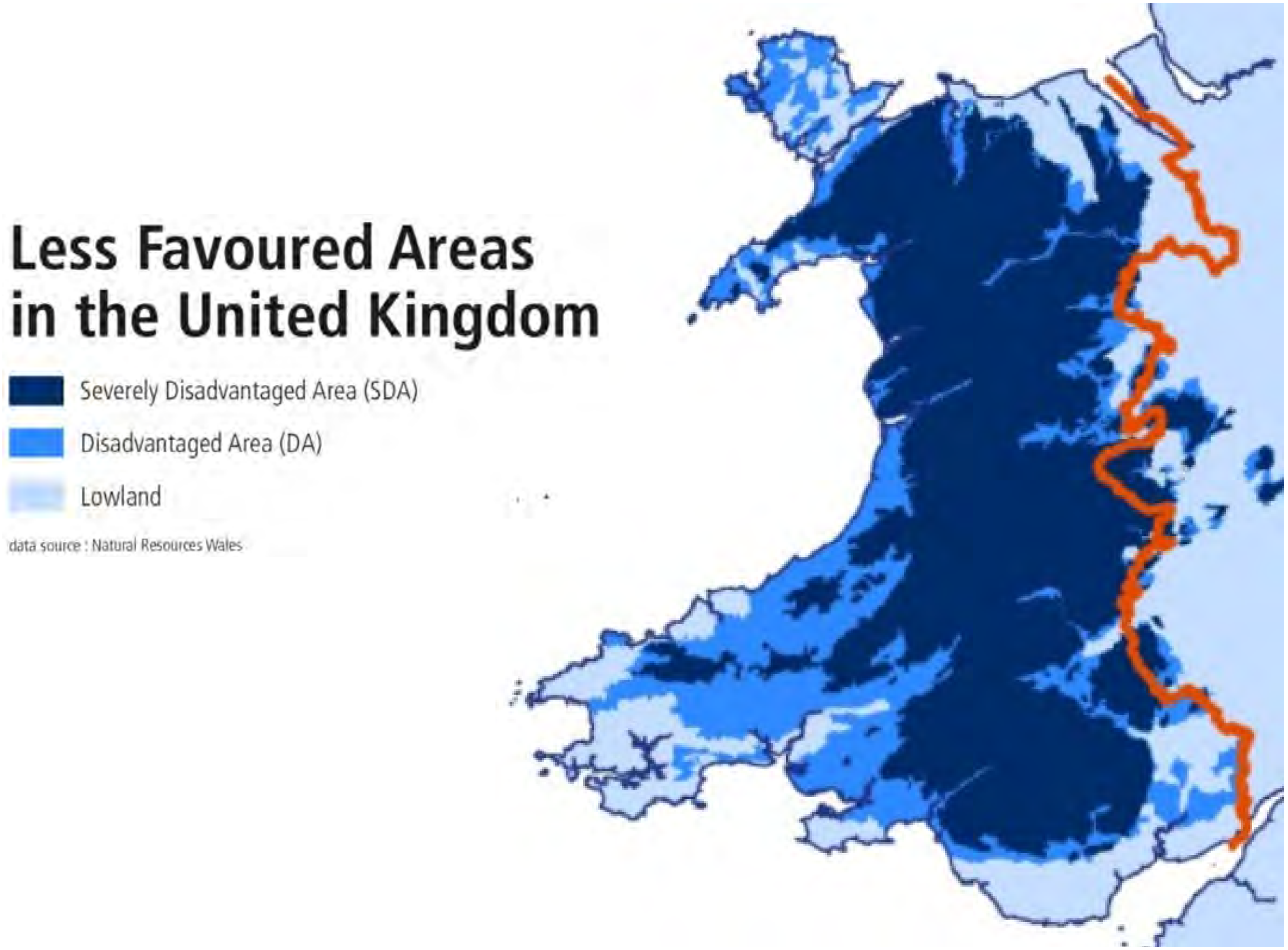
Severely Disadvantaged Areas/ Disadvantaged Areas in Wales



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Glossary: Key Acronyms (IV)

- RFT : Robust Farm Type
  - Robust farm type (used in previous Welsh Farm Practice Surveys).
  - Classes: Cereals; General Cropping; Horticulture; Specialist Pigs; Dairy; LFA Grazing Livestock; Lowland Grazing Livestock and Mixed.
- EFT: ERAMMP Farm Type
  - ERAMMP farm type (used within the IMP) is based on the RFT with additional detail on less favoured areas.
  - Classes: Cereals, General cropping, Dairy, Lowland cattle / sheep, Mixed , Specialist Sheep (SDA), Specialist Beef (SDA), DA various grazing, SDA mixed grazing .
- SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation: Names and acronyms for models within the IMP (see slide 79)

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Glossary: Key Acronyms (V)

- ERAMMP – Environment and Rural Affairs Mapping and Modelling Project.
  - Consortium Project led by the UK Centre for Ecology & Hydrology (UKCEH) and funded by the Welsh Government (WG).
  - Consortium members involved in these slide packs include Cranfield University, ADAS, the British Trust for Ornithology (BTO), eftec, Forest Research (FR) and UKCEH.
- IMP – Integrated Modelling Platform
  - The modelling platform used to produce the results shown in this slide pack. The platform combines the following models which pass data to one another as large multi-parameter data cubes:
    - SFARMOD: Whole farm model
    - ESC: Tree species suitability
    - CARBINE: Forest products, carbon and forest net present value
    - LAM: Land allocation model
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - Woodland habitat connectivity model
    - Ecosystem service models for carbon and water quality
    - EMEP4UK Emulator: health impacts of air pollution
    - Valuation: monetary and non-monetary valuation of public goods

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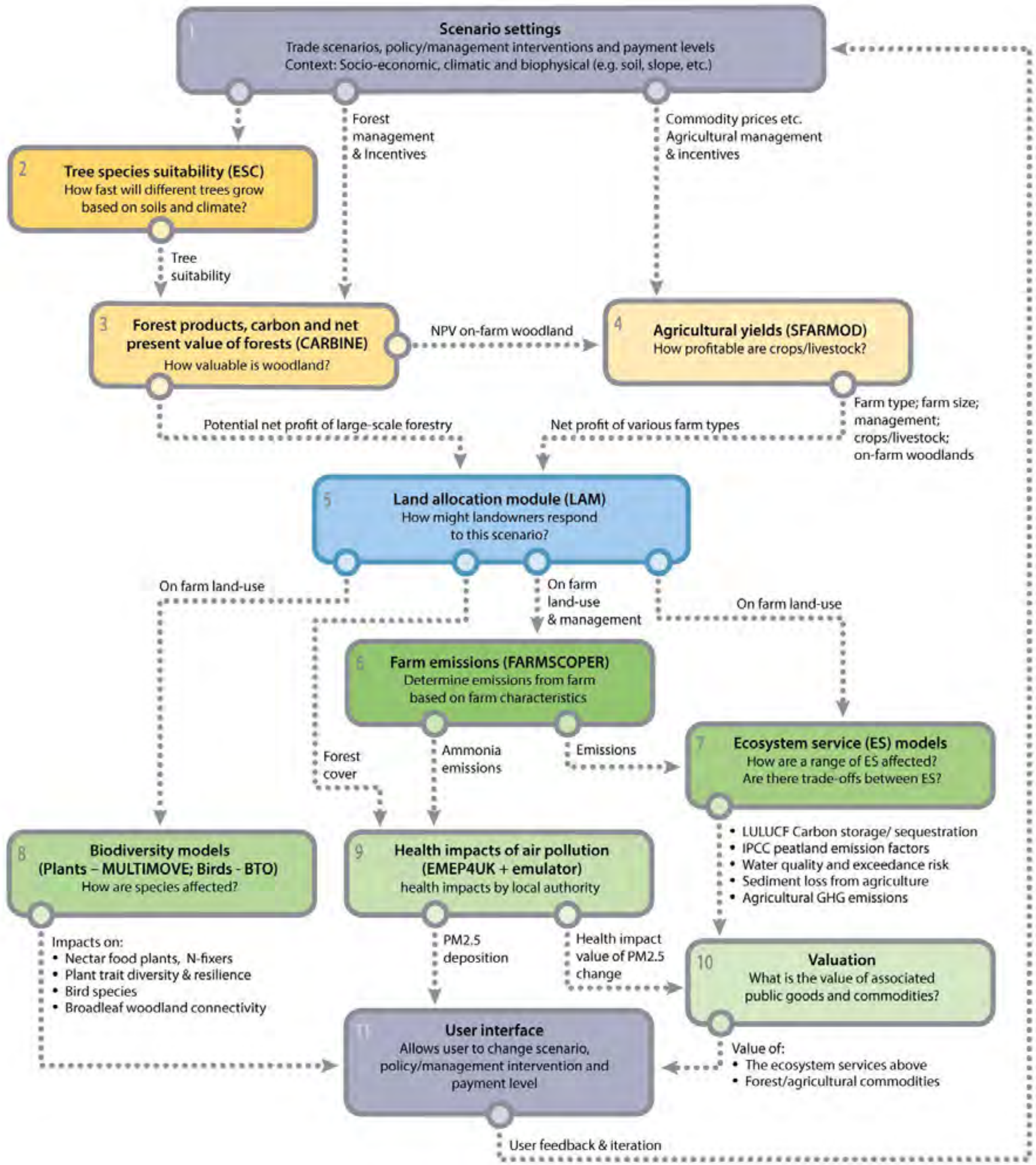
Integrated Modelling Platform schematic



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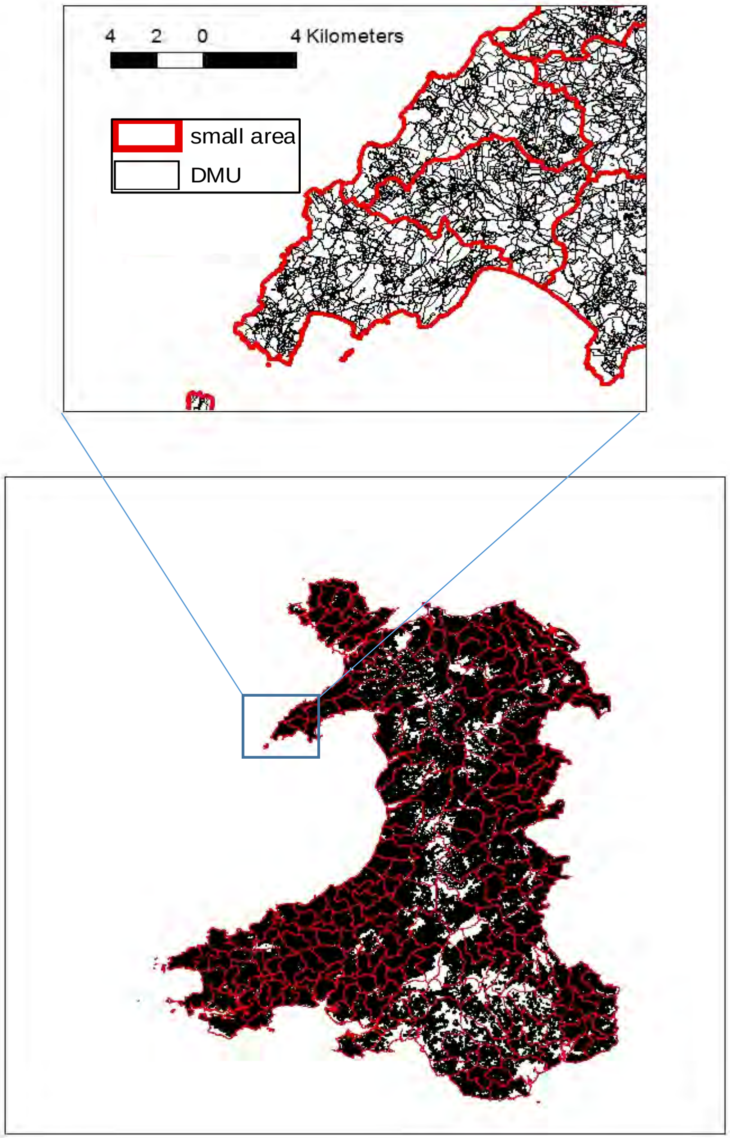
IMP modelling scales



- The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
- The finest spatial resolution used by Sfarmod and the Land Allocation Module (LAM) for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
- A DMU is defined as a managerially homogenous cluster of soil type, rainfall and land cover.
- Results in the slide pack are aggregated to small agricultural areas as findings are more robust at this level.

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4: ERAMMP_IMP_LandUseScenarios_T4_Slidepack

Funded by:

Llywodraeth Cymru
Welsh Government

Canolfan Ecoleg a Hydroleg y DU
UK Centre for Ecology & Hydrology

INTEGRATED MODELLING PLATFORM

Land Use Scenarios (T4)

UK Centre for Ecology & Hydrology

Cranfield University

ADAS

Forest Research

eftec

BTO

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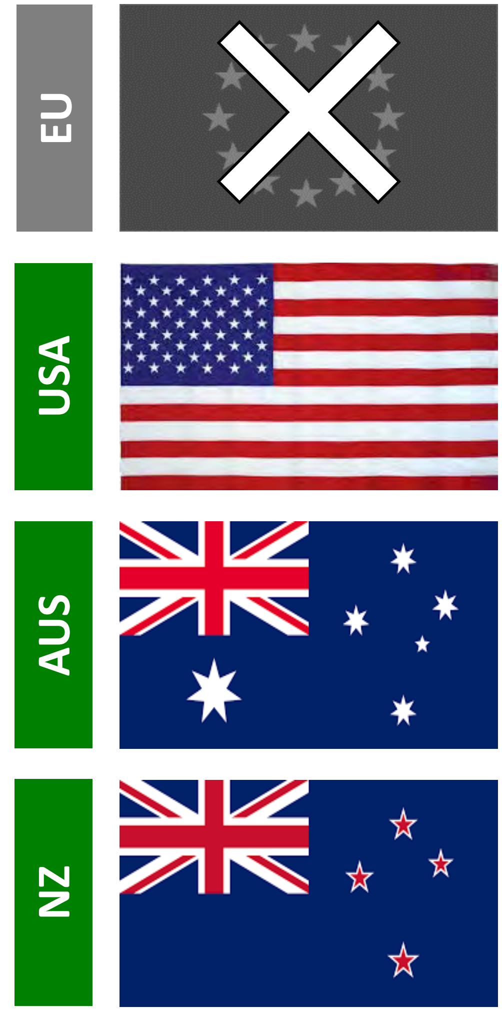
Scenario description (T4)

- Free trade agreements with USA, Australia and New Zealand, but no EU FTA.
- WG held a stakeholder workshop to discuss and quantify changes in farm-gate prices from current figures for milk, lamb and beef:
  - Increase for milk due to increased home consumption and with less EU competition, some competition from traded commodities (butter/cheese), NZ takes trade from Republic of Ireland
  - Beef and lamb come under pressure from Aus and NZ, and beef from USA.
  - UK lamb looses EU market and beef carousel stops
  - Republic of Ireland beef replaced by beef imports from USA, NZ and Aus
- Scenario settings:

	Milk (p/litre)	Beef (£/kg LWT)	Lamb (£/kg LWT)
Baseline (2015)	35	1.85	1.68
T4	**36.8**	**1.39**	**1.26**



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PART 1: Agriculture

Background information

The agricultural models are applied to all full-time farms

	No.	Area (ha)
Full-time	7726	1010891
Spare / Part-time	12738	409150
Total	**20464**	**1420041**

Farm Business Income classes within T4:

As baseline farm type	As alternative farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture
<£6000 p.a.	>£6000 p.a.	Farm under pressure	Likely to change farm type through sale to another enterprise
£6K-£13K	Any amount	Farms staying the same	Able to continue but unlikely to be able to change farm type
>£13000	<£13K +FBI uplift+finance	Farms staying the same	Insufficient economic incentive to change farm type
>£13000	>=£13K +FBI uplift+finance	Farms changes type	Likely to be sufficient economic incentive to change farm type

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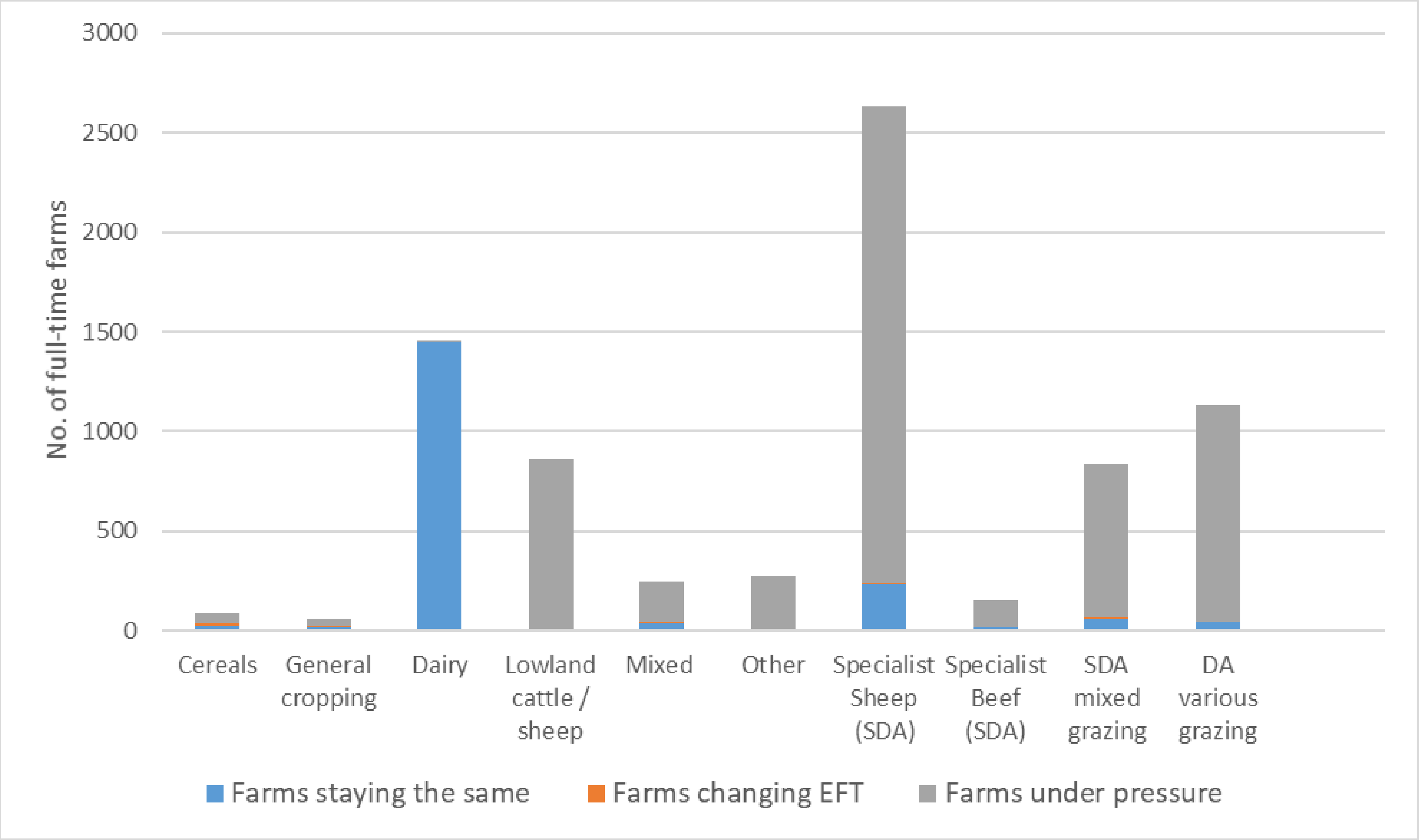
Simulated status of current full-time farms under T4



Baseline number of simulated full-time farms: 7726

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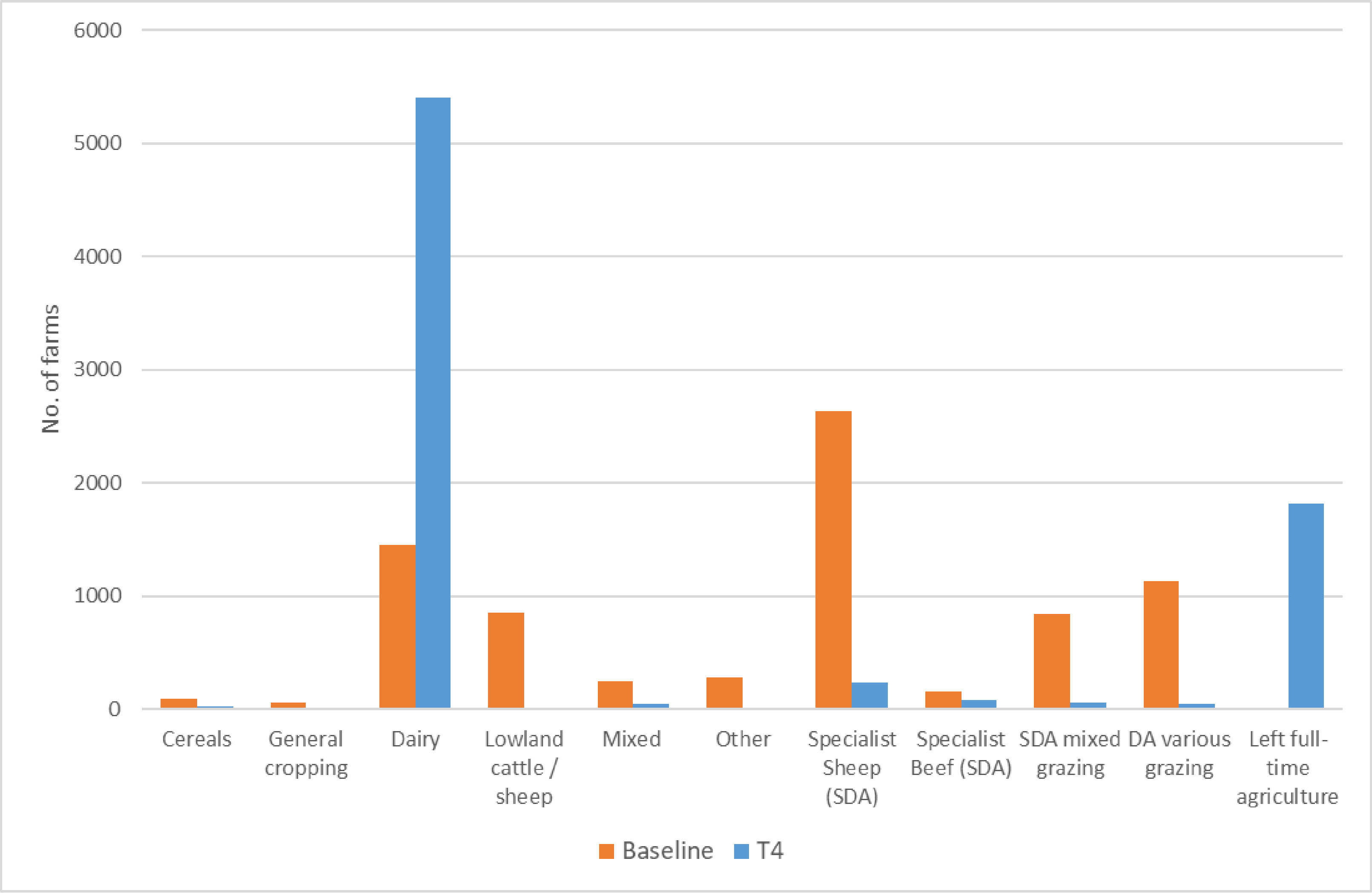
Farm numbers by farm-type (Baseline vs T4)



Total number of simulated full-time farms: 7726 in Baseline; 5911 in T4

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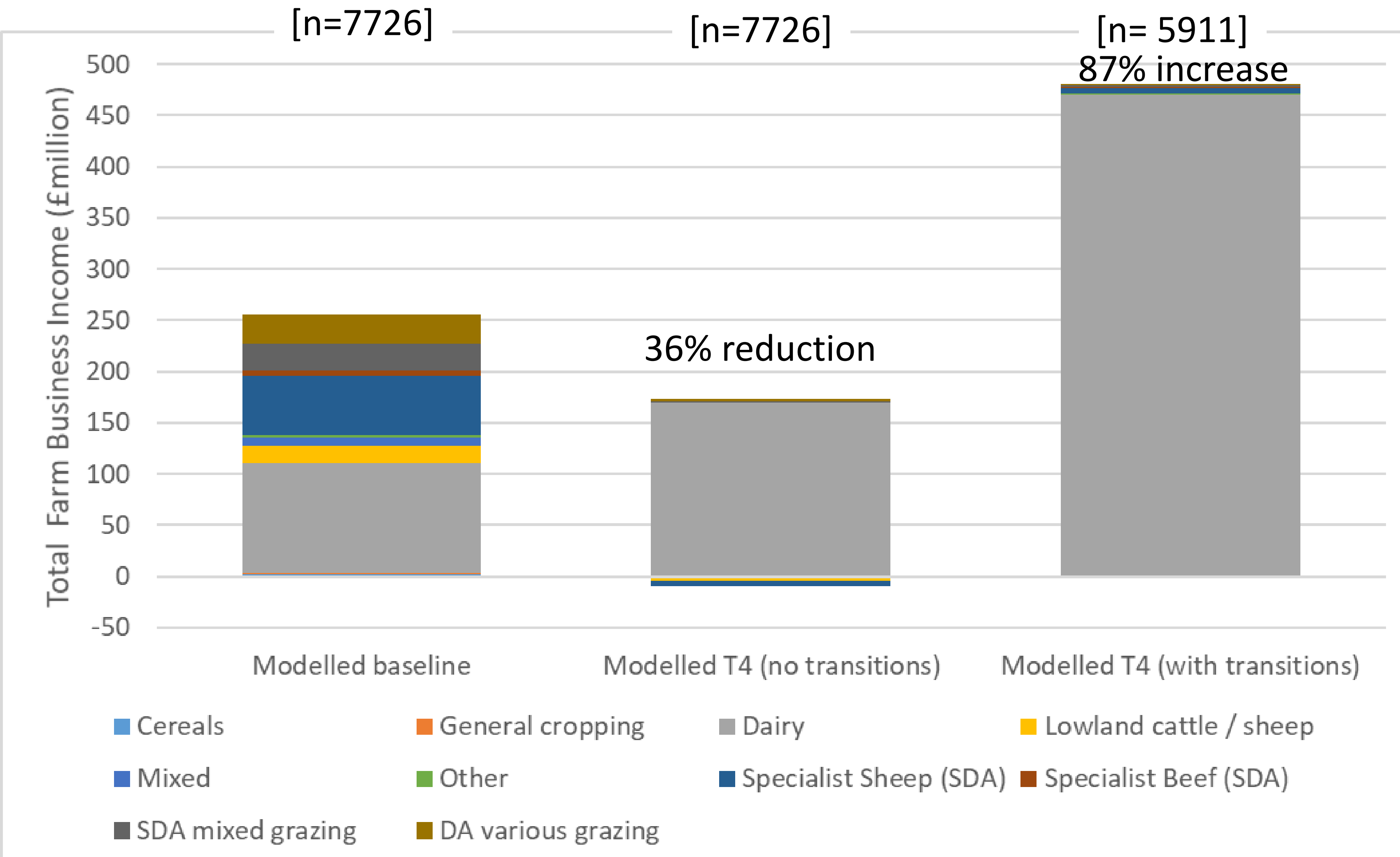
Total simulated Farm Business Income from full-time farms (T4)



Total number of simulated full-time farms: 7726 in Baseline; 5911 in T4

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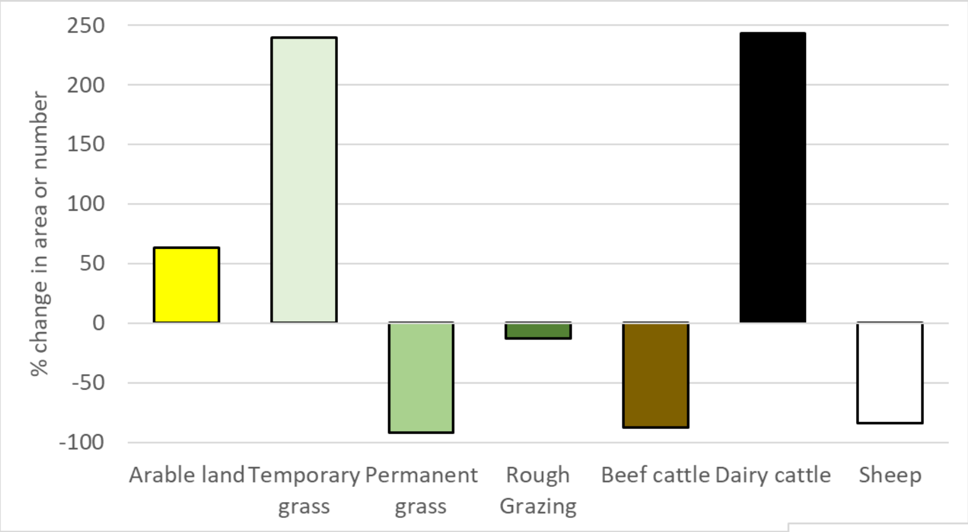
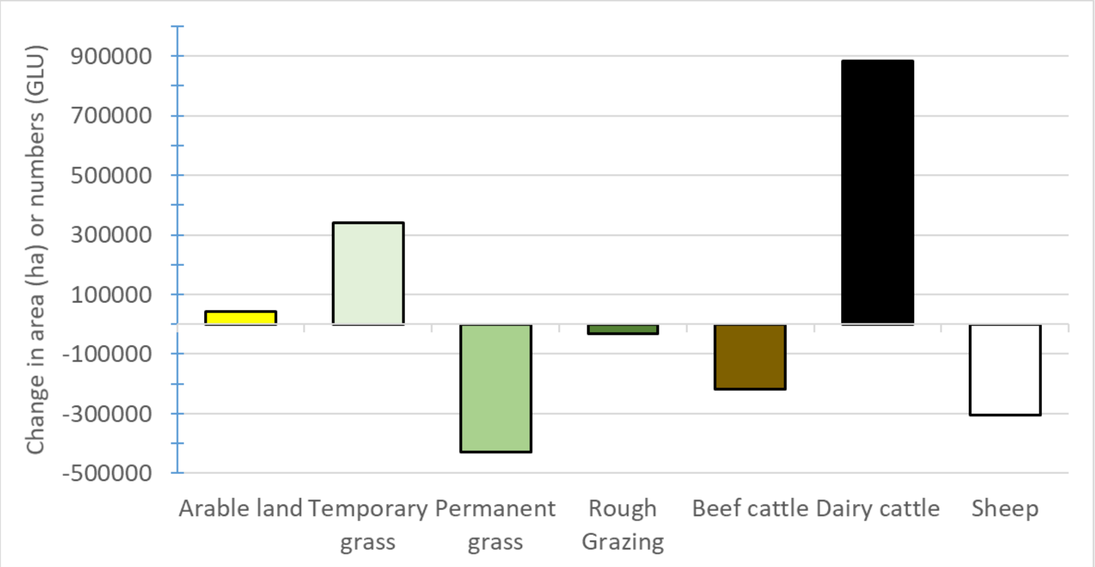
Change in simulated managed land use and stock (T4)



Percentage change (relative to simulated baseline)

Absolute change in simulated areas (ha) and numbers (Grazing Livestock Units)



Simulated farms remaining in full-time agriculture: 5911

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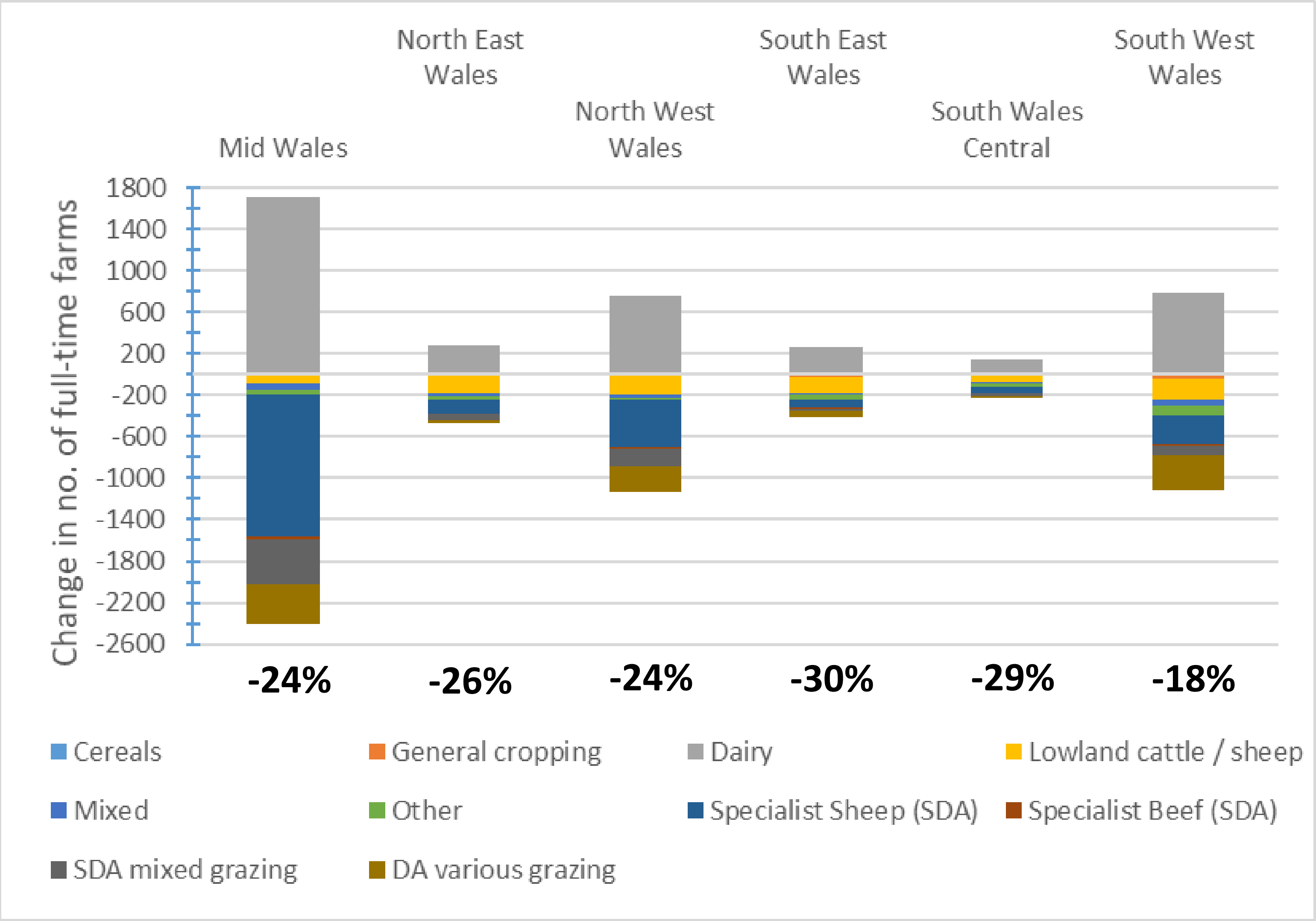
Change in farm numbers by farm-type (T4)



Simulated farms remaining in full-time agriculture: 5911

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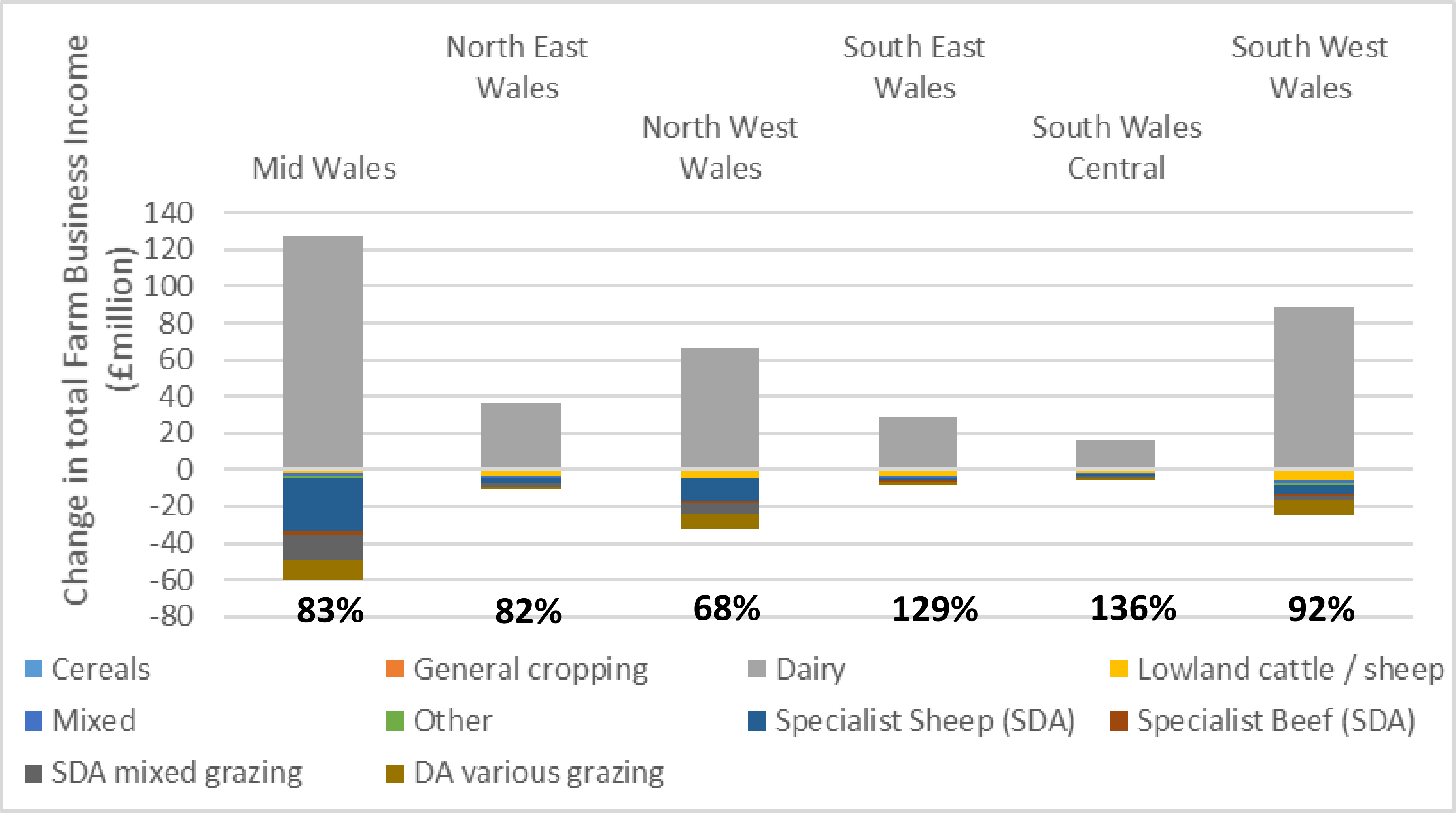
Change in total simulated Farm Business Income from remaining full-time farms (T4)



Simulated number remaining in full-time agriculture: 5911

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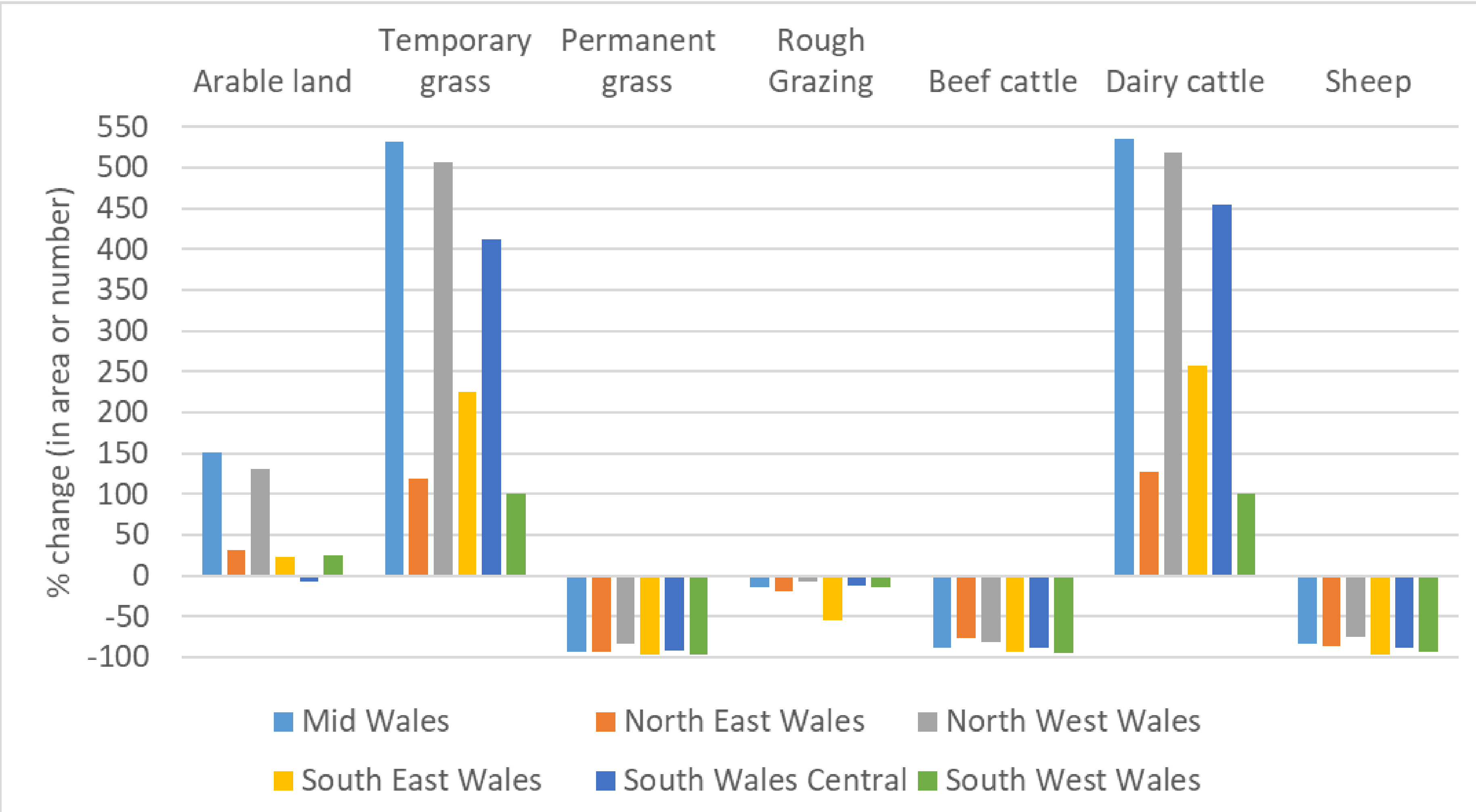
Regional change in land use and livestock (T4)



Simulated number remaining in full-time agriculture: 5911

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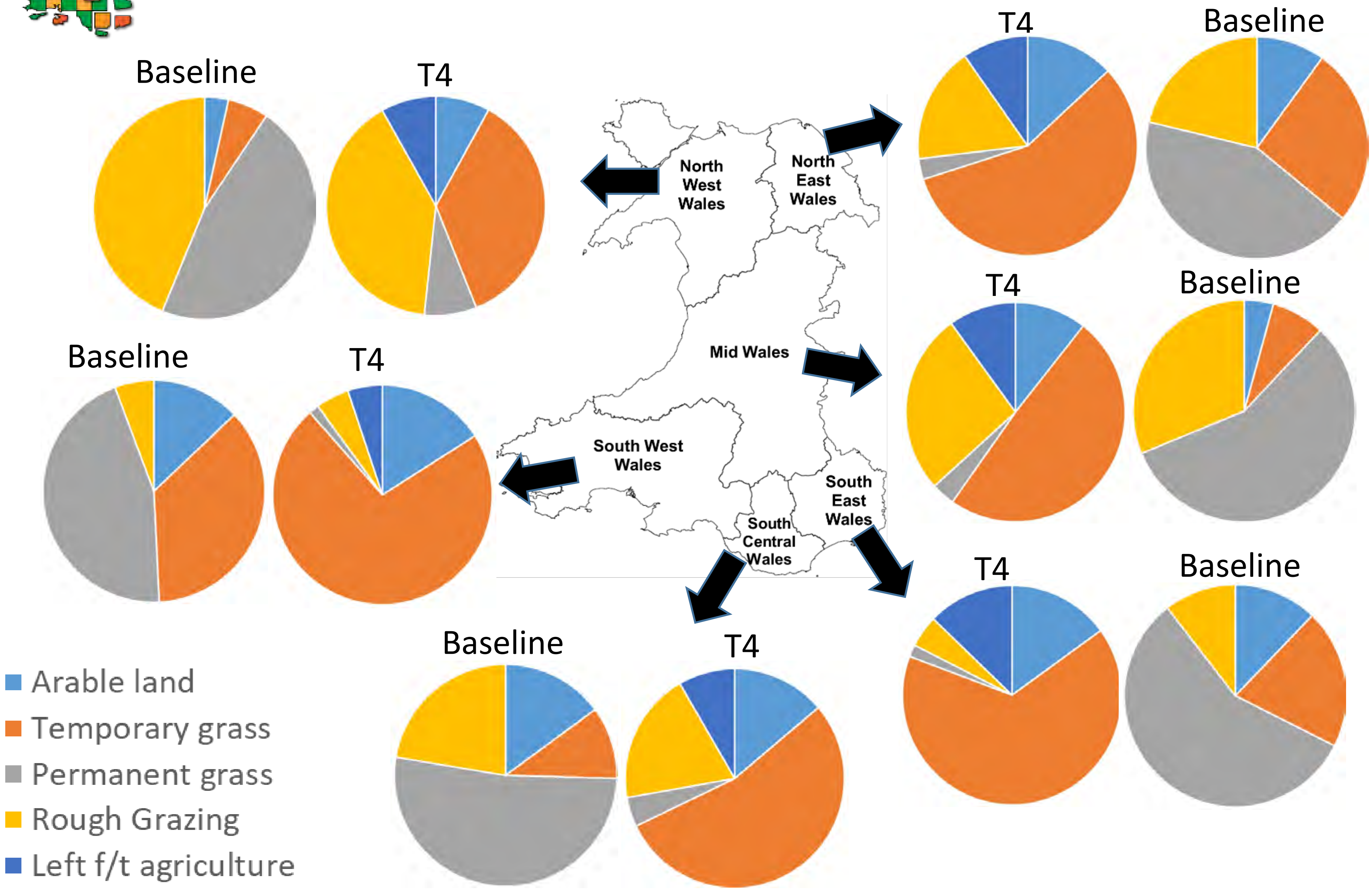
Regional land use proportions in T4



Simulated number remaining in full-time agriculture: 5911

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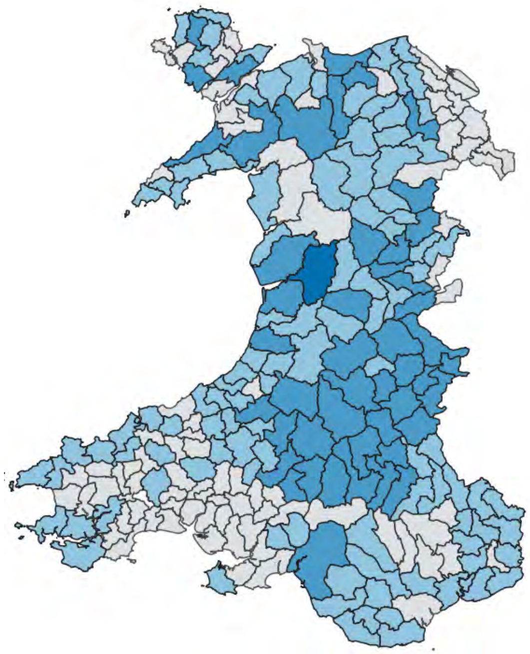
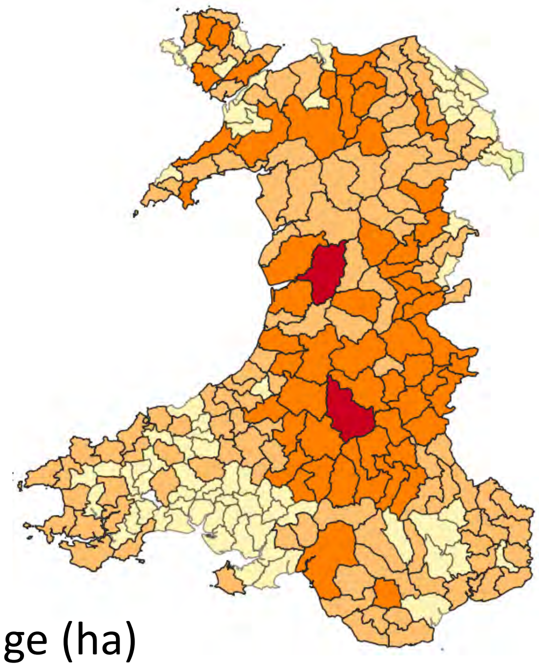
Simulated change in land use (T4)

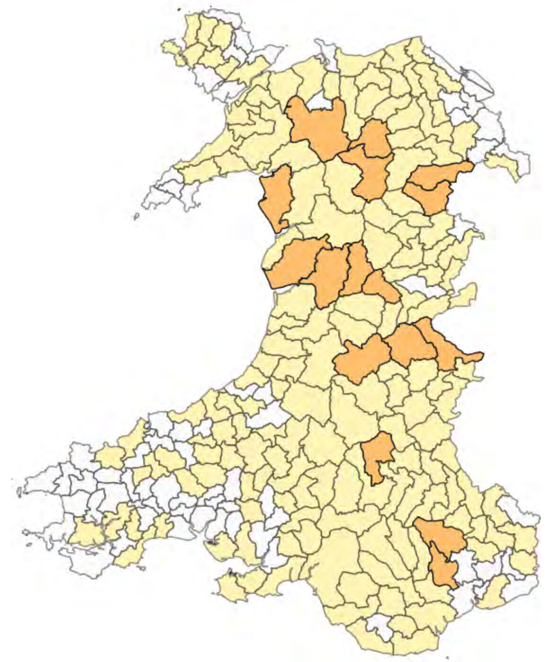
Change in cultivated / temporary grassland



Change in permanent grassland



Change in agricultural area



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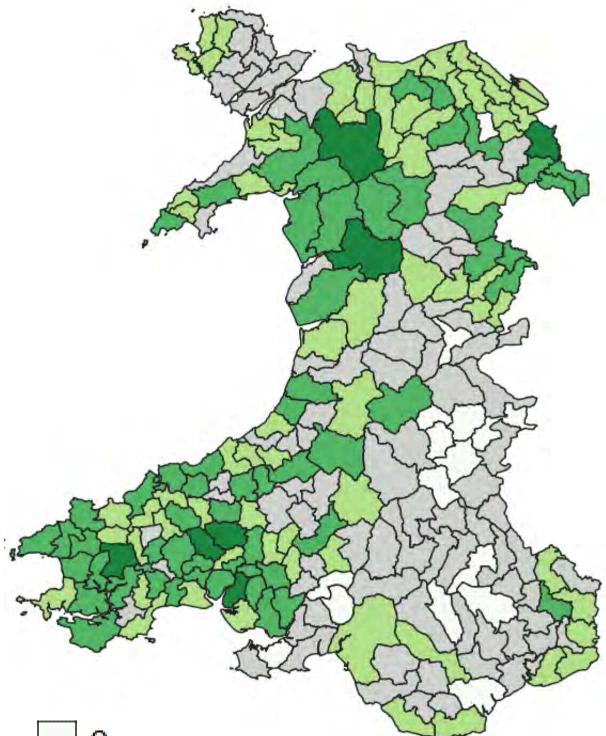
Simulated status of current full-time farms under T4

Farms staying the same

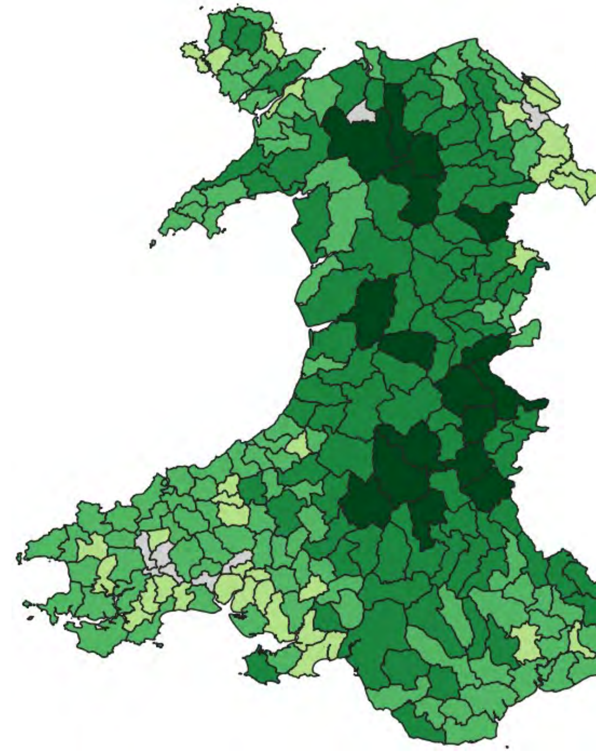


n=1868

Farms changing type

n=49

Farms under pressure



n=5809

- 0
- 1 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- > 50

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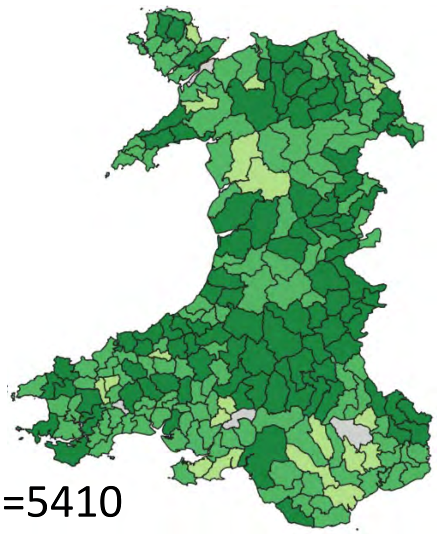
Simulated farm type numbers under T4

Dairy specialists

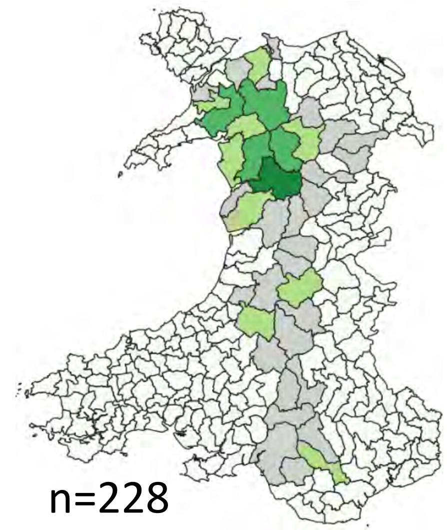


n=5410

Beef specialists

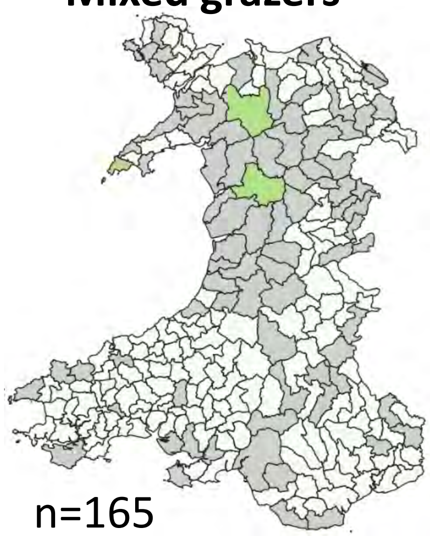
n=73

Sheep specialists



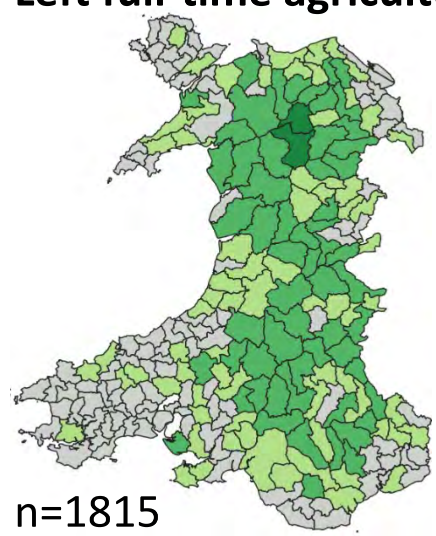
n=228

Mixed grazers

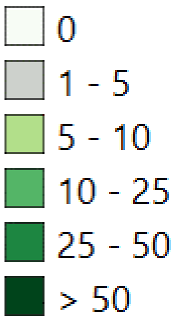


n=165

Left full-time agriculture



n=1815



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Farms leaving full-time agriculture

Farm Business Income classes within T4:

As Baseline Farm type	As alternative Farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture

A farm that is unable to achieve a full-time annual FBI of £6,000 may:

- Implement cost savings and struggle on;
- Transition to part-time farming, to enable increased non-agricultural income though diversification and / or off-farm employment;
- Leave agriculture in the short-term
- Leave agriculture in the longer-term (e.g. due to retirement / inter-generational change)

As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested

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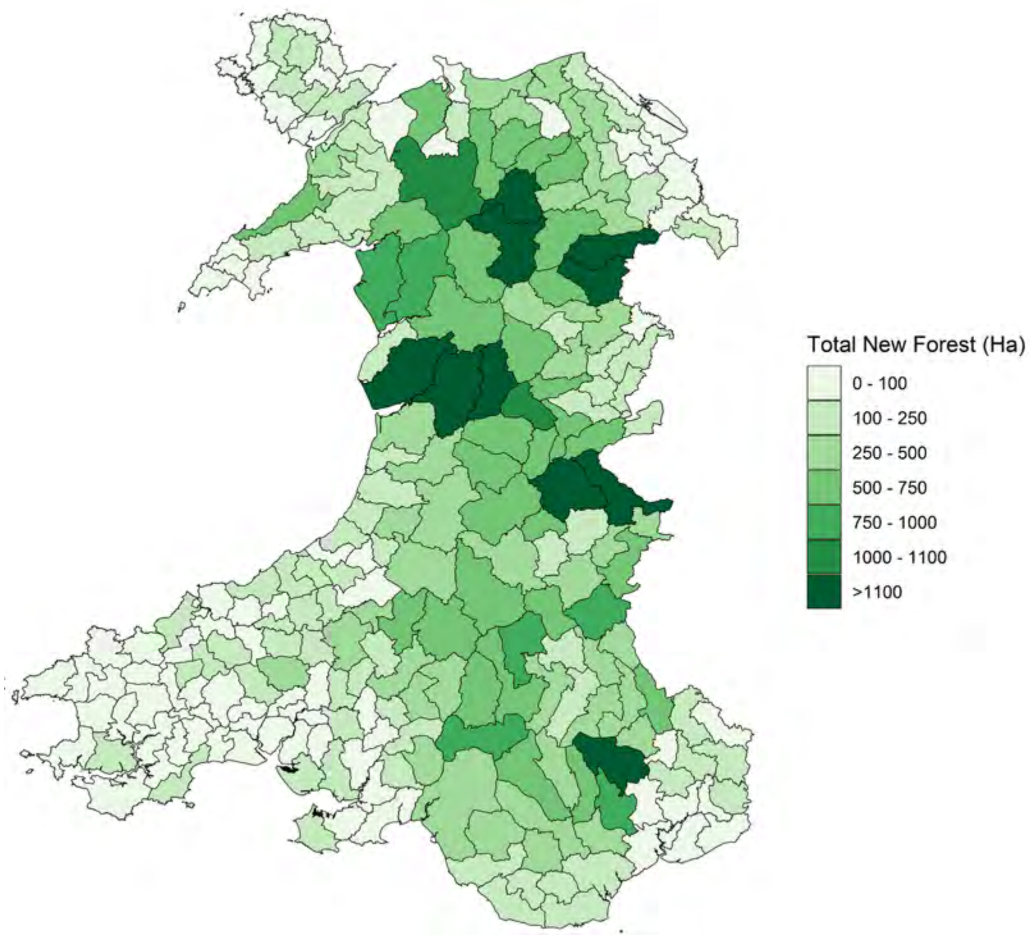
Simulated new woodland on farms leaving full-time agriculture (T4)



- Total new forest area (ha) from afforestation and natural regeneration.
- Totals largely driven by afforestation: 51,925 ha.
- Afforestation will only occur on abandoned land that will generate a positive net present value (NPV) from forestry.

Total area of new forest: 69,605 ha
(55% increase for modelled >1 FTE farms)

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PART 2: Biodiversity

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Biodiversity summary – Birds (T4)

- Increases and decreases in bird population sizes are an inevitable consequence of changes in land use.
- By **2050**, under the T4 scenario, increases in the cover of maize, rotational grass and coniferous woodland are simulated.
- Overall, a greater number of species are simulated to decline in the T4 scenario than increase in population size.
- Woodland species are simulated to perform better under this scenario, with declines more common in farmland and generalist species.
- Patchy declines are simulated across the country, particularly in the North-East, Mid-Wales and Anglesey.

Eaton, Mark, et al. "Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man." British Birds 108.12 (2015): 708-746.

Bladwell et al. “The state of birds in Wales 2018.” (2018). The RSPB, BTO, NRW and WOS. RSPB Cymru, Cardiff

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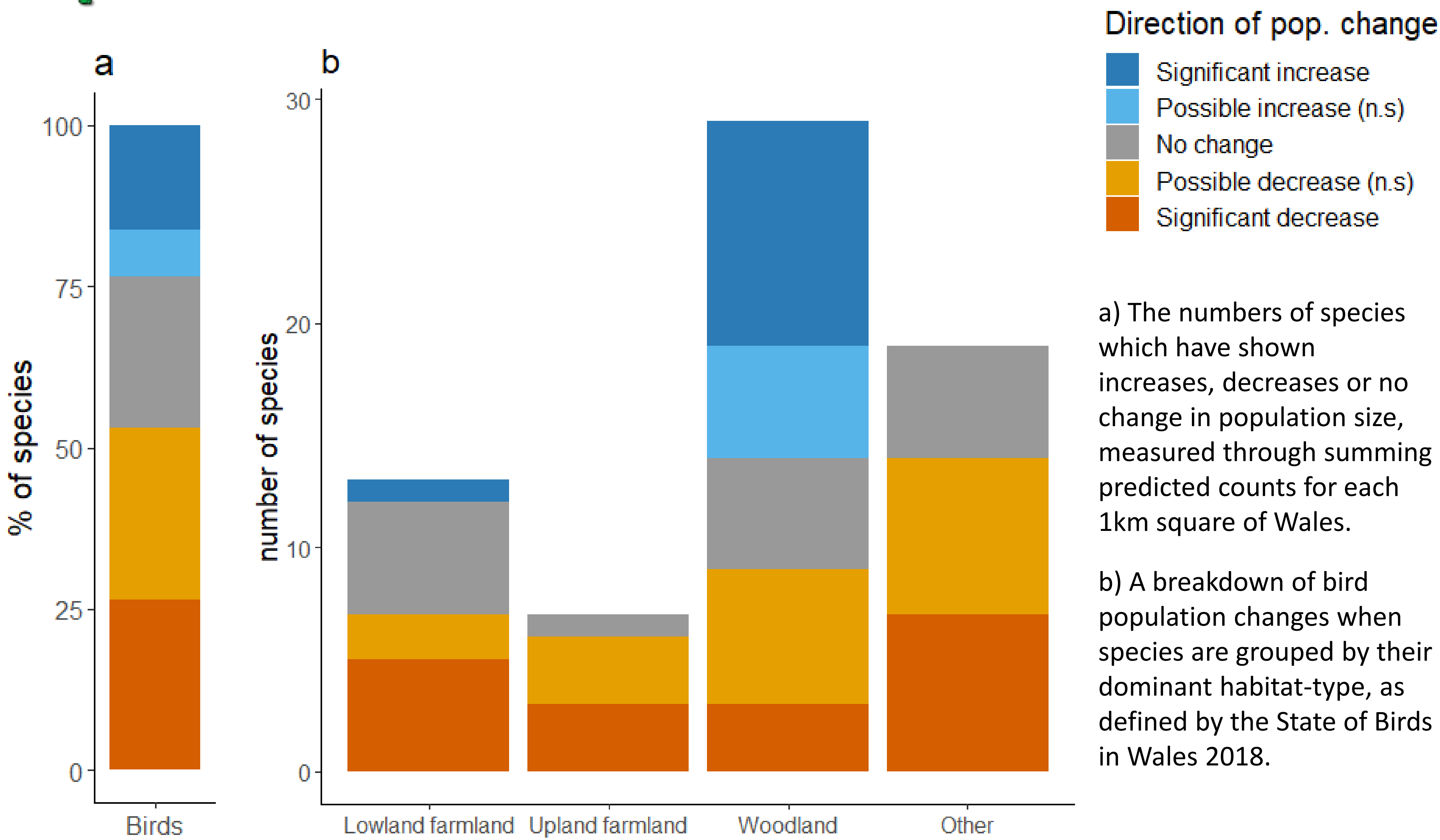
Overall bird population change in T4



a) The numbers of species which have shown increases, decreases or no change in population size, measured through summing predicted counts for each 1km square of Wales.

b) A breakdown of bird population changes when species are grouped by their dominant habitat-type, as defined by the State of Birds in Wales 2018.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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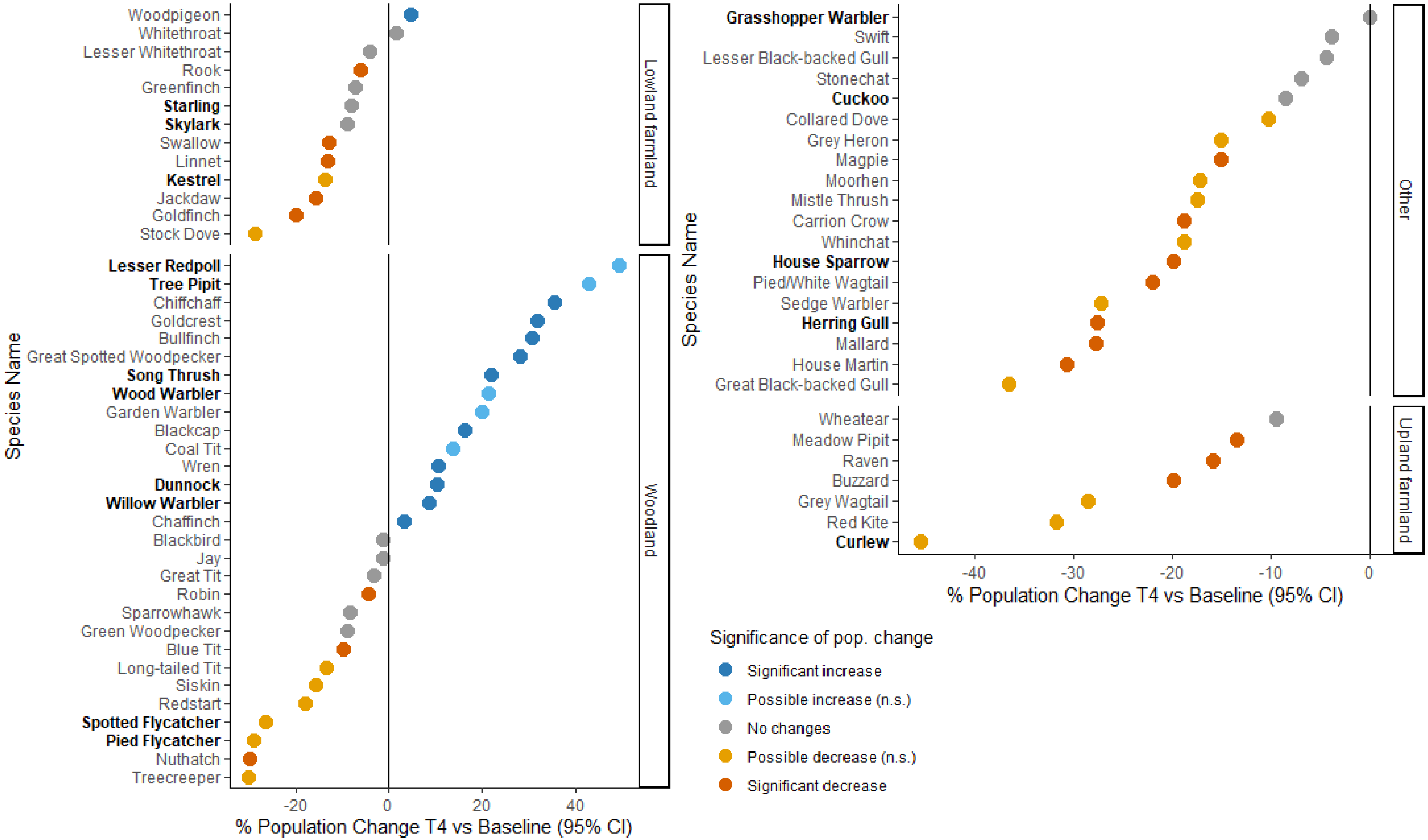
Population changes per bird species in T4



- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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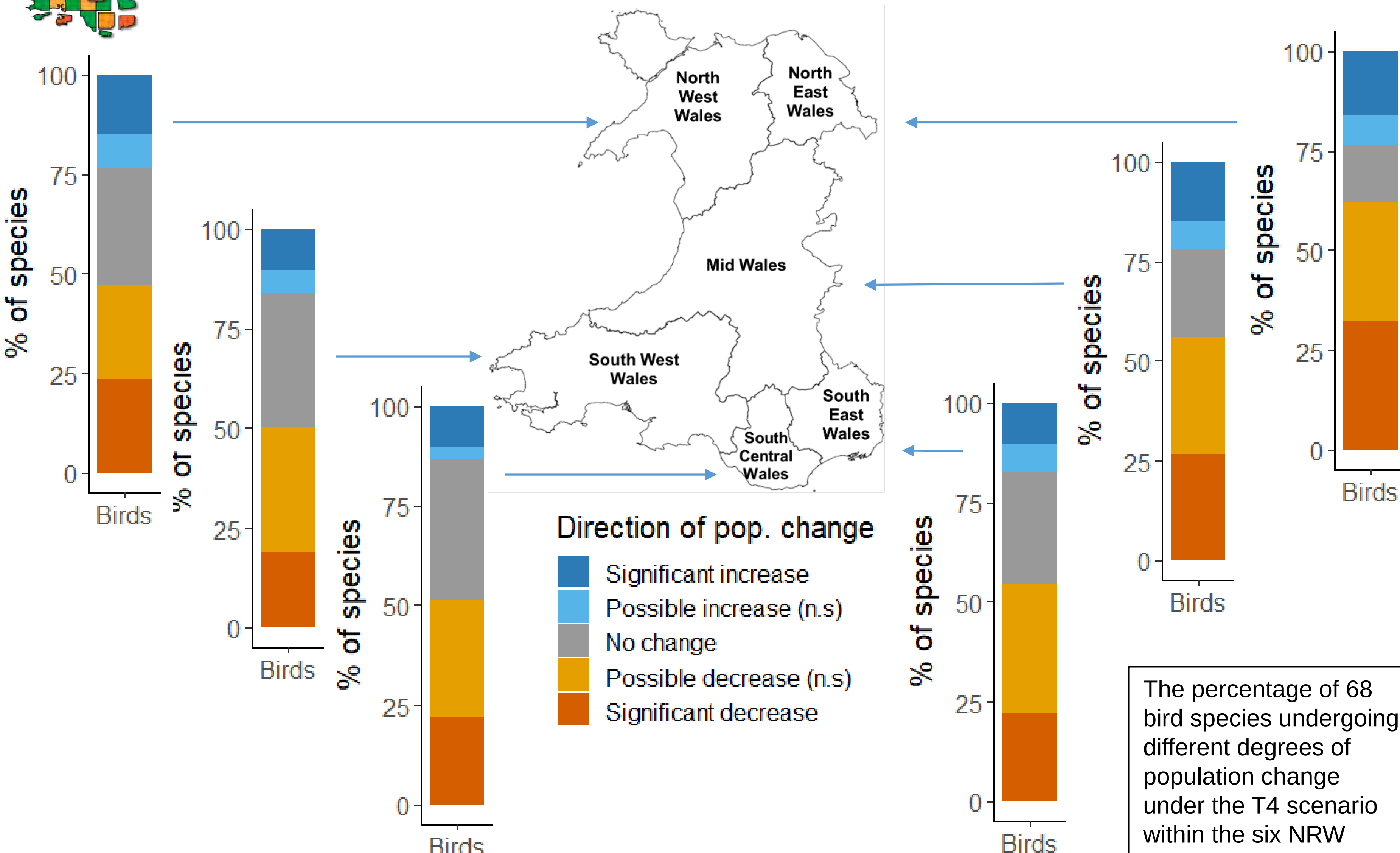
Regional bird population impacts in T4



The percentage of 68 bird species undergoing different degrees of population change under the T4 scenario within the six NRW regions.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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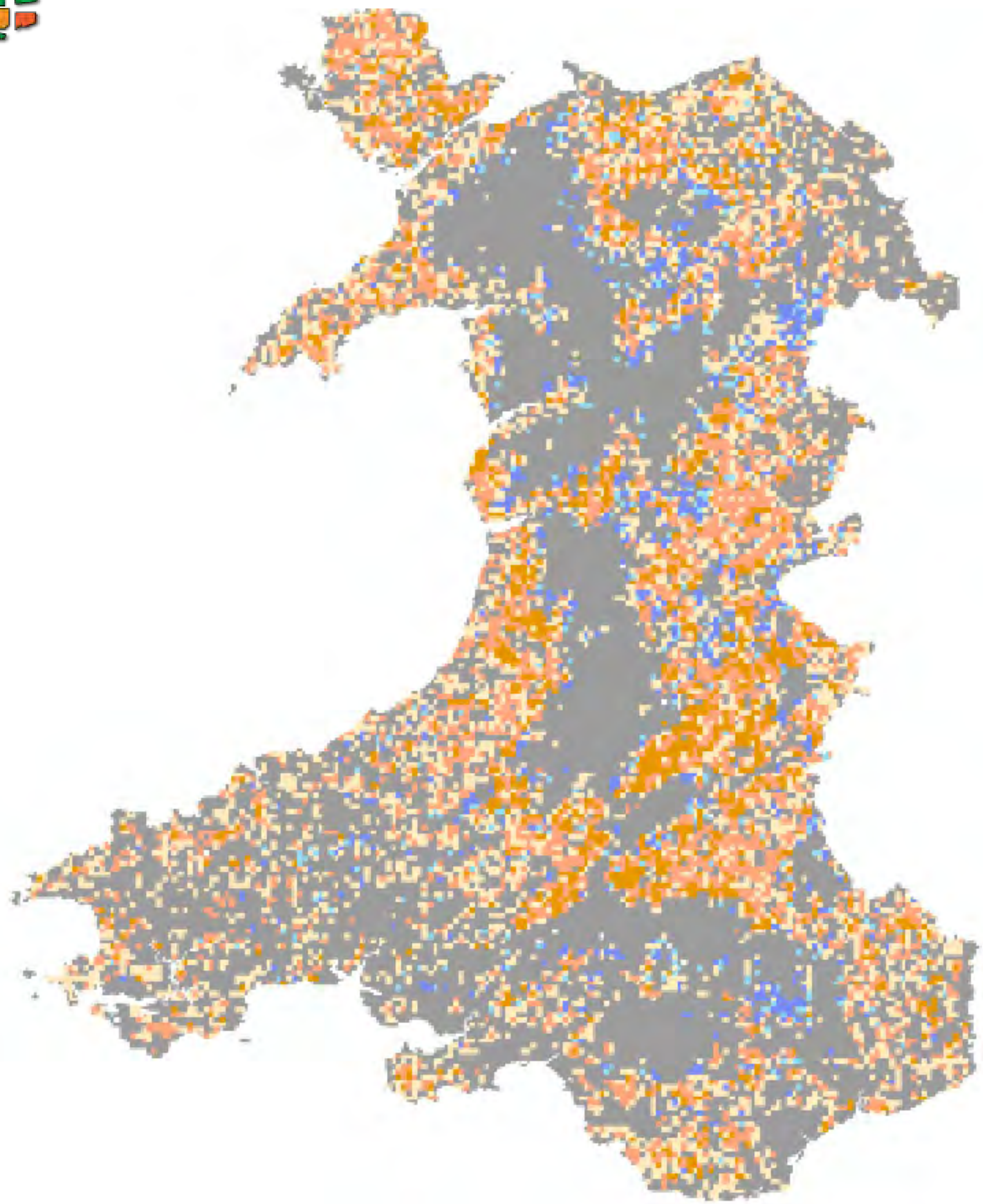
Local bird species change in T4



Ratio of species change

- +3 to +18
- +1 to +2
- 0
- -1 to -8
- -9 to -20
- -20 or greater

The ratio of 68 bird species undergoing significant increases *vs* decreases for each 1km square of Wales. Bolder colours are indicative of greater change. Note that under this metric, any square seeing large, but equal numbers of increases and decreases will be represented by grey colouration, identical to that of a square seeing no changes.

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Biodiversity summary – Plants (T4)

- Overall, simulated shifts between agricultural sectors are intermediate between T1 and T2 and very similar to T3. The shift is toward temporary grass and dairy, and away from sheep and permanent grass; on balance an intensification trajectory but accompanied by a projected possible movement out of agriculture in the SDA areas largely impacting specialist sheep. The result is a shift in land use to new forestry and natural succession, but where the size of this shift is significant though not as great in terms of area as T1.
- The result is a degree of polarisation. Woodland and semi-natural habitat specialists are simulated to increase if shade-tolerant, while grassland, wetland and heathland specialists see reduced suitable niche space in areas that shift from permanent to more intensive temporary grassland. These patterns are broadly similar across all regions, except for South Central Wales where very little change is estimated across all three groups.
- Summary: Our modelling shows that the suitability of ecological conditions across much of Wales increases or decreases depending on the balance of intensification related to agricultural activity.

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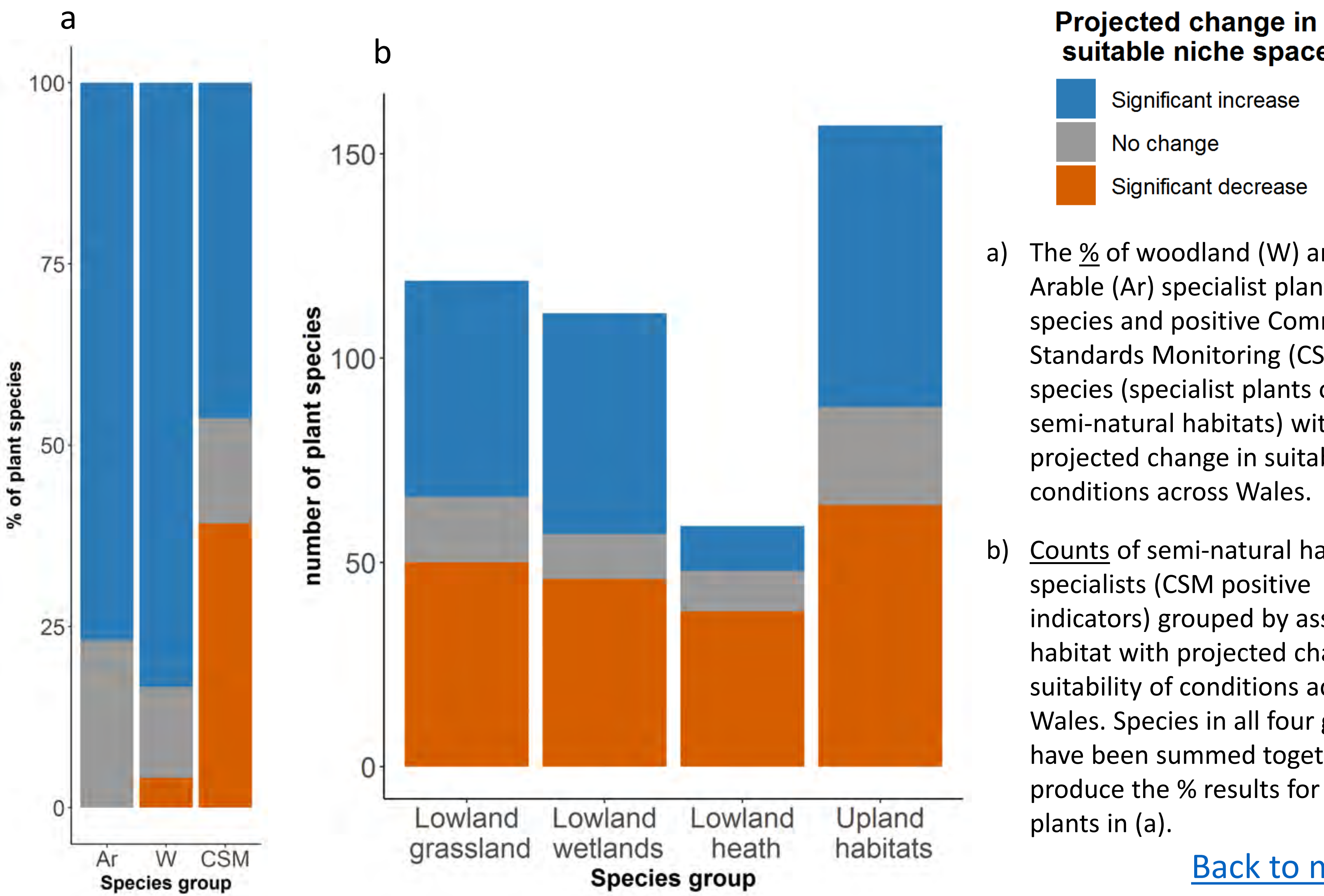
National change in habitat suitability for plants over 25 years (T4)



a) The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales.

b) Counts of semi-natural habitat specialists (CSM positive indicators) grouped by associated habitat with projected change in suitability of conditions across Wales. Species in all four groups have been summed together to produce the % results for CSM plants in (a).

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% change in habitat suitability per plant species in T4 (Examples)

Woodland specialists for Wales [1]

Latin	% change in suitability	Sig change
Sorbus aucuparia	2.2	+
Ilex aquifolium	2.1	+
Oxalis acetosella	1.0	+
Campanula latifolia	0.8	+
Allium ursinum	0.7	+
Luzula sylvatica	0.0	ns
Potentilla sterilis	-0.2	ns

Arable specialists [2]

Latin	% change in suitability	Sig change
Polygonum aviculare	1.3	+
Veronica arvensis	0.7	+
Geranium molle	0.3	+
Anagallis arvensis	0.2	+
Lamium purpureum	0.2	+
Papaver rhoeas	0.0	+
Anthemis cotula	0.0	ns

Excerpts from lists of species with projected change in suitability of ecological conditions across Wales. Click here to view the modelled niche of each species in Britain.

Semi-natural habitat specialists (CSM +ve indicators)

Latin	% change in suitability	Sig change
Agrostis capillaris	-15.5	-
Leucanthemum vulgare	-12.5	-
Festuca rubra	-10.2	-
Galium saxatile	-6.9	-
Veronica officinalis	-1.3	-
Euphrasia officinalis agg.	-0.7	-
Briza media	-0.6	-
Epilobium palustre	-0.5	-
Molinia caerulea	-0.5	-
Angelica sylvestris	-0.4	-
Pimpinella saxifraga	-0.3	ns
Betonica officinalis	0.0	-
Silene dioica	0.3	ns

[1] Glaves D et al. (2009) A Survey of the Coverage, Use and Application of Ancient Woodland Indicator Lists in the UK. Appendix 1. Hallam Environmental Consultants, Sheffield.
[2] Walker, K.J. (2018) Vascular plant 'axiophyte' scores for Great Britain, derived from the assessments of the vice-county recorders of the Botanical Society of Britain and Ireland (May 2016). NERC Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/af2ac4af-12c6-4152-8ed7-e886ed19622b

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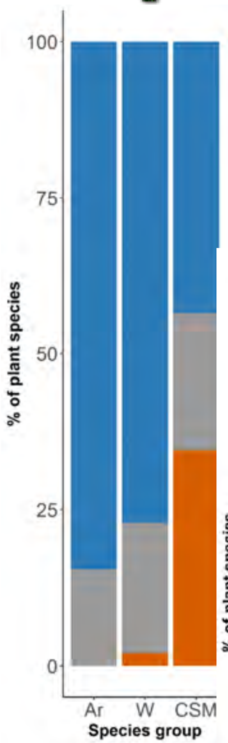
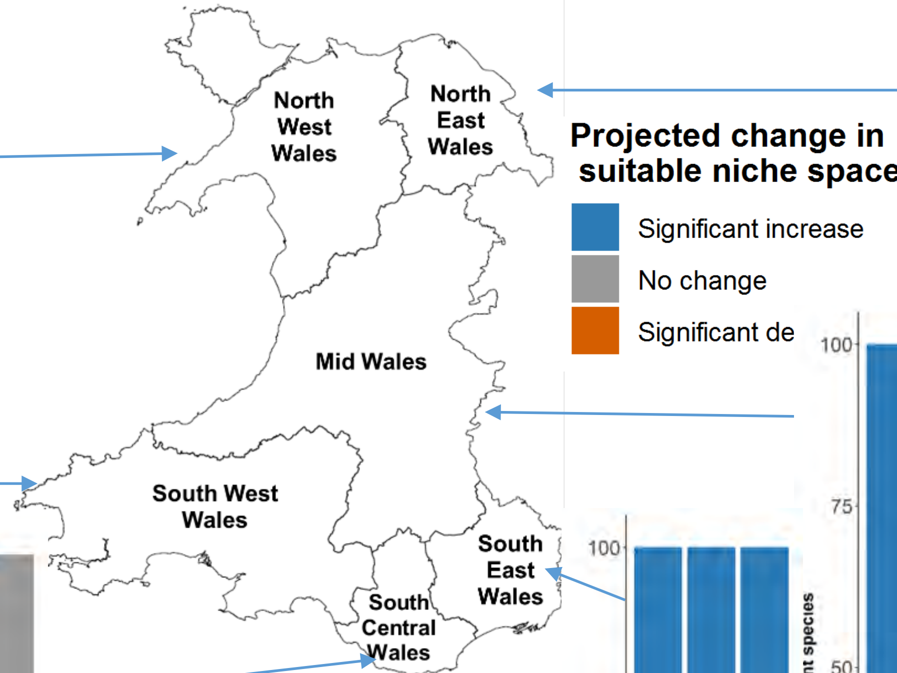
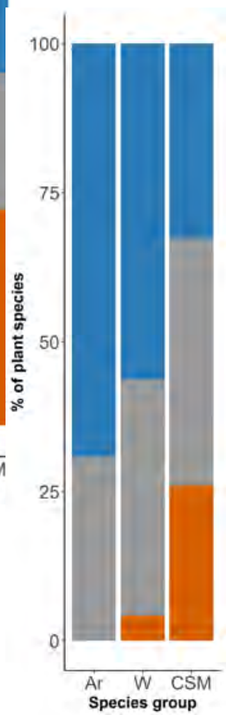
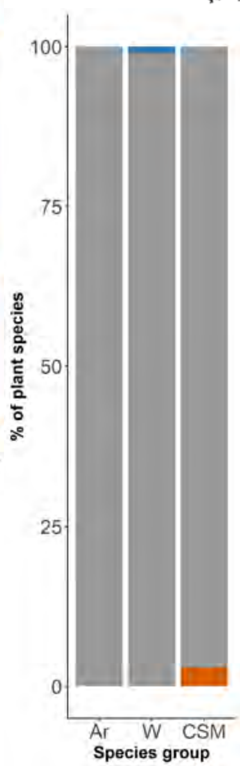
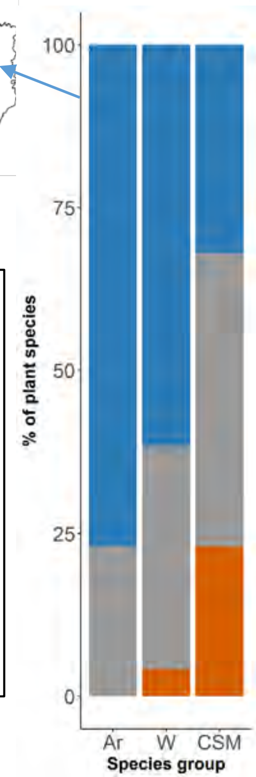
Regional impacts on plant species in T4

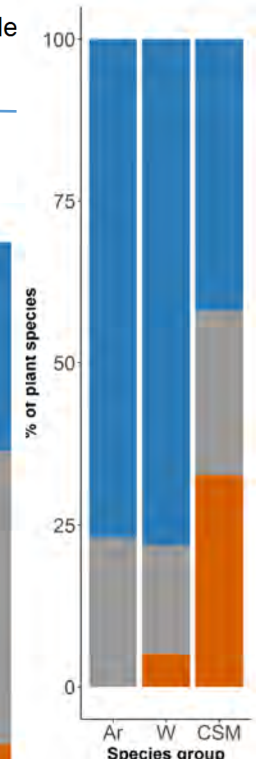


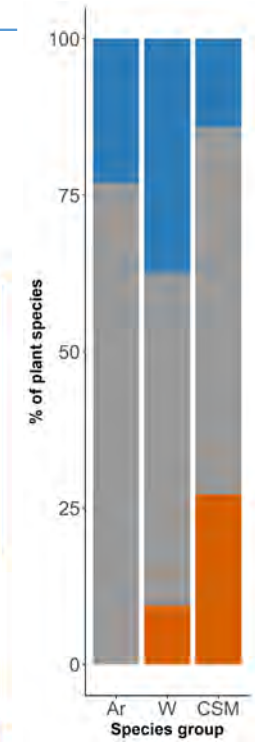












The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales under T4.

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Woodland habitat connectivity: Background information

- Woodland connectivity was modelled using a simple approach based on the distance species can travel (dispersal distance) and minimum habitat area requirements (patch size).
- Land within the dispersal distance of more than one patch could connect those patches if trees were planted.
- We identified a range of parameter combinations from the literature and applied these for Wales, broken down into NRW Area Statement regions.
- Baseline woodland was assigned using NFI data, combined with LCM2017, and data on woody linear features.

