Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Report-134: Integrated Modelling Platform (IMP) Preferred Way Forward (PWF) Scenarios

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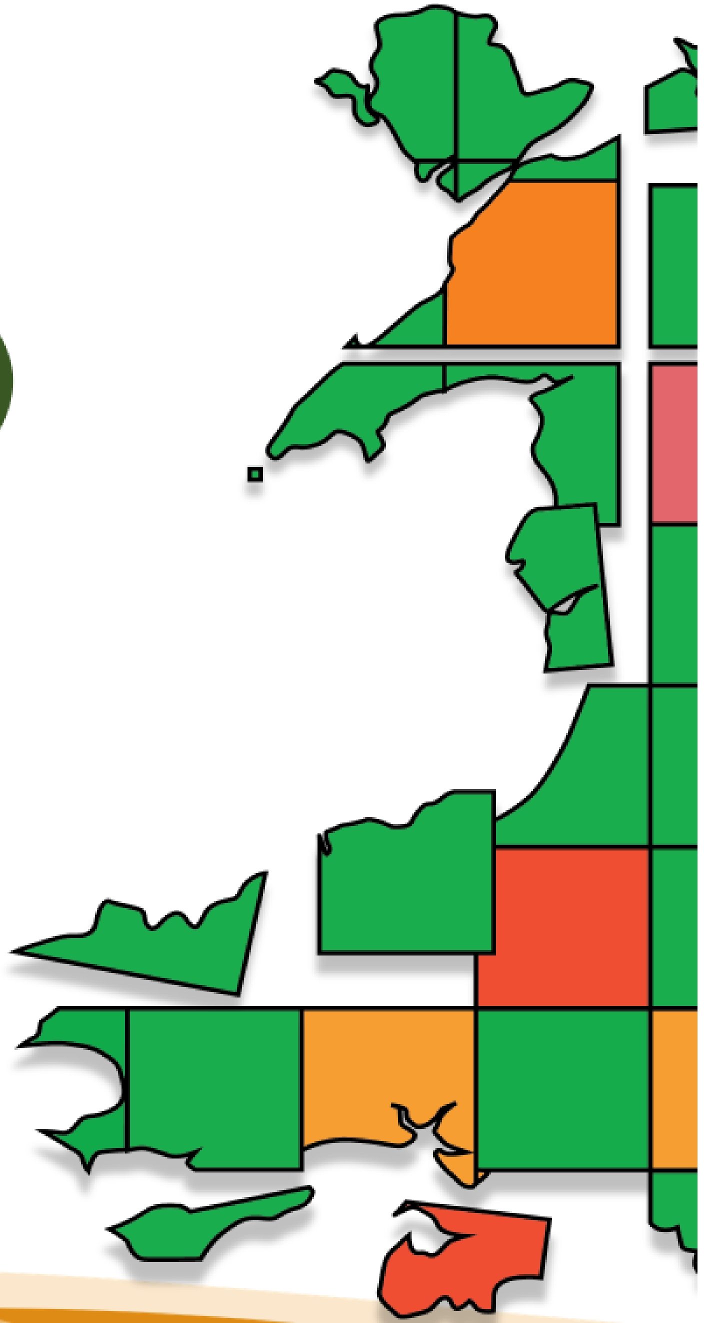
ERAMMP
Integrated Modelling Platform (IMP)

Preferred Way Forward (PWF) Scenarios

May 2025



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The Baseline:
Summary of 2024 updates to the modelling framework and baseline data

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Between May and November 2024, the IMP Consortium was tasked to update the modelling framework and baseline.
The previous IMP assumptions can be found in Annex 1 of the Land Use Scenarios Report (https://erammp.wales/sites/default/files/2023-08/60-ERAMMP-Report-60-IMP-Land-Use-Scenarios-Final-Report_en.pdf)

The ERAMMP2 IMP Model Assumptions (as used in the PWF scenarios) can be found at: www.erammp.wales/133

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Baseline data: Economic baseline

- The IMP **economic baseline is 2023**.
  - The Farm Business Survey (FBS) is a key input, the most recent available data at the time of updates was 2022-23. This is also consistent with separate ADAS economic modelling.
- **Costs and commodity prices from the John Nix Farm Management Pocketbook 2023**
  - John Nix prices were used over actual market prices as the milk prices were particularly high in 2022/23. Nix prices are conservative in that they smooth over price spikes in both inputs and outputs.
  - Nix prices were deemed more appropriate as SFARMOD is a long-term business planning model; not designed to simulate the short-term response of the industry.
  - Using a single year of high prices would have resulted in high simulated dairy profitability that is unreflective of longer-term conditions.

Earlier IMP runs used a baseline of 2015

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Updates to baseline data: Farm boundaries & type

- The farm boundaries, farm type and standard labour requirement classification (part-time, spare-time or full-time classes) were **updated to 2021** from 2017.
- This was the most recent June Agricultural Survey and Land Parcel Information System (LPIS) farm and field boundary data available at the time of updates.

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https://metadata.naturalresources.wales/geonetwork/srv/api/records/EXT_DS100191?language=eng

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Updates to baseline data: spatial infrastructure and land cover

- The IMP land cover was **updated to use LCM 2021** from LCM 2015 in combination with detailed RPW Woodland Canopy Cover data.
- The IMP uses Decision Management Units (DMUs) as the fundamental spatial units for agricultural modelling of each farm.
- A DMU is fields or clusters of fields defined according to farm-specific discretised (banded) soil, rainfall, slope, altitude and recent farm type and land cover.
- The DMUs have been updated with new farm type, boundaries and biophysical data (including LCM 2021, RPW Woodland Canopy Cover, peat, topography and river networks).
- LPIS polygons within 'enclosed' and 'unenclosed' land were treated differently.
    - Enclosed: LPIS fields were used as the spatial basis for the DMUs.
    - Unenclosed: LPIS fields were split based on a combination of land cover and soil type.

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Updates to the LAM thresholds: economic viability and uptake

The Land Allocation Module (LAM) of the IMP assesses the response of each > 1 FTE farm across Wales by comparing the simulated Farm Business Income (FBI) against a series of thresholds and rulesets which determine viability, sale and ERAMMP farm type (EFT) change.

The following updates were made:

1. **SFS Uptake**: No changes made: farms enter SFS if the farm > £1 more profitable (FBI) than if they don't enter SFS.
2. **Farm Viability Threshold**: Reduced from £6,000/yr to £0
    - Given farm variability in Wales there is no single appropriate threshold, and each farm will make different decisions on long-term viability. Only farms modelled to make a long-term loss are considered as 'unviable' within the modelling.
3. **Farm sale or abandonment**: Farms no longer leave agriculture through sale or abandonment if 'unviable'. They instead transition to part-time (staying as the current EFT). Note, the IMP assumes no change to the management of the farm.

Run descriptions

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Baseline: 100% BPS

- Assuming 100% payment of BPS
- 2023 prices used (based on farm-gate prices from John Nix Farm Management Pocketbook).
- Farm type transitions (changing EFT, leaving full-time agriculture) **are not** allowed in the baseline.
- The Good Agricultural & Environmental Conditions (GAEC) requirements and costs **are** included.
- Control of Agri-Pollution Regulation (CoAP) regulation requirements and costs **are not** included.

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EFT: ERAMMP Farm Type

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Counterfactual: 100% BPS & CoAP

- Assuming 100% payment of BPS
- 2023 prices used (based on farm-gate prices from John Nix Farm Management Pocketbook).
- Farm type transitions (changing EFT, leaving full-time agriculture) **are not** allowed in the baseline.
- The Good Agricultural & Environmental Conditions (GAEC) requirements and costs **are** included.
- Control of Agri-Pollution Regulation (CoAP) regulation requirements and costs **are** included.

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EFT: ERAMMP Farm Type

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PWF Scenarios: SFS Universal Layer

- The PWF scenarios represent elements of the SFS Universal Scheme (at the time of scenario development)
- Payment rates (see following slides).
- GAEC and CoAP requirements and costs **are** included.
- Farm type transitions (changing EFT, leaving full-time agriculture) **are not** allowed*.
- Each farm has the option of entering the **SFS Universal scheme** or not:
  - Farms are assumed to enter if the simulated Farm Business Income (FBI) at the given payment level is greater within the scheme that outside (compared to the 0% BPS & CoAP simulation);
  - If a farm enters SFS, all applicable components of SFS Universal Layer are implemented.

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*Farm transitions were turned off for PWF. The LAM allows transitions between farm types when the simulated farm FBI exceeds a series of thresholds. Thresholds include those for long-term sustainability, business capacity to adapt to change, profit incentive to finance change and minimum herd sizes for dairy farms. Transitions represent a core component of the economic optimisation within the IMP and allow understanding of where, given the scenario being modelling, it may be economically advantageous for farm businesses to change enterprise over the longer term.

The Universal Layer of the scheme is not the totality of the SFS. Whilst not timebound, farm transitions simulate changes that may occur over the longer term as the sector responds to a new policy environment. Given the Universal Layer will be accompanied by the Optional/Collaborative scheme layers, it was agreed that it is not informative to simulate a longer-term structural response to the Universal Actions only. Furthermore, turning farm transitions on adds complexity to the outputs. The new baseline year was particularly profitable for dairy. This, combined with high scheme uptake may lead to unrealistically high levels of farm transitions, particularly to dairy.