Dispersal distance/ patch size	**100m: snails**	**200m: woodland specialist plants**	**500m: invertebrates**	**1km: max. for snakes; amphibians; moths**	**2km: max. for woodland flora/fauna**
1 ha: low area requirements	not modelled	modelled	modelled	not modelled	not modelled
10 ha: high area requirements	not modelled	modelled	modelled	not modelled	not modelled
40 ha: NE recommended minimum size for wildlife site	not modelled	modelled	modelled	not modelled	modelled

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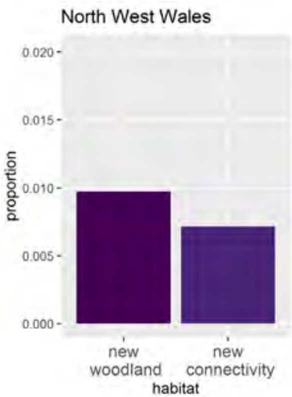
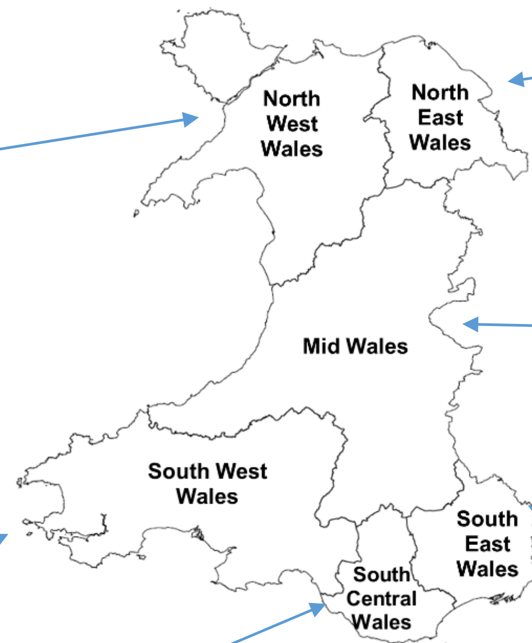
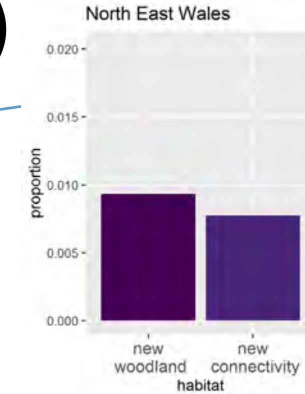
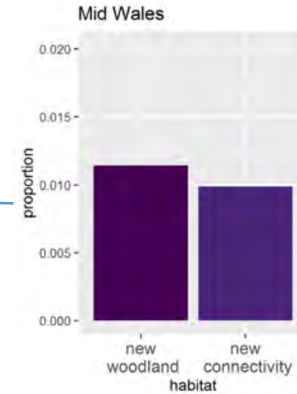
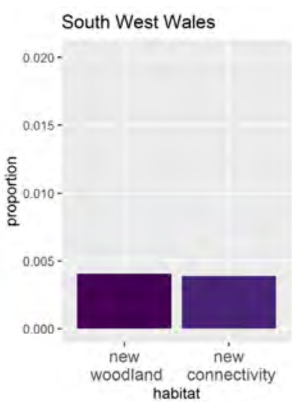
Woodland habitat connectivity: Regional variation in opportunity and predicted change (T4)

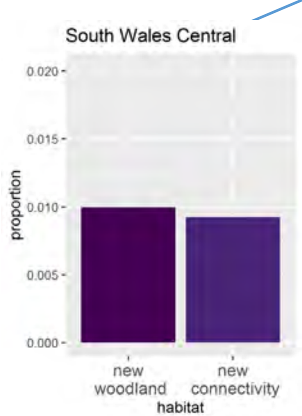


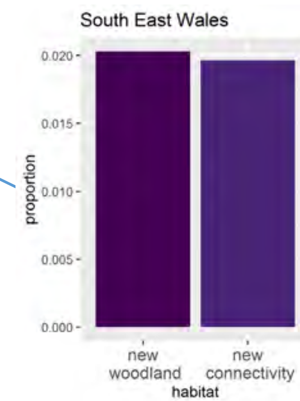












Most of the new woodland increases connectivity for at least one of our species type groups

- Total area new habitat woodland (ha)
- Total area providing increased connectivity

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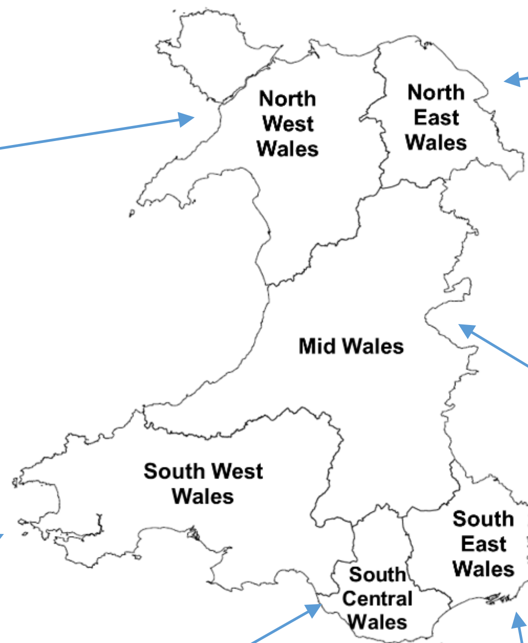
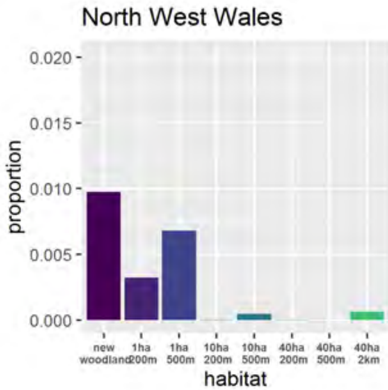
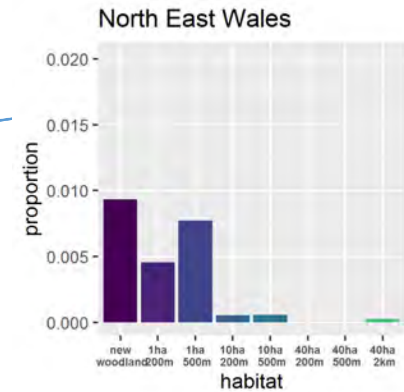
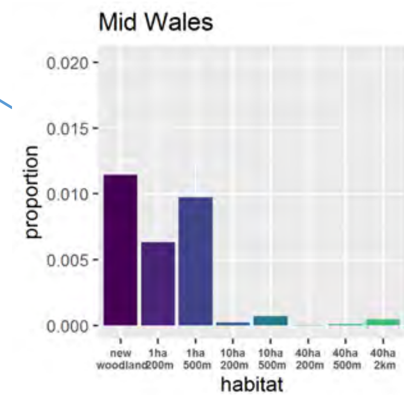
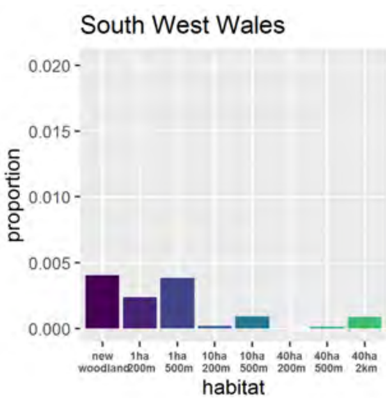
Breakdown of woodland connectivity type in NRW regions (T4)

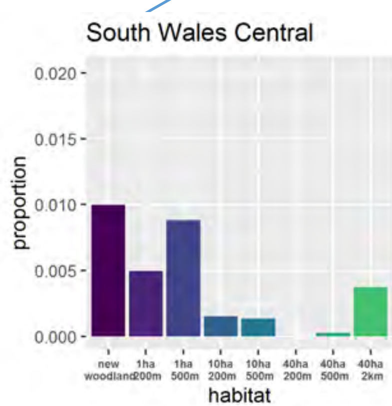


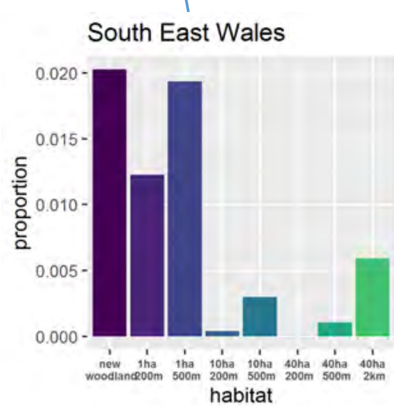












Connectivity increase:

- New woodland habitat
- 1ha 200m
- 1ha 500m
- 10ha 200m
- 10ha 500m
- 20ha 200m
- 40ha 500m
- 40ha 2km

PART 3: Ecosystem Services

3a: Carbon

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Carbon summary:
Stocks and GHG emissions (T4)

(Note: Negative numbers indicate sequestration or avoided emissions)	**Increased emissions or losses of carbon by the year:**		
Inventory category:	**2025**	**2050**	**2100**
Losses from carbon stocks in Land use change and forestry + harvested wood products (4 A, B, C & G) (KtCO2eq)	11,630	18,515	14,696
Additional emissions from wetlands (4D) flux (KtCO2eq)	-85	-510	-1,361
Additional agricultural GHG flux (KtCO2eq)	19,632	117,790	314,106
TOTAL	31,177	135,795	327,441

- Overall, a **reduction in C stocks by 2100**, alongside an **increased agricultural GHG emissions** is simulated for the T4 scenario, creating a **net increase in atmospheric GHGs**.
- Modelled increase in greenhouse gas emissions associated with changes in livestock and nutrient inputs dominates the overall C budget, greatly exceeding the predicted emissions from carbon loss from vegetation and soils associated with agricultural land use change (LULUCF 4 A, B, C & G).

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Carbon stock and change in LULUCF categories (T4)

This table compares Carbon stock and change in the LULUCF categories:

LULUCF category	Baseline	Change to 2100
Cropland and Grassland (4B + 4C)(Kt) C	173,399	Loss of: 13,630 (Kt) Gain of: 127 (Kt)
Forest Land (4A) (Kt)C	Baseline woodland C data are not available	Gain of: 7,341 (Kt)
Harvested Wood products (4G) (Kt) C		Gain of: 2,153(Kt)

- Carbon in cropland and grassland systems (LULUCF category 4B and 4C) is simulated to reduce in the T4 scenario, due to conversion of grassland to arable/grass rotation.
- There are also smaller simulated gains on land going out of agriculture.
- Some gains in C storage are simulated for forest land and harvested wood products related to agricultural land that is converted to woodland. Note, this outcome is strongly dependant on the small area of new woodland planting as modelled here, based on planting on former agricultural land with net positive NPV. Note also that data are not available to account for C storage in existing woodland.

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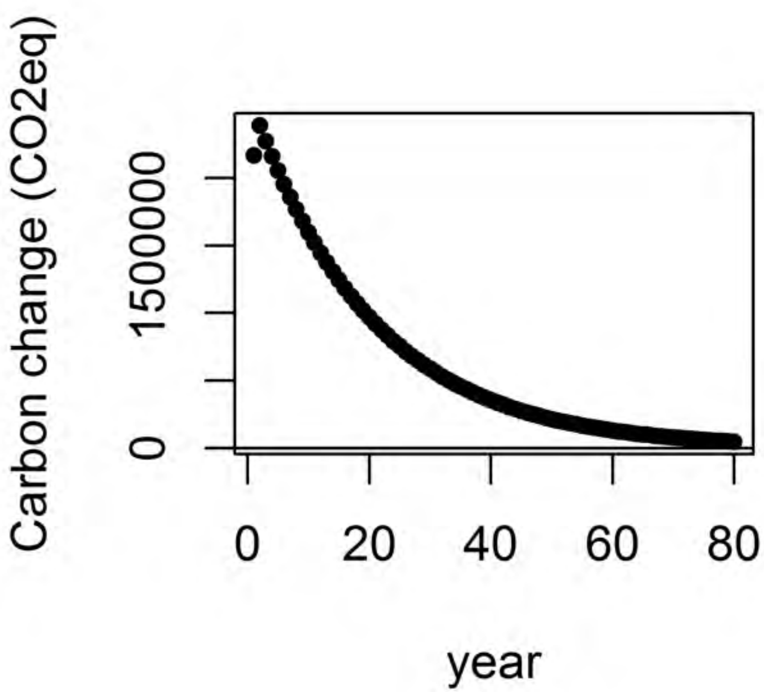
Agricultural carbon stock for Wales (T4)

Rate of C emissions from soils and vegetation at agricultural sites:
Initially high losses in C stock, decreasing exponentially over time



(Plot for agricultural land staying in agriculture)

- Carbon stock in croplands and grasslands (LULUCF 4B + 4C) are simulated to decrease, rapidly at first with high initial emissions, but slowing over time, approaching a new equilibrium by 2100.
- Total losses to 2100 account for around 8% of total IMP modelled C stocks in agricultural vegetation and soils.

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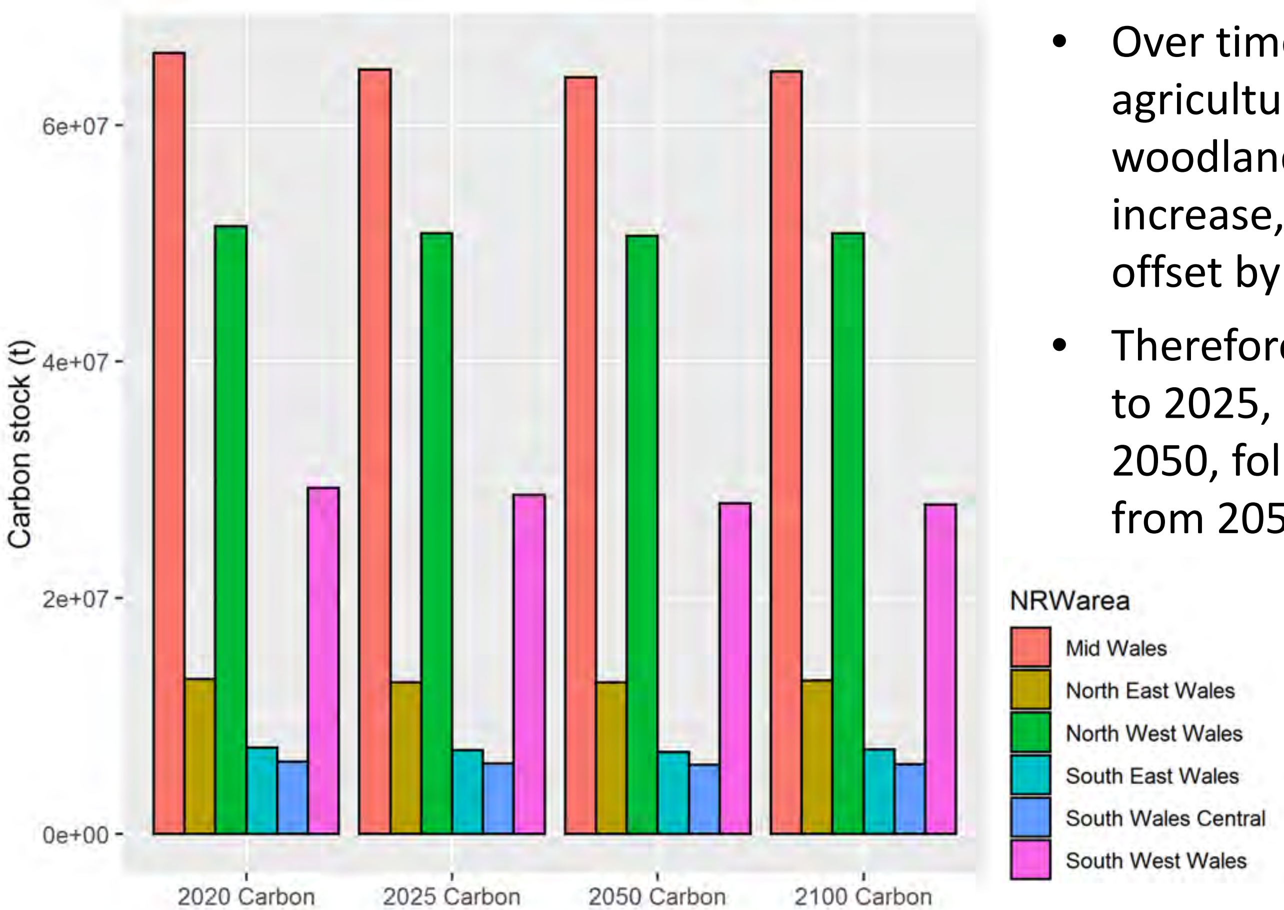
Carbon stock over time (T4)

Total C stock for all modelled land in: 2020, 2025, 2050 and 2100



- Carbon stock in woodland systems increases slowly over time, with initial losses at some sites due to soil disturbance.
- Over time, initial rapid losses from agricultural changes slow down and woodland sequestration rates increase, hence losses are partially offset by woodland sequestration.
- Therefore, total C stock decreases to 2025, with further decrease to 2050, followed by a small increase from 2050 to 2100.

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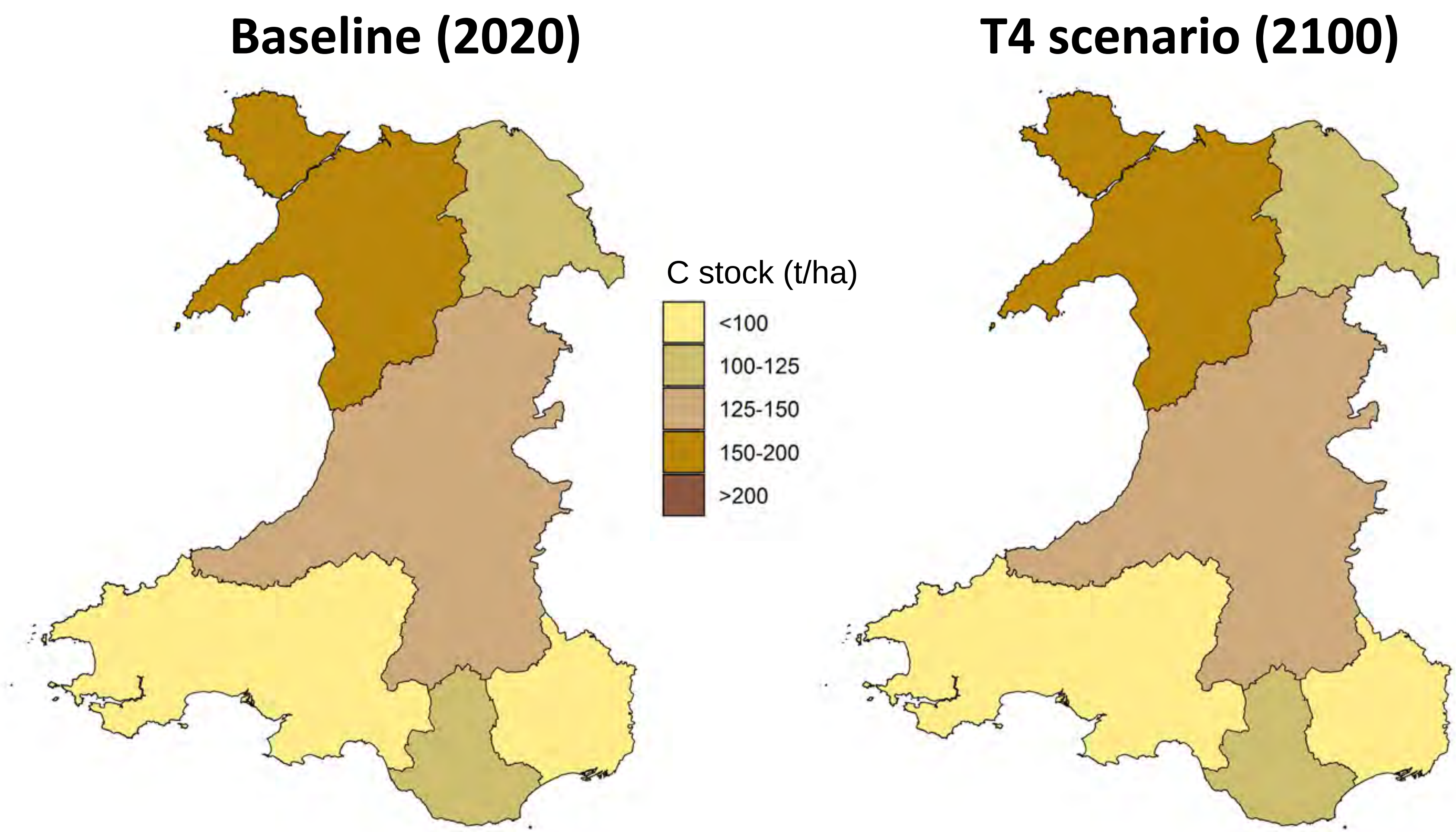
Carbon stock for NRW regions (T4)



Data are for LULUCF categories 4 A, B, C & G
and are displayed per ha of land modelled

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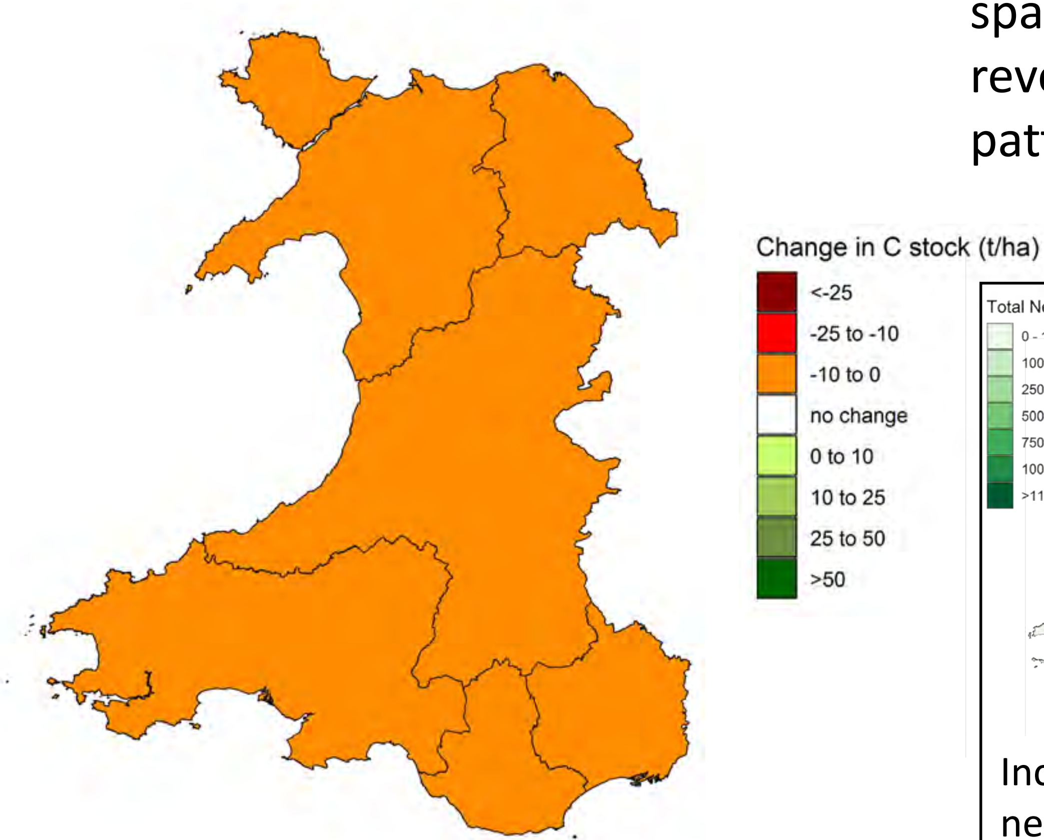
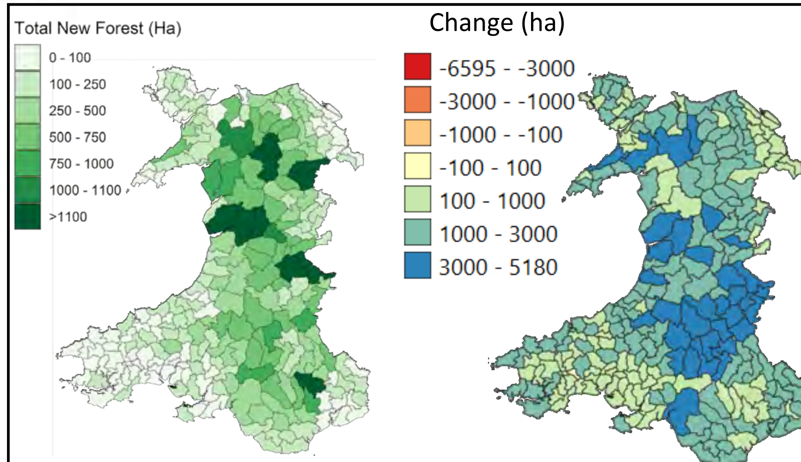
Carbon change for T4 scenario

Carbon change 2020-2100 (tC/ha)



A small net loss is simulated for all NRW regions. However, the finer spatial detail in the maps that follow reveal that this net increase masks a pattern of increase/decrease.



Increase in arable/grass rotation and area of new woodland must be considered together to understand the change in carbon

Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

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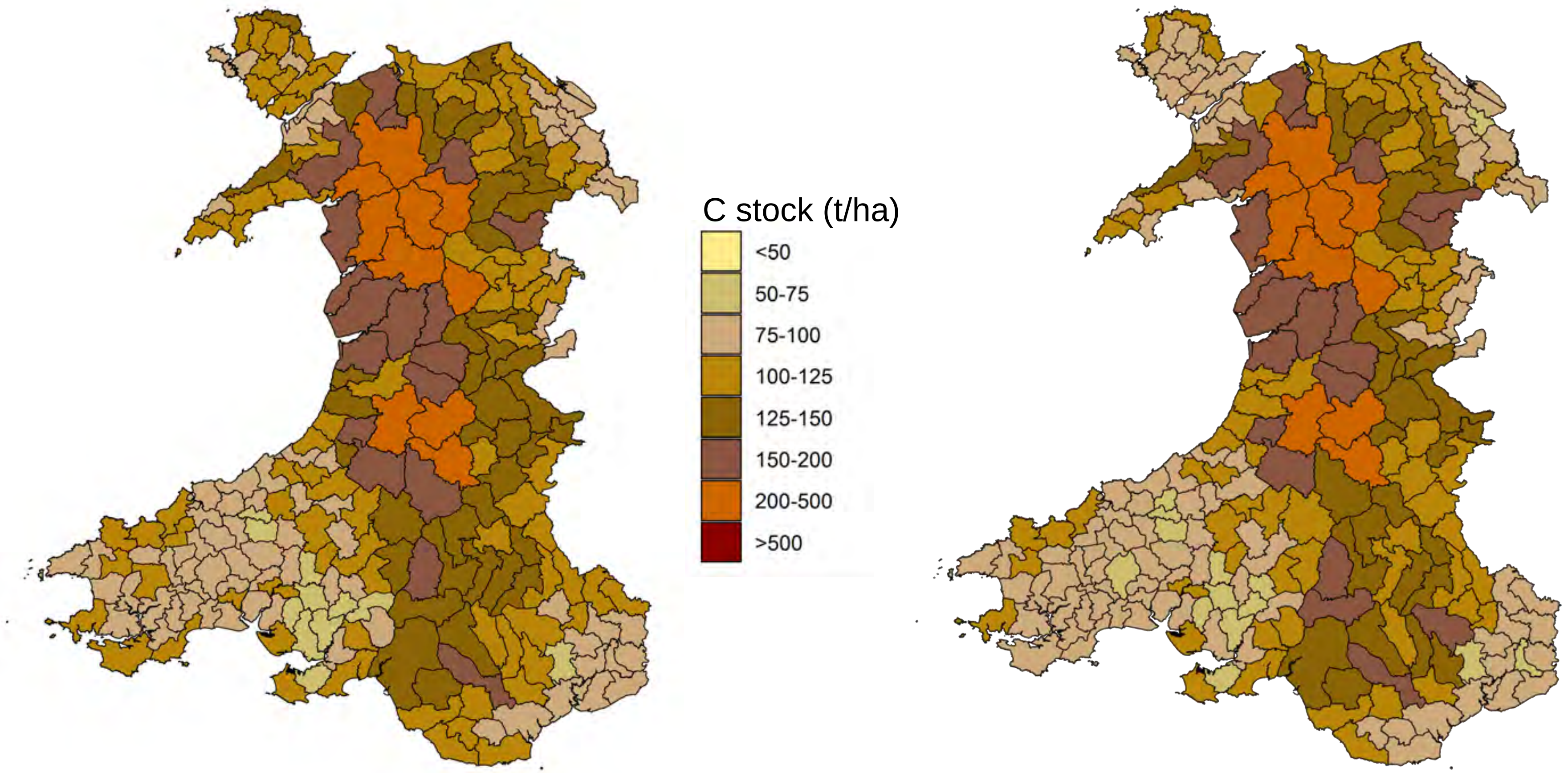
Carbon stock for small agricultural areas (T4)

Baseline (2020) **T4 scenario (2100)**



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

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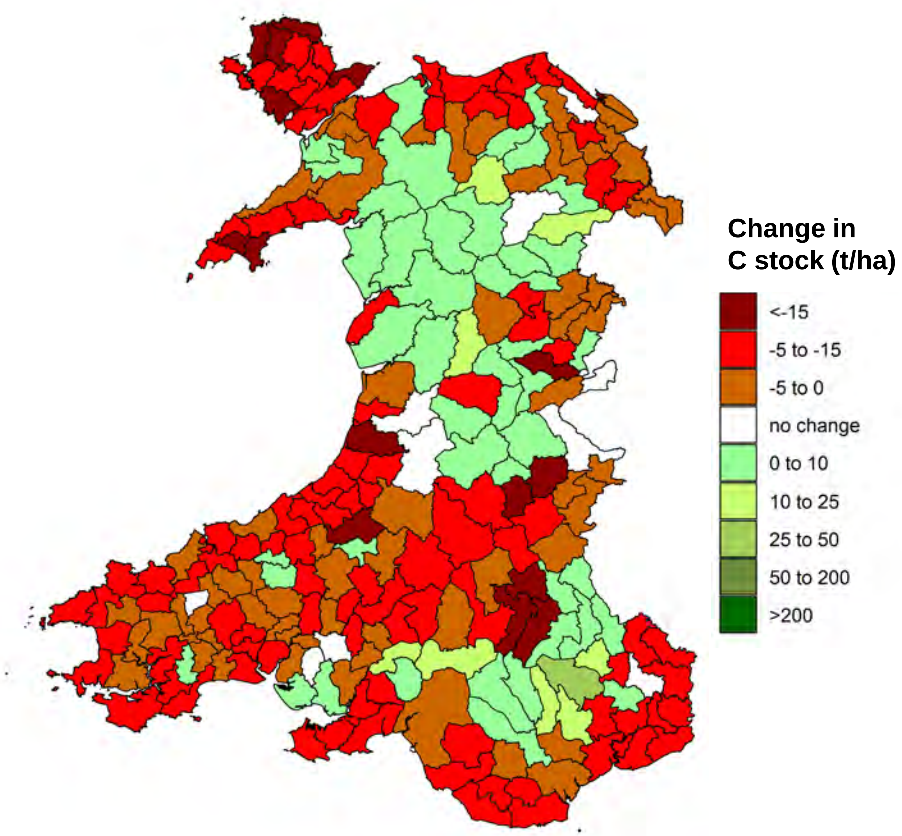
Carbon change for small agricultural areas (T4)

Map: tC/ha change 2020-2100



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

- Carbon stocks are simulated to increase in some areas and decrease in others.
- Areas of decrease reflect the large increase in land under arable/grass rotation
- Areas of increase reflect new woodland (see slide 38), largely due to the significant C storage potential of biomass and harvested wood products.
- Some increase may also be attributed to sequestration on land reverting to short vegetation

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GHG emissions: Peat and agriculture (T4)

This table compares total agricultural emissions and wetland emissions for farms modelled by IMP:

LULUCF category	Baseline	Scenario
Wetlands (4D) flux (KtCO2eq/yr)	873	856
Agricultural GHG flux (KtCO2eq/yr)	4,816	8,742

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Agricultural GHG emissions are simulated to increase reflecting large increases in dairy cattle which are not offset by reductions in sheep and beef.
- GHG emissions from wetlands are simulated to reduce slightly, reflecting a small area of peat modelled as coming out of agricultural use.

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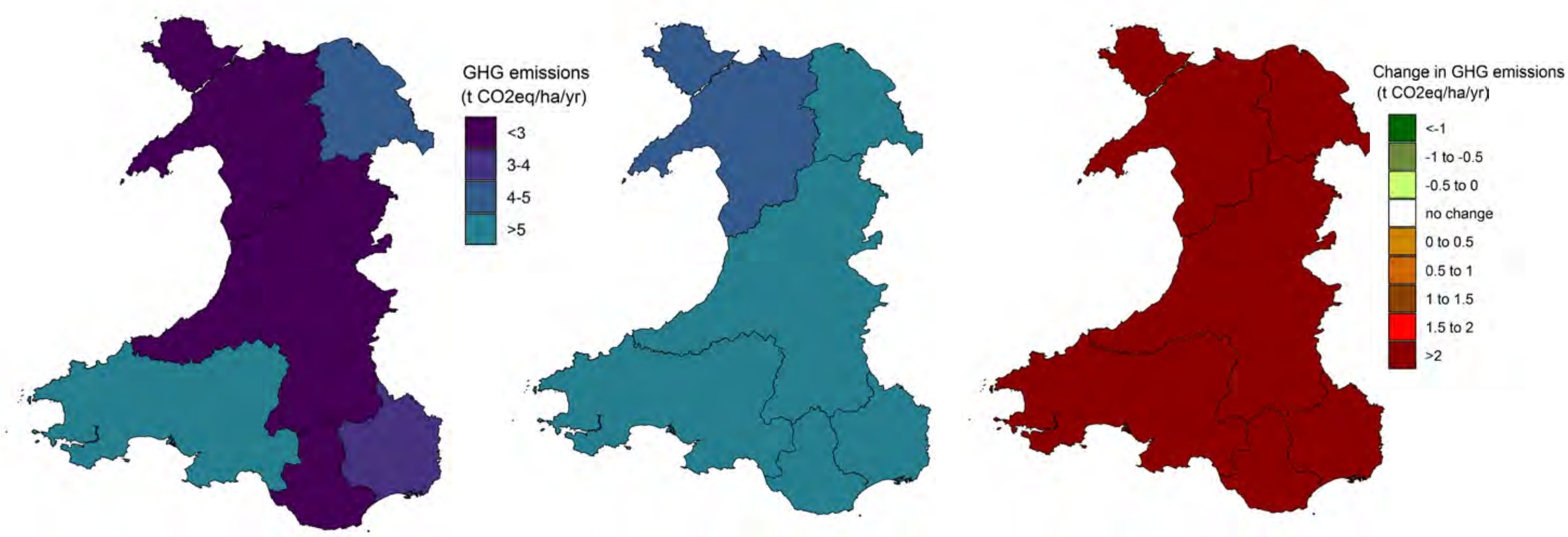
GHG emissions for NRW regions (livestock and management) (T4)

Baseline | **T4 scenario** | **Change**



- Data are displayed per ha of land modelled, and reflect patterns of livestock, land use and management.
- Large increases reflect increased agricultural intensity due to the major expansion of dairy simulated for all NRW regions.

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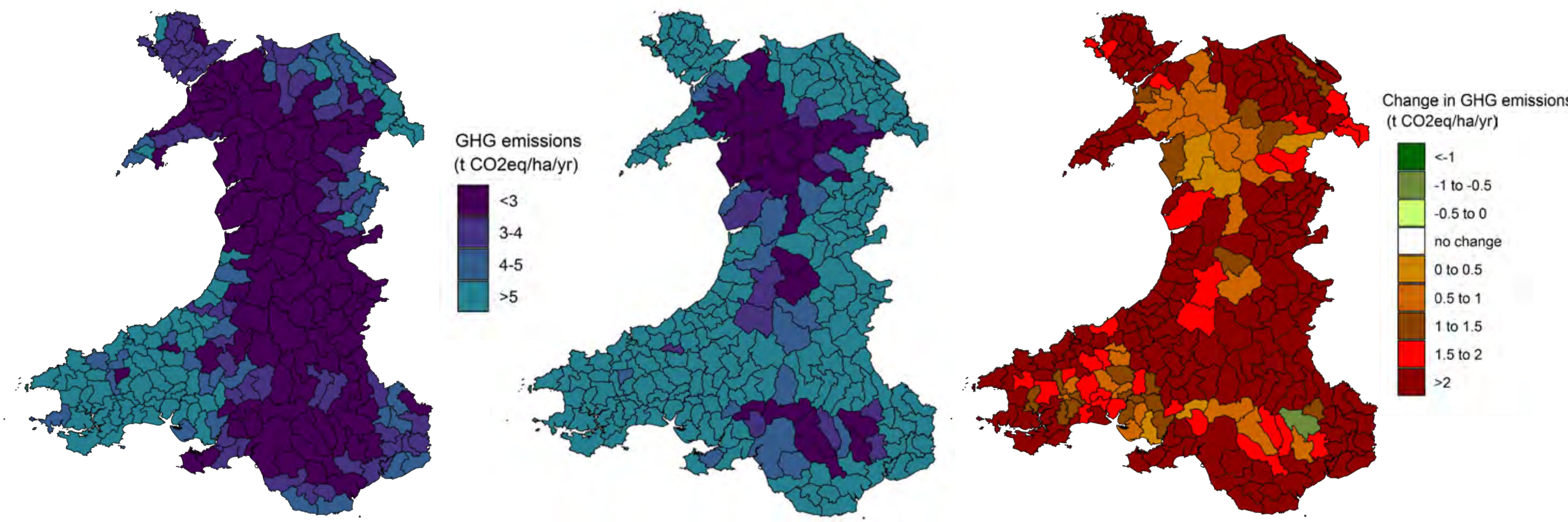
GHG emissions for small agricultural areas (livestock and management) (T4)

Baseline **T4 scenario** **Change**



- The finer scale data reveal the greater magnitude of local changes.
- Increases in most areas reflect increased agricultural intensity due to the simulated expansion of dairy.
- Reductions in a few areas reflect land coming out of agricultural use.

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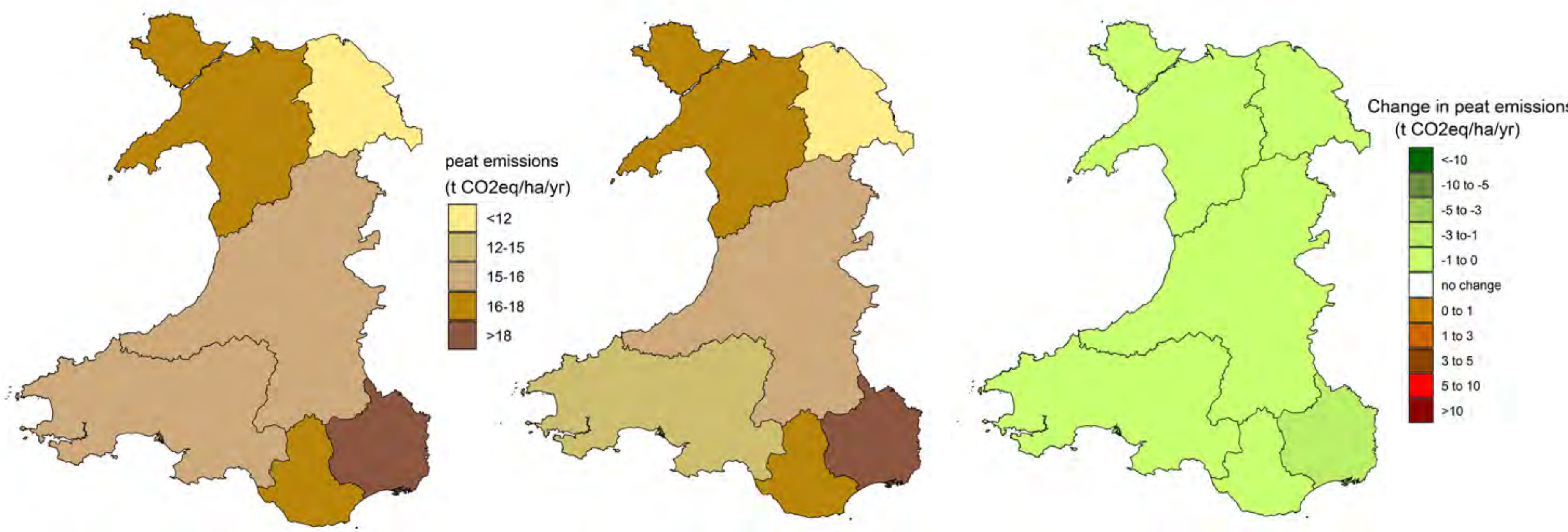
GHG emissions for NRW regions (peat) (T4)

Baseline **T4 scenario** **Change**



- Data are displayed per ha of peat modelled, and reflect land use and inferred management.
- Emissions are simulated to slightly reduce in all areas under the T4 scenario, due to land on peat modelled as coming out of agricultural use.

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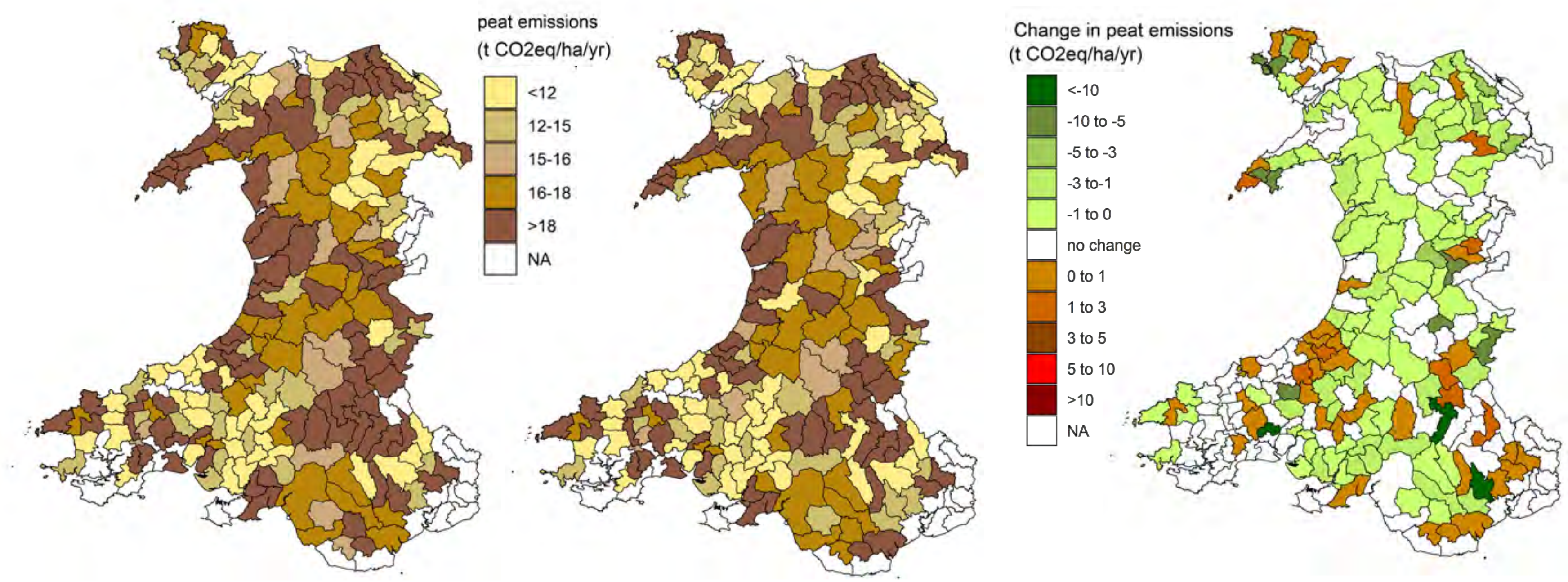
GHG emissions for small agricultural areas (peat) (T4)

Baseline **T4 scenario** **Change**



- Emissions are simulated to decrease to 2100 in most areas, but increase in a few areas due to simulated agricultural intensification on peat.
- Some small agricultural areas do not contain peat, or do not experience predicted land use change on peat.

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PART 3b: Water quality

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Water Quality: Background information 1

- Water quality impacts must be considered for WFD catchments, therefore, loads calculated at the DMU level **(in kg/ha)** must be processed to in-stream loads, by aggregating at the catchment level.
- We also add in non-agricultural sources of pollutants, as well as estimates of pollutants for farms not modelled by the IMP (<1FTE).
- We then account for flow (and nutrient) accumulation to downstream catchments, and account for stream flow to calculate concentration for N and P.
- Data for N and P are processed to units reflecting the relevant thresholds: **annual average concentration for P and 95th percentile for N**.
- Data on sediments are calculated as **annual average loads**. River sediment concentrations are controlled by event driven inputs and in-river processes occurring over a range of timescales, so it is hard to measure average concentrations using infrequent grab samples and difficult to predict these from annual average inputs to watercourses as predicted by the IMP.

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Water Quality: Background information 2

- The water quality analyses are based on the scenario being applied to farms >1FTE only. Farms <1FTE are modelled as not responding to the scenario.
- We assume afforestation or reversion to short vegetation or natural woodland on the "non-economically viable" farms.
- Changes in water quality are not modelled for lakes, but these may be important for recreation, and associated businesses in Wales.
- Data outputs relate to a new long-term average reflecting land use and management for the scenario: we do not account for time lags in the nitrogen system.
- Predicted loads are based on average climate data (1961-1990).
- Data reflect average losses rather than those that might occur once in several years due to an intense rainfall event causing significant erosion (particularly important for sediment and P).
- Some measures might change soil P status or soil organic N supply, which happen over a period of 10+ years to reach a new equilibrium. Our scenario outputs assume these changes have already occurred.

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Water Quality for Wales: Change in N, P and sediment load (T4)

This table compares total agricultural loading for farms modelled by the IMP:

	Farms < 1FTE	Baseline	T4 scenario	Change	% change	Glastir impacts
Nitrate kt NO3 N	4.13	30.11	51.87	21.76	72%	-1%
Phosphorus kt P	0.18	0.72	0.92	0.20	28%	-0.9%
Sediment kt Z	68	194	209	14.94	8%	-0.1%

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Increases are simulated in all pollutants for the T4 scenario.
- This reflects increased intensity of agricultural land use, with major expansion of dairy.
- Glastir impacts, modelled from 2016 uptake data, are shown for comparison.

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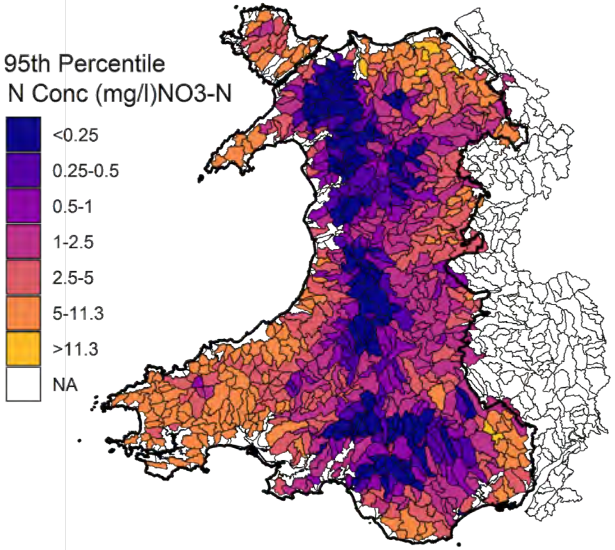
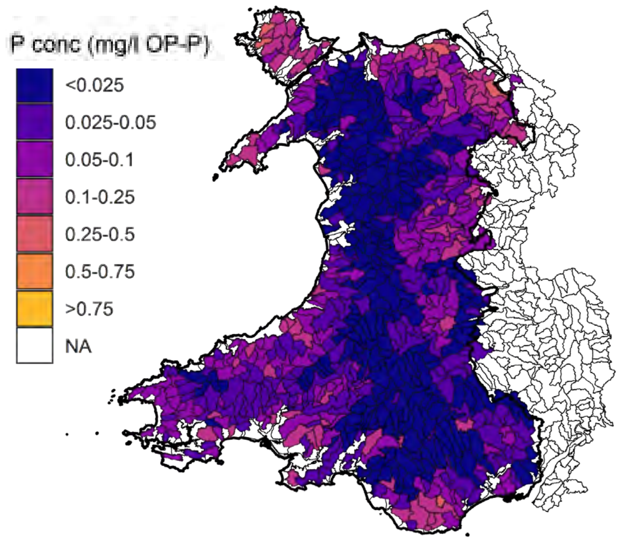
N, P and sediment load for baseline and T4

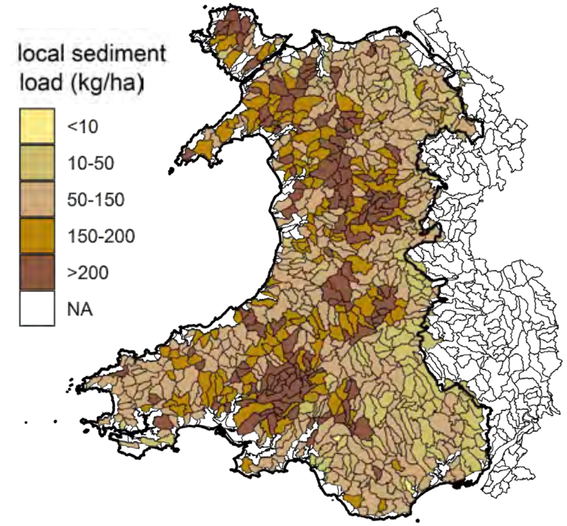
Baseline N



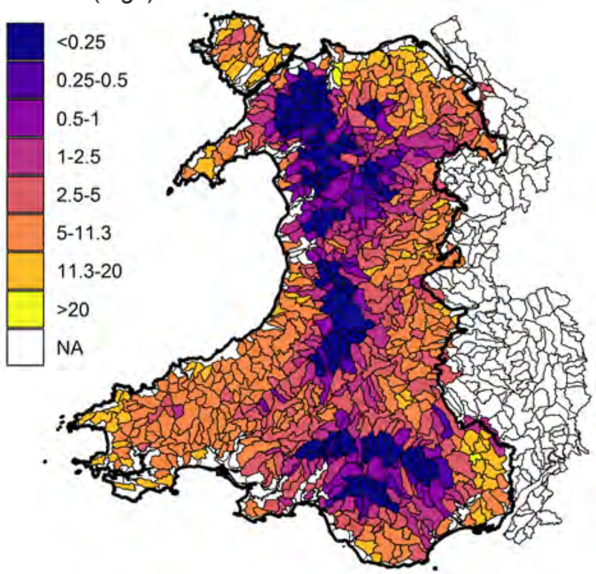
Baseline P



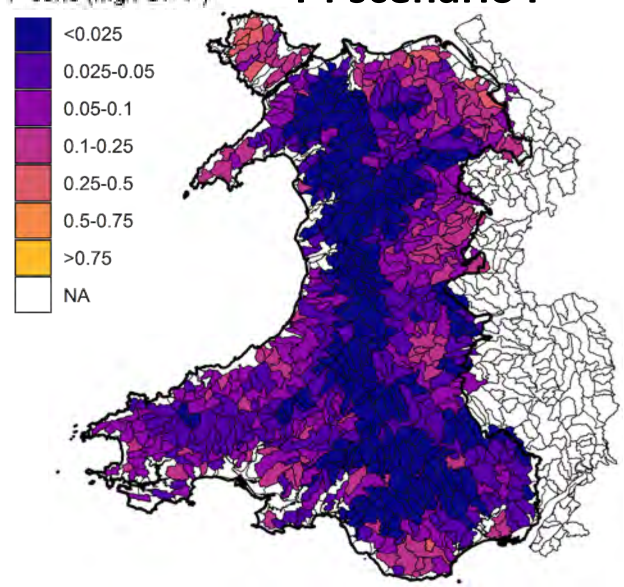
Baseline Sediment



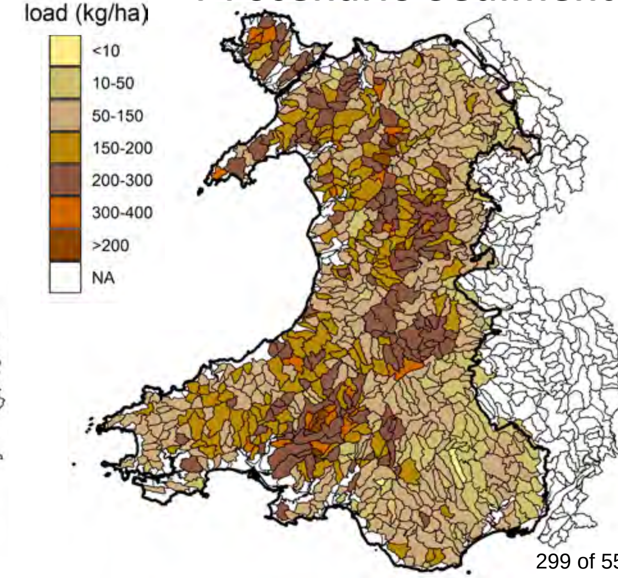
T4 scenario N



T4 scenario P

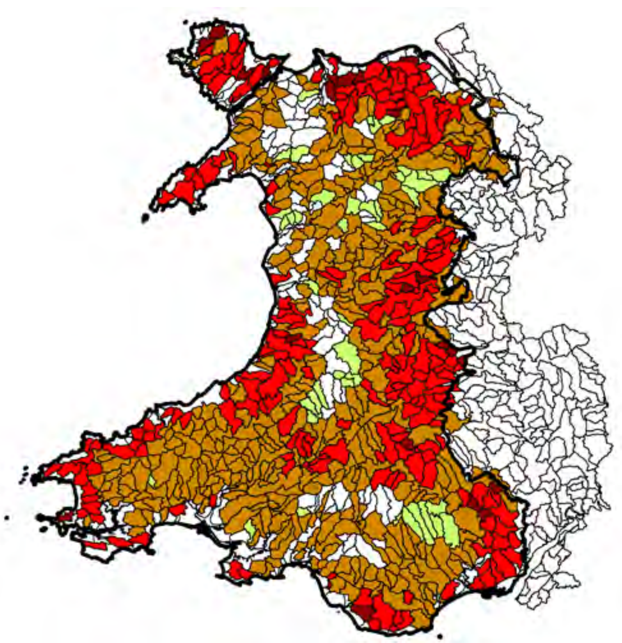


T4 scenario Sediment



Change in N, P and sediment load (T4)

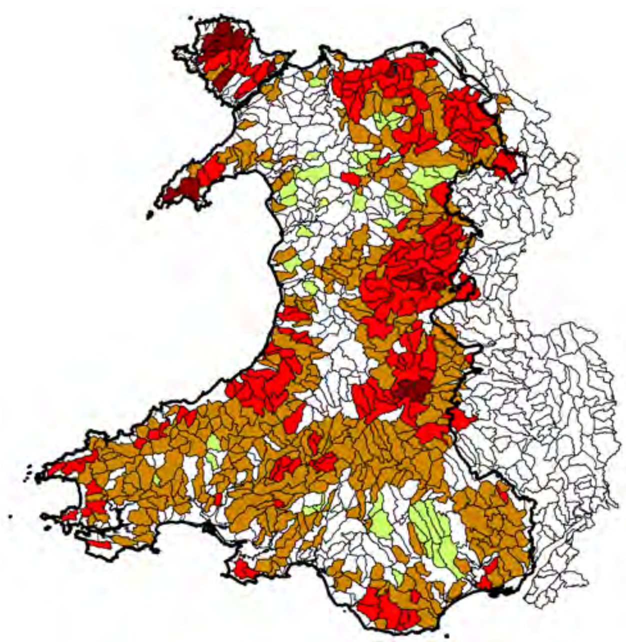
N change



Change in 95th Percentile N Conc (mg/l)NO3-N

- <- 5
- -5 to -2.5
- -2.5 to
- no change
- 0 to 2.5
- 2.5 to 7.5
- >7.5
- NA

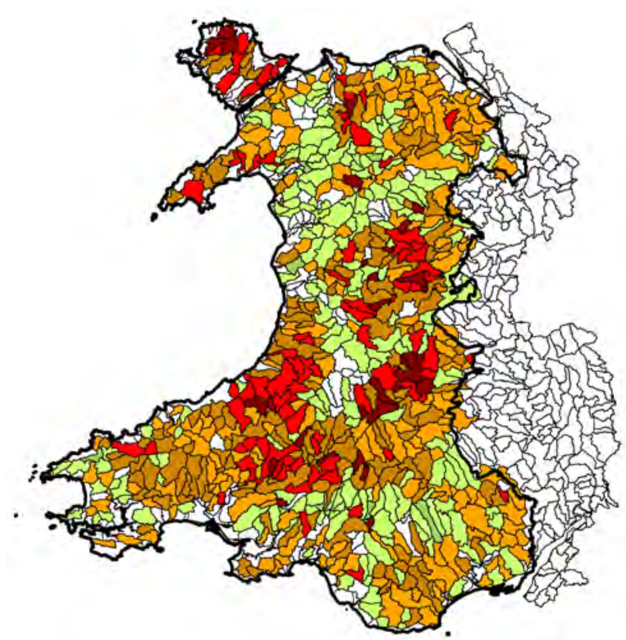
P change



Change in P conc (mg/l OP-P)

- <- 0.05
- -0.05 to 0
- no change
- 0 to 0.01
- 0.01 to 0.05
- >0.05
- NA

Sediment change



Change in local sediment load (t/ha)

- <-200
- -200 to -100
- -100 to -50
- -50 to 0
- no change
- 0 to 10
- 10 to 25
- 25 to 50
- >50
- NA

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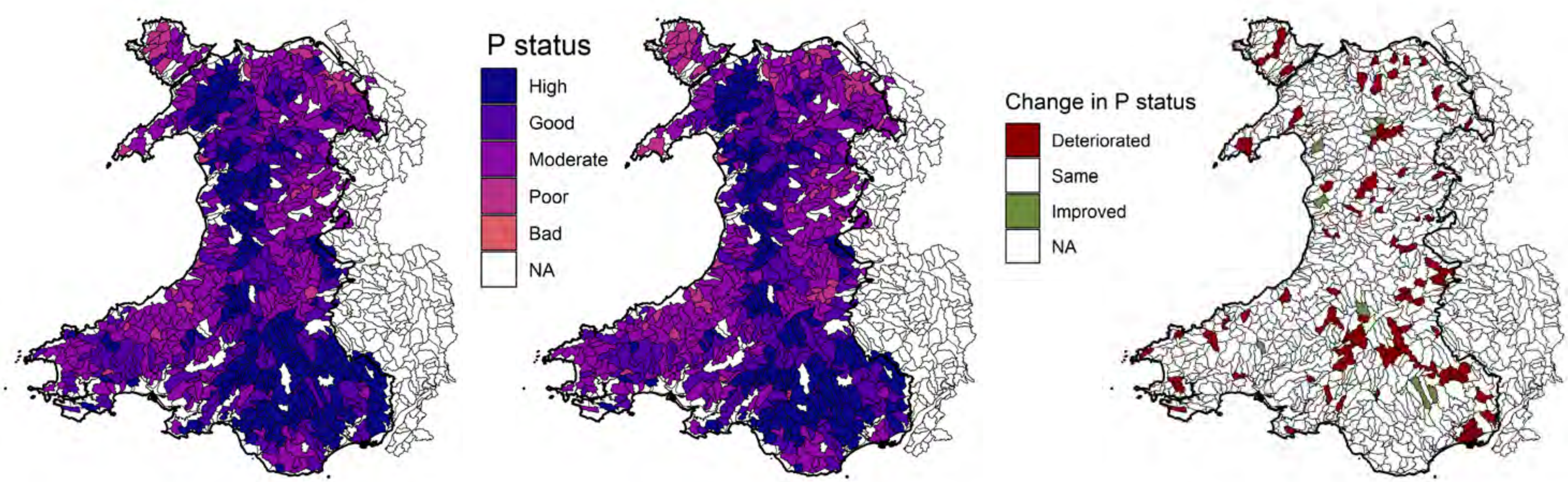
WFD P status (T4)

Baseline | **T4 scenario** | **Change**



- WFD P status is simulated to deteriorate in some catchments under the T4 scenario where agricultural intensity increases.
- WFD P status is simulated to improve in a few catchments.
- Change in status may be modelled for very small changes in concentrations where baseline is close to a threshold.

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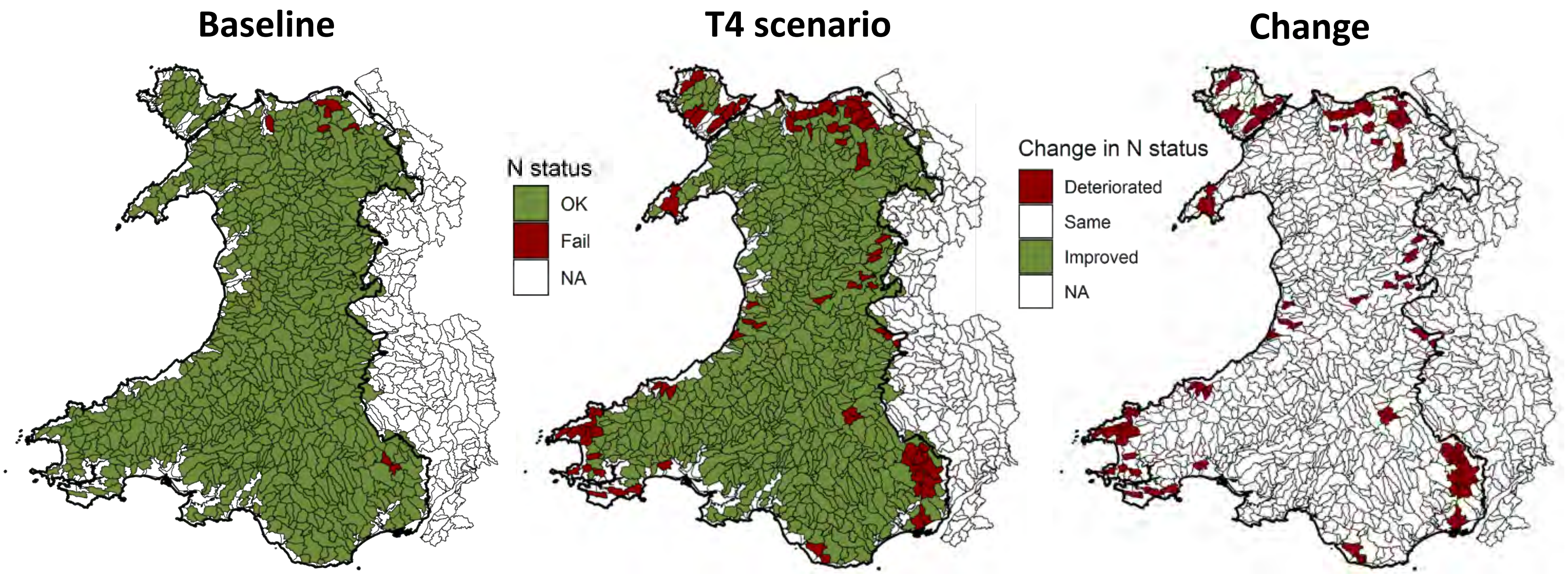
Drinking water N status (T4)



- Drinking water N status is projected to change little under this scenario, but to deteriorate in key areas coinciding with increased agricultural intensity.
- No change in status was projected for most catchments, in spite of the 72% increase in total load from IMP modelled farms

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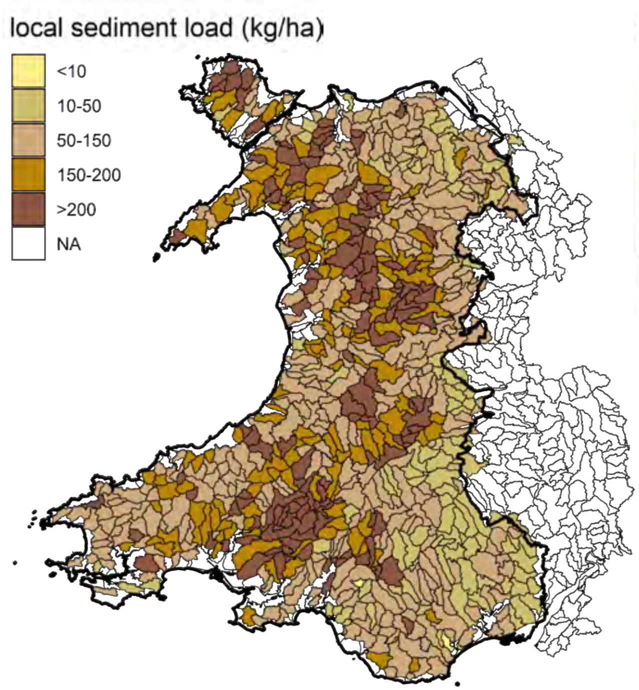
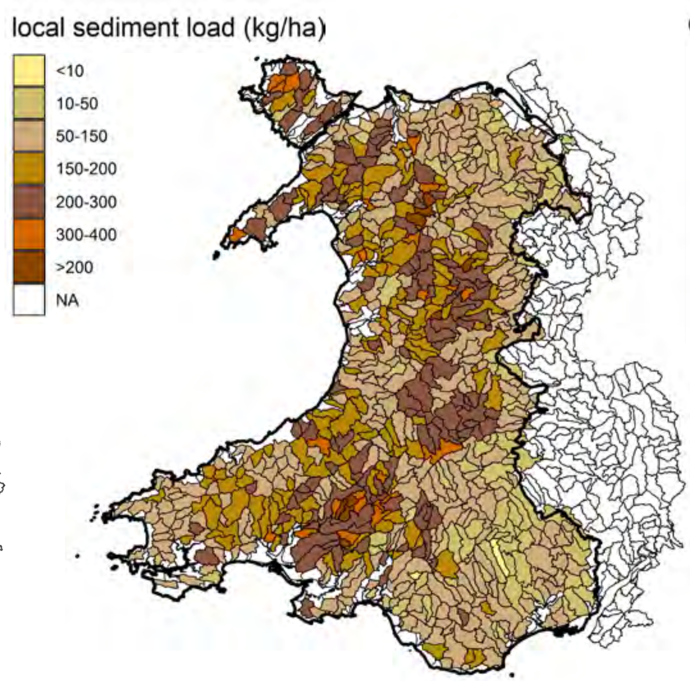
Change in sediment load (T4)

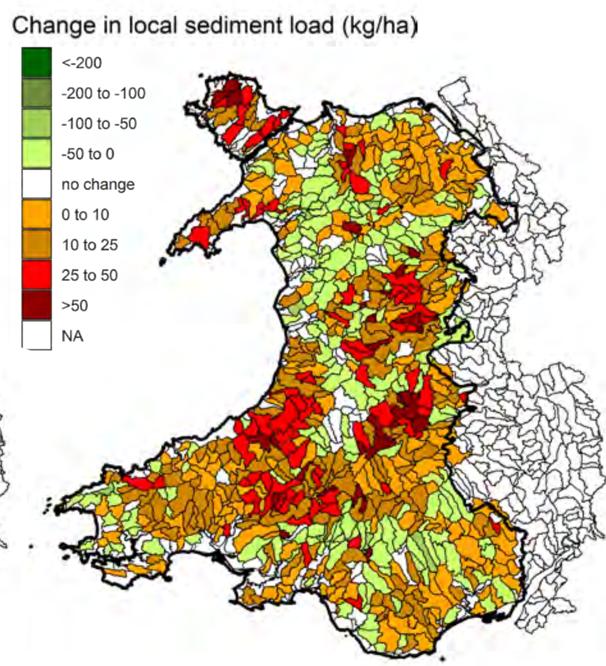
Baseline



T4 scenario



Change



- Increases in sediment loading are simulated coinciding with areas with increased agricultural intensity.
- Small decreases are simulated in some WFD catchments reflecting land coming out of agricultural use.

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PART 3c: Air quality

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Air quality – Wales overview (T4)

This table shows changes in PM2.5 concentration and life years lost under the T4 scenario:

Average Change in PM2.5 Concentration	Life Years Lost (LYL)
+0.06	+77.8

- PM2.5 concentrations are simulated to increase on average for Wales, as a result of increases in NH_3 emissions and only small areas of new woodland.
- This leads to a net health dis-benefit of +77.8 Life Years Lost.
- BUT spatial patterns vary …

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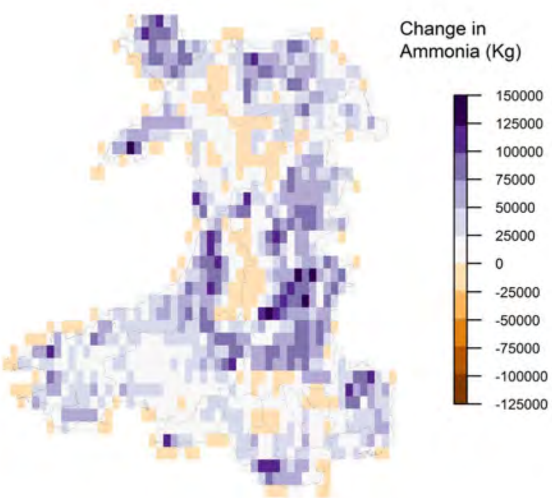
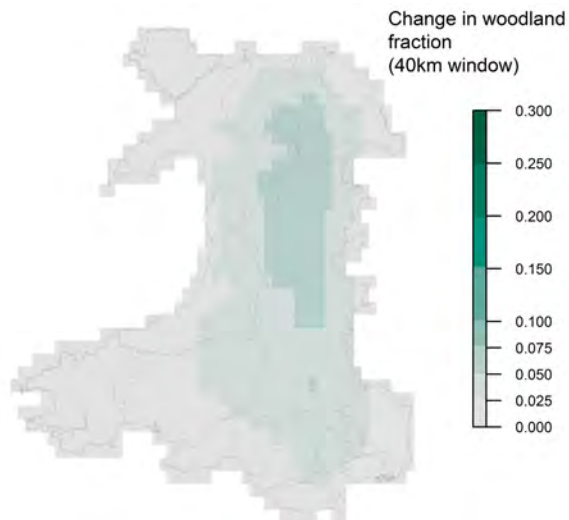
Health outcome from change in air quality (T4)

NH3 emissions



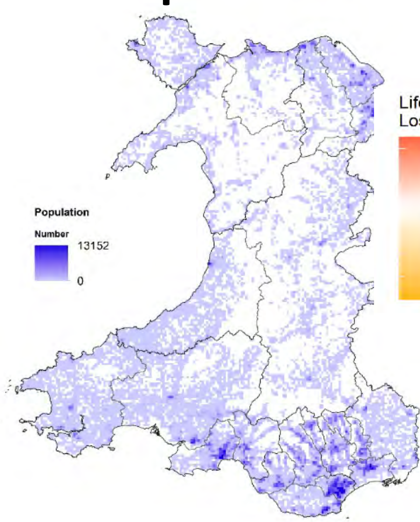
New woodland



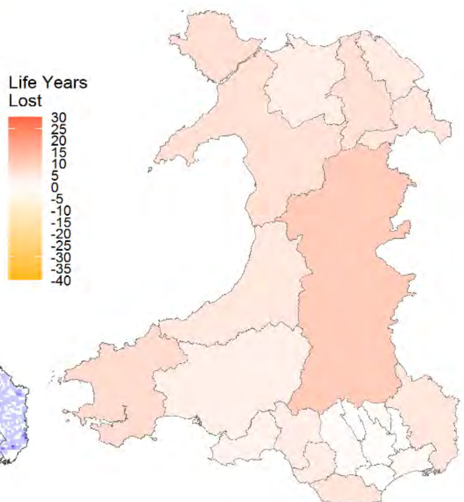
PM2.5 change

- Change in PM2.5 is a function of change in NH3 emissions and little new woodland planted.
- Increases in PM2.5 are simulated where NH3 emissions increase (mainly from dairy).

Population



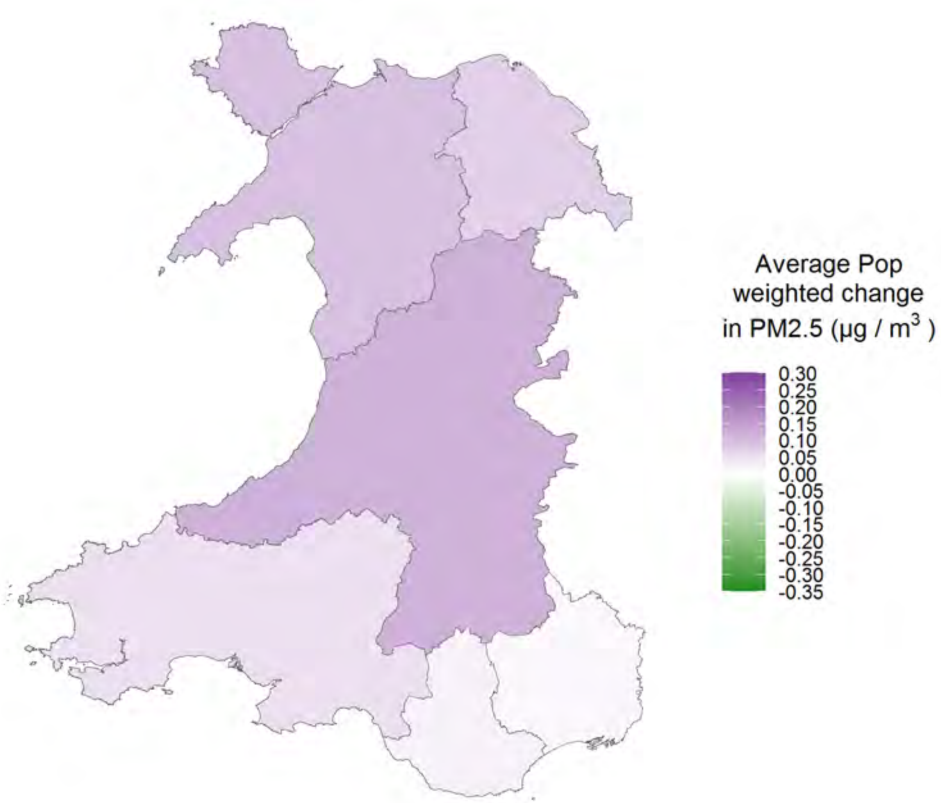
Life Years Lost



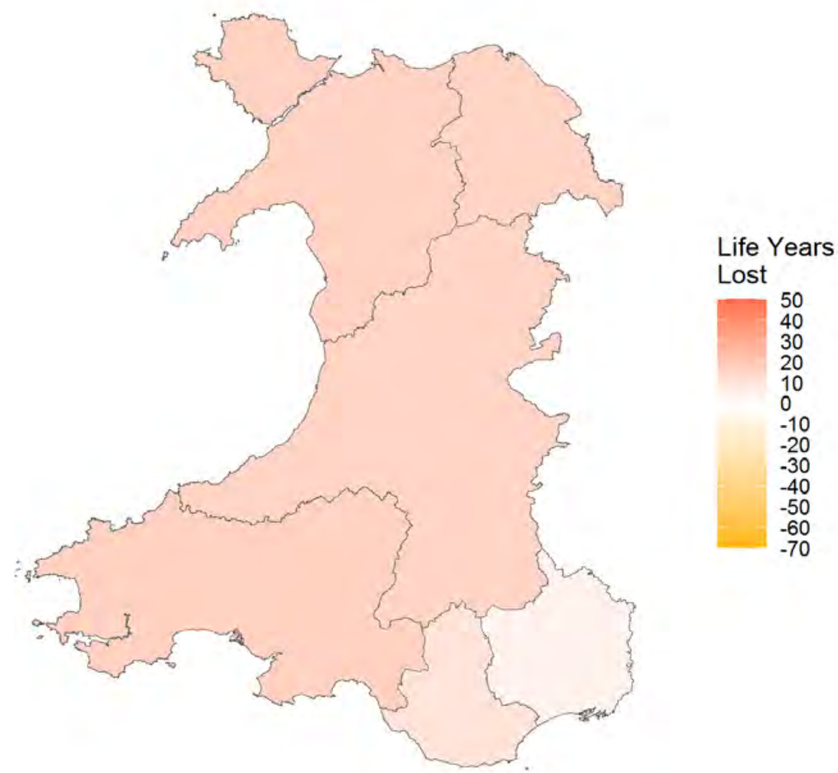
- Health outcomes are a function of change in exposure of the population.
- **Net negative benefit in all areas, *except Blaenau Gwent, Torfaen & Merthyr Tydfil.***

Air quality for NRW regions in T4

Average change in PM2.5 concentration



Avoided Life Years Lost (total)



Greatest dis-benefits are in parts of north, mid & south wales

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PART 4: Valuation

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Valuation results: Background information

- Price year: 2020
- Present values: 75 year time horizon
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g. 3.5% declining discount rate/ health discount rate for air quality):
  - Values are based on BIES (2018) guidance on carbon values for appraisals by Government.
  - This was prior to the release of updated values in September 2021.
  - The 2018 values do not fully reflect the requirements of the Paris Agreement 2016, the domestic net zero target, and other recent policy developments.
- Results given to 3 significant figures.

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Summary of public goods values (T4)

Benefits	Physical measure	Units	Present value, 75 yrs, £	Type of value
Air Quality	Increase of 78 years	Life Years Lost each year	- £ 111m	Reduction in costs of health impacts from air pollution
Water Quality	147 Deteriorate, 8 Improve	Expected changes in WFD status due to changes in P and N	- £ 67m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 309m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 21,367m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- The figures are an estimate of the value of the increase in wellbeing to people over 75 years under this scenario. Negative costs for air quality indicate increasing health care expenditure needed.
- Figures indicate order of magnitude of values of expected changes in the Welsh Environment.

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Breakdown of public goods values (T4)

Benefits	Present value, £m			Type of value
	5 yrs	25 yrs	75 yrs	
Air Quality	- £ 6m	- £ 35m	- £ 111m	Reduction in costs of health impacts from air pollution
Water Quality	- £ 11m	- £ 41m	- £ 67m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs:				Benefit of reducing GHG sources:
Agriculture	- £ 1,367m	- £ 7,056m	- £ 20,287m	Agricultural sources (livestock and inputs)
Land use	- £ 810m	- £1,330m	- £1,167m	LULUCF sources (soils, vegetation and harvested wood products)
Wetlands	£ 6m	£ 31m	£ 88m	Wetland sources (peatlands)
Total GHGs	- £ 2,171m	- £ 8,355m	- £ 21,367m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- All figures are based on simplifying assumptions of change over time.

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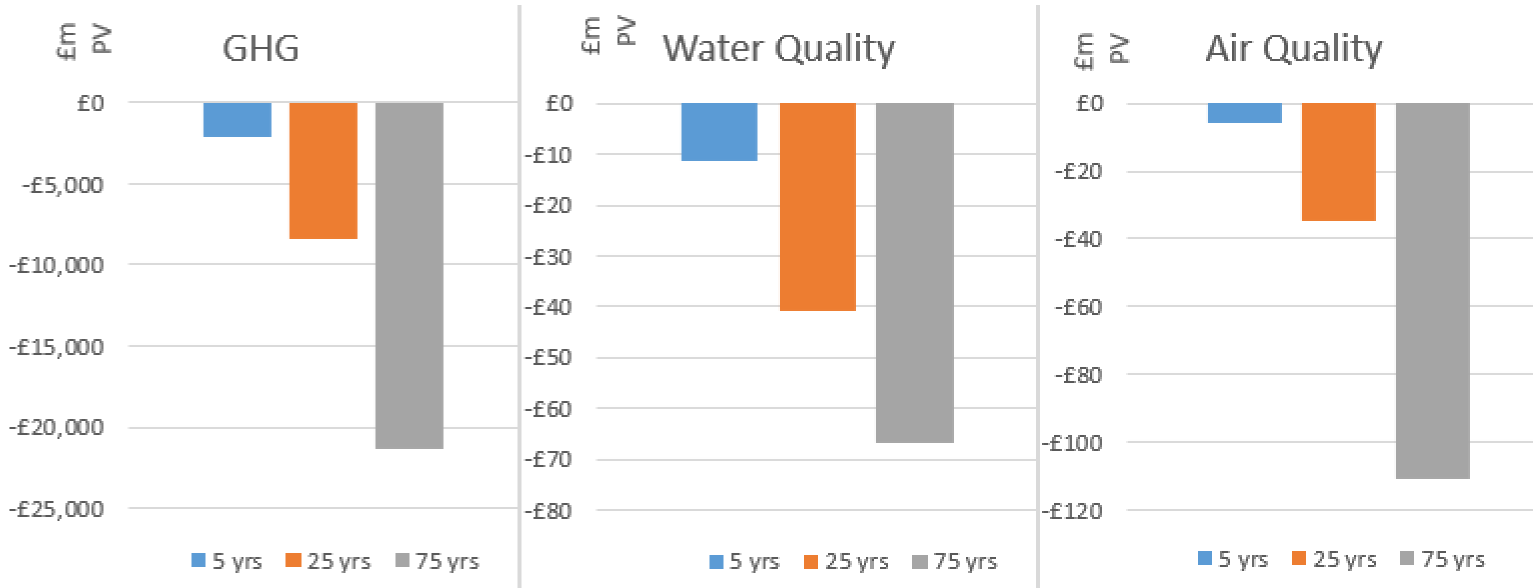
Public Goods Values for different time horizons (T4)



- A sustained loss of value of all three ecosystem services is simulated under the T4 scenario.
- The changes reflect increased agricultural impacts due to expansion of dairy in some areas.

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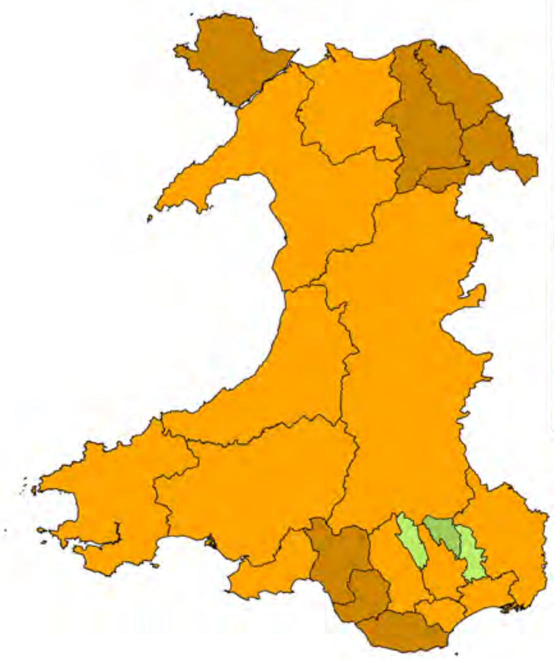
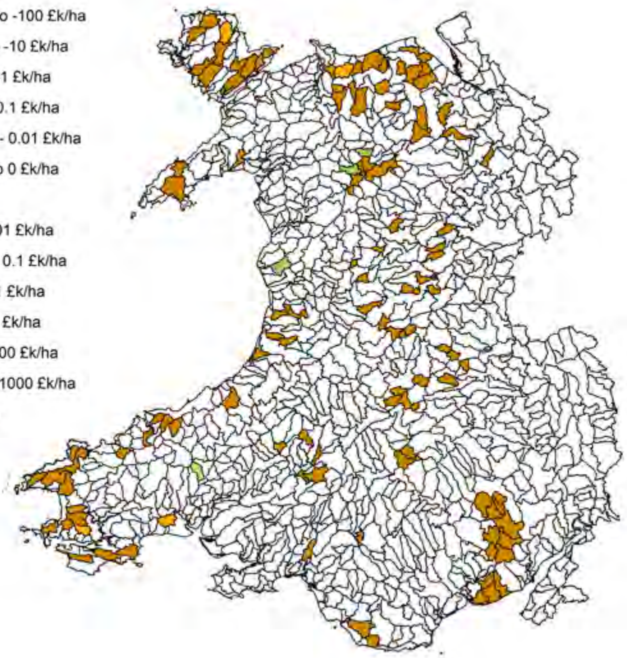
Spatial distribution of values (T4) (finest resolution)

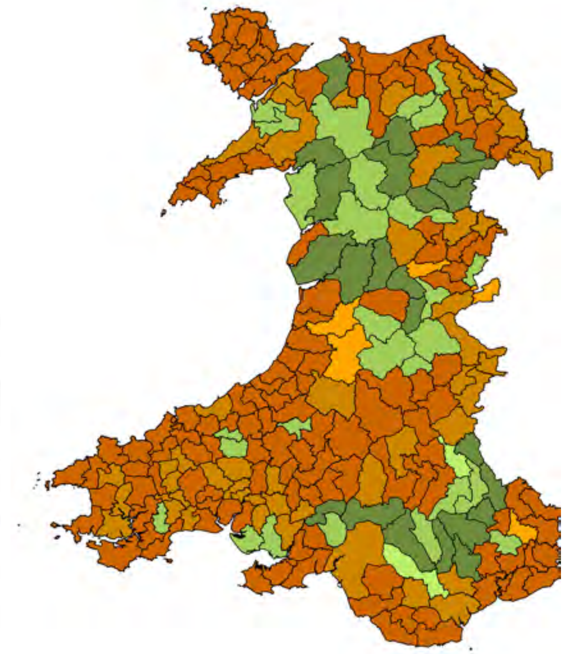
Reduction in costs of air pollution



Value of change in status of freshwater bodies



Value of change in LULUCF carbon stock in vegetation and



- The greatest costs for the T4 scenario come from LULUCF carbon losses, as well as deterioration in air and water quality.
- There are improvements in air quality in some local authorities and from LULUCF carbon in many small agricultural areas.

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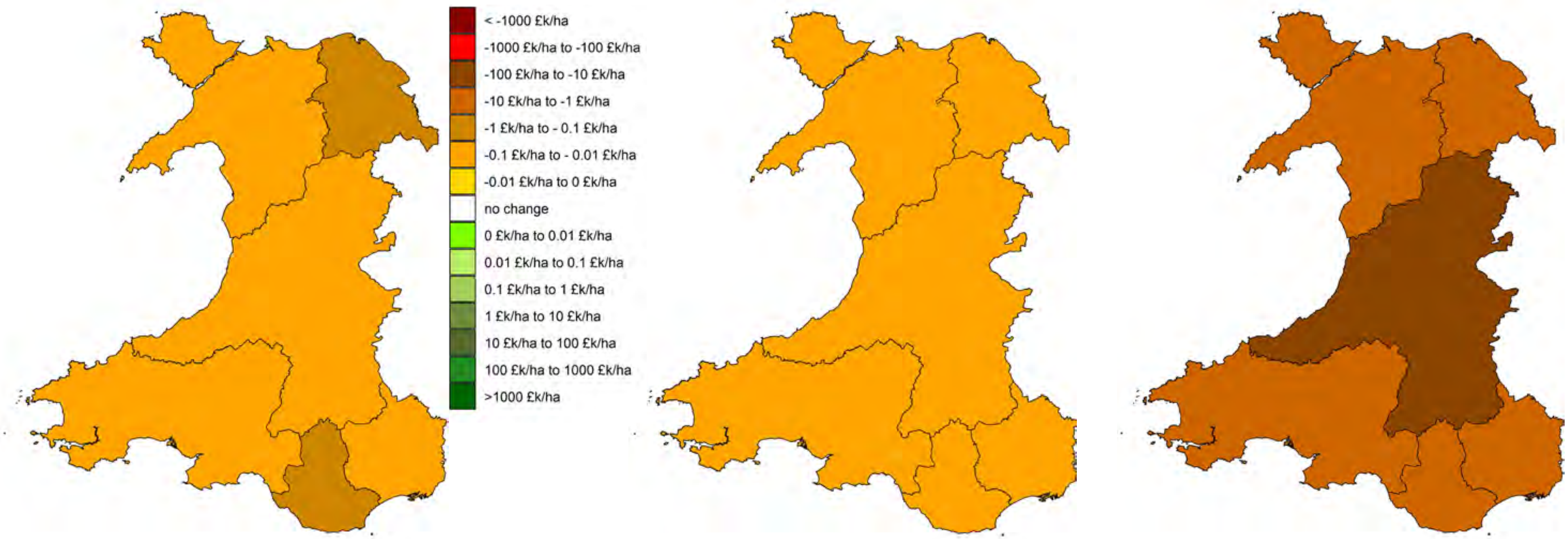
Spatial distribution of values (T4) (NRW regions)

Reduction in costs of air pollution

Value of change in status of freshwater bodies

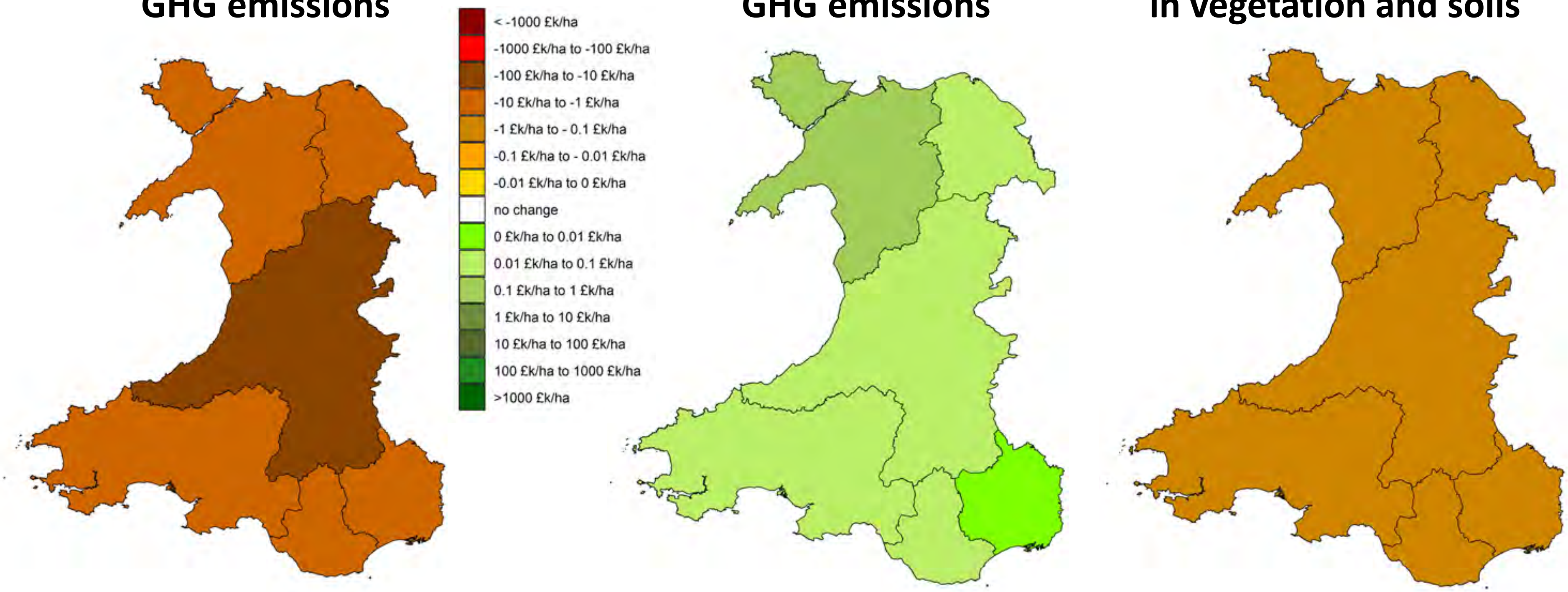
Value of combined change in GHG and carbon balance



- The greatest costs for the T4 scenario come from GHG and LULUCF carbon losses, as well as deterioration in air and water quality.
- The fine scale improvements for some local authorities and small agricultural areas are negated by deterioration in other areas when the data are aggregated to NRW regions.

Breakdown of values for Carbon and GHGs (T4) (NRW regions)

Value of change in agricultural GHG emissions | **Value of change in wetland (peat) GHG emissions** | **Value of change in LULUCF carbon stock in vegetation and soils**



- The change in carbon and GHGs is mostly attributed to an increase in GHG emissions, as well as the losses of LULUCF carbon. The small economic benefit for reduced peat GHG partly reduces these costs.

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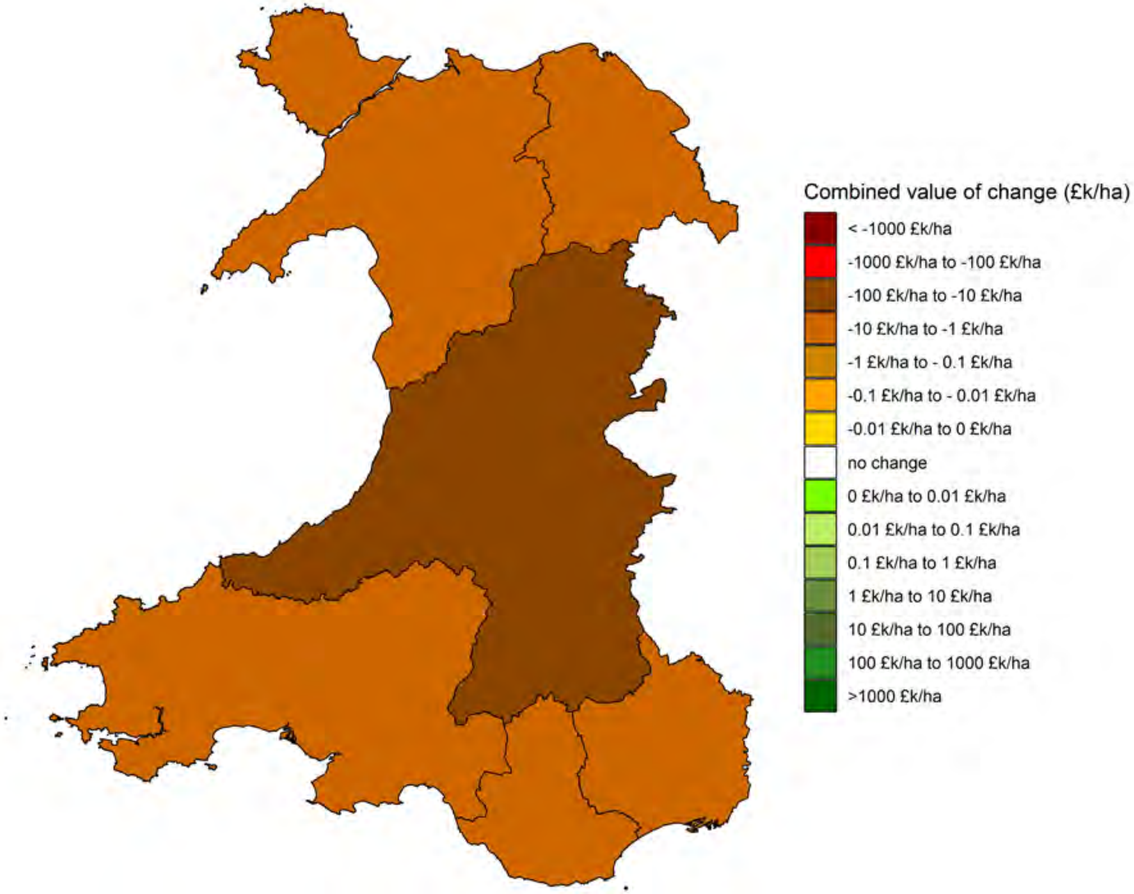
Sum of public goods values (T4) (NRW regions)

Sum of public goods values for all 3 benefits (air quality, water quality and carbon & GHGs):



- All regions are simulated to experience net costs in terms of deterioration of public goods under this scenario.
- This reflects the increased agricultural intensity with significant expansion of dairy and associated GHGs and ammonia, as well as the loss of carbon from conversion of land to arable/grass rotation.

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PART 5: Conclusion

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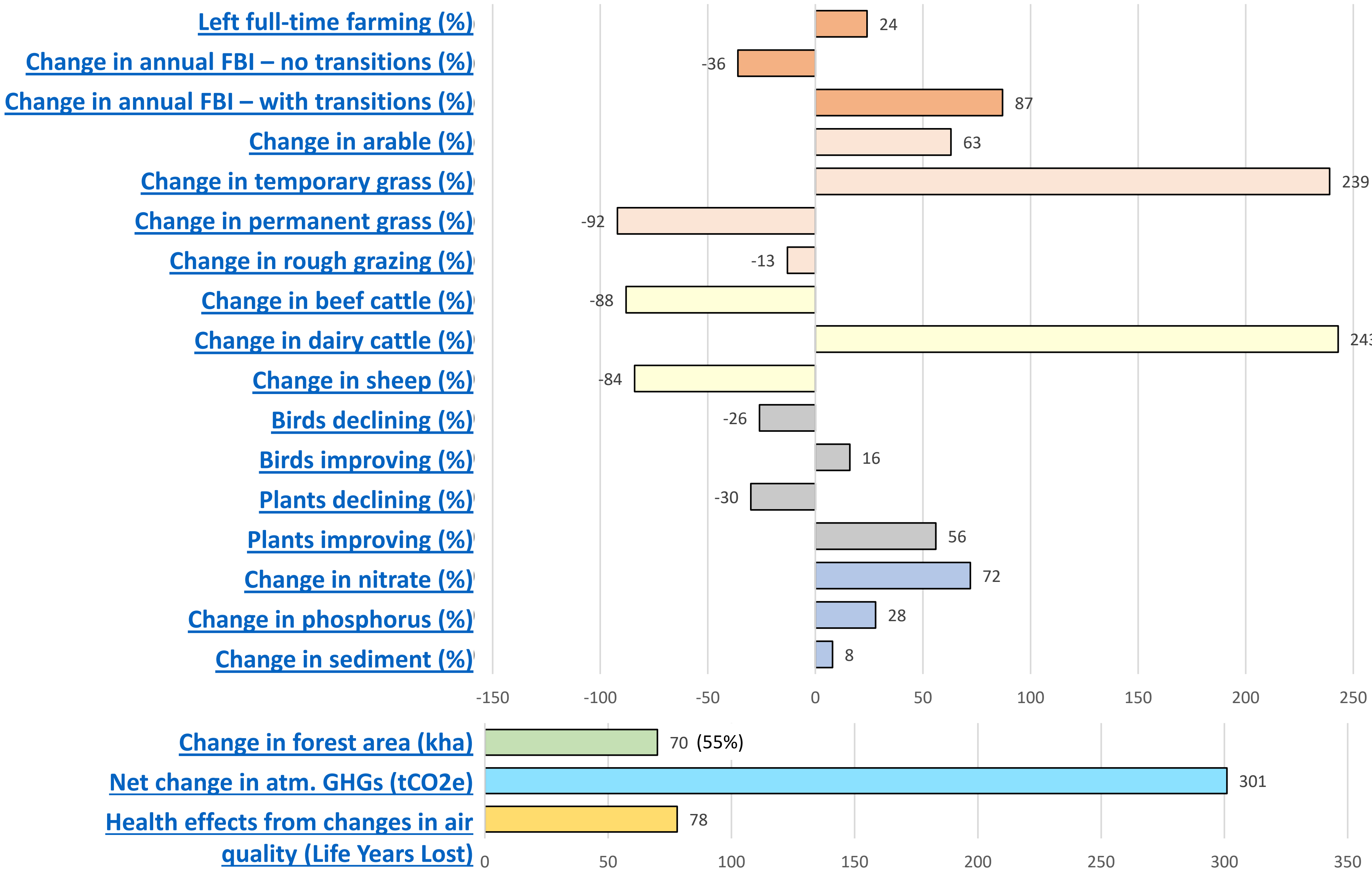
Summary of Impacts 1 (T4)



Summary of Impacts 2 (T4)

Impacts	Physical measure	Units	Present value, 75 yrs, £	Type of value
Agricultural Income	-23%	Farms at risk of leaving full time agriculture	-92m (no EFT transitions) +223m (if EFT transition)	Total farm business income (per year)
Air Quality	77.8	Life Years Lost each year	- £ 111m	Reduction in costs of health impacts from air pollution
Water Quality	147 Deteriorate, 8 Improve	Expected changes in WFD status due to changes in P and N	- £ 67m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 309m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 21,367m	Benefit of reducing atmospheric GHG concentrations from non-traded sources
Biodiversity	26% Decline, 16% Improve	Bird species	N/A	Percentage of species with significant increase or decrease
	30% Decline, 56% Improve	Plant species	N/A	Percentage of groups with significant increase or decrease

Final Considerations

- This slide pack shows results from applying the Integrated Modelling Platform to one (out of six) trade scenarios.
- The scenarios were provided by Welsh Government based on a series of internal and external workshops as changes in farm gate (output) prices and input costs.
- All scenarios were applied to a baseline that includes CAP Pillar 1 payments.
- The economic accounts presented are partial and based solely on the components explicitly mentioned. Other significant aspects (e.g. recreation) are not valued here.
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses.
- The IMP is applied to only full-time farms (> 1 FTE labour).
- A farm that is categorised as under pressure is based on being unable to achieve a full-time annual FBI of £6,000. As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.
- The IMP has been developed following Aqua book guidelines. All the assumptions underlying the IMP are fully documented and have been signed-off by Welsh Government.

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PART 6: Glossary and Context

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Glossary: Key Acronyms (I)

- FAPRI: Food and Agricultural Policy Research Institute
  - FAPRI-UK Model was used to underpin assessments of the impacts of Brexit on the UK agricultural sector. More information: (Web-link)
  - Macro-economic model of the UK in a global context. Used to identify impacts of global trade. The FAPRI-UK model (created and maintained by staff in AFBI-Economics) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with submodels covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) model run by FAPRI at the University of Missouri.
- MFTA: Multi-lateral free trade agreement
  - Free trade agreement between three or more countries without discrimination between those involved.

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Glossary: Key Acronyms (II)

- LULUCF: Land use, land-use change, and forestry
  - Standardised approach to the greenhouse gas inventory that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.
  - Used in this project to quantify impacts of land use change on carbon.
- MFN: Most Favoured Nation
  - World Trade Organisation (WTO) terminology. Under the WTO agreements, countries cannot normally discriminate between their trading partners. As such countries must treat all other WTO members as they would their "Most Favoured Nation". More information: (Web-link)
  - Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

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Glossary: Key Acronyms (III)

- WFD: Water Framework Directive
  - EU directive targeted at improving water quality and integrated catchment management.
- UKTAG: UK Technical Advisory Group (on the WFD)
  - The UKTAG is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies.
- LFA: Less-favoured area
  - Term used to describe an area with natural handicaps (lack of water, climate, short crop season and tendencies of depopulation), or that is mountainous or hilly, as defined by its altitude and slope.
- SDA / DA: Severely Disadvantaged Areas / Disadvantaged Areas
  - Sub-classes of LFA separating out the most severely disadvantaged areas for the purposes of basic payment scheme (BPS) grant payments.

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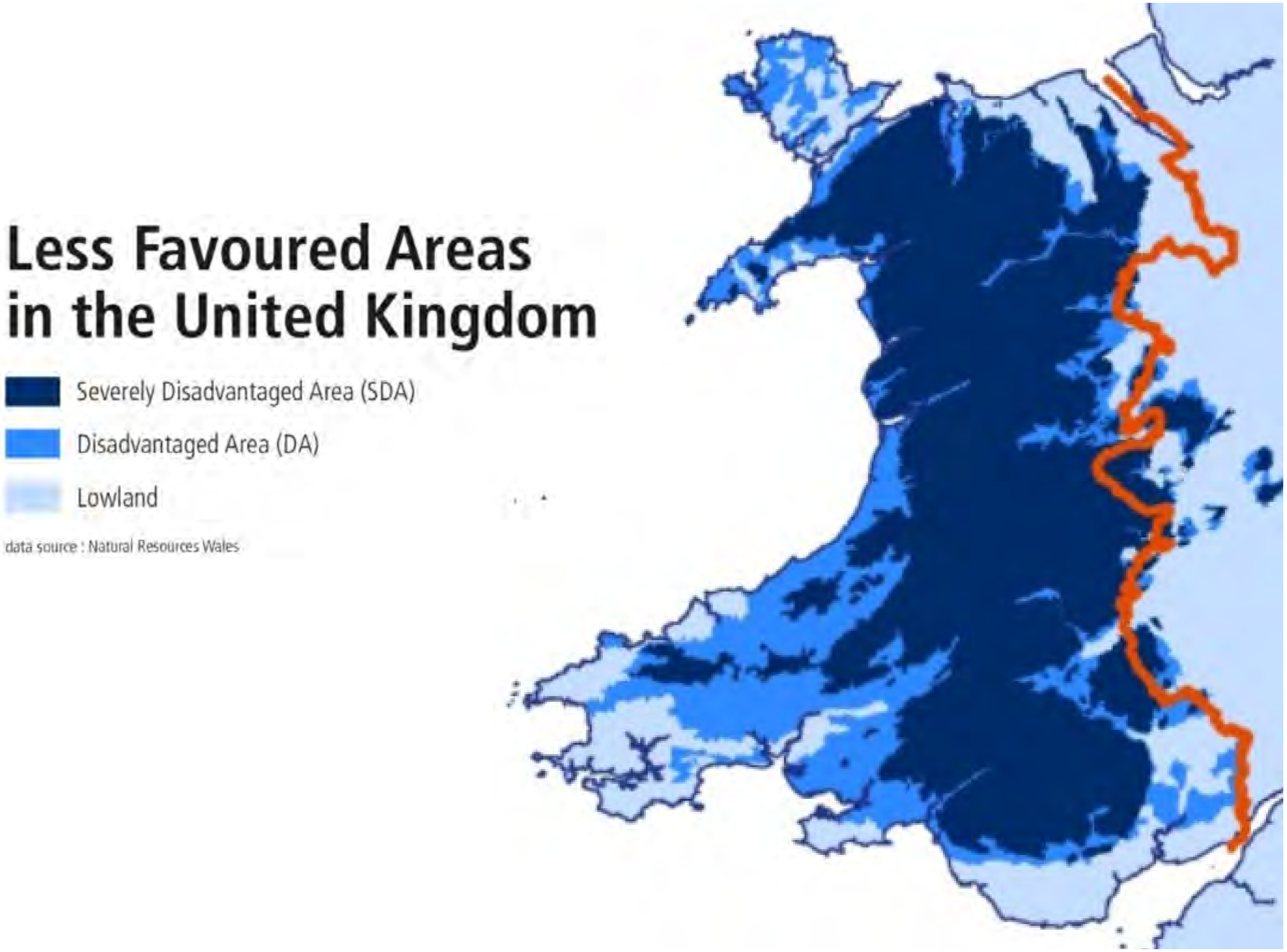
Severely Disadvantaged Areas/ Disadvantaged Areas in Wales



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Glossary: Key Acronyms (IV)

- RFT : Robust Farm Type
  - Robust farm type (used in previous Welsh Farm Practice Surveys).
  - Classes: Cereals; General Cropping; Horticulture; Specialist Pigs; Dairy; LFA Grazing Livestock; Lowland Grazing Livestock and Mixed.
- EFT: ERAMMP Farm Type
  - ERAMMP farm type (used within the IMP) is based on the RFT with additional detail on less favoured areas.
  - Classes: Cereals, General cropping, Dairy, Lowland cattle / sheep, Mixed , Specialist Sheep (SDA), Specialist Beef (SDA), DA various grazing, SDA mixed grazing .
- SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation: Names and acronyms for models within the IMP (see slide 79)

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Glossary: Key Acronyms (V)

- ERAMMP – Environment and Rural Affairs Mapping and Modelling Project.
  - Consortium Project led by the UK Centre for Ecology & Hydrology (UKCEH) and funded by the Welsh Government (WG).
  - Consortium members involved in these slide packs include Cranfield University, ADAS, the British Trust for Ornithology (BTO), eftec, Forest Research (FR) and UKCEH.
- IMP – Integrated Modelling Platform
  - The modelling platform used to produce the results shown in this slide pack. The platform combines the following models which pass data to one another as large multi-parameter data cubes:
    - SFARMOD: Whole farm model
    - ESC: Tree species suitability
    - CARBINE: Forest products, carbon and forest net present value
    - LAM: Land allocation model
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - Woodland habitat connectivity model
    - Ecosystem service models for carbon and water quality
    - EMEP4UK Emulator: health impacts of air pollution
    - Valuation: monetary and non-monetary valuation of public goods

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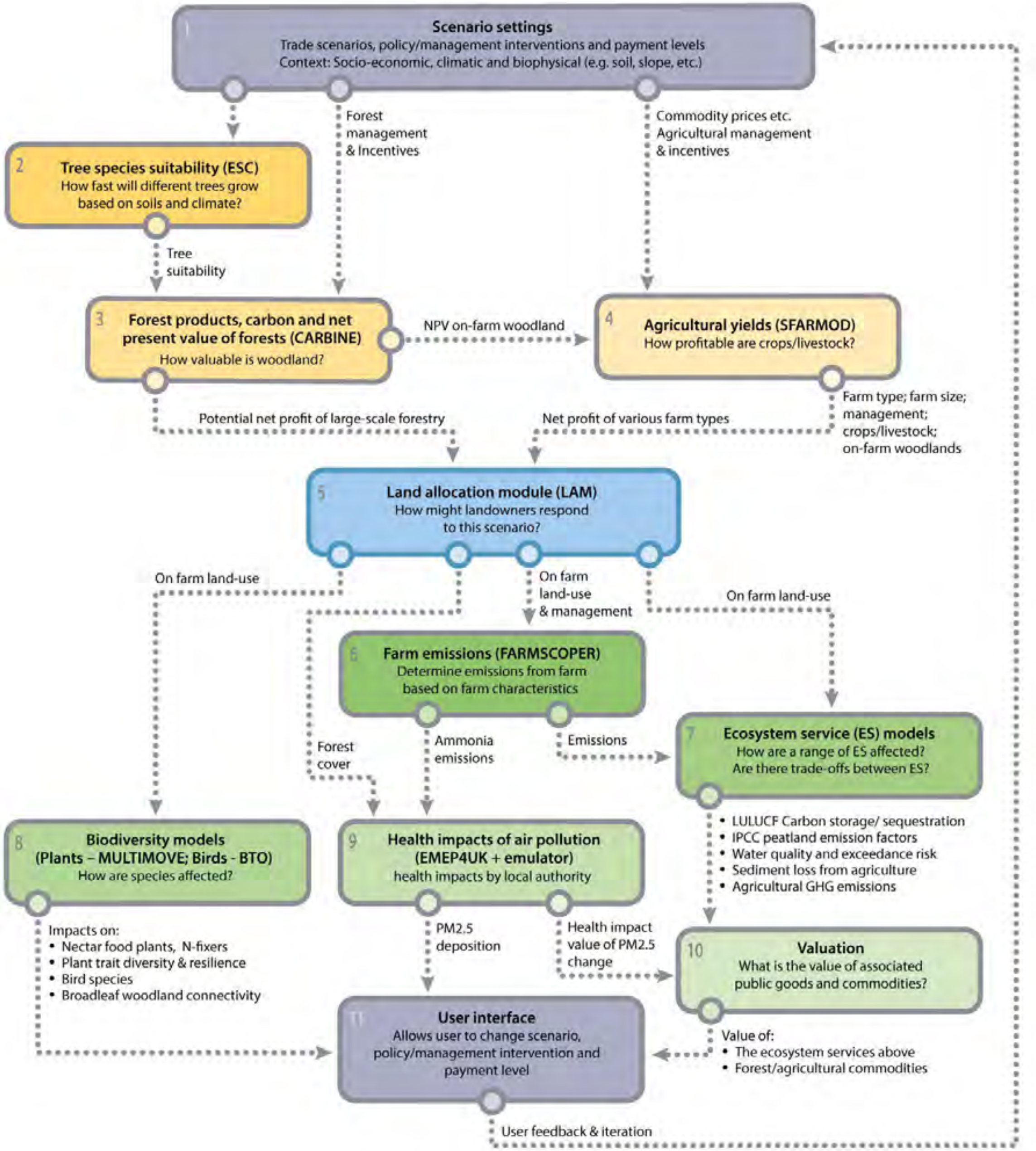
Integrated Modelling Platform schematic



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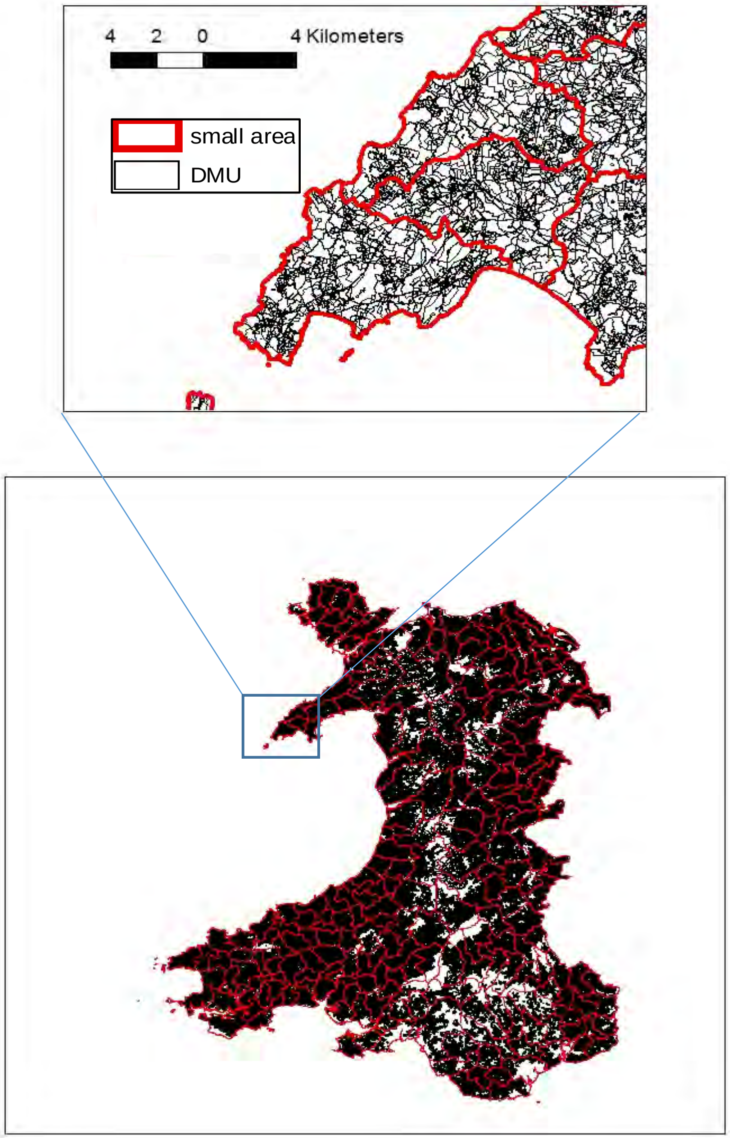
IMP modelling scales



- The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
- The finest spatial resolution used by Sfarmod and the Land Allocation Module (LAM) for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
- A DMU is defined as a managerially homogenous cluster of soil type, rainfall and land cover.
- Results in the slide pack are aggregated to small agricultural areas as findings are more robust at this level.

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5: ERAMMP_IMP_LandUseScenarios_T5_Slidepack

Funded by:

Llywodraeth Cymru
Welsh Government

Canolfan Ecoleg a Hydroleg y DU
UK Centre for Ecology & Hydrology

INTEGRATED MODELLING PLATFORM

Land Use Scenarios (T5)

UK Centre for Ecology & Hydrology | Cranfield University | ADAS | Forest Research | eftec | BTO

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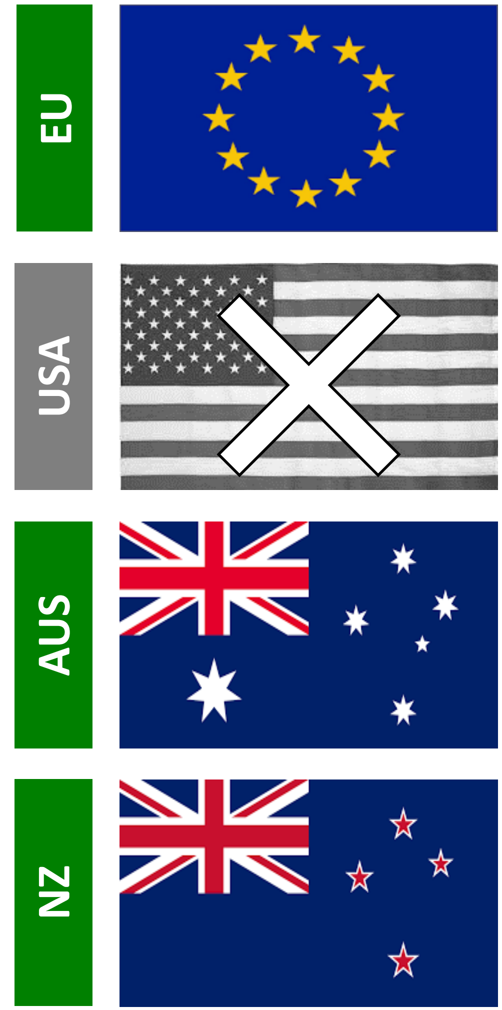
Scenario description (T5)

- Free trade agreements with EU, Australia and New Zealand, but no FTA with USA.
- WG held a stakeholder workshop to discuss and quantify changes in farm-gate prices from current figures for milk, lamb and beef:
  - Increase for milk due to increased home consumption, but competition from traded commodities (butter/cheese).
  - Decreases for lamb and beef as both come under pressure from Aus and NZ despite continuing trade with EU. No competition from USA in this option.
- Scenario settings:

	Milk (p/litre)	Beef (£/kg LWT)	Lamb (£/kg LWT)
Baseline (2015)	35	1.85	1.68
T5	**36.8**	**1.57**	**1.51**



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PART 1: Agriculture

Background information

The agricultural models are applied to all full-time farms

	No.	Area (ha)
Full-time	7726	1010891
Spare / Part-time	12738	409150
Total	**20464**	**1420041**

Farm Business Income classes within T5:

As baseline farm type	As alternative farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture
<£6000 p.a.	>£6000 p.a.	Farm under pressure	Likely to change farm type through sale to another enterprise
£6K-£13K	Any amount	Farms staying the same	Able to continue but unlikely to be able to change farm type
>£13000	<£13K +FBI uplift+finance	Farms staying the same	Insufficient economic incentive to change farm type
>£13000	>=£13K +FBI uplift+finance	Farms changes type	Likely to be sufficient economic incentive to change farm type

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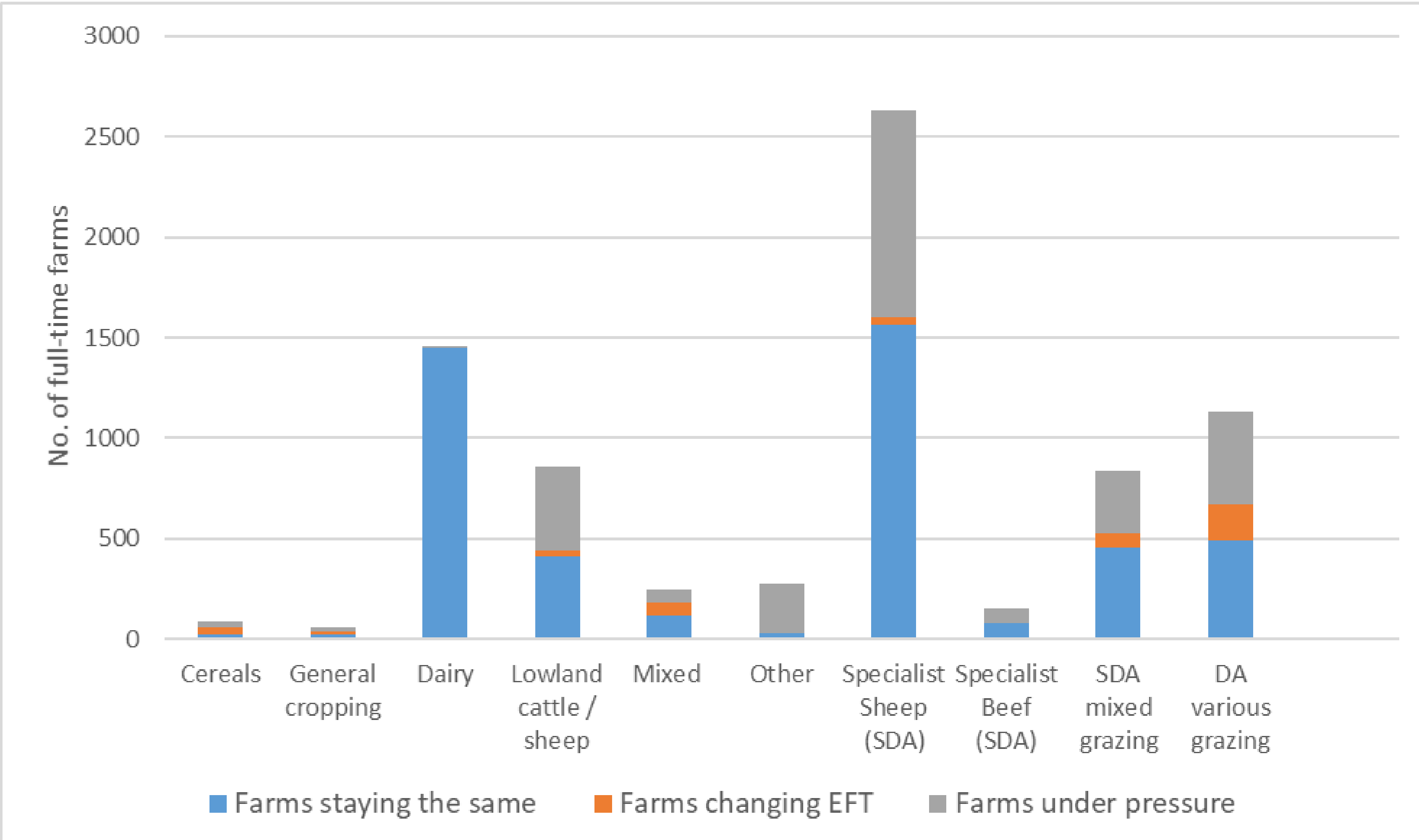
Simulated status of current full-time farms under T5



Baseline number of simulated full-time farms: 7726

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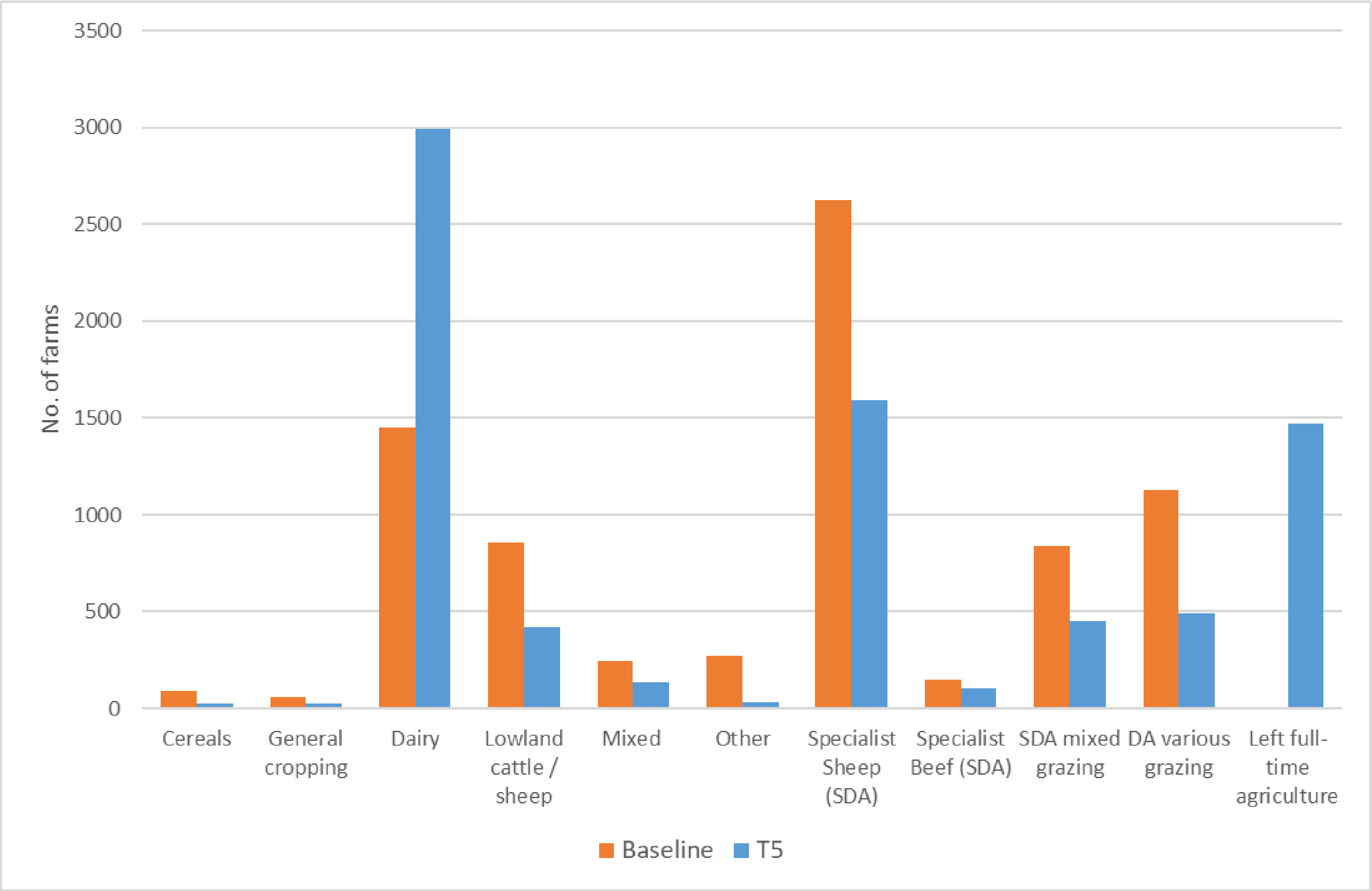
Farm numbers by farm-type (Baseline vs T5)



Total number of simulated full-time farms: 7726 in Baseline; 6257 in T5

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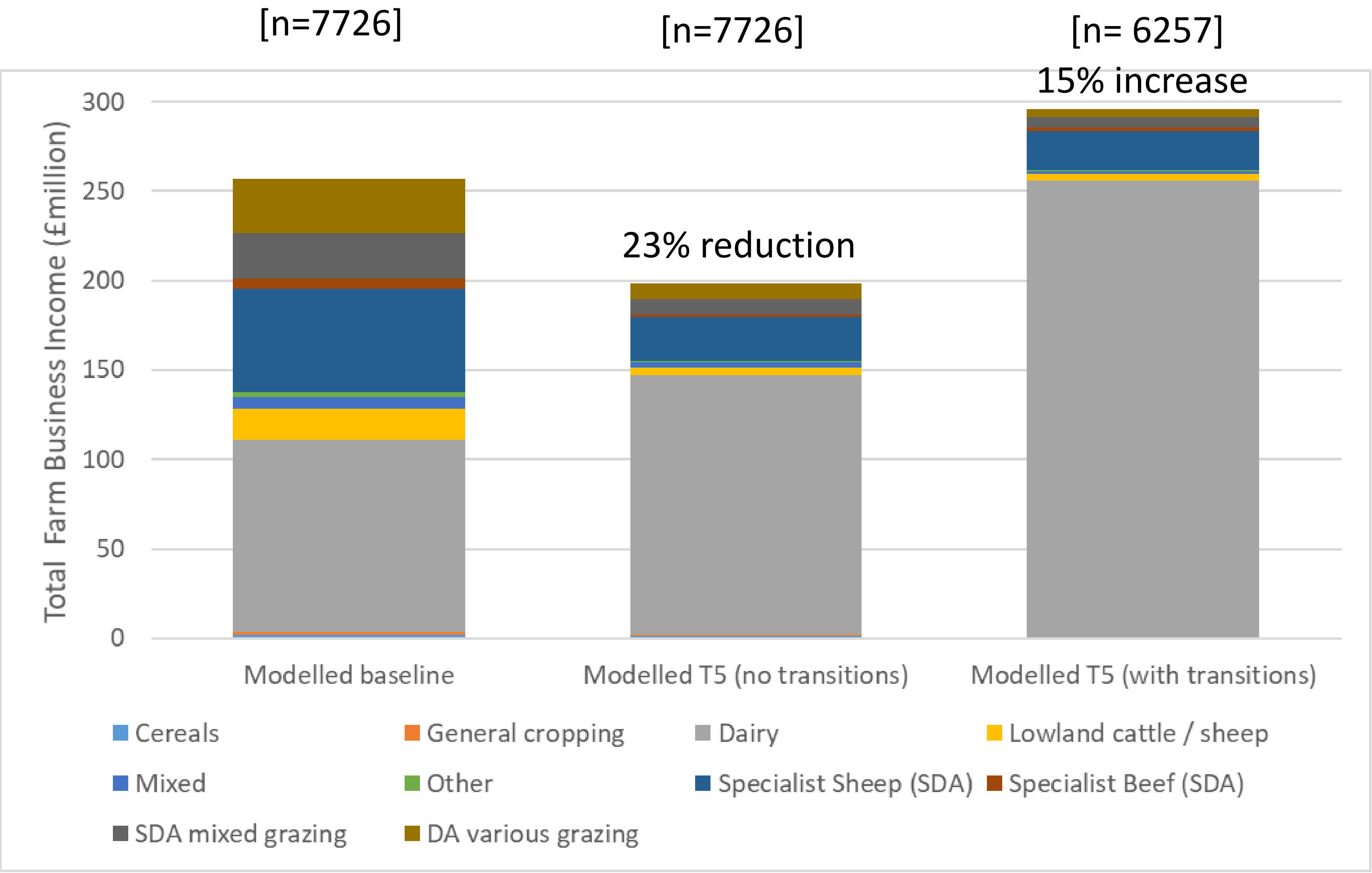
Total simulated Farm Business Income from full-time farms (T5)



Total number of simulated full-time farms: 7726 in Baseline; 6257 in T5

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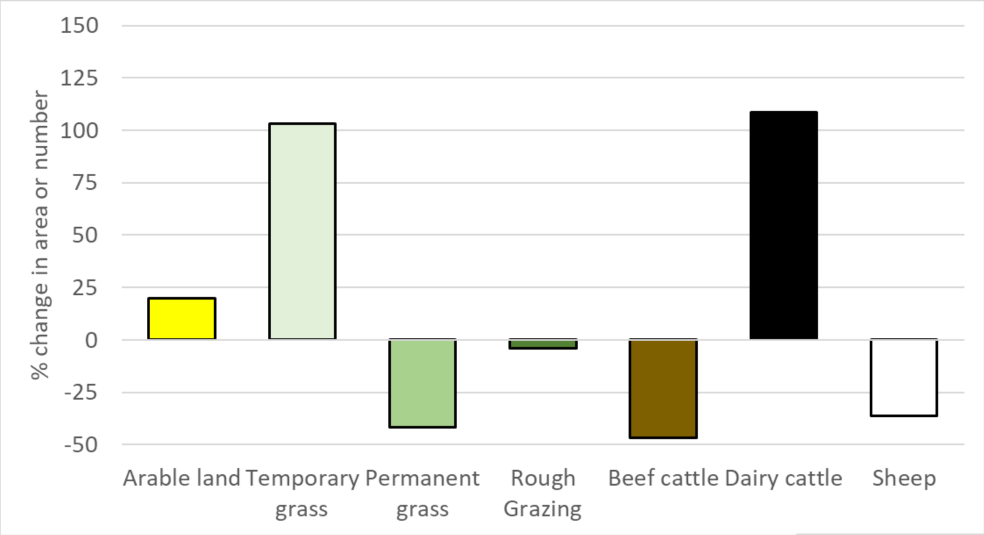
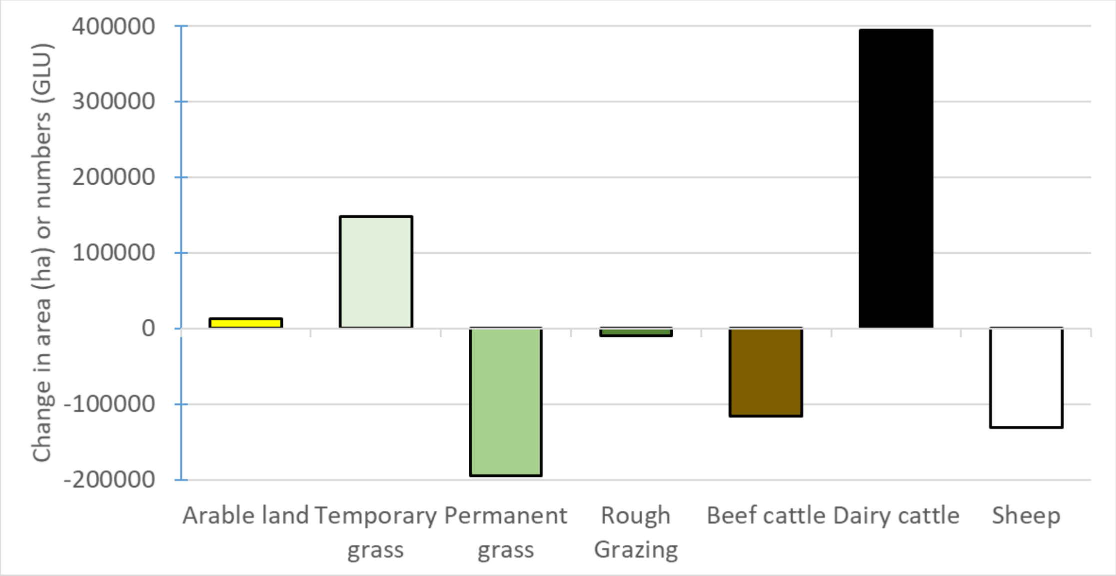
Change in simulated managed land use and stock (T5)



Percentage change (relative to simulated baseline)

Absolute change in simulated areas (ha) and numbers (Grazing Livestock Units)



Simulated farms remaining in full-time agriculture: 6257

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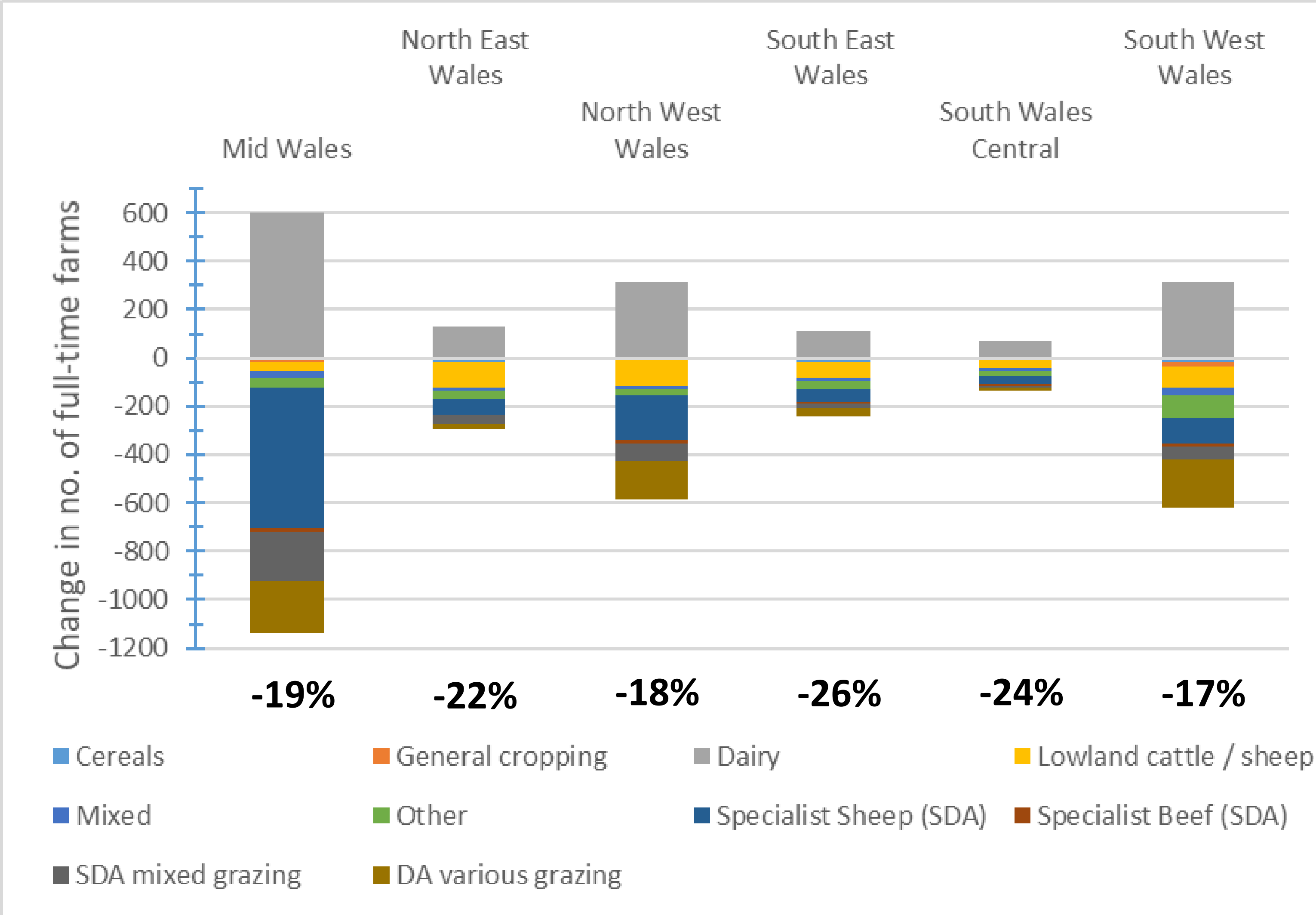
Change in farm numbers by farm-type (T5)



Simulated farms remaining in full-time agriculture: 6257

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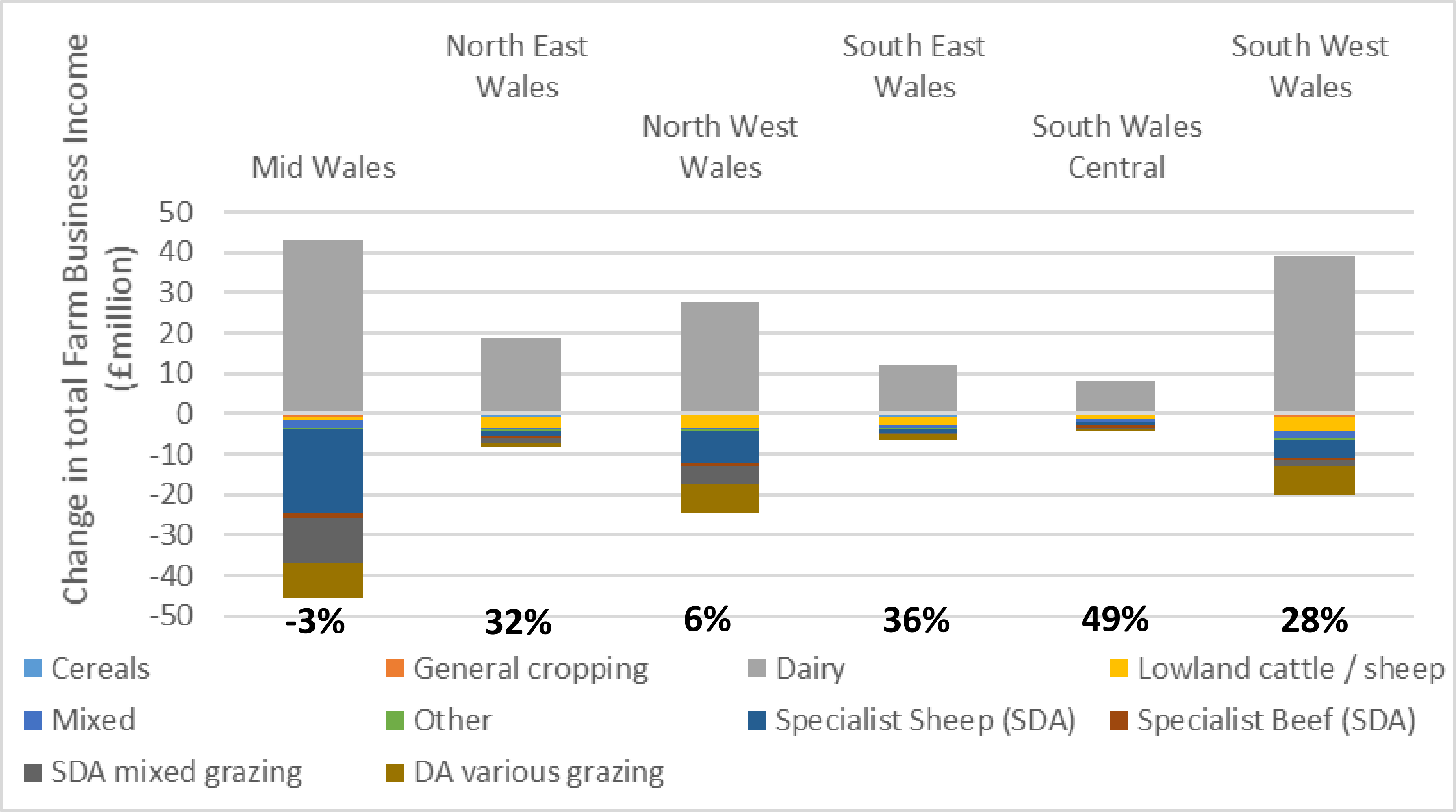
Change in total simulated Farm Business Income from remaining full-time farms (T5)



Simulated number remaining in full-time agriculture: 6257

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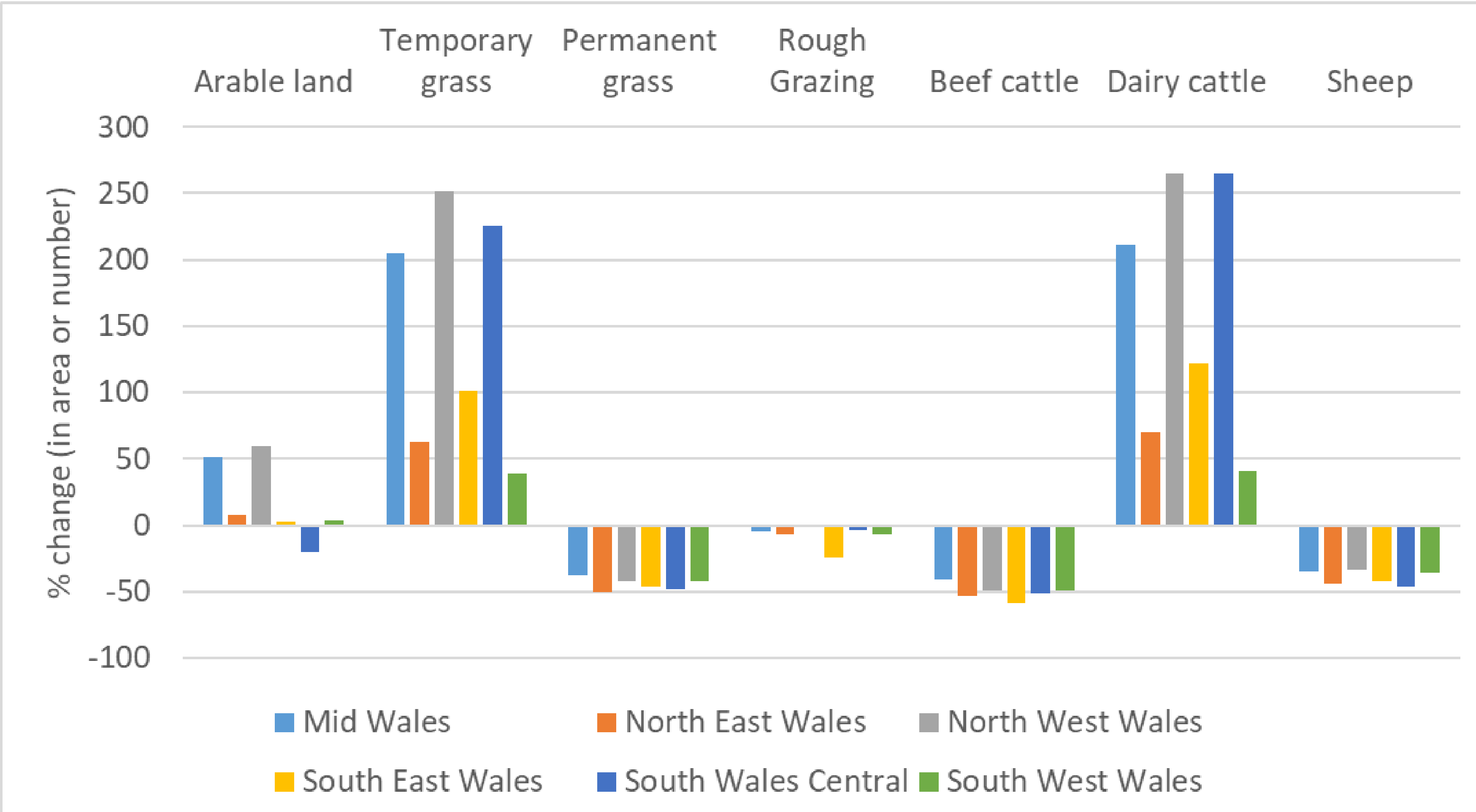
Regional change in land use and livestock (T5)



Simulated number remaining in full-time agriculture: 6257

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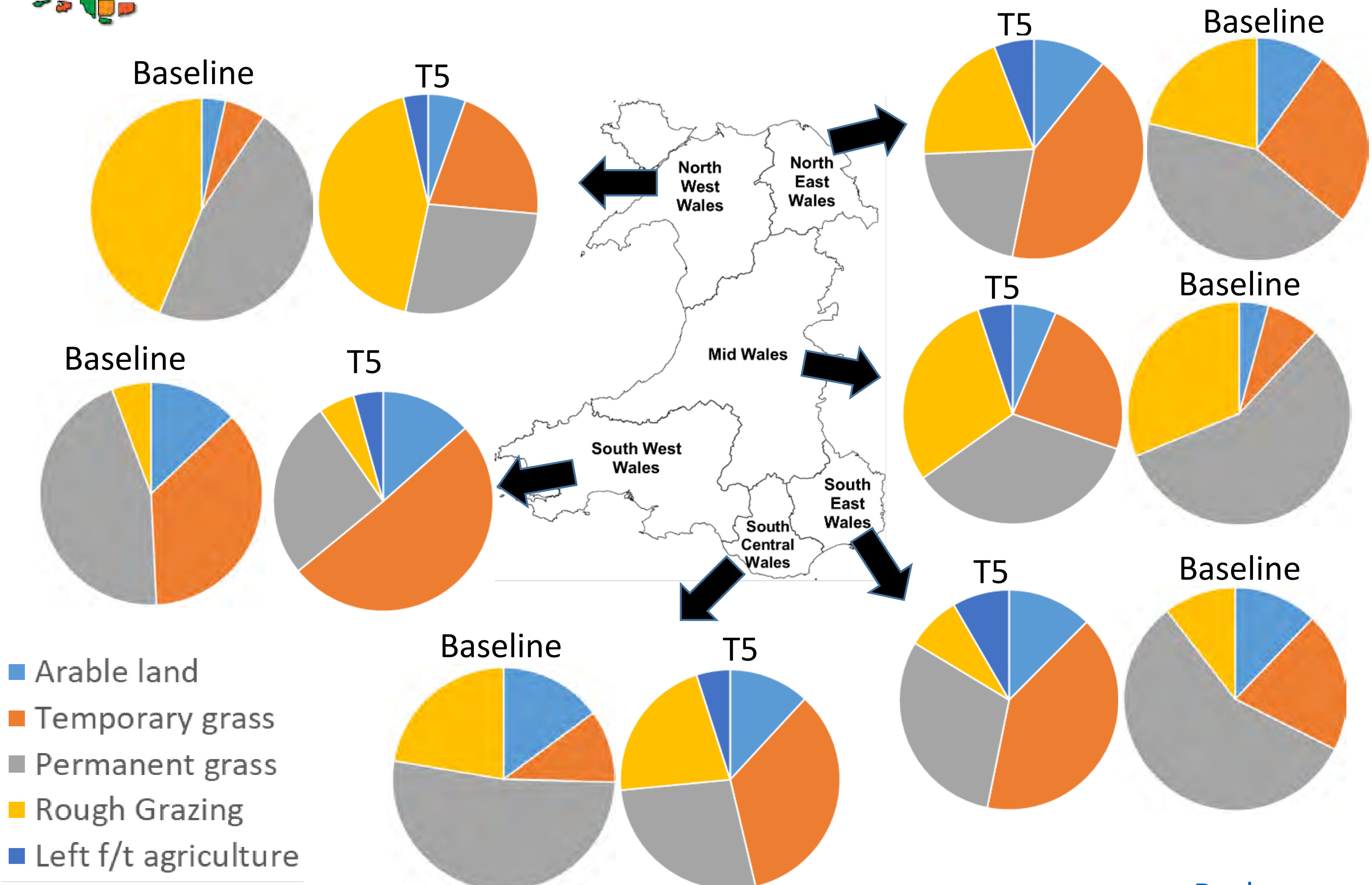
Regional land use proportions in T5



Simulated number remaining in full-time agriculture: 6257

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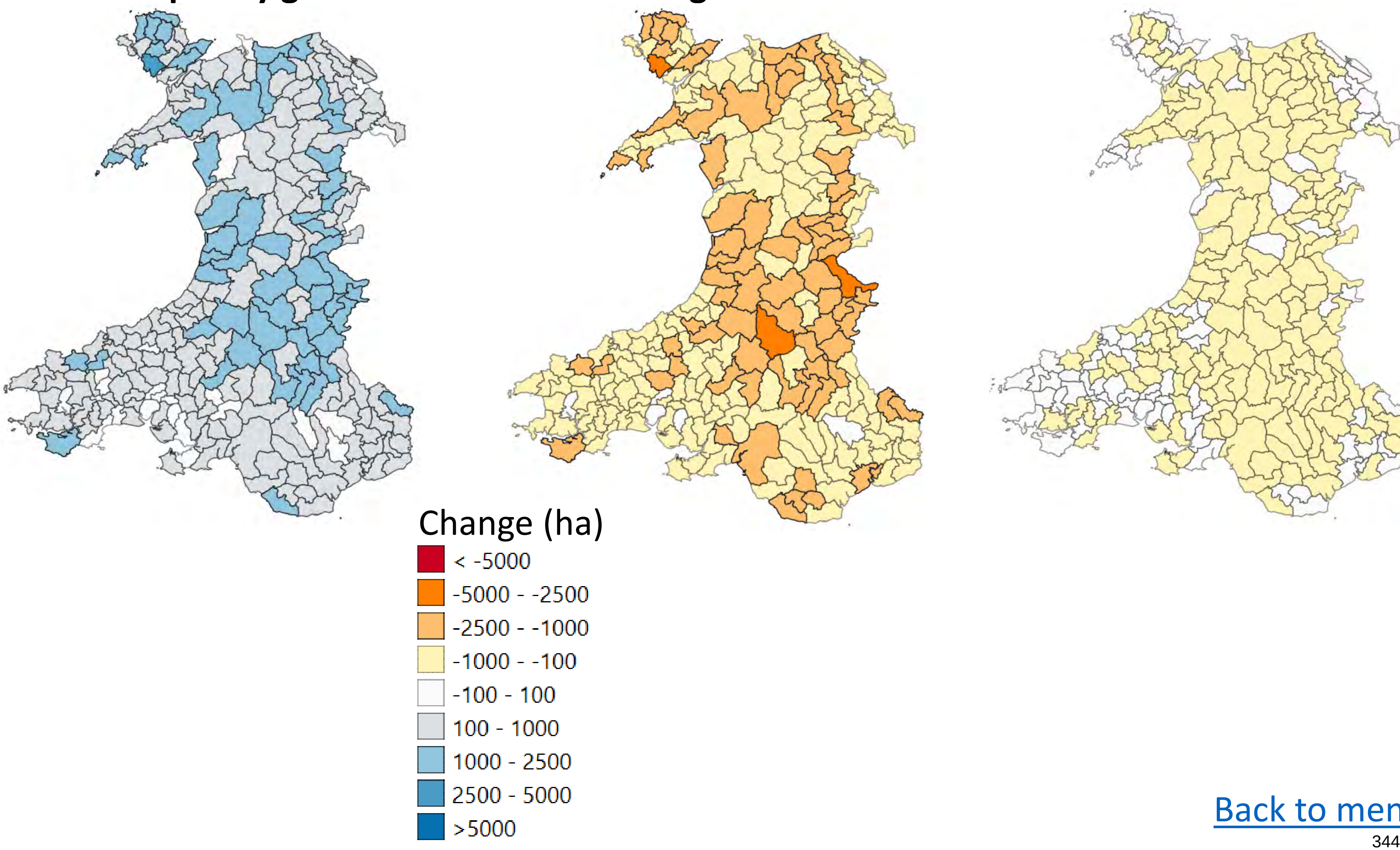
Simulated change in land use (T5)

Change in cultivated / temporary grassland | **Change in permanent grassland** | **Change in agricultural area**



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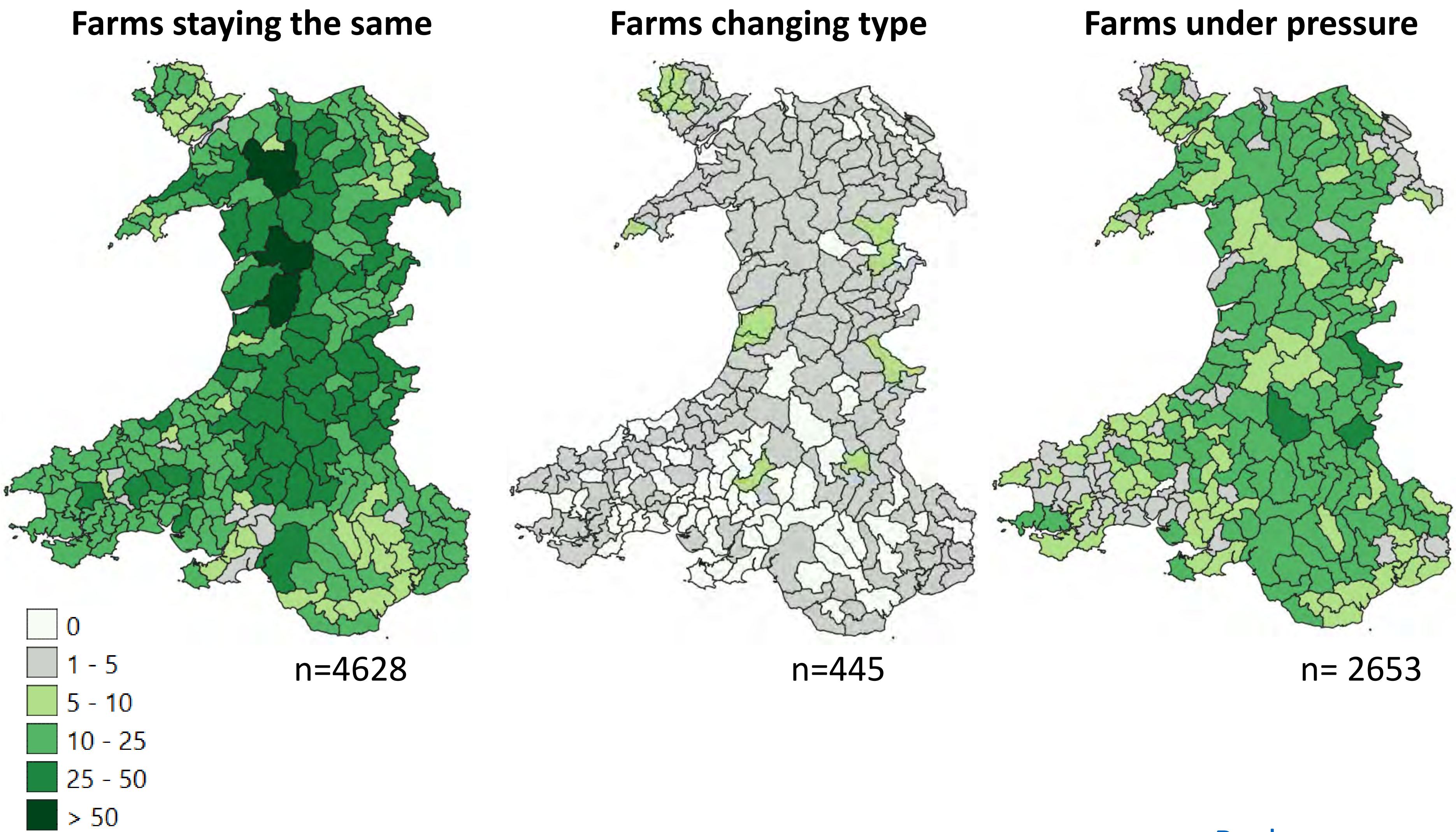
Simulated status of current full-time farms under T5



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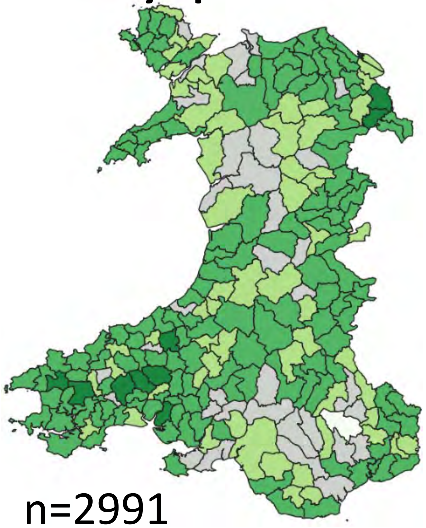
Simulated farm type numbers under T5

Dairy specialists

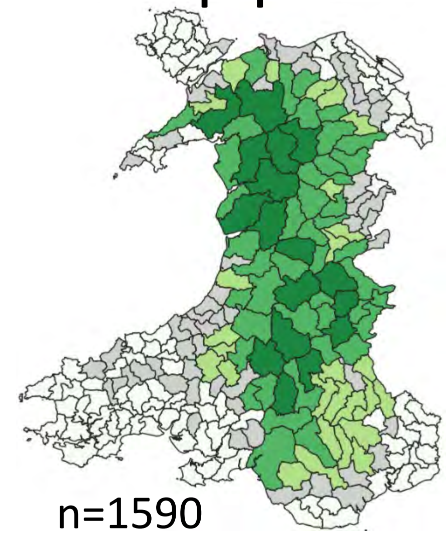


n=2991

Beef specialists

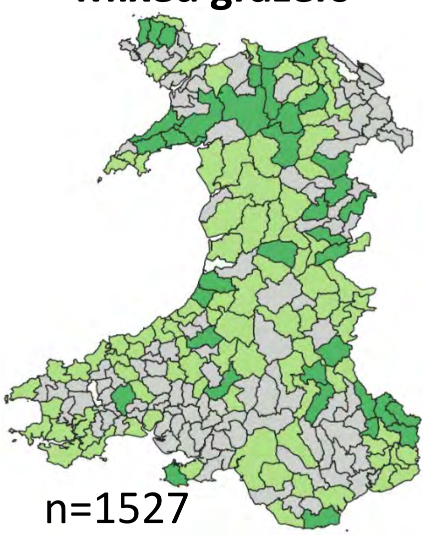
n=101

Sheep specialists



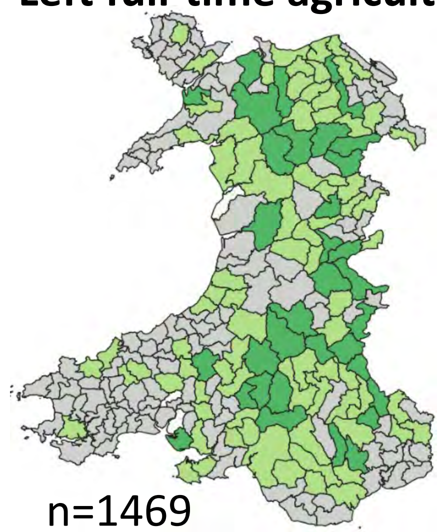
n=1590

Mixed grazers

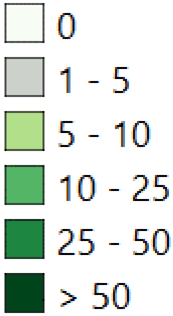


n=1527

Left full-time agriculture



n=1469



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Farms leaving full-time agriculture

Farm Business Income classes within T5:

As Baseline Farm type	As alternative Farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture

A farm that is unable to achieve a full-time annual FBI of £6,000 may:

- Implement cost savings and struggle on;
- Transition to part-time farming, to enable increased non-agricultural income though diversification and / or off-farm employment;
- Leave agriculture in the short-term;
- Leave agriculture in the longer-term (e.g. due to retirement / inter-generational change).

As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.

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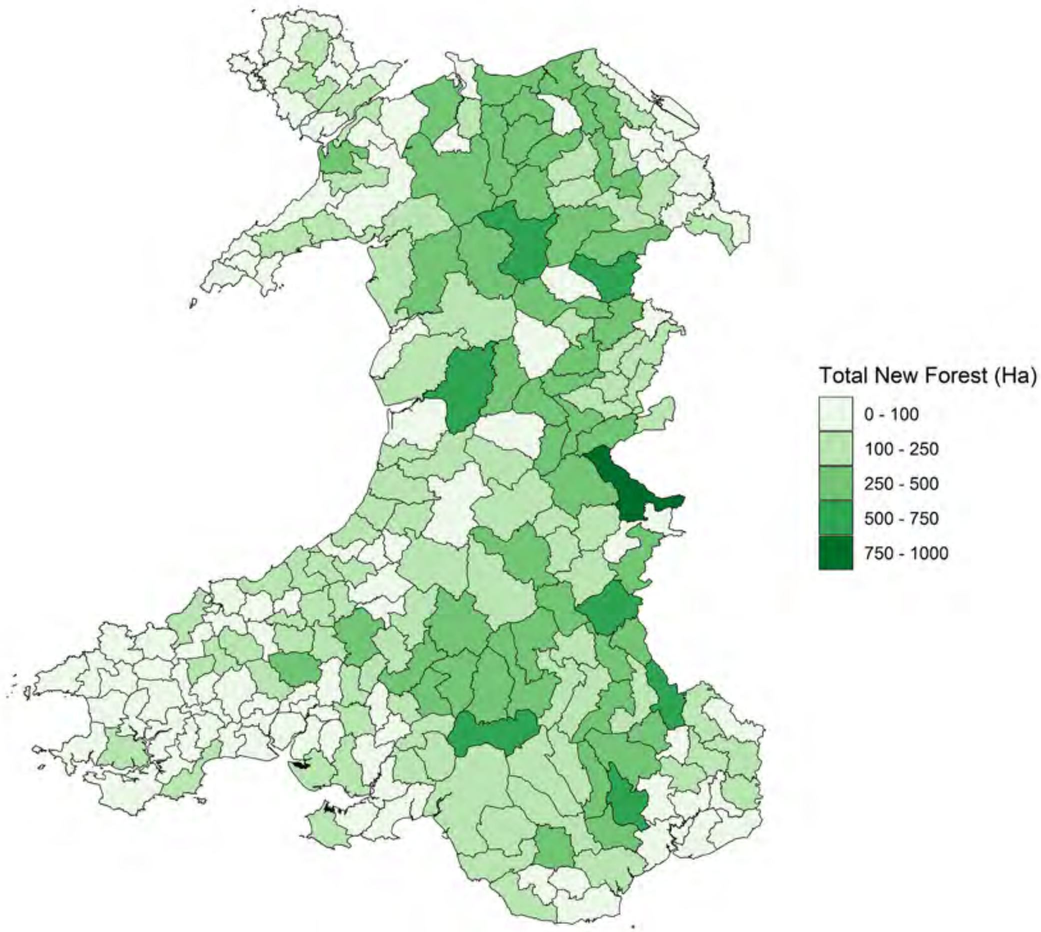
Simulated new woodland on farms leaving full-time agriculture (T5)



- Total new forest area (ha) from afforestation and natural regeneration.
- Totals largely driven by afforestation: 30,896 ha.
- Afforestation will only occur on abandoned land that will generate a positive net present value (NPV) from forestry.

Total area of new forest: 39,270 ha
(31% increase for modelled >1 FTE farms)

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PART 2: Biodiversity

Biodiversity summary – Birds (T5)

- Increases and decreases in bird population sizes are an inevitable consequence of changes in land use.
- By **2050**, under the T5 scenario, increases in the cover of coniferous woodland & decreases in the cover of wheat and maize are simulated.
- Overall, a greater number of species are simulated to decline in the T5 scenario than increase in population size.
- Woodland species are simulated to perform better under this scenario, with declines more common in generalist species.
- Change in species diversity is minimal in upland regions, but some localised declines are projected in lowland areas.

Eaton, Mark, et al. "Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man." British Birds 108.12 (2015): 708-746.

Bladwell et al. "The state of birds in Wales 2018." (2018). The RSPB, BTO, NRW and WOS. RSPB Cymru, Cardiff

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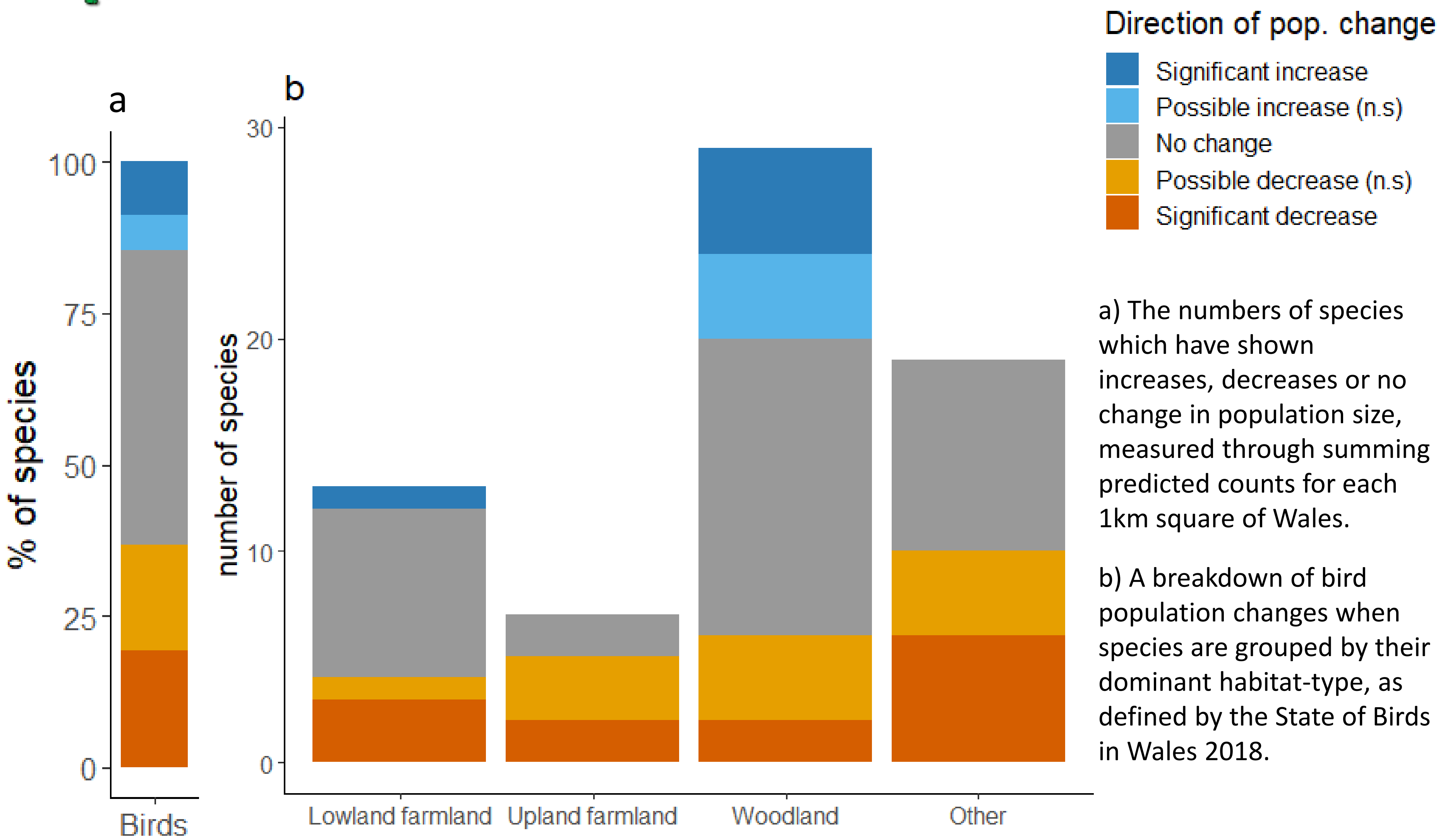
Overall bird population change in T5



a) The numbers of species which have shown increases, decreases or no change in population size, measured through summing predicted counts for each 1km square of Wales.

b) A breakdown of bird population changes when species are grouped by their dominant habitat-type, as defined by the State of Birds in Wales 2018.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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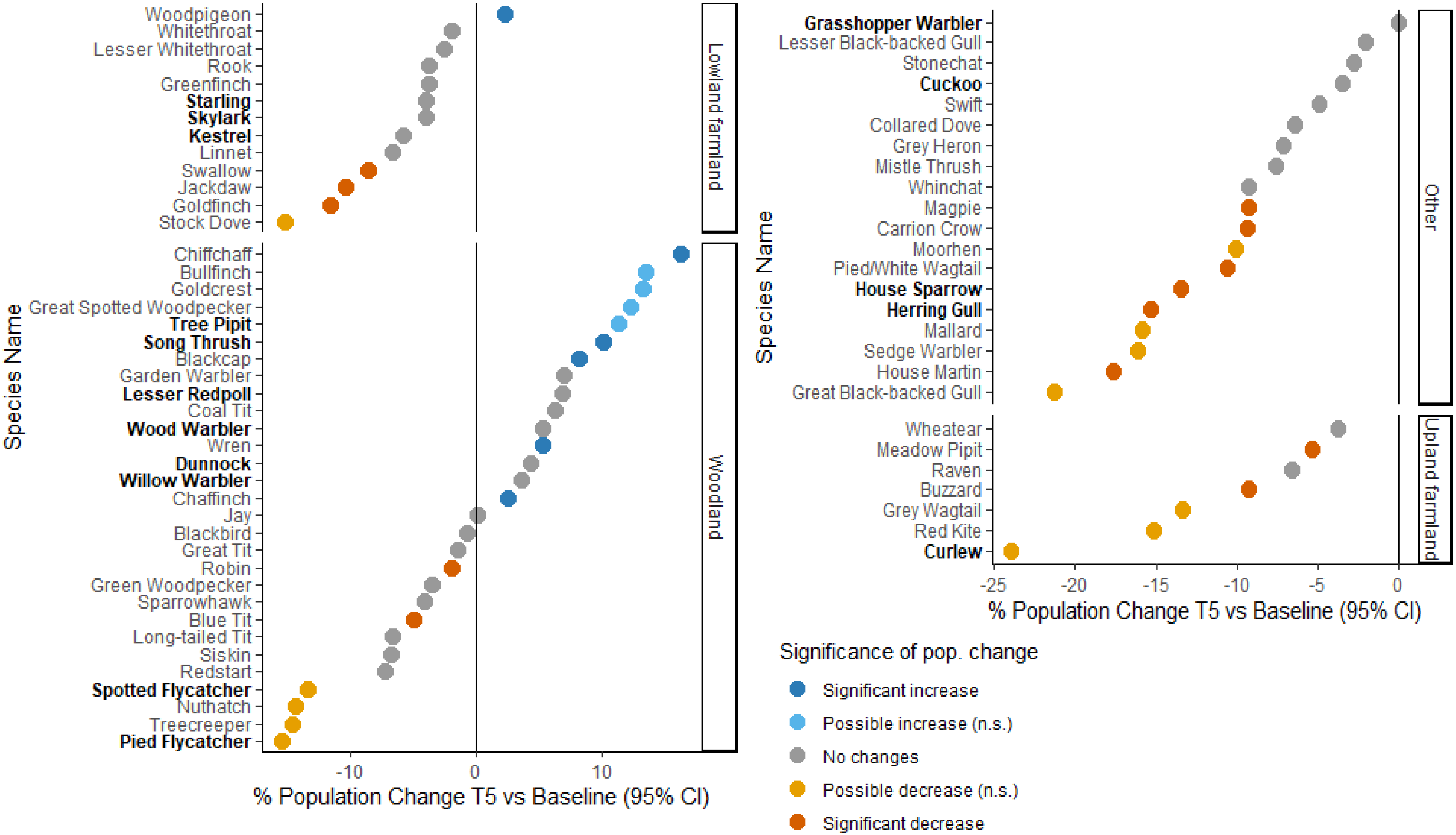
Population changes per bird species in T5



- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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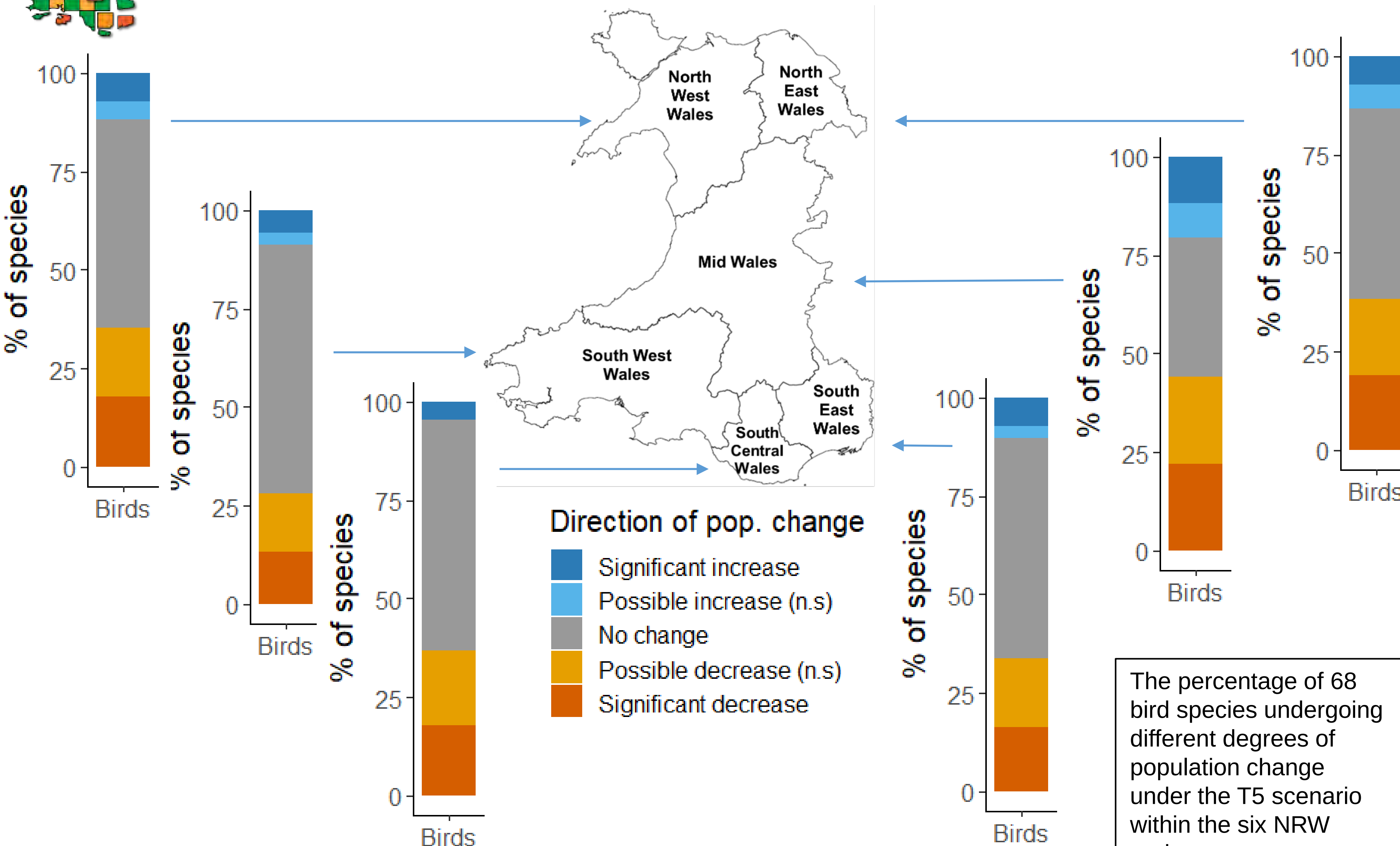
Regional bird population impacts in T5



The percentage of 68 bird species undergoing different degrees of population change under the T5 scenario within the six NRW regions.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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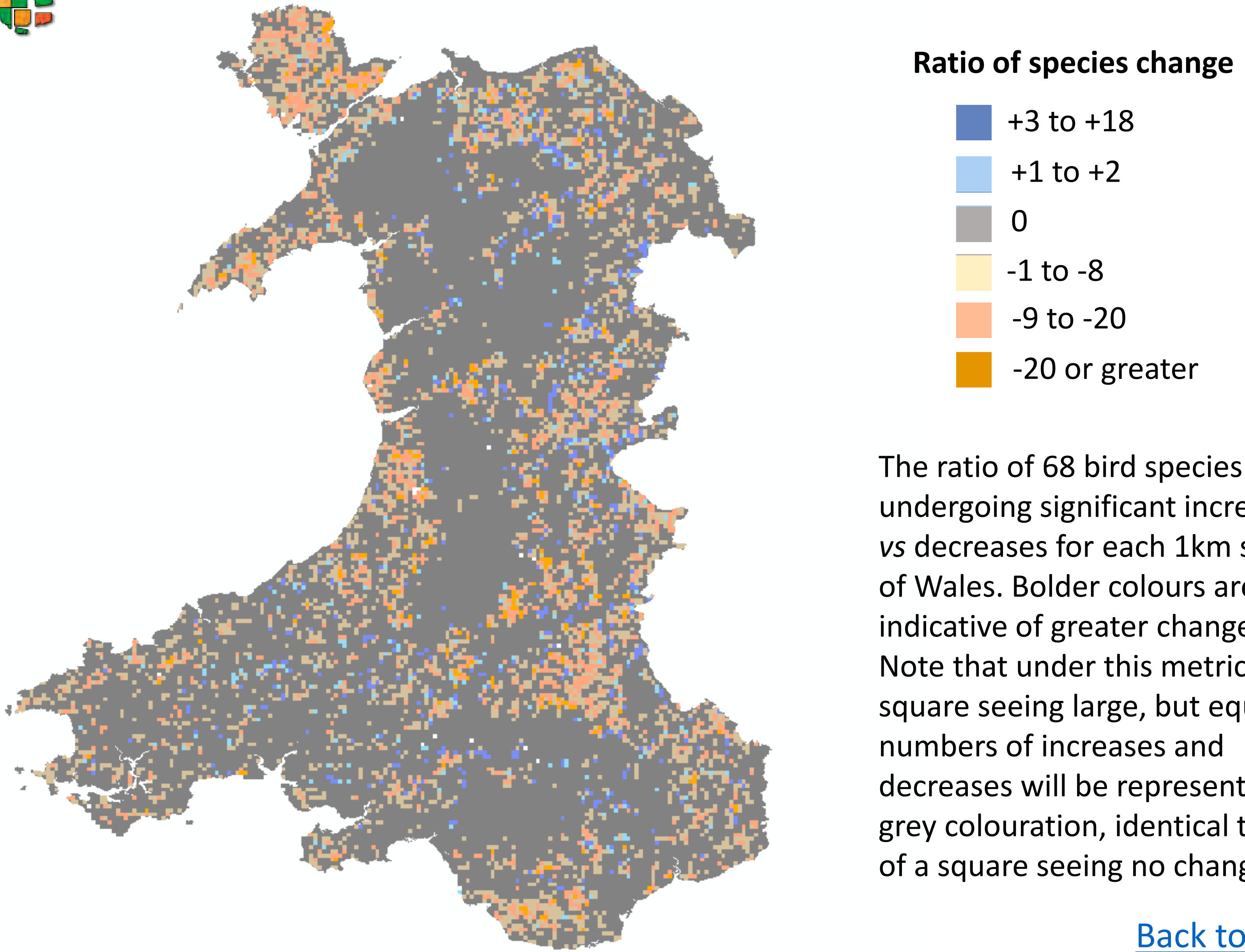
Local bird species change in T5



The ratio of 68 bird species undergoing significant increases *vs* decreases for each 1km square of Wales. Bolder colours are indicative of greater change. Note that under this metric, any square seeing large, but equal numbers of increases and decreases will be represented by grey colouration, identical to that of a square seeing no changes.

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Biodiversity summary – Plants (T5)

- Overall, simulated shifts between agricultural sectors are very similar to T4 but with fewer changes to and from farm types and therefore less area changing overall. Like T4, the pattern is dominated by gains to temporary grass and dairy and away from sheep and permanent grass. About 50% of the number of SDA farms moving to 'under pressure' in T4 moved in T5. This results in less polarisation of projected land use change.

- Overall simulated counts of plant species increasing or decreasing are very similar in T5 and T4, consistent with the similarity in land use change, but the *size* of the impact on habitat suitability for woodland specialists is reduced because less land changes to woodland in T5. Woodland and semi-natural habitat specialists are simulated to increase if shade-tolerant while grassland, wetland and heathland specialists see reduced suitability under intensification. These patterns are broadly similar across all regions except for South Central Wales where very little change is estimated across all three groups.

- Summary: Our modelling shows that the suitability of ecological conditions across much of Wales increases or decreases depending on the balance of intensification related to agricultural activity.

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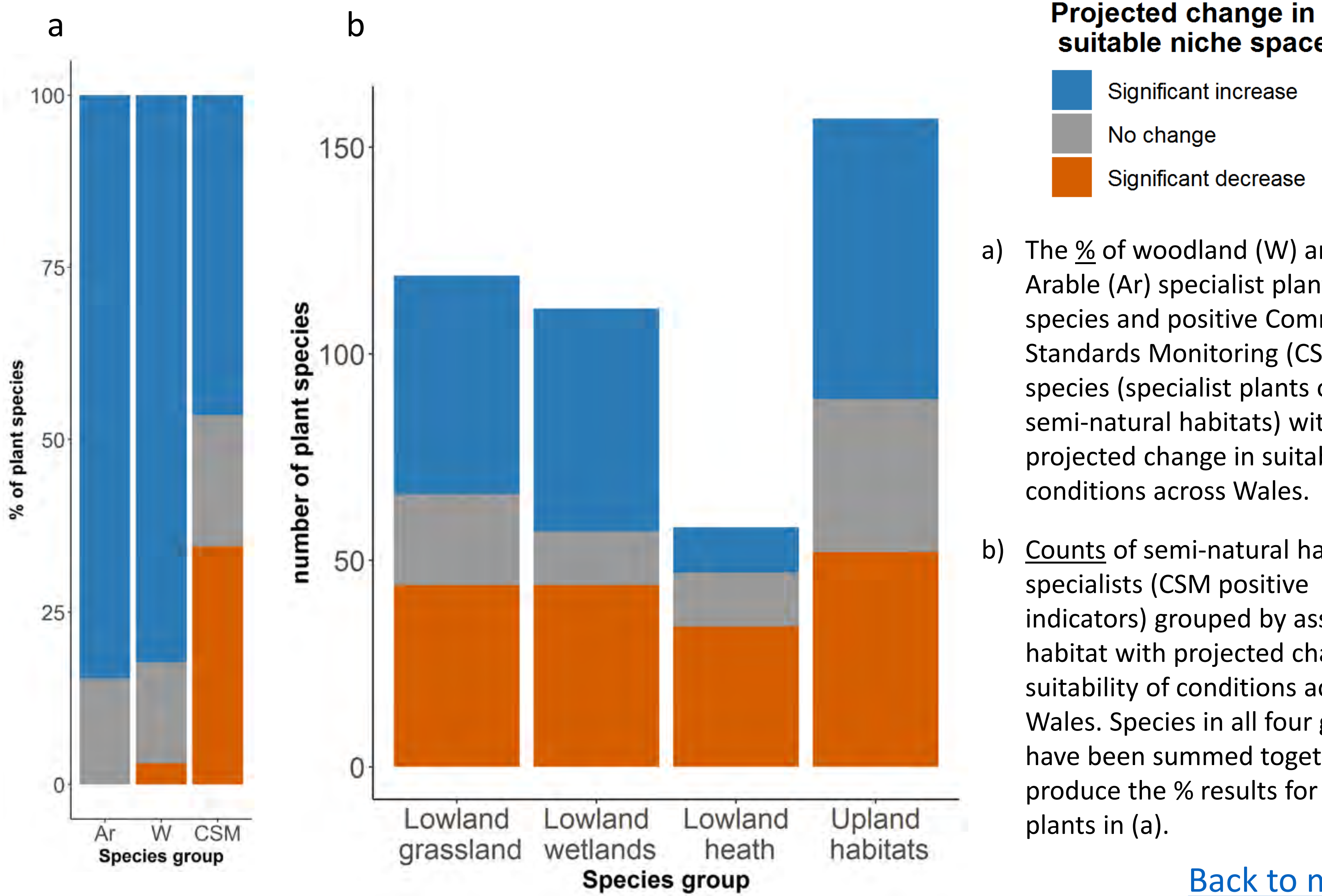
National change in habitat suitability for plants over 25 years (T5)



a) The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales.

b) Counts of semi-natural habitat specialists (CSM positive indicators) grouped by associated habitat with projected change in suitability of conditions across Wales. Species in all four groups have been summed together to produce the % results for CSM plants in (a).

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% change in habitat suitability per plant species in T5 (Examples)

Woodland specialists for Wales [1]

Latin	% change in suitability	Sig change
Sorbus aucuparia	1.2	+
Ilex aquifolium	1.1	+
Oxalis acetosella	0.8	+
Campanula latifolia	0.7	+
Allium ursinum	0.5	+
Luzula sylvatica	0.0	ns
Potentilla sterilis	-0.1	ns

Arable specialists [2]

Latin	% change in suitability	Sig change
Polygonum aviculare	1.2	+
Veronica arvensis	0.6	+
Geranium molle	0.3	+
Anagallis arvensis	0.2	+
Lamium purpureum	0.2	+
Papaver rhoeas	0.0	+
Anthemis cotula	0.0	+

Semi-natural habitat specialists (CSM +ve indicators)

Latin	% change in suitability	Sig change
Agrostis capillaris	-9.6	-
Festuca rubra	-6.3	-
Leucanthemum vulgare	-5.2	-
Galium saxatile	-3.1	-
Veronica officinalis	-0.5	-
Euphrasia officinalis agg.	-0.5	-
Briza media	-0.4	-
Angelica sylvestris	-0.3	-
Epilobium palustre	-0.3	-
Molinia caerulea	-0.2	ns
Pimpinella saxifraga	-0.1	ns
Betonica officinalis	0.0	ns
Silene dioica	0.1	ns

Excerpts from lists of species with projected change in suitability of ecological conditions across Wales. Click here to view the modelled niche of each species in Britain.

[1] Glaves D et al. (2009) A Survey of the Coverage, Use and Application of Ancient Woodland Indicator Lists in the UK. Appendix 1. Hallam Environmental Consultants, Sheffield.
[2] Walker, K.J. (2018) Vascular plant 'axiophyte' scores for Great Britain, derived from the assessments of the vice-county recorders of the Botanical Society of Britain and Ireland (May 2016). NERC Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/af2ac4af-12c6-4152-8ed7-e886ed19622b

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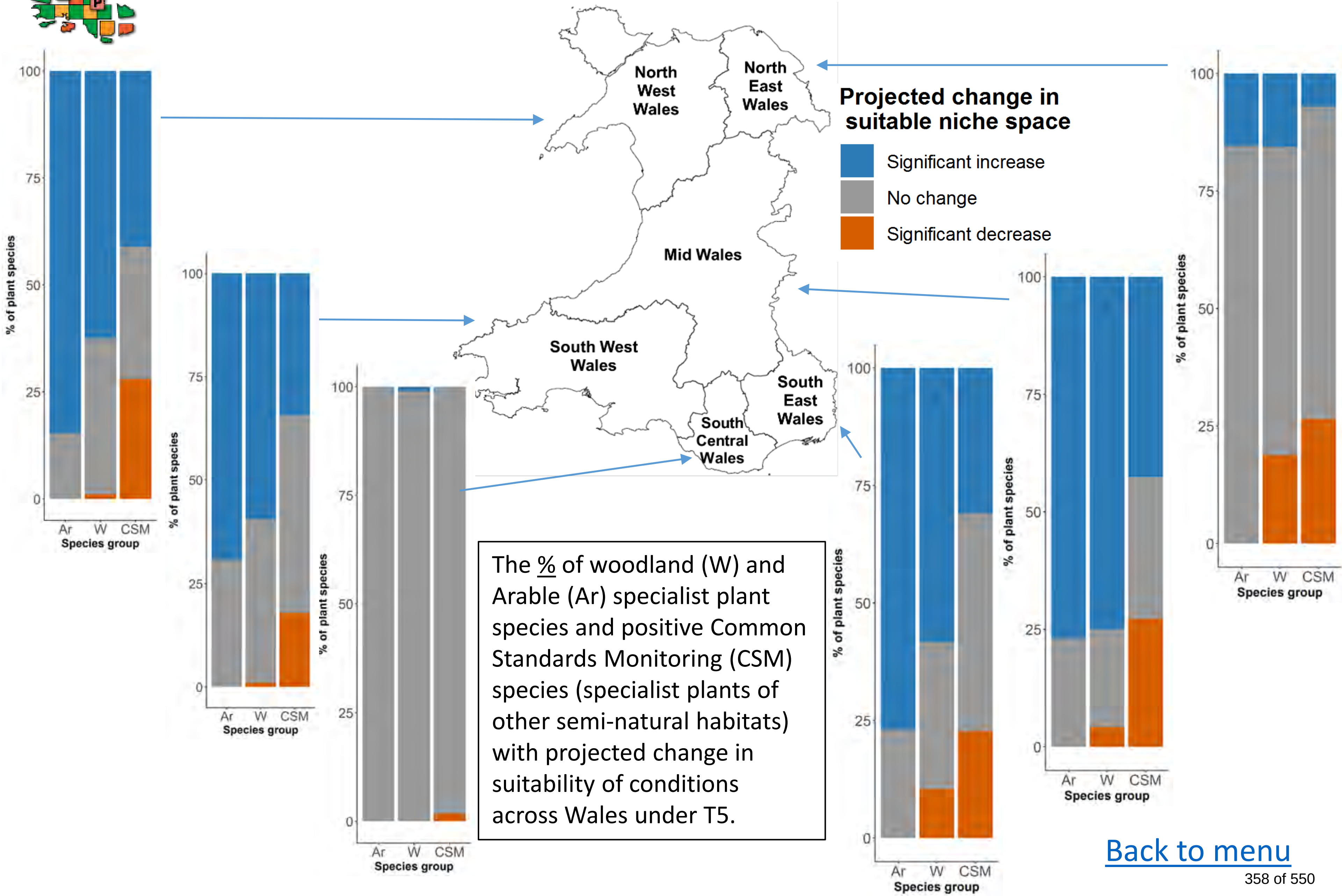
Regional impacts on plant species in T5



The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales under T5.