Farms with an FBI < £0 are assumed to transition to part-time but the IMP does not model this through the chain. When farms transition to part-time farming, there are many options available to the farmer, such as reducing herd size, changing farm composition, renting out land or increasing non-agricultural sources of income. As the range of options is large and potentially complex, the IMP assumes no change to the current management of the farm.

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Summary of runs

Run	Name	BPS	GAEC	CoAP	SFS	Farm Transitions
1	Baseline: 100% BPS	✓	✓	X	X	X
2	Counterfactual: 100% BPS	✓	✓	✓	X	X
3	Scenario PWFa: 0% BPS & SFS (payment 1)	X	✓	✓	✓	X
4	Scenario PWFb: 0% BPS & SFS (payment 2)	X	✓	✓	✓	X

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BPS: Basic Payment Scheme
GAEC: Good Agricultural and Environmental Conditions
CoAP: Control of Agricultural Pollution Regulations
SFS: Sustainable Farming Scheme
PWF: Preferred way forward
ToC: Top of Chain (agricultural and land allocation module components of the IMP)

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Preferred Way Forwards (PWF) scenario runs

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Scenario: PWF

The SFS sits above the minimum requirements set out in law (GAEC & CoAP) and comprises three layers:

1. **Universal layer – (modelled in the PWF scenarios) comprises of actions which all farmers participating in the scheme need to undertake, in exchange for being paid the Universal Baseline Payment.**
2. Optional layer (not currently modelled) – optional actions are where farmers can choose actions above and beyond the Universal Actions depending on what suits their farm business and ambitions the most, in exchange for being paid additional scheme payments.
3. Collaborative layer (not currently modelled) – collaborative actions are where farmers can choose to work together and with others in a coordinated way to collectively deliver outcomes that cannot be delivered on a single farm scale, in exchange for being paid additional scheme payments.

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Scenario: PWF

The modelled PWF Universal Layer Scenario comprises of:

1. Entry requirements: completion of a carbon
2. Twelve mandatory actions (subject to constraints & eligibility)
3. One scheme rule: At least 10% of eligible land in each farm is managed as habitat

The modelled PWF Universal Layer Scenario reflects scheme design at the time of model development, therefor it is possible that alterations have been made to the scheme since then. For up-to-date scheme information, please refer to the Welsh Government website.

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Scenario: PWF Universal Layer Payments

The modelled PWF scenario payments are made via the **Universal Baseline Payment plus Social Value.**

The Universal Baseline and is an estimate of average cost-incurred and income forgone for a farmer to undertake the Universal Actions. This will be paid against the whole farm, taking account of improved land, areas of woodland and habitat, and any common land grazing rights (not modelled in IMP).

	Payment	Description	PWFa (£/ha)	PWFb (£/ha)
Universal Baseline Payment	**Maintenance of existing woodland**	Payment value for each hectare of existing woodland that is managed	62	62
	Habitat maintenance (farmland)	Payment value for each hectare of semi-natural habitat managed, and/or each additional hectare of temporary habitat up to the required 10%, once created	69	69
	Whole Farm Payment*	Payment value for each hectare covering all other Universal Actions on the total eligible area	31	31
	Social Value Payment*	This payment is per hectare in addition to any costs incurred and income forgone. Applied to the whole farm	**115**	**70**

*Payable to Common Land

- Two of the four Universal Baseline Payment elements are payable to commons land (subject to Common Land Collaboration). Payments will be made following the same approach as in BPS to prevent multiple payments for the same land.
- The IMP does not model Common Land in Sfarmod or the LAM as it cannot be reliably identified or linked to farms by either JAS or LPIS.

During the Transition Period (2025 – 2029), any farms joining SFS and receiving a BPS payment in 2024 *may* receive a Stability Payment. **This is not represented in IMP SFS7. The tapered BPS payment is also not modelled.**

No other payment elements (e.g. capping of higher value payments) are represented in the IMP PWF Scenarios.

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Scenario: PWF Universal Layer cost assumptions

The following are the cost assumptions implemented within the IMP where they are aggregated to the farm level. Costs are applied to the modelled farms to understand, alongside the simulated payment rates, whether it is of economic benefit to enter the Scheme but also influence the economic optimisation of model farm structures (e.g. land use, stocking), All Universal Action (UA) interventions are mandatory (where not subject to constraints):

	Action	Assumptions
*	Habitat Baseline Review	Regarded as part of the application process. No cost within SFS
*	Carbon calculator	1 day per year of farmer time
UA1	Soil health	Per field: 18 minutes plus analytical cost of testing
UA1	Nutrient management plan	2 days per year of farmer time
UA1	Nutrient management reporting	1 day per year of farmer time
UA2	Integrated Pest Management (IPM)	2 days per year of farmer time
UA3	Benchmarking	1 day per year of farmer time
UA4	CPD	Minimum 7-year hours per year. 6 hours + mandatory H & S
UA5	Habitat Maintenance	Stock reduction on rough grazing if baseline stocking exceeds habitat-based threshold*** Pond maintenance: cost/m2/yr irrespective of pond size
UA6	Creation of temporary habitat	Land out of production on arable and intensive grassland
UA7	Designated sites	1 day per year of farmer time
UA8	Hedgerow maintenance	Planting of new hedgerow trees in hedgerows not in management at baseline
UA9	Woodland maintenance	Cost neutral
UA10	Tree planting opportunity plan	1 day per year of farmer time
UA11	Historic features	1.5 days per year of farmer time
UA12	Animal welfare	3.3 hrs per year of farmer time
UA12	Animal Health Improvement Cycle (AHIC)	1 day per year of farmer time, 0.5 days per year of vet time
UA12	Biosecurity	0.5 days per year of farmer time, 0.5 days per year of vet time

The ERAMMP2 IMP Model Assumptions (as used in the PWF scenarios) can be found at: www.erammp.wales/133

*Part of the SFS application process
** Additional to the CoAP
***This is a simplifying assumption to reflect that, whilst some habitat land may be more than 1 ewe per ha over the guidance levels, some stock is likely to be moved elsewhere on the farm rather than removed but this is not a response which is modelled.

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Scenario: PWF Woodland maintenance assumptions

- On-farm woodland is identified from both the 2021 LCM and RPW Woodland Canopy Cover. It is classed as broadleaf, conifer, mixed broadleaf, mixed conifer or unknown.
- Conifer woodland > 30ha is assumed to be in active management. All other farm woodland is assumed to be not managed in the baseline (and to not generate a positive contribution to FBI).
- All existing broadleaf woodland (> 0.1ha) and single trees/groups of trees (< 0.1ha) of any type are brought into management to meet habitat land target requirements.
- Woodland maintenance is assumed to be cost neutral, with no effect on FBI. This is due to the large uncertainty around the age and condition of existing woodland, and the extensive range of options for woodland.
- The IMP assumes no change in carbon from woodland maintenance.

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Scenario: PWF Hedgerow maintenance assumptions

- All existing hedgerows are maintained on entry to the SFS.
- Unmanaged hedgerows (not in an existing Agri-Environment Scheme (AES) at baseline):
  - Increase by 5cm every 2 years from a baseline size of 1m x 1m to an optimal width and height of 3m x 2m respectively.
  - One native tree sapling is planted every 50m. The cost of hedgerow tree planting is modelled as being incurred by the farmer and not covered by the SFS payment rate. Costs from John Nix Farm Management Pocketbook, 2023.
- Managed hedgerows (in an existing AES at baseline):
  - Increase by 5cm every 2 years from a baseline size of 2m x 2m to an optimal width and height of 3m x 2m respectively.
  - One native tree sapling is supported to grow every 50m. No costs incurred.

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Existing hedges were identified using the Woody Linear Features layer. https://www.ceh.ac.uk/data/woody-linear-features-framework