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Woodland habitat connectivity: Background information

- Woodland connectivity was modelled using a simple approach based on the distance species can travel (dispersal distance) and minimum habitat area requirements (patch size).
- Land within the dispersal distance of more than one patch could connect those patches if trees were planted.
- We identified a range of parameter combinations from the literature and applied these for Wales, broken down into NRW Area Statement regions.
- Baseline woodland was assigned using NFI data, combined with LCM2017, and data on woody linear features.

Dispersal distance/ patch size	**100m: snails**	**200m: woodland specialist plants**	**500m: invertebrates**	**1km: max. for snakes; amphibians; moths**	**2km: max. for woodland flora/fauna**
1 ha: low area requirements	not modelled	modelled	modelled	not modelled	not modelled
10 ha: high area requirements	not modelled	modelled	modelled	not modelled	not modelled
40 ha: NE recommended minimum size for wildlife site	not modelled	modelled	modelled	not modelled	modelled

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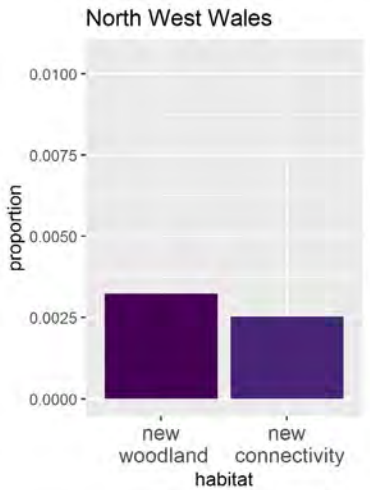
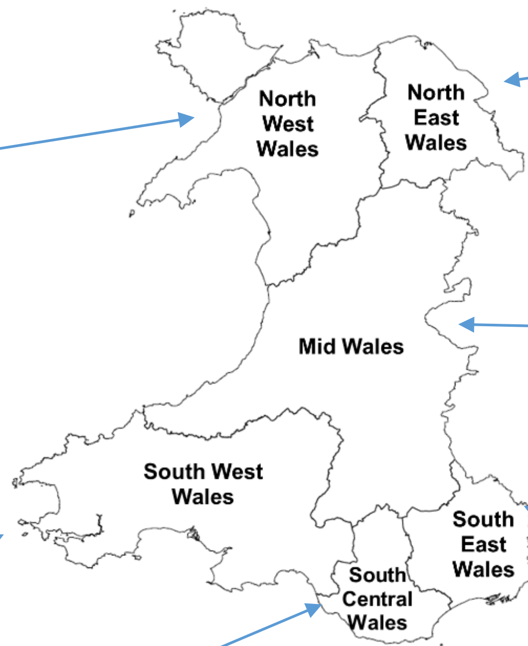
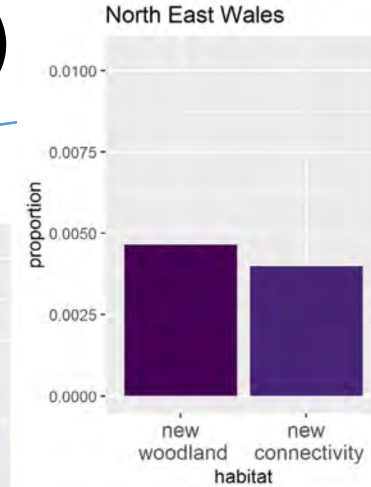
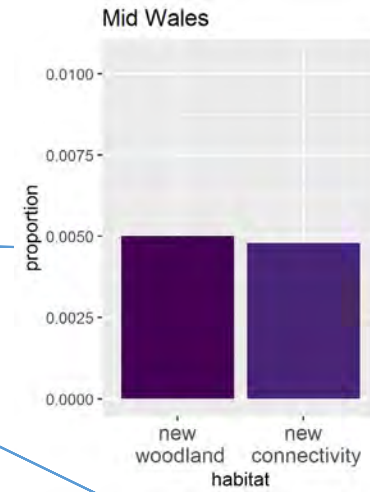
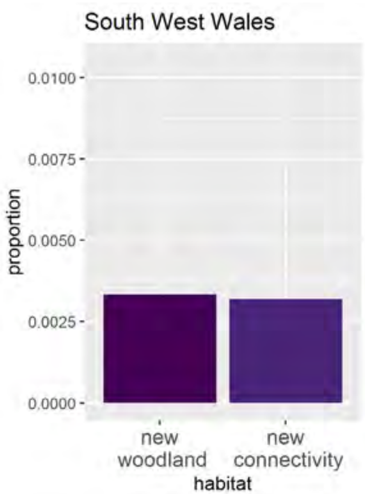
Woodland habitat connectivity: Regional variation in opportunity and predicted change (T5)

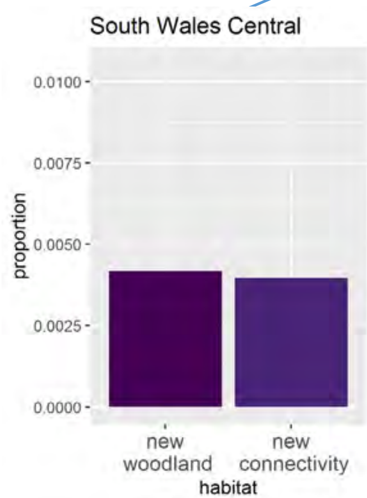


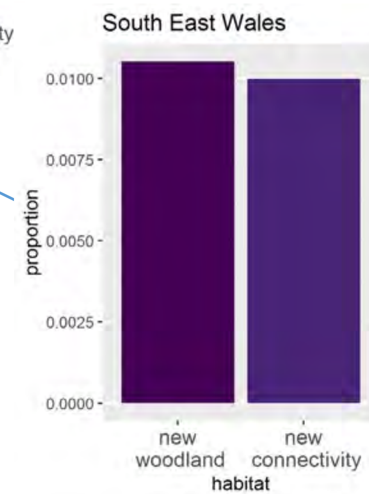












Most of the new woodland increases connectivity for at least one of our species type groups

- Total area new habitat woodland (ha)
- Total area providing increased connectivity

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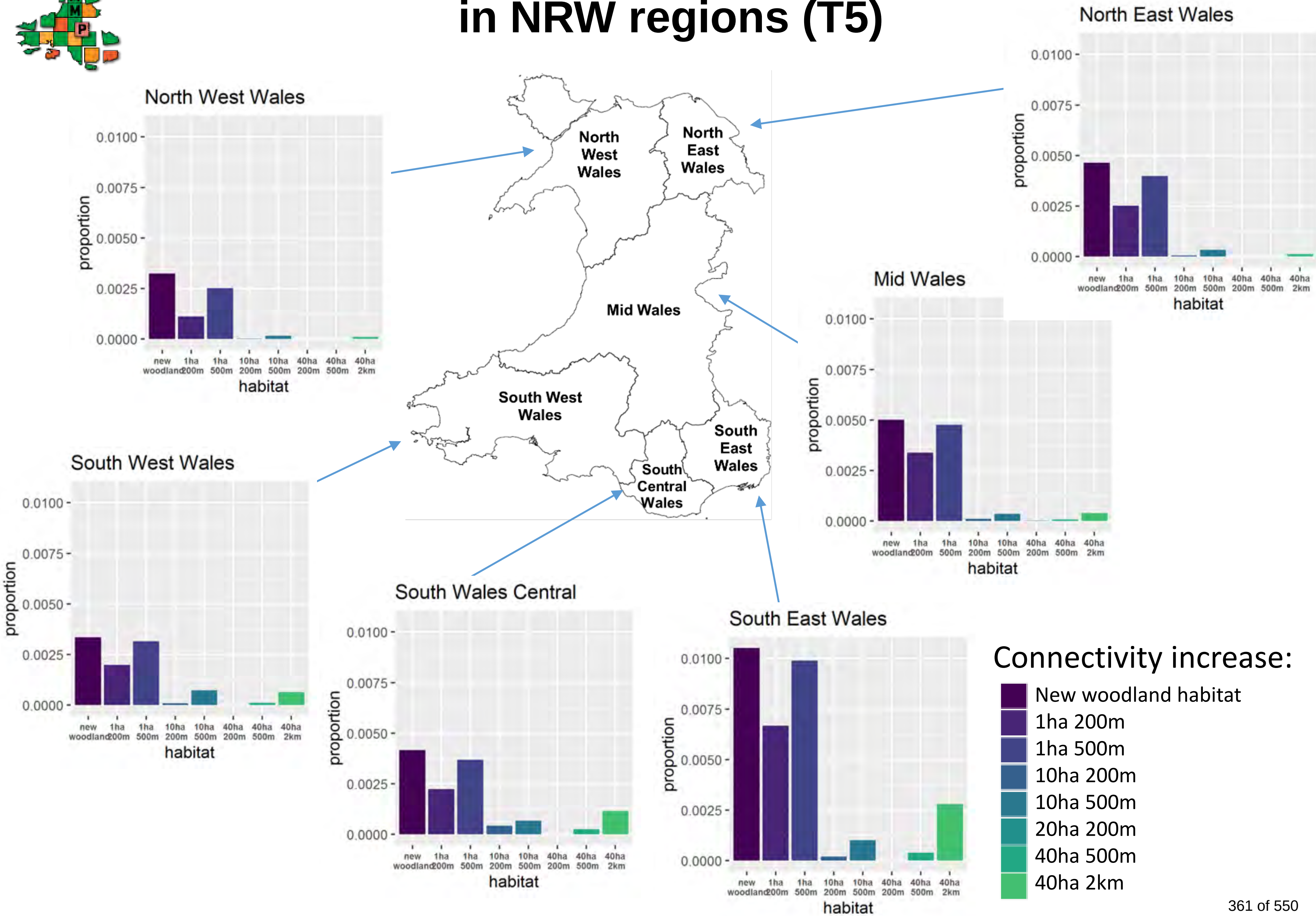
Breakdown of woodland connectivity type in NRW regions (T5)



PART 3: Ecosystem Services

3a: Carbon

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Carbon summary: Stocks and GHG emissions (T5)

(Note: Negative numbers indicate sequestration or avoided emissions)	**Increased emissions or losses of carbon by the year:**		
Inventory category:	**2025**	**2050**	**2100**
Losses from carbon stocks in Land use change and forestry + harvested wood products (4 A, B, C & G) (KtCO2eq)	5,039	3,756	-199
Additional emissions from wetlands (4D) flux (KtCO2eq)	-32	-194	-518
Additional agricultural GHG flux (KtCO2eq)	8,024	48,141	128,377
TOTAL	13,030	51,703	127,660

- Overall, a **small increase in C stocks by 2100**, alongside a **larger increase in GHG emissions** is simulated for the T5 scenario, creating **net increase in atmospheric GHGs**.
- Modelled increase in greenhouse gas emissions associated with changes in livestock and nutrient inputs dominates the overall C budget, greatly exceeding the predicted small sequestration in vegetation and soils associated with agricultural land use change (LULUCF 4 A, B, C & G) and the small reduction in wetland GHG emissions.

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Carbon summary for Wales (T5)

This table compares Carbon stock and change in the LULUCF categories:

LULUCF category	Baseline	Change to 2100
Cropland and Grassland (4B + 4C)(Kt) C	173,399	Loss of: 5,776 (Kt) Gain of: 83 (Kt)
Forest Land (4A) (Kt)C	Baseline woodland C data are not available	Gain of: 4,369 (Kt)
Harvested Wood products (4G) (Kt) C		Gain of: 1,378 (Kt)

- Carbon in cropland and grassland systems (LULUCF category 4B and 4C) is simulated to be lost in the T5 scenario due to transitions from permanent grassland into arable/grass rotation, which exceeds carbon gains due to land going out of agriculture.
- Gains in C storage are simulated for forest land and harvested wood products related to agricultural land that is converted to woodland. Note, this outcome is strongly dependant on the area of new woodland planting as modelled here, based on planting on former agricultural land with net positive NPV. Note also that data are not available to account for C storage in existing woodland.

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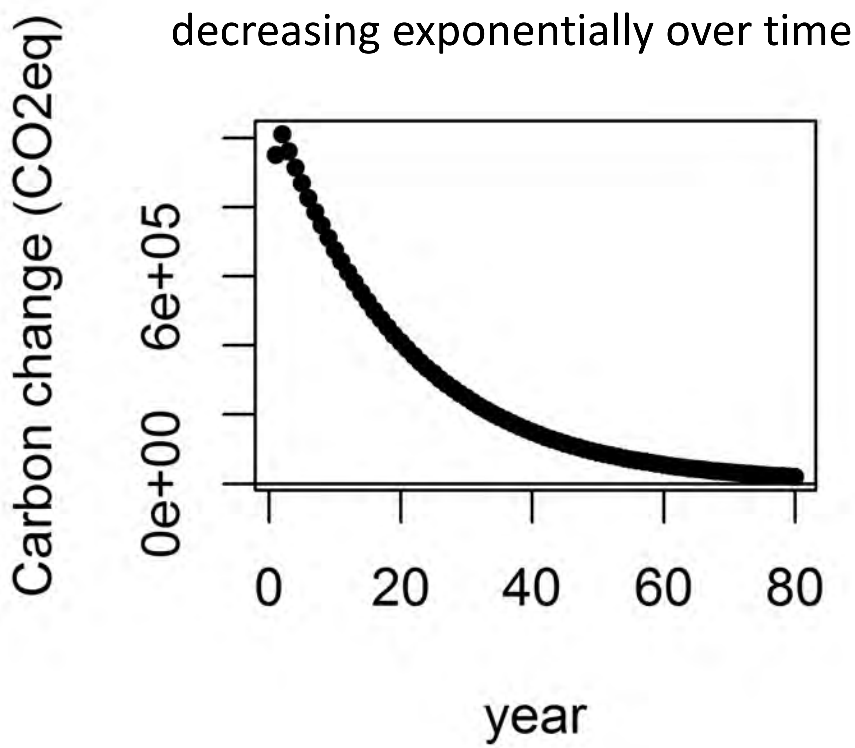
Agricultural carbon stock for Wales (T5)

Rate of C emissions from soils and vegetation at agricultural sites:
Initially high losses in C stock, decreasing exponentially over time



(Plot for agricultural land staying in agriculture)

- Carbon stock in croplands and grasslands (LULUCF 4B + 4C) is simulated to decrease, rapidly at first with high initial emissions, but slowing over time, approaching a new equilibrium by 2100.
- Total losses to 2100 on this agricultural land account for around 3% of total IMP modelled C stocks in agricultural vegetation and soils.

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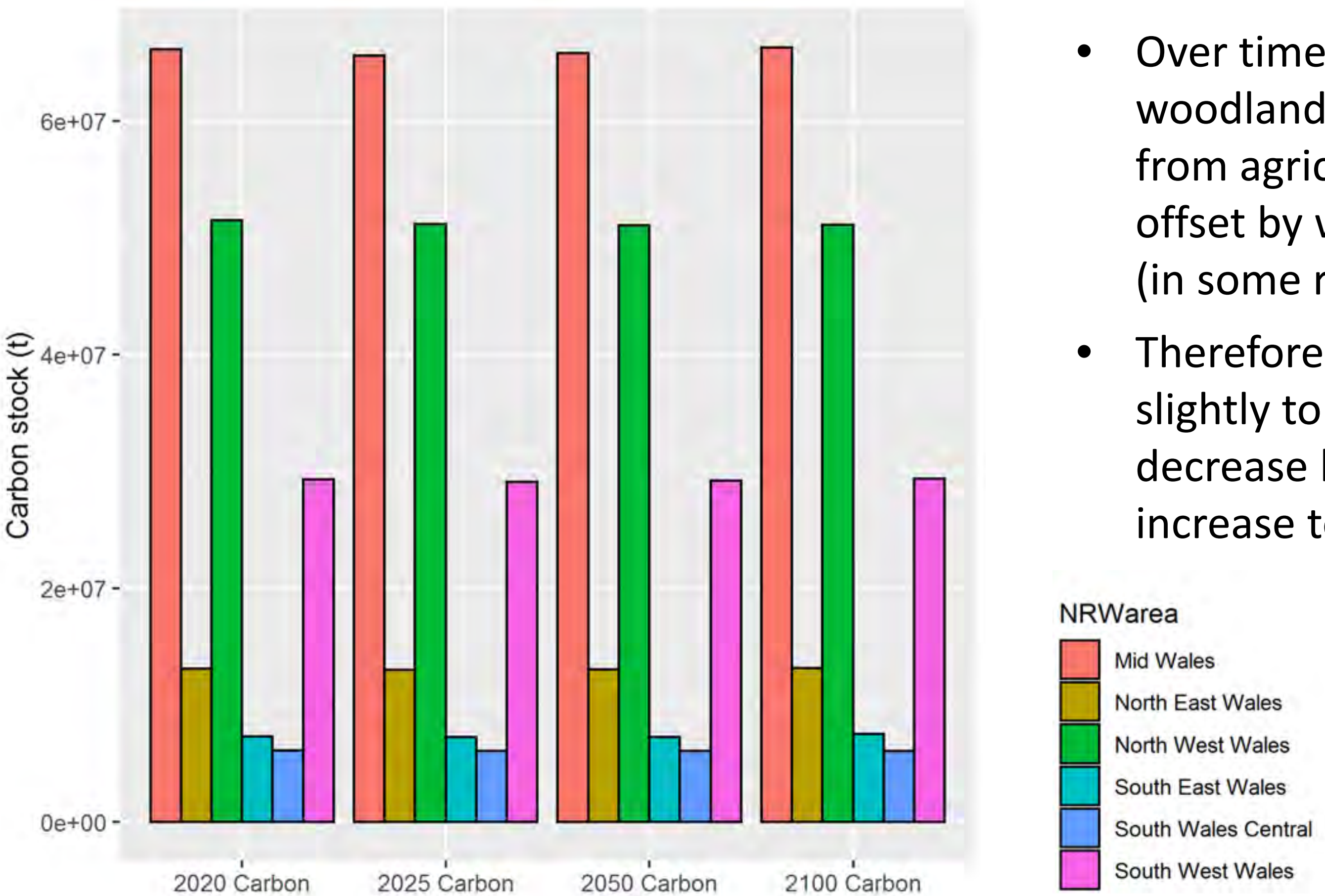
Carbon stock over time (T5)

Total C stock for all modelled land in: 2020, 2025, 2050 and 2100



- Carbon stock in woodland systems increases slowly over time, with initial losses at some sites due to soil disturbance.
- Over time, initial losses from woodland disturbance and losses from agricultural changes are offset by woodland sequestration (in some regions).
- Therefore, total C stock decreased slightly to 2025, with further slight decrease by 2050 and a small net increase to 2100.

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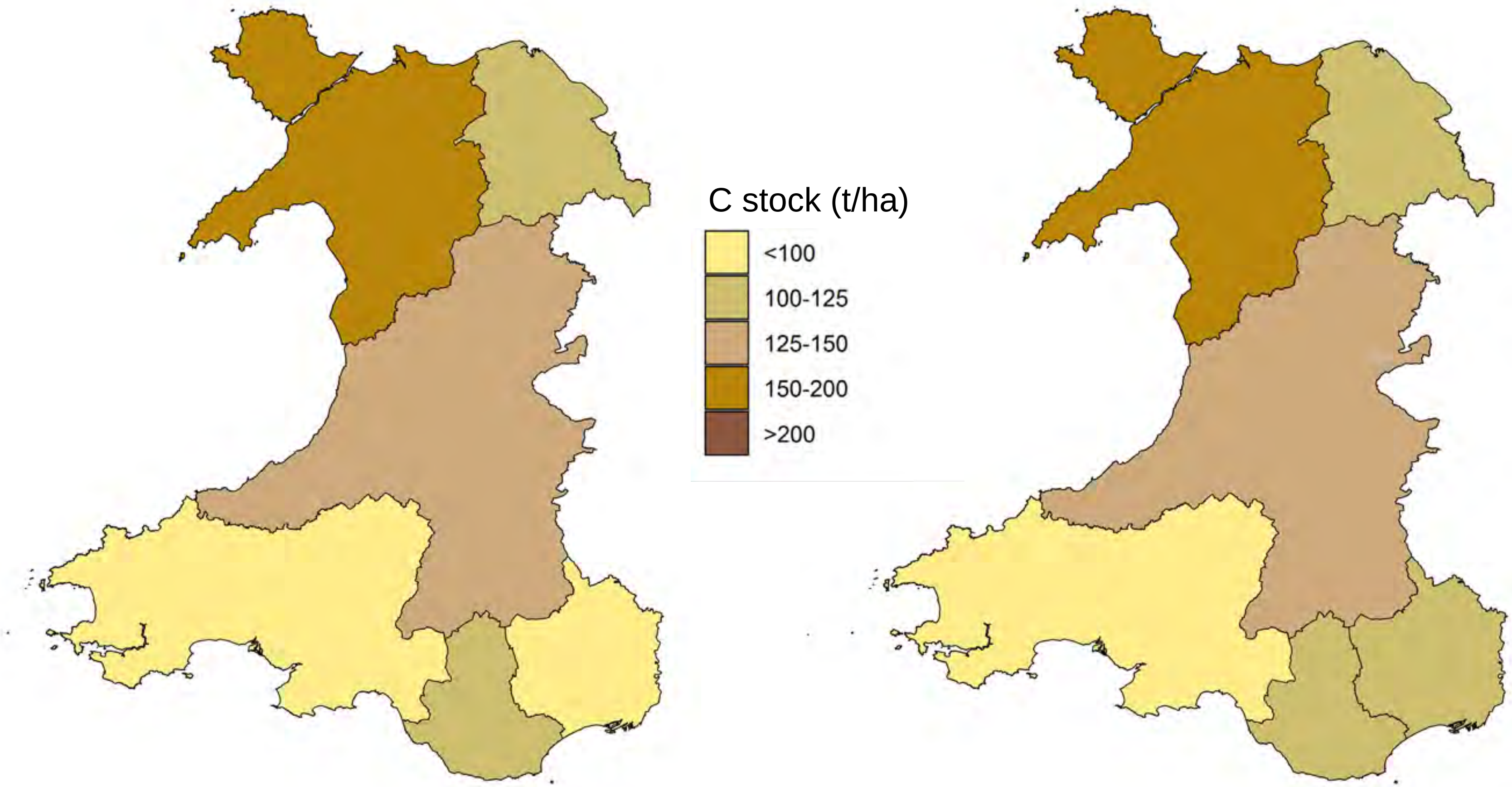
Carbon stock for NRW regions (T5)

Baseline (2020) | **T5 scenario (2100)**



Data are for LULUCF categories 4 A, B, C & G
and are displayed per ha of land modelled

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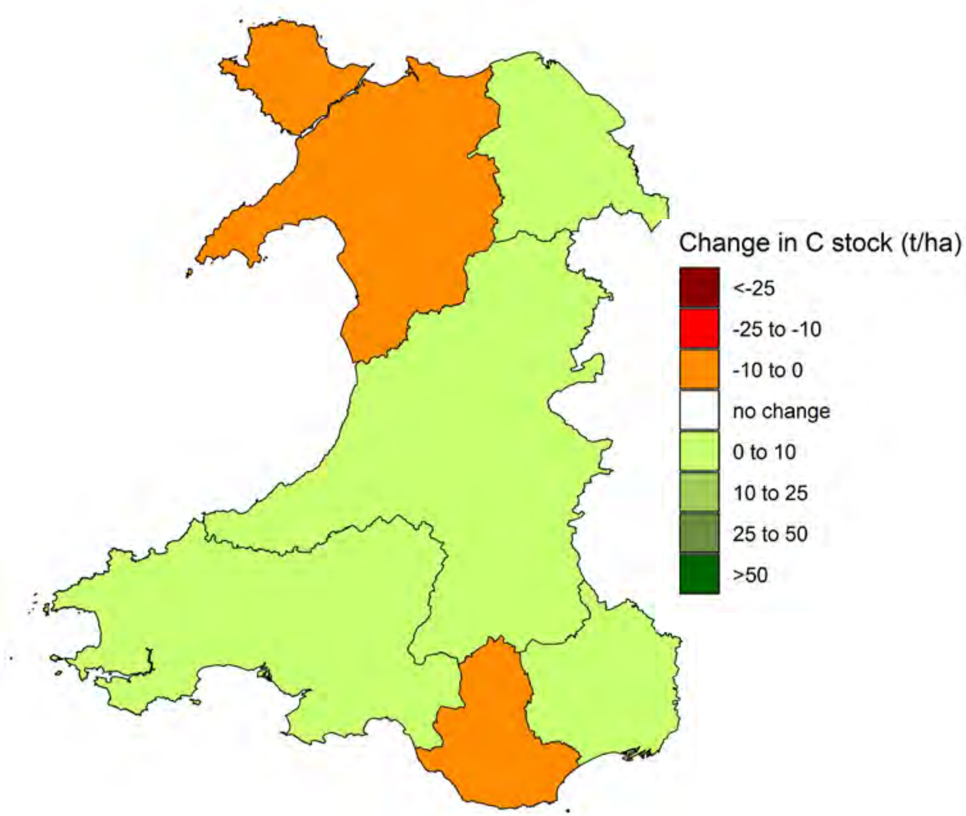
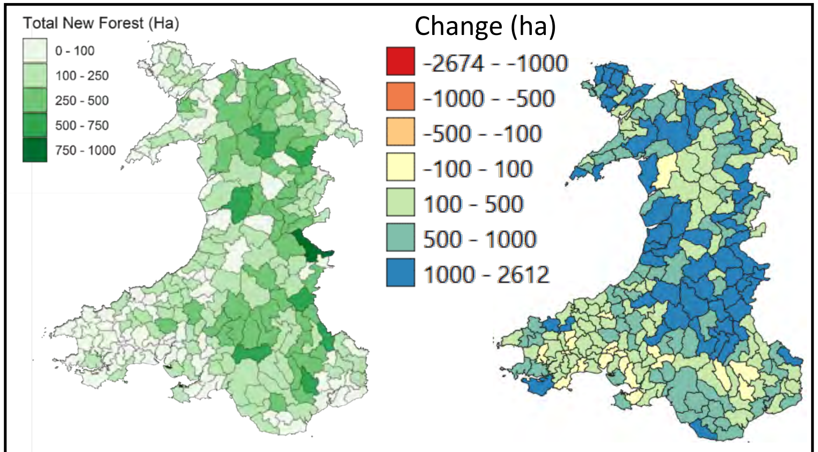
Carbon change for T5 scenario

Carbon change 2020-2100 (tC/ha)



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

- Either a small increase or decrease is simulated for NRW regions. However, the finer spatial detail in the maps that follow reveal that this masks a pattern of larger increases and decreases.



Increase in arable/grass rotation and area of new woodland must be considered together to understand the change in carbon

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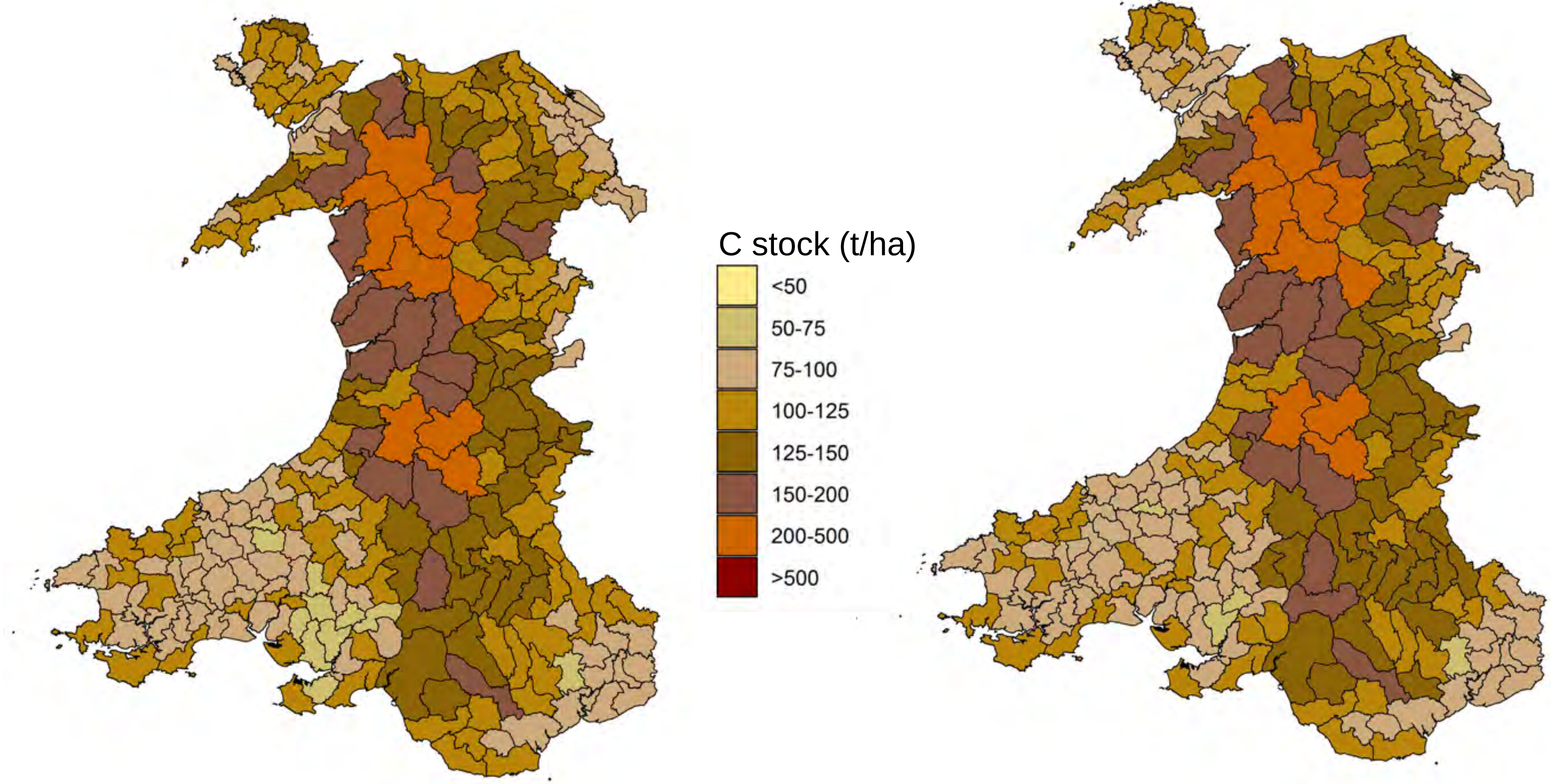
Carbon stock for small agricultural areas (T5)

Baseline (2020) **T5 scenario (2100)**



Data are for LULUCF categories 4 A, B, C & G
and are displayed per ha of land modelled

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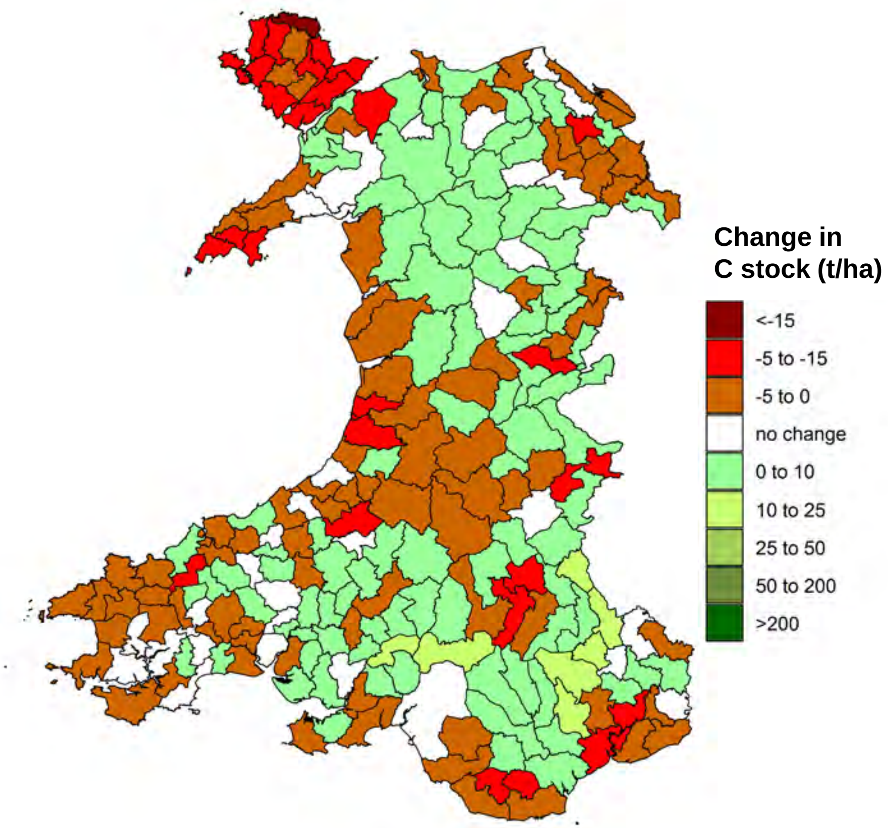
Carbon change for small agricultural areas (T5)

Map: tC/ha change 2020-2100



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

- Carbon stocks are simulated to increase in some areas and decrease in others, across all NRW regions.
- Areas of decrease reflect increased arable/grass rotation.
- Areas of increase reflect new woodland (see slide 38), largely due to the significant C storage potential of biomass and harvested wood products.
- Some increase may also be attributed to sequestration on land reverting to short vegetation.

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GHG emissions: Peat and agriculture (T5)

This table compares total agricultural emissions and wetland emissions for farms modelled by IMP:

LULUCF category	Baseline	Scenario
Wetlands (4D) flux (KtCO2eq/yr)	873	867
Agricultural GHG flux (KtCO2eq/yr)	4,816	6,420

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Agricultural GHG emissions are simulated to increase reflecting increases in dairy cattle, which are not offset by decreases in sheep and beef.
- GHG emissions from wetlands are simulated to decrease slightly, reflecting a small reduction in agricultural land use on peat.

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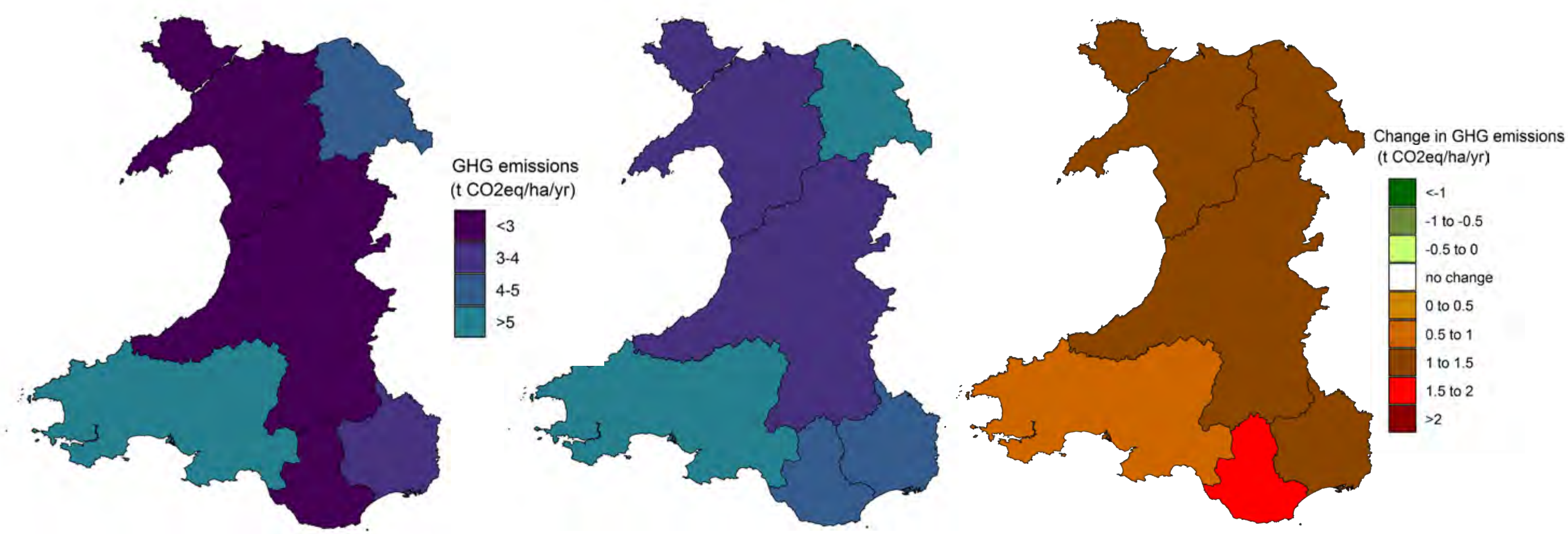
GHG emissions for NRW regions (livestock and management) (T5)

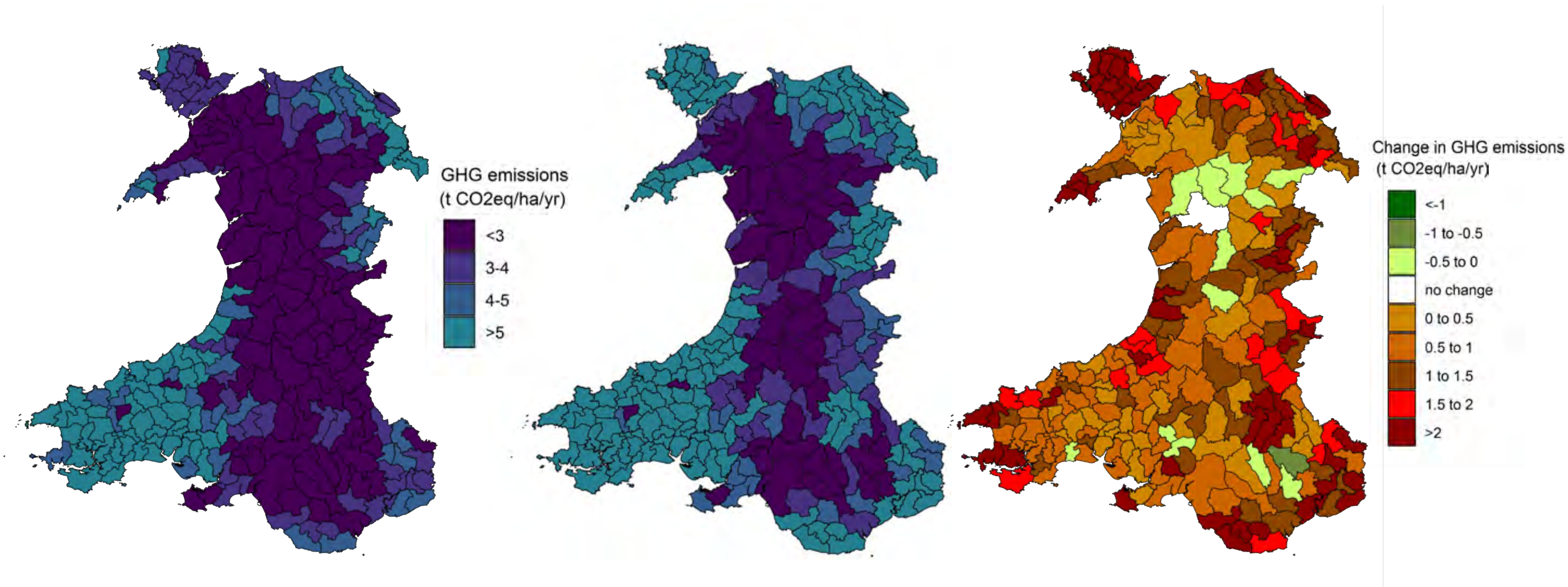
Baseline **T5 scenario** **Change**



- Data are displayed per ha of land modelled, and reflect patterns of livestock, land use and management.
- Increases reflect increased agricultural intensity with increased dairy, which is most significant in South Central Wales.

GHG emissions for small agricultural areas (livestock and management) (T5)

Baseline **T5 scenario** **Change**



- The finer scale data reveal the greater magnitude of local changes.
- Increases in most areas reflect increased agricultural intensity due to the simulated expansion of dairy.
- Reductions in a few areas reflect land coming out of agricultural use.

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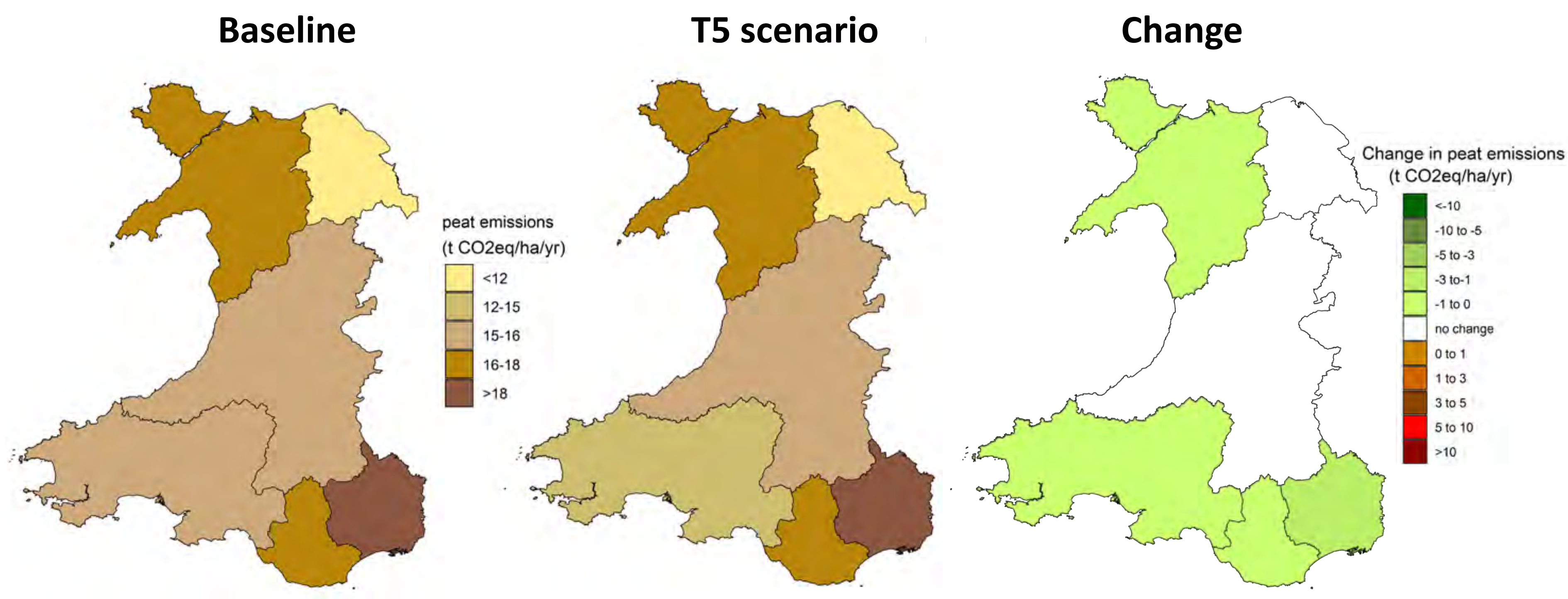
GHG emissions for NRW regions (peat) (T5)



- Data are displayed per ha of peat modelled, and reflect land use and inferred management.
- Emissions are simulated to slightly reduce in some areas under the T5 scenario, due to land on peat going to non-agricultural use.

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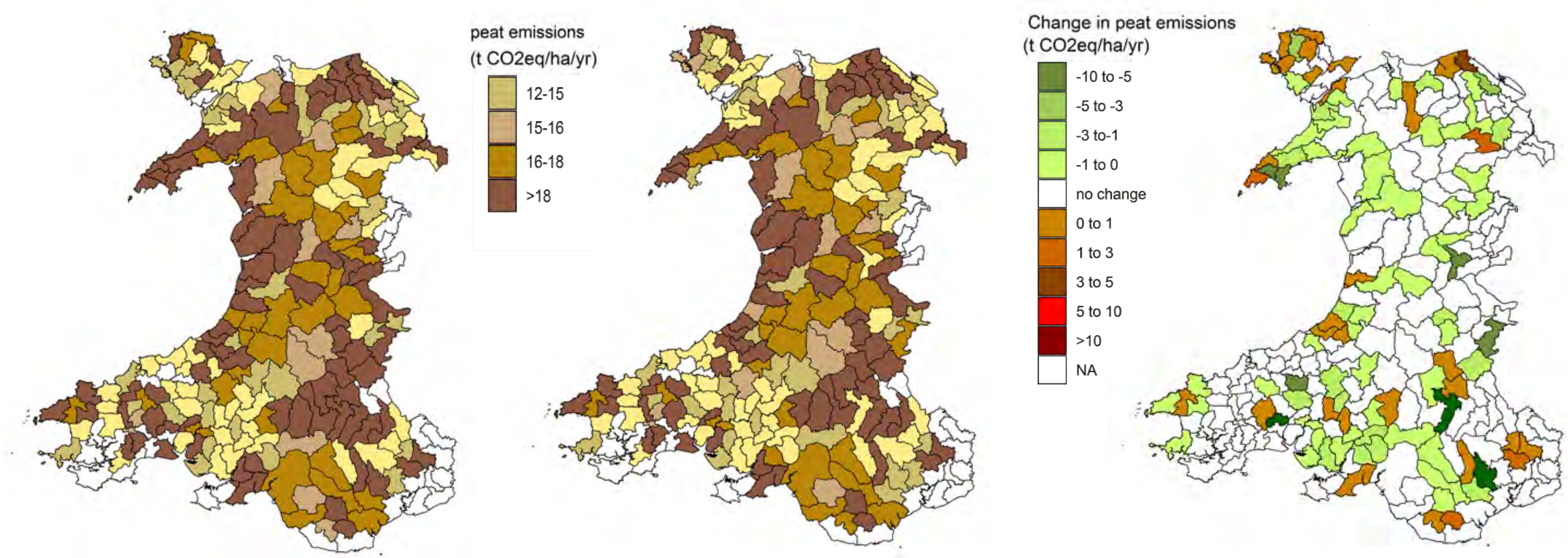
GHG emissions for small agricultural areas (peat) (T5)

Baseline **T5 scenario** **Change**



- Emissions are simulated to decrease to 2100 in some areas, but increase in a few areas due to simulated agricultural intensification on peat.
- Some small agricultural areas do not contain peat, or do not experience predicted land use change on peat.

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PART 3b: Water quality

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Water Quality: Background information 1

- Water quality impacts must be considered for WFD catchments, therefore, loads calculated at the DMU level **(in kg/ha)** must be processed to in-stream loads, by aggregating at the catchment level.
- We also add in non-agricultural sources of pollutants, as well as estimates of pollutants for farms not modelled by the IMP (<1FTE).
- We then account for flow (and nutrient) accumulation to downstream catchments, and account for stream flow to calculate concentration for N and P.
- Data for N and P are processed to units reflecting the relevant thresholds: **annual average concentration for P and 95th percentile for N**.
- Data on sediments are calculated as **annual average loads**. River sediment concentrations are controlled by event driven inputs and in-river processes occurring over a range of timescales, so it is hard to measure average concentrations using infrequent grab samples and difficult to predict these from annual average inputs to watercourses as predicted by the IMP.

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Water Quality: Background information 2

- The water quality analyses are based on the scenario being applied to farms >1FTE only. Farms <1FTE are modelled as not responding to the scenario.
- We assume afforestation or reversion to short vegetation or natural woodland on the "non-economically viable" farms.
- Changes in water quality are not modelled for lakes, but these may be important for recreation, and associated businesses in Wales.
- Data outputs relate to a new long-term average reflecting land use and management for the scenario: we do not account for time lags in the nitrogen system.
- Predicted loads are based on average climate data (1961-1990).
- Data reflect average losses rather than those that might occur once in several years due to an intense rainfall event causing significant erosion (particularly important for sediment and P).
- Some measures might change soil P status or soil organic N supply, which happen over a period of 10+ years to reach a new equilibrium. Our scenario outputs assume these changes have already occurred.

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Water Quality for Wales: Change in N, P and sediment load (T5)

This table compares total agricultural loading for farms modelled by the IMP:

	Farms <1FTE	Baseline	T5 scenario	Change	% change	Glastir impacts
Nitrate kt NO3 N	4.13	30.11	38.92	8.81	29%	-1%
Phosphorus kt P	0.18	0.72	0.79	0.07	9%	-0.9%
Sediment kt Z	68	194	196	1.86	1%	-0.1%

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Increases are simulated in all pollutants for the T5 scenario.
- This reflects increase in dairy and in arable/grass rotation, which is not offset by decreases in numbers for sheep and beef cattle.
- Glastir impacts, modelled from 2016 uptake data, are shown for comparison.

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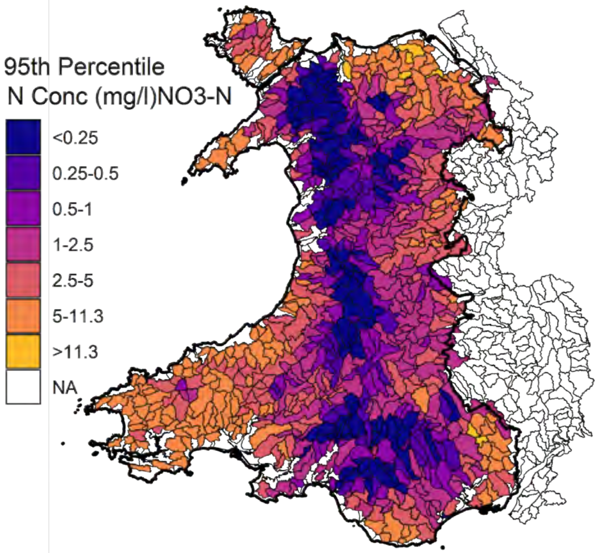
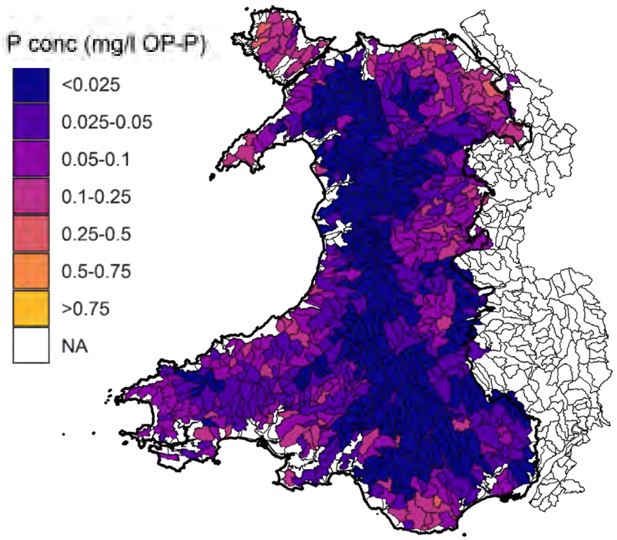
N, P and sediment load for baseline and T5

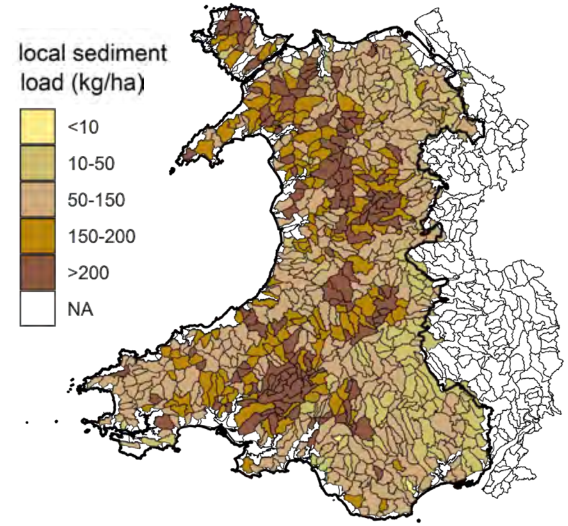
Baseline N



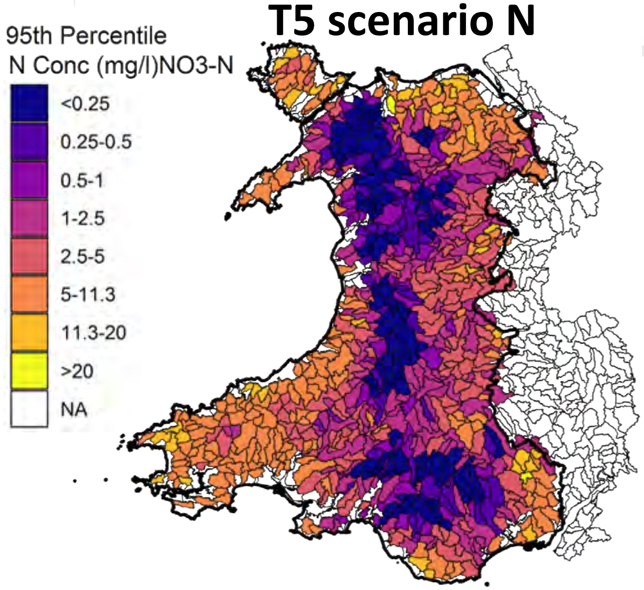
Baseline P



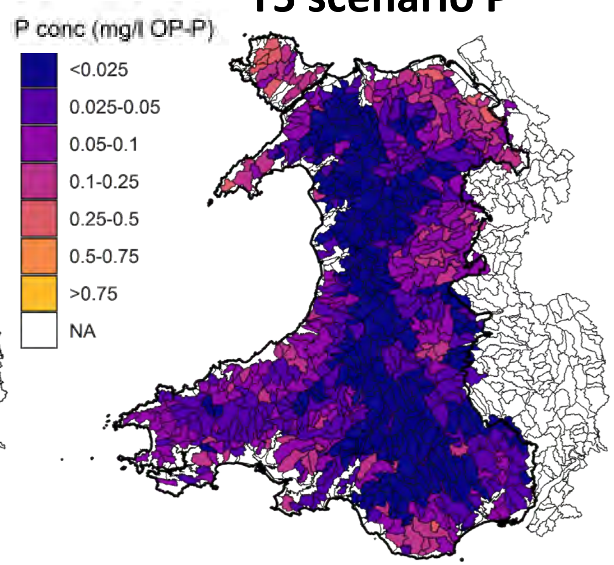
Baseline Sediment



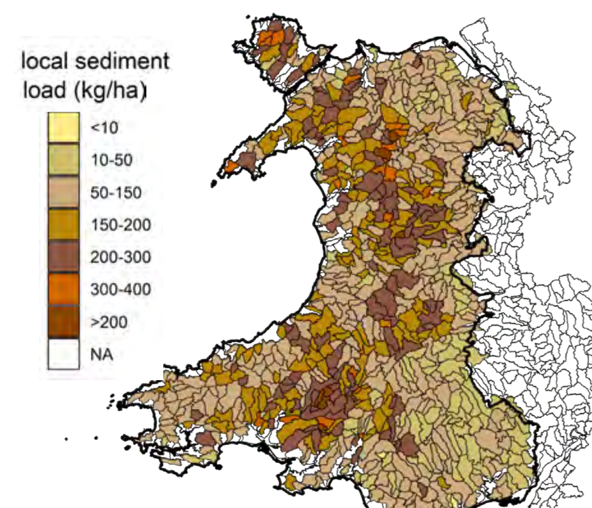
T5 scenario N



T5 scenario P

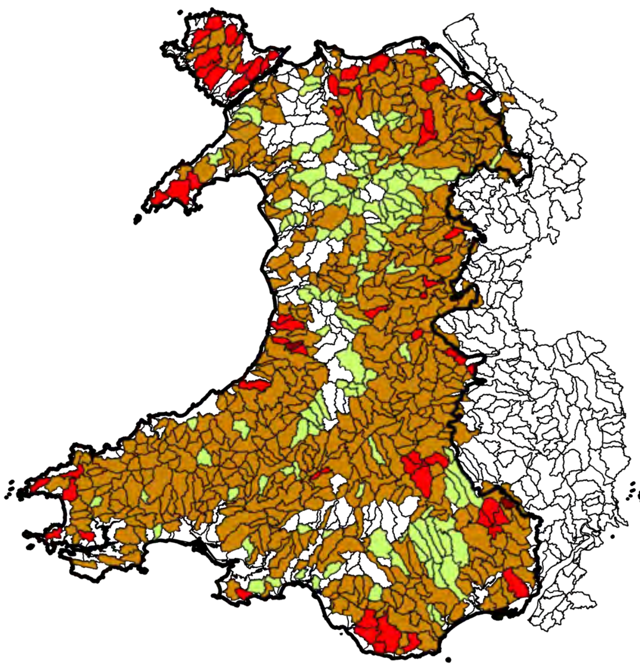


T5 scenario Sediment



Change in N, P and sediment load (T5)

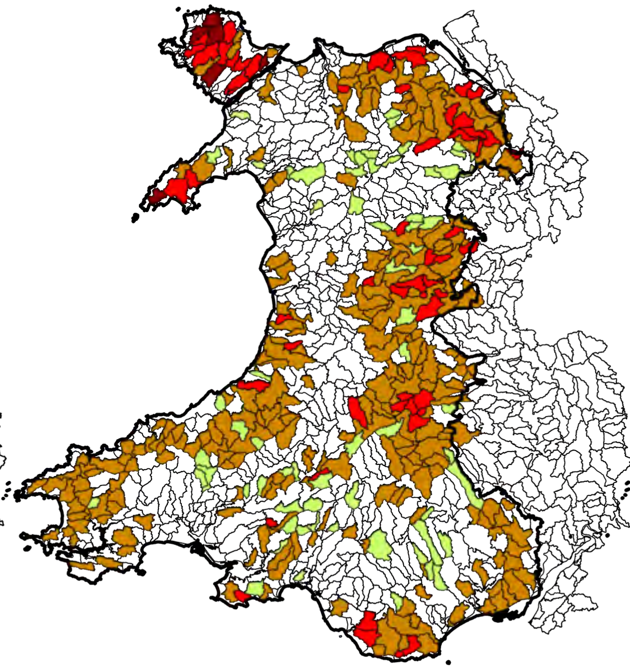
N change



Change in 95th Percentile N Conc (mg/l)NO3-N

- <- 5
- -5 to -2.5
- -2.5 to
- no change
- 0 to 2.5
- 2.5 to 7.5
- >7.5
- NA

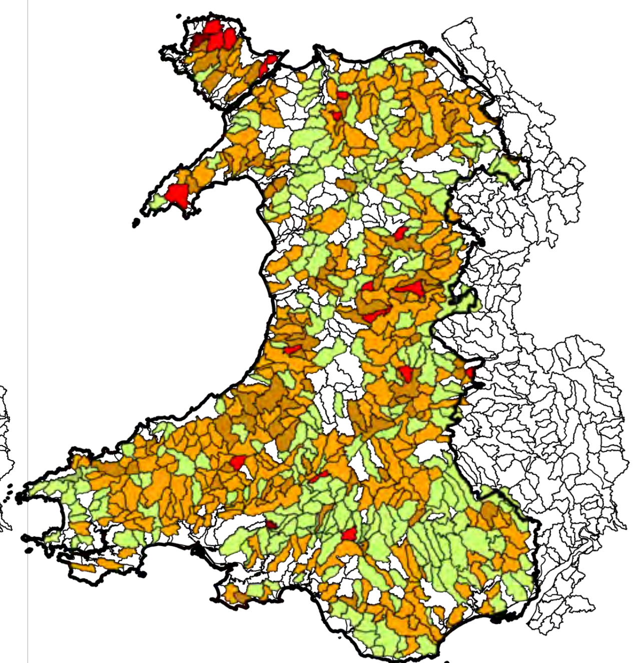
P change



Change in P conc (mg/l OP-P)

- <- 0.05
- -0.05 to 0
- no change
- 0 to 0.01
- 0.01 to 0.05
- >0.05
- NA

Sediment change



Change in local sediment load (t/ha)

- <-200
- -200 to -100
- -100 to -50
- -50 to 0
- no change
- 0 to 10
- 10 to 25
- 25 to 50
- >50
- NA

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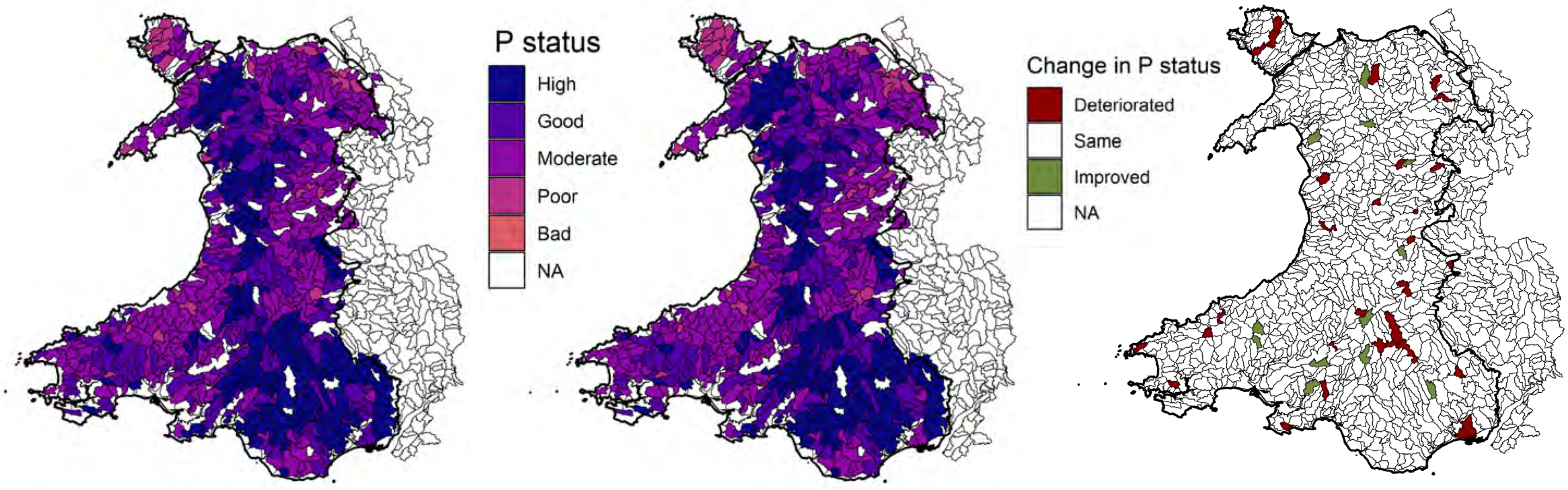
WFD P status (T5)

Baseline **T5 scenario** **Change**



- WFD P status is simulated to deteriorate in several catchments under the T5 scenario, reflecting agricultural intensification.
- WFD P status is simulated to improve in a few catchments, largely where agricultural area was modelled to decrease.

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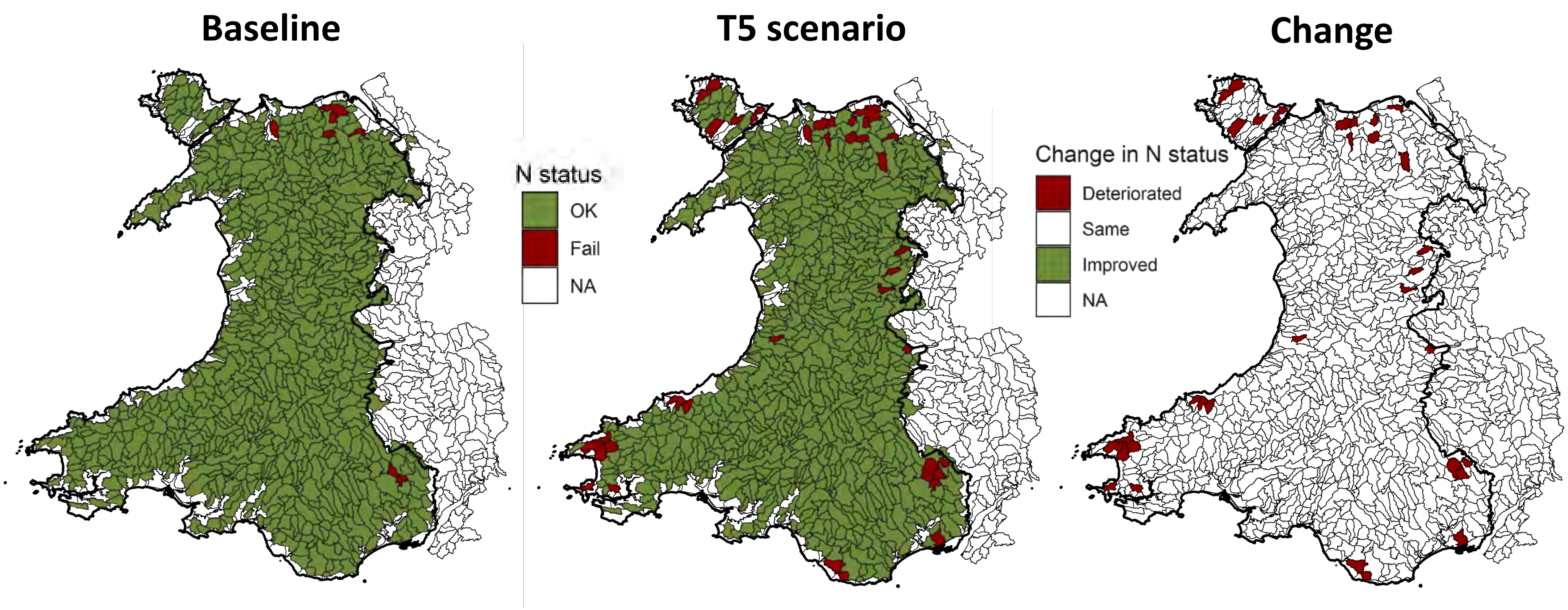
Drinking water N status (T5)



- Drinking water N status is simulated to be largely unaffected by the scenario, but to deteriorate in key areas coinciding with increased agricultural intensity.
- No change in status was projected for most catchments, in spite of the 29% increase in total nitrate load from IMP modelled farms.

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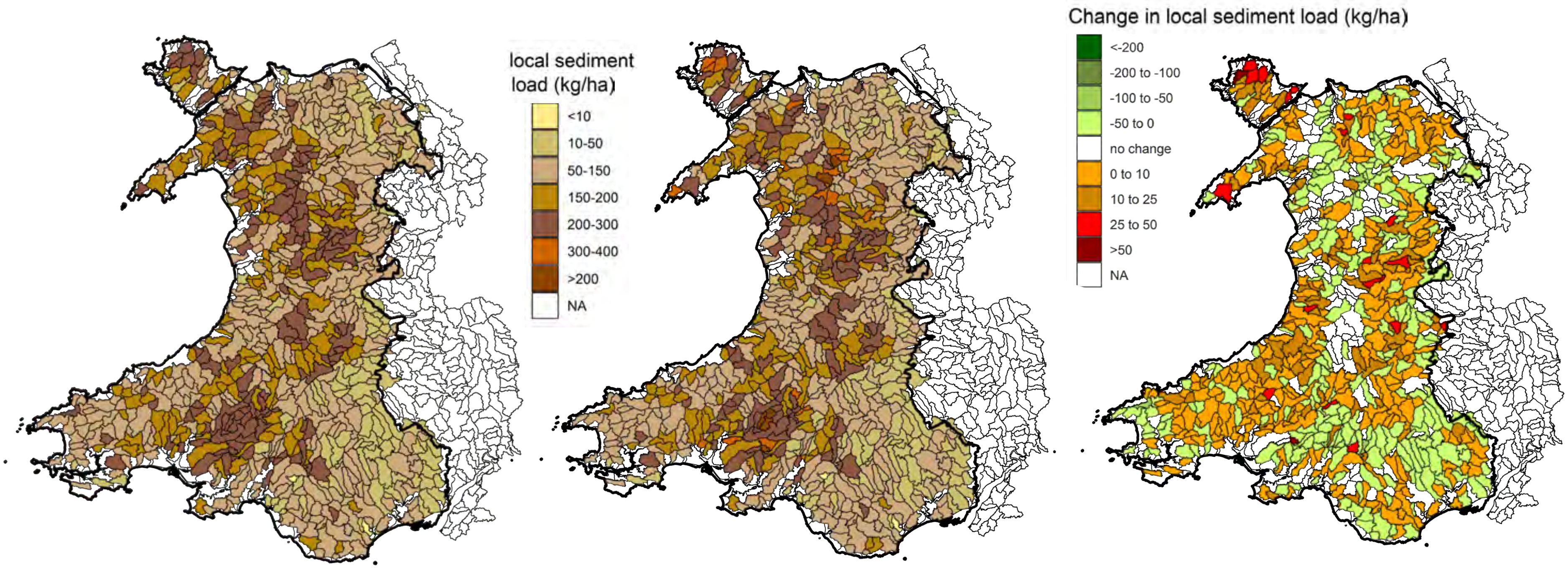
Change in sediment load (T5)

Baseline **T5 scenario** **Change**



- Increases in sediment loading are simulated for many catchments, coinciding with areas of agricultural intensification.
- Decreases are simulated for many other catchments, reflecting land coming out of agricultural use.
- This averages out to a very small percentage change in sediment loading nationally, but impacts locally may be important.

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PART 3c: Air quality

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Air quality – Wales overview (T5)

This table shows changes in PM2.5 concentration and life years lost under the T5 scenario:

Average Change in PM2.5 Concentration	Life Years Lost (LYL)
+0.03	+29.4

- PM2.5 concentrations are simulated to increase on average for Wales, as a result of increases in NH3 emissions and limited new woodland.
- This leads to a net health dis-benefit of +29.4 Life Years Lost
- BUT spatial patterns vary …

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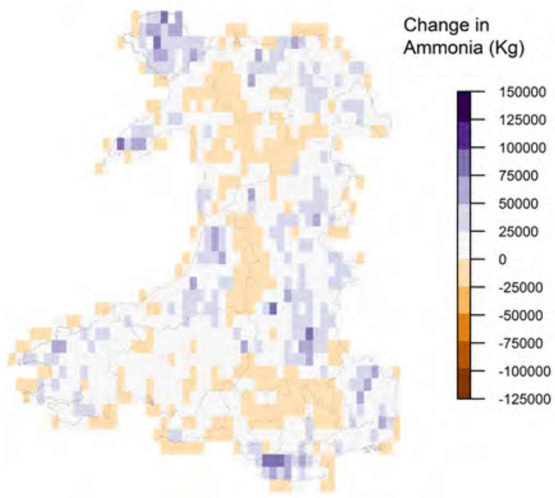
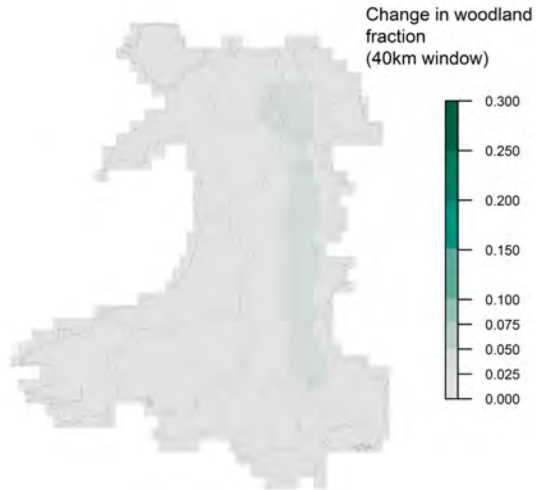
Health outcome from change in air quality (T5)

NH3 emissions



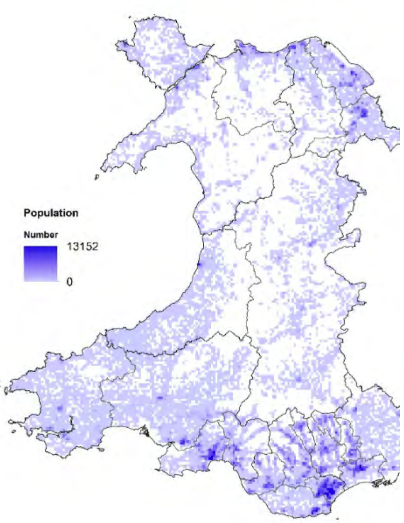
New woodland



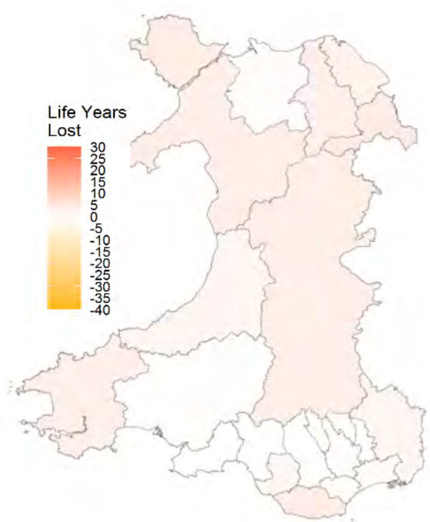
PM2.5 change

- Change in PM2.5 is a function of change in NH3 emissions and little new woodland.
- Increases in PM2.5 are simulated where NH3 emissions increase (mainly from dairy).

Population



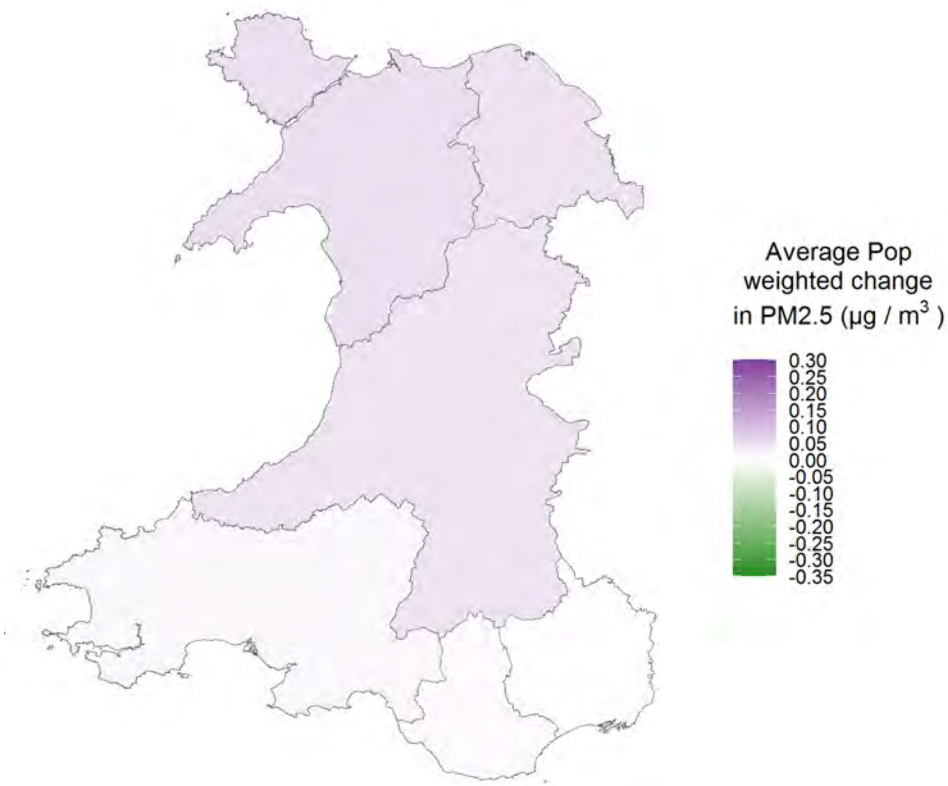
Avoided 'Life Years Lost'



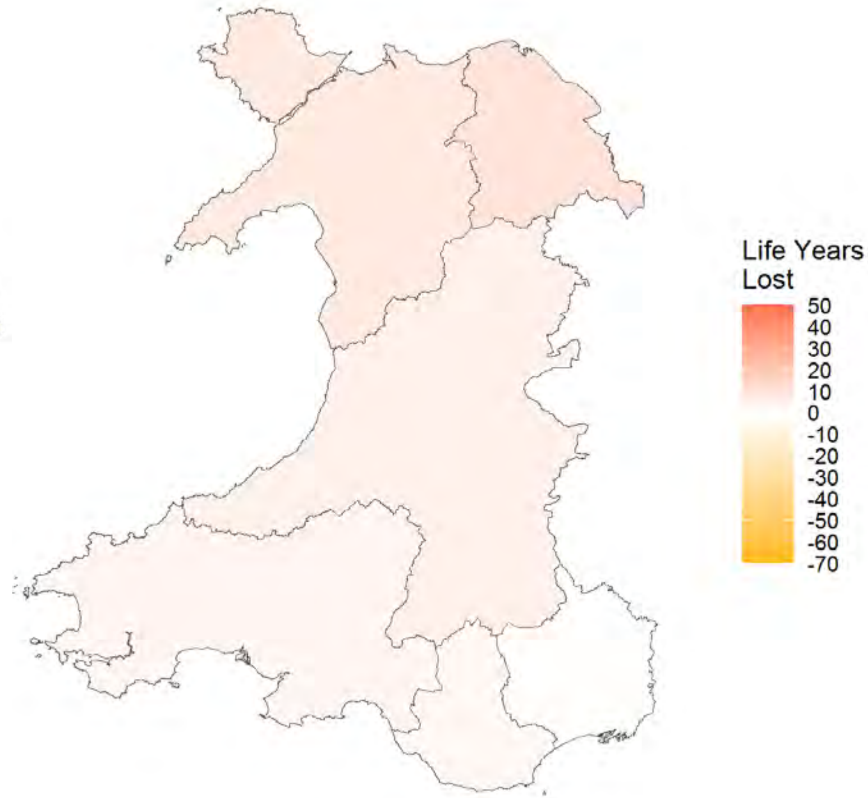
- Health outcomes are a function of change in exposure of the population.
- **Net negative benefit in all areas, except Cardiff, Caerphilly, Rhondda Cynon Taf, Blaenau Gwent & Merthyr Tydfil.**

Air quality for NRW regions in T5

Average change in PM2.5 concentration



Avoided Life Years Lost (total)



Greatest dis-benefits are in parts of North and Mid Wales.

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PART 4: Valuation

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Valuation results: Background information

- Price year: 2020
- Present values: 75 year time horizon
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g. 3.5% declining discount rate/ health discount rate for air quality):
  - Values are based on BIES (2018) guidance on carbon values for appraisals by Government.
  - This was prior to the release of updated values in September 2021.
  - The 2018 values do not fully reflect the requirements of the Paris Agreement 2016, the domestic net zero target, and other recent policy developments.
- Results given to 3 significant figures.

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Summary of public goods values (T5)

Benefits	Physical measure	Units	Present value, 75 yrs, £	Type of value
Air Quality	Increase of 29 years	Life Years Lost each year	- £ 42m	Reduction in costs of health impacts from air pollution
Water Quality	59 Deteriorate, 12 Improve	Expected changes in WFD status due to changes in P and N	- £ 26m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 120m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 8,307m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- The figures are an estimate of the value of the increase in wellbeing to people over 75 years under this scenario. Negative costs for air quality indicate increasing health care expenditure needed.
- Figures indicate order of magnitude of values of expected changes in the Welsh Environment.

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Breakdown of public goods values (T5)

Benefits	Present value, £m			Type of value
	5 yrs	25 yrs	75 yrs	
Air Quality	- £ 2m	- £ 13m	- £ 42m	Reduction in costs of health impacts from air pollution
Water Quality	- £ 4m	- £ 16m	- £ 26m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs:				Benefit of reducing GHG sources:
Agriculture	- £ 559m	- £ 2,884m	- £ 8,292m	Agricultural sources (livestock and inputs)
Land use	- £ 351m	- £328m	- £49m	LULUCF sources (soils, vegetation and harvested wood products)
Wetlands	£ 2m	£ 12m	£ 33m	Wetland sources (peatlands)
Total GHGs	- £ 907m	- £ 3,200m	- £ 8,307m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- All figures are based on simplifying assumptions of change over time.

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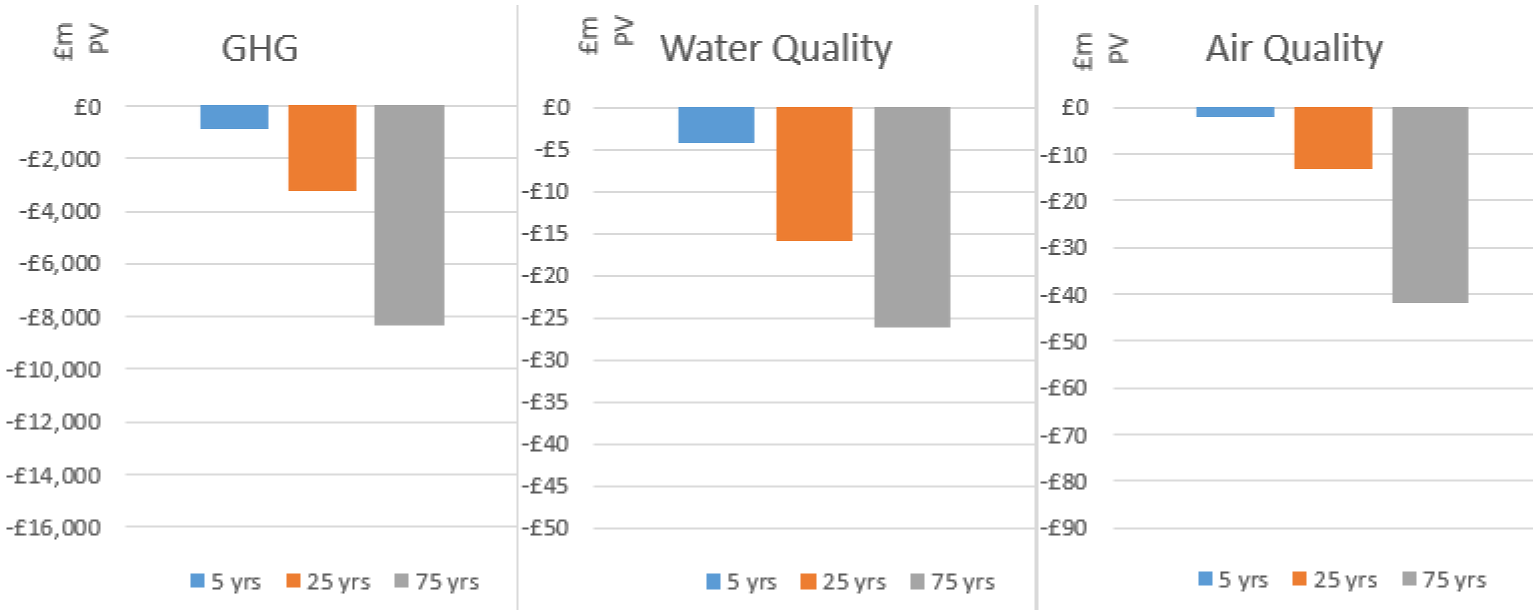
Public Goods Values for different time horizons (T5)



- A sustained loss of value of all three ecosystem services is simulated under the T5 scenario.
- The changes reflect the balance of new woodland vs land transitioning to arable-grass rotation
- Change over time for GHGs also reflects the time taken for woodland to start sequestering carbon; cost of LULUCF carbon loss decreases over time as the cost of agricultural GHG emissions increases

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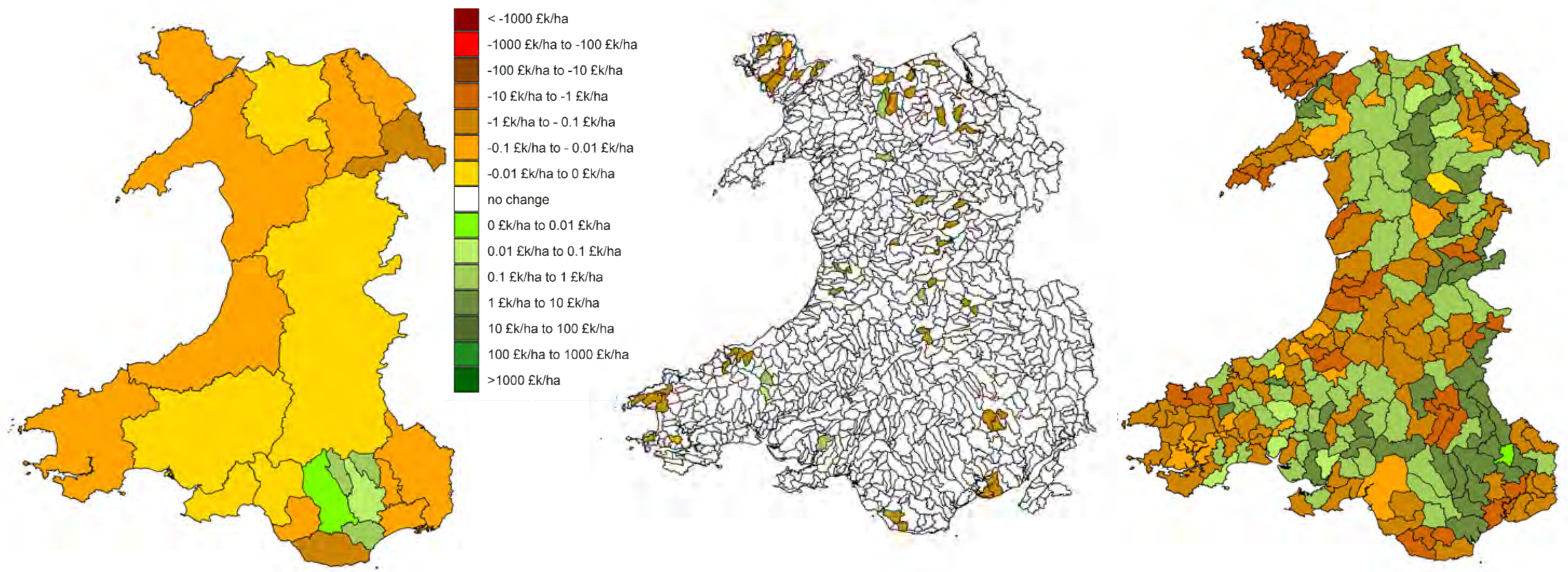
Spatial distribution of values (T5) (finest resolution)

Reduction in costs of air pollution

Value of change in status of freshwater bodies

Value of change in LULUCF carbon stock in vegetation and soils



- The greatest costs for the T5 scenario come from LULUCF carbon losses, as well as deterioration in air and water quality.
- There were also simulated benefits from improvements in air quality in some local authorities and from LULUCF carbon in many small agricultural areas, relating largely to woodland expansion.

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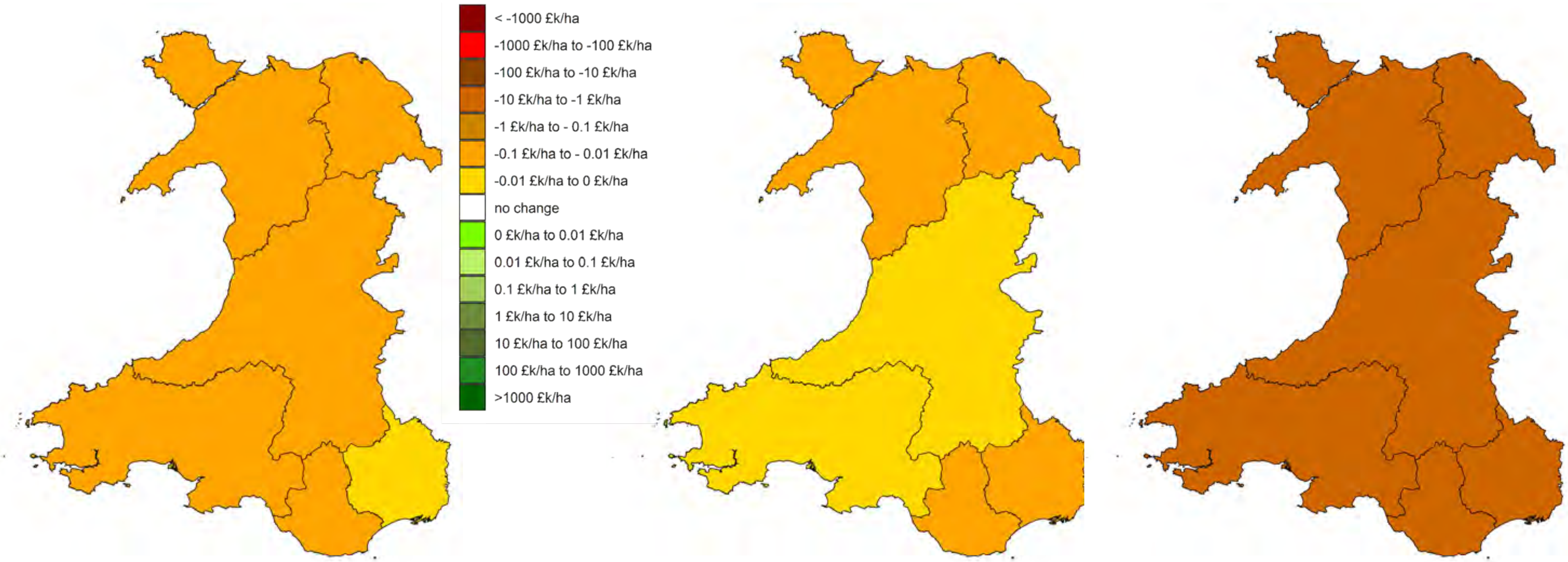
Spatial distribution of values (T5) (NRW regions)

Reduction in costs of air pollution

Value of change in status of freshwater bodies

Value of combined change in GHG and carbon balance



- The greatest costs for the T5 scenario come from GHG and LULUCF carbon losses, as well as deterioration in air and water quality.
- The fine scale improvements for some local authorities and small agricultural areas are negated by deterioration in other areas when the data are aggregated to NRW regions.

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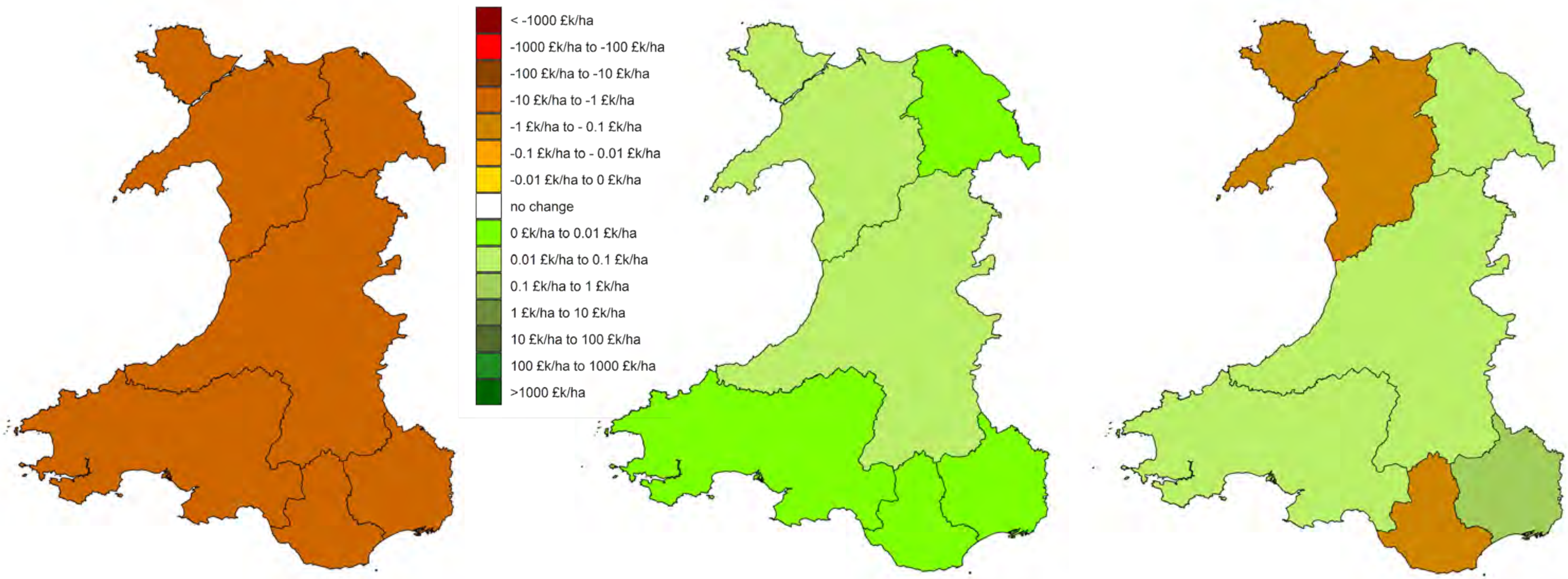
Breakdown of values for Carbon and GHGs (T5) (NRW regions)

Value of change in agricultural GHG emissions

Value of change in wetland (peat) GHG emissions

Value of change in LULUCF carbon stock in vegetation and soils



- The change in carbon and GHGs is mostly attributed to increases in GHG emissions, as well as the losses of LULUCF carbon.
- The small economic benefit for reduced peat GHG partly reduces these costs.

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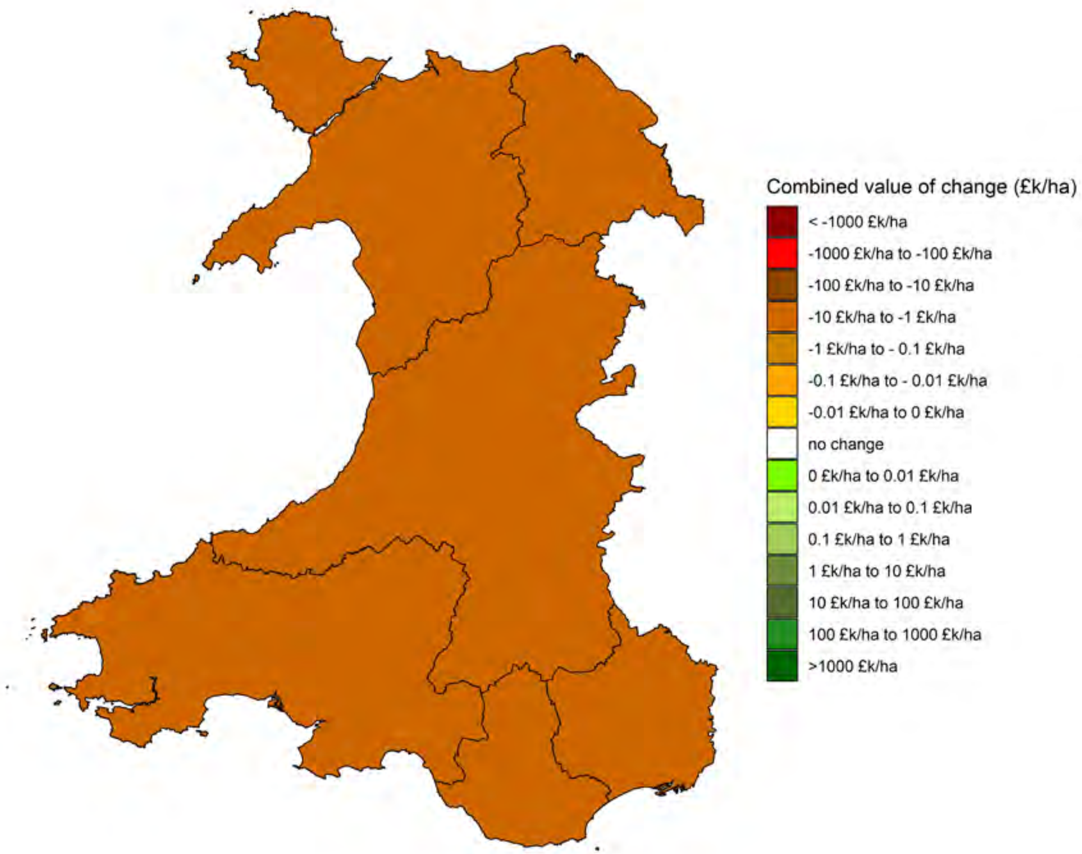
Sum of public goods values (T5) (NRW regions)

Sum of public goods values for all 3 benefits (air quality, water quality and carbon & GHGs):



- All regions are simulated to experience net costs in terms of deterioration of public goods under this scenario.
- This reflects the increased agricultural intensity with significant expansion of dairy and associated GHGs and ammonia, as well as the loss of carbon from conversion of land to arable/grass rotation.

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PART 5: Conclusion

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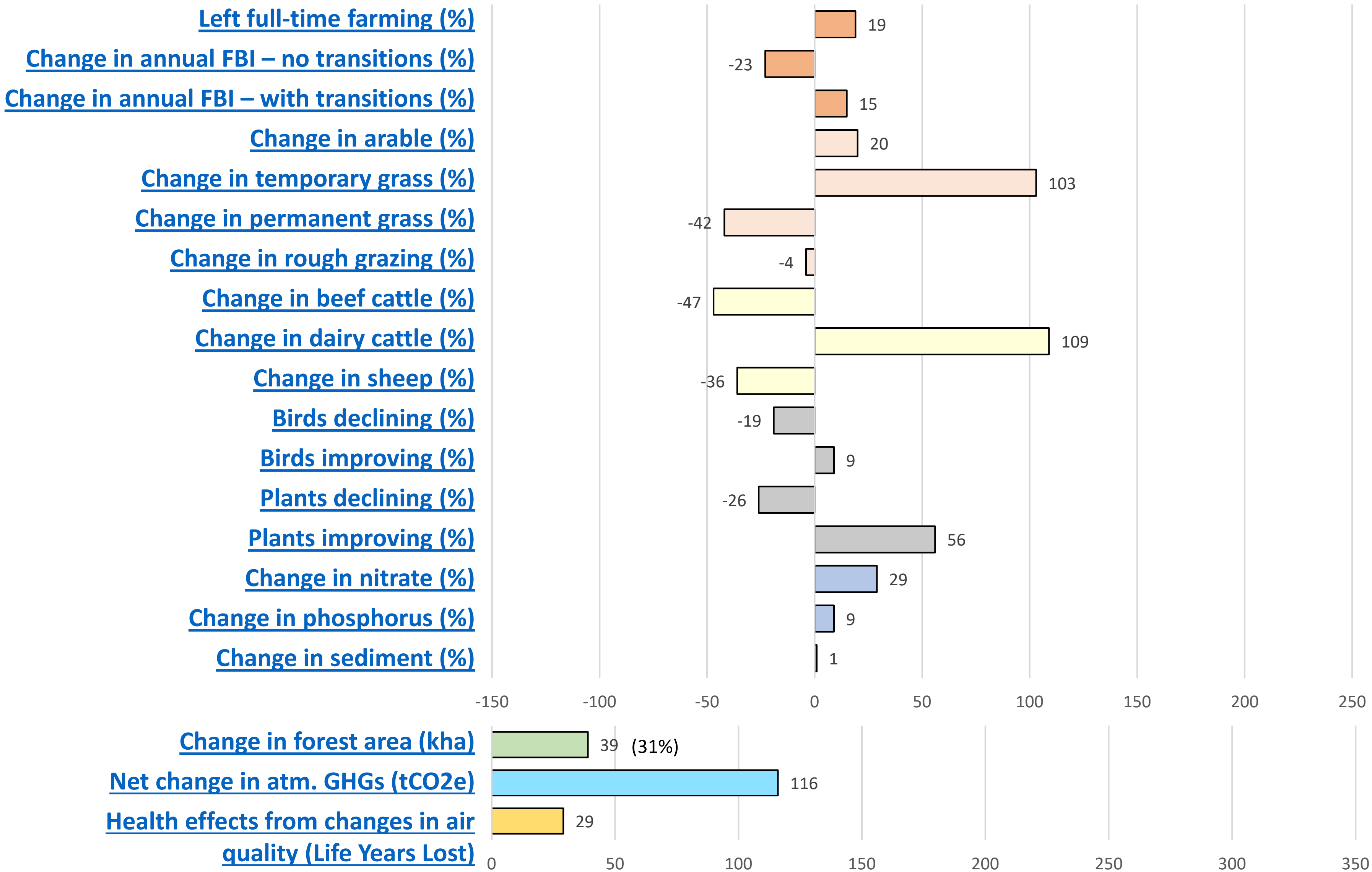
Summary of Impacts 1 (T5)



Summary of Impacts 2 (T5)

Impacts	Physical measure	Units	Present value, 75 yrs, £	Type of value
Agricultural Income	-19%	Farms at risk of leaving full time agriculture	-58m (no EFT transitions) +39m (if EFT transition)	Total farm business income (per year)
Air Quality	Increase of 29 years	Life Years Lost each year	- £ 42m	Reduction in costs of health impacts from air pollution
Water Quality	59 Deteriorate, 12 Improve	Expected changes in WFD status due to changes in P and N	- £ 26m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 120m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 8,307m	Benefit of reducing atmospheric GHG concentrations from non-traded sources
Biodiversity	19% Decline, 9% Improve	Bird species	N/A	Percentage of species with significant increase or decrease
	26% Decline 56% Improve	Plant species	N/A	Percentage of groups with significant increase or decrease

Final Considerations

- This slide pack shows results from applying the Integrated Modelling Platform to one (out of six) trade scenarios.
- The scenarios were provided by Welsh Government based on a series of internal and external workshops as changes in farm gate (output) prices and input costs.
- All scenarios were applied to a baseline that includes CAP Pillar 1 payments.
- The economic accounts presented are partial and based solely on the components explicitly mentioned. Other significant aspects (e.g. recreation) are not valued here.
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses.
- The IMP is applied to only full-time farms (> 1 FTE labour).
- A farm that is categorised as under pressure is based on being unable to achieve a full-time annual FBI of £6,000. As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.
- The IMP has been developed following Aqua book guidelines. All the assumptions underlying the IMP are fully documented and have been signed-off by Welsh Government.

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PART 6: Glossary and Context

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Glossary: Key Acronyms (I)

- FAPRI: Food and Agricultural Policy Research Institute
  - FAPRI-UK Model was used to underpin assessments of the impacts of Brexit on the UK agricultural sector. More information: (Web-link)
  - Macro-economic model of the UK in a global context. Used to identify impacts of global trade. The FAPRI-UK model (created and maintained by staff in AFBI-Economics) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with submodels covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) model run by FAPRI at the University of Missouri.
- MFTA: Multi-lateral free trade agreement
  - Free trade agreement between three or more countries without discrimination between those involved.

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Glossary: Key Acronyms (II)

- LULUCF: Land use, land-use change, and forestry
  - Standardised approach to the greenhouse gas inventory that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.
  - Used in this project to quantify impacts of land use change on carbon.
- MFN: Most Favoured Nation
  - World Trade Organisation (WTO) terminology. Under the WTO agreements, countries cannot normally discriminate between their trading partners. As such countries must treat all other WTO members as they would their "Most Favoured Nation". More information: (Web-link)
  - Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

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Glossary: Key Acronyms (III)

- WFD: Water Framework Directive
  - EU directive targeted at improving water quality and integrated catchment management.
- UKTAG: UK Technical Advisory Group (on the WFD)
  - The UKTAG is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies.
- LFA: Less-favoured area
  - Term used to describe an area with natural handicaps (lack of water, climate, short crop season and tendencies of depopulation), or that is mountainous or hilly, as defined by its altitude and slope.
- SDA / DA: Severely Disadvantaged Areas / Disadvantaged Areas
  - Sub-classes of LFA separating out the most severely disadvantaged areas for the purposes of basic payment scheme (BPS) grant payments.

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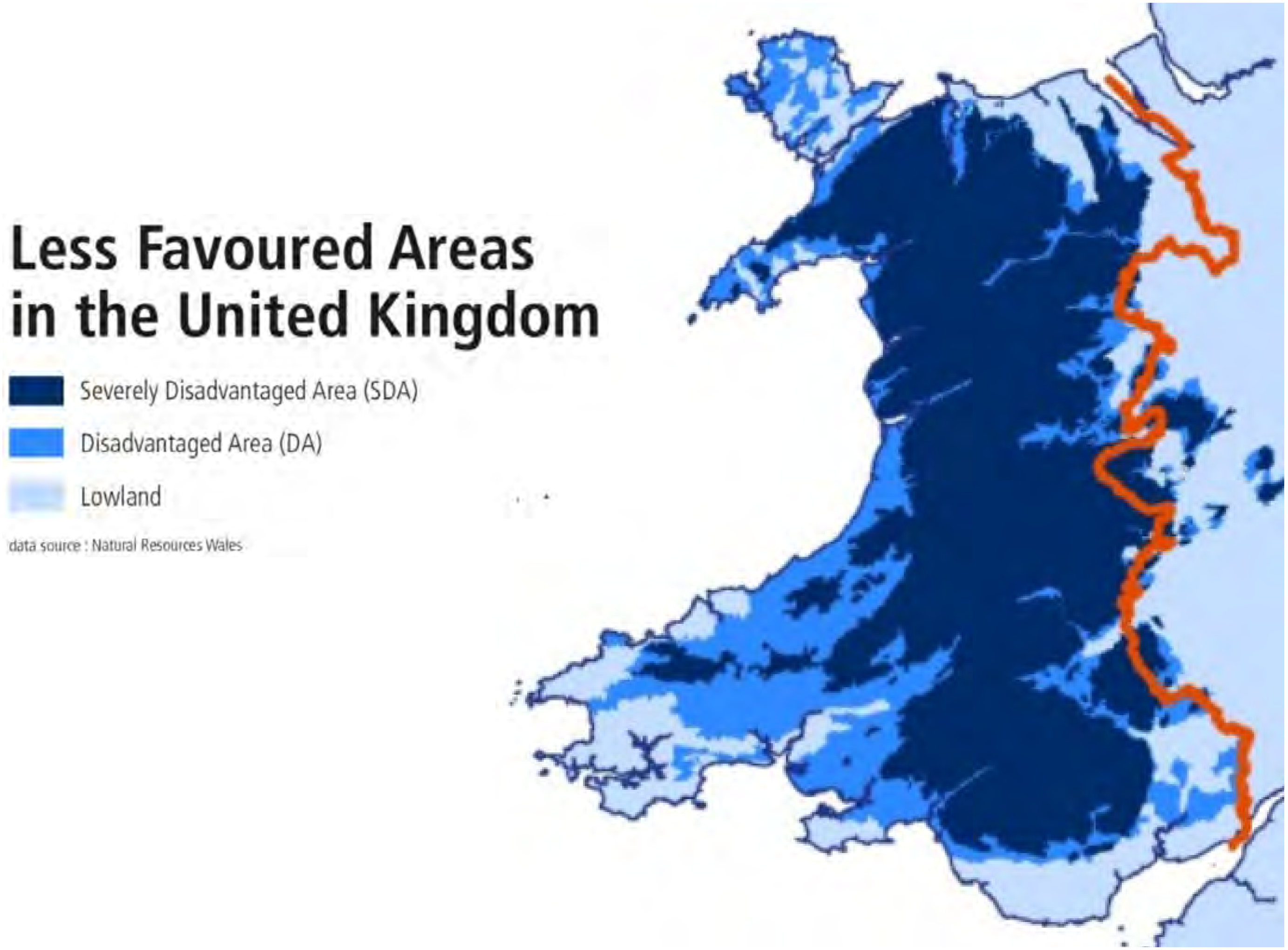
Severely Disadvantaged Areas/ Disadvantaged Areas in Wales



Glossary: Key Acronyms (IV)

- RFT : Robust Farm Type
  - Robust farm type (used in previous Welsh Farm Practice Surveys).
  - Classes: Cereals; General Cropping; Horticulture; Specialist Pigs; Dairy; LFA Grazing Livestock; Lowland Grazing Livestock and Mixed.
- EFT: ERAMMP Farm Type
  - ERAMMP farm type (used within the IMP) is based on the RFT with additional detail on less favoured areas.
  - Classes: Cereals, General cropping, Dairy, Lowland cattle / sheep, Mixed , Specialist Sheep (SDA), Specialist Beef (SDA), DA various grazing, SDA mixed grazing .
- SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation: Names and acronyms for models within the IMP (see slide 79)

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Glossary: Key Acronyms (V)

- ERAMMP – Environment and Rural Affairs Mapping and Modelling Project.
  - Consortium Project led by the UK Centre for Ecology & Hydrology (UKCEH) and funded by the Welsh Government (WG).
  - Consortium members involved in these slide packs include Cranfield University, ADAS, the British Trust for Ornithology (BTO), eftec, Forest Research (FR) and UKCEH.
- IMP – Integrated Modelling Platform
  - The modelling platform used to produce the results shown in this slide pack. The platform combines the following models which pass data to one another as large multi-parameter data cubes:
    - SFARMOD: Whole farm model
    - ESC: Tree species suitability
    - CARBINE: Forest products, carbon and forest net present value
    - LAM: Land allocation model
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - Woodland habitat connectivity model
    - Ecosystem service models for carbon and water quality
    - EMEP4UK Emulator: health impacts of air pollution
    - Valuation: monetary and non-monetary valuation of public goods

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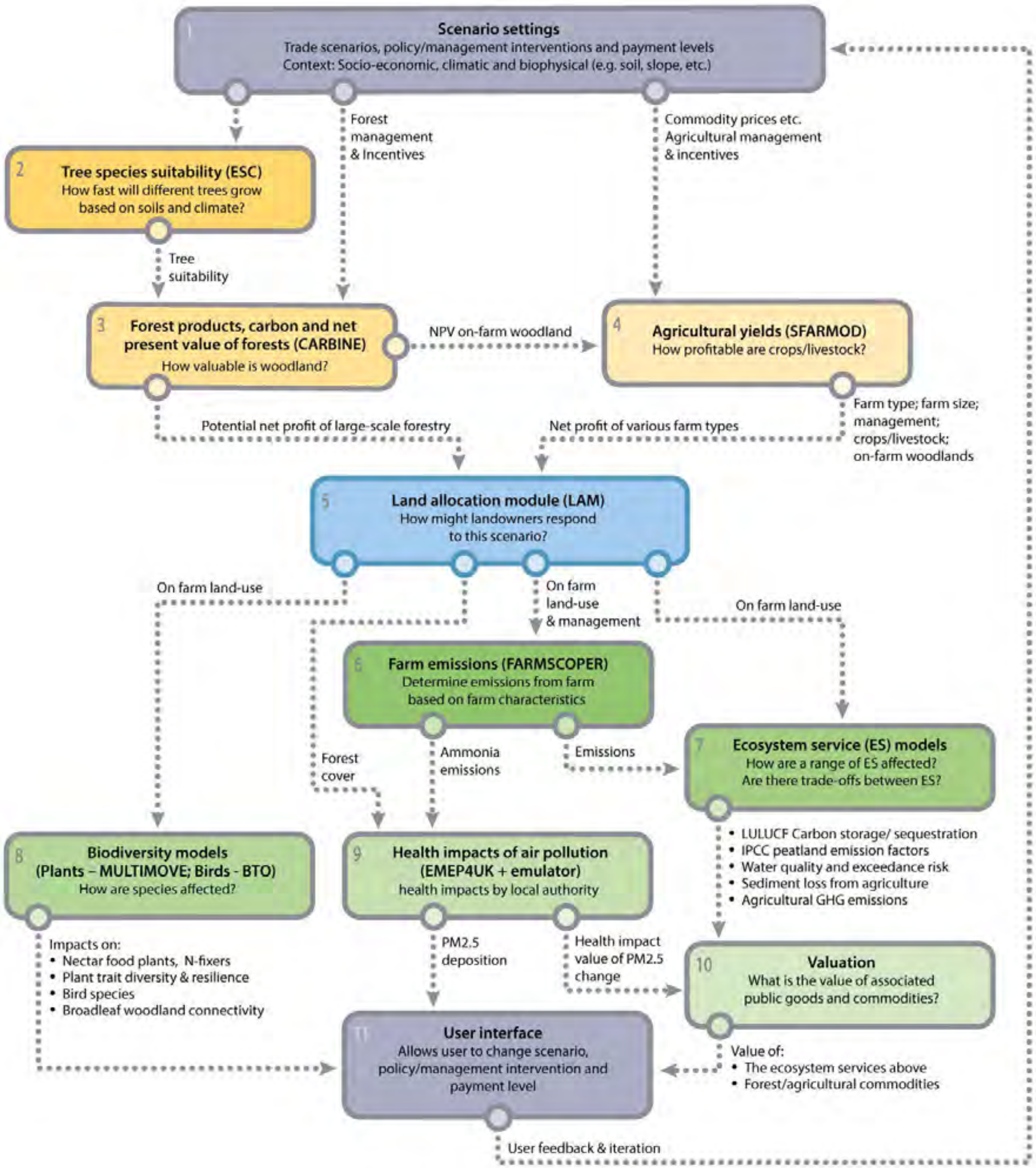
Integrated Modelling Platform schematic



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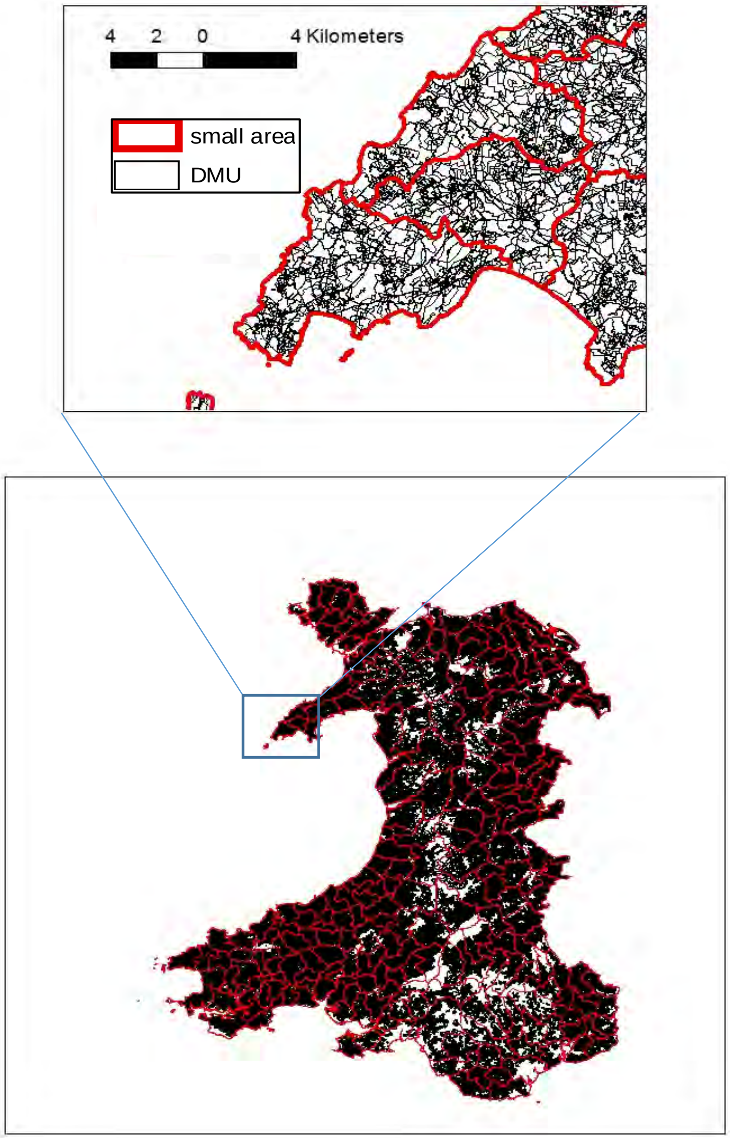
IMP modelling scales



- The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
- The finest spatial resolution used by Sfarmod and the Land Allocation Module (LAM) for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
- A DMU is defined as a managerially homogenous cluster of soil type, rainfall and land cover.
- Results in the slide pack are aggregated to small agricultural areas as findings are more robust at this level.

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6: ERAMMP_IMP_LandUseScenarios_T6_Slidepack

Funded by:

Llywodraeth Cymru
Welsh Government

Canolfan Ecoleg a Hydroleg y DU
UK Centre for Ecology & Hydrology

INTEGRATED MODELLING PLATFORM

Land Use Scenarios (T6)

UK Centre for Ecology & Hydrology

Cranfield University

ADAS

Forest Research

eftec

BTO

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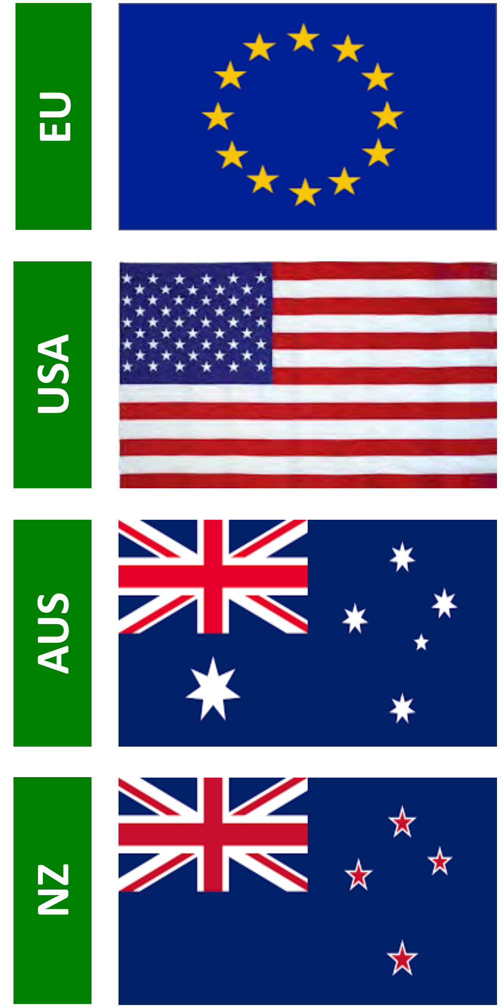
Scenario description (T6)

- Free trade agreements with EU, USA, Australia and New Zealand.
- T6 is a WG-requested alternative version of the FTA with all scenario (T3) with settings that consider a negative impact on dairy.
- Explanation and quantification:
  - Welsh market may attract some dairy commodity imports – butter and hard cheese. This could reduce UK milk prices.
  - Beef and lamb come under pressure from both Aus and NZ, and beef from USA.
- Scenario settings:

	Milk (p/litre)	Beef (£/kg LWT)	Lamb (£/kg LWT)
Baseline (2015)	35	1.85	1.68
T6	**33.3**	**1.48**	**1.43**



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PART 1: Agriculture

Background information

The agricultural models are applied to all full-time farms

	No.	Area (ha)
Full-time	7726	1010891
Spare / Part-time	12738	409150
Total	**20464**	**1420041**

Farm Business Income classes within T6:

As baseline farm type	As alternative farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture
<£6000 p.a.	>£6000 p.a.	Farm under pressure	Likely to change farm type through sale to another enterprise
£6K-£13K	Any amount	Farms staying the same	Able to continue but unlikely to be able to change farm type
>£13000	<£13K +FBI uplift+finance	Farms staying the same	Insufficient economic incentive to change farm type
>£13000	>=£13K +FBI uplift+finance	Farms changes type	Likely to be sufficient economic incentive to change farm type

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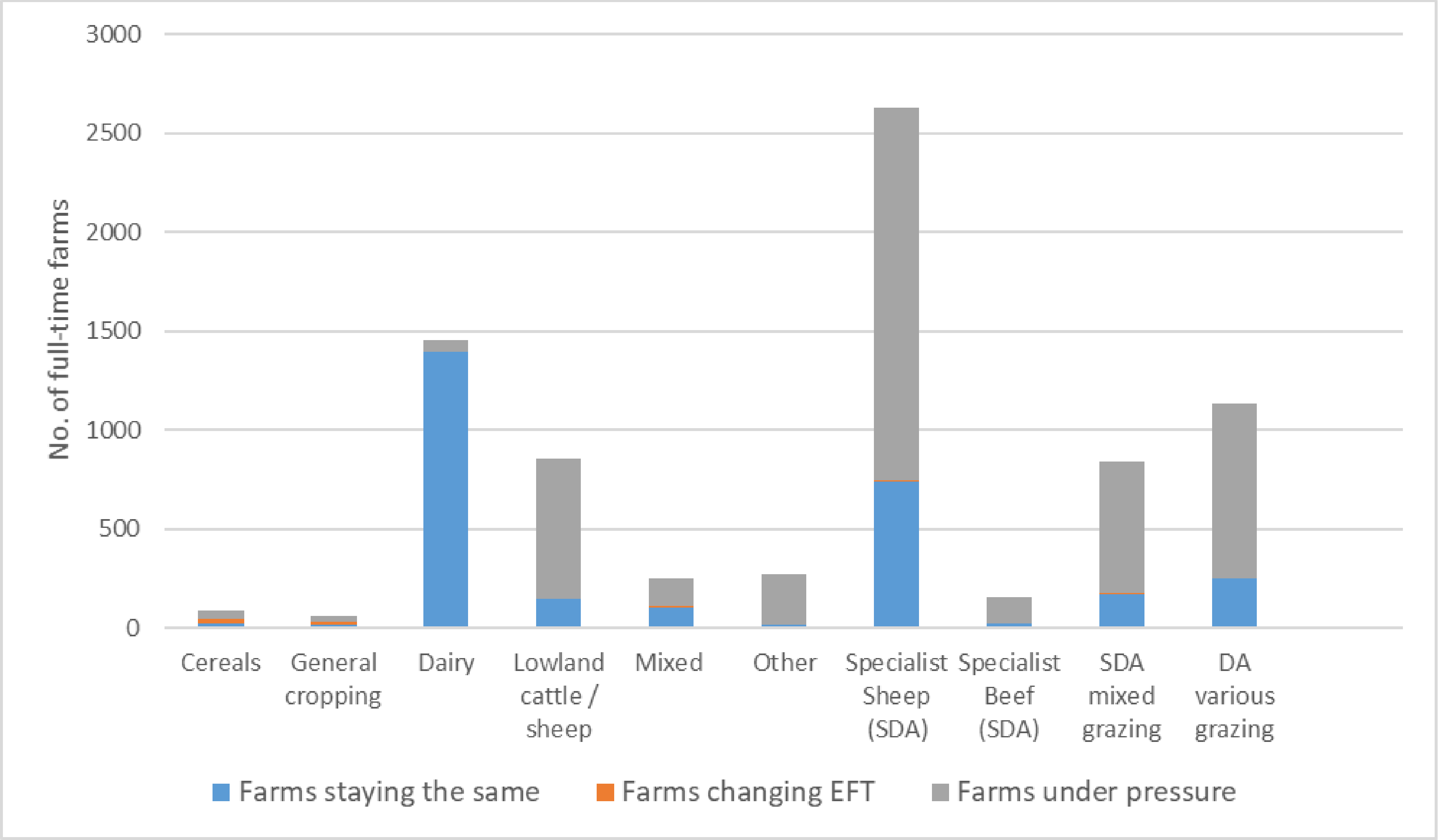
Simulated status of current full-time farms under T6



Baseline number of simulated full-time farms: 7726

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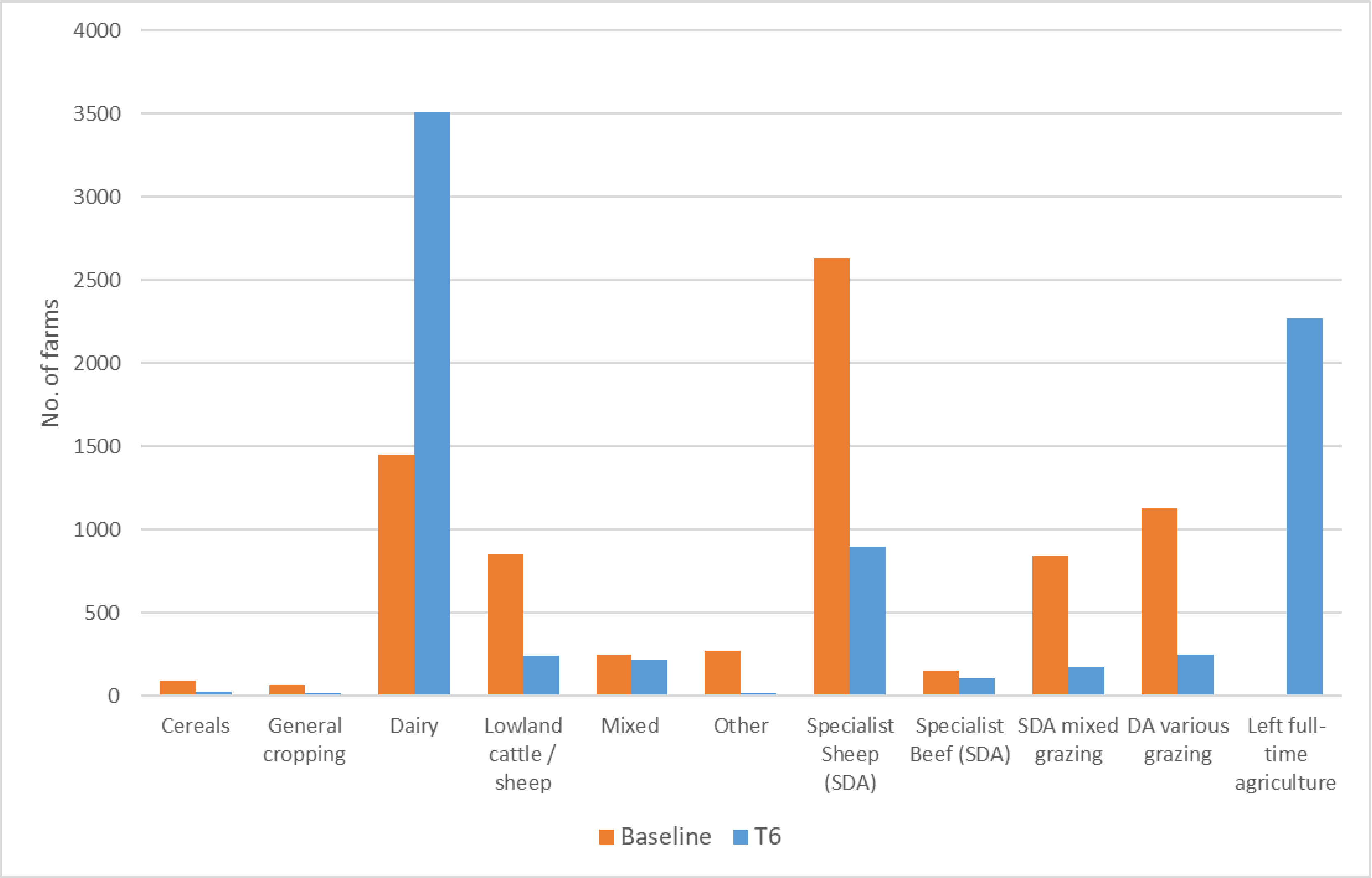
Farm numbers by farm-type (Baseline vs T6)



Total number of simulated full-time farms: 7726 in Baseline; 5455 in T6

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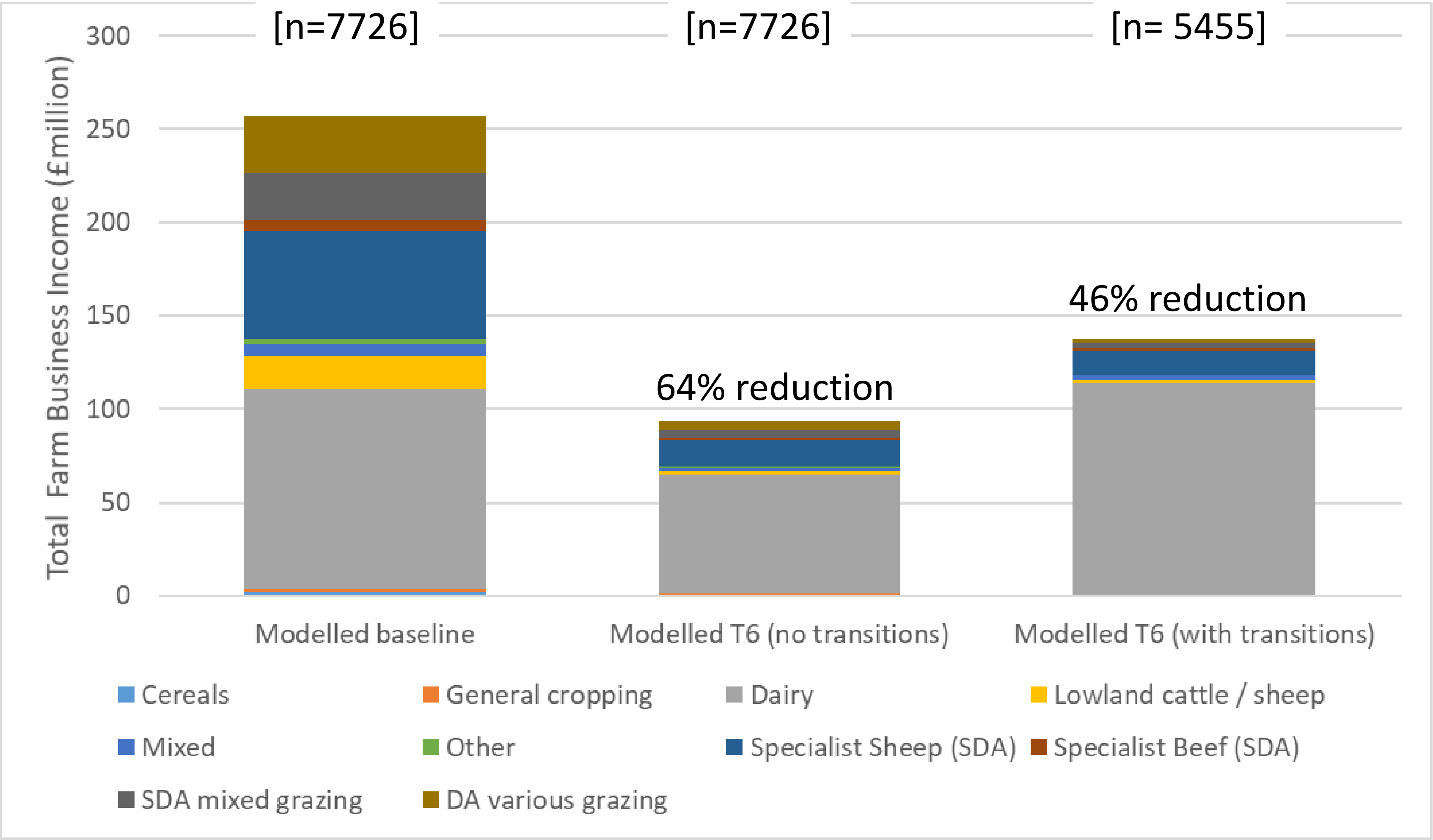
Total simulated Farm Business Income from full-time farms



Total number of simulated full-time farms: 7726 in Baseline; 5455 in T6

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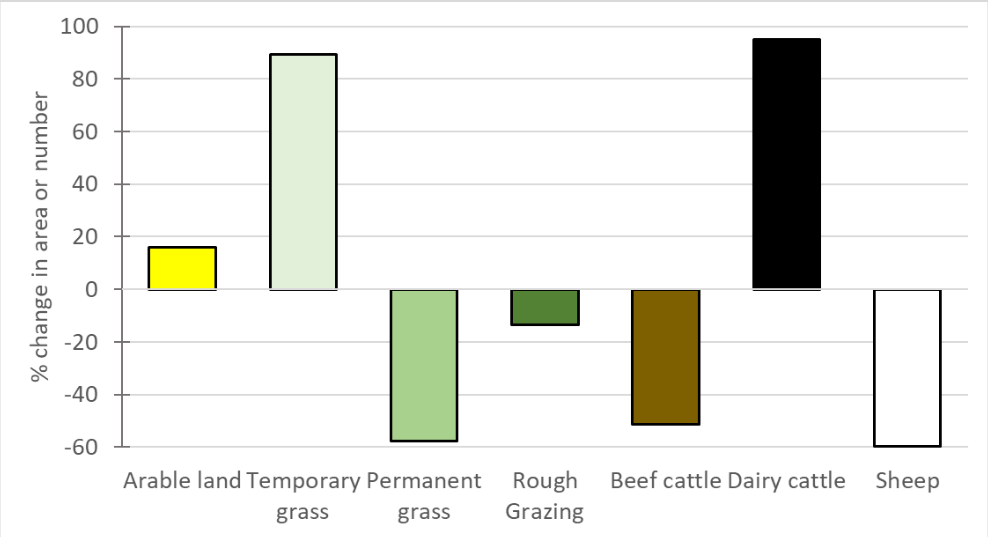
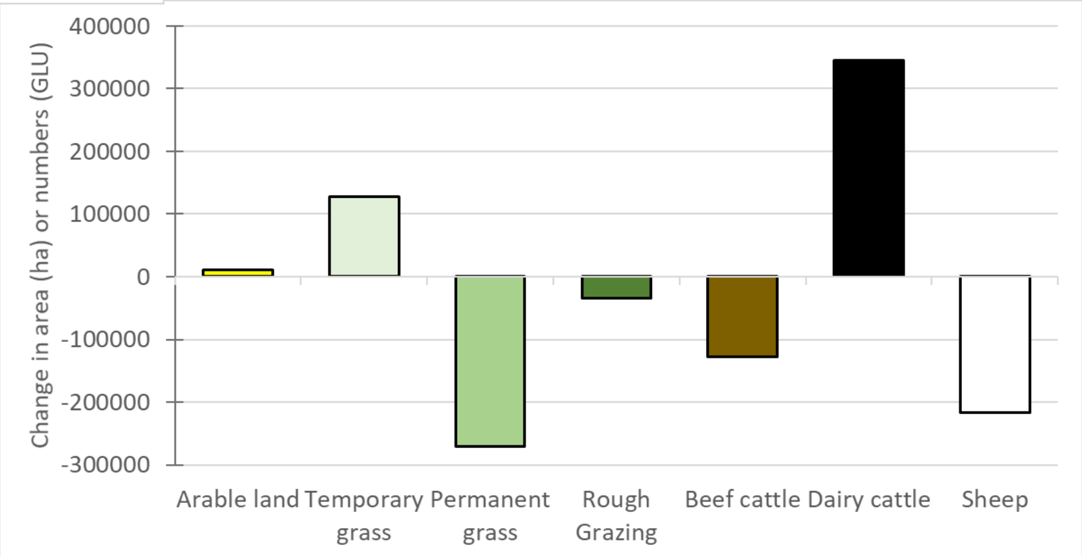
Change in simulated managed land use and stock (T6)



Percentage change (relative to simulated baseline)

Absolute change in simulated areas (ha) and numbers (Grazing Livestock Units)



Simulated farms remaining in full-time agriculture: 5455

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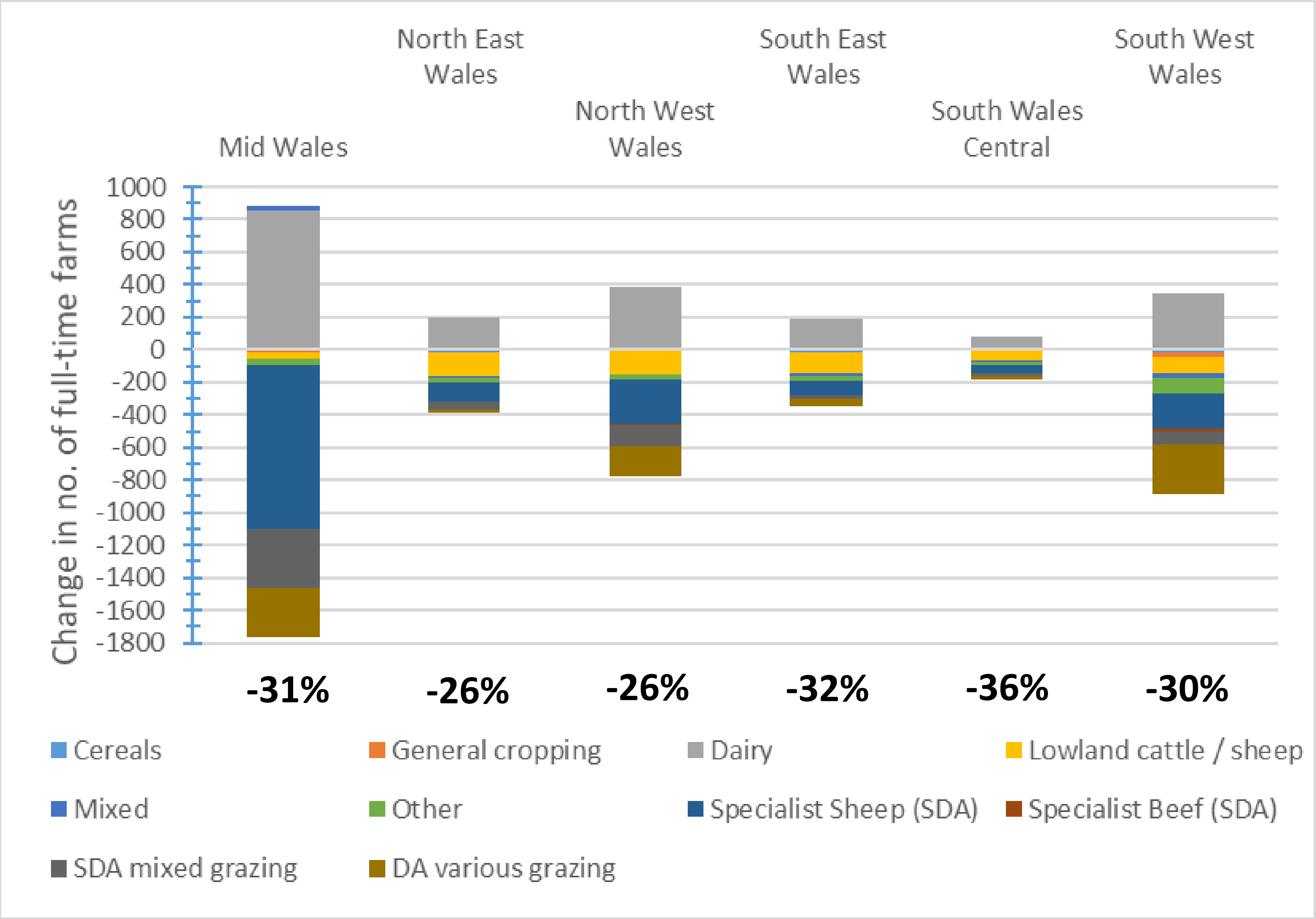
Change in farm numbers by farm-type (T6)



Simulated farms remaining in full-time agriculture: 5455

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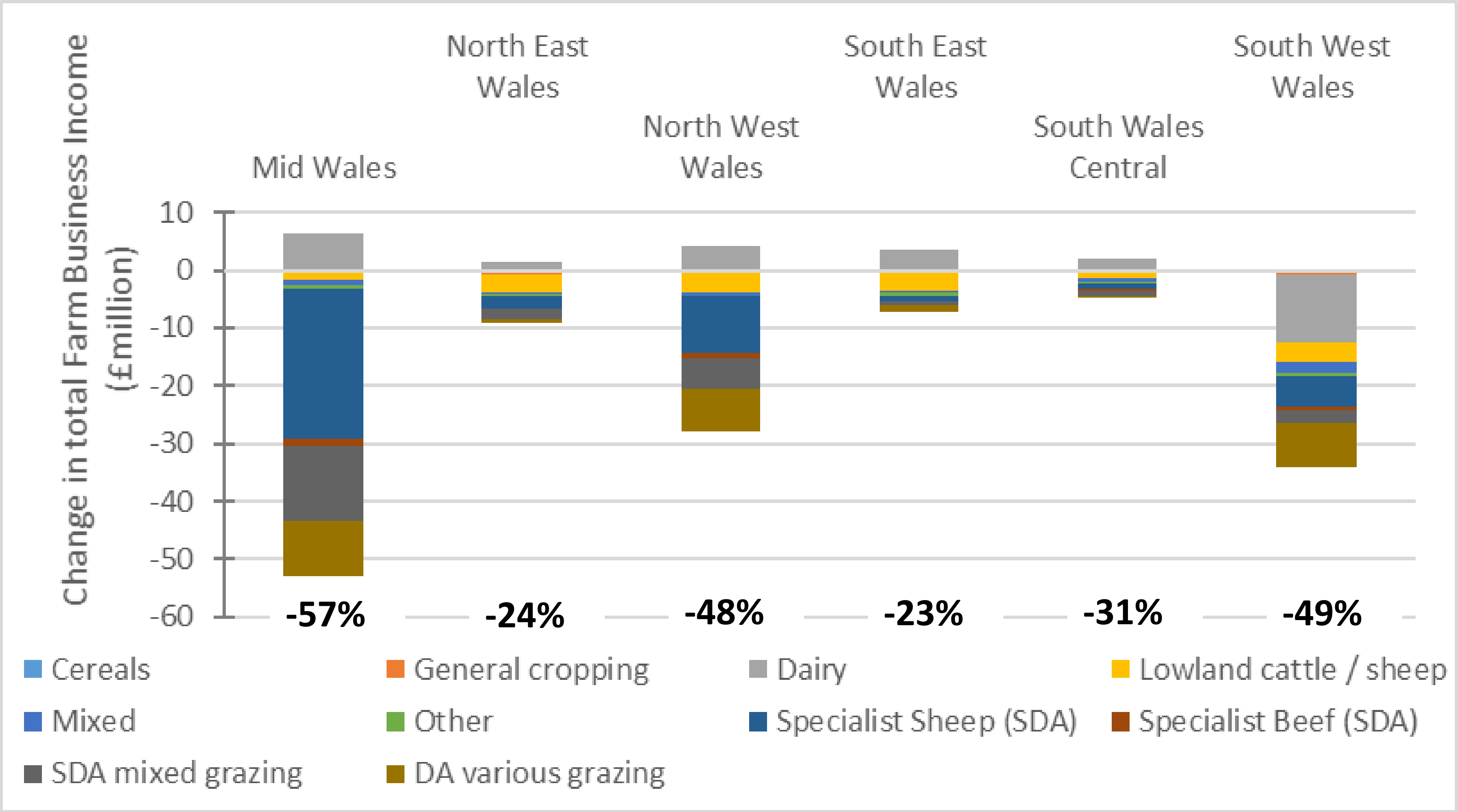
Change in total simulated Farm Business Income from remaining full-time farms (T6)



Simulated number remaining in full-time agriculture: 5455

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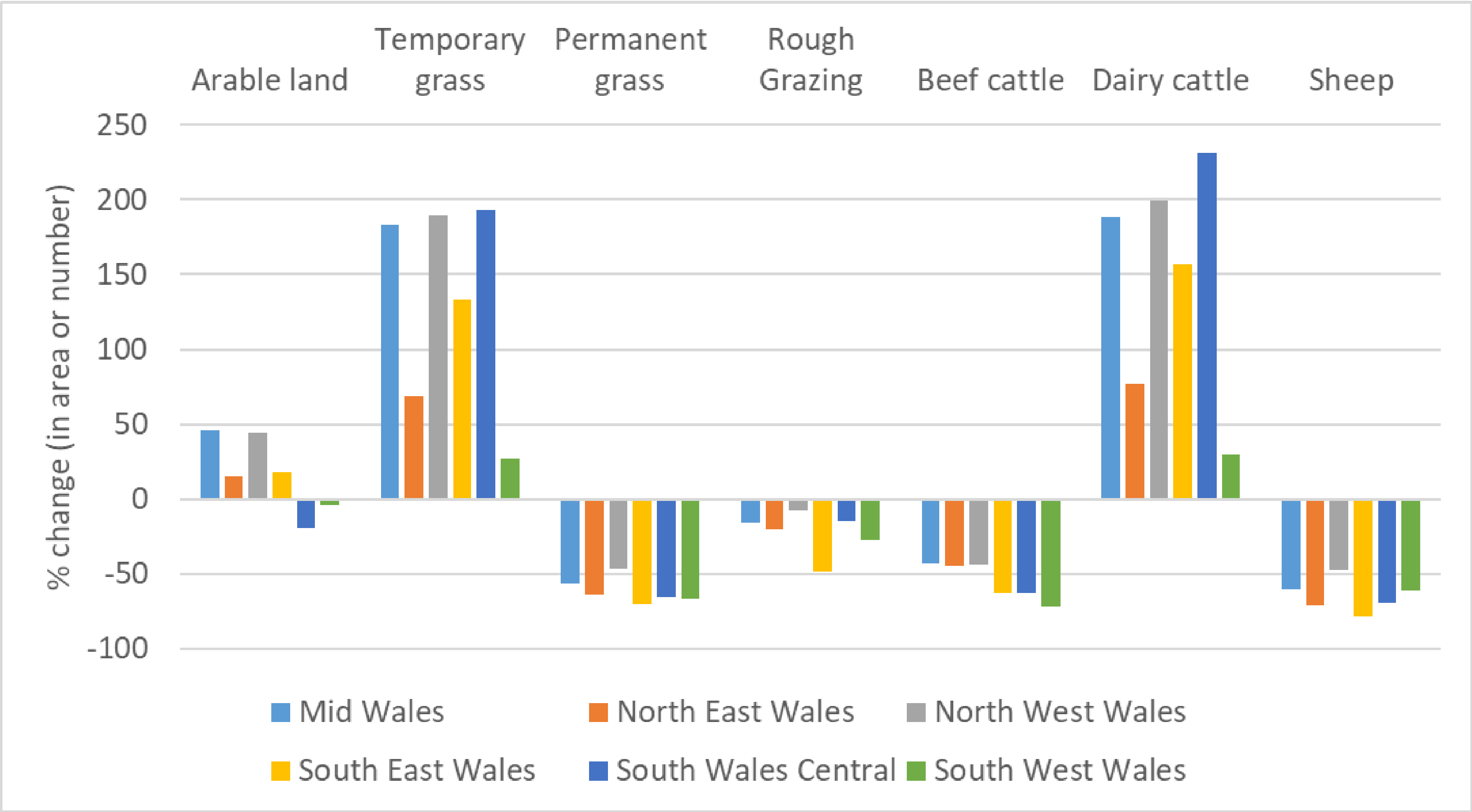
Regional change in land use and livestock (T6)



Simulated number remaining in full-time agriculture: 5455

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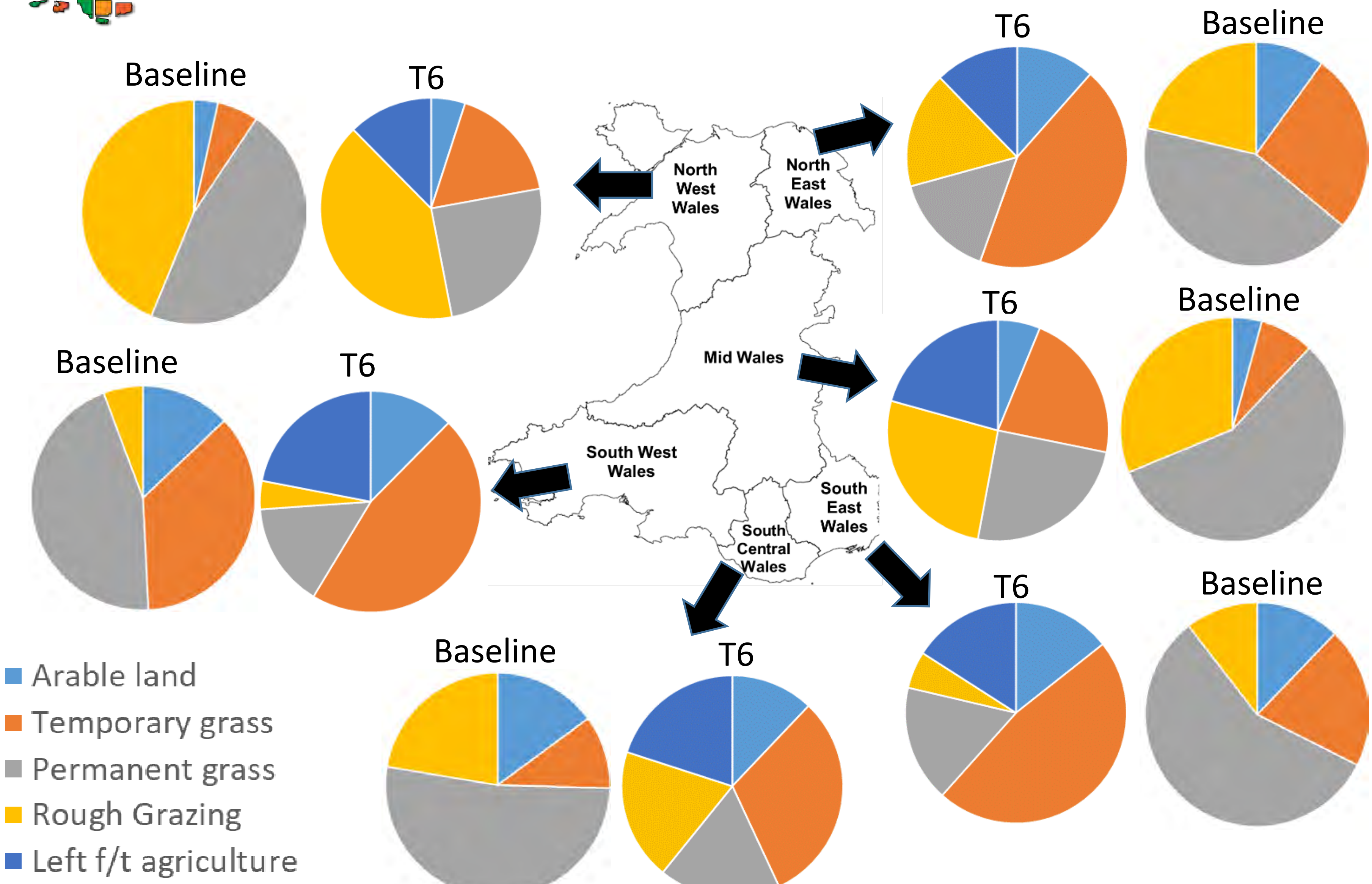
Regional land use proportions in T6



Simulated number remaining in full-time agriculture: 5455

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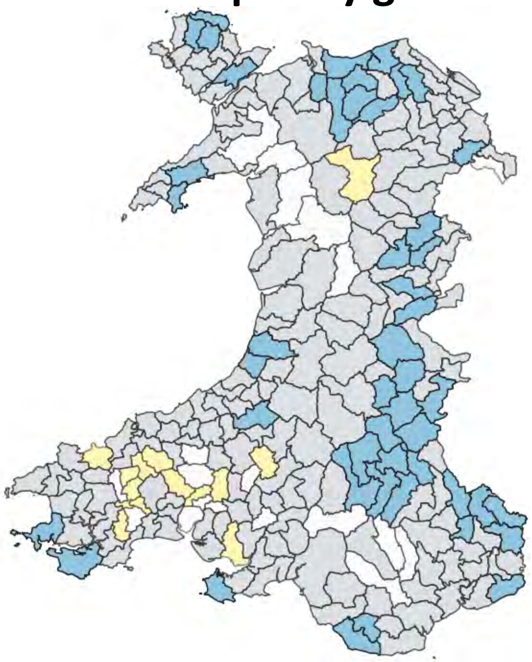
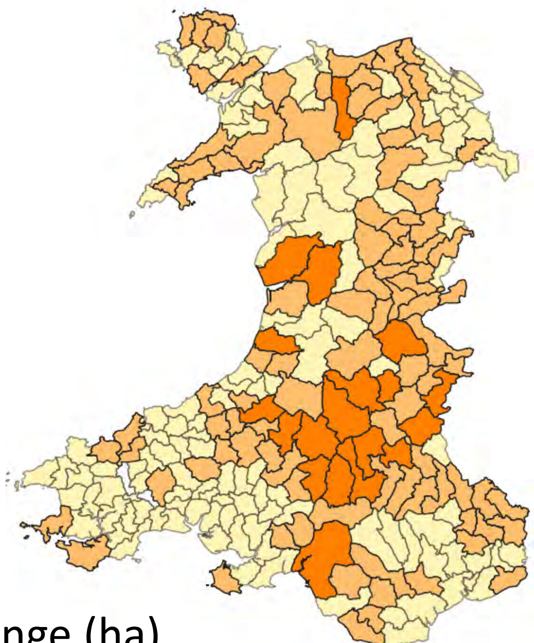
Simulated change in land use (T6)

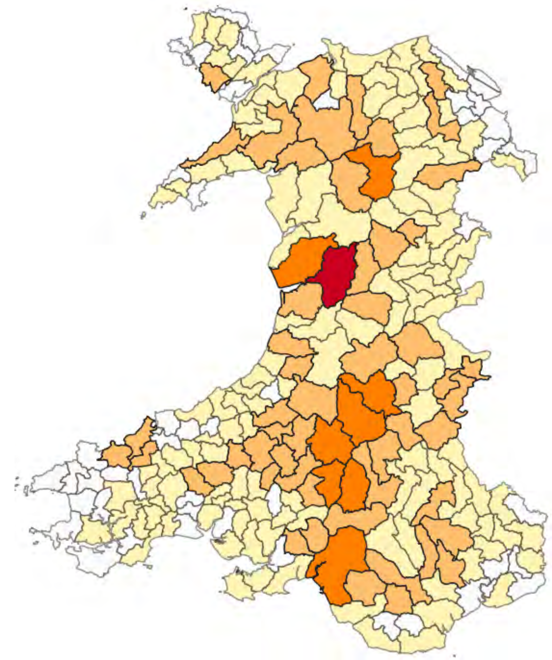
Change in cultivated / temporary grassland



Change in permanent grassland



Change in agricultural area



Change (ha)

- < -5000
- -5000 - -2500
- -2500 - -1000
- -1000 - -100
- -100 - 100
- 100 - 1000
- 1000 - 2500
- 2500 - 5000
- >5000

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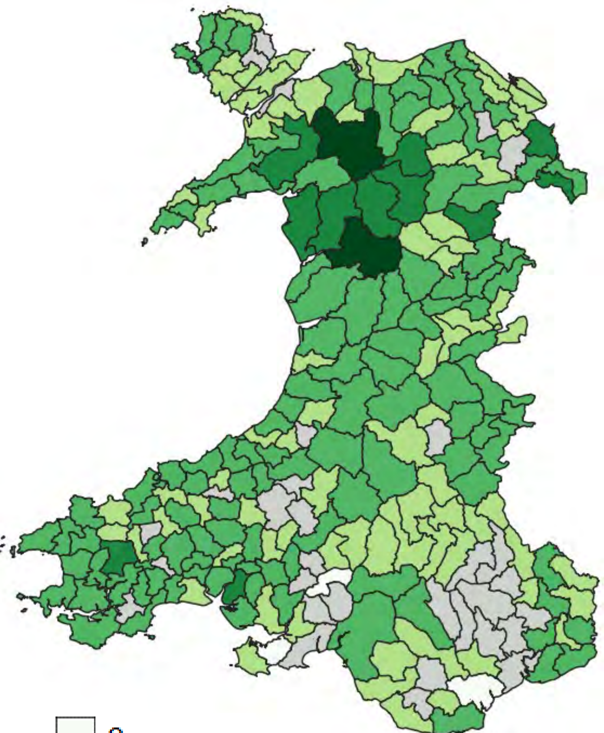
Simulated status of current full-time farms under T6

Farms staying the same

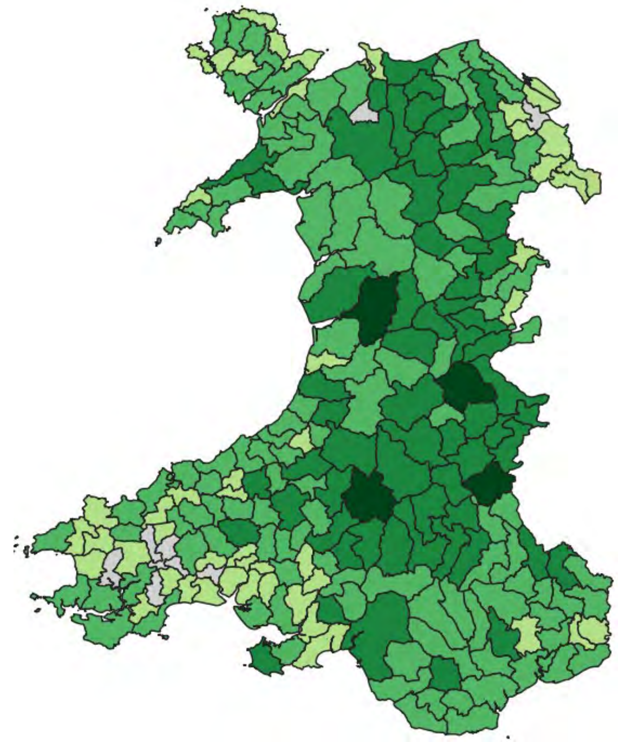


n= 2888

Farms changing type

n= 48

Farms under pressure



n= 4790

- 0
- 1 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- > 50

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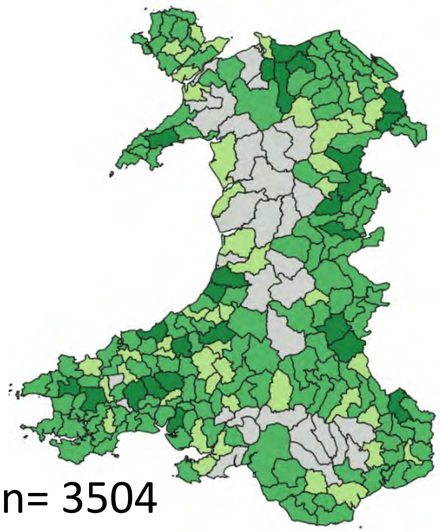
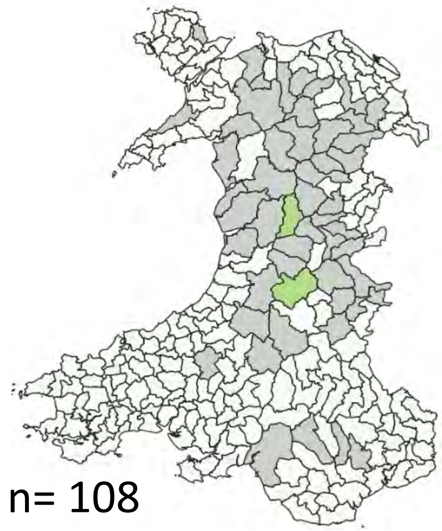
Simulated farm type numbers under T6

Dairy specialists



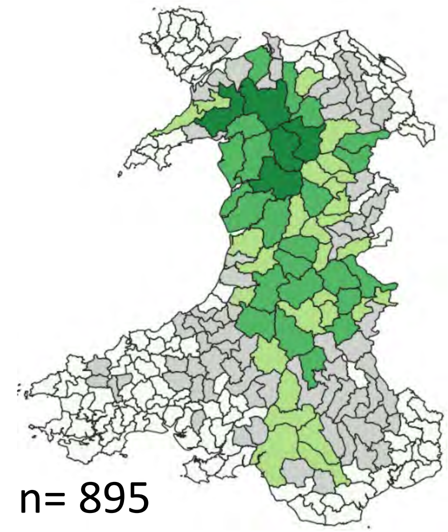
n= 3504

Beef specialists



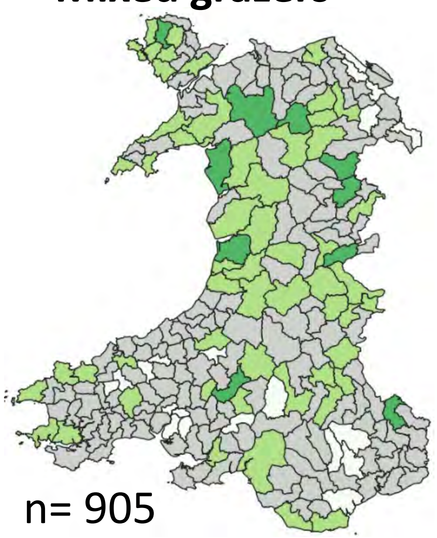
n= 108

Sheep specialists



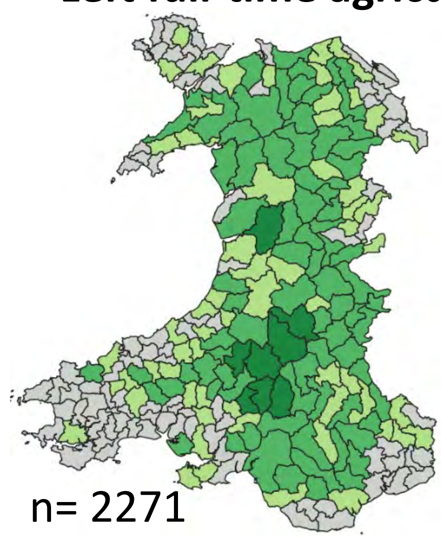
n= 895

Mixed grazers

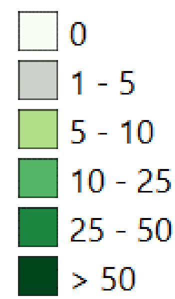


n= 905

Left full-time agriculture



n= 2271



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Farms leaving full-time agriculture

Farm Business Income classes within T6:

As Baseline Farm type	As alternative Farm types	Classification	Interpretation
<£6000 p.a.	<£6000 p.a.	Farm under pressure	Likely to leave full-time agriculture

A farm that is unable to achieve a full-time annual FBI of £6,000 may:

- Implement cost savings and struggle on;
- Transition to part-time farming, to enable increased non-agricultural income though diversification and / or off-farm employment;
- Leave agriculture in the short-term;
- Leave agriculture in the longer-term (e.g. due to retirement / inter-generational change).

As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.

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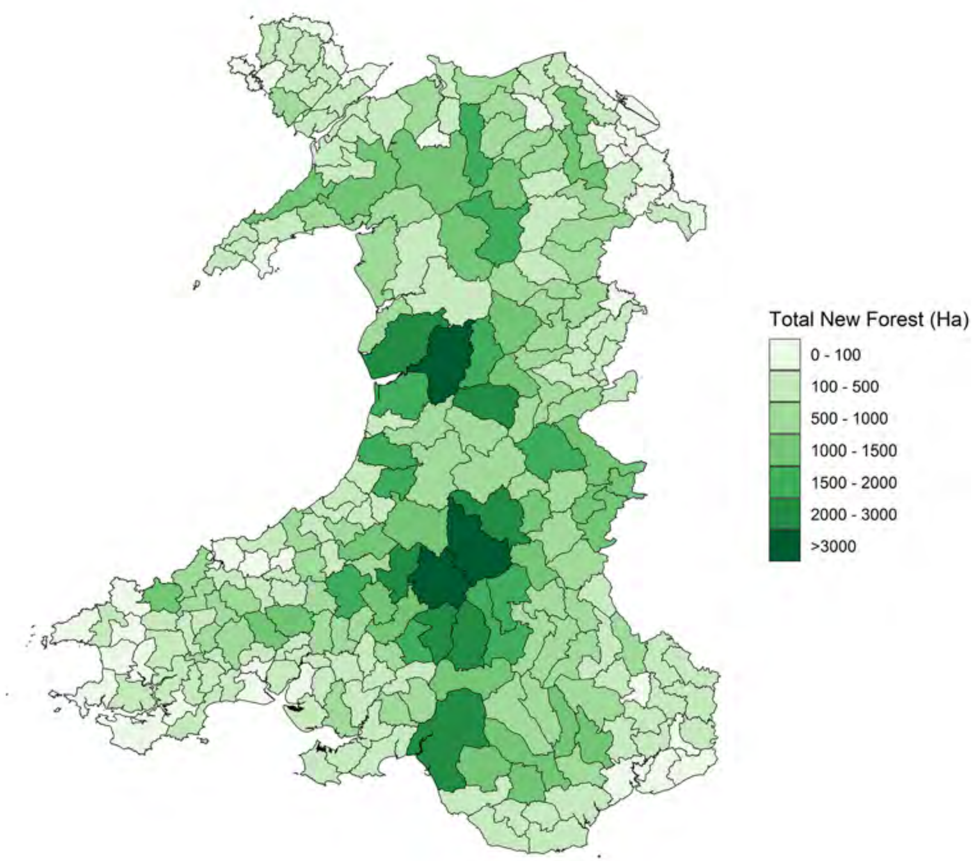
Simulated new woodland on farms leaving full-time agriculture (T6)



- Total new forest area (ha) from afforestation and natural regeneration.
- Totals largely driven by afforestation: 112,403 ha.
- Afforestation will only occur on abandoned land that will generate a positive net present value (NPV) from forestry.

Total area of new forest: 149,075 ha (117% increase for modelled >1 FTE farms)

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PART 2: Biodiversity

Biodiversity summary – Birds (T6)

- Increases and decreases in bird population sizes are an inevitable consequence of changes in land use.
- By **2050**, under the T6 scenario, increases in the cover of coniferous woodland & rotational grass are simulated, as well as decreases in the cover of permanent grass.
- Overall, slightly more species are simulated to significantly decrease in population size than those which significantly increase.
- Woodland species are simulated to perform better under this scenario, with declines more common in lowland farmland birds.
- The greatest increases to species diversity are projected in the west of Wales.

Eaton, Mark, et al. "Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man." British Birds 108.12 (2015): 708-746.

Bladwell et al. “The state of birds in Wales 2018.” (2018). The RSPB, BTO, NRW and WOS. RSPB Cymru, Cardiff

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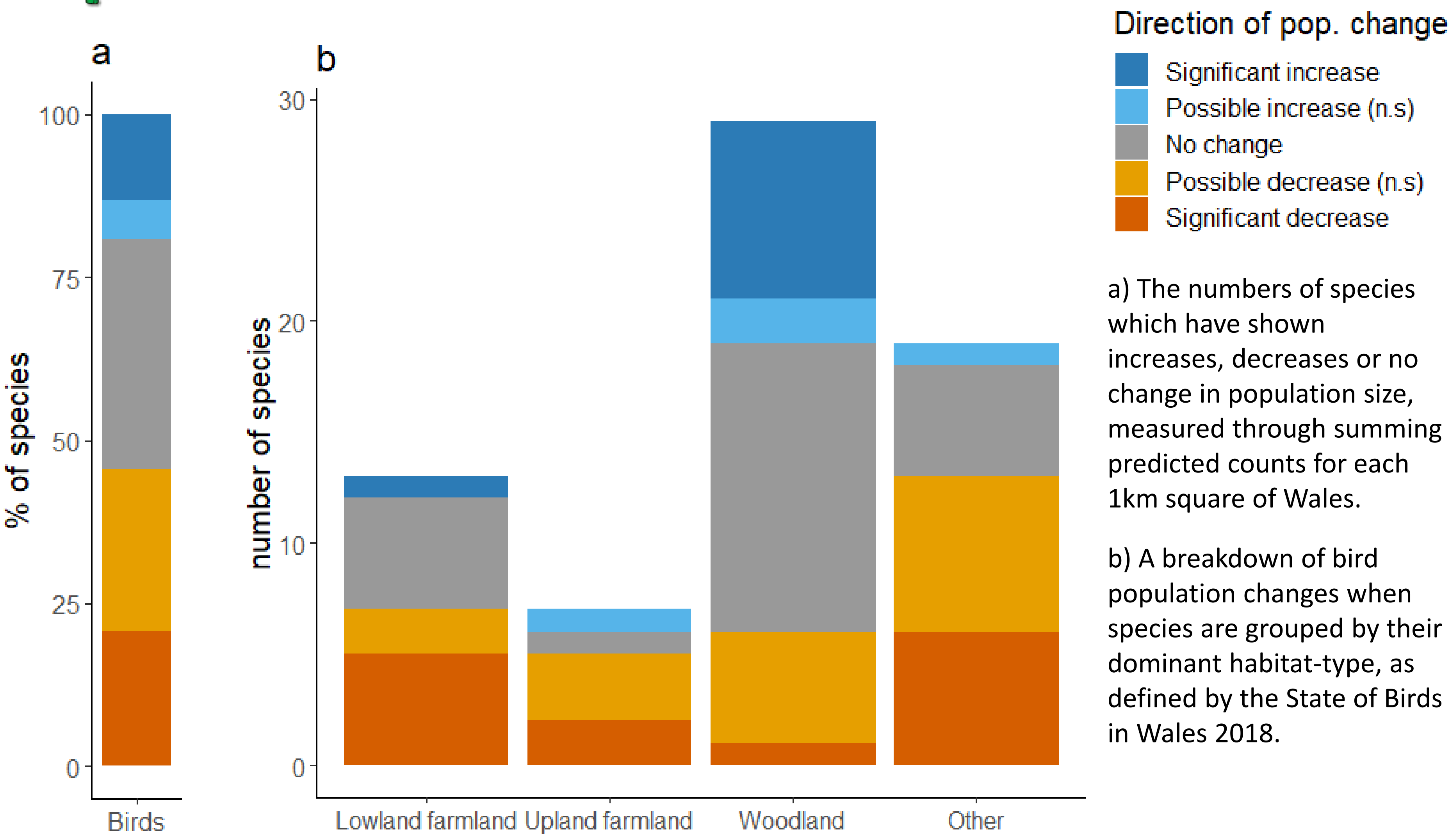
Overall bird population change in T6



a) The numbers of species which have shown increases, decreases or no change in population size, measured through summing predicted counts for each 1km square of Wales.

b) A breakdown of bird population changes when species are grouped by their dominant habitat-type, as defined by the State of Birds in Wales 2018.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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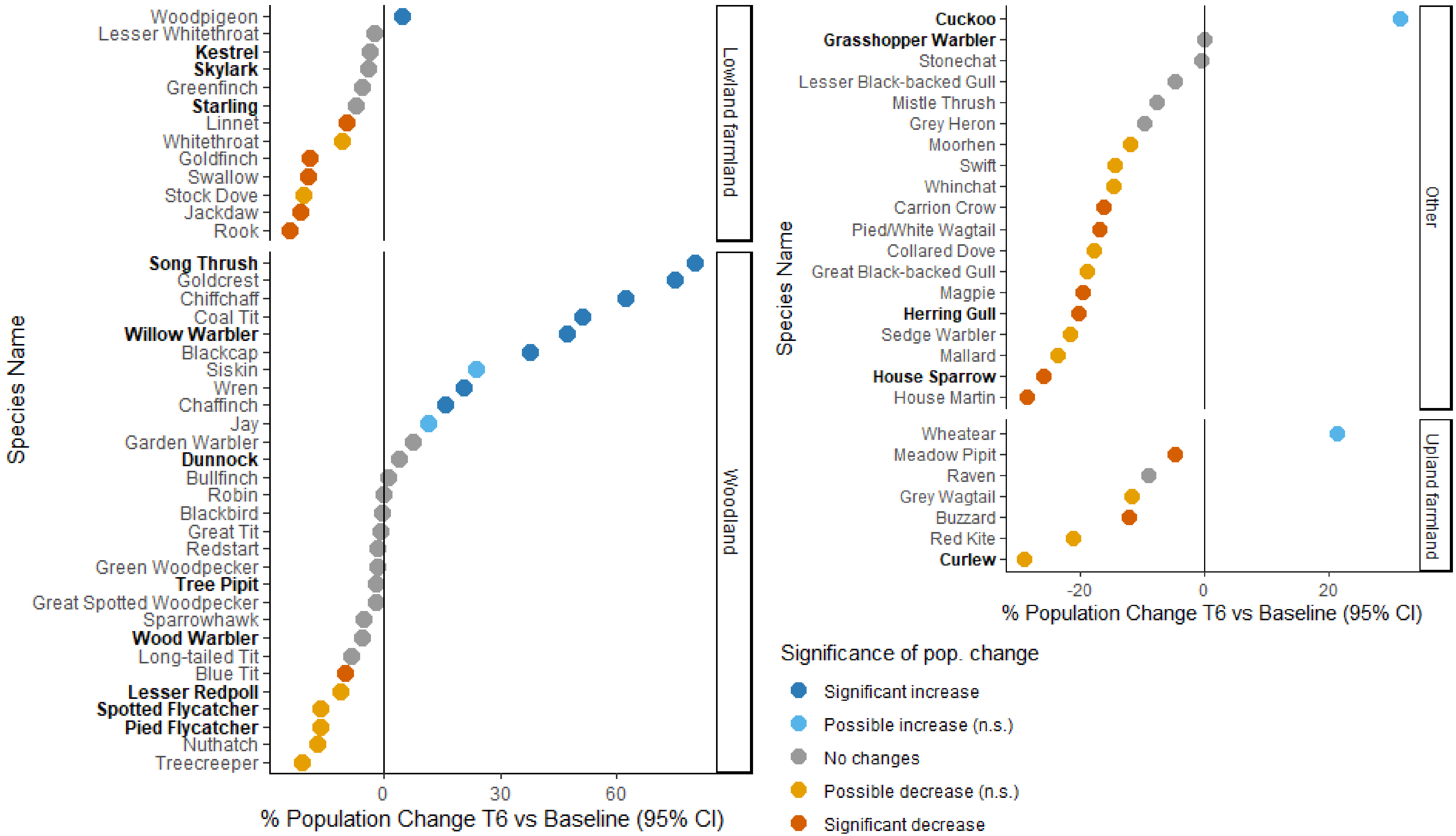
Population changes per bird species in T6



- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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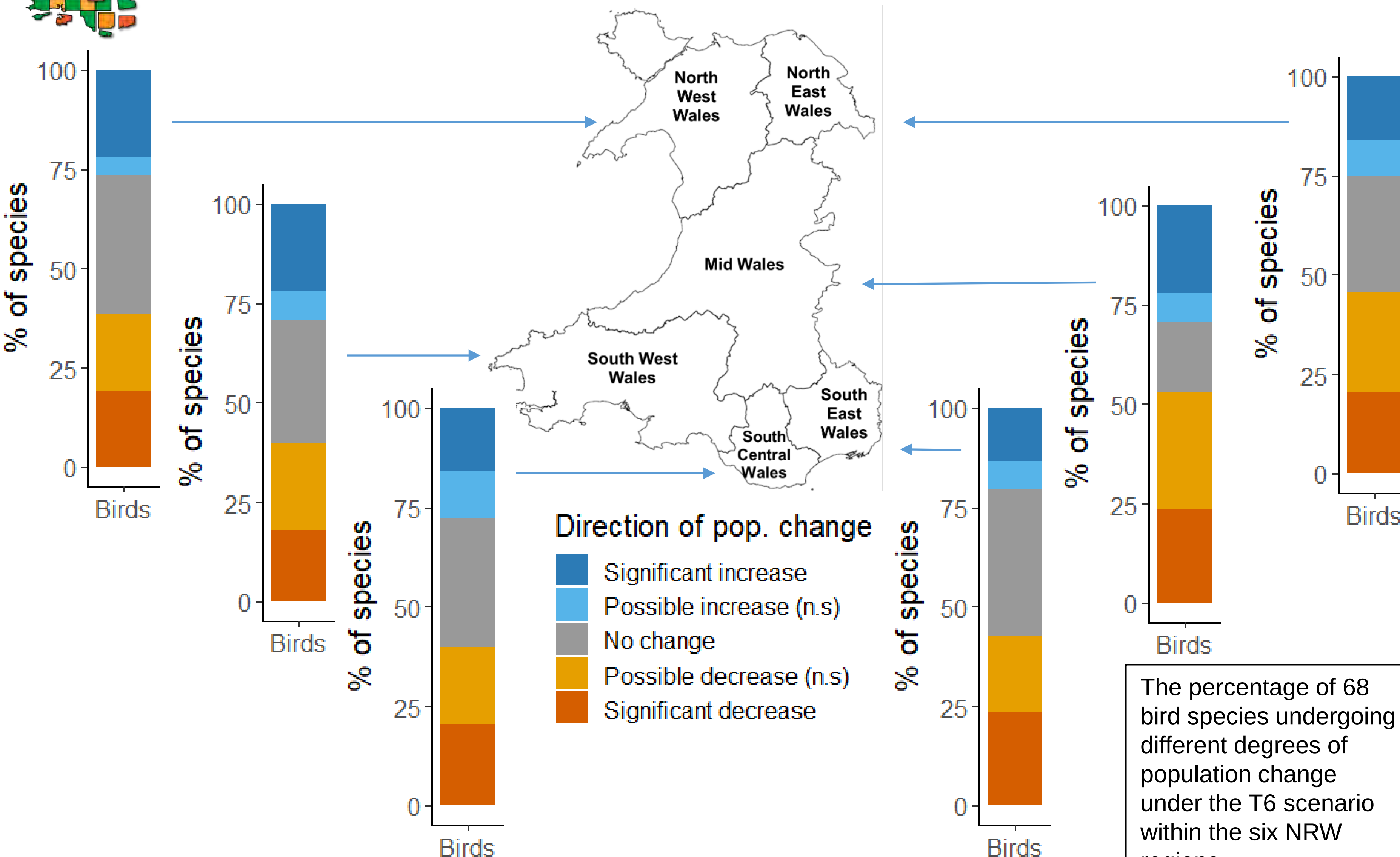
Regional bird population impacts in T6



The percentage of 68 bird species undergoing different degrees of population change under the T6 scenario within the six NRW regions.

- Changes are labelled as significant if non-overlapping confidence intervals between baseline and scenario population sizes
- Changes are labelled as possible if confidence intervals overlap but the predicted change is greater than 10%

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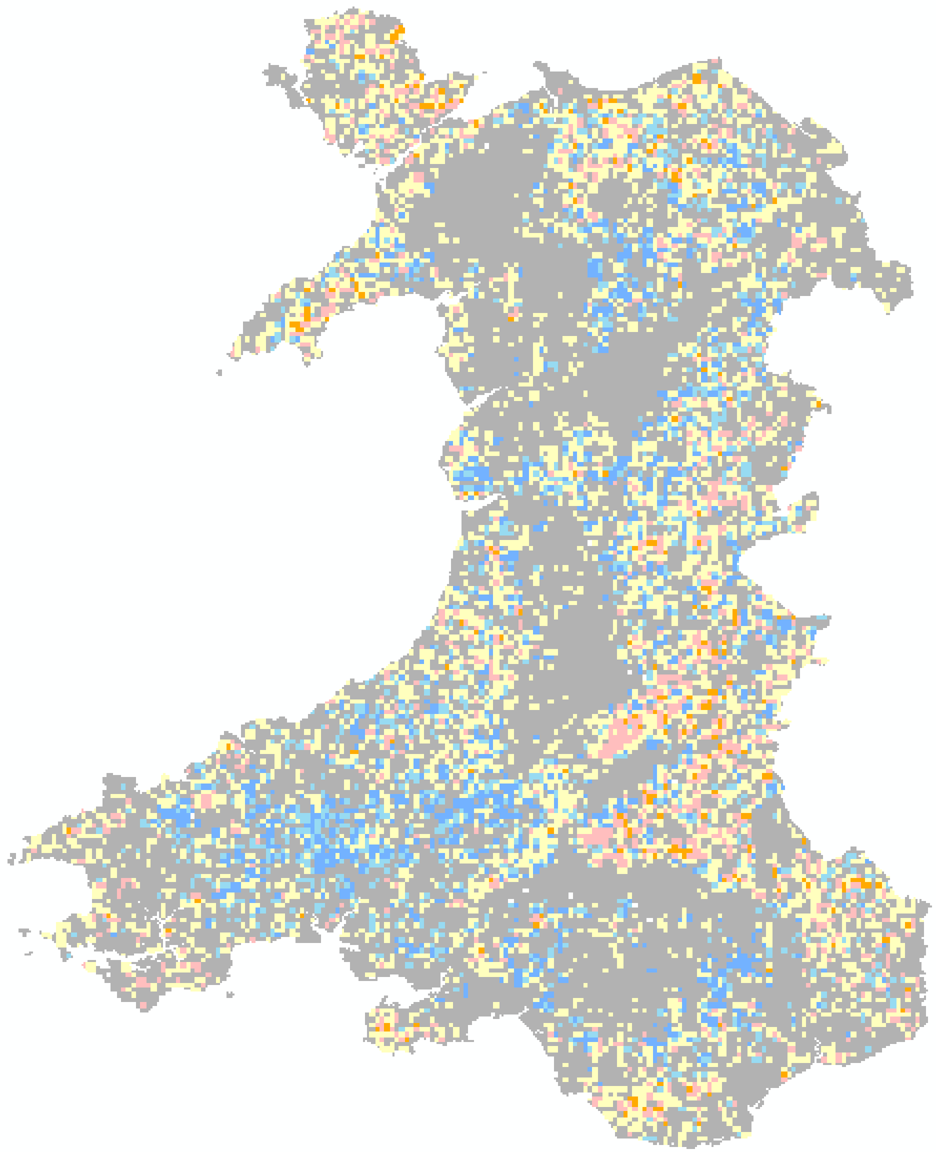
Local bird species change in T6



Ratio of species change

- +3 to +18
- +1 to +2
- 0
- -1 to -8
- -9 to -20
- -20 or greater

The ratio of 68 bird species undergoing significant increases *vs* decreases for each 1km square of Wales. Bolder colours are indicative of greater change. Note that under this metric, any square seeing large, but equal numbers of increases and decreases will be represented by grey colouration, identical to that of a square seeing no changes.

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Biodiversity summary – Plants (T6)

- Overall, simulated shifts between agricultural sectors show gains in temporary grass (from permanent grass) and an increase in conifer plantation and broadleaved woodland from natural succession associated with a simulated movement of 'farms under pressure' out of full-time farming. The pattern appears most similar to the T1 scenario, but here there is a greater increase in Dairy with roughly half the number of farms leaving full-time agriculture in T6 than predicted under T1.
- In T6 the simulated shift to more intensive temporary grassland and a gain in woodland area results in greater habitat suitability for woodland and semi-natural habitat specialists if shade-tolerant, while other grassland, wetland and heathland specialists see reduced suitability under intensification. These patterns are broadly similar across all regions except for South Central Wales where very little change is estimated across all three groups.
- <u>Summary:</u> Our modelling shows that the suitability of ecological conditions across much of Wales increases or decreases depending on the balance between intensification and reduced agricultural activity.

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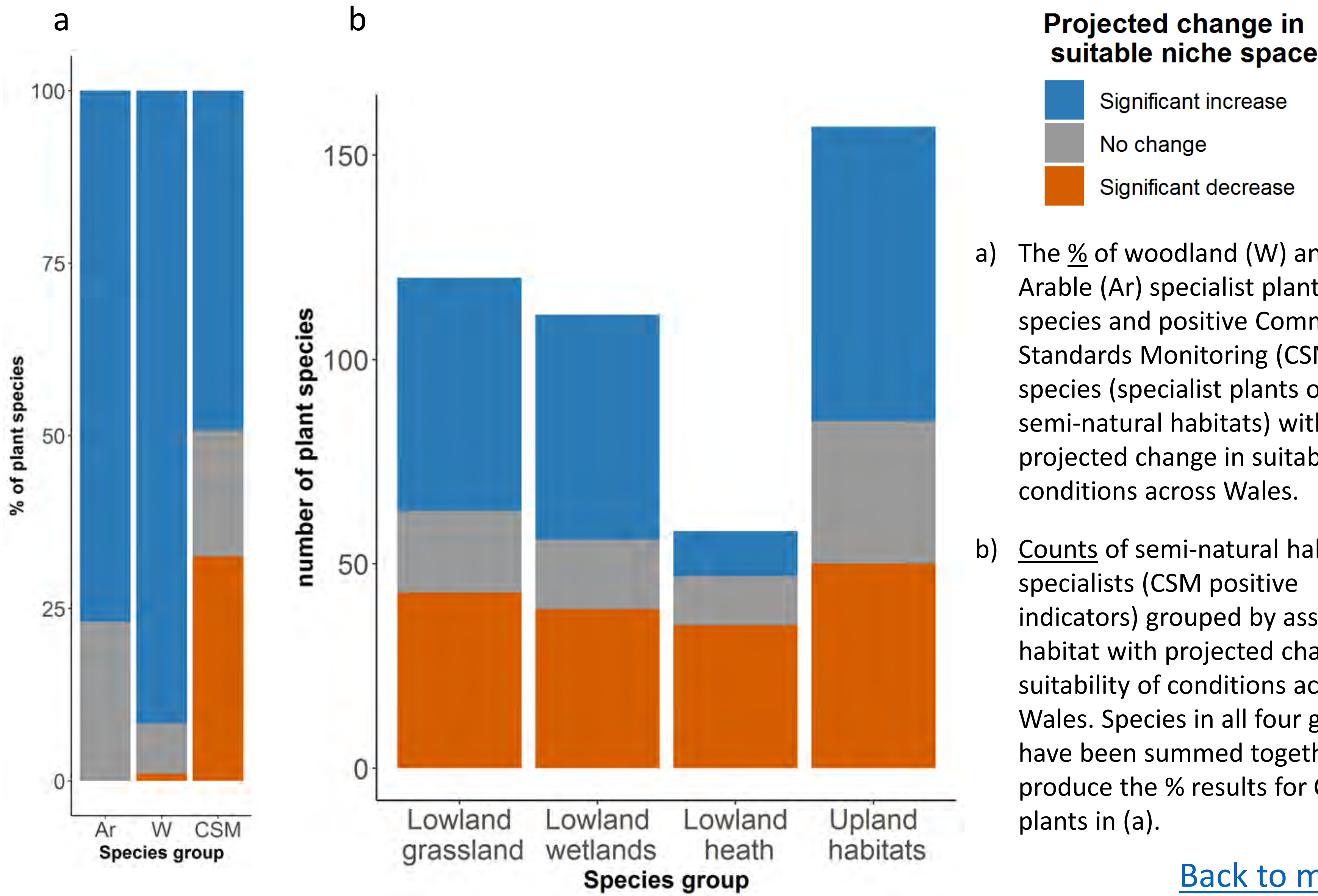
National change in habitat suitability for plants over 25 years (T6)



a) The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales.

b) Counts of semi-natural habitat specialists (CSM positive indicators) grouped by associated habitat with projected change in suitability of conditions across Wales. Species in all four groups have been summed together to produce the % results for CSM plants in (a).