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Context

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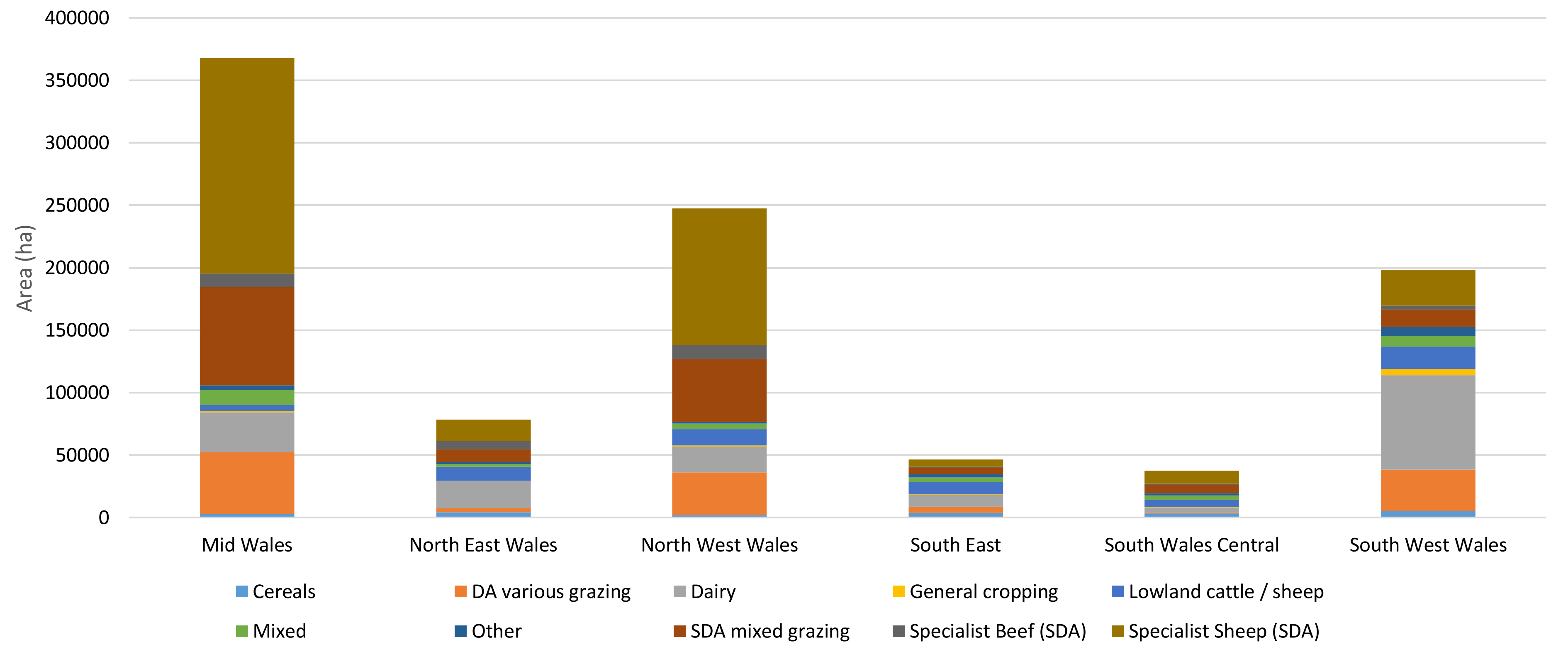
Farm type and area by region

Agricultural models are applied to all full-time farms

Calculations use productive agricultural area for full-time farms: 853,353 ha and exclude: bare rock, buildings & yards, sand dunes and mud flats

Farm Type	Number	Area (ha)
Full-time	7,401	973,278
Spare / Part-time	8,887	338,131
Total	**16,288**	**1,311,409**



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The largest farm area is in Mid Wales (38% of total farm area), almost 50% of its farm area comprises Specialist Sheep SDA farms. The region with the smallest agricultural area is South Wales Central, 28% of its farm area comprises Specialist Sheep SDA farms. South West Wales has the highest proportion of dairy farms (39%).

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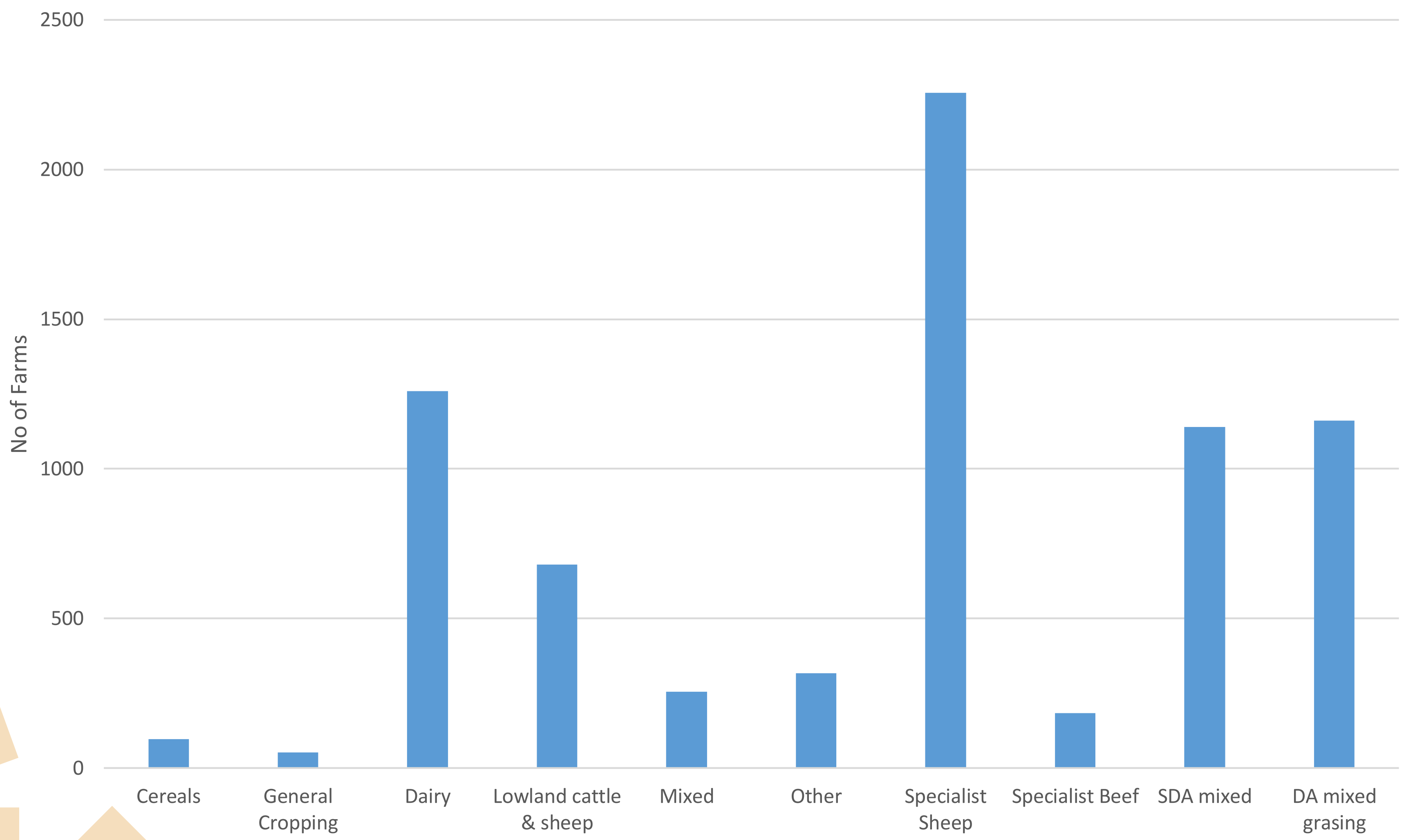
Farm numbers by type



- Total number of full-time farms in baseline: 7401
- Specialist Sheep account for 30% of all farms
- Dairy accounts for 17% of all farms
- General cropping represent <1% of all farms

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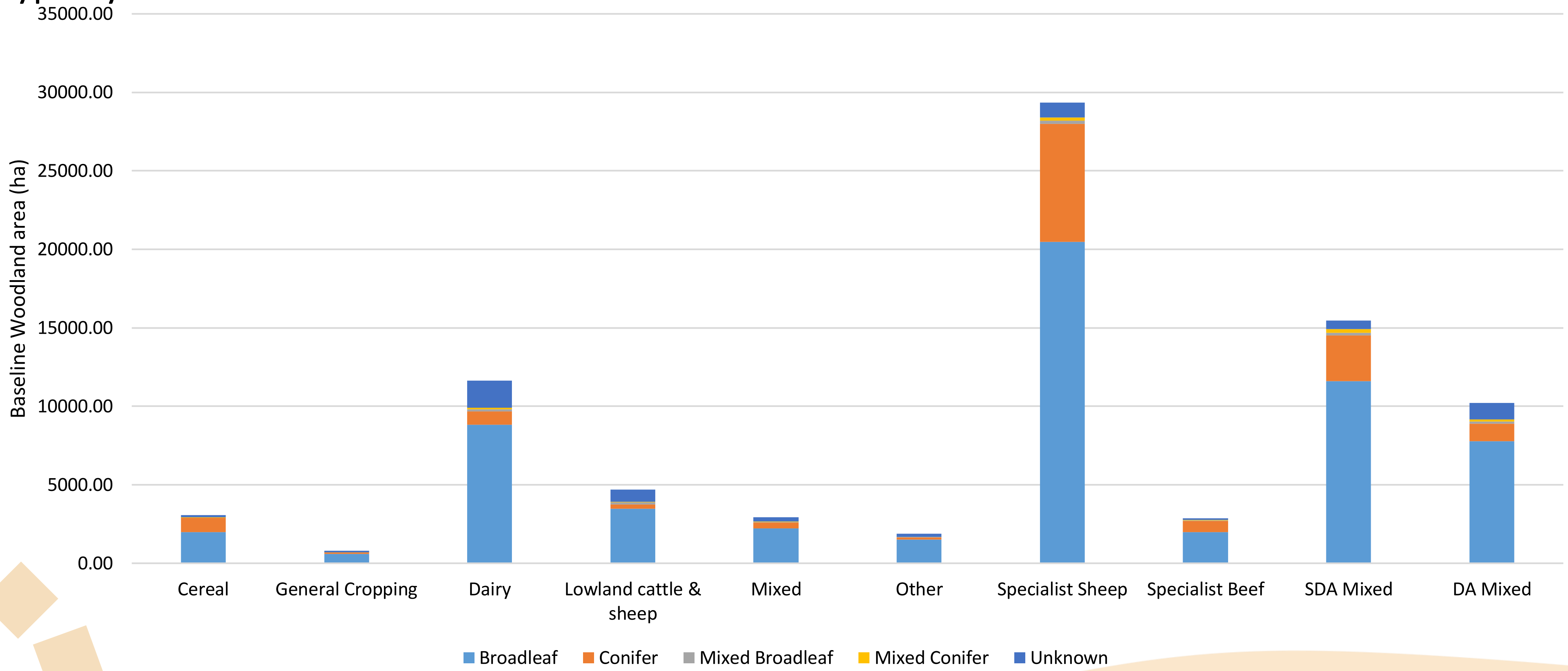
Baseline woodland area

- 8.5% of modelled farm area is currently woodland (82,857 ha)
- Current woodland is 75% broadleaved (61,350 ha), 20% coniferous woodland (17,295 ha), and 5% is unknown.
- The largest area of woodland is on specialist sheep farms in severely disadvantaged (SD) Areas, which is the largest farm type by area.