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% change in habitat suitability per plant species in T6 (Examples)

Woodland specialists for Wales [1]
Total number of species = 98

Latin	% change in suitability	Sig change
Sorbus aucuparia	3.9	+
Ilex aquifolium	4.0	+
Oxalis acetosella	2.7	+
Potentilla sterilis	1.2	+
Allium ursinum	1.1	+
Campanula latifolia	1.1	+
Luzula sylvatica	0.7	+

Arable specialists [2]
Total number of species = 15

Latin	% change in suitability	Sig change
Anthemis cotula	0.0	ns
Veronica arvensis	0.6	+
Anagallis arvensis	0.2	+
Geranium molle	0.3	+
Lamium purpureum	0.2	+
Papaver rhoeas	0.1	+
Polygonum aviculare	1.0	+

Excerpts from lists of species with projected change in suitability of ecological conditions across Wales. Click here to view the modelled niche of each species in Britain.

Semi-natural habitat specialists (CSM +ve indicators)
Total number of species = 360

Latin	% change in suitability	Sig change
Agrostis capillaris	-9.7	-
Leucanthemum vulgare	-8.1	-
Festuca rubra	-7.9	-
Galium saxatile	-3.6	-
Euphrasia officinalis agg.	-0.8	-
Briza media	-0.5	-
Epilobium palustre	-0.4	-
Veronica officinalis	-0.4	-
Pimpinella saxifraga	-0.1	ns
Molinia caerulea	-0.1	ns
Angelica sylvestris	0.0	ns
Betonica officinalis	0.0	ns
Silene dioica	1.3	+

[1] Glaves D et al. (2009) A Survey of the Coverage, Use and Application of Ancient Woodland Indicator Lists in the UK. Appendix 1. Hallam Environmental Consultants, Sheffield.
[2] Walker, K.J. (2018) Vascular plant 'axiophyte' scores for Great Britain, derived from the assessments of the vice-county recorders of the Botanical Society of Britain and Ireland (May 2016). NERC Environmental Information Data Centre. (Dataset). https://doi.org/10.5285/af2ac4af-12c6-4152-8ed7-e886ed19622b

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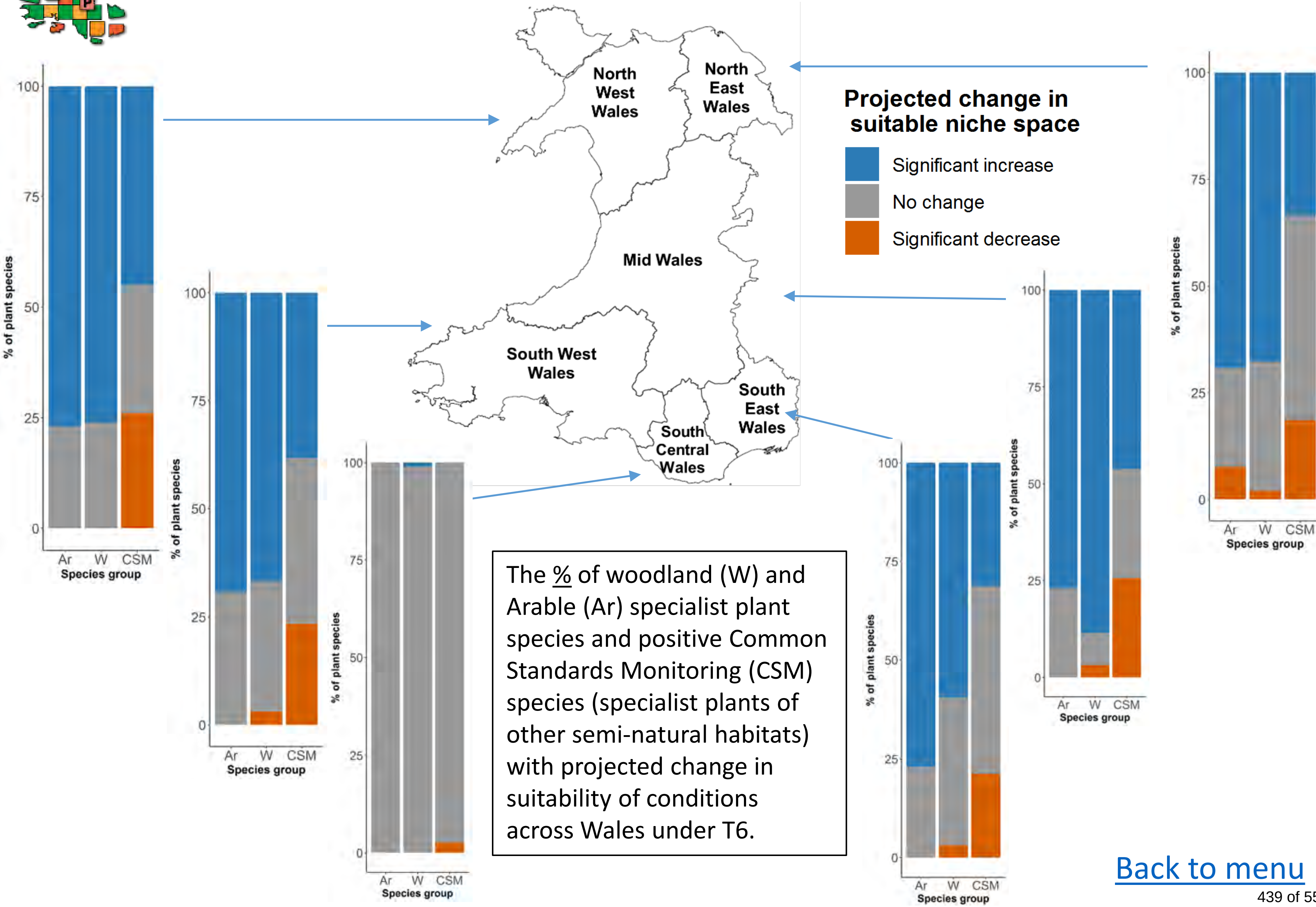
Regional impacts on plant species in T6



The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales under T6.

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Woodland habitat connectivity: Background information

- Woodland connectivity was modelled using a simple approach based on the distance species can travel (dispersal distance) and minimum habitat area requirements (patch size).
- Land within the dispersal distance of more than one patch could connect those patches if trees were planted.
- We identified a range of parameter combinations from the literature and applied these for Wales, broken down into NRW Area Statement regions.
- Baseline woodland was assigned using NFI data, combined with LCM2017, and data on woody linear features.

Dispersal distance/ patch size	**100m: snails**	**200m: woodland specialist plants**	**500m: invertebrates**	**1km: max. for snakes; amphibians; moths**	**2km: max. for woodland flora/fauna**
1 ha: low area requirements	not modelled	modelled	modelled	not modelled	not modelled
10 ha: high area requirements	not modelled	modelled	modelled	not modelled	not modelled
40 ha: NE recommended minimum size for wildlife site	not modelled	modelled	modelled	not modelled	modelled

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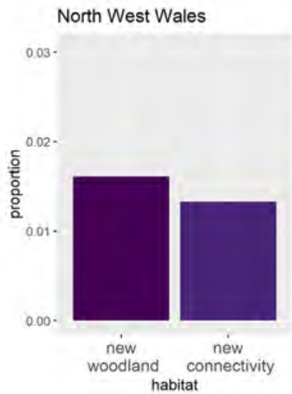
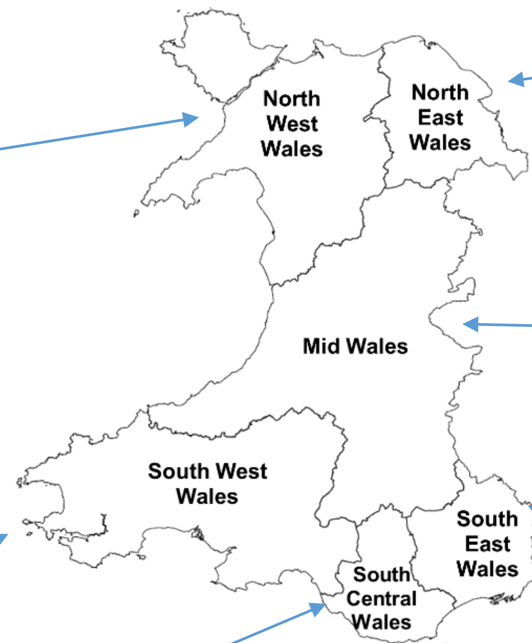
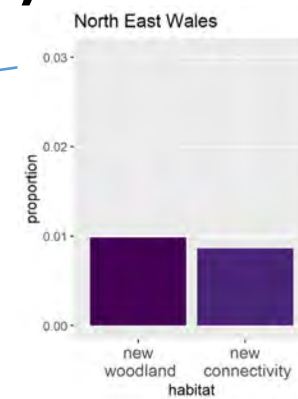
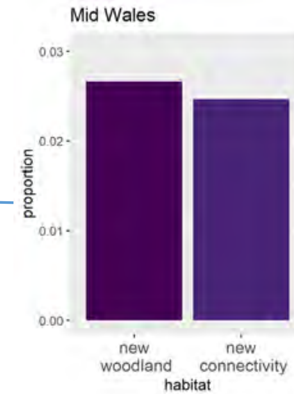
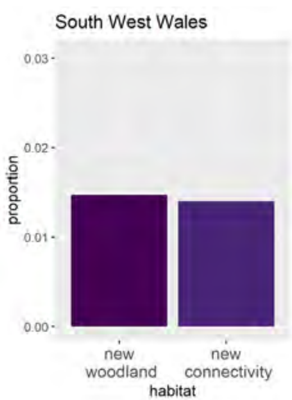
Woodland habitat connectivity: Regional variation in opportunity and predicted change (T6)

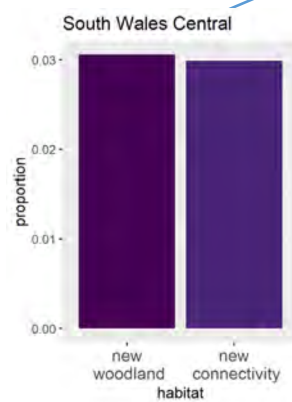


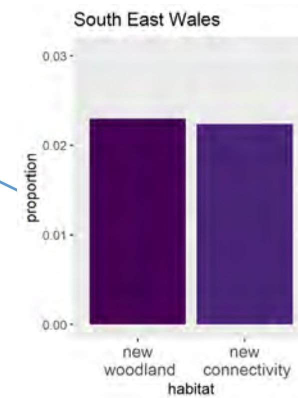












Most of the new woodland increases connectivity for at least one of our species type groups

Total area new habitat woodland (ha)

Total area providing increased connectivity

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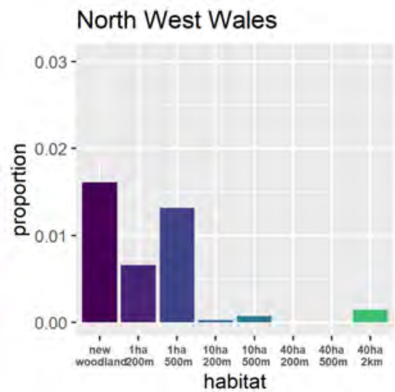
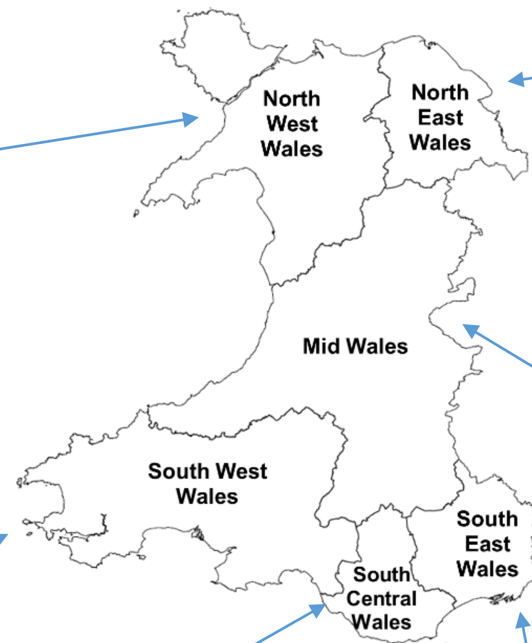
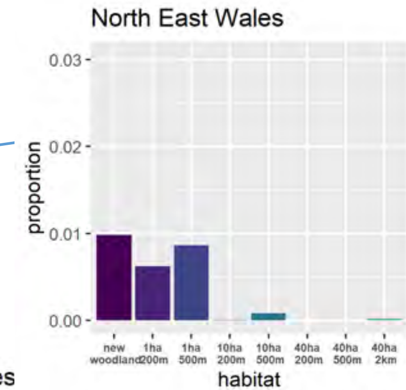
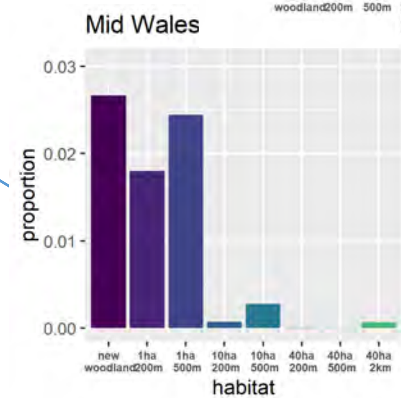
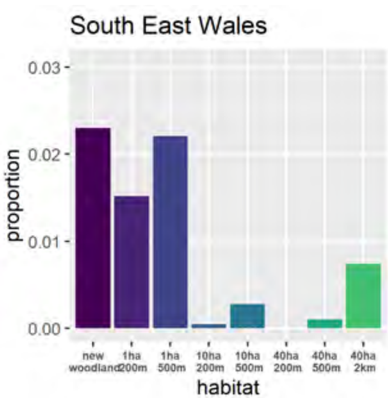
Breakdown of woodland connectivity type in NRW regions (T6)

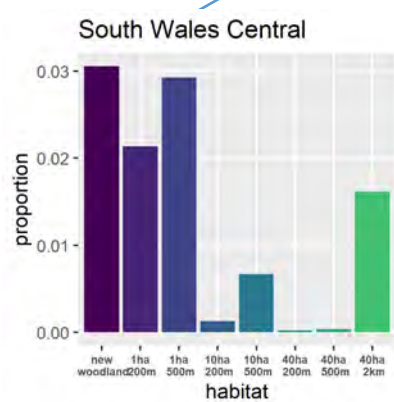


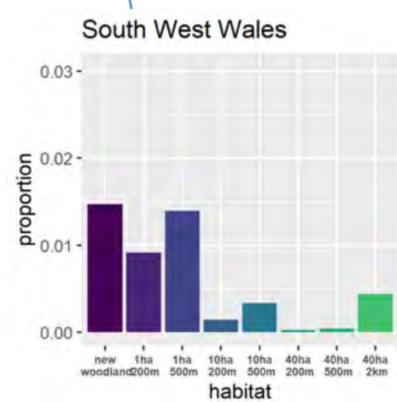












Connectivity increase:

- New woodland habitat
- 1ha 200m
- 1ha 500m
- 10ha 200m
- 10ha 500m
- 20ha 200m
- 40ha 500m
- 40ha 2km

PART 3: Ecosystem Services

3a: Carbon

Carbon summary:
Stocks and GHG emissions (T6)

(Note: Negative numbers indicate sequestration or avoided emissions)	**Increased emissions or losses of carbon by the year:**		
Inventory category:	**2025**	**2050**	**2100**
Losses from carbon stocks in Land use change and forestry + harvested wood products (4 A, B, C & G) (KtCO2eq)	6,007	-29,849	-55,133
Additional emissions from wetlands (4D) flux (KtCO2eq)	-228	-1,366	-3,642
Additional agricultural GHG flux (KtCO2eq)	5,046	30,278	80,742
TOTAL	10,825	-937	21,967

- Overall, an **increase in C stocks by 2100**, offset by a greater **increase in GHG emissions** is simulated for the T6 scenario, creating a **small net increase in atmospheric GHGs**.
- Modelled increase in GHG emissions associated with changes in livestock and nutrient inputs dominates the overall C budget to 2100, slightly exceeding the predicted sequestration from carbon gains in vegetation and soils associated with land use change (LULUCF 4 A, B, C & G).

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Carbon summary for Wales (T6)

This table compares Carbon stock and change in the LULUCF categories:

LULUCF category	Baseline	Change to 2100
Cropland and Grassland (4B + 4C)(Kt) C	173,399	Loss of: 5,618 (Kt) Gain of: 248 (Kt)
Forest Land (4A) (Kt)C	Baseline woodland C data are not available	Gain of: 15,930 (Kt)
Harvested Wood products (4G) (Kt) C		Gain of: 4,477 (Kt)

- Carbon in cropland and grassland systems (LULUCF category 4B and 4C) is simulated to reduce in the T6 scenario, due to conversion of grassland to arable/grass rotation.
- Small gains in carbon in LULUCF 4B + 4C are due to land going out of agriculture.
- Larger gains in C storage are simulated for forest land and harvested wood products related to agricultural land that is converted to woodland. Note, this outcome is strongly dependant on the large area of new woodland planting as modelled here, based on planting on former agricultural land with positive NPV. Note also that data are not available to account for C storage in existing woodland.

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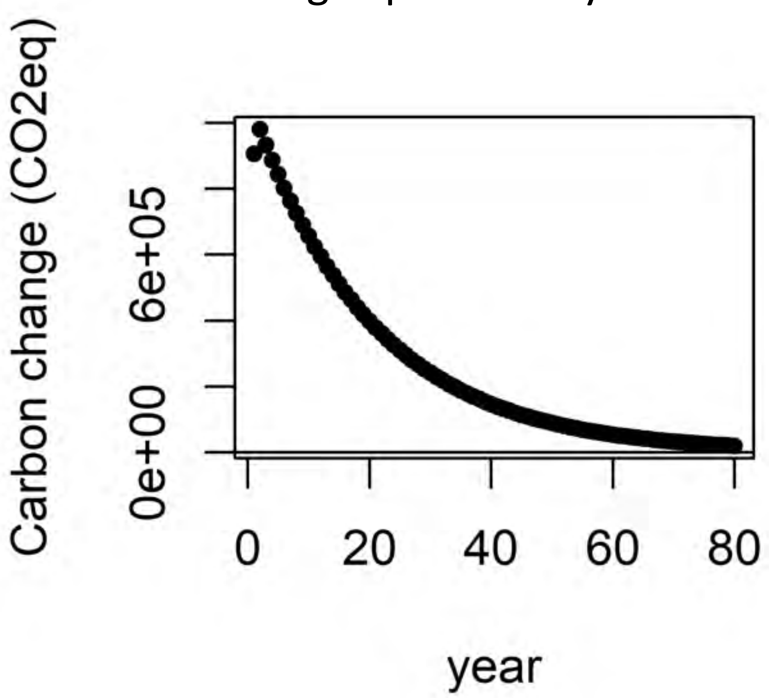
Agricultural carbon stock for Wales (T6)

Rate of C emissions from soils and vegetation at agricultural sites: Initially high losses in C stock, decreasing exponentially over time



(Plot for agricultural land staying in agriculture)

- Carbon stock in croplands and grasslands (LULUCF 4B + 4C) are simulated to decrease, rapidly at first with high initial emissions, but slowing over time, approaching a new equilibrium by 2100.
- Total losses to 2100 on this agricultural land account for around 3.4% of total IMP modelled C stocks in agricultural vegetation and soils.

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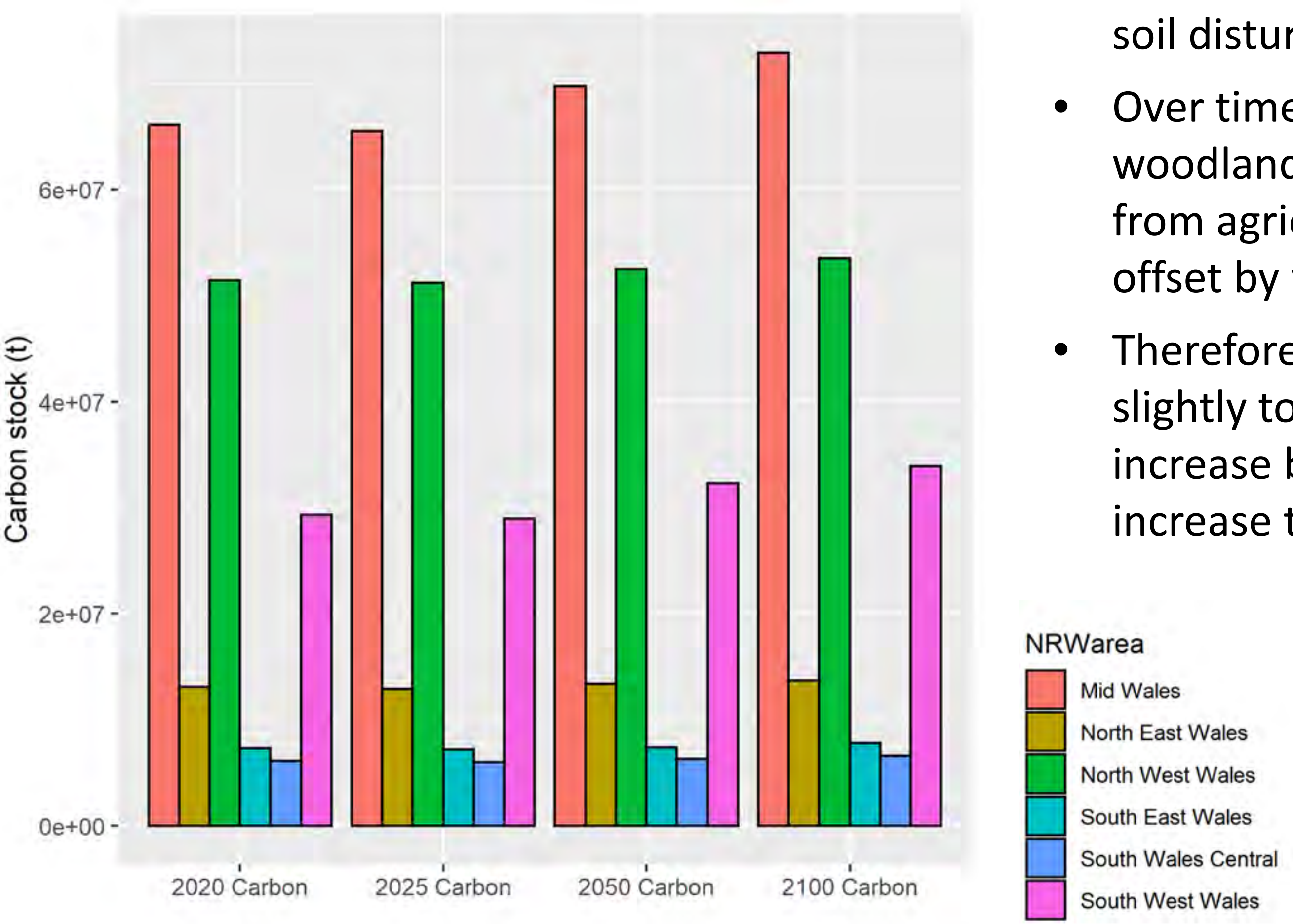
Carbon stock over time (T6)

Total C stock for all modelled land in: 2020, 2025, 2050 and 2100



- Carbon stock in woodland systems increases slowly over time, with initial losses at some sites due to soil disturbance.
- Over time, initial losses from woodland disturbance and losses from agricultural changes are offset by woodland sequestration.
- Therefore, total C stock decreases slightly to 2025, followed by an increase by 2050 and further increase to 2100.

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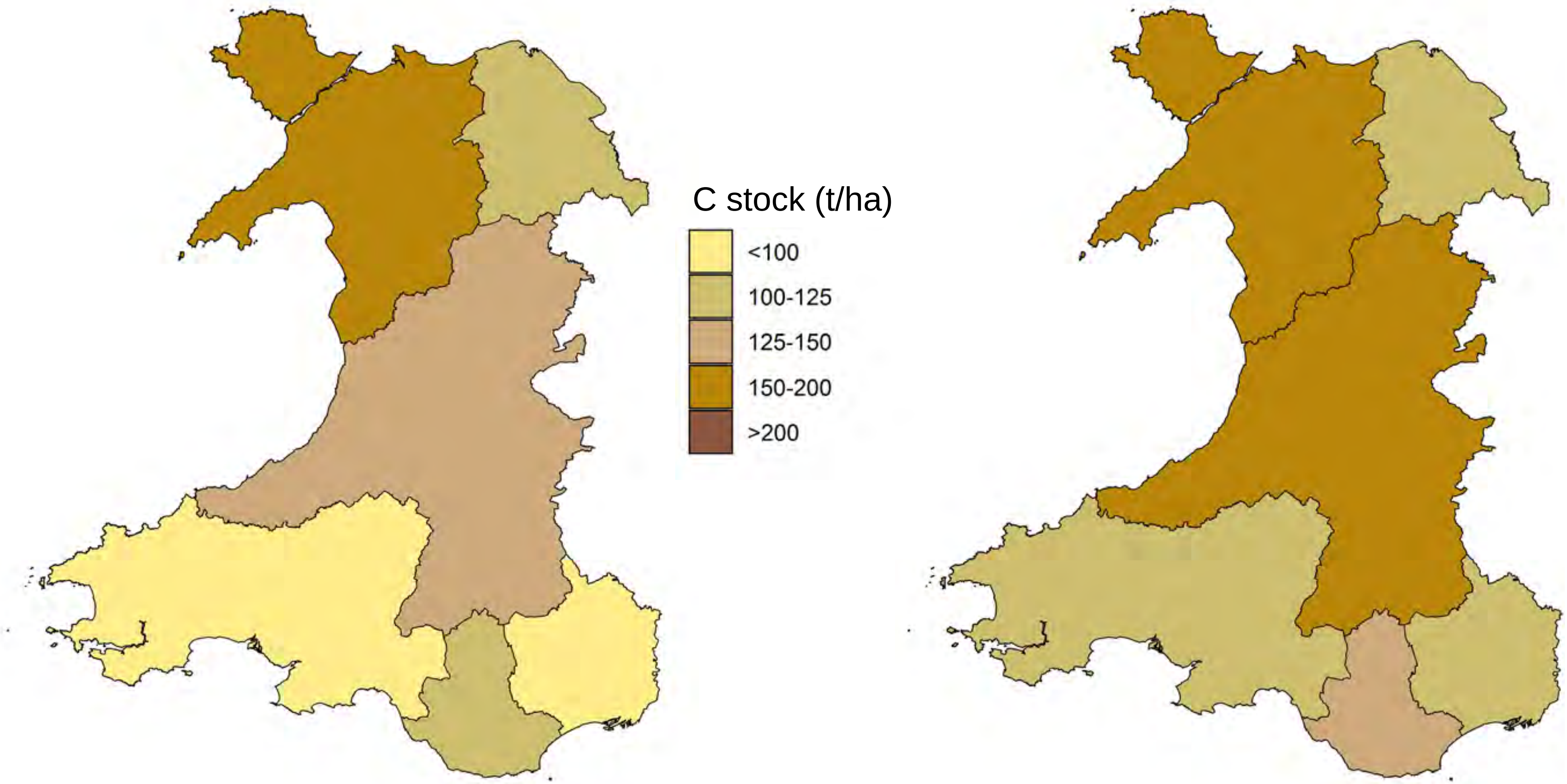
Carbon stock for NRW regions (T6)

Baseline (2020) | **T6 scenario (2100)**



Data are for LULUCF categories 4 A, B, C & G
and are displayed per ha of land modelled

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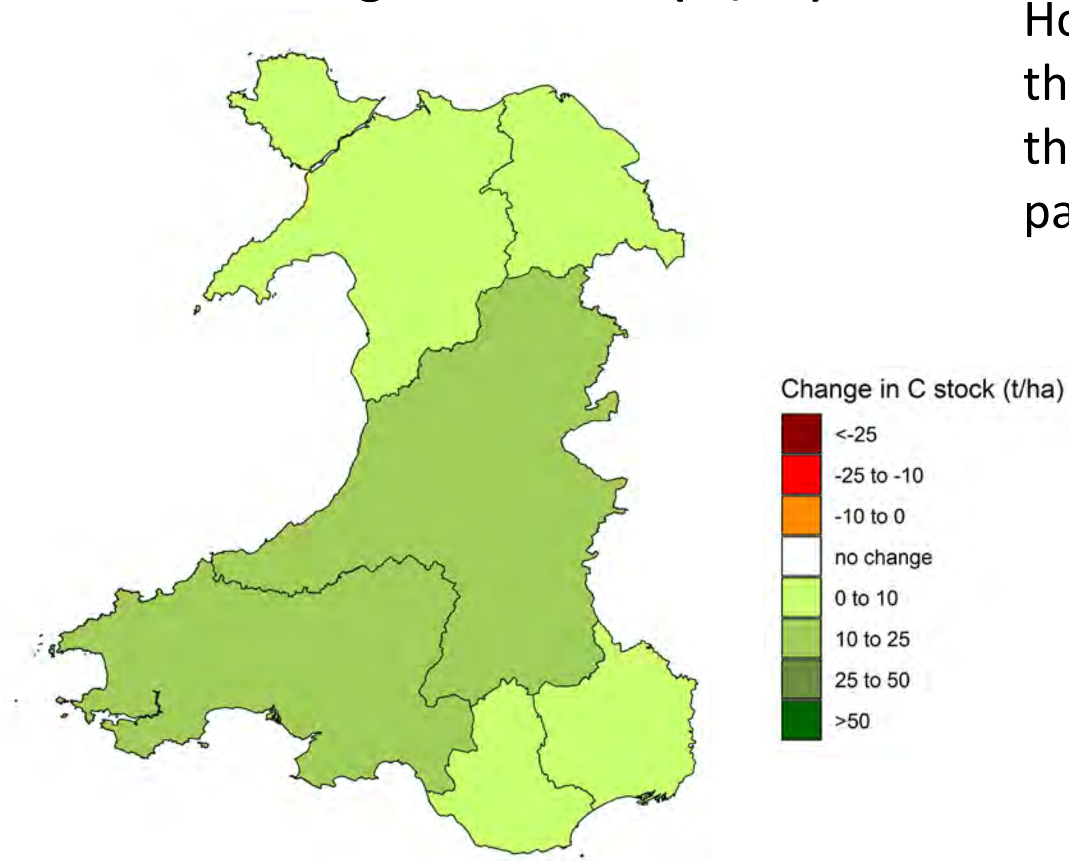
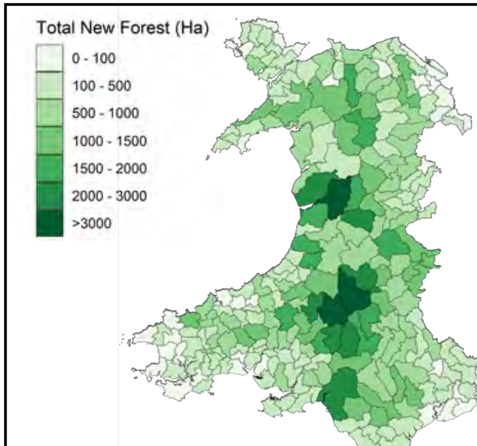
Carbon change for T6 scenario

Carbon change 2020-2100 (tC/ha)



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

A net increase in carbon stock is simulated for all NRW regions. However, the finer spatial detail in the maps that follow reveal that this net increase masks a mixed pattern of increases and decreases.



New woodland is the main control on change in carbon stock

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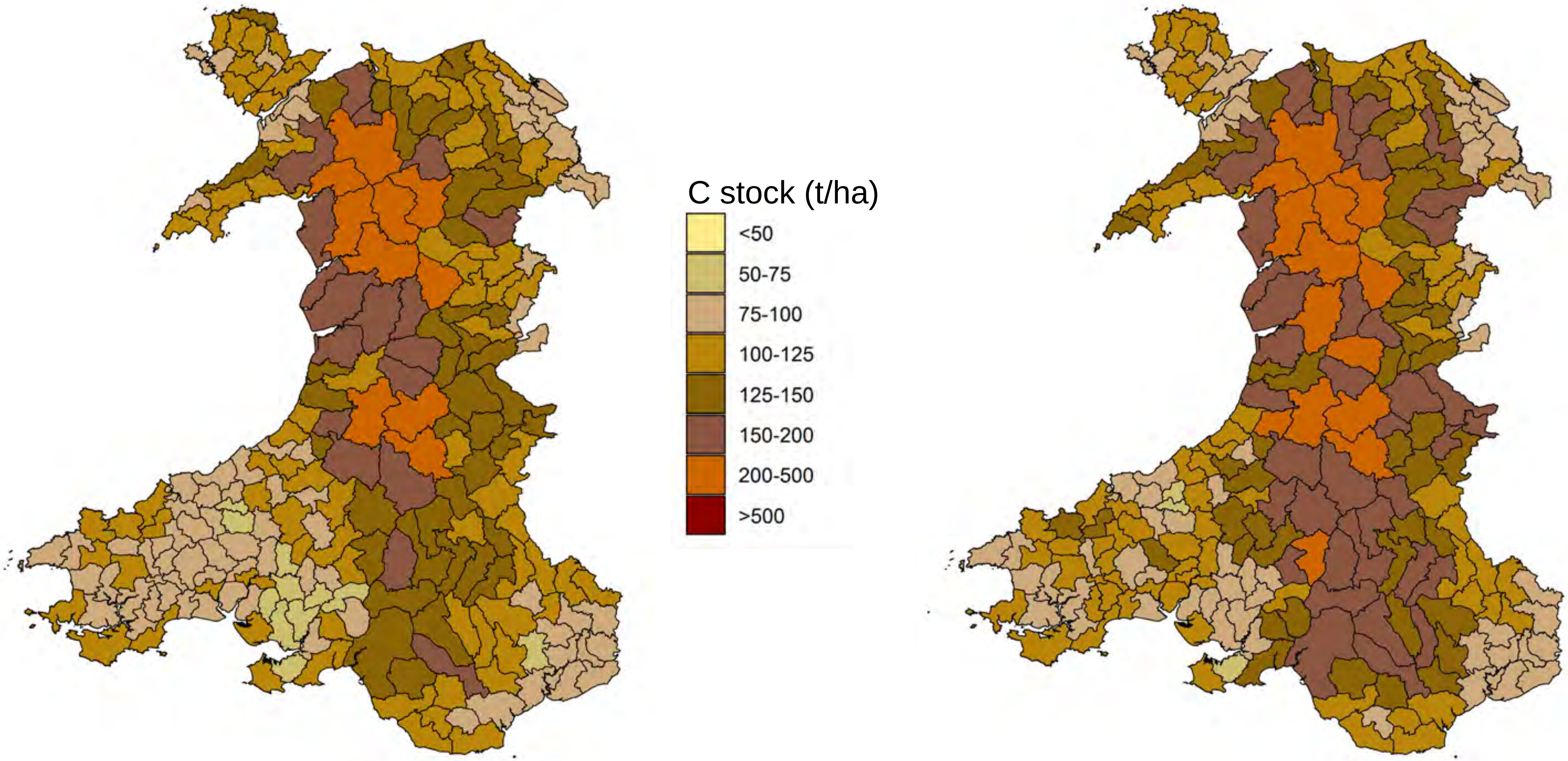
Carbon stock for small agricultural areas (T6)

Baseline (2020)

T6 scenario (2100)



Data are for LULUCF categories 4 A, B, C & G
and are displayed per ha of land modelled

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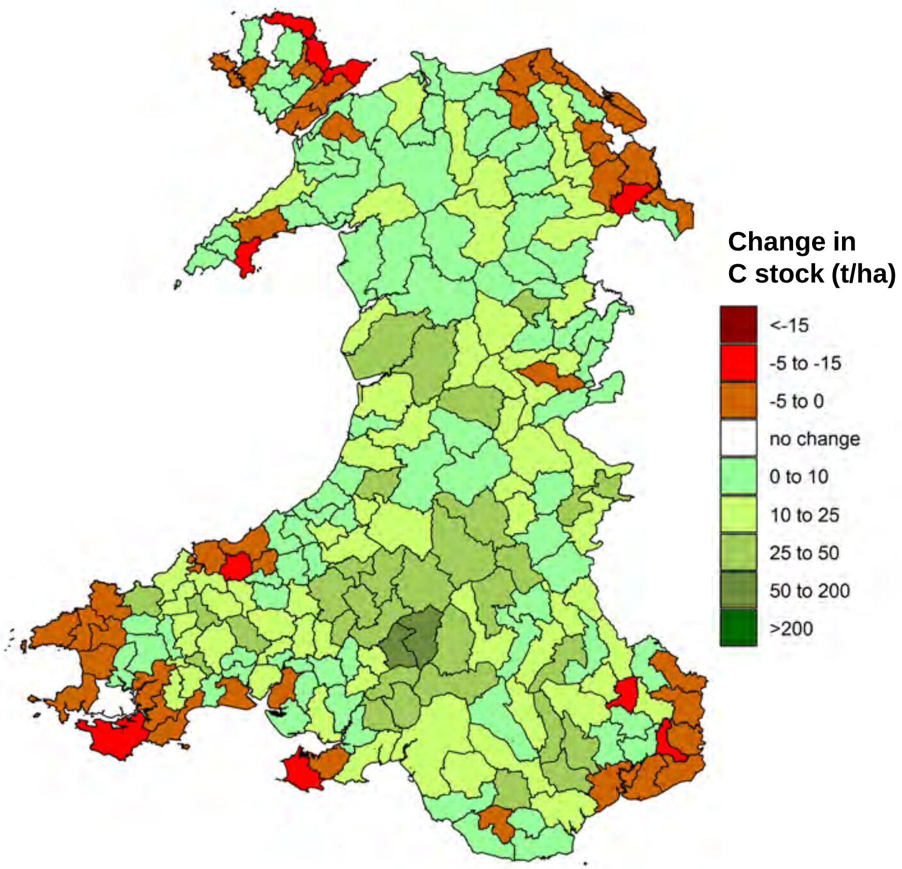
Carbon change for small agricultural areas (T6)

Map: tC/ha change 2020-2100



Data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled

- Carbon stocks are simulated to increase in some areas and decrease in others.
- Areas of decrease reflect the large increase in land under arable/grass rotation.
- Areas of increase reflect new woodland (see slide 38), largely due to the significant C storage potential of biomass and harvested wood products.
- Some increase may also be attributed to sequestration on land reverting to short vegetation.

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GHG emissions: Peat and agriculture (T6)

This table compares total agricultural emissions and wetland emissions for farms modelled by IMP:

LULUCF category	Baseline	Scenario
Wetlands (4D) flux (KtCO2eq/yr)	873	828
Agricultural GHG flux (KtCO2eq/yr)	4,816	5,825

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- Agricultural GHG emissions are projected to increase reflecting increases in dairy cattle, which is not offset by reductions in sheep and beef.
- GHG emissions from wetlands are projected to reduce slightly, reflecting a small area of peat modelled as coming out of agricultural use.

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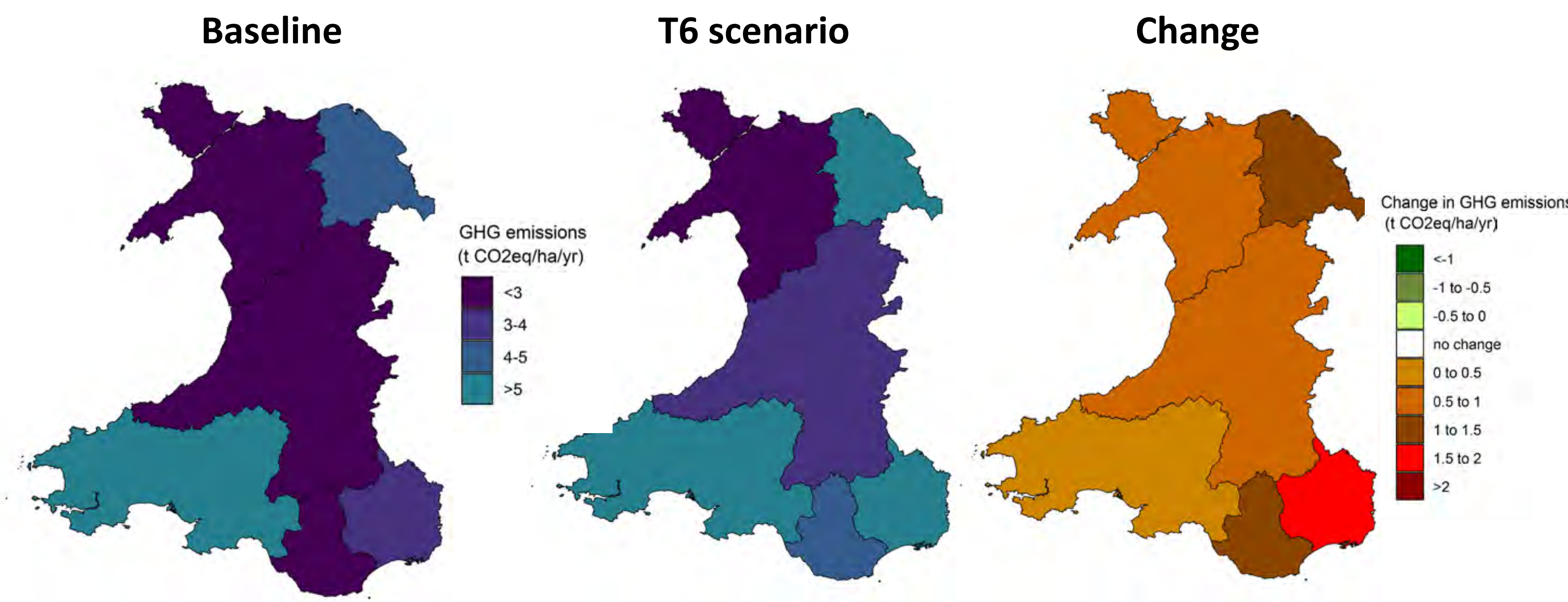
GHG emissions for NRW regions (livestock and management) (T6)



- Data are displayed per ha of land modelled, and reflect patterns of livestock, land use and management.
- Increases reflect increased agricultural intensity with the expansion of dairy simulated for all NRW regions.

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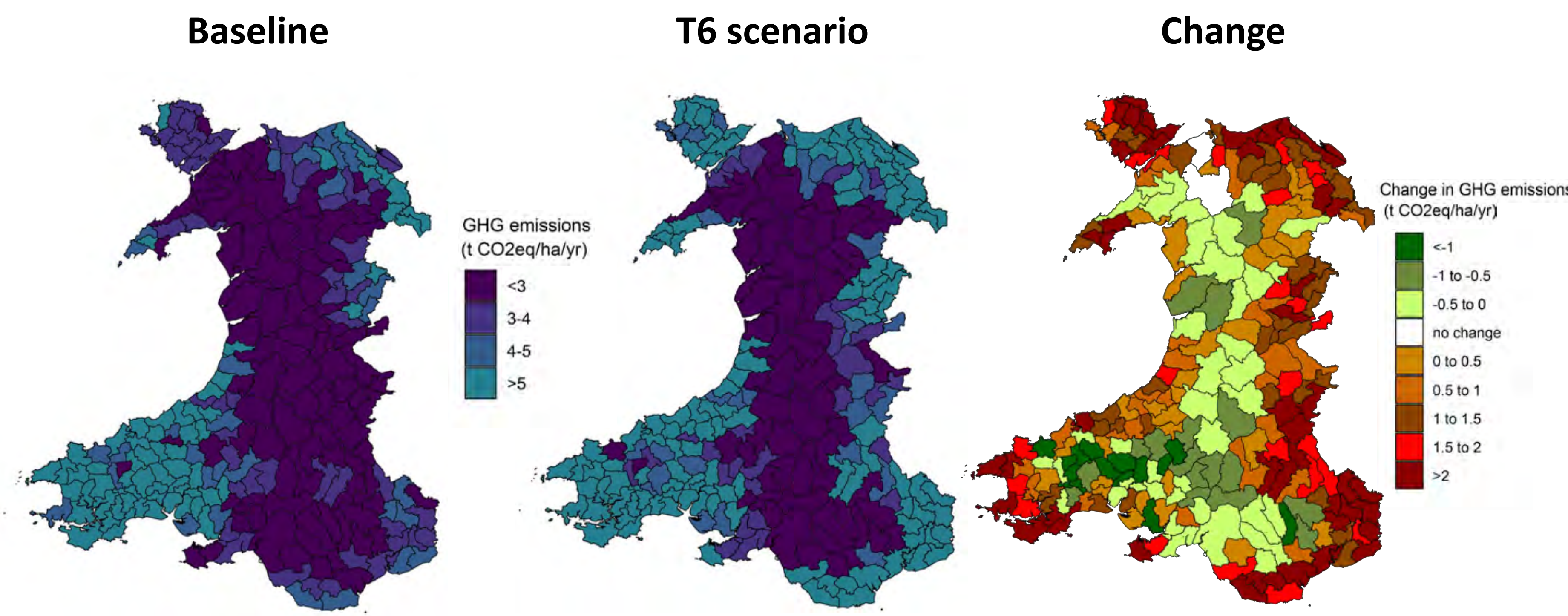
GHG emissions for small agricultural areas (livestock and management) (T6)



- The finer scale data reveal the greater magnitude of local changes, as well as decreases for some small agricultural areas.
- Reductions reflect land modelled as coming out of agricultural use.
- Increases in many areas reflect increased agricultural intensity due to the simulated expansion of dairy.

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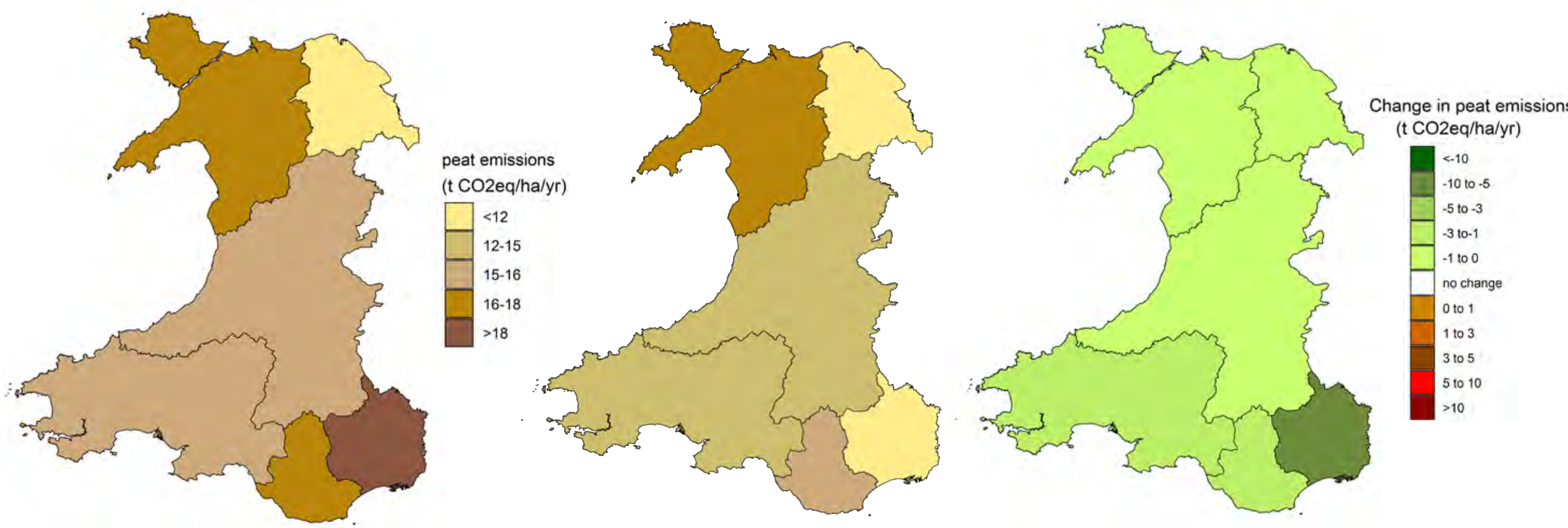
GHG emissions for NRW regions (peat) (T6)

Baseline **T6 scenario** **Change**



- Data are displayed per ha of peat modelled, and reflect land use and inferred management.
- Emissions are slightly reduced in all areas under the T6 scenario, due to land on peat going to non-agricultural use, with the greatest decrease in South East Wales.

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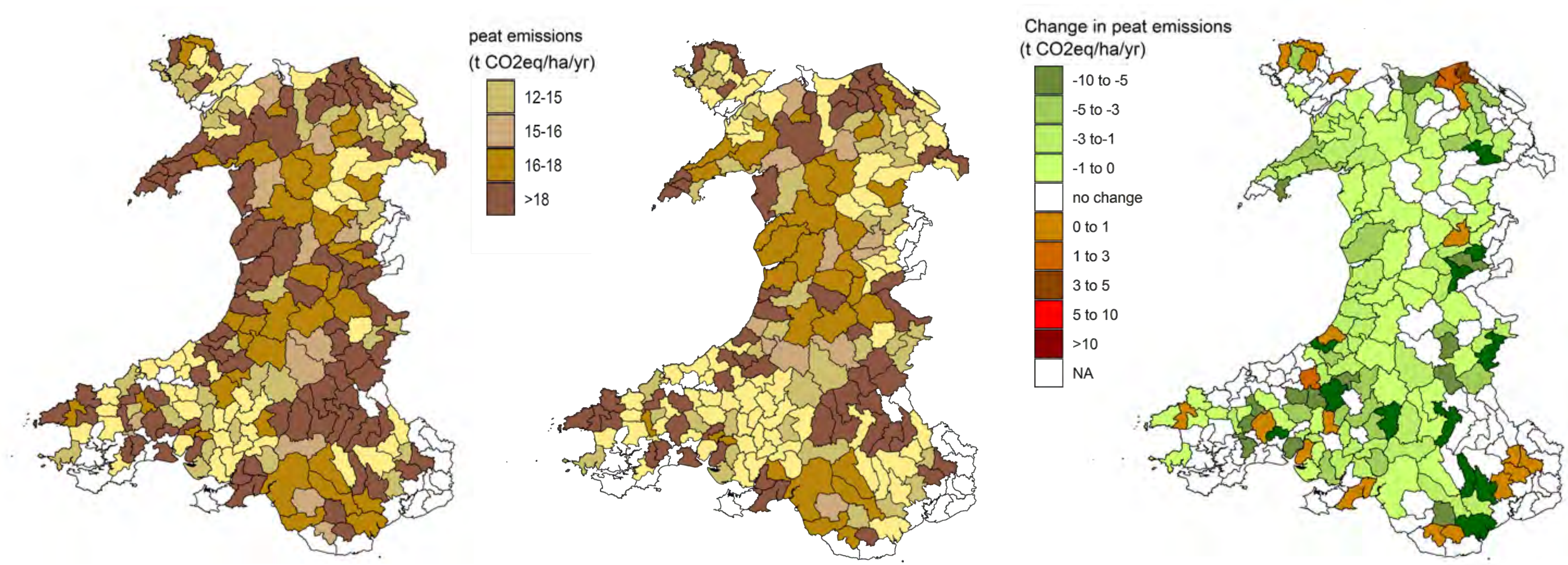
GHG emissions for small agricultural areas (peat) (T6)

Baseline | **T6 scenario** | **Change**



- Emissions are simulated to decrease to 2100 in most areas, but increase in a few where agricultural intensification is simulated to occur on peat.
- Some small agricultural areas do not contain peat, or do not experience predicted land use change on peat.

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PART 3b: Water quality

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Water Quality: Background information 1

- Water quality impacts must be considered for WFD catchments, therefore, loads calculated at the DMU level **(in kg/ha)** must be processed to in-stream loads, by aggregating at the catchment level.
- We also add in non-agricultural sources of pollutants, as well as estimates of pollutants for farms not modelled by the IMP (<1FTE).
- We then account for flow (and nutrient) accumulation to downstream catchments, and account for stream flow to calculate concentration for N and P.
- Data for N and P are processed to units reflecting the relevant thresholds: **annual average concentration for P and 95th percentile for N**.
- Data on sediments are calculated as **annual average loads**. River sediment concentrations are controlled by event driven inputs and in-river processes occurring over a range of timescales, so it is hard to measure average concentrations using infrequent grab samples and difficult to predict these from annual average inputs to watercourses as predicted by the IMP.

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Water Quality: Background information 2

- The water quality analyses are based on the scenario being applied to farms >1FTE only. Farms <1FTE are modelled as not responding to the scenario.
- We assume afforestation or reversion to short vegetation or natural woodland on the "non-economically viable" farms.
- Changes in water quality are not modelled for lakes, but these may be important for recreation, and associated businesses in Wales.
- Data outputs relate to a new long-term average reflecting land use and management for the scenario: we do not account for time lags in the nitrogen system.
- Predicted loads are based on average climate data (1961-1990).
- Data reflect average losses rather than those that might occur once in several years due to an intense rainfall event causing significant erosion (particularly important for sediment and P).
- Some measures might change soil P status or soil organic N supply, which happen over a period of 10+ years to reach a new equilibrium. Our scenario outputs assume these changes have already occurred.

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Water Quality for Wales: Change in N, P and sediment load (T6)

This table compares total agricultural loading for farms modelled by the IMP:

	Farms <1FTE	Baseline	T6 scenario	Change	% change	Glastir impacts
Nitrate kt NO3 N	4.13	30.11	35.13	5.02	17%	-1%
Phosphorus kt P	0.18	0.72	0.68	-0.04	-6%	-0.9%
Sediment kt Z	68	194	167	-26.91	-14%	-0.1%

- Increases and decreases reflect the changes in farm type and associated land use and management, and associated pollutants.
- An increase is modelled for nitrates for the T6 scenario, whilst reductions are projected for phosphorus and sediment.
- This reflects increases in dairy, decreases in sheep and beef, and a large area of land being simulated to come out of agricultural use.
- Glastir impacts, modelled from 2016 uptake data, are shown for comparison.

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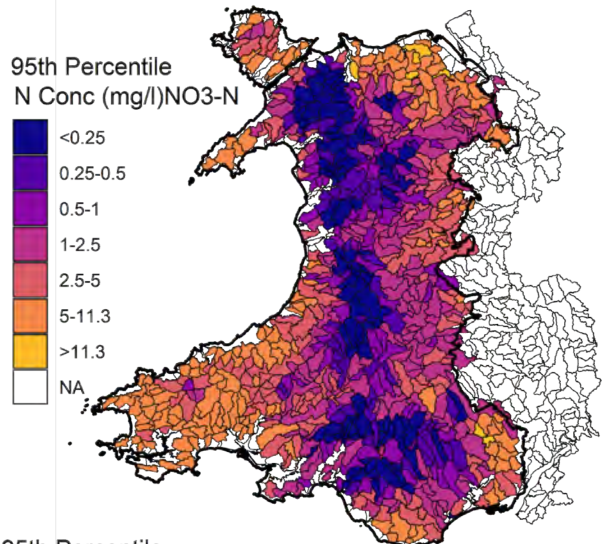
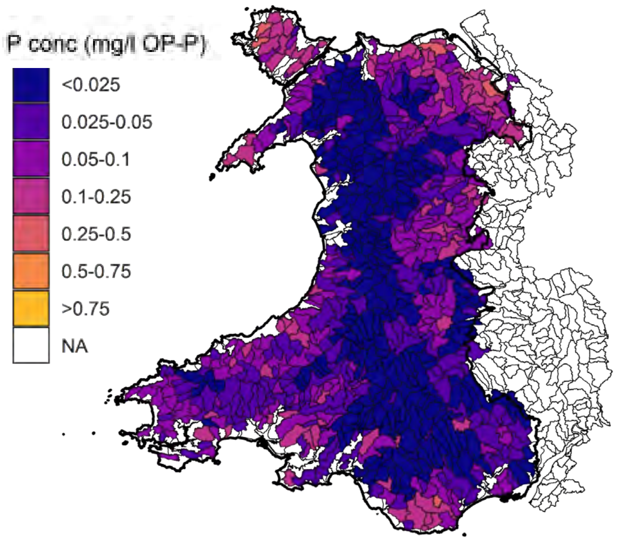
N, P and sediment load for baseline and T6

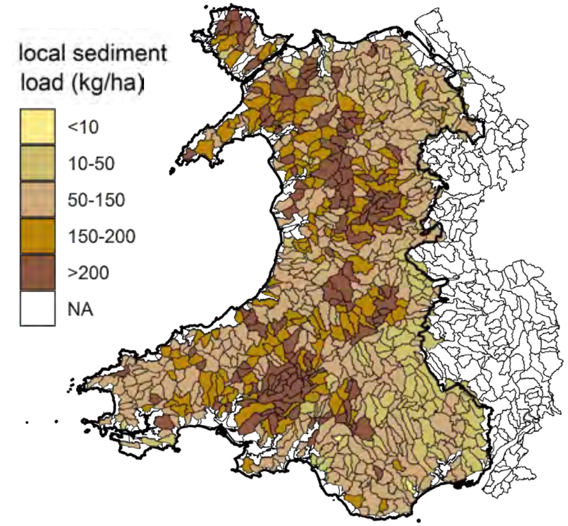
Baseline N



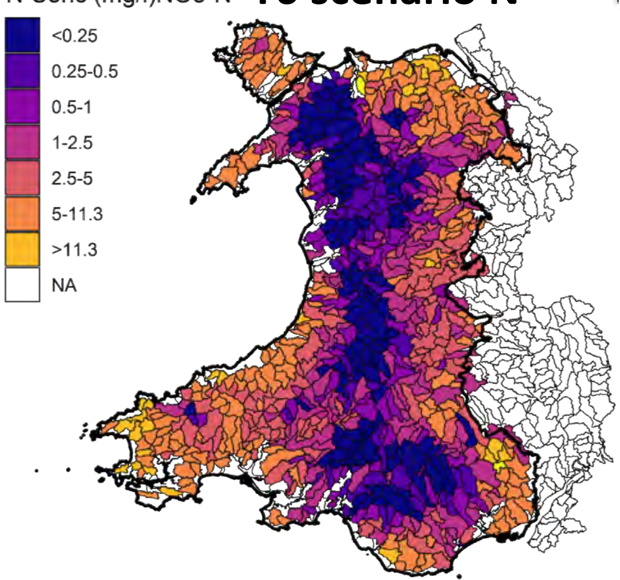
Baseline P



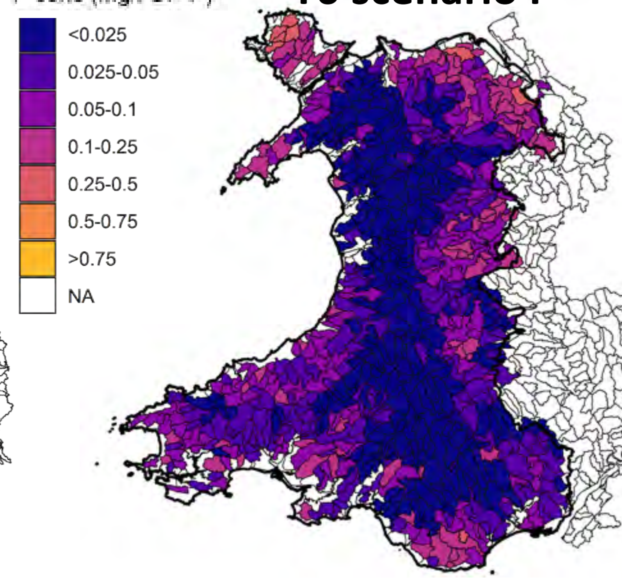
Baseline Sediment



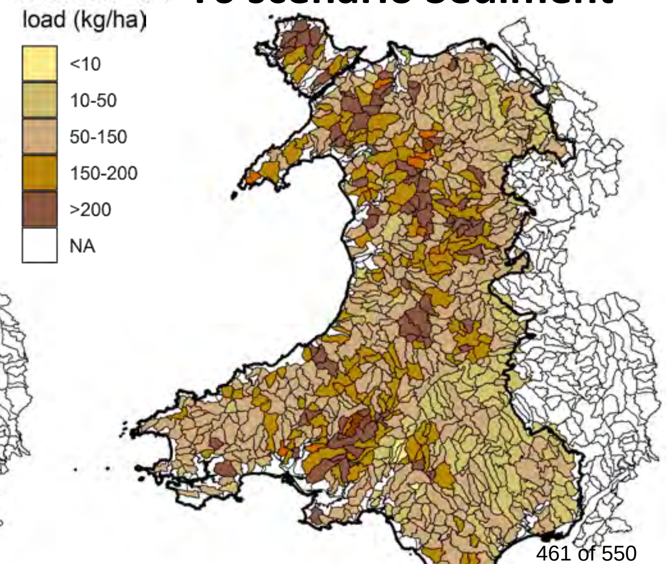
T6 scenario N



T6 scenario P

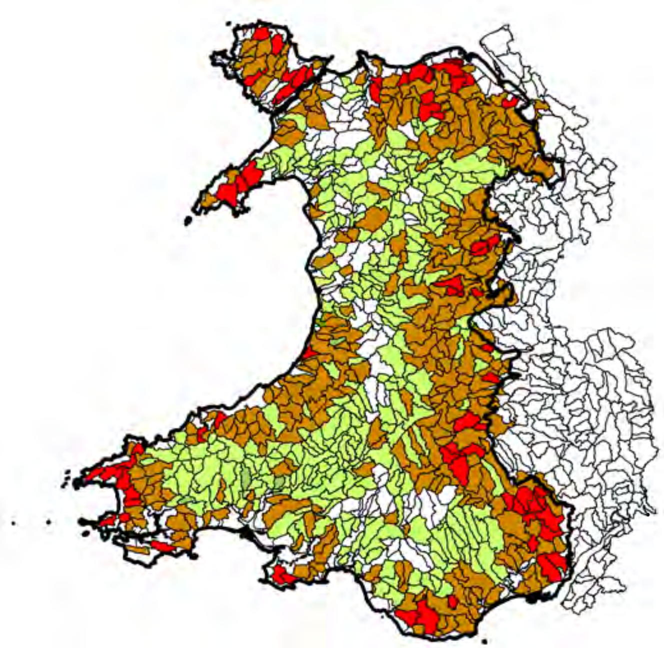


T6 scenario Sediment

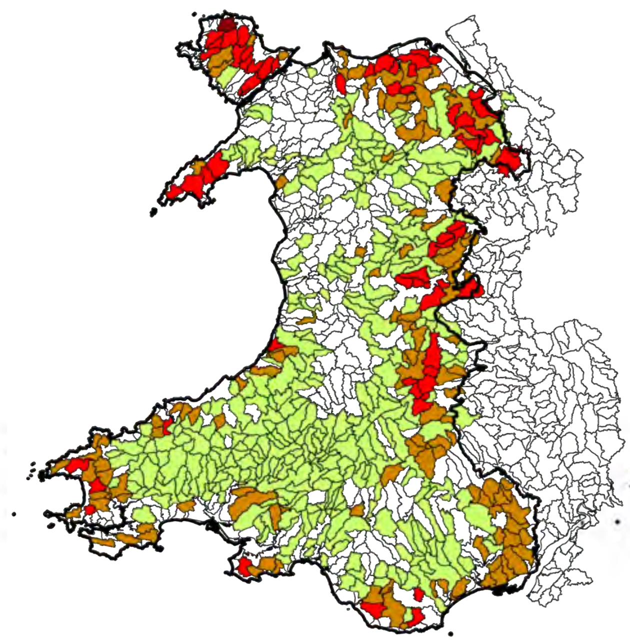


Change in N, P and sediment load (T6)

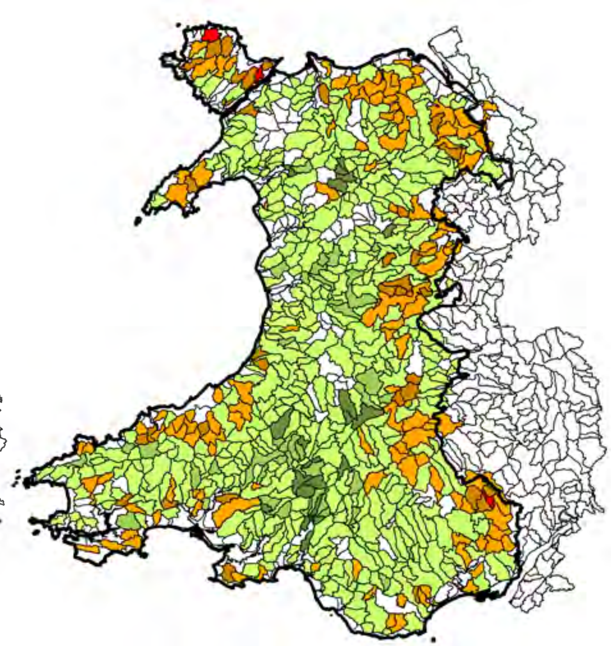
N change



P change



Sediment change



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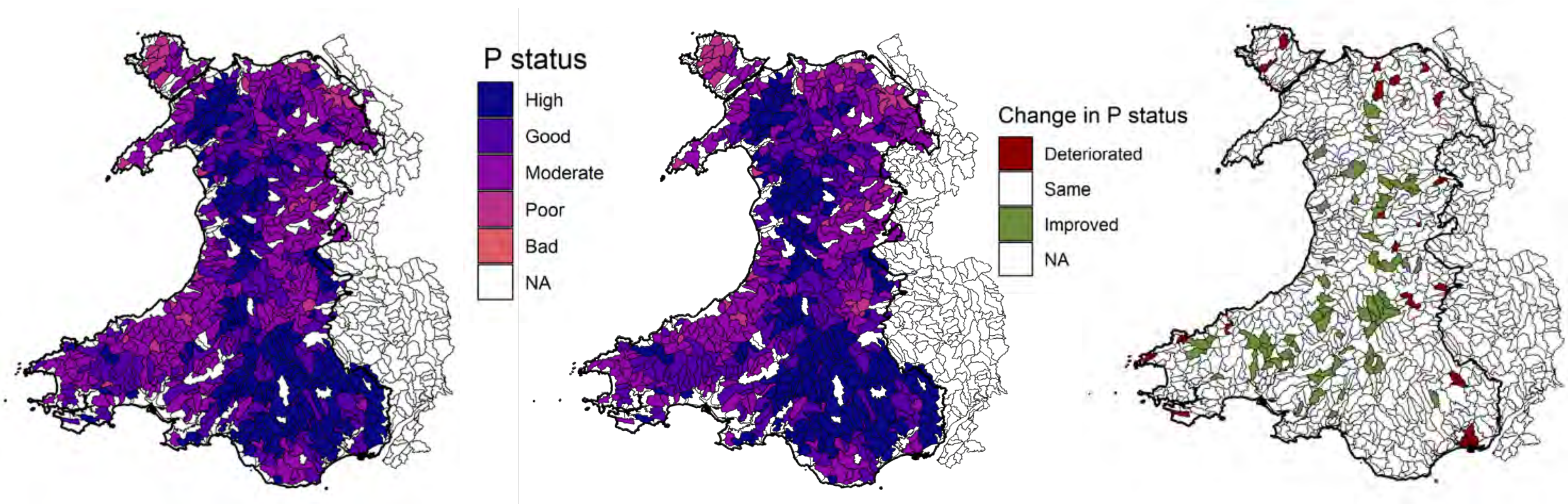
WFD P status (T6)

Baseline **T6 scenario** **Change**



- WFD P status is simulated to improve under the T6 scenario in many catchments, reflecting reduced agricultural intensity.
- WFD P status is simulated to deteriorate in a few catchments where dairy expansion is greater.
- Change in status may be modelled for very small changes in concentrations where baseline is close to a threshold.

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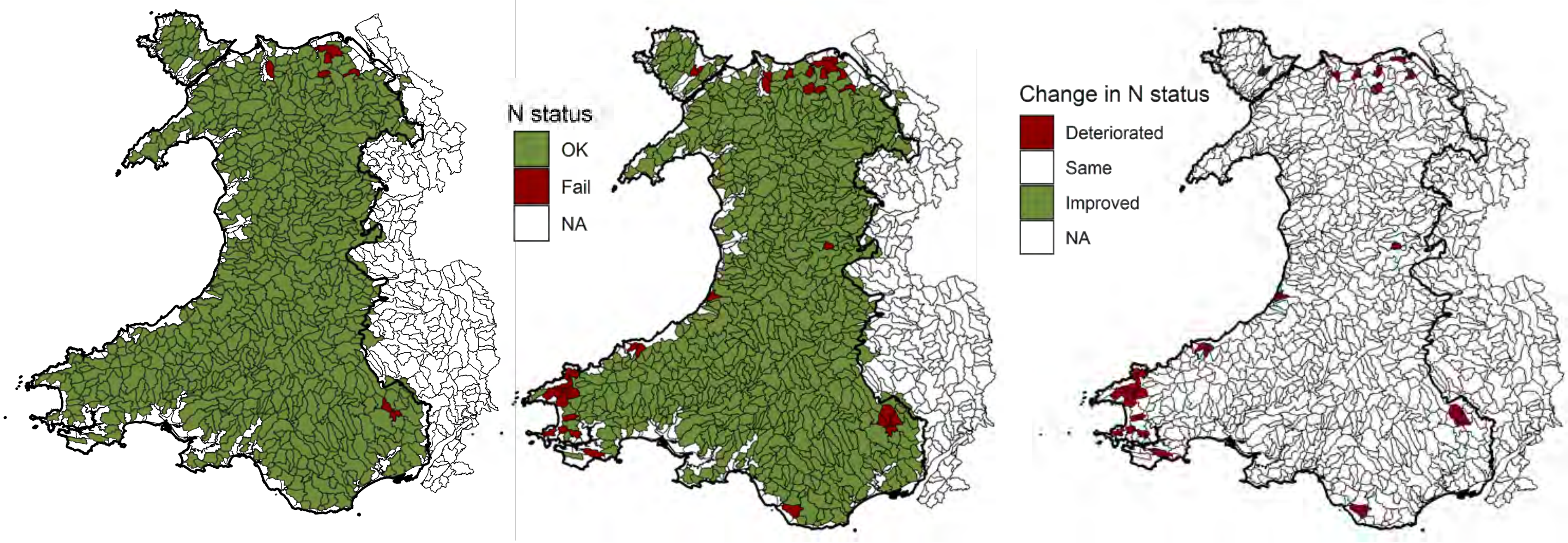
Drinking water N status (T6)

Baseline **T6 scenario** **Change**



- Drinking water N status is simulated to deteriorate in key areas coinciding with the expansion of dairy.
- No change in status is projected for most catchments, in spite of the 17% increase in total load from IMP modelled farms.

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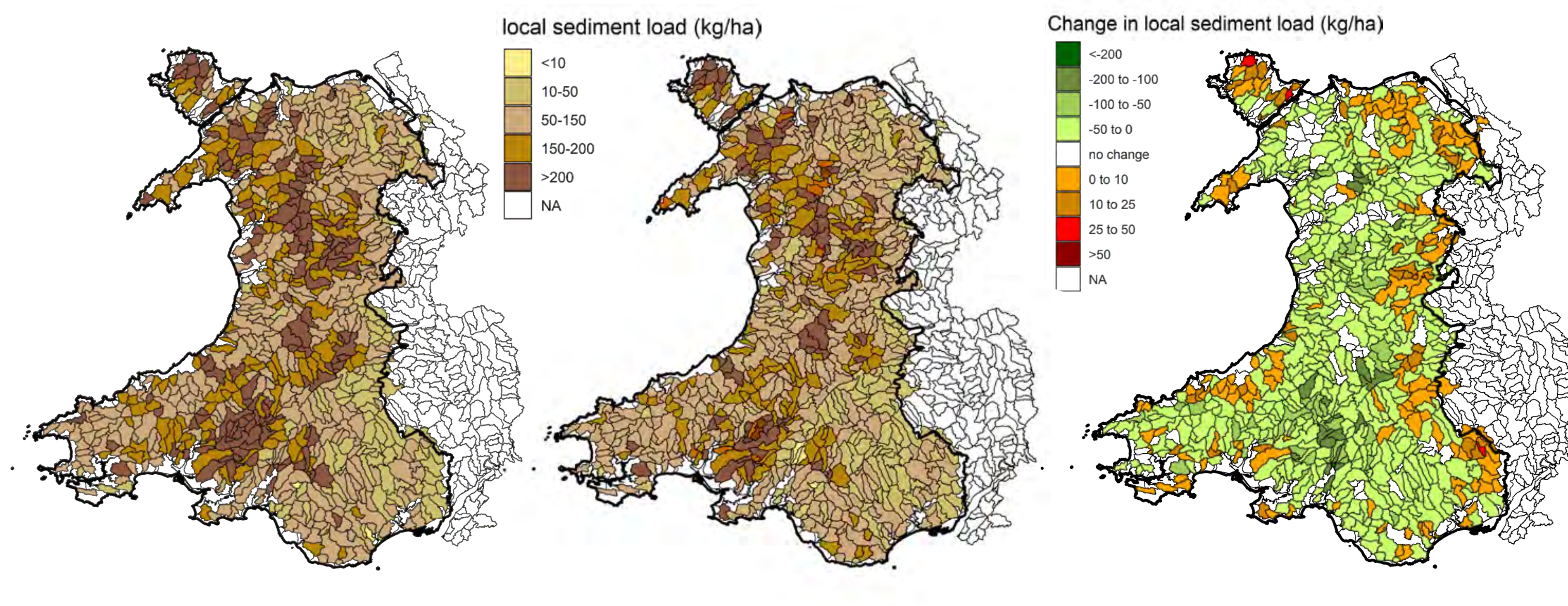
Change in sediment load (T6)

Baseline | **T6 scenario** | **Change**



- Increases in sediment loading are simulated, coinciding with a few areas with increased agricultural intensity.
- Decreases in sediment loaded are simulated for most other catchments in Wales reflecting land coming out of agricultural use.

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PART 3c: Air quality

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Air quality – Wales overview (T6)

This table shows changes in PM2.5 concentration and life years lost under the T6 scenario:

Average Change in PM2.5 Concentration	Life Years Lost (LYL)
-0.02	-54.11

- PM2.5 concentrations are simulated to decrease as a result of changes in NH3 emissions and new woodland.
- This leads to a net health benefit of -54.11 Life Years Lost.
- BUT spatial patterns vary …

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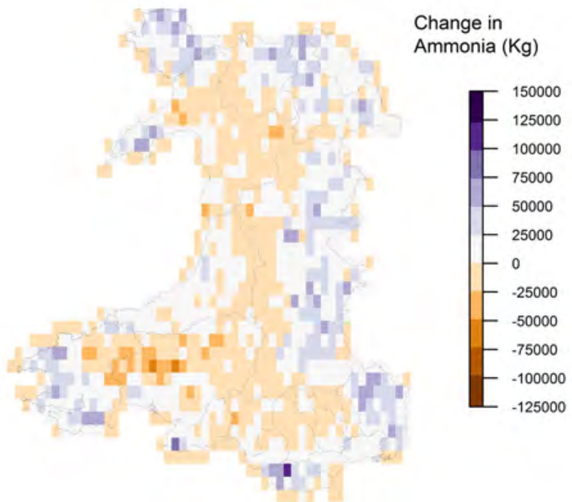
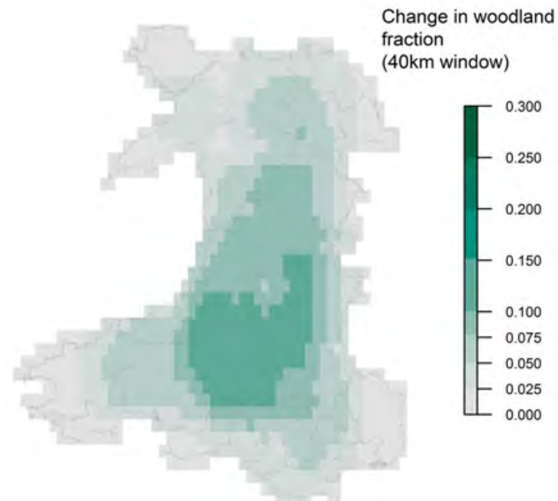
Health outcome from change in air quality (T6)

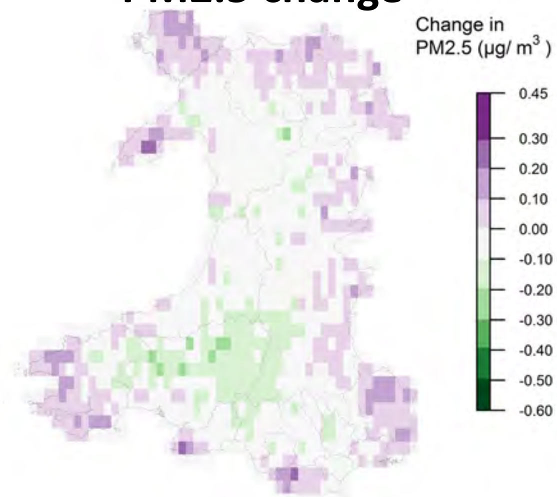
NH3 emissions



New woodland

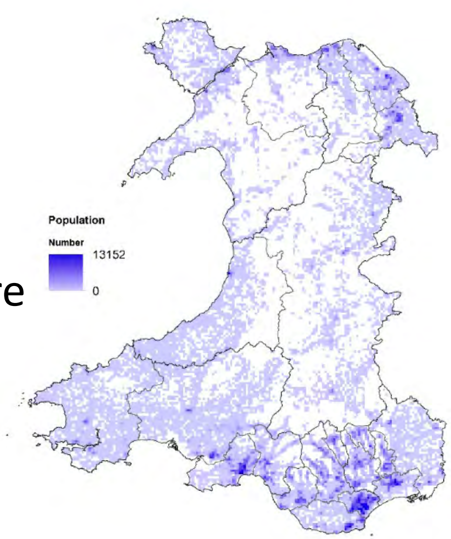


PM2.5 change

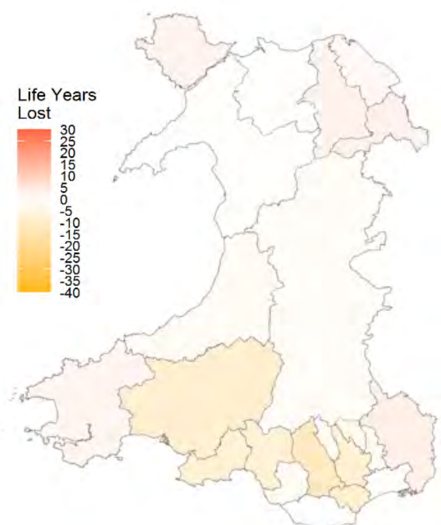


- Change in PM2.5 is a function of change in NH3 emissions and new woodland planted.
- Decreases in PM2.5 are simulated where NH3 emissions decrease AND where there is new woodland.

Population



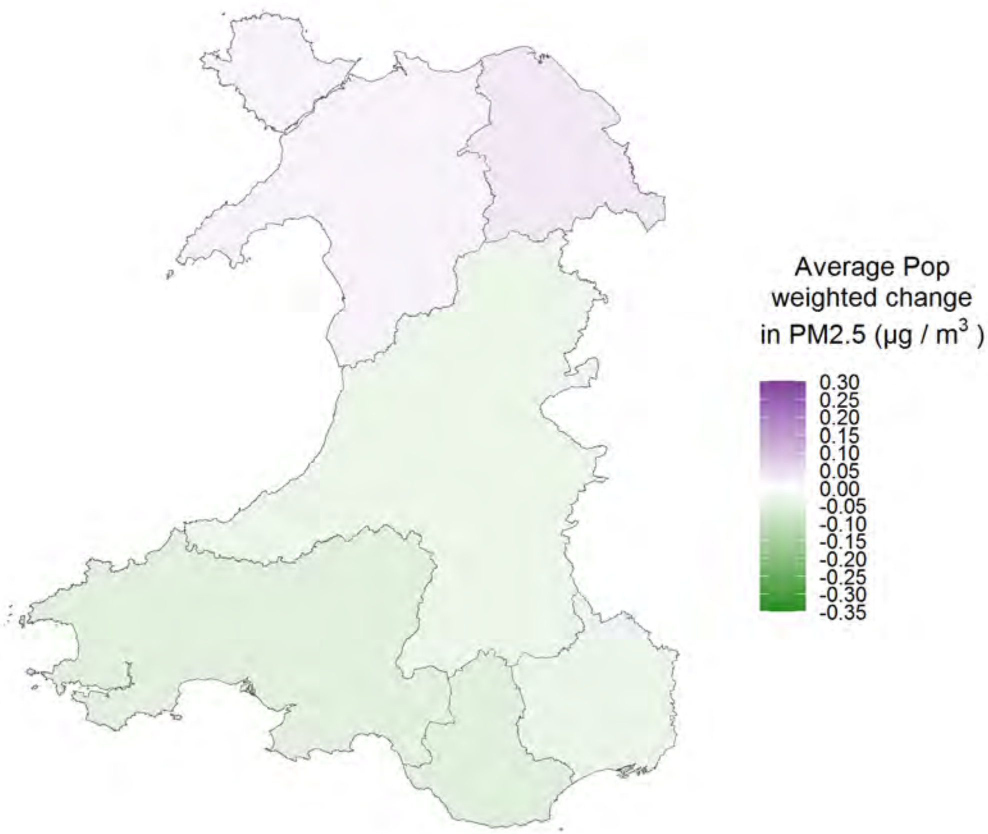
Avoided 'Life Years Lost'



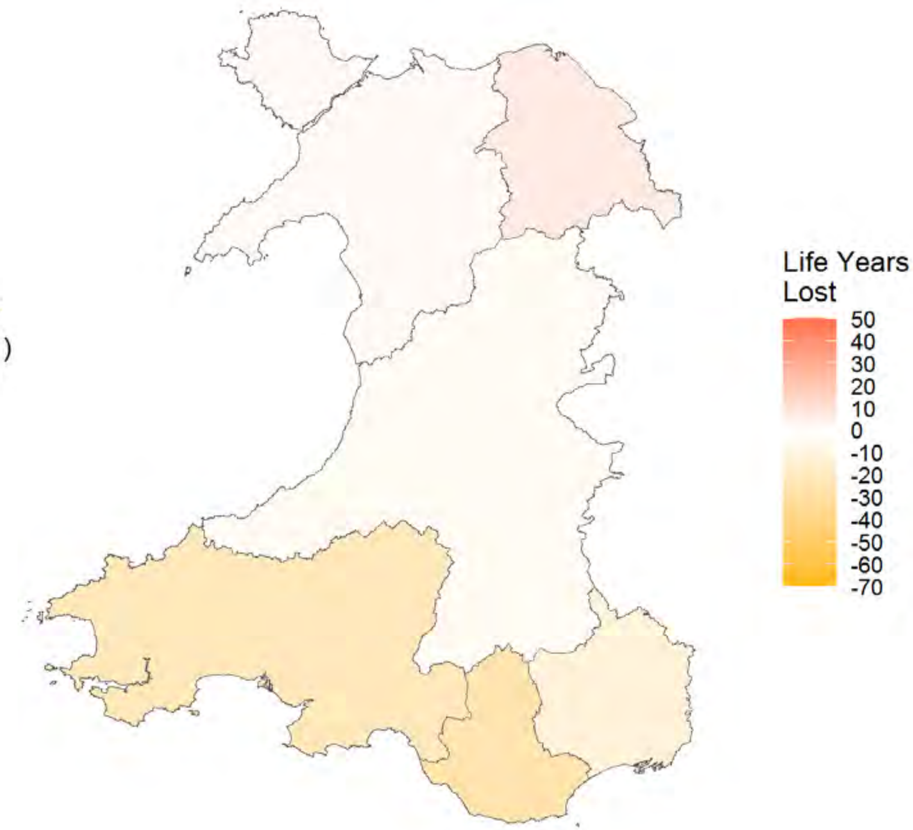
- Health outcomes are a function of change in exposure of the population.
- **Net positive benefit in areas except Anglesey, Gwynedd, Denbighshire, Flintshire, Wrexham, Pembrokeshire & Monmouthshire.**

Air quality for NRW regions (T6)

Average change in PM2.5 concentration



Avoided Life Years Lost (total)



Greatest benefits are in parts of mid to south Wales

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PART 4: Valuation

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Valuation results: Background information

- Price year: 2020
- Present values: 75 year time horizon
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g. 3.5% declining discount rate/ health discount rate for air quality):
  - Values are based on BIES (2018) guidance on carbon values for appraisals by Government.
  - This was prior to the release of updated values in September 2021.
  - The 2018 values do not fully reflect the requirements of the Paris Agreement 2016, the domestic net zero target, and other recent policy developments.
- Results given to 3 significant figures.

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Summary of public goods values (T6)

Benefits	Physical measure	Units	Present value, 75 yrs, £	Type of value
Air Quality	Decrease of 54 years	Life Years Lost each year	£ 67m	Reduction in costs of health impacts from air pollution
Water Quality	44 Deteriorate, 58 Improve	Expected changes in WFD status due to changes in P and N	£ 4m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 20m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 1,243m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- The figures are an estimate of the value of the change in wellbeing to people over 75 years under this scenario.
- Figures indicate order of magnitude of values of expected changes in the Welsh Environment.

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Breakdown of public goods values (T6)

Benefits	Present value, £m			Type of value
	5 yrs	25 yrs	75 yrs	
Air Quality	£ 3m	£ 21m	£ 67m	Reduction in costs of health impacts from air pollution
Water Quality	£ 0.6m	£ 2m	£ 4m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs:				Benefit of reducing GHG sources:
Agriculture	- £ 351m	- £ 1,814m	- £ 5,215m	Agricultural sources (livestock and inputs)
Land use	- £ 418m	£ 1,611m	£ 3,736m	LULUCF sources (soils, vegetation and harvested wood products)
Wetlands	£ 16m	£ 82m	£ 235m	Wetland sources (peatlands)
Total GHGs	- £ 753m	£ 120m	- £ 1,243m	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- All figures are based on simplifying assumptions of change over time.

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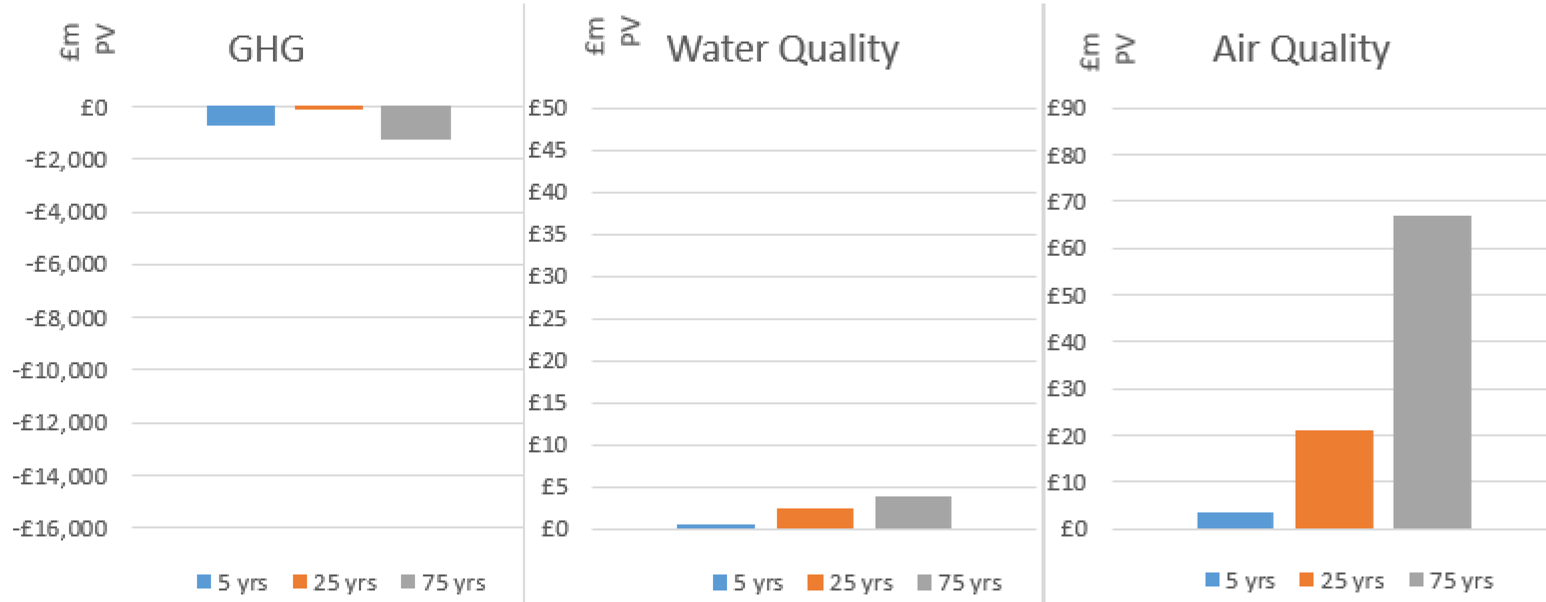
Public Goods Values for different time horizons (T6)



- Fluctuations in GHG emissions reflect balance of larger changes:
  - 5 years: net emissions from short-term land use change combined with increased agricultural GHGs;
  - 25 years: higher rates of GHG sequestration in new woodlands outweigh the increase in agricultural GHGs;
  - 75 years: continuing emissions from agriculture outweigh slowed woodland sequestration.
- A sustained increase in water and air quality, but of a lower order of magnitude of value.

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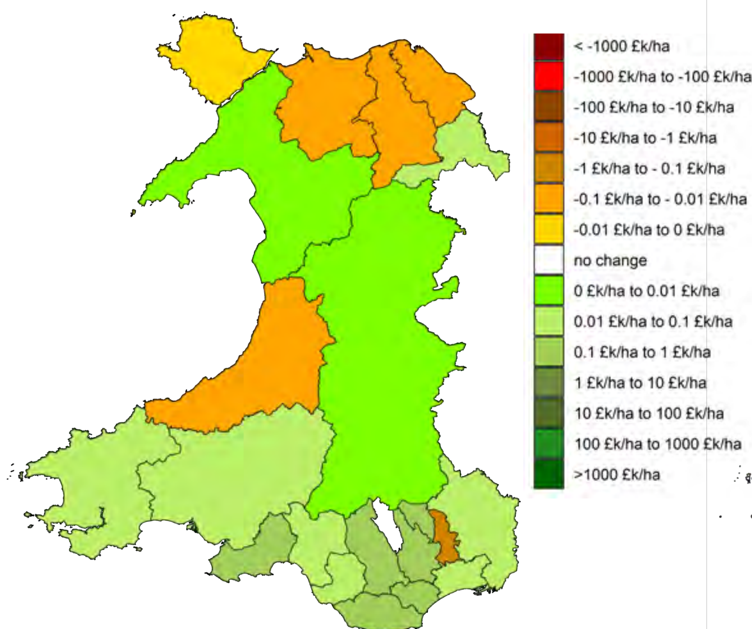
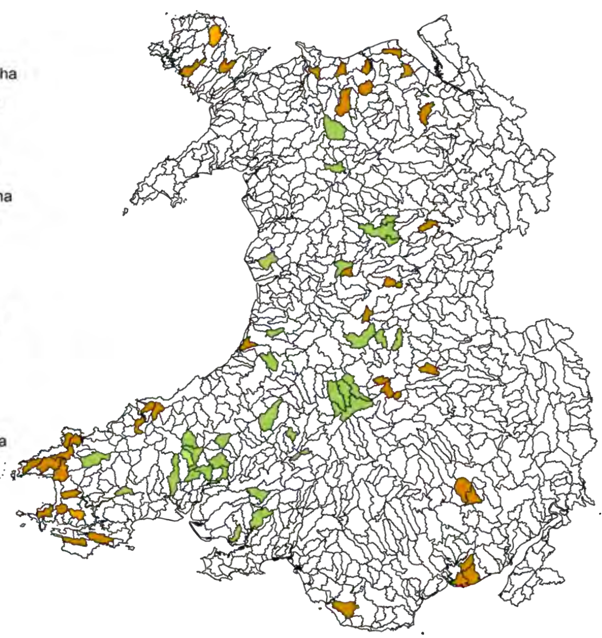
Spatial distribution of values (T6) (finest resolution)

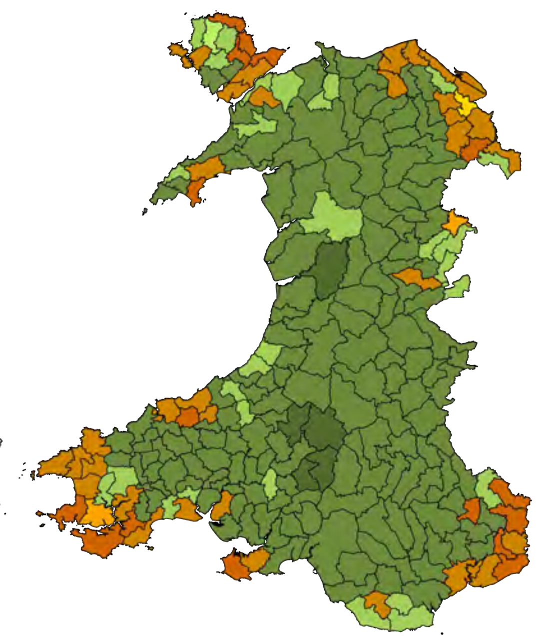
Reduction in costs of air pollution



Value of change in status of freshwater bodies



Value of change in LULUCF carbon stock in vegetation and soils



- The greatest per ha values for the T6 scenario comes from LULUCF carbon, as gains are simulated in many areas, but losses in others.
- Benefits are also simulated for air quality for most regions, but only a few of the WFD waterbodies show benefits.

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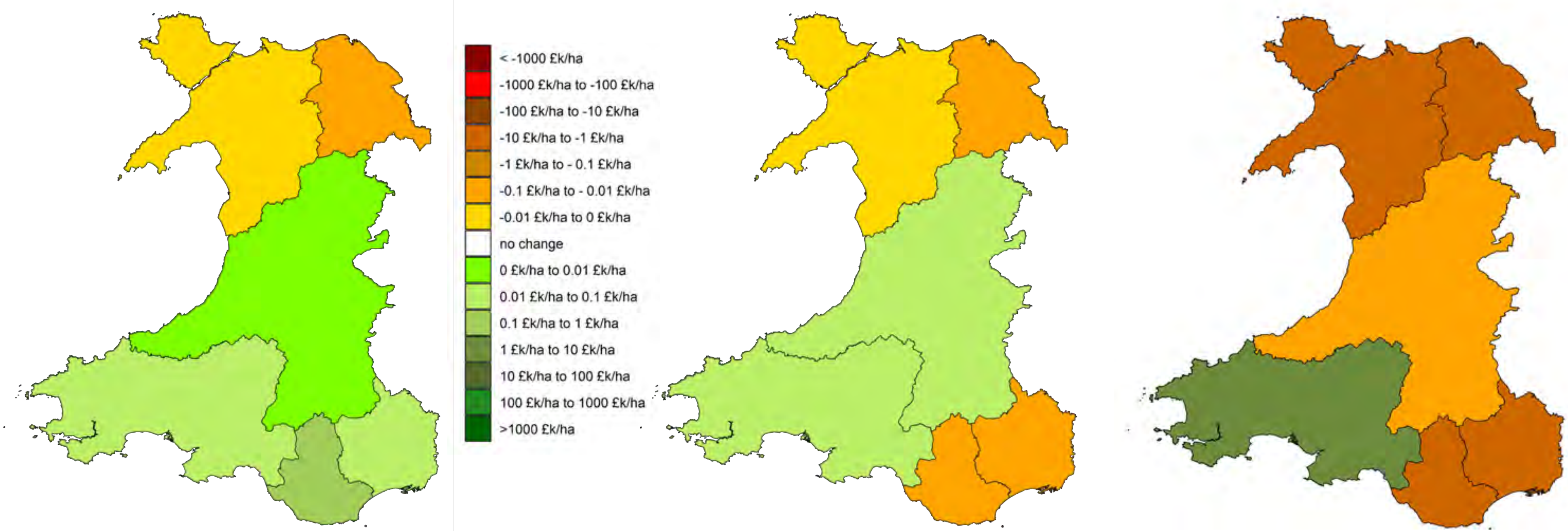
Spatial distribution of values (T6) (NRW regions)

Reduction in costs of air pollution | **Value of change in status of freshwater bodies** | **Value of combined change in GHG and carbon balance**



- The greatest per ha costs for the T6 scenario come from GHG and LULUCF carbon losses, as well as deterioration in air and water quality in some regions.
- Large gains can also be seen in some regions, e.g. South West Wales for carbon and South Central Wales for air quality.

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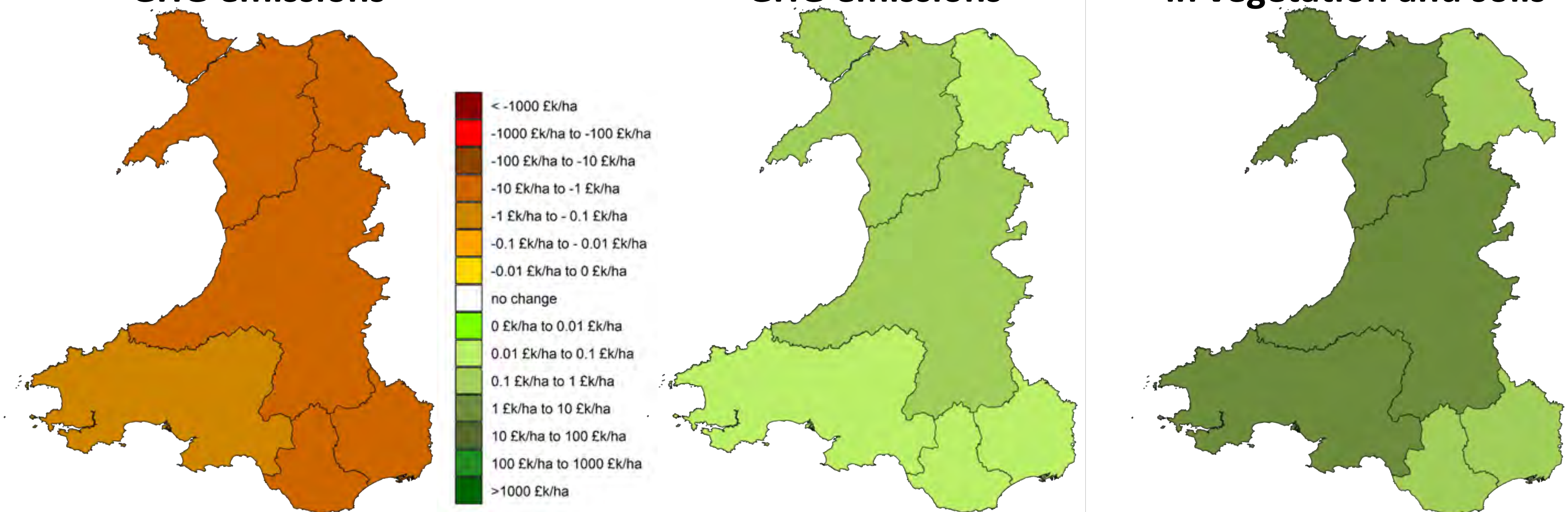
Breakdown of values for Carbon and GHGs (T6) (NRW regions)

Value of change in agricultural GHG emissions

Value of change in wetland (peat) GHG emissions

Value of change in LULUCF carbon stock in vegetation and soils



- The net change in carbon is mostly attributed to increases in GHG which are counterbalanced by increases in LULUCF carbon to a varying extent.
- The previous slide shows that in some regions the increased LULUCF stocks exceed the increase in GHG, whilst in others they do not.
- The value of reduced peat GHG also partly counterbalances the increased agricultural GHG emissions in all regions.

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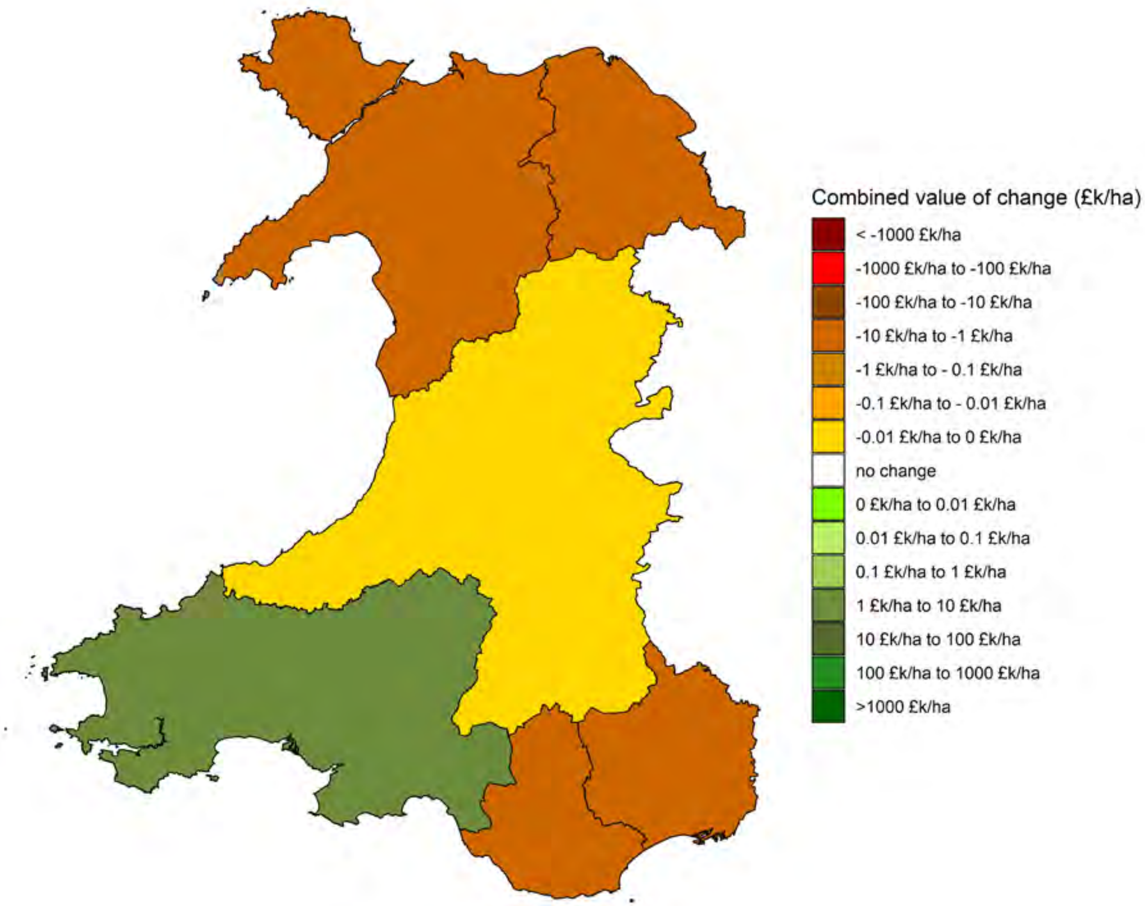
Sum of public goods values (T6) (NRW regions)

Sum of public goods values for all 3 benefits (air quality, water quality and carbon & GHGs):



- Some regions are simulated to experience net benefits, whilst others experience net cost.
- Benefits and costs were contributed by all of the services modelled, in different regions.
- Net costs are modelled for most regions, and are dominated by increased agricultural GHGs.

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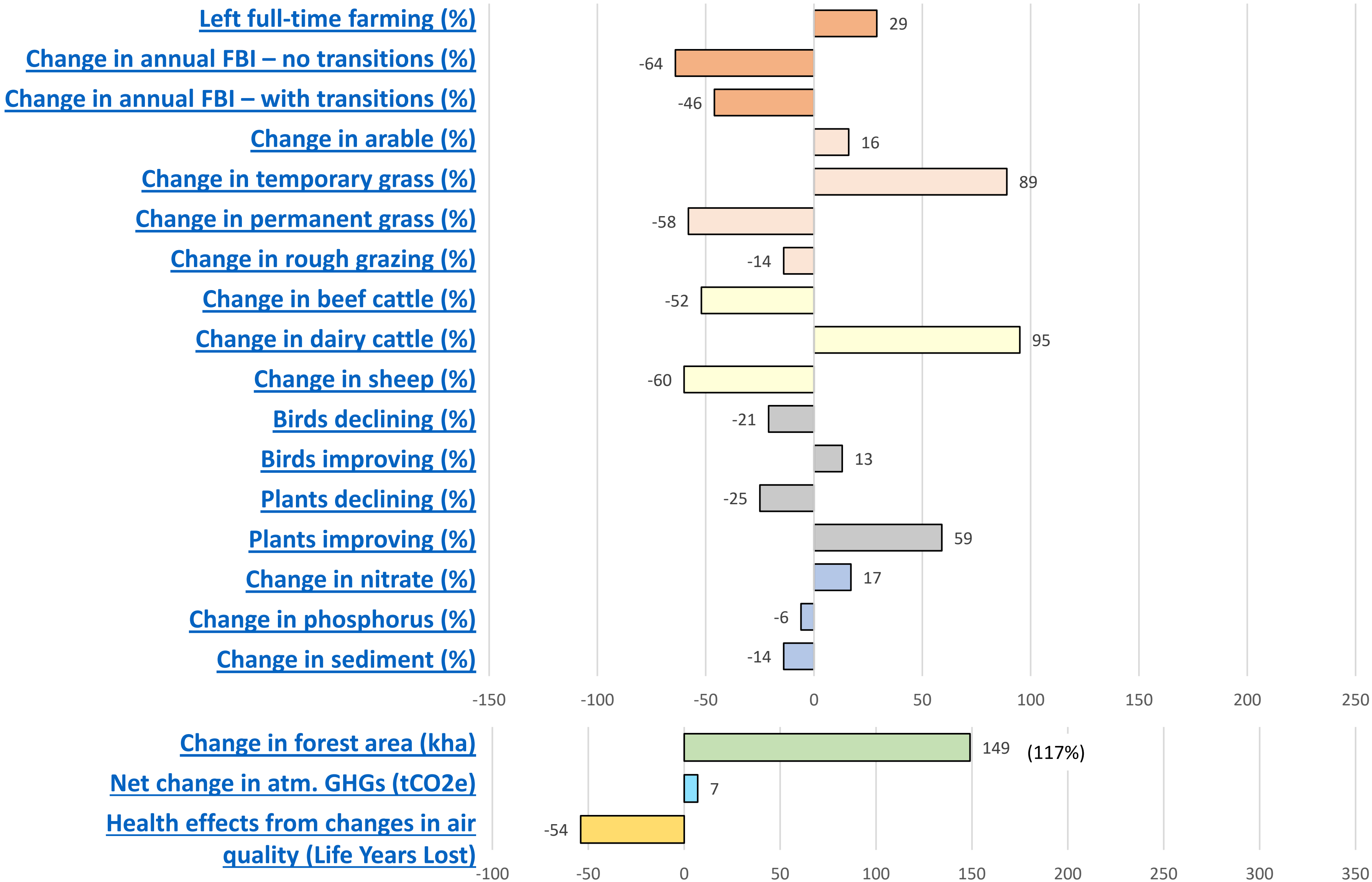
PART 5: Conclusion

Summary of Impacts 1 (T6)



Summary of Impacts 2 (T6)

Impacts	Physical measure	Units	Present value, 75 yrs, £	Type of value
Agricultural Income	Decrease of 29%	Farms at risk of leaving full time agriculture	-£ 163m (no EFT transitions) -£ 119m (if EFT transitions)	Total farm business income (per year)
Air Quality	Decrease of 54 years	Life Years Lost each year	£ 67m	Reduction in costs of health impacts from air pollution
Water Quality	44 Deteriorate, 58 Improve	Expected changes in WFD status due to changes in P and N	£ 4m	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs	Increase of 20m tCO_2e	Net change in atmospheric TCO_2eq over 75 years	- £ 1,243m	Benefit of reducing atmospheric GHG concentrations from non-traded sources
Biodiversity	21% Decline, 13% Improve	Bird species	N/A	Percentage of species with significant increase or decrease
	25% Decline, 59% Improve	Plant species	N/A	Percentage of groups with significant increase or decrease

Final Considerations

- This slide pack shows results from applying the Integrated Modelling Platform to one (out of six) trade scenarios.
- The scenarios were provided by Welsh Government based on a series of internal and external workshops as changes in farm gate (output) prices and input costs.
- All scenarios were applied to a baseline that includes CAP Pillar 1 payments.
- The economic accounts presented are partial and based solely on the components explicitly mentioned. Other significant aspects (e.g. recreation) are not valued here.
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses.
- The IMP is applied to only full-time farms (> 1 FTE labour).
- A farm that is categorised as under pressure is based on being unable to achieve a full-time annual FBI of £6,000. As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.
- The IMP has been developed following Aqua book guidelines. All the assumptions underlying the IMP are fully documented and have been signed-off by Welsh Government.

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PART 6: Glossary and Context

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Glossary: Key Acronyms (I)

- FAPRI: Food and Agricultural Policy Research Institute
  - FAPRI-UK Model was used to underpin assessments of the impacts of Brexit on the UK agricultural sector. More information: (Web-link)
  - Macro-economic model of the UK in a global context. Used to identify impacts of global trade. The FAPRI-UK model (created and maintained by staff in AFBI-Economics) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with submodels covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) model run by FAPRI at the University of Missouri.
- MFTA: Multi-lateral free trade agreement
  - Free trade agreement between three or more countries without discrimination between those involved.

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Glossary: Key Acronyms (II)

- LULUCF: Land use, land-use change, and forestry
  - Standardised approach to the greenhouse gas inventory that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.
  - Used in this project to quantify impacts of land use change on carbon.
- MFN: Most Favoured Nation
  - World Trade Organisation (WTO) terminology. Under the WTO agreements, countries cannot normally discriminate between their trading partners. As such countries must treat all other WTO members as they would their "Most Favoured Nation". More information: (Web-link)
  - Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

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Glossary: Key Acronyms (III)

- WFD: Water Framework Directive
  - EU directive targeted at improving water quality and integrated catchment management.
- UKTAG: UK Technical Advisory Group (on the WFD)
  - The UKTAG is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies.
- LFA: Less-favoured area
  - Term used to describe an area with natural handicaps (lack of water, climate, short crop season and tendencies of depopulation), or that is mountainous or hilly, as defined by its altitude and slope.
- SDA / DA: Severely Disadvantaged Areas / Disadvantaged Areas
  - Sub-classes of LFA separating out the most severely disadvantaged areas for the purposes of basic payment scheme (BPS) grant payments.

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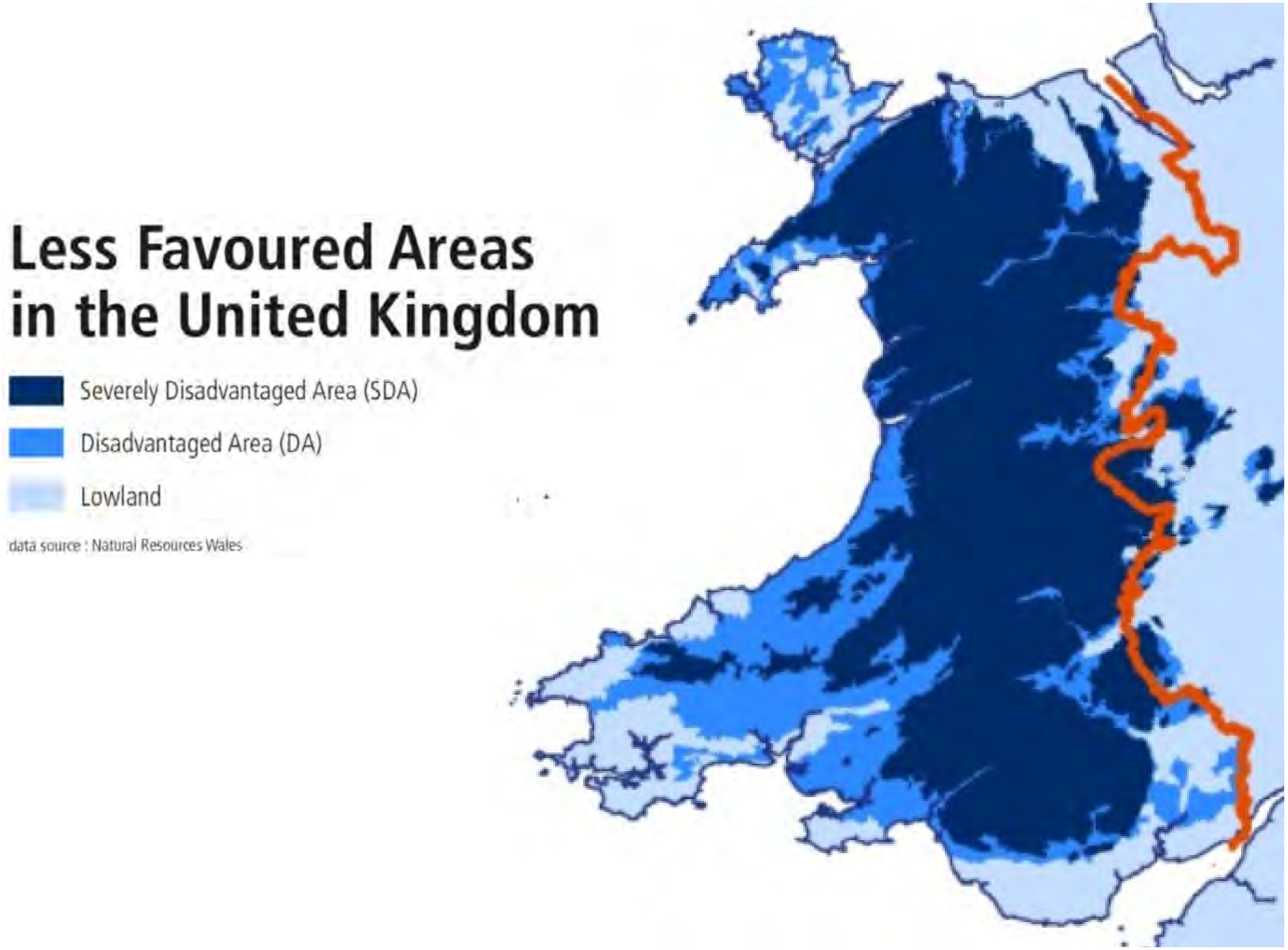
Severely Disadvantaged Areas/ Disadvantaged Areas in Wales



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Glossary: Key Acronyms (IV)

- RFT : Robust Farm Type
  - Robust farm type (used in previous Welsh Farm Practice Surveys).
  - Classes: Cereals; General Cropping; Horticulture; Specialist Pigs; Dairy; LFA Grazing Livestock; Lowland Grazing Livestock and Mixed.
- EFT: ERAMMP Farm Type
  - ERAMMP farm type (used within the IMP) is based on the RFT with additional detail on less favoured areas.
  - Classes: Cereals, General cropping, Dairy, Lowland cattle / sheep, Mixed , Specialist Sheep (SDA), Specialist Beef (SDA), DA various grazing, SDA mixed grazing .
- SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation: Names and acronyms for models within the IMP (see slide 79)

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Glossary: Key Acronyms (V)

- ERAMMP – Environment and Rural Affairs Mapping and Modelling Project.
  - Consortium Project led by the UK Centre for Ecology & Hydrology (UKCEH) and funded by the Welsh Government (WG).
  - Consortium members involved in these slide packs include Cranfield University, ADAS, the British Trust for Ornithology (BTO), eftec, Forest Research (FR) and UKCEH.
- IMP – Integrated Modelling Platform
  - The modelling platform used to produce the results shown in this slide pack. The platform combines the following models which pass data to one another as large multi-parameter data cubes:
    - SFARMOD: Whole farm model
    - ESC: Tree species suitability
    - CARBINE: Forest products, carbon and forest net present value
    - LAM: Land allocation model
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - Woodland habitat connectivity model
    - Ecosystem service models for carbon and water quality
    - EMEP4UK Emulator: health impacts of air pollution
    - Valuation: monetary and non-monetary valuation of public goods

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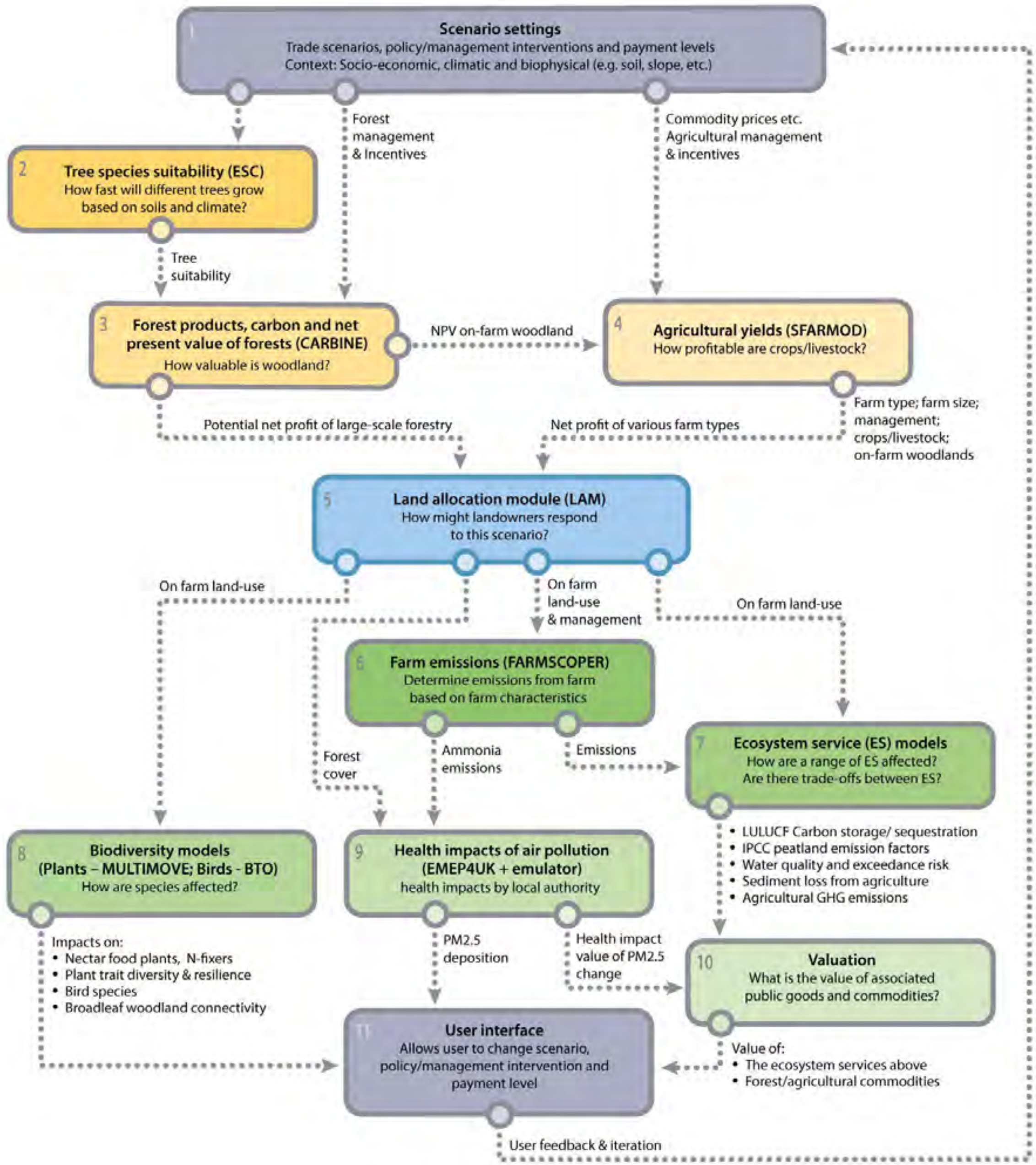
Integrated Modelling Platform schematic



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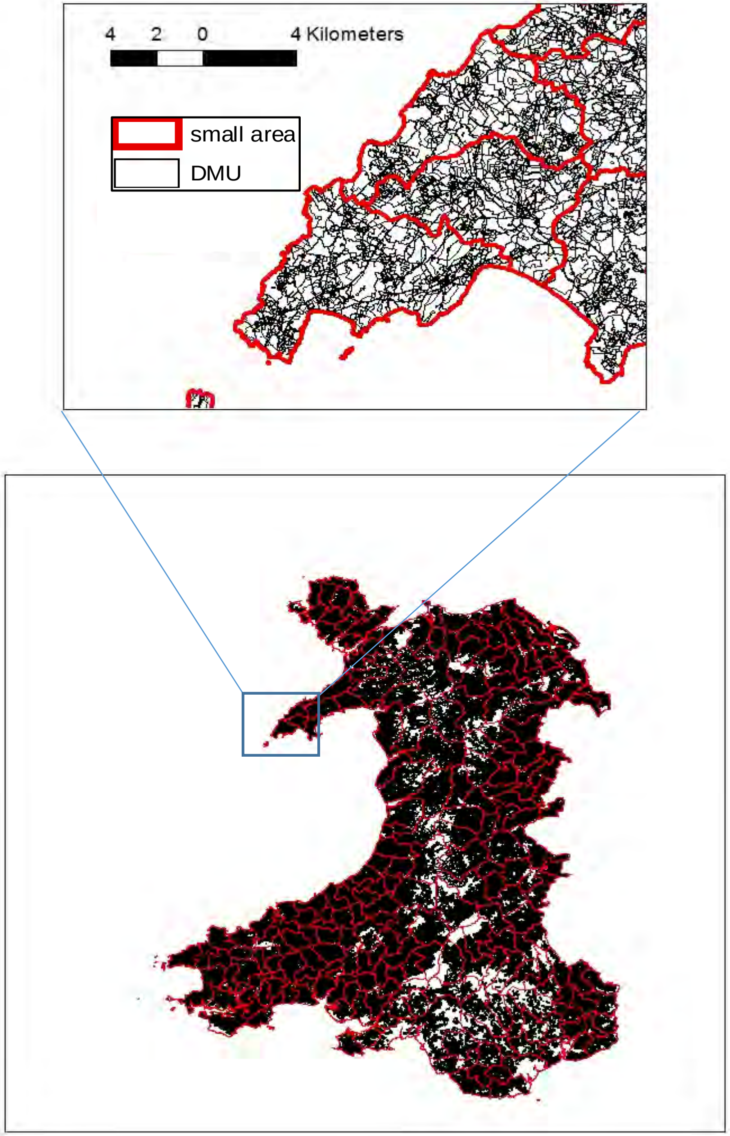
IMP modelling scales



- The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
- The finest spatial resolution used by Sfarmod and the Land Allocation Module (LAM) for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
- A DMU is defined as a managerially homogenous cluster of soil type, rainfall and land cover.
- Results in the slide pack are aggregated to small agricultural areas as findings are more robust at this level.

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7: ERAMMP_IMP_Cross-LandUseScenarios_T2-T3-T5-T6_Slidepack

Funded by:

Llywodraeth Cymru
Welsh Government

Canolfan Ecoleg a Hydroleg y DU
UK Centre for Ecology & Hydrology

INTEGRATED MODELLING PLATFORM

Land Use Scenarios:

Comparison across EU scenarios

(T2, T3, T5, T6)

UK Centre for Ecology & Hydrology

Cranfield University

ADAS

Forest Research

eftec

BTO

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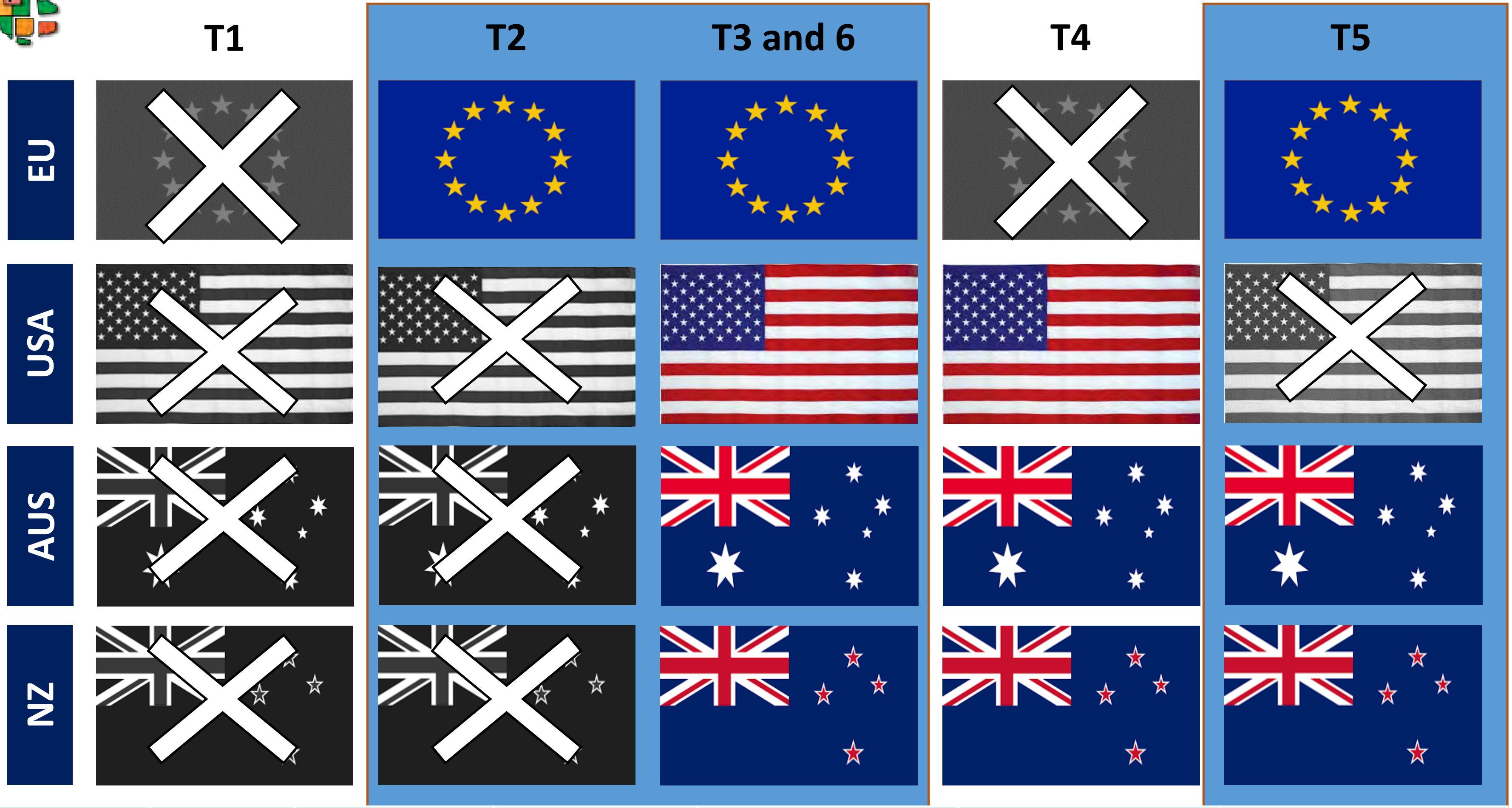
Scenario Overview



	Baseline (2015)	T1	T2	T3 / T6	T4	T5
Milk (p/litre)	35	31.6	35.4	36.8/33.3	38.5	36.8
Beef (£/kg LWT)	1.85	1.02	1.80	1.48	1.39	1.57
Lamb (£/kg LWT)	1.68	1.19	1.66	1.43	1.26	1.51

PART 1: Agriculture

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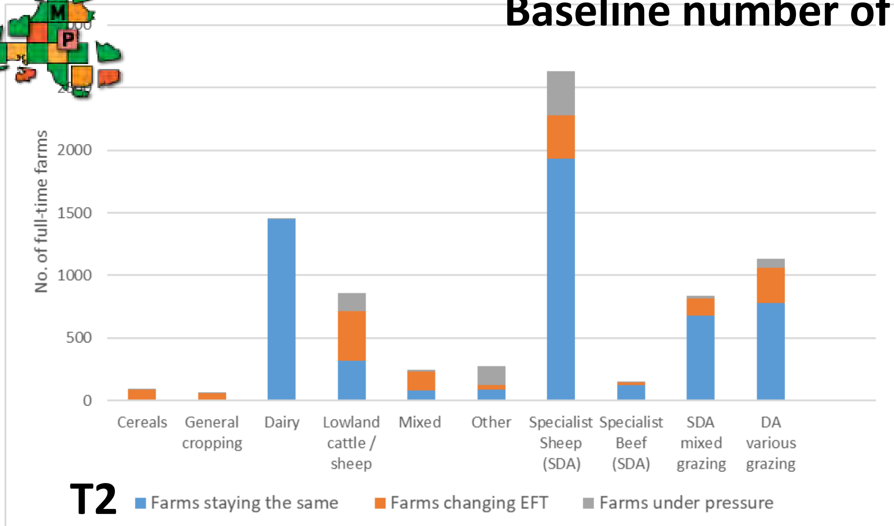
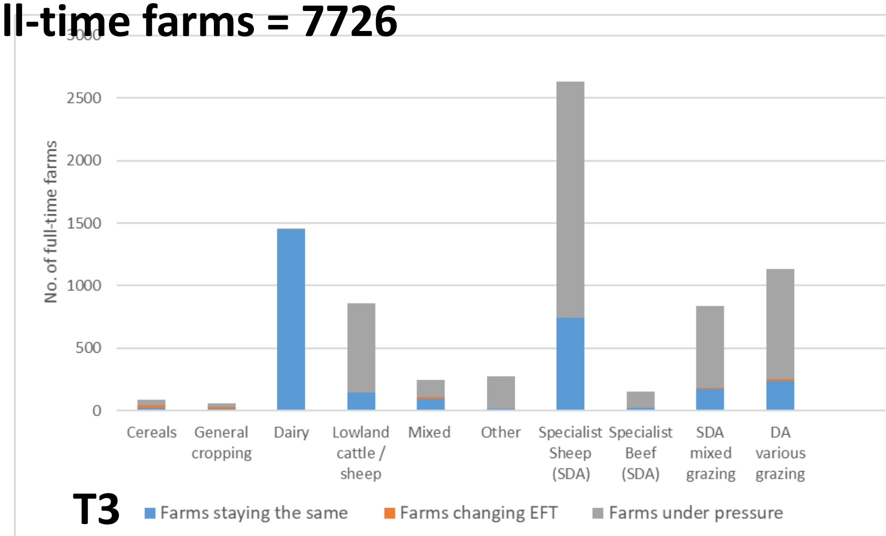
Simulated status of current full-time farms

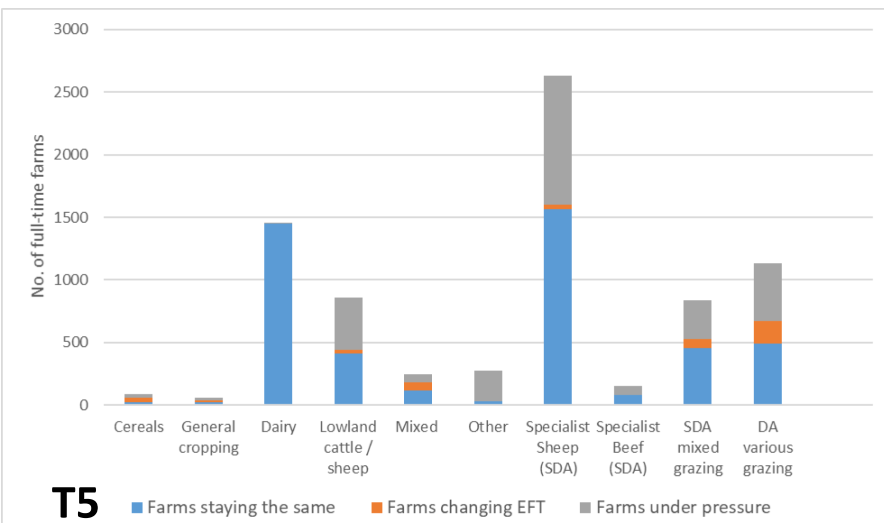
Baseline number of full-time farms = 7726



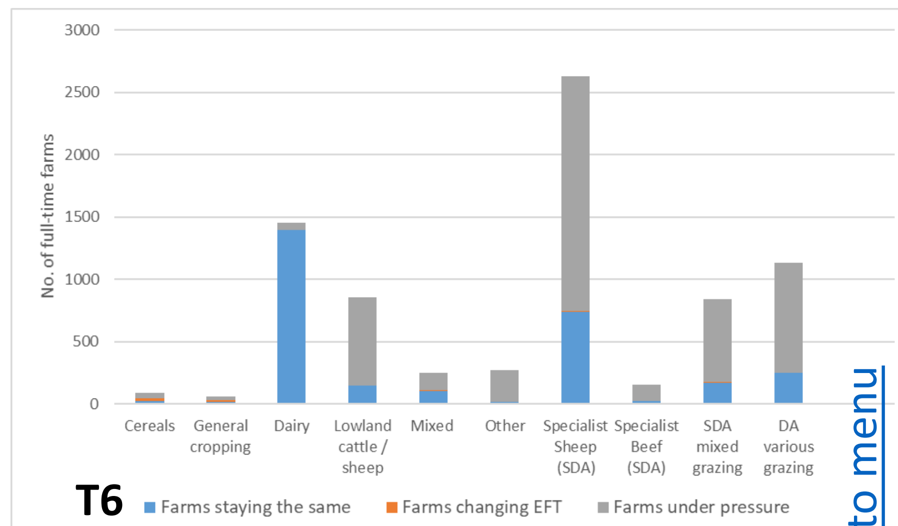
7117 F/T farms	7% under pressure	+£43M with transition	-£20M no transition



6052 F/T farms	22% under pressure	+£70M with transition	-£91M no transition



6257 F/T farms	19% under pressure	+£39M with transition	-£58M no transition



5455 F/T farms	29% under pressure	-£119M with transition	-£163M no transition

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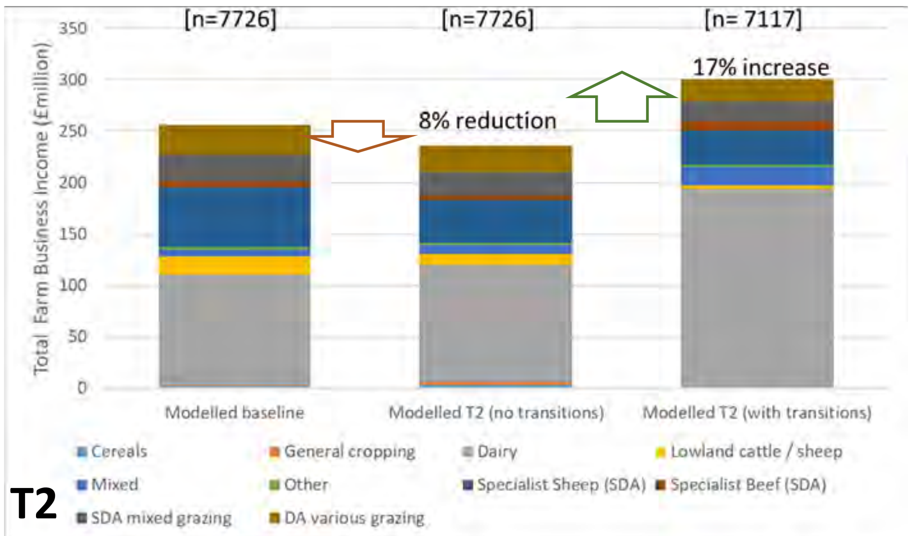
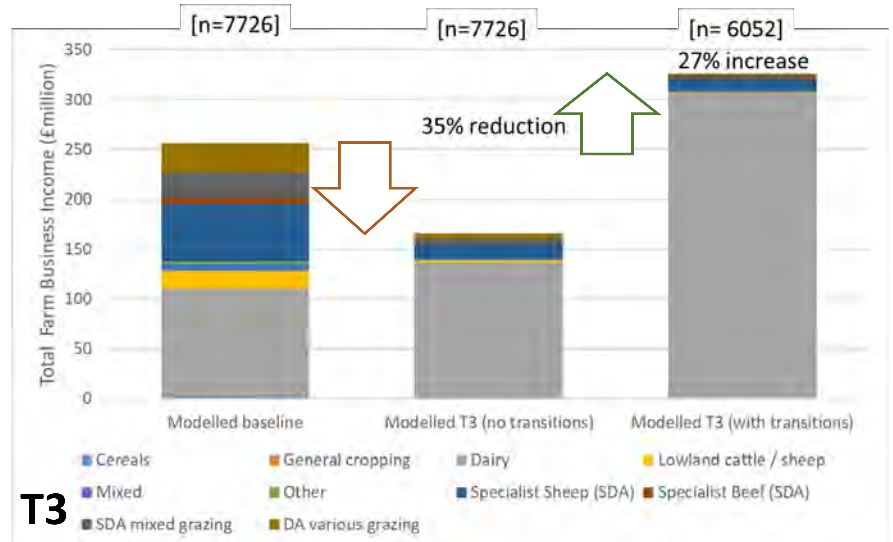
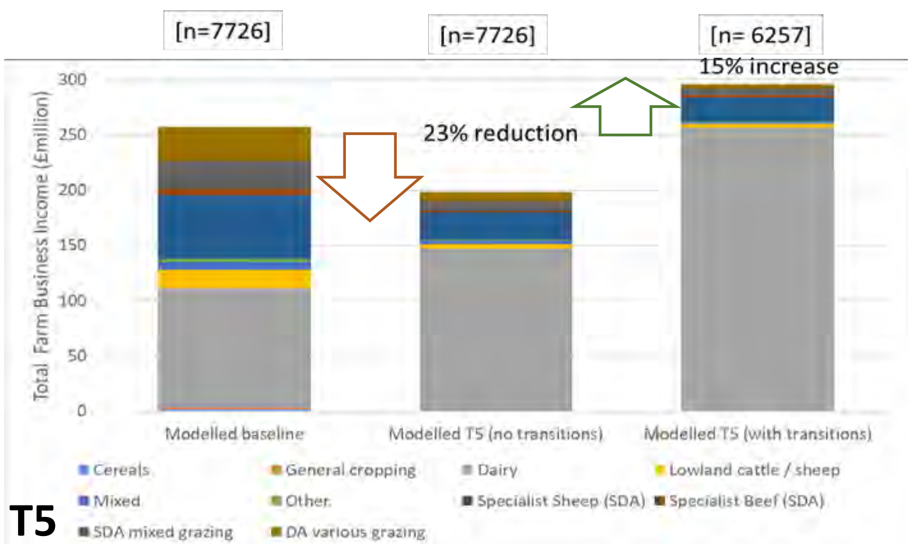
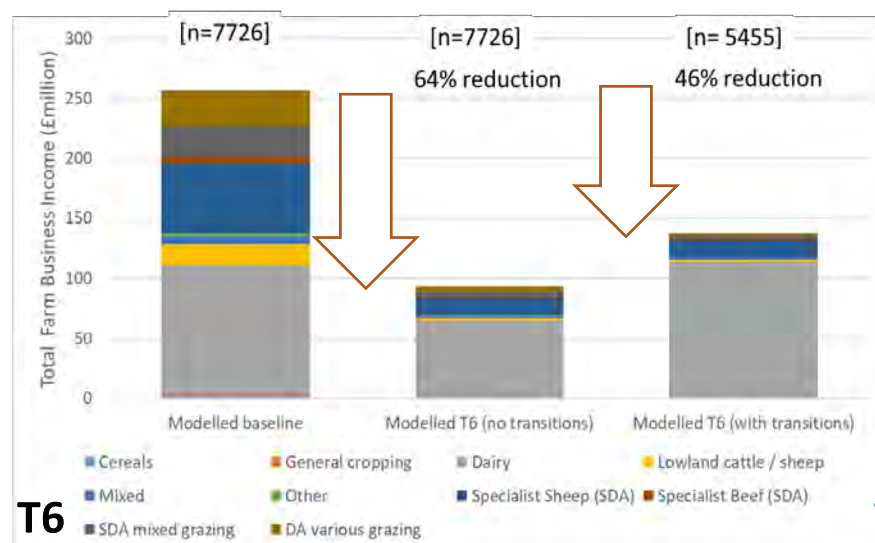
Total simulated Farm Business Income from full-time farms









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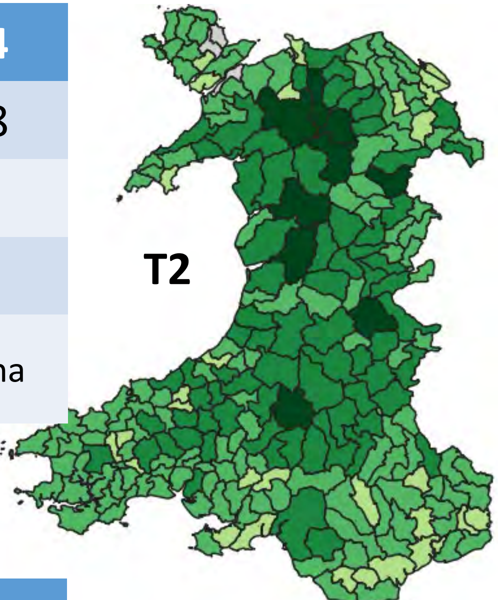
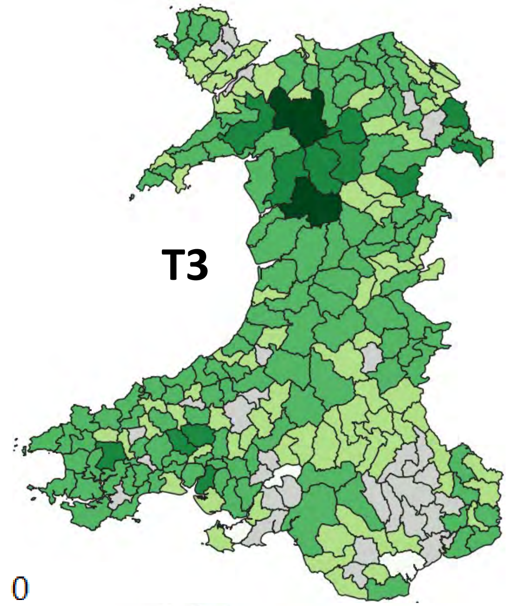
Simulated status of current full-time farms

Farms staying the same

Same	5464
Change	1488
Pressure	774
Leaving F/T	549
New woodland	6,060 ha

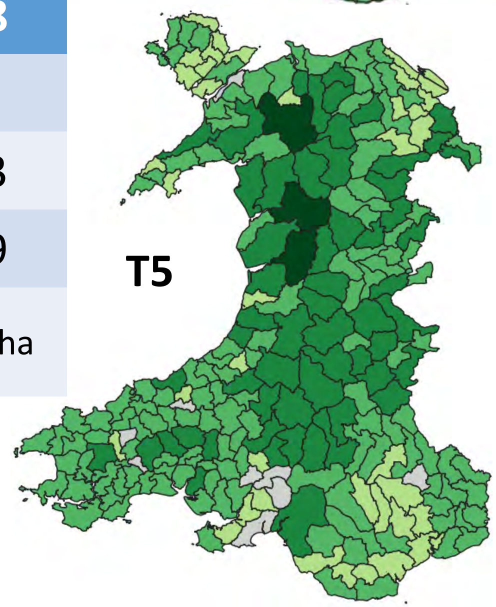


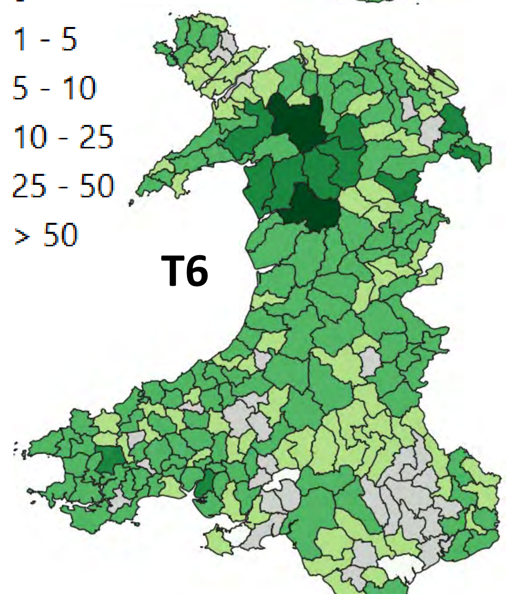


Same	2916
Change	69
Pressure	4741
Leaving F/T	1674
New woodland	53,995 ha

0
1 - 5
5 - 10
10 - 25
25 - 50
> 50

Same	4628
Change	445
Pressure	2653
Leaving F/T	1469
New woodland	39,270 ha





Same	2888
Change	48
Pressure	4790
Leaving F/T	2271
New woodland	149,075 ha

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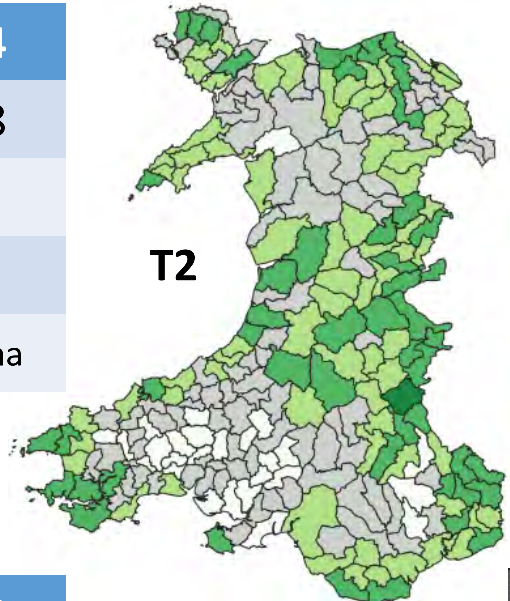
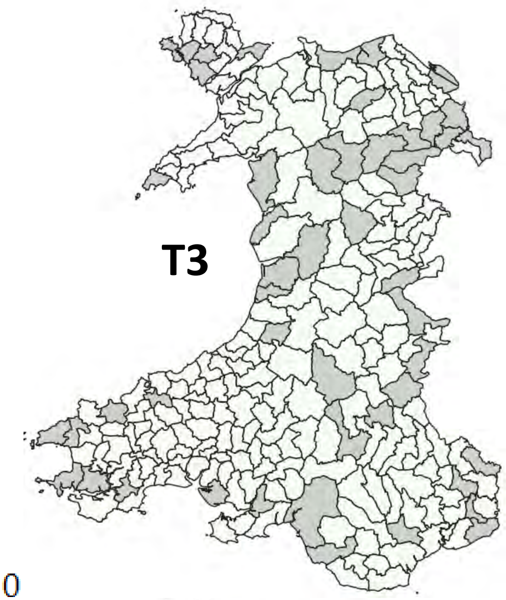
Simulated status of current full-time farms

Farms changing type

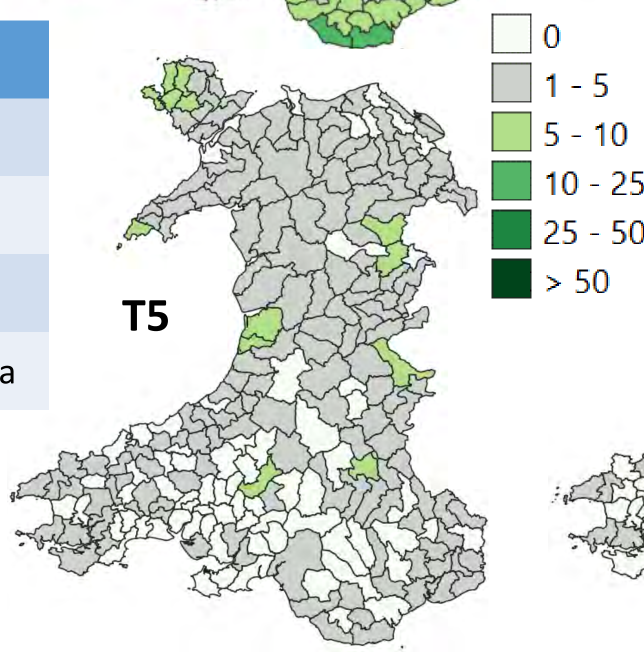
Same	5464
Change	1488
Pressure	774
Leaving F/T	549
New Forest	6,060 ha

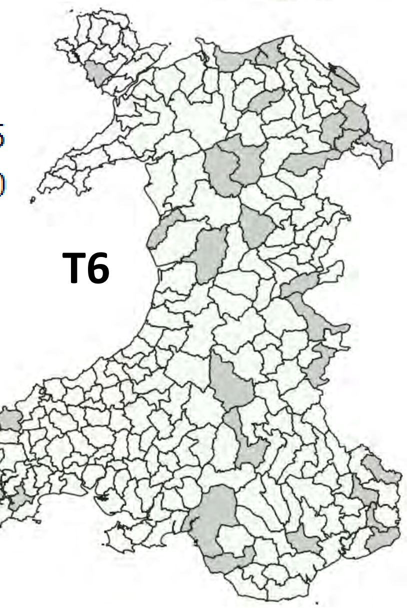




Same	2916
Change	69
Pressure	4741
Leaving F/T	1674
New Forest	53,995 ha

Same	4628
Change	445
Pressure	2653
Leaving F/T	1469
New Forest	39,270 ha





Same	2888
Change	48
Pressure	4790
Leaving F/T	2271
New Forest	149,075 ha

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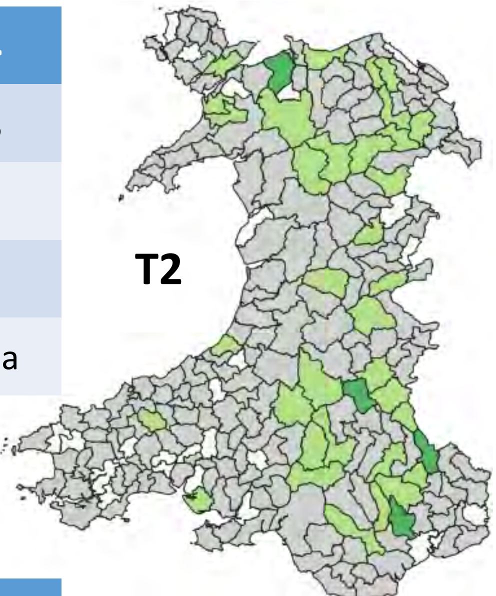
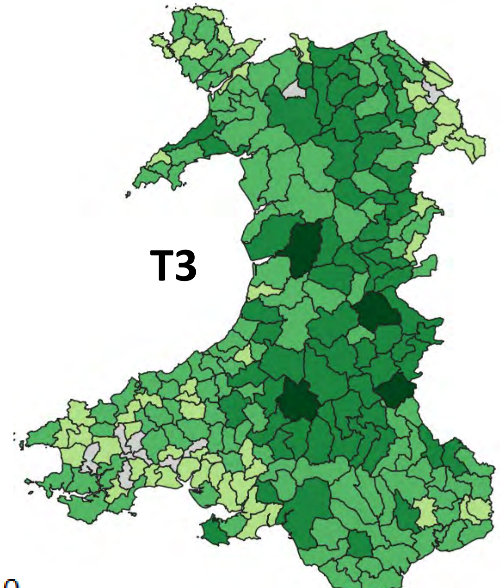
Simulated status of current full-time farms

Farms under pressure

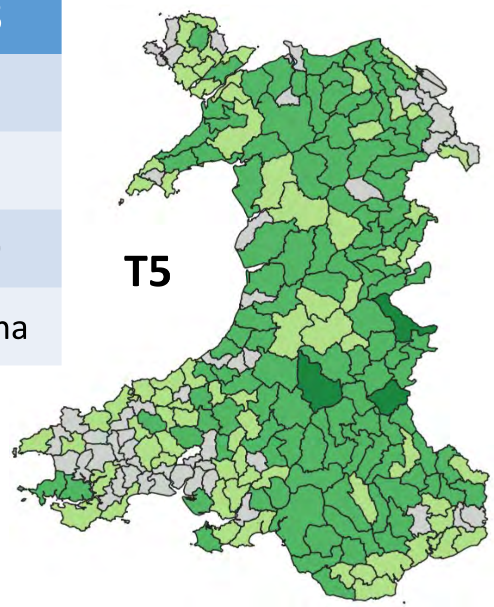
Same	5464
Change	1488
Pressure	774
Leaving F/T	549
New Forest	6,060 ha





Same	2916
Change	69
Pressure	4741
Leaving F/T	1674
New Forest	53,995 ha

Same	4628
Change	445
Pressure	2653
Leaving F/T	1469
New Forest	39,270 ha



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1 - 5
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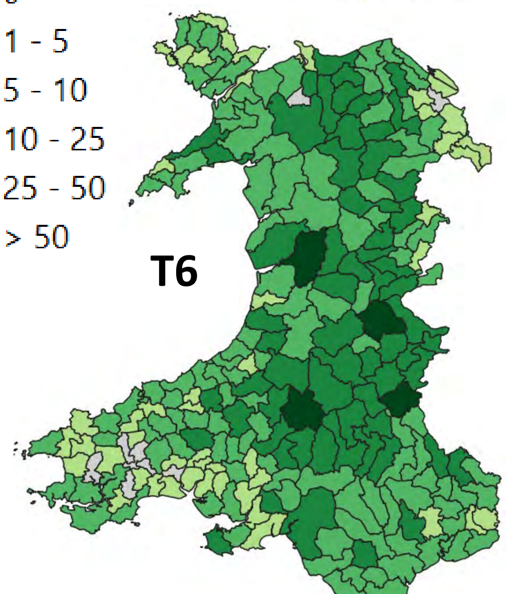
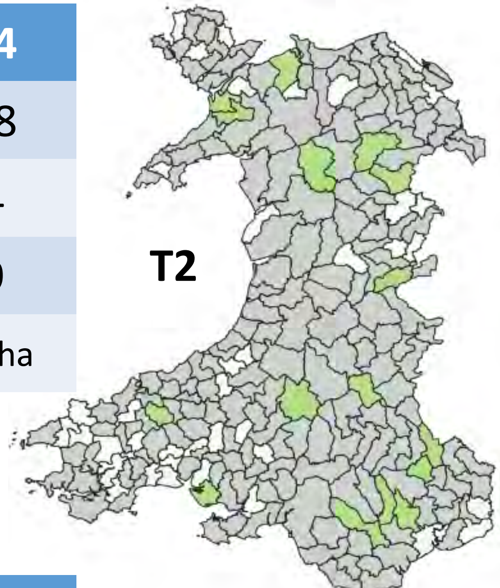


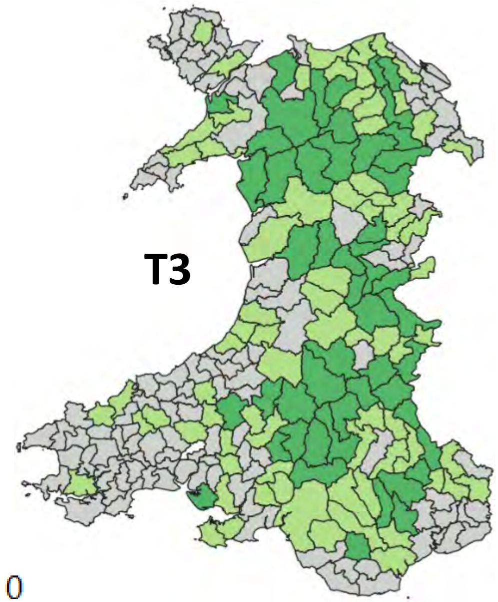
Same	2888
Change	48
Pressure	4790
Leaving F/T	2271
New Forest	149,075 ha

[Back to menu]

Simulated farms leaving full-time agriculture

Same	5464
Change	1488
Pressure	774
Leaving F/T	549
New Forest	6,060 ha





Same	2916
Change	69
Pressure	4741
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New Forest	53,995 ha

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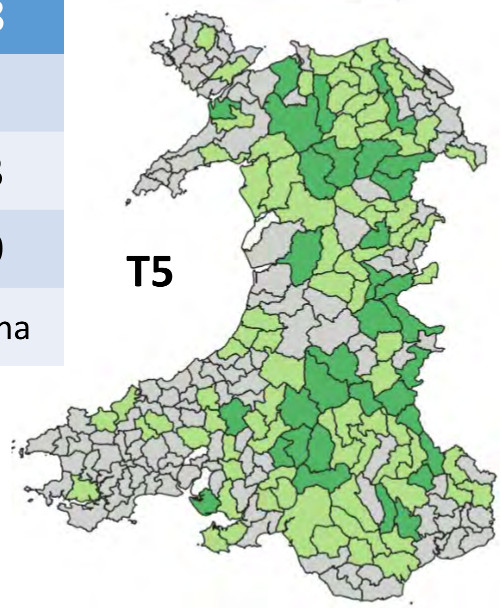
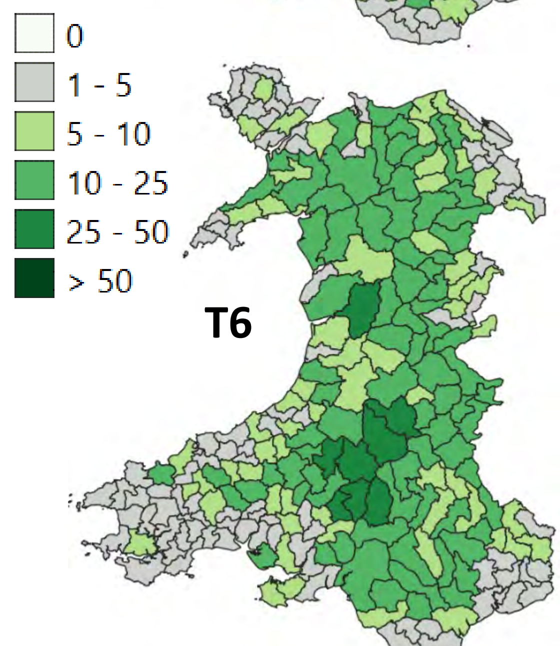
Pressure	2653
Leaving F/T	1469
New Forest	39,270 ha





Same	2888
Change	48
Pressure	4790
Leaving F/T	2271
New Forest	149,075 ha

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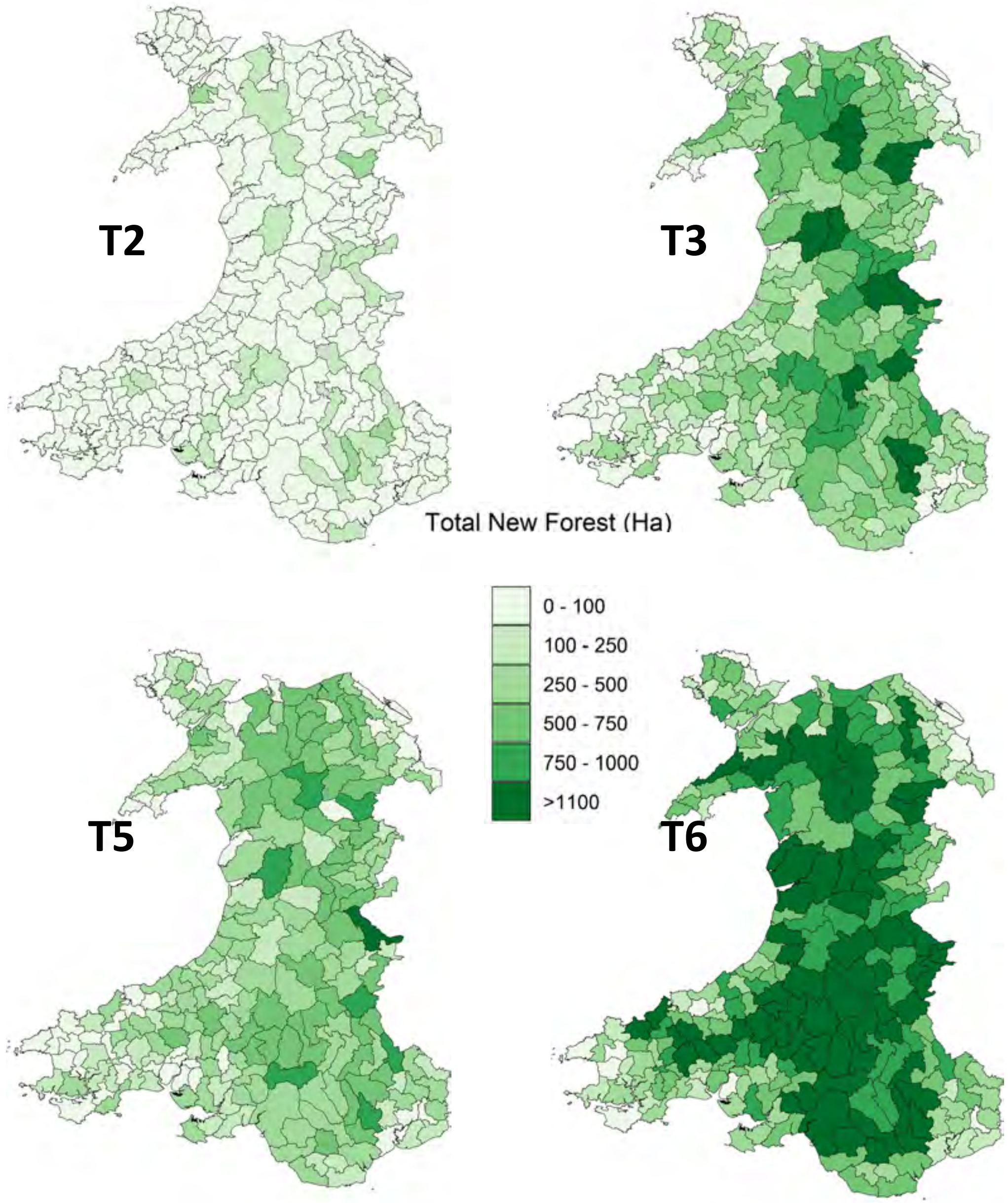
Simulated new woodland on farms leaving full-time agriculture

Same	5464
Change	1488
Pressure	774
Leaving F/T	549
New Forest	6,060 ha

Same	2916
Change	69
Pressure	4741
Leaving F/T	1674
New Forest	53,995 ha



Same	4628
Change	445
Pressure	2653
Leaving F/T	1469
New Forest	39,270 ha

Same	2888
Change	48
Pressure	4790
Leaving F/T	2271
New Forest	149,075 ha

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PART 2: Biodiversity

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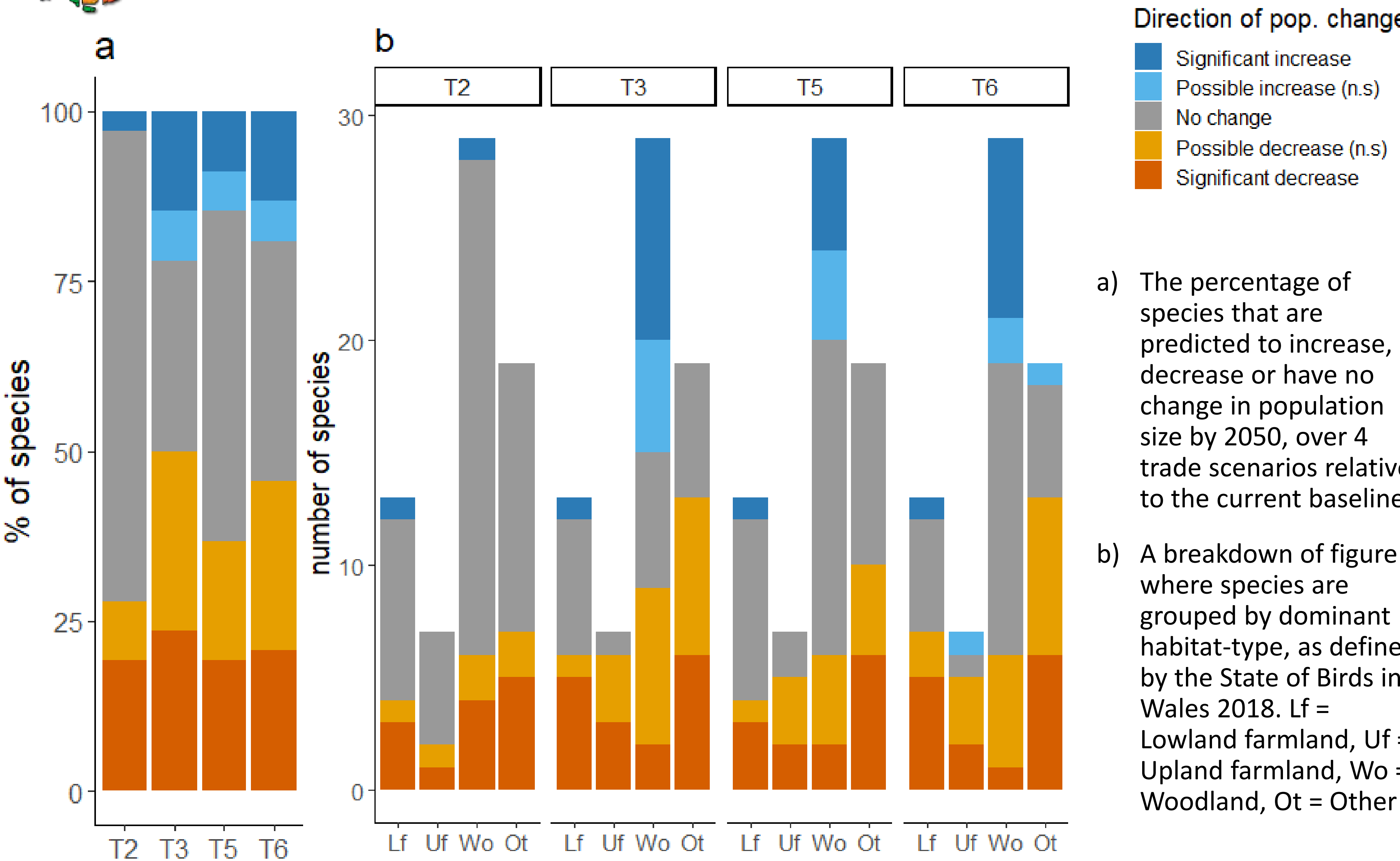
Overall bird population change



a) The percentage of species that are predicted to increase, decrease or have no change in population size by 2050, over 4 trade scenarios relative to the current baseline.

b) A breakdown of figure a) where species are grouped by dominant habitat-type, as defined by the State of Birds in Wales 2018. Lf = Lowland farmland, Uf = Upland farmland, Wo = Woodland, Ot = Other

- Changes are labelled as *significant* if confidence intervals of baseline and scenario population sizes did not overlap
- Changes are labelled as *possible* if confidence intervals overlap but the predicted change is greater than 10%

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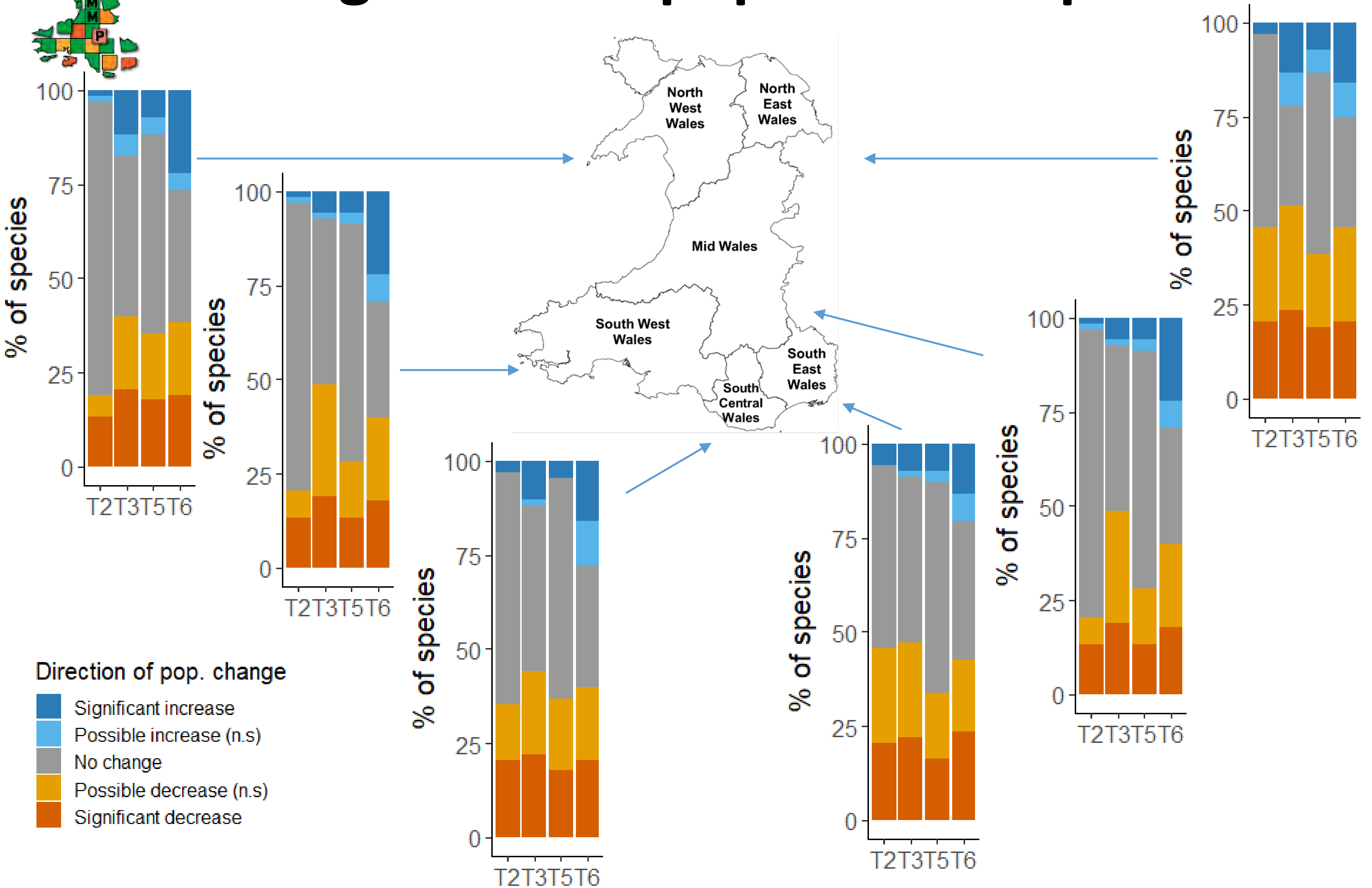
Regional bird population impacts



- Changes are labelled as *significant* if confidence intervals of baseline and scenario population sizes did not overlap
- Changes are labelled as *possible* if confidence intervals overlap but the predicted change is greater than 10%

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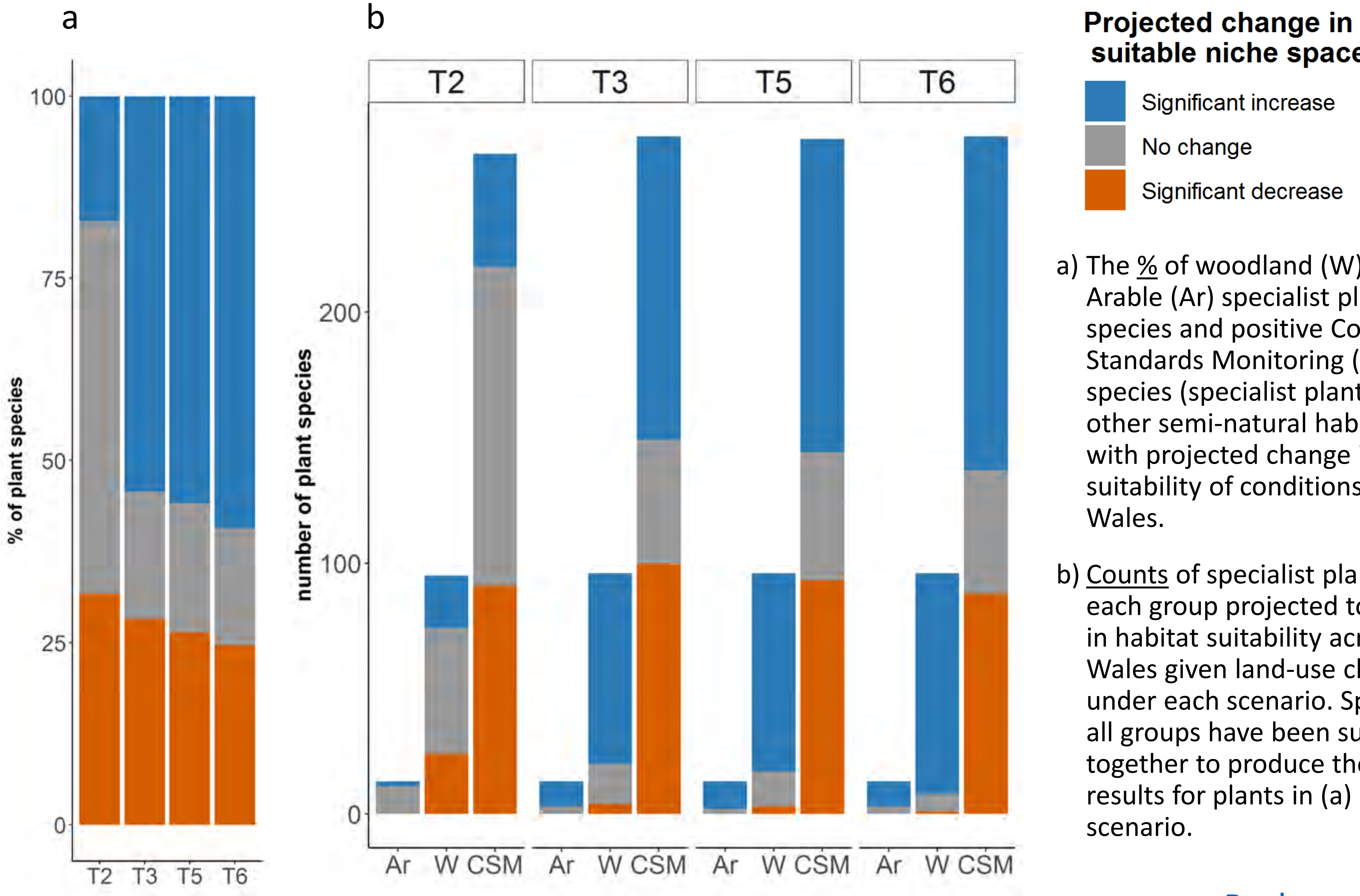
Habitat suitability for plants



a) The % of woodland (W) and Arable (Ar) specialist plant species and positive Common Standards Monitoring (CSM) species (specialist plants of other semi-natural habitats) with projected change in suitability of conditions across Wales.

b) Counts of specialist plants in each group projected to change in habitat suitability across Wales given land-use change under each scenario. Species in all groups have been summed together to produce the % results for plants in (a) by scenario.

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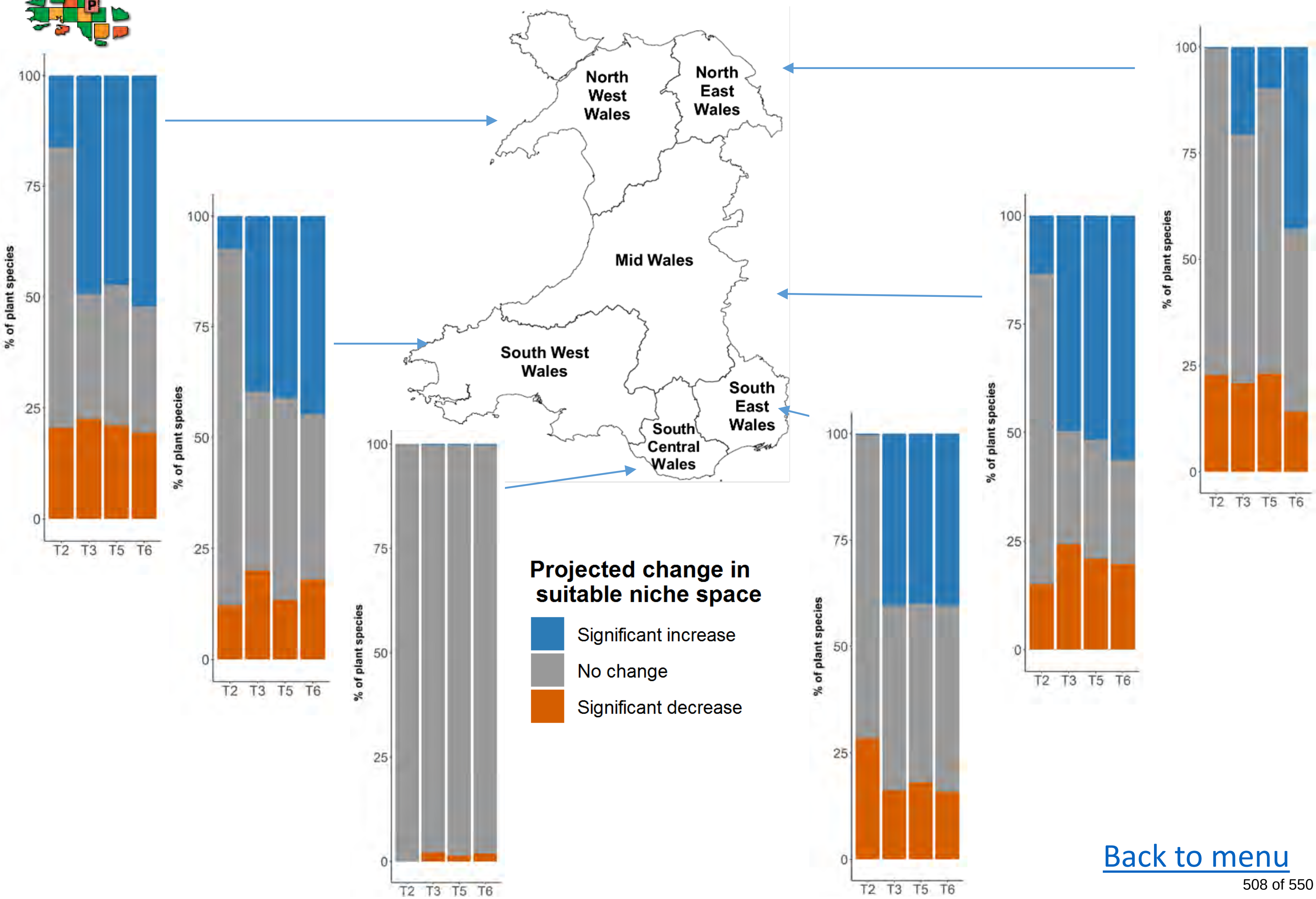
Regional impacts on plant species



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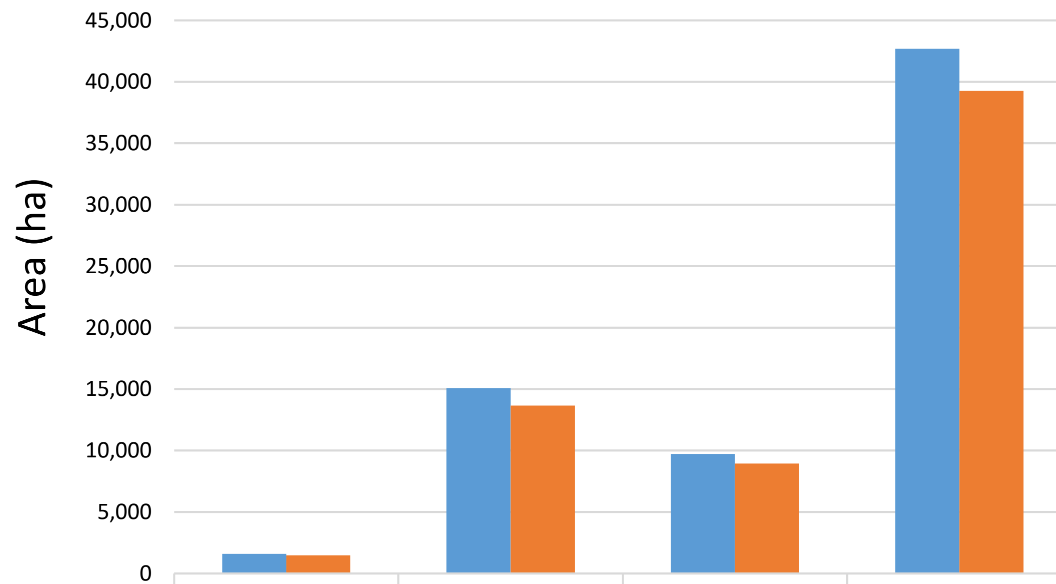
Woodland habitat connectivity

Almost all new woodland led to a simulated increase in connectivity (for at least one patch size/dispersal distance combination)

Increased total connectivity



	T2	T3	T5	T6
New Habitat Woodland	1,589	15,081	9,722	42,688
Increased Connectivity (any)	1,479	13,651	8,939	39,252

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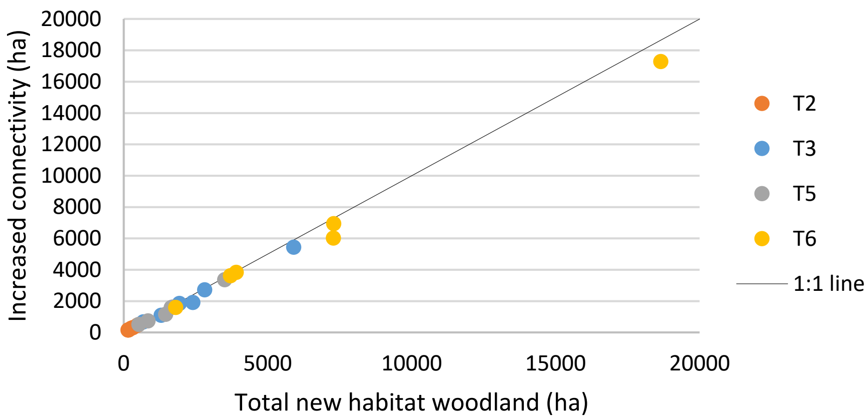
Woodland habitat connectivity:

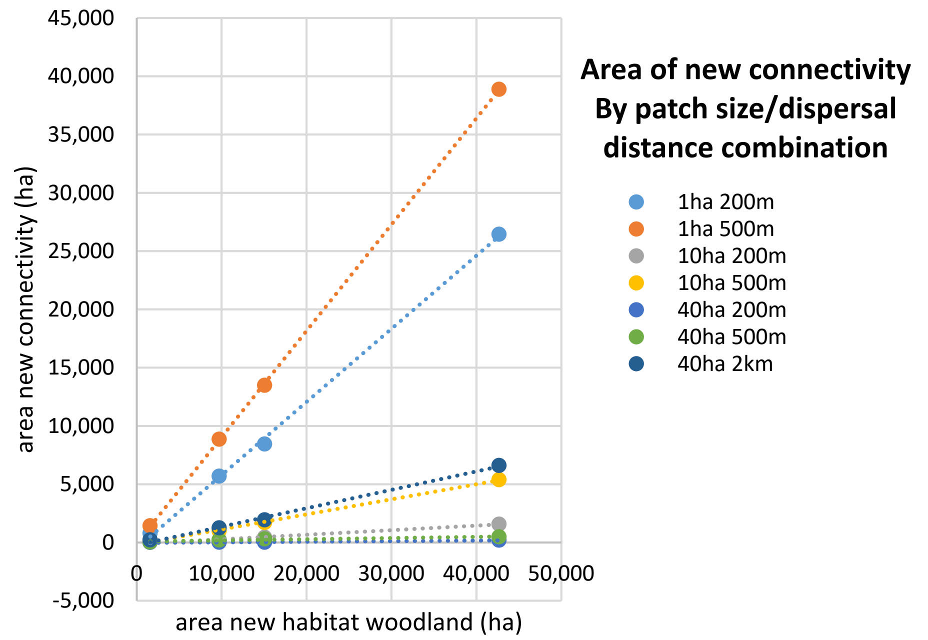
Regional variation in opportunity and projected change

Increased total connectivity: comparing relationship at NRW level



The increase in connectivity for almost all new woodland created is seen when data are disaggregated to NRW regions.

- When the different connectivity types are compared, the greatest benefits are consistently seen for smaller patch size/greater dispersal distance combinations.
- In particular, greater dispersal distance increases the area with opportunity for new connectivity.



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PART 3: Ecosystem Services

3a: Carbon

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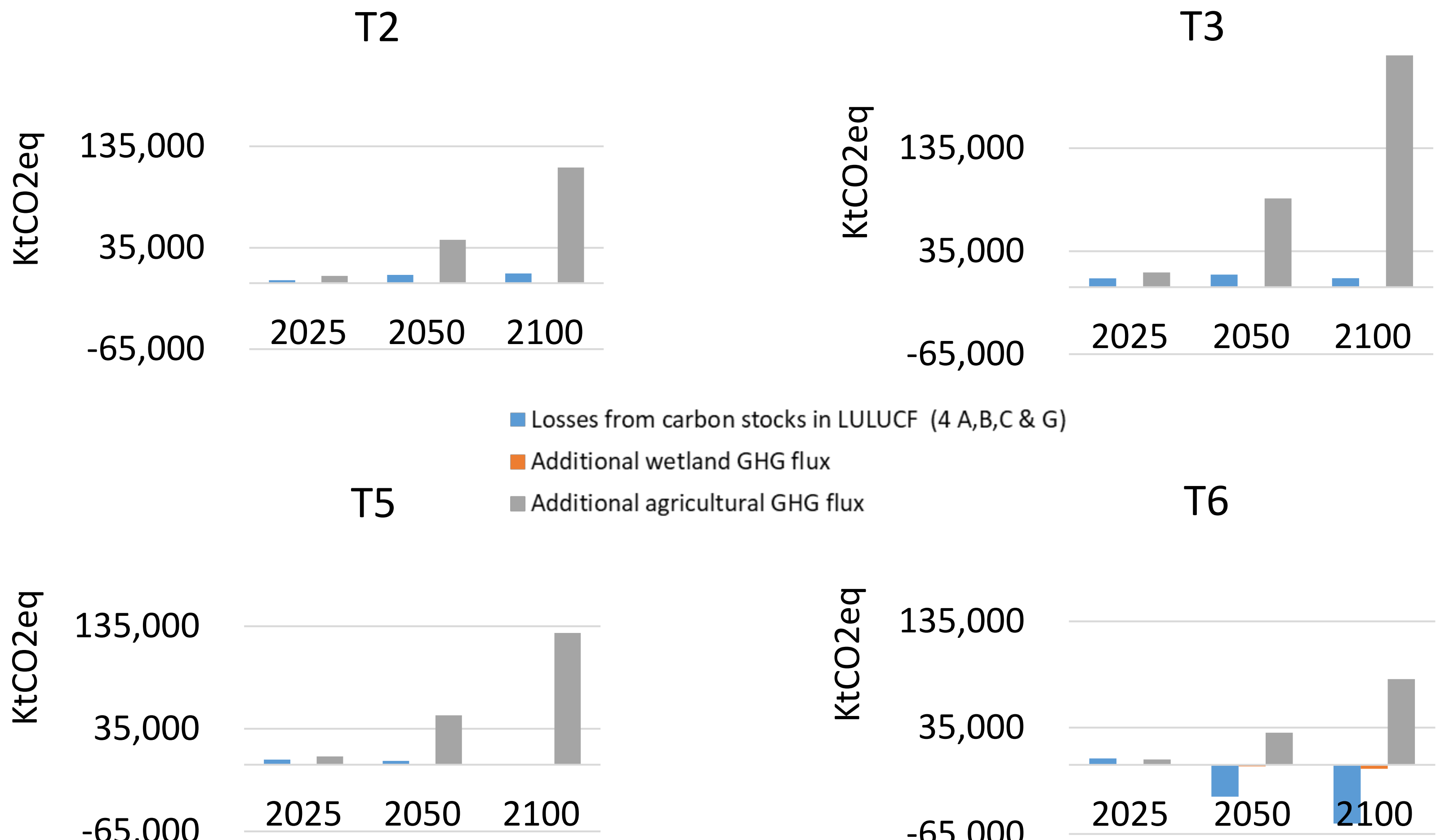
LULUCF Carbon and agricultural GHG:

Change over time



- All scenarios show increased agricultural GHG emissions and reduced wetland GHG flux.
- Most scenarios show losses for LULUCF carbon, except T6 where final sequestration almost counterbalances the increased agricultural emissions.