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(>0.1ha only)

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PART 1: Agriculture

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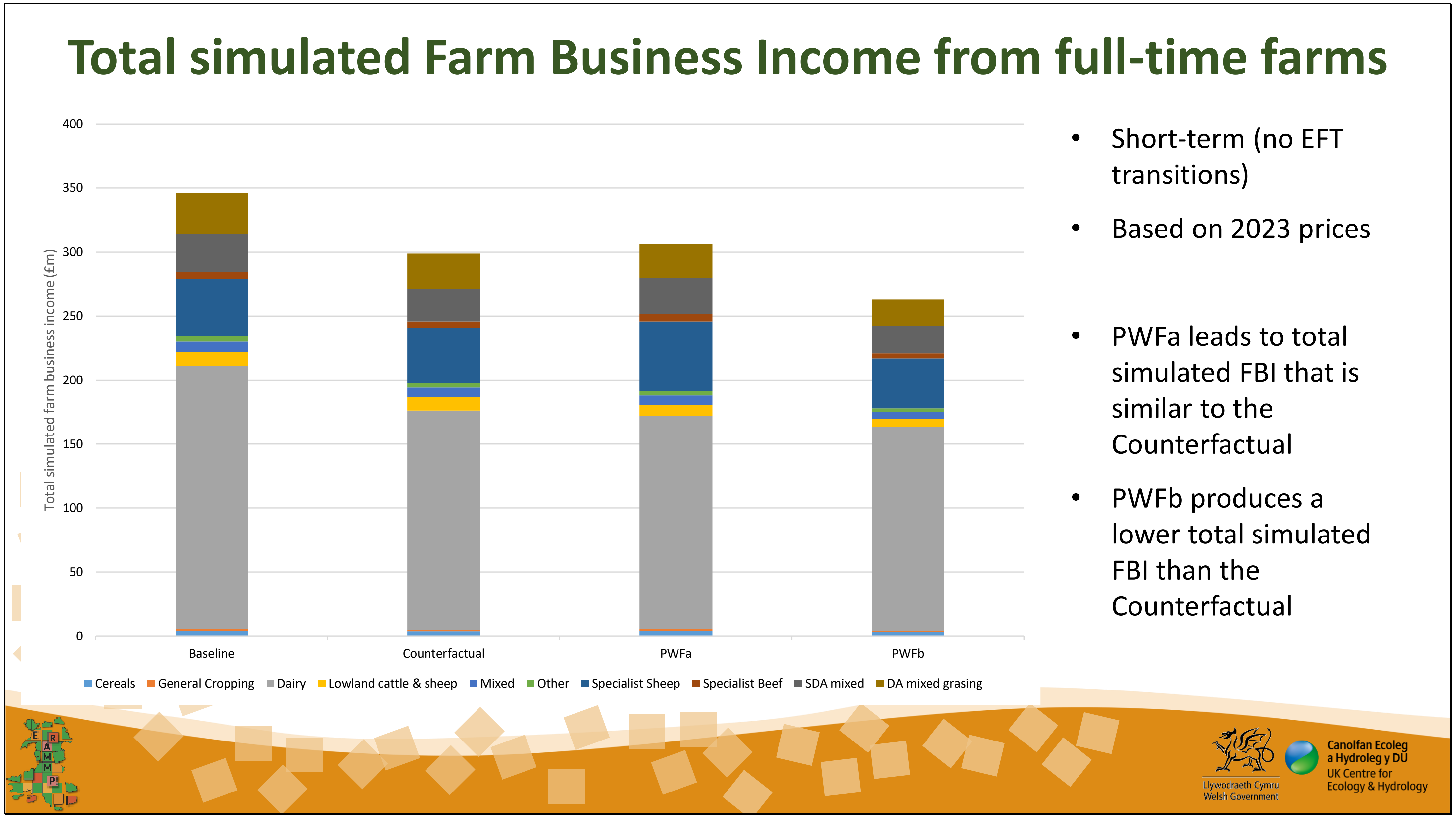

This slide shows the simulated aggregate FBI in the short-term (assuming no farm transitions).

Introduction of CoAP (Baseline to Counterfactual):
The introduction of the CoAP leads to a reduction in total simulated FBI of 13.6% from baseline, this is mainly attributable to the reduction in dairy GLUs (-9%), costs of N export due to the limits on N inputs (for which beef and sheep GLUs are unaffected) and N input restrictions.

Introduction of SFS (Counterfactual to PWFa and PWFb):
In comparison to the Counterfactual, the total simulated FBI is increased for PWFa, but reduced for PWFb. The higher social value payment in PWFa increases the simulated aggregate FBI to a level very similar to that in the Counterfactual (100% BPS & CoAP), a 2.5% difference. The lower social value payment of PWFb reduces the simulated aggregate FBI by 14% (£43.5m).

Reduction in PWF Social Value payment (PWFa to PWFb):
Dairy FBI is least impacted by the reduction in social value payment (-4%). Lowland cattle & sheep, Specialist Sheep (SDA) and Specialist Beef (SDA) see the greatest reduction in simulated FBI when the social value payment is reduced (33%, 28% and 28% respectively).

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Total simulated Farm Business Income from full-time farms

Change in aggregate FBI	**£m**	**% change**
Baseline to Counterfactual	-47.04	-13.60
Counterfactual to PWFa	+ 7.50	+ 2.51
Counterfactual to PWFb	-36.01	-12.05
Difference in aggregate FBI	**£m**	**% difference**
PWFa to PWFb	-43.52	-14.20

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This slide shows the simulated aggregate FBI in the short-term (assuming no farm transitions).

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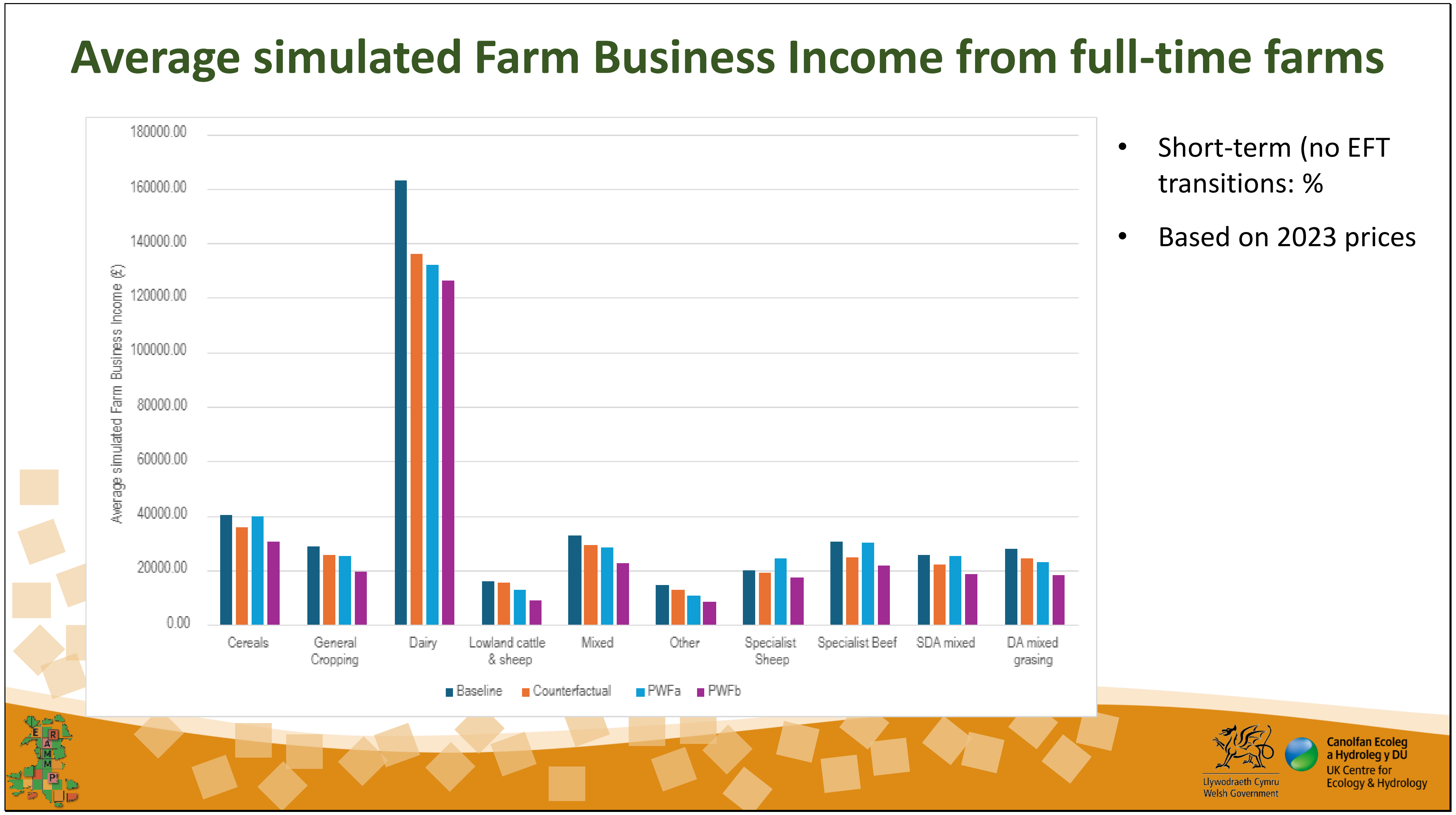

This slide shows the average simulated FBI in full-time farms

Introduction of CoAP (Baseline to Counterfactual):
The introduction of the CoAP leads to a 17% reduction in average FBI in dairy from baseline, this is mainly attributable to the reduction in dairy GLUs (-9%), the cost of N export due to the limits on N inputs (with beef and sheep GLUs unaffected) and N input restrictions. Although non-dairy farm types do not exceed holding N limit (and therefore do not need to export N), their FBI is also affected by the additional costs of the CoAP, e.g., record keeping, closed periods for spreading etc.

Introduction of SFS (Counterfactual to PWFa):
The higher social value payment in PWFa increases the simulated aggregate FBI to a level very similar to that in the Counterfactual (100% BPS & CoAP) for dairy, general cropping, mixed and DA mixed grazing (between a -1 and -6% difference). The PWFa payment rate increases the average FBI above that for the Counterfactual for cereals, specialist sheep, specialist beef and SDA mixed grazing (between 11% and 27% higher).

Reduction in PWF Social Value payment (PWFa to PWFb):
Average FBI for dairy is least impacted by the reduction in social value payment (-7%). The other EFTs see a relatively consistent reduction of 21-33%.

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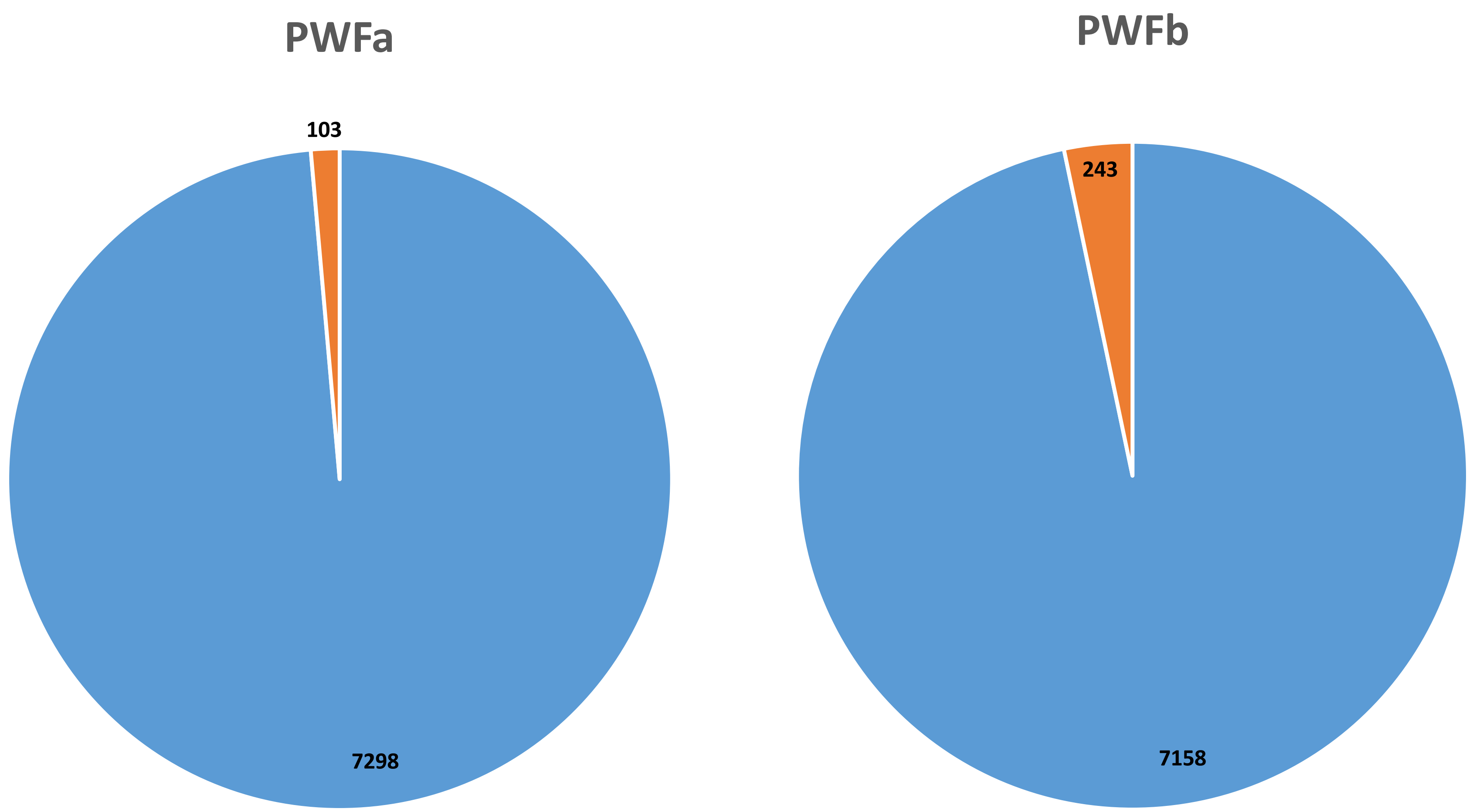
Effect of PWF payment rates on SFS adoption



- Adopting PWFa: 7298 out of 7401 (99%)
- Adopting PWFb: 7158 out of 7401 (97%)

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The LAM simulates SFS uptake against a scenario of 0% BPS & CoAP (not presented in this slidepack).

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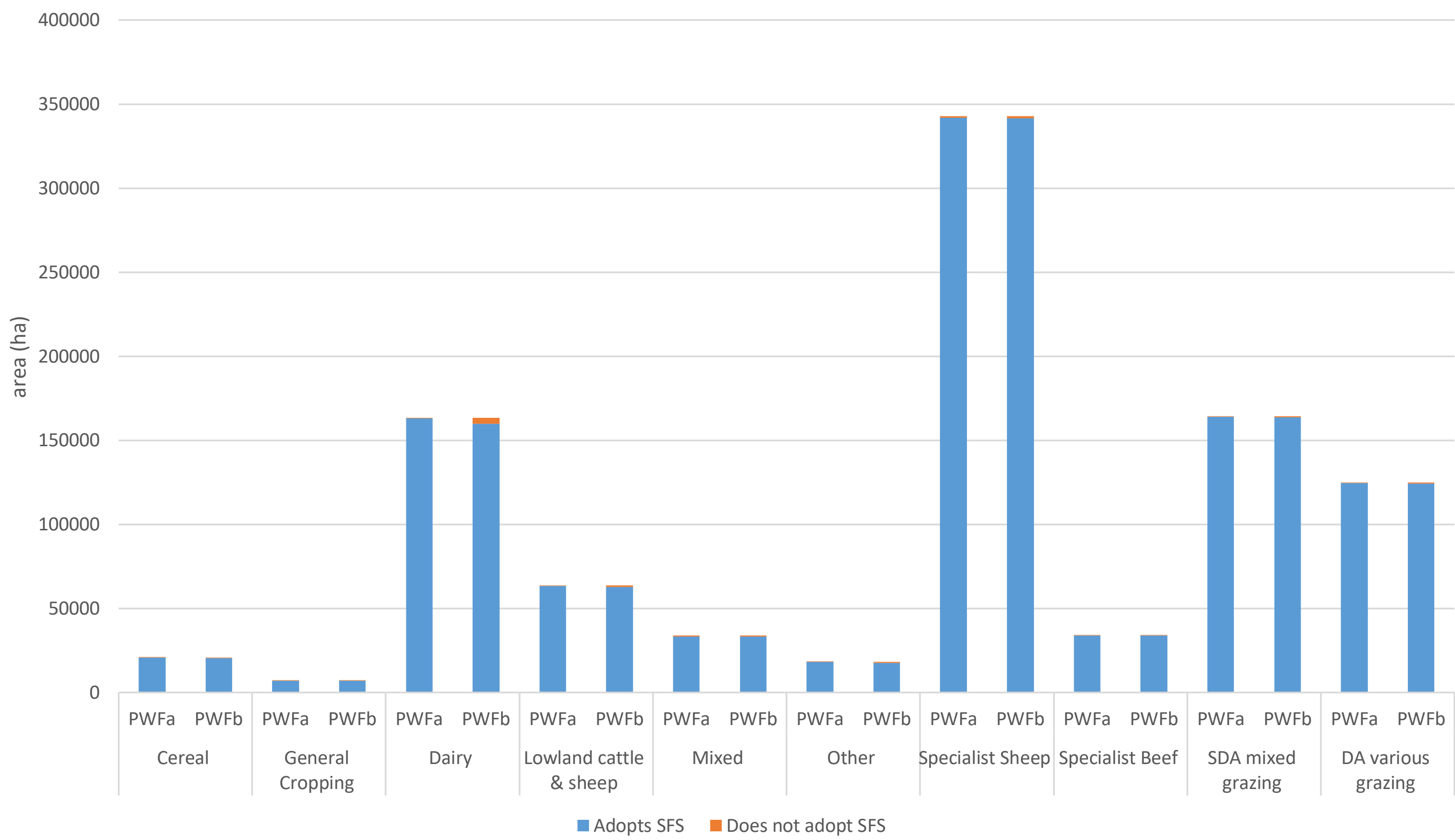
Adoption of the SFS is high for both scenarios. The higher social value payment in PWFa leads to higher levels of adoption than PWFb.