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LULUCF Carbon: Change over time

Losses from carbon stocks in Land use change and forestry + harvested wood products (4 A, B, C & G) (KtCO2eq)	Increased emissions or losses of carbon by the year: 2025	2050	2100
T2	2,960	8,269	9,668
T3	8,644	12,330	8,795
T5	5,039	3,756	-199
T6	6,007	- 29,849	- 55,133

- Variation between the scenarios reflects the relative areas undergoing agricultural intensification or woodland creation, and the varying rates of carbon stock change over time under these transitions.
- All scenarios simulate initial losses for LULUCF carbon - this reflects intensification on some agricultural land, with some contribution from initial losses for new woodland.
- By 2050, accumulated LULUCF loss is simulated to increase for T2 and T3, and decrease for T5 due to offsetting from woodland carbon sequestration.
- By 2050, negative numbers for T6 indicate that sequestration for new woodland and other land coming out of agriculture has offset LULUCF losses on agricultural land undergoing intensification, and by 2100, significant sequestration was simulated.
- By 2100, T5 also has net sequestration, whereas losses increase for T2 and reduce for T3.

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Wetland (peat) GHG: Change over time

Additional wetland GHG flux (KtCO2eq)	Increased emissions or losses of carbon by the year:		
	2025	2050	2100
T2	-6	-34	-91
T3	-47	-282	-753
T5	-32	-194	-518
T6	-228	-1,366	-3,642

- All scenarios simulated reduced wetland GHG emissions.
- Variation between the scenarios reflects both the varying land use changes projected and how these spatially overlay with the locations of wetlands.
- The reduction in emissions is greatest for T6, then T3, then T5, and least for T2.
- The reduction reflects land coming out of agricultural use (land remaining in the agricultural category shows a small increase in most of the scenarios) to either short vegetation or natural woodland regeneration.

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Agricultural GHG: Change over time

Additional agricultural GHG flux (KtCO2eq)	Increased emissions or losses of carbon by the year: 2025	2050	2100
T2	7,137	42,823	114,196
T3	14,359	86,152	229,738
T5	8,024	48,141	128,377
T6	5,046	30,278	80,742

- Variation between the scenarios reflects the varying land use changes projected and the relative areas undergoing agricultural intensification or coming out of agricultural use.
- All scenarios simulated increased agricultural GHG emissions, which is largely attributable to the expansion of dairy.
- The increase in emissions is greatest for T3, then T5, then T2, and least for T6.

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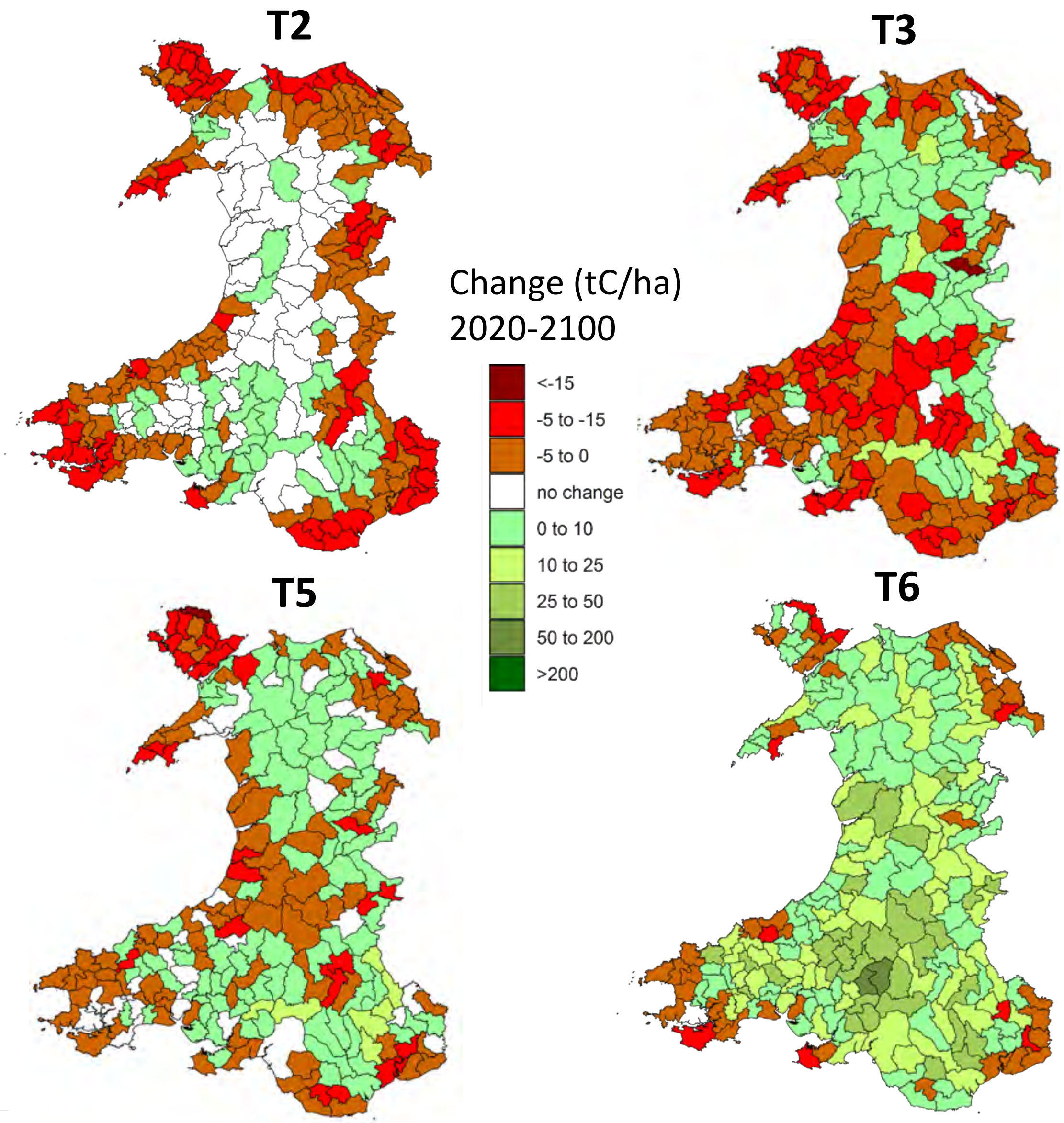
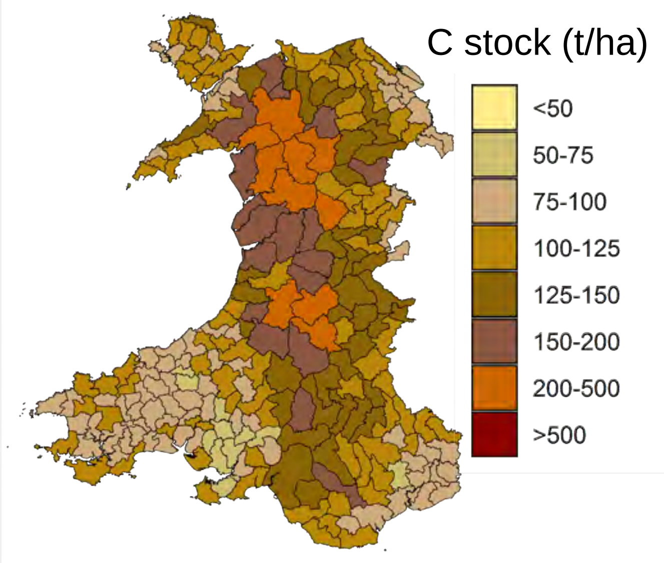
Carbon stock and change for small agricultural areas

These data are for LULUCF categories 4 A, B, C & G and are displayed per ha of land modelled



Baseline Stock (2020)



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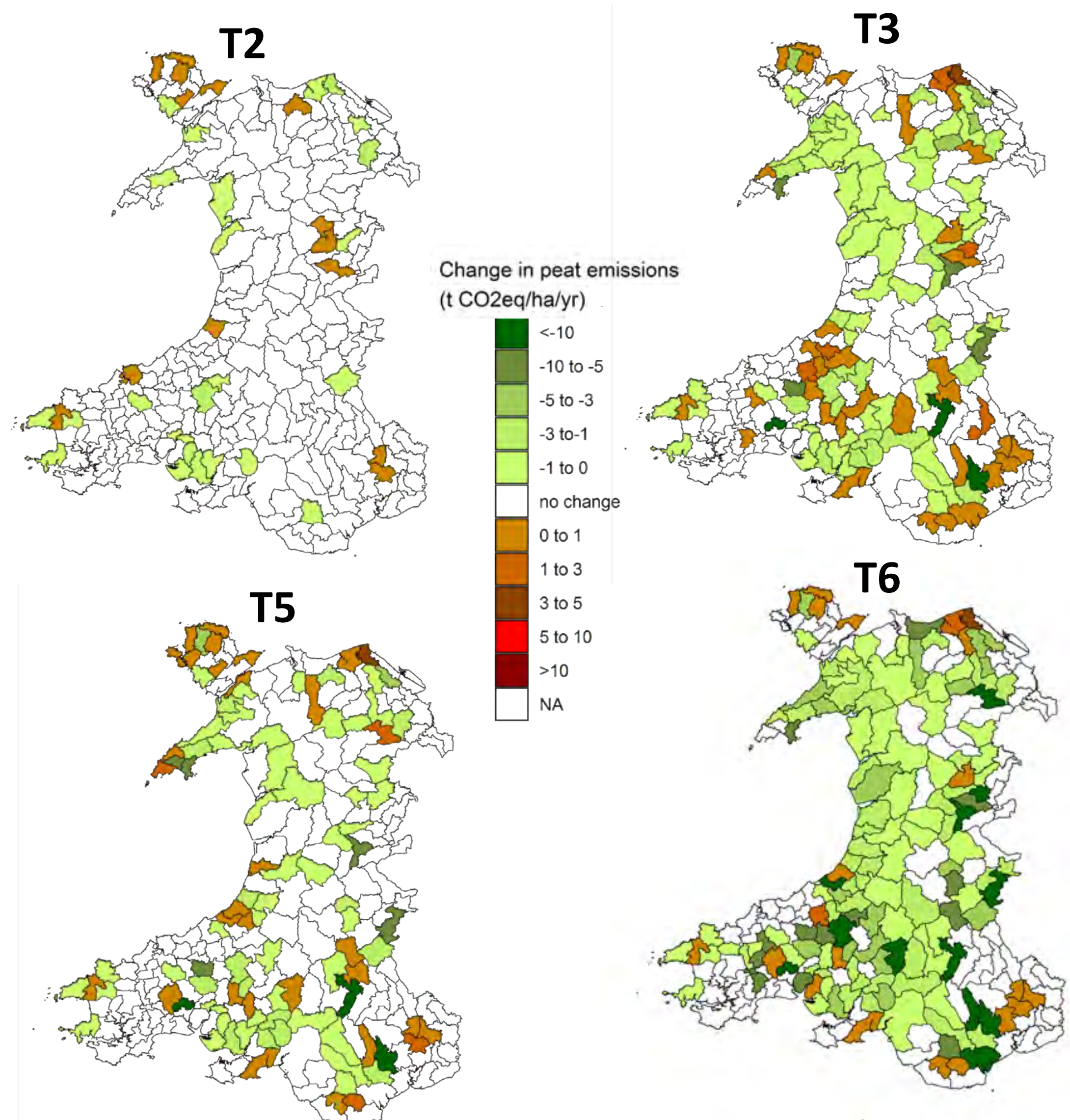
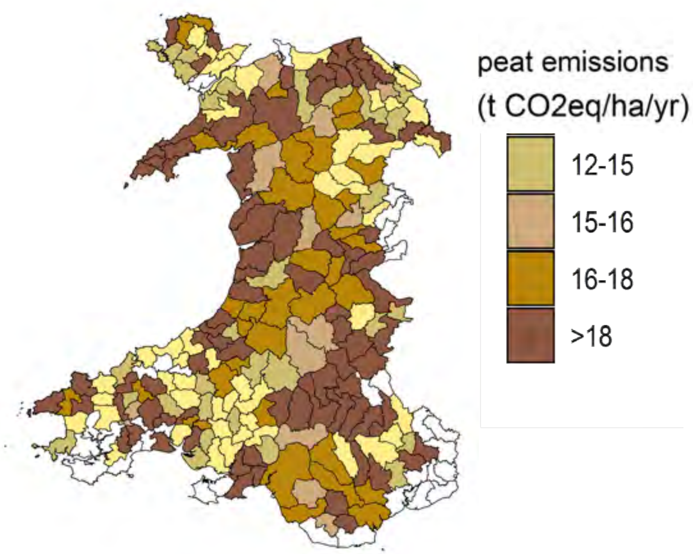
Peat GHG baseline and change for small agricultural areas

These data are for wetland greenhouse gas emissions, reflecting land use and management



Baseline peat GHG emissions (2020)



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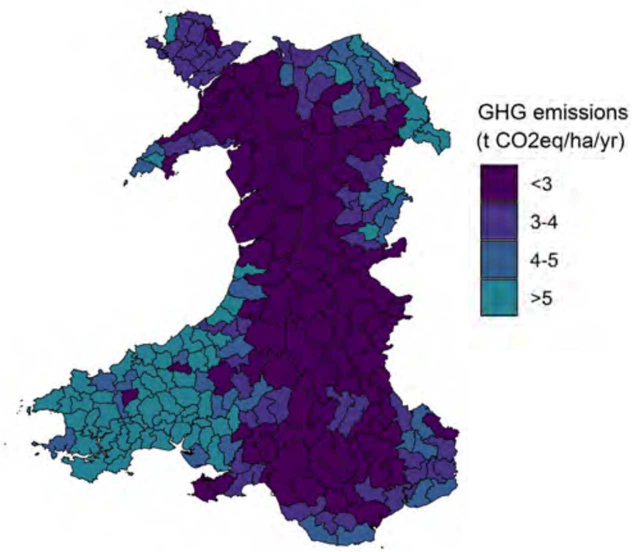
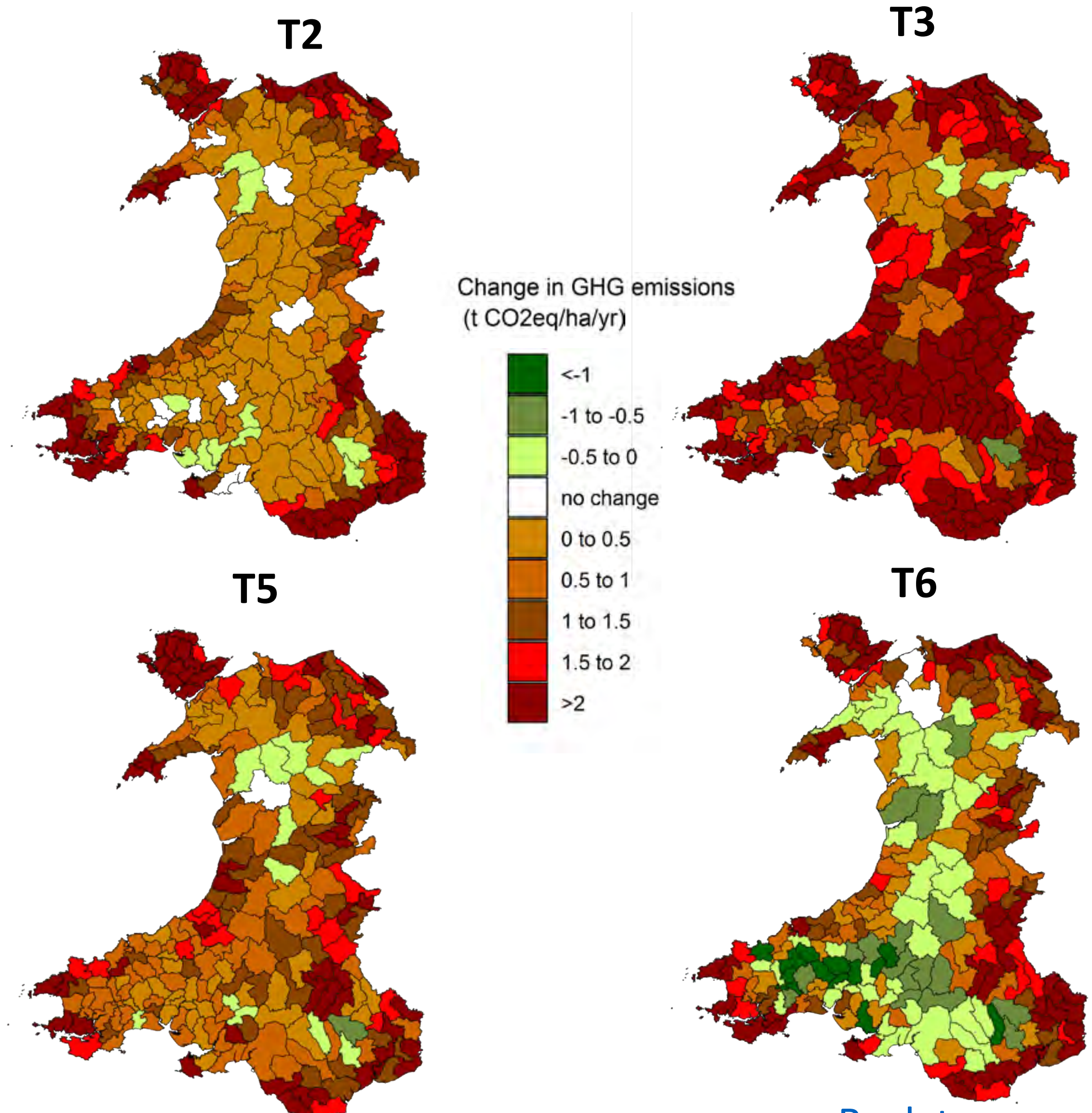
Agricultural GHG baseline and change for small agricultural areas

These data are for agricultural greenhouse gas emissions associated with livestock and nutrient inputs

Baseline agricultural GHG emissions (2020)





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PART 3b: Water quality

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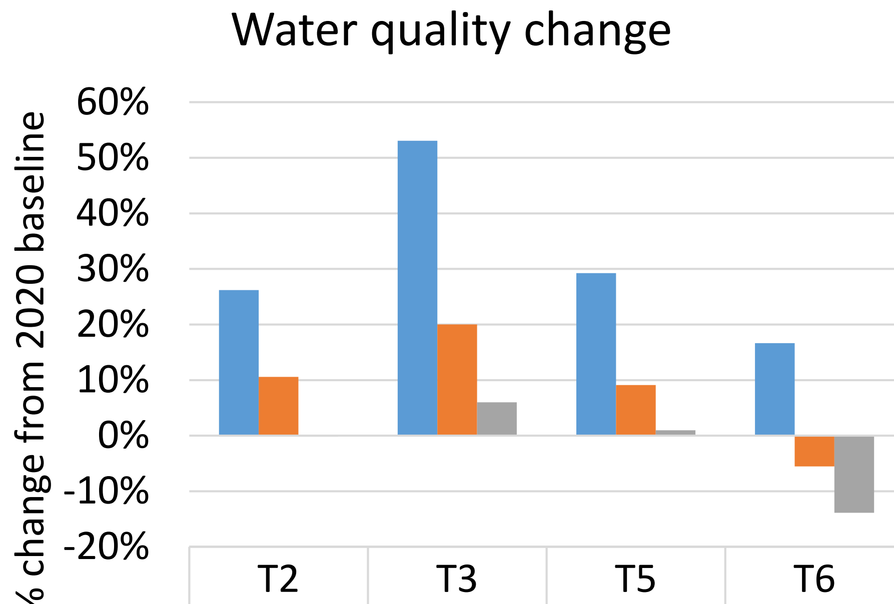
Water Quality for Wales: Change in N, P and sediment load

- T2, T3, and T5 simulate an increase in all modelled pollutants.
- Greatest proportional increase was always modelled for N, then P, then sediment (z).
- For T6, an increase was only modelled for N pollutants, whilst P and sediment were reduced.
- These patterns reflect the relative contributions of different agricultural land uses to these different pollutant types, and the pattern of agricultural change.



	T2	T3	T5	T6
N	26%	53%	29%	17%
P	11%	20%	9%	-6%
z	0%	6%	1%	-14%

- Dairy creates more N than the other pollutants, when compared to other land uses, hence our findings are to be expected with dairy increase set against contraction of other sectors.

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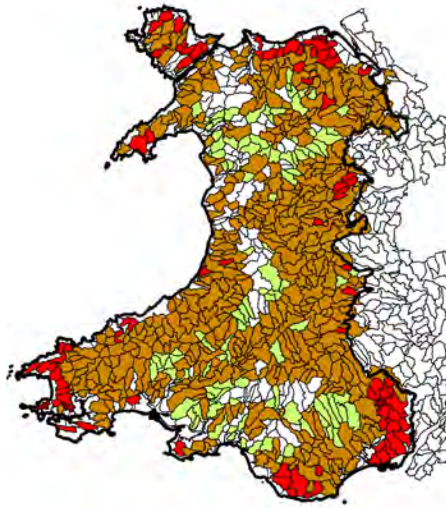
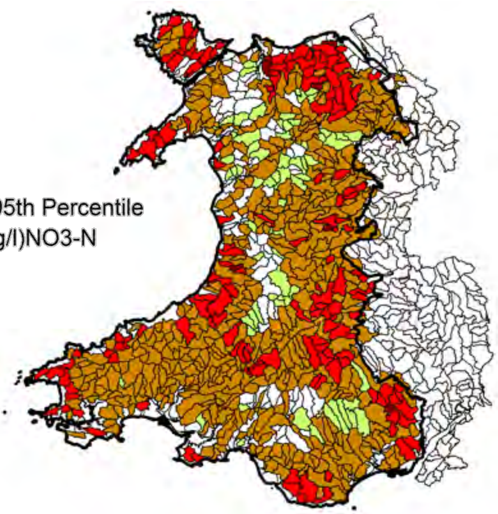
N concentration and change

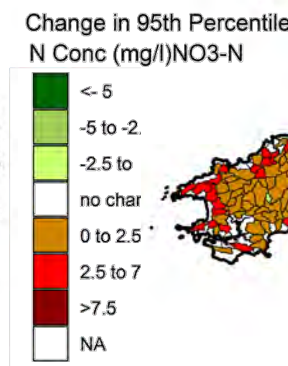
- Most waterbodies are projected to increase in N for all but the T6 scenario.
- All scenarios also have some waterbodies with falling N projected, particularly upstream waterbodies.

T2

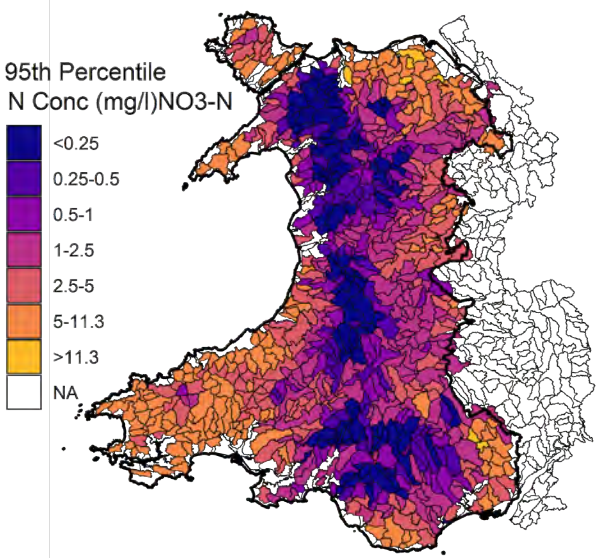


T3

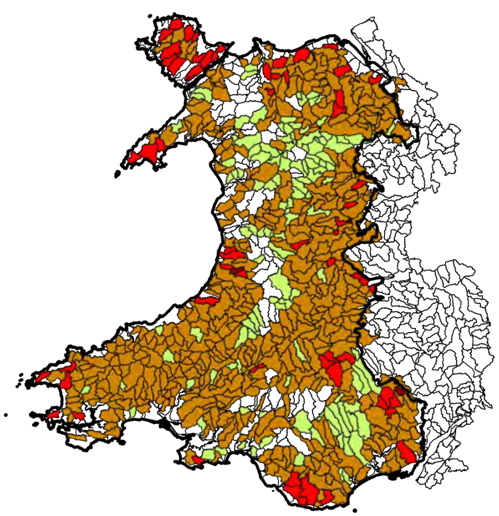




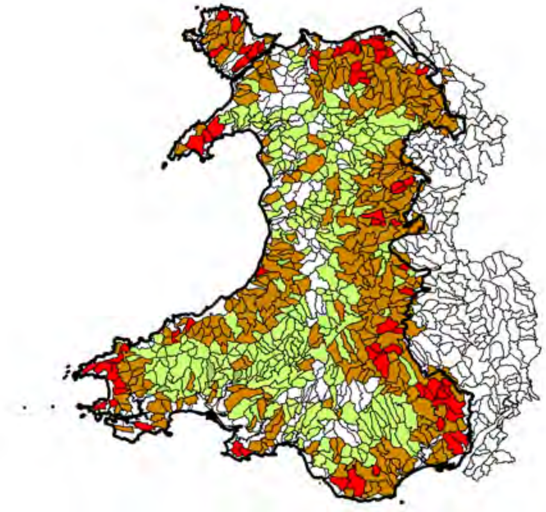
Baseline N



T5



T6



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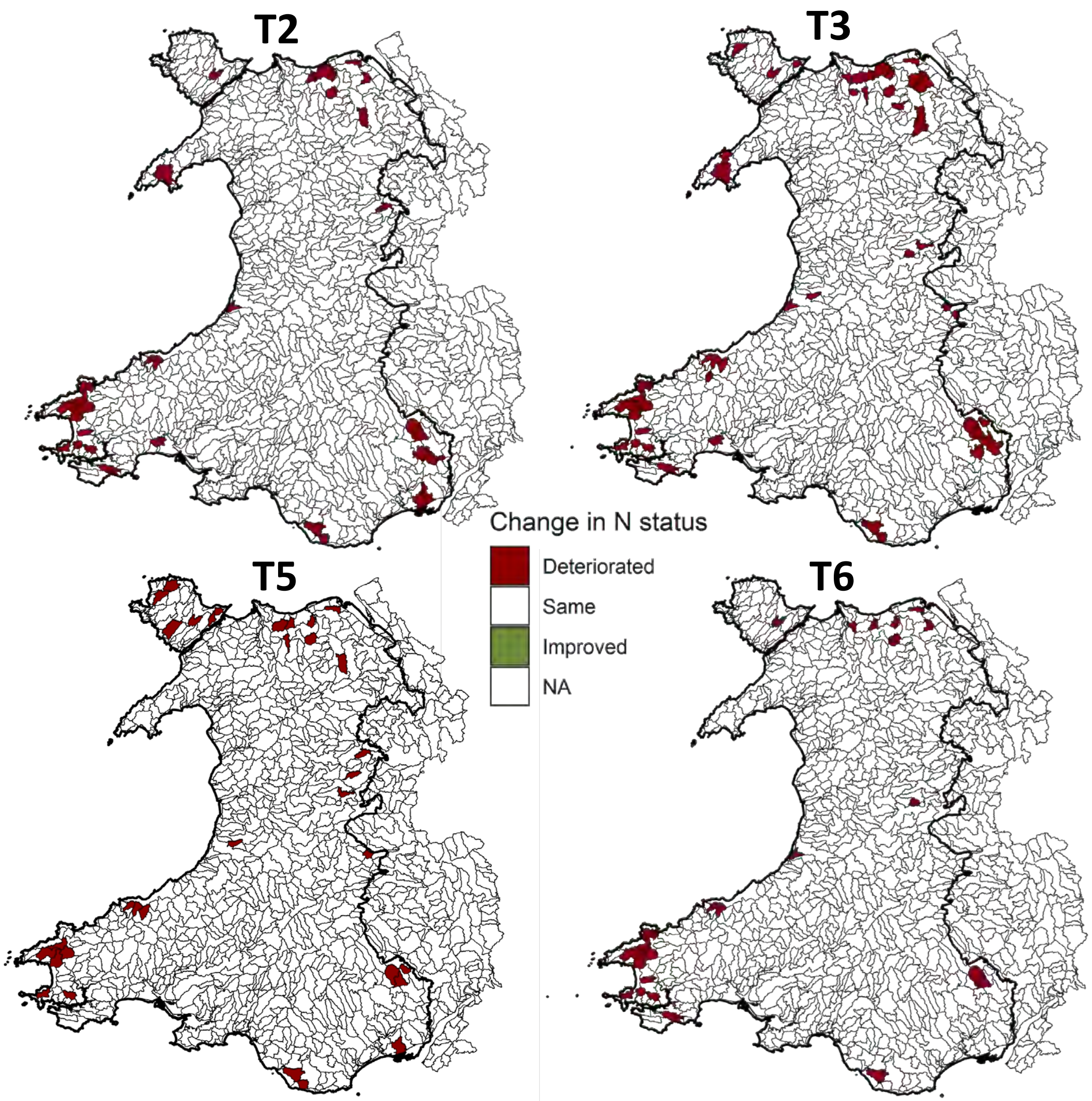
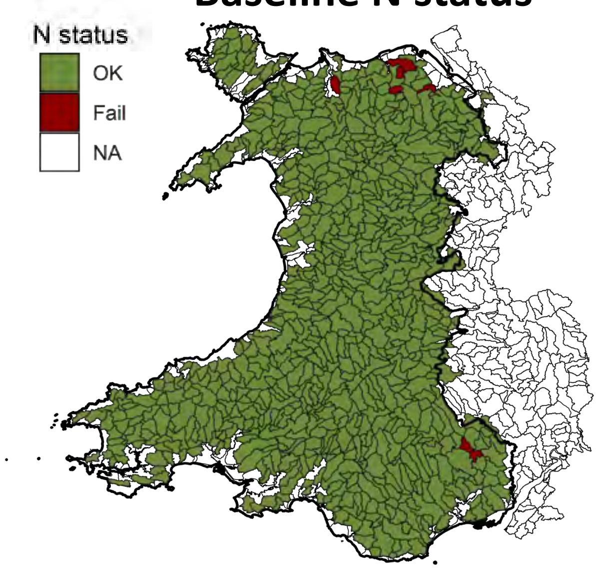
N status and change

- N drinking water status is modelled as OK across most of Wales, with very few waterbodies failing.
- Few waterbodies are projected to deteriorate in N drinking water status, across all scenarios.



Baseline N status



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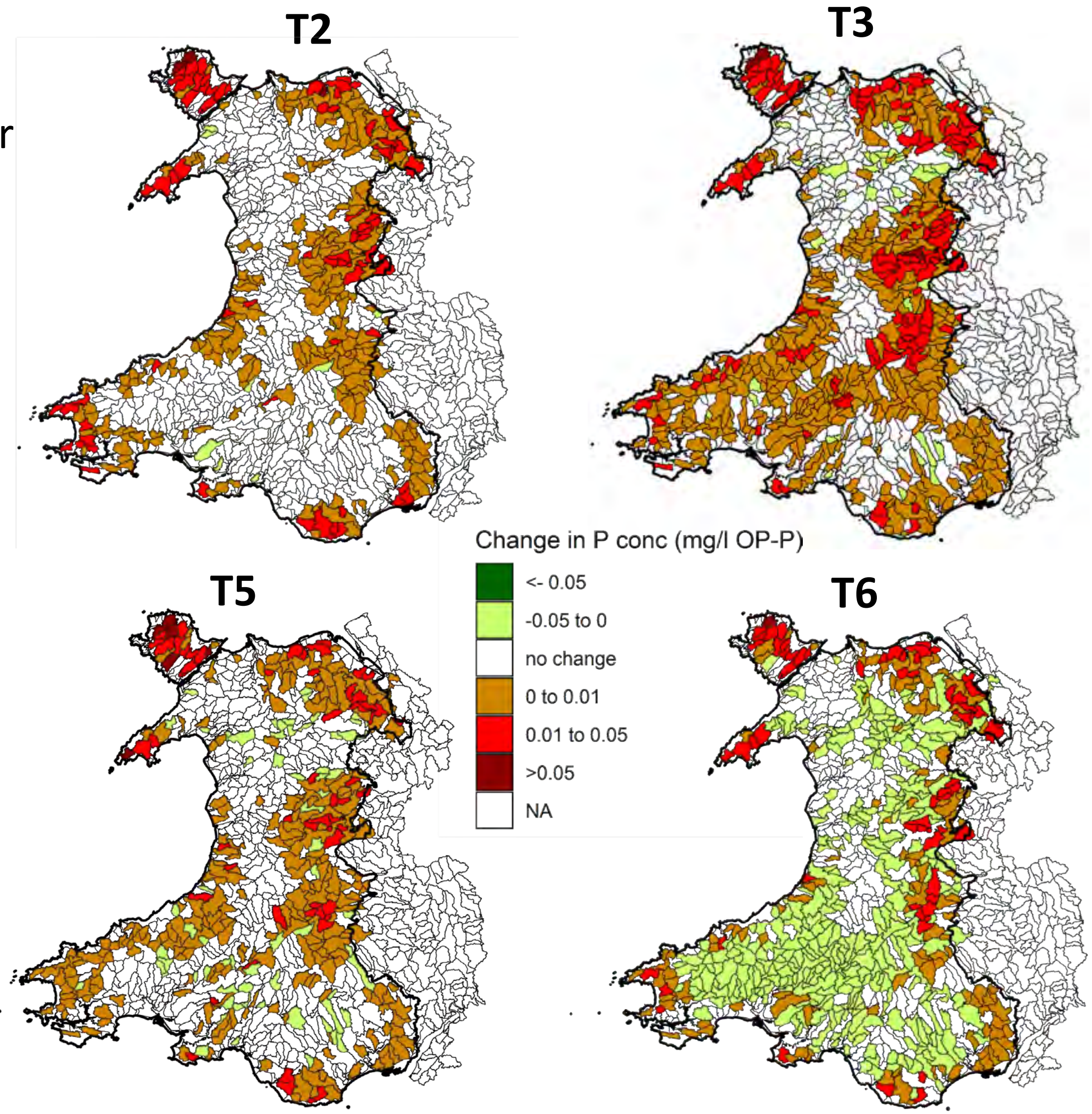
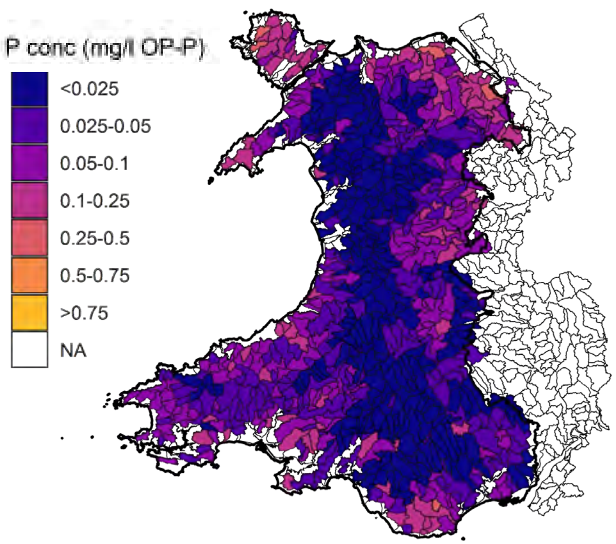
P concentration and change

- An increase or no change in P is projected for most waterbodies, for all but the T6 scenario.
- All scenarios also have some waterbodies with projected decreases in P concentrations, particularly upstream waterbodies.
- Reductions in P concentration dominate the T6 scenario.



Baseline P



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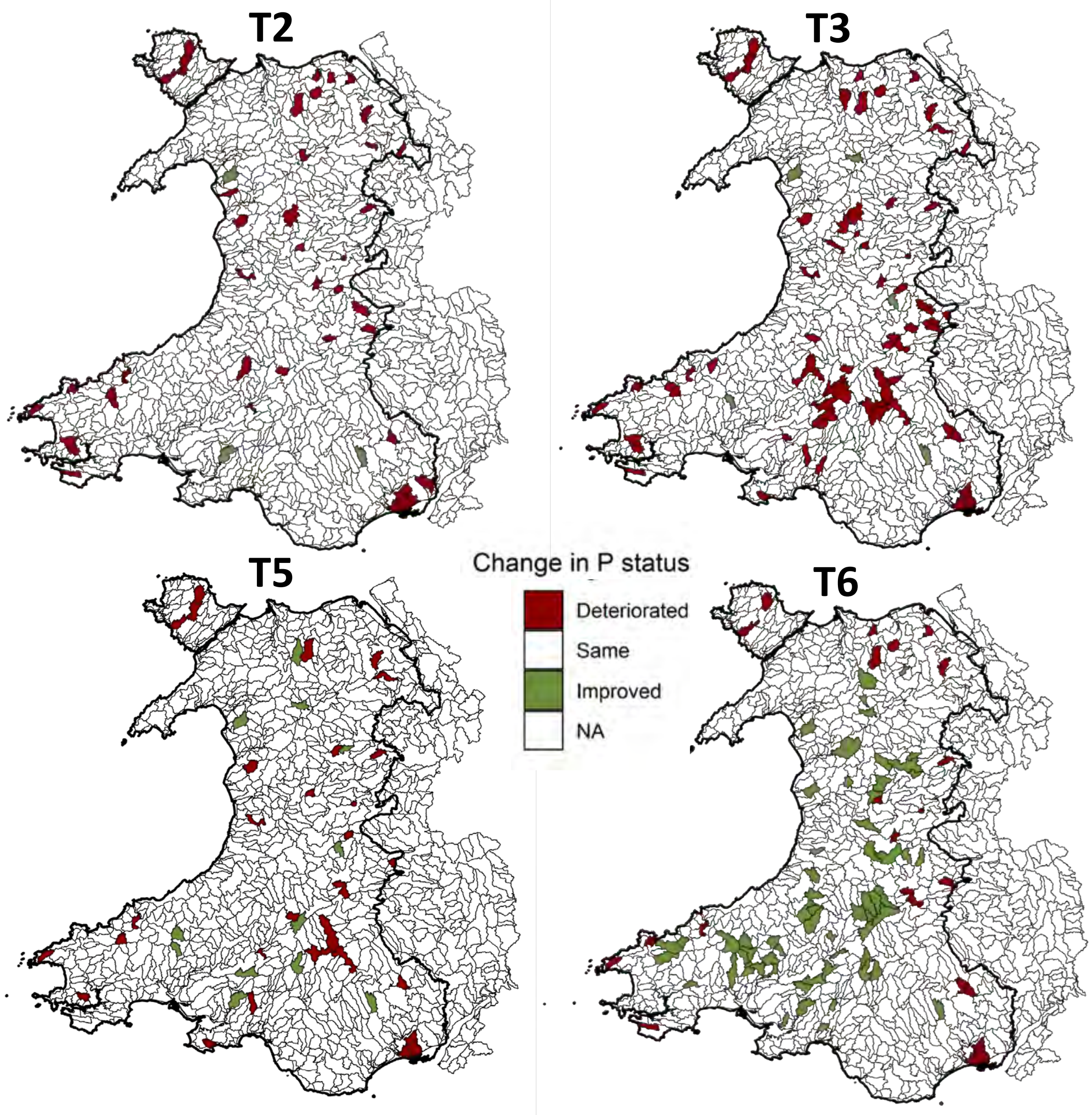
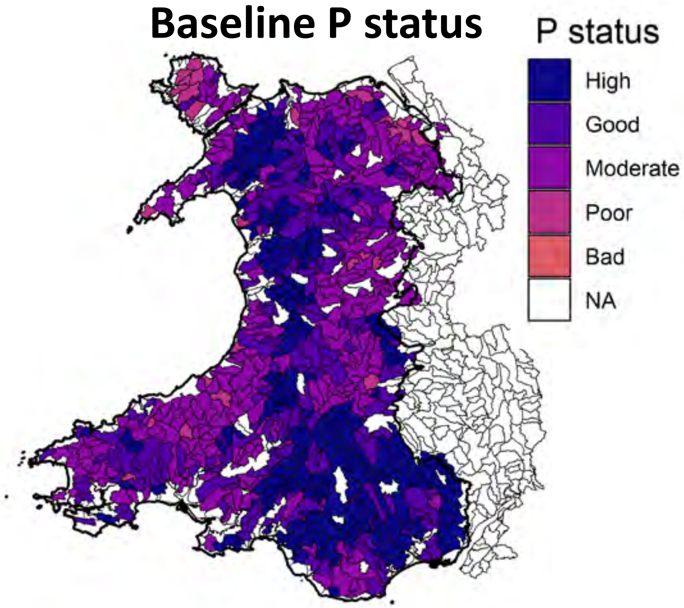
P status and change

- Baseline modelled WFD P status varies significantly across Wales.
- Improvement or deterioration in status was projected for some waterbodies across all scenarios.
- T6 had the most waterbodies with improved status, and T3 had most waterbodies with deteriorating status.



Baseline P status



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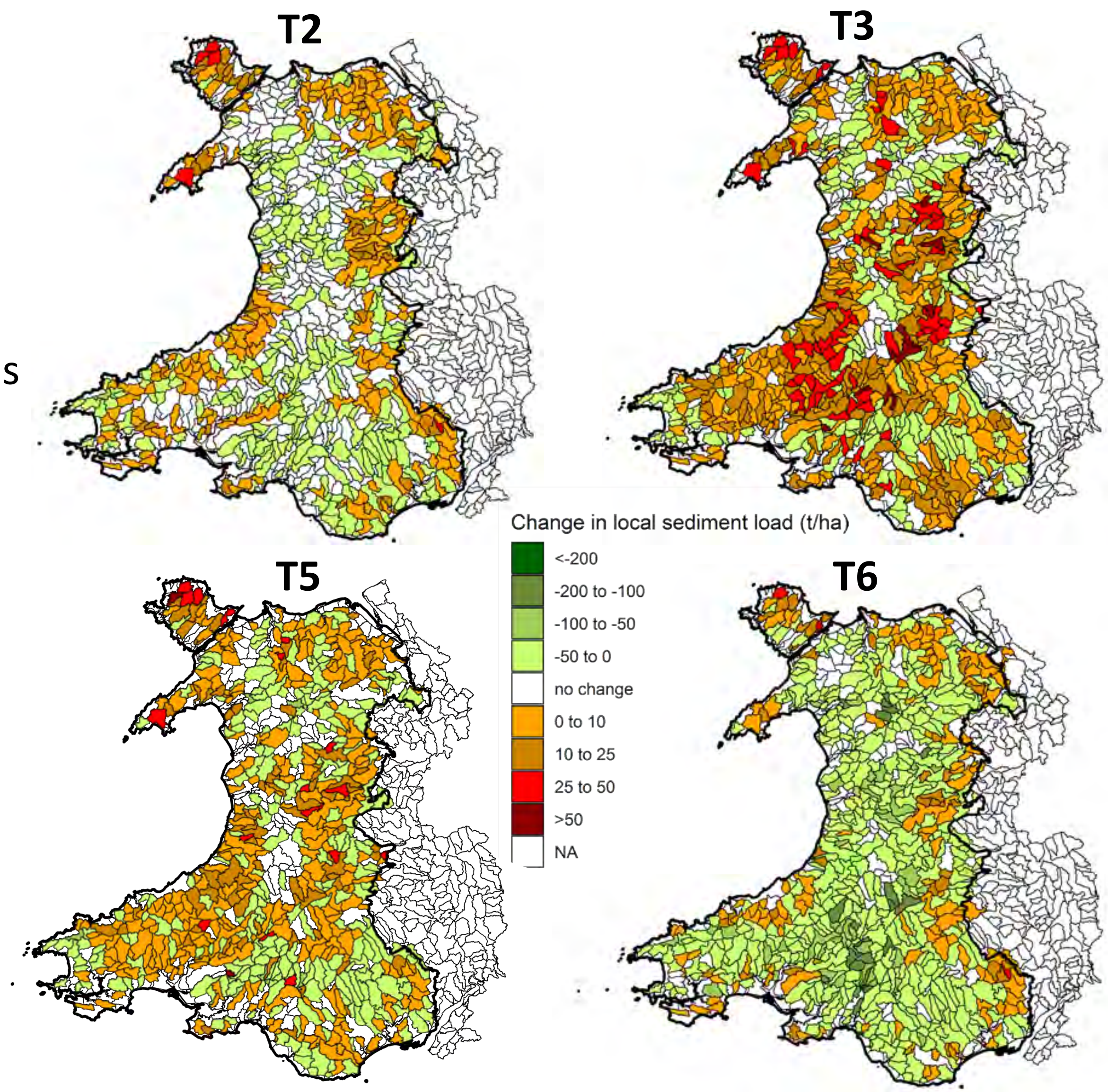
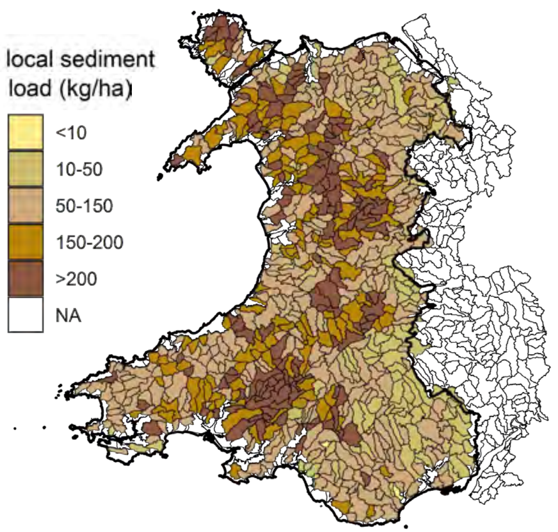
Sediment load and change

- An increase or no change in sediment is projected for most waterbodies, for all but the T6 scenario.
- Decreases in sediment load is projected for some waterbodies under all scenarios.
- Reductions in sediment load dominate the T6 scenario.



Baseline Sediment



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PART 3c: Air quality

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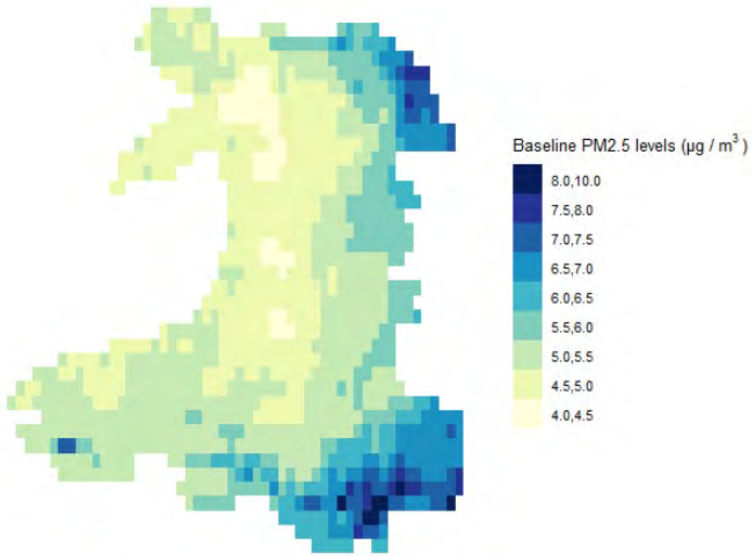
PM2.5 concentration for Wales

Baseline 2015 PM2.5 levels across Wales:



In each 3.5km by 6.5km grid cell, changes in ammonia and in the amount of woodland within a 20km radius result in local changes to PM2.5 levels

Wales - grid cell	T2	T3	T5	T6
Average change in NH_3 (kg)	+11,938	+22,604	+12,665	+8,955
Average change in woodland fraction within 20km radius	0.00	+0.02	+0.01	+0.05
Average change in PM2.5 concentration (µg/m^3)	+0.03	+0.05	+0.03	-0.03

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Patterns of NH_3 & planted woodland differ by scenario, causing differences in net PM2.5 change

NH_3

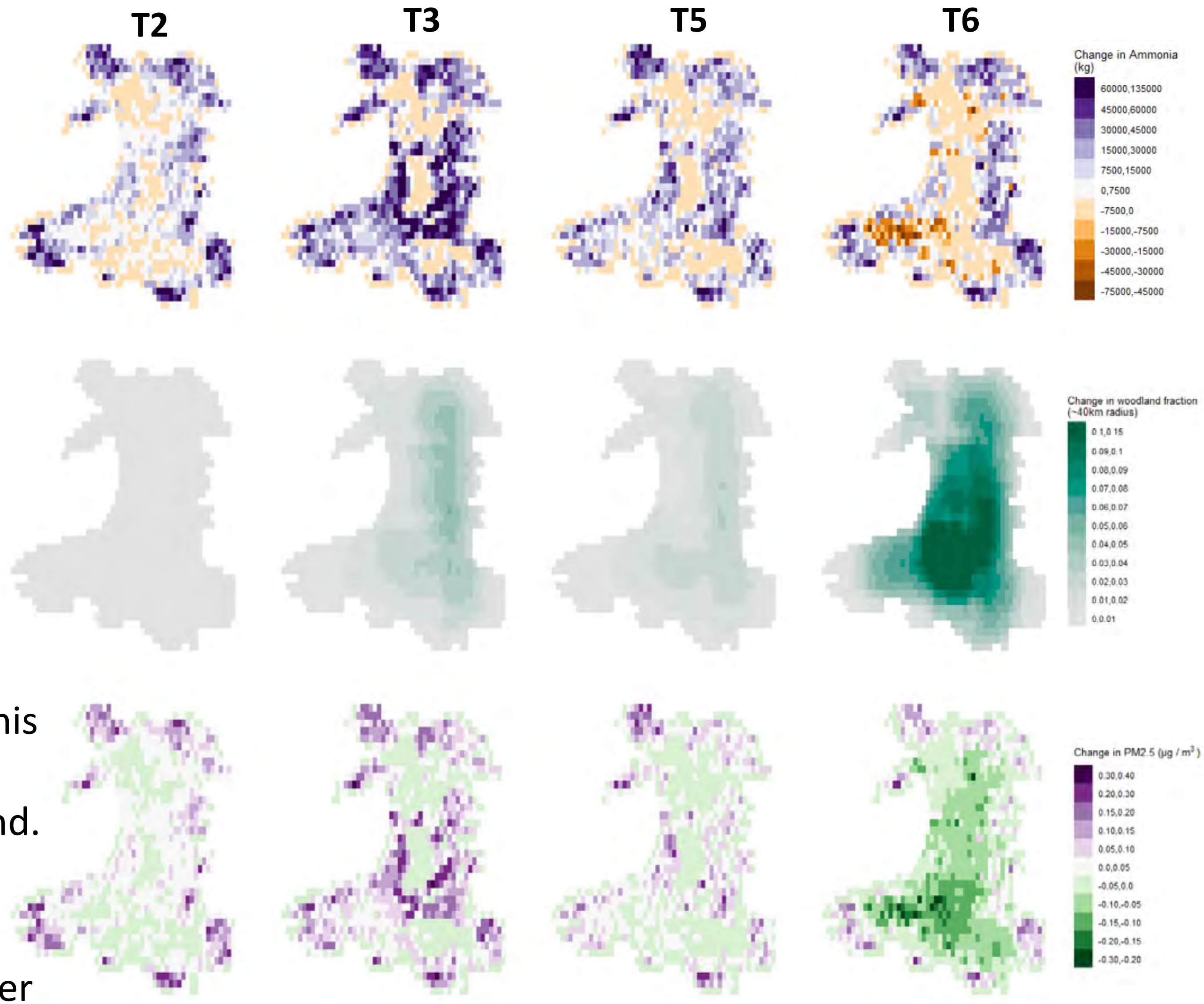
- Greatest increase in T3
- Greatest decrease in T6

Woodland

- Greatest increase in T6
- Smallest increase in T2

PM2.5

- Greatest decrease in T6
- Greatest increases in T2 & T3



- Though T3 has greater NH_3 increases than T2, this is offset somewhat by planting of new woodland.
- Smaller NH_3 increases in T5 with some new woodland leads to smaller changes in PM2.5 levels.

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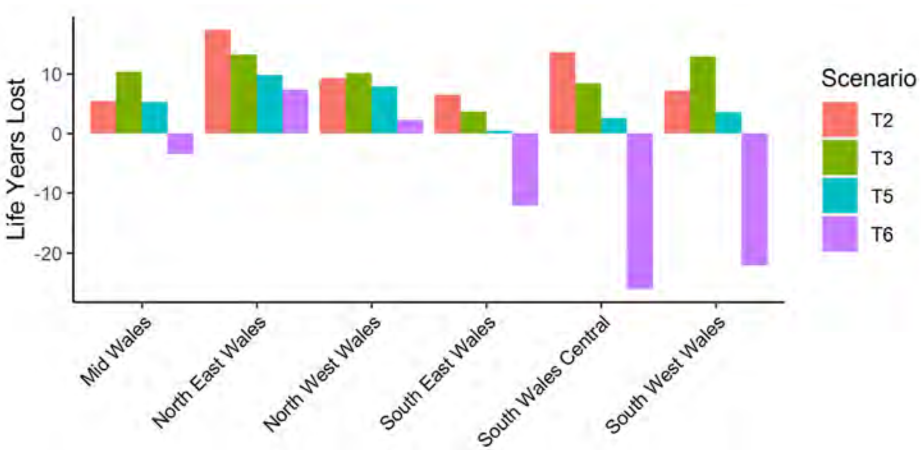
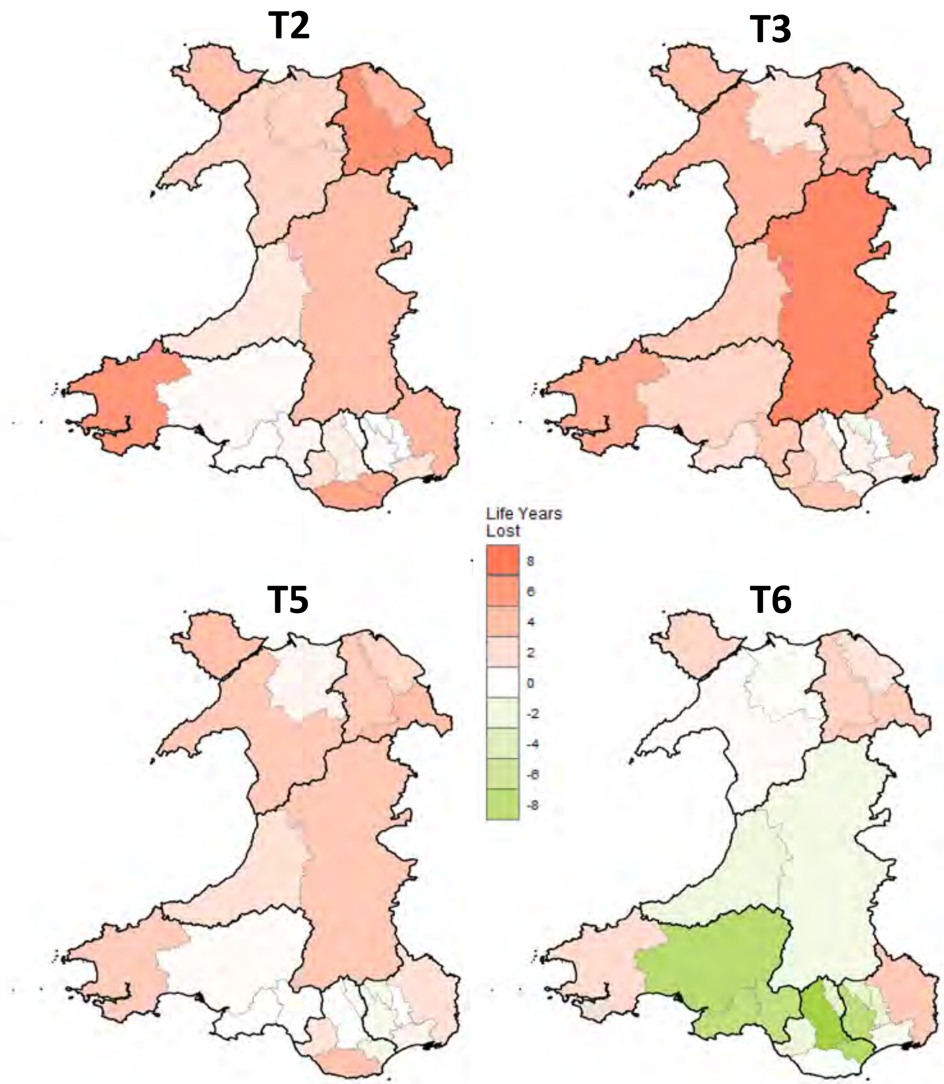
Life Years Lost due to air quality

- Impacts on human health depend on the number of people exposed to lower (or higher) pollution levels.
- At country level - T6 gives the best health outcomes, T2 gives the worst.

Wales	T2	T3	T5	T6
Total change in Life Years Lost	+59.5	+58.6	+29.4	-54.1
Average population weighted change in PM2.5 conc (µg/m³)	+0.04	+0.04	+0.03	-0.02





Impact of PM2.5 levels is measured in Life Years Lost. This metric is the loss of life years across the population in the area of study. A decrease in the number of Life Years Lost is a positive outcome.

PART 4: Valuation

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Valuation results: Background information

- Price year: 2020
- Present values: 75 year time horizon
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g. 3.5% declining discount rate/ health discount rate for air quality):
  - Values are based on BIES (2018) guidance on carbon values for appraisals by Government.
  - This was prior to the release of updated values in September 2021.
  - The 2018 values do not fully reflect the requirements of the Paris Agreement 2016, the domestic net zero target, and other recent policy developments.
- Results given to 3 significant figures.

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Summary of public goods values

	T2		T3		T5		T6		Units
Air Quality	+60 life years lost	- £85m	+59 life years lost	- £85m	+29 life years lost	- £42m	-54 life years lost	£67m	Life Years Lost each year
Water Quality	65 ↘ 3 ↗	- £33m	108 ↘ 5 ↗	- £47m	59 ↘ 12 ↗	- £26m	44 ↘ 58 ↗	£4m	Expected changes in WFD status due to changes in P and N ↘ Deteriorate ↗ Improve
GHG	+117m	- £8,074m	+ 224m	-£15,509m	+120m	- £8,307m	+20m	- £1,243m	Net change in atmospheric TCO_2eq over 75 years

- Colour of cell reflects cost (orange) or benefit (blue) in terms of total monetary value.
- Air quality: Reduction in costs of health impacts from air pollution.
- Water quality: Benefit to people from knowing of/enjoying higher quality freshwater environments.
- GHG: Benefit of reducing atmospheric GHG concentrations from non-traded sources.

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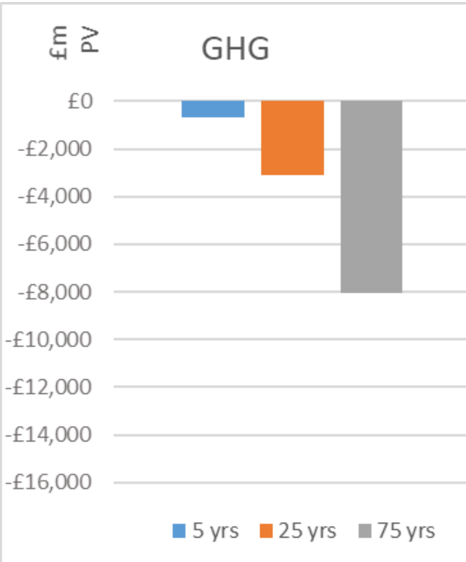
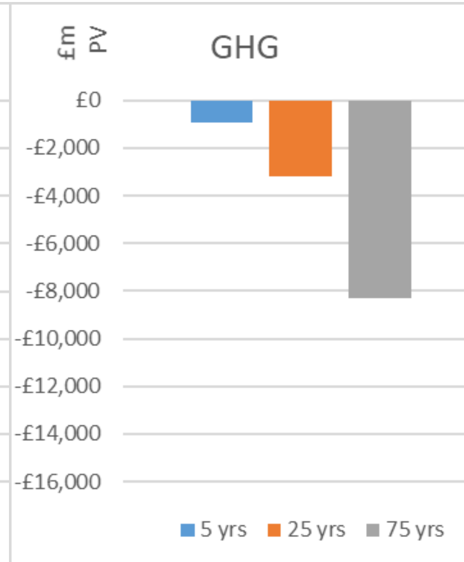
GHG Public Goods Values:
Change over time

T2

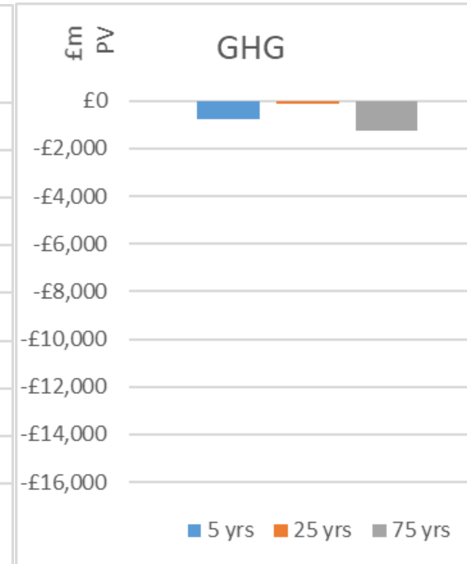


T3

T5



T6



Patterns in GHG emissions reflect combinations of changes:

- Simulated increases in emissions lead to negative £ values in T2, T3 and T5.
- The size of negative value depends on the degree of agricultural intensification and how much this is counterbalanced by sequestration in new woodland.
- Positive and negative emissions from agricultural, woodland and other land use changes broadly cancel out in T6.

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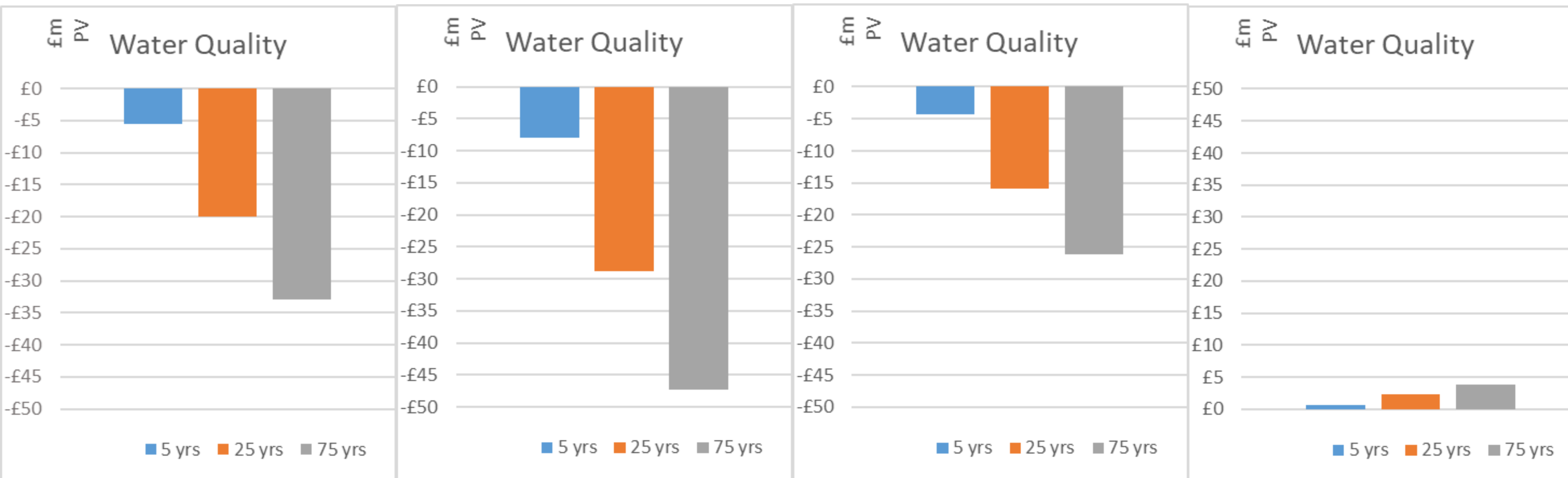
Water Quality Public Goods Values:
Change over time

T2 T3 T5 T6



- Deterioration of water quality is simulated in T2, T3 and T5, which is mainly driven by agricultural intensification and/or change.
- In T6, deteriorations in water quality due to agricultural intensification are slightly outweighed by improvements due to some farmland converting to woodland.

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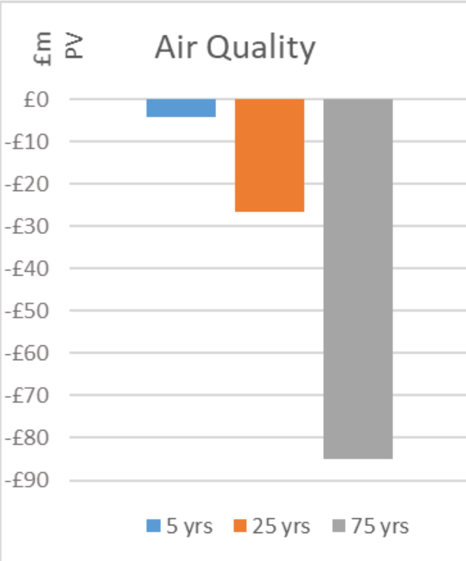
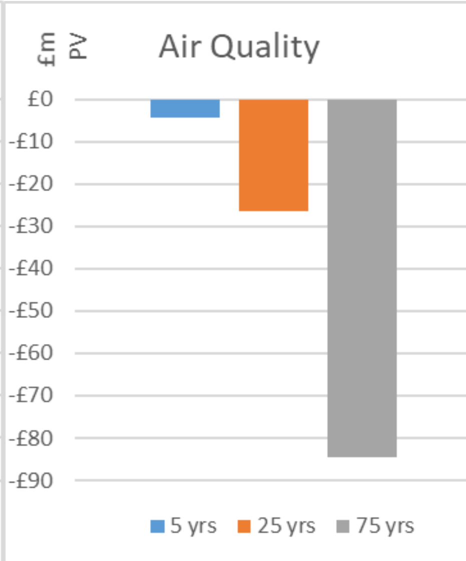
Air Quality Public Goods Values:
Change over time

T2

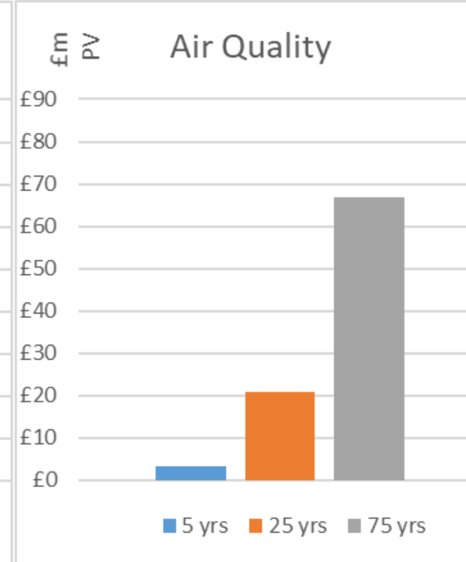


T3



T5

T6



- Deterioration of air quality is simulated in T2, T3 and T5 reflecting the negative impact of agricultural intensification outweighing impact of new woodland creation.
- Improvements in air quality are simulated in T6 due to farmland converting to woodland, particularly closer to urban settlements in Northeast, South and Southeast Wales.

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PART 5: Conclusion

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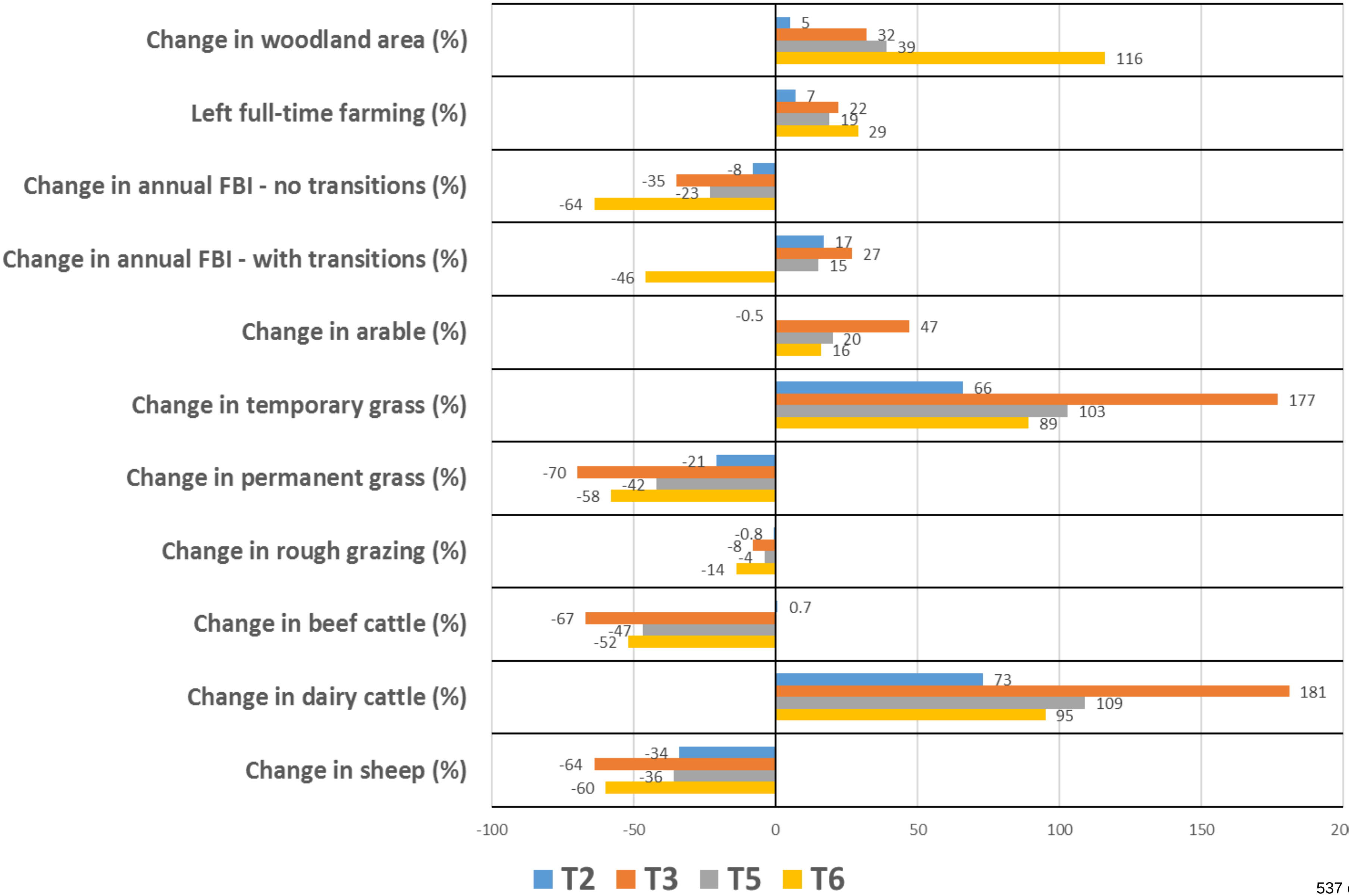
Summary of Impacts (Land Use)



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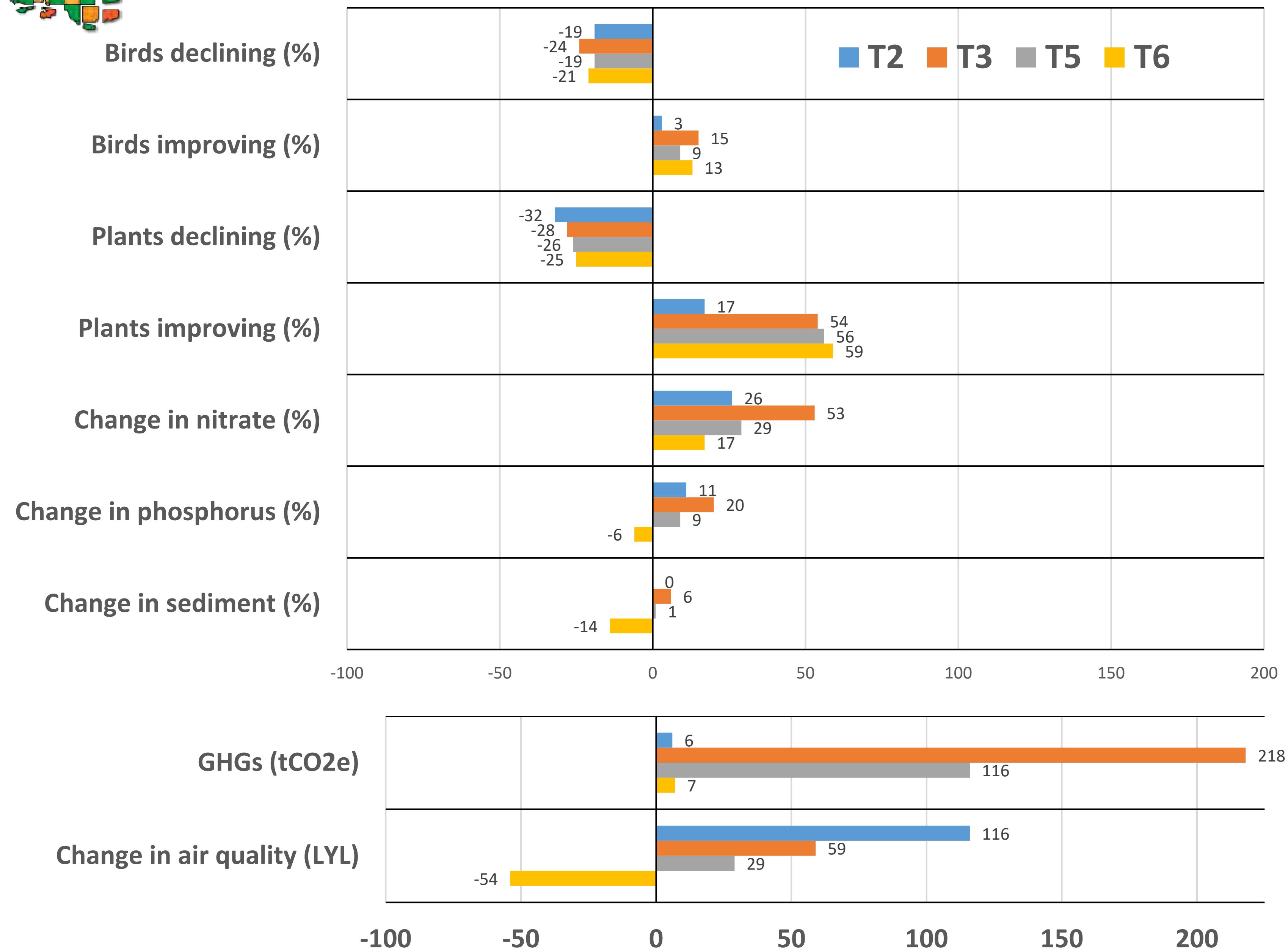
Summary of Impacts (Public goods)



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Summary of Impacts:
Physical and Monetary Values

	Physical Values					Monetary Values				
	T2	**T3**	**T5**	**T6**	**Units**	**T2**	**T3**	**T5**	**T6**	**Type of value**
Agricultural Income	7%	22%	19%	29%	Farms at risk of leaving full time agriculture	-20M (No Transition) +43M (with transition)	-91M (No Transition) +70M (with transition)	-58M (No Transition) +39M (with transition)	-163M (No Transition) -119M (with transition)	Total farm business income (per year)
Air Quality	+60 LY lost	+59 LY lost	+29 LY lost	-54 LY Lost	Life Years Lost each year	- £ 85M	- £ 85M	- £ 42M	+£ 67M	Reduction in costs of health impacts from air pollution
Water Quality	65↘ 3↗	108↘ 5↗	59↘ 12↗	44↘ 58↗	Expected changes in WFD status due to changes in P and N	- £ 33M	- £ 47M	- £ 26M	+£ 4M	Benefit to people from knowing of/ enjoying higher quality freshwater environments
	(number of water bodies)									
GHG	+117M	+ 224M	+120M	+20M	Net change in atmospheric TCO_2eq over 75 years	- £ 8,074M	-15,509M	- £ 8,307M	- £ 1,243M	Benefit of reducing atm GHG concentrations from non-traded sources
Biodiversity	19%↘ 3%↗	24%↘ 15%↗	19%↘ 9%↗	21%↘ 13%↗	Bird species	N/A				Percentage of groups with significant increase or decrease
	32%↘ 17%↗	28%↘ 54%↗	26%↘ 56%↗	25%↘ 59%↗	Plant species	N/A				

Final Considerations

- This slide pack shows results from applying the Integrated Modelling Platform to four trade scenarios all of which include a deal with the EU.
- The scenarios were provided by Welsh Government based on a series of internal and external workshops as changes in farm gate (output) prices and input costs.
- All scenarios were applied to a baseline that includes CAP Pillar 1 payments. Any SFS payments are considered to be cost neutral and do not influence farm economics.
- The economic accounts presented are partial and based solely on the components explicitly mentioned. Other significant aspects (e.g. recreation) are not valued here.
- Changes in land use are driven by on-farm economics and land suitability. They do not take into account skills or cultural and behaviour responses.
- The IMP is applied to only full-time farms (> 1 FTE labour).
- A farm that is categorised as under pressure is based on being unable to achieve a full-time annual FBI of £6,000. As a simplification, the biodiversity and ecosystem service models in the IMP assume that such a farm will leave agriculture in the short-term, with the land undergoing natural regeneration or being afforested.
- The IMP has been developed following Aqua book guidelines. All the assumptions underlying the IMP are fully documented and have been signed-off by Welsh Government.

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PART 6: Glossary and Context

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Glossary: Key Acronyms (I)

- FAPRI: Food and Agricultural Policy Research Institute
  - FAPRI-UK Model was used to underpin assessments of the impacts of Brexit on the UK agricultural sector. More information: (Web-link)
  - Macro-economic model of the UK in a global context. Used to identify impacts of global trade. The FAPRI-UK model (created and maintained by staff in AFBI-Economics) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with submodels covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) model run by FAPRI at the University of Missouri.
- MFTA: Multi-lateral free trade agreement
  - Free trade agreement between three or more countries without discrimination between those involved.

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Glossary: Key Acronyms (II)

- LULUCF: Land use, land-use change, and forestry
  - Standardised approach to the greenhouse gas inventory that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.
  - Used in this project to quantify impacts of land use change on carbon.
- MFN: Most Favoured Nation
  - World Trade Organisation (WTO) terminology. Under the WTO agreements, countries cannot normally discriminate between their trading partners. As such countries must treat all other WTO members as they would their "Most Favoured Nation". More information: (Web-link)
  - Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

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Glossary: Key Acronyms (III)

- WFD: Water Framework Directive
  - EU directive targeted at improving water quality and integrated catchment management.
- UKTAG: UK Technical Advisory Group (on the WFD)
  - The UKTAG is a working group of experts drawn from environment and conservation agencies. It was formed to provide technical advice to the UK's government administrations and its own member agencies.
- LFA: Less-favoured area
  - Term used to describe an area with natural handicaps (lack of water, climate, short crop season and tendencies of depopulation), or that is mountainous or hilly, as defined by its altitude and slope.
- SDA / DA: Severely Disadvantaged Areas / Disadvantaged Areas
  - Sub-classes of LFA separating out the most severely disadvantaged areas for the purposes of basic payment scheme (BPS) grant payments.

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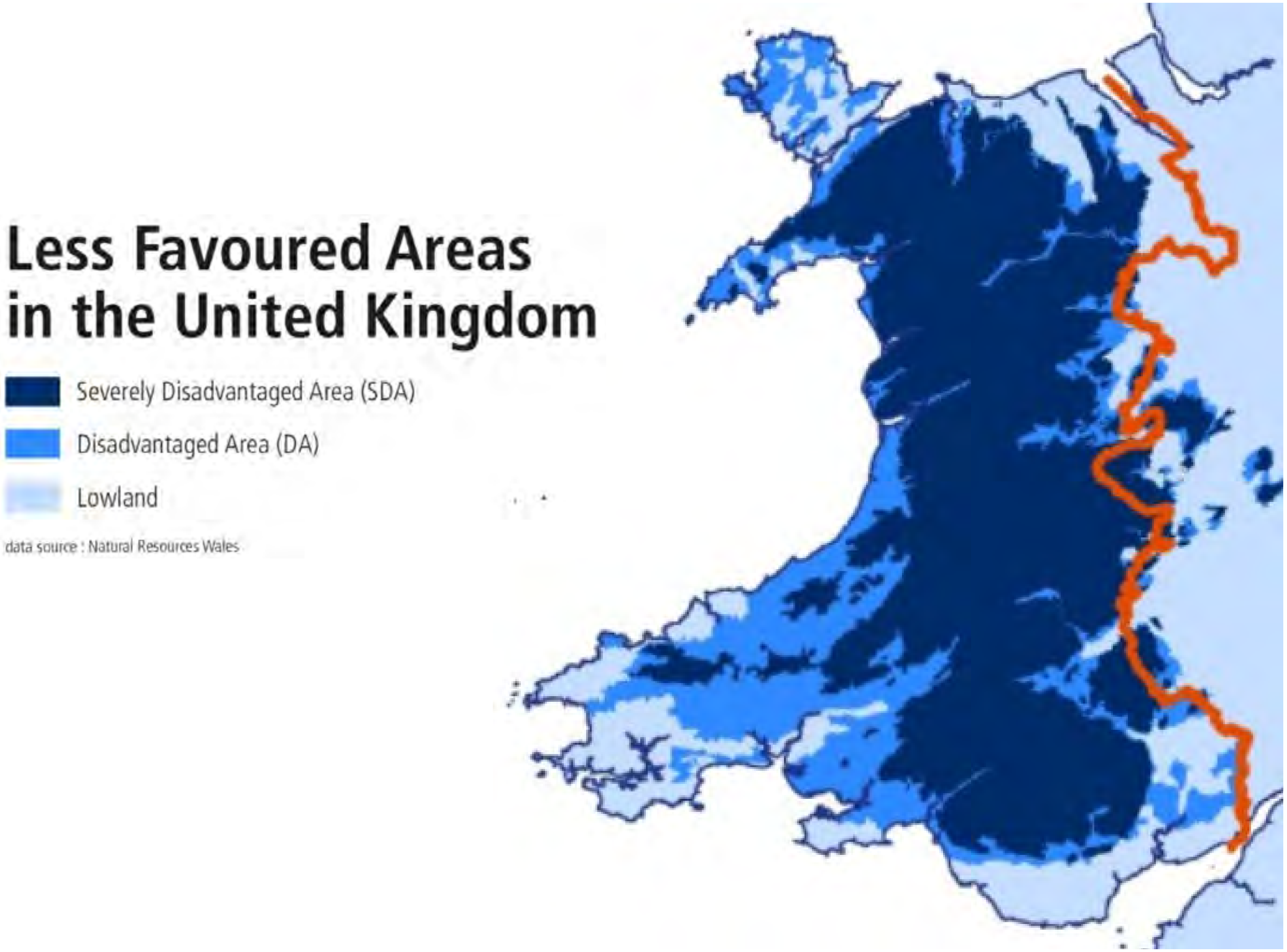
Severely Disadvantaged Areas/ Disadvantaged Areas in Wales



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Glossary: Key Acronyms (IV)

- RFT : Robust Farm Type
  - Robust farm type (used in previous Welsh Farm Practice Surveys).
  - Classes: Cereals; General Cropping; Horticulture; Specialist Pigs; Dairy; LFA Grazing Livestock; Lowland Grazing Livestock and Mixed.
- EFT: ERAMMP Farm Type
  - ERAMMP farm type (used within the IMP) is based on the RFT with additional detail on less favoured areas.
  - Classes: Cereals, General cropping, Dairy, Lowland cattle / sheep, Mixed , Specialist Sheep (SDA), Specialist Beef (SDA), DA various grazing, SDA mixed grazing .
- SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation: Names and acronyms for models within the IMP (see this slide)

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Glossary: Key Acronyms (V)

- ERAMMP – Environment and Rural Affairs Mapping and Modelling Project.
  - Consortium Project led by the UK Centre for Ecology & Hydrology (UKCEH) and funded by the Welsh Government (WG).
  - Consortium members involved in these slide packs include Cranfield University, ADAS, the British Trust for Ornithology (BTO), eftec, Forest Research (FR) and UKCEH.
- IMP – Integrated Modelling Platform
  - The modelling platform used to produce the results shown in this slide pack. The platform combines the following models which pass data to one another as large multi-parameter data cubes:
    - SFARMOD: Whole farm model
    - ESC: Tree species suitability
    - CARBINE: Forest products, carbon and forest net present value
    - LAM: Land allocation model
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - Woodland habitat connectivity model
    - Ecosystem service models for carbon and water quality
    - EMEP4UK Emulator: health impacts of air pollution
    - Valuation: monetary and non-monetary valuation of public goods

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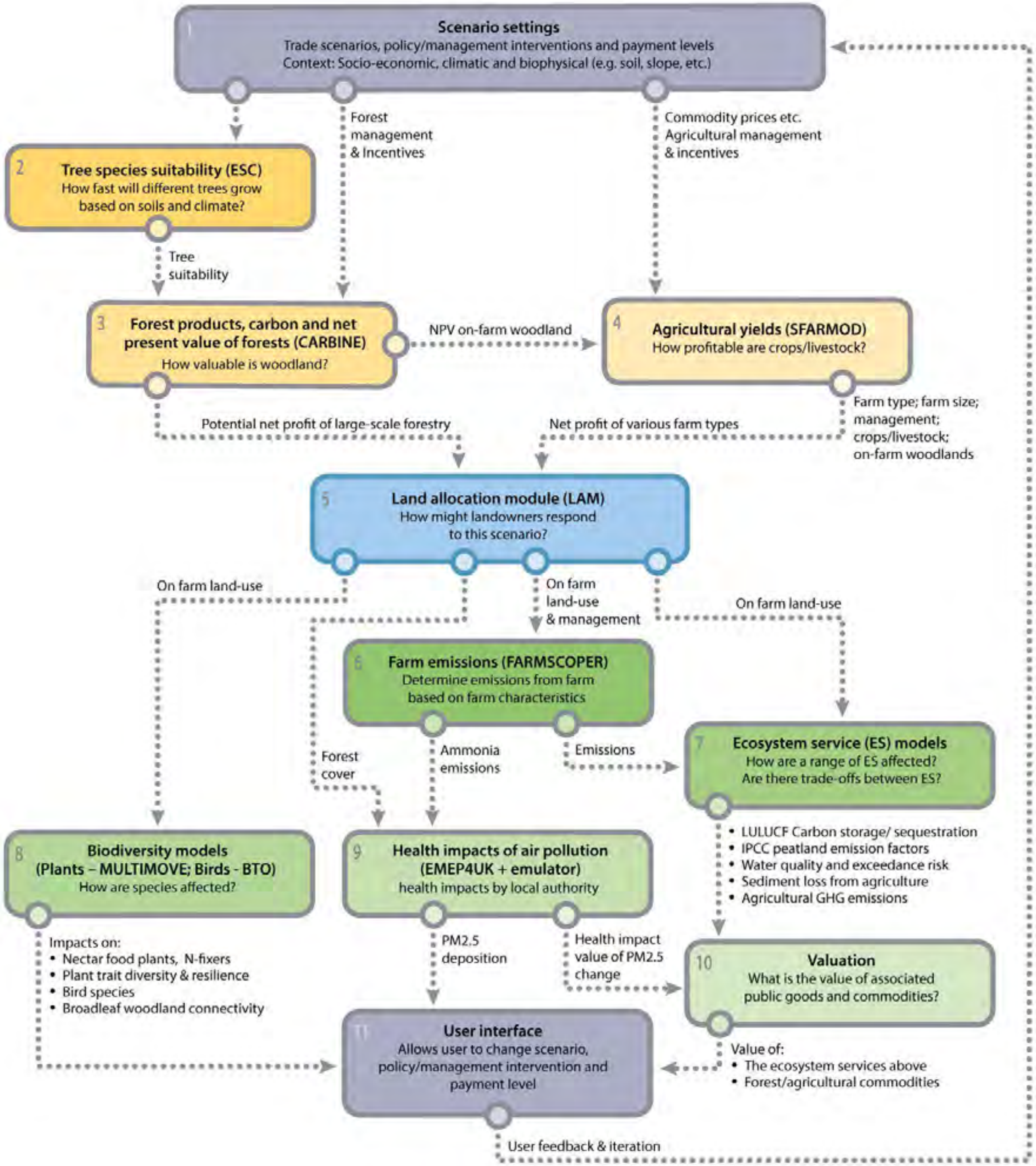
Integrated Modelling Platform schematic



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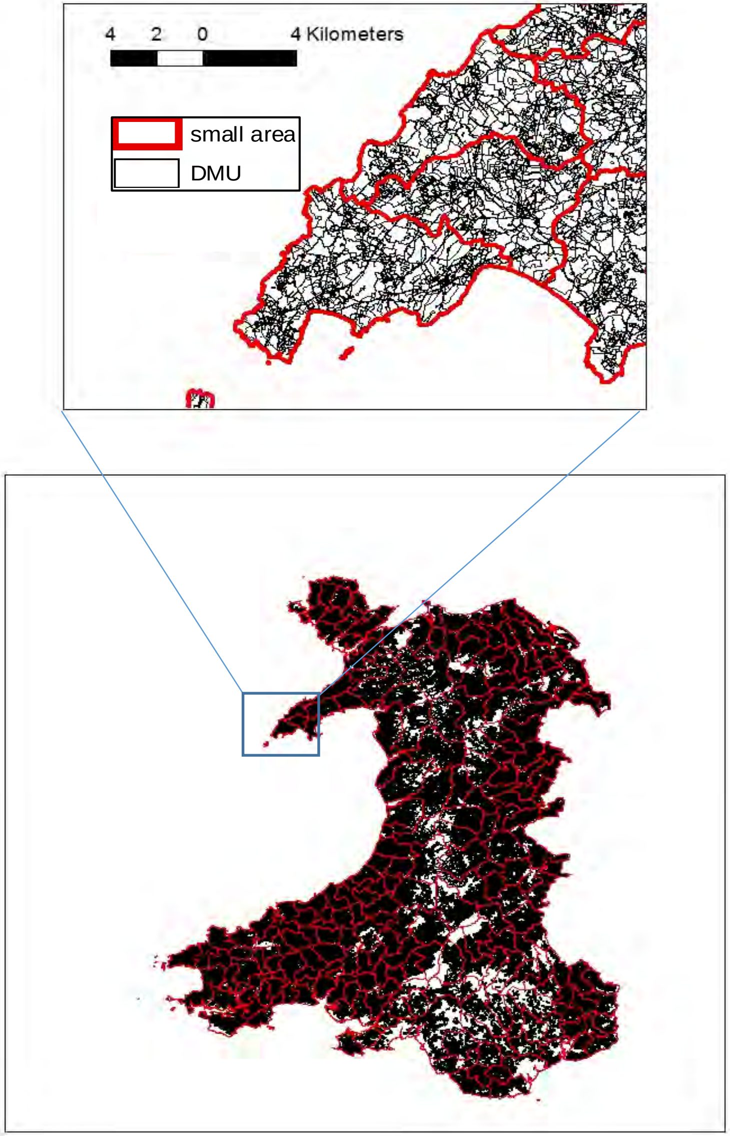
IMP modelling scales



- The IMP operates at various spatial resolutions depending on what scale is most appropriate for the indicator being simulated.
- The finest spatial resolution used by Sfarmod and the Land Allocation Module (LAM) for simulating farm type and land use transitions is the Decision-Making Unit (DMU).
- A DMU is defined as a managerially homogenous cluster of soil type, rainfall and land cover.
- Results in the slide pack are aggregated to small agricultural areas as findings are more robust at this level.

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