Farms and their combined areas adopting SFS by EFT



- Adoption of SFS is high for all ETFs. Adoption is > 94% for all EFTs, except ‘Other’, across both PWFa and PWFb scenarios.
- Adoption of SFS is lowest for EFT type ‘Other’. Adoption is 89% and 79% for PWFa and PWFb, respectively.

Specialist Sheep (SDA), SDA mixed grazing farms and Dairy farms have the greatest area in scheme, reflecting their large numbers (30%, 15% and 17% of total farms respectively) and their large area (35%, 17% and 17% of total farm area respectively).

Adoption of SFS is high (> 94%) across both scenarios for all EFTs, except for the Other EFT where adoption is 89% & 79% for PWFa and PWFb respectively.

Adoption is lower in the Other EFT due to its high proportion of small farms - the average farm area of Other EFT farms not joining the PWFa is 8.2ha. Because most costs incurred are fixed irrespective of farm size, adoption of the SFS is less attractive on small farms. Despite lower adoption across Other farms, a high % of Other EFT area adopts the SFS.

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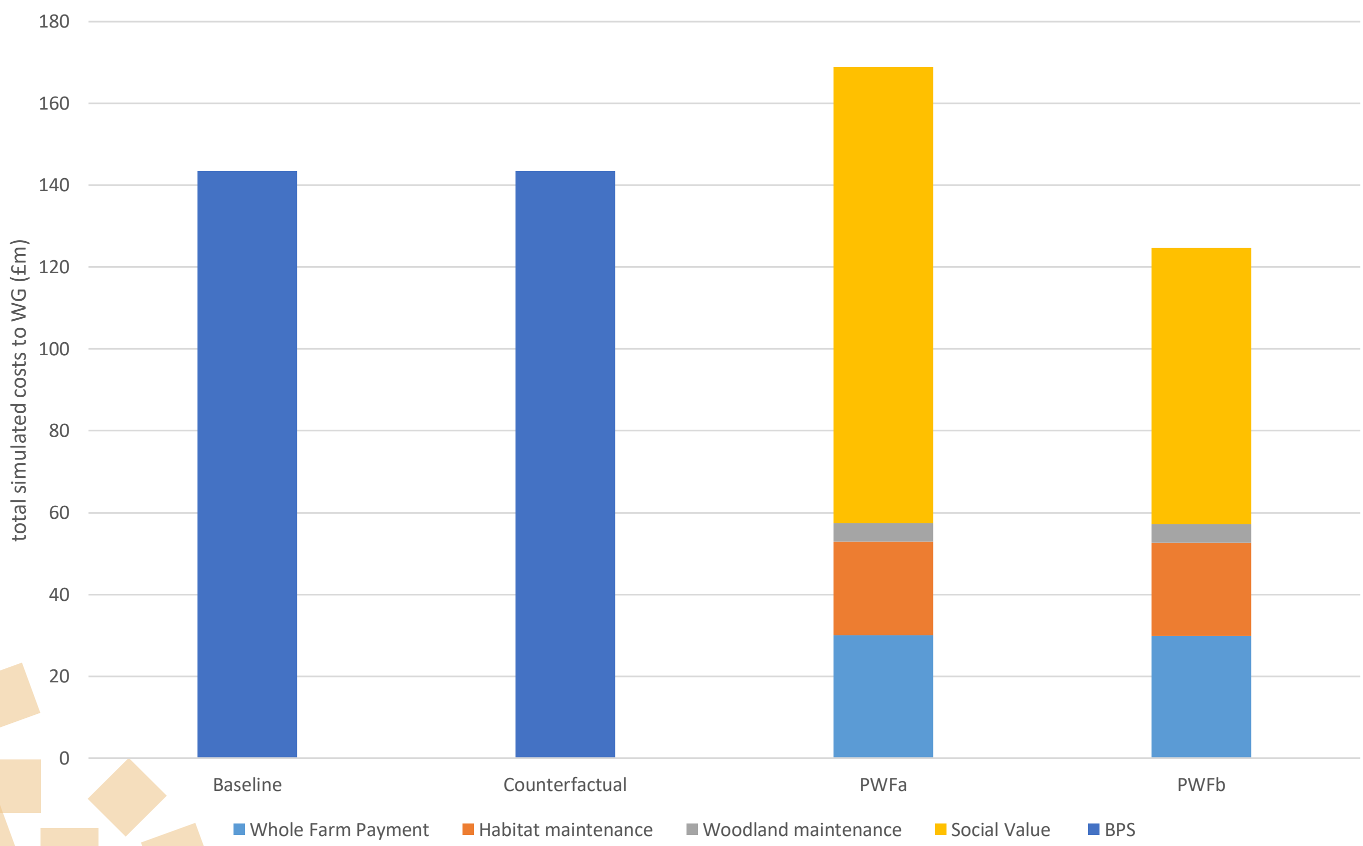
Total WG payments for PWF payment categories



- Replacement of BPS with SFS leads to simulated change in WG payments of +£25.4M (PWFa) and -£18.8M (PWFb).
- Social value payments represent 54% (PWFb) to 66% (PWFa) of total SFS payments.
- The lower social value payment in PWFb leads to a simulated difference in WG payments of -£44.2m from PWFa.

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This slide shows the total BPS or PWF payments (for those farms > 1 FTE adopting the SFS based on 2022/23 prices). The simulated WG BPS payments within the baseline and Counterfactual are shown on the left (based on the area payment and redistributive payment on the first 54ha). On the right, the simulated PWF payments are shown for scenarios PWFa and PWFb.

The PWF whole farm, habitat maintenance and woodland maintenance payment rates are consistent across scenarios PWFa and PWFb. A higher social value payment is applied in PWFa. The difference between the costs of the PWF payments between the two scenarios is attributable to the higher social value payment and higher adoption of SFS (an additional 140 farms equating to 5566ha) in PWFa.

Most payments are made via the social value and whole farm payments as these are payable to a larger farm area. For PWFa, 66% of payments are for social value, 18% for whole farm, 14% for habitat maintenance and 3% for woodland maintenance.

Note, payments exclude common land and Young Farmer Top Up.

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Change or difference in WG payments for PWF payment categories

Change in total WG payments	Change (£m)	Change (%)
Baseline to Counterfactual	0	0
Counterfactual to PWFa	+ 25.36	+ 17.67
Counterfactual to PWFb	-18.88	-13.15
Difference in total WG PWF payments	**Difference (£m)**	**Difference (%)**
PWFa to PWFb	-44.24	-26.20

Difference in total WG payments for PWF payment categories (PWFa to PWFb)	Difference (£m)	Difference (%)
Whole Farm	-0.17	-0.57
Habitat Maintenance	-0.04	-0.18
Woodland Maintenance	-0.02	-0.53
Social Value	-44.00	-39.48

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There is no difference in WG payments between the Baseline and Counterfactual as both are 100% BPS.

The difference in WG payments between PWFa and PWFb (and the Counterfactual) is -£44m, the majority of which is attributable to the lower Social Value payment in PWFb, reducing from £115/ha in PWFa to £70/ha in PWFb. Differences in other payment categories are the result of different levels of SFS adoption across scenarios.

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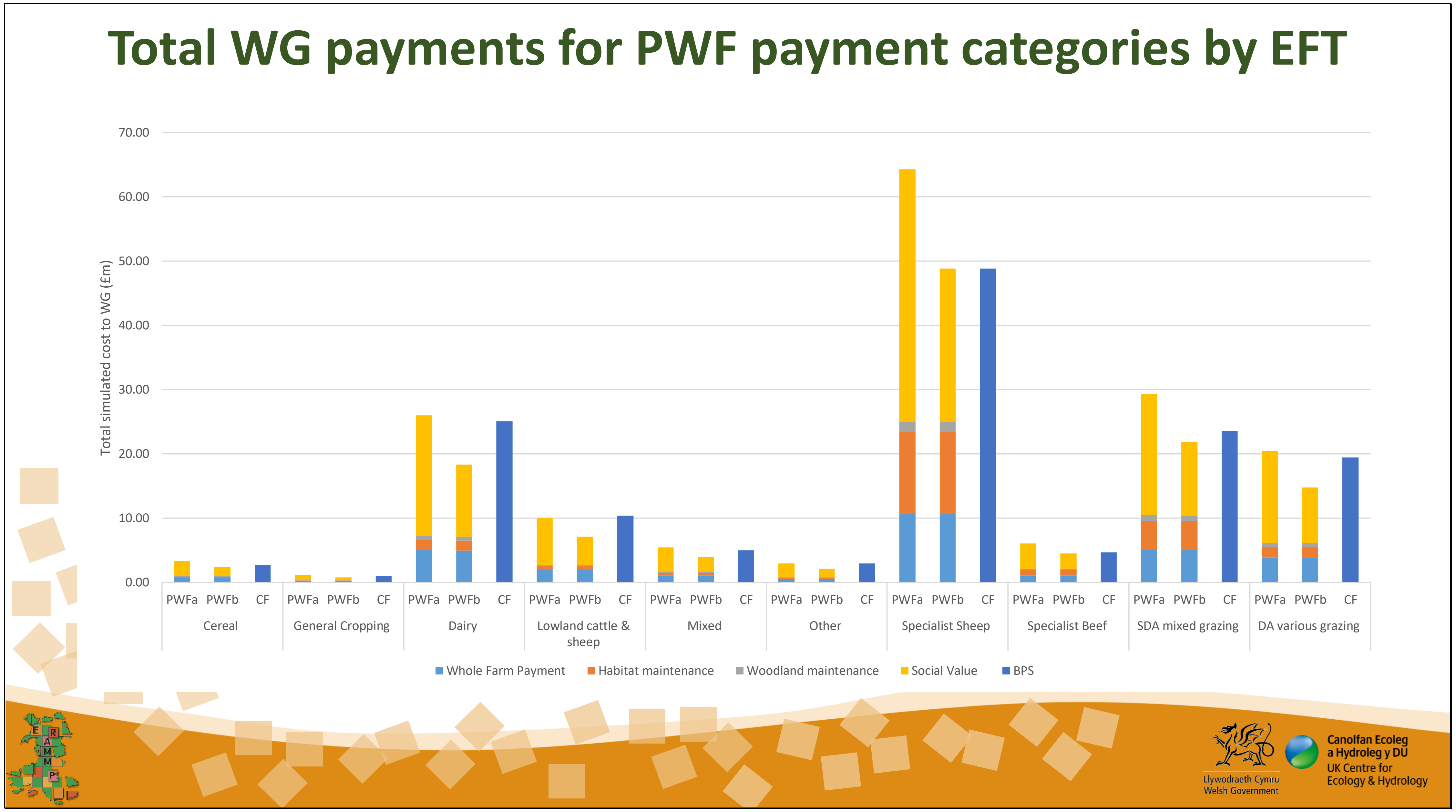

This slide shows the total PWF payments for those farms adopting the SFS based on 2022/23 prices. The PWF Whole Farm, Habitat Maintenance and Woodland Maintenance payment rates are consistent across both PWF scenarios, a higher Social Value payment is applied in PWFa.
The difference in the cost of PWF payments is attributable to the higher social value payment and higher adoption of the SFS (an additional 140 farms equating to 5566ha) in PWFa.

Most PWF payments are made to Specialist Sheep (SDA), SDA mixed grazing farms and Dairy farms reflecting the high scheme adoption combined with a) their large numbers (30%, 15% and 17% of total farms respectively) and b) their large area (35%, 17% and 17% of total farm area respectively).

Most payments are made via social value and whole farm payments. For PWFa, 66% of payments are for social value, 18% for whole farm, 14% for habitat maintenance and 3% for woodland maintenance.

Total simulated BPS payments within the Counterfactual (CF) have a similar distribution across the EFTs to the SFS. For the major lowland EFTs (Dairy and Lowland Cattle & Sheep), the total BPS is similar to PWFa (with PWFb providing lower aggregate payments). In contrast, within the SDA and DA farms, PWFa tends to give higher aggregate payments than the BPS (due to their greater habitat payments and larger farm size).

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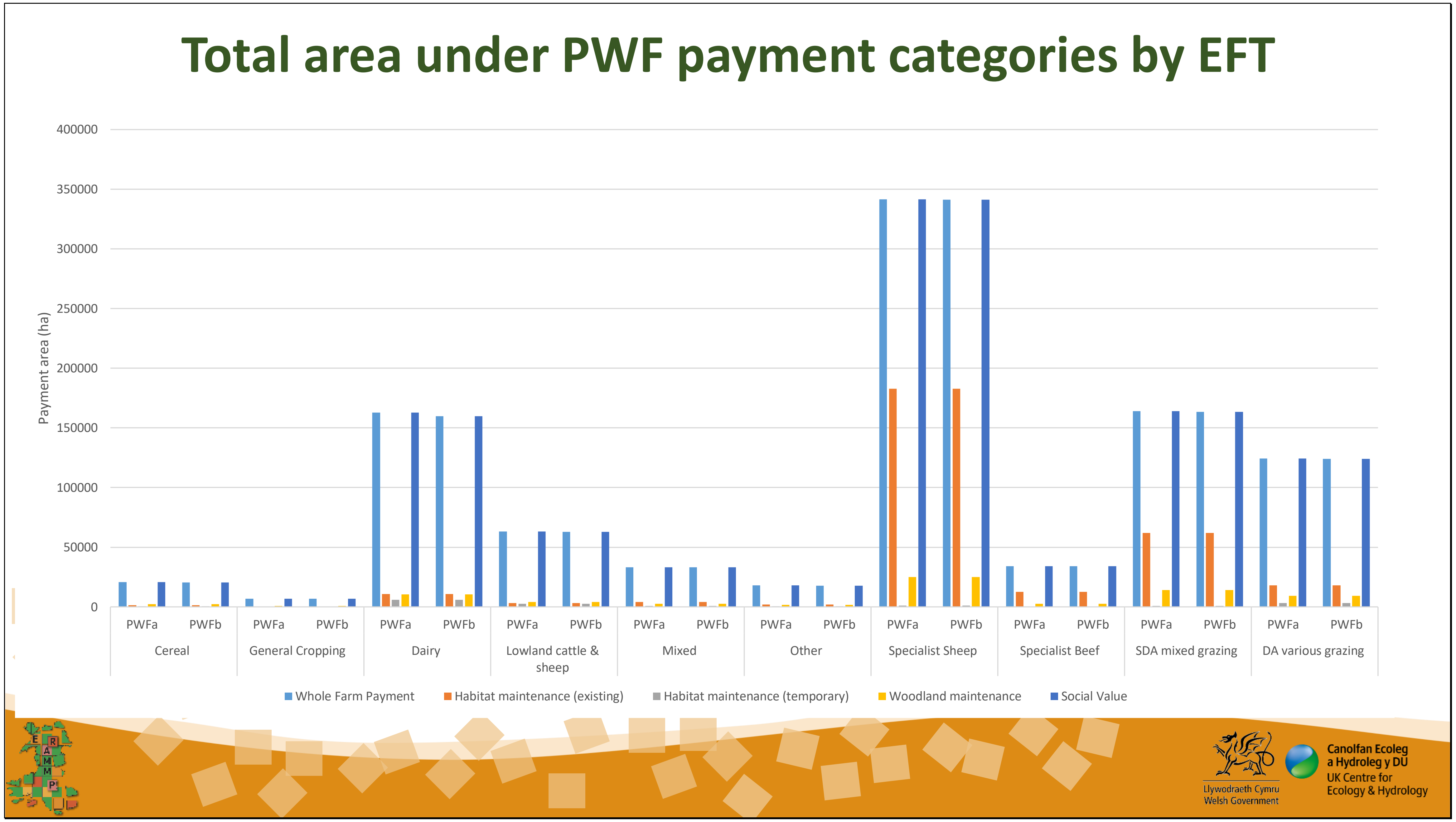

This slide shows the area receiving each of the PWF Universal Action payments for those farms adopting the SFS, noting that areas of land have differing eligibility for different payments and that some land attracts multiple payments.

SDA farms receive most of the Habitat Maintenance payments for existing habitat, whereas the area attracting payments for temporary habitat is greatest on Dairy farms and Lowland Cattle and Sheep (although much less than the area of permanent habitat).

Areas attracting Woodland Maintenance payments are mostly within the DA and SDA farms, but also within Dairy farms.

Areas attracting the Whole Farm payment and Social Value payment are the same – and are slightly higher in PWFa reflecting the greater uptake.

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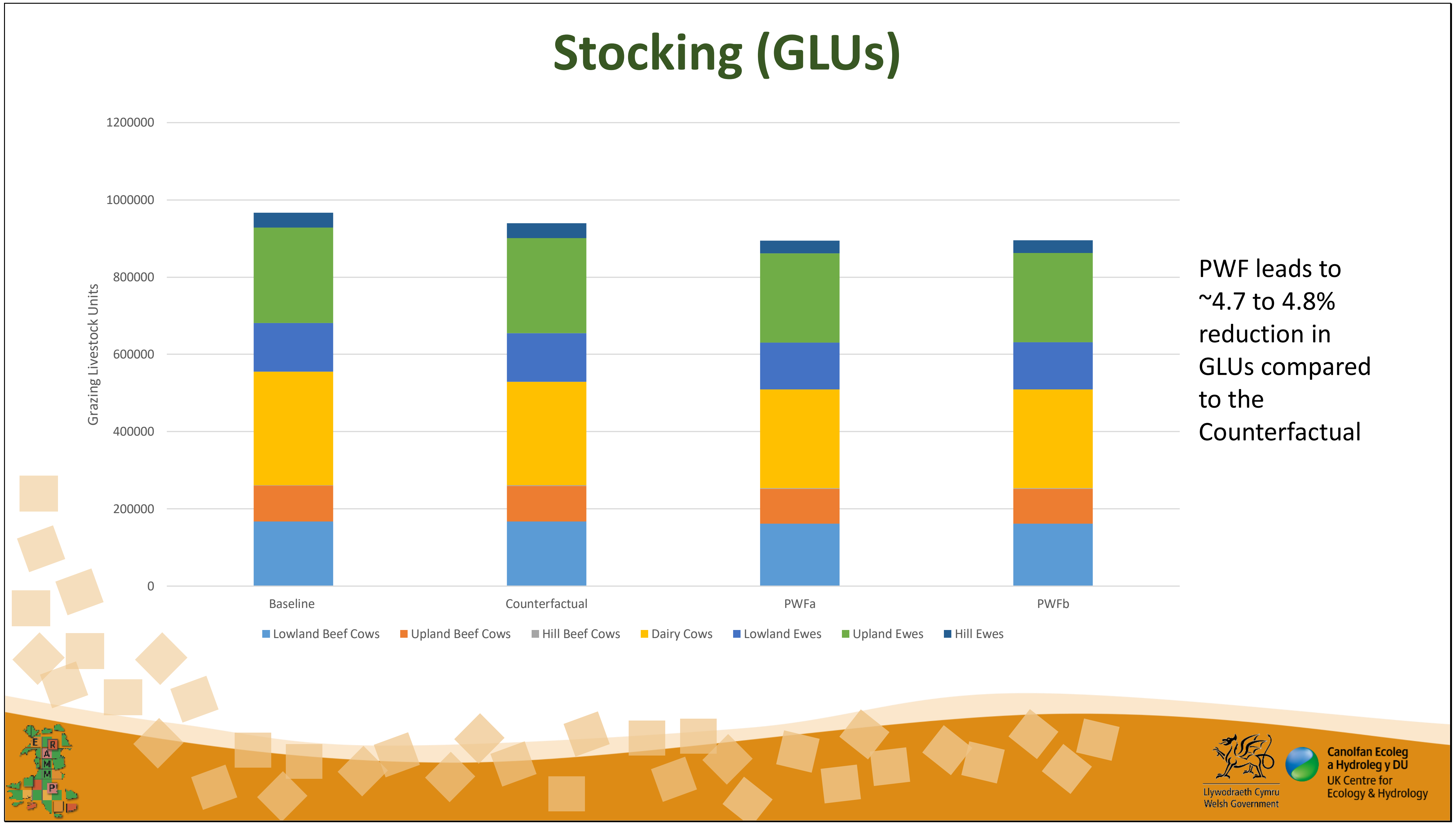

This slide shows the breakdown of simulated livestock numbers (as Grazing Livestock Units) in Wales, where:

- Hill – land higher than 400m asl
- Upland – land between 200m and 400m asl
- Lowland – land below 200m asl.

The introduction of the CoAP leads to a reduction in dairy GLUs due to the limits on N inputs, with beef and sheep GLUs being unaffected.

With the introduction of PWF, there are reductions in sheep, beef and dairy. The sheep and beef reductions are attributable to the stock reductions associated with UA5 maintenance of existing habitat, whilst the sheep, beef and dairy reductions can also be attributed to the loss of improved grassland to UA6 creation of temporary habitat.

There is a smaller reduction in livestock from PWFa to PWFb (compared to the Counterfactual) which reflects lower scheme adoption so less land is removed from production for the creation of temporary habitat or reduced in line with UA5 stocking reductions.

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Change or difference in stocking (GLUs)

% change in stocking (GLUS)				
	Beef	Sheep	Dairy	Total
Baseline v Counterfactual	-0.11	0.00	-9.01	-2.77
Counterfactual v PWFa	-3.02	-6.20	-4.40	-4.81
Counterfactual v PWFb	-2.99	-6.19	-4.23	-4.74
% difference in stocking (GLUs)				
PWFa v PWFb	0.03	0.01	0.18	0.07

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This slide shows the breakdown of simulated livestock numbers (as Grazing Livestock Units) in Wales, where:

- Hill – land higher than 400m asl
- Upland – land between 200m and 400m asl
- Lowland – land below 200m asl.

All stock types decreased under PWF. Numbers decrease under the PWF due to stock reductions associated with UA5 maintenance of existing habitat (beef and sheep), and loss of improved grassland to UA6 creation of temporary habitat (sheep, beef and dairy).

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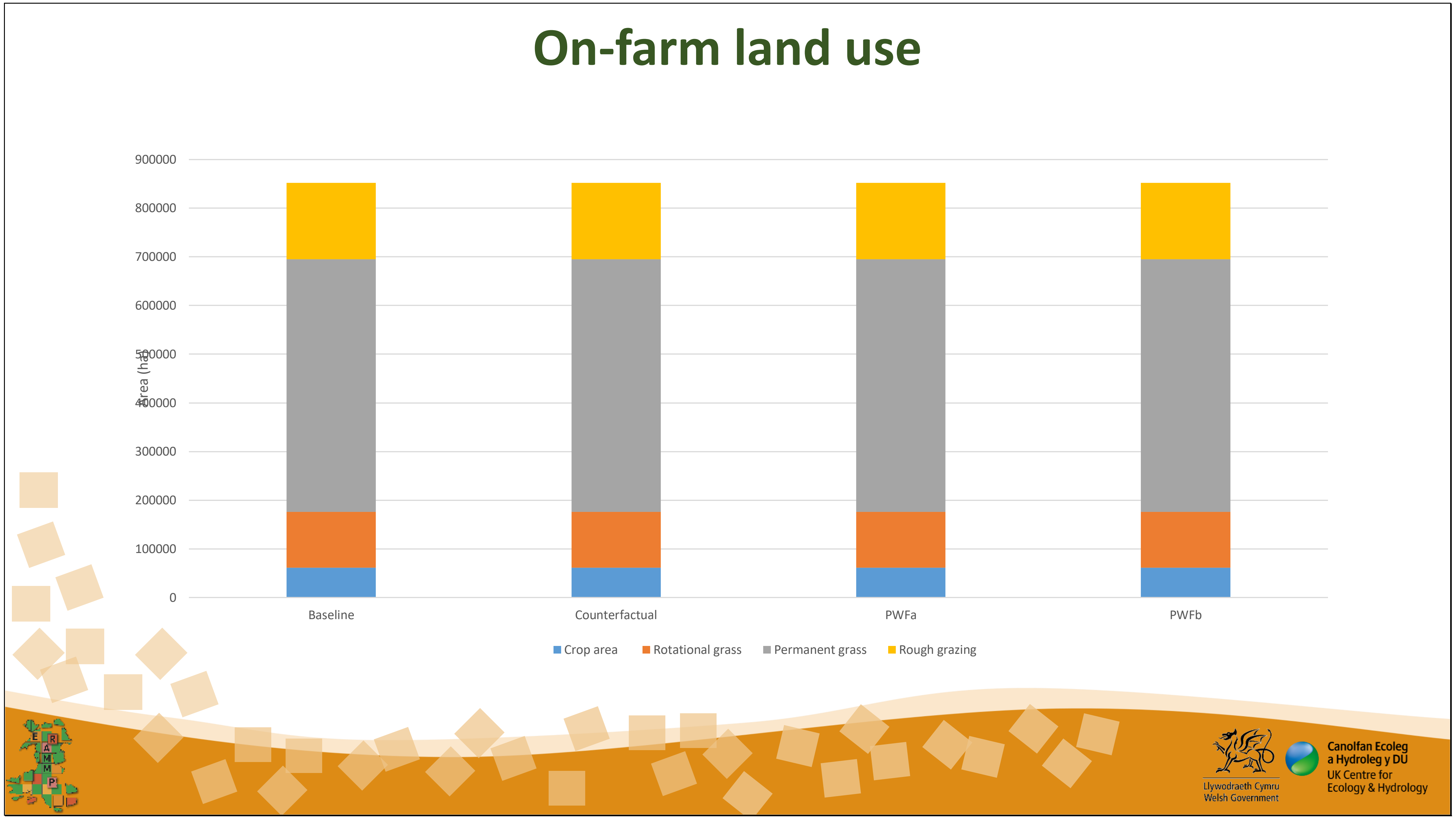

The change in land use across the scenarios is very minor because the only action resulting in land use change is UA6 Creation of temporary habitat.

UA6 is represented in the IMP by rough grass margins (on arable) and mixed leys (on rotational and permanent grass).

The introduction of PWF leads to small changes in simulated crop mix, with decreases in forage maize (and stubble turnips and winter oilseed rape) being offset by increases in other crop types. The total area of temporary habitat created is 16,018ha for PWFa and 15,673ha for PWFb, a difference of 2.16%.

Most of the UA6 temporary habitat is mixed leys created on permanent grass (Intensive Grassland DMUs). This accounts for 60% in PWFa, mixed leys on rotational grass account for 38% and rough grass margins on arable only 3%.

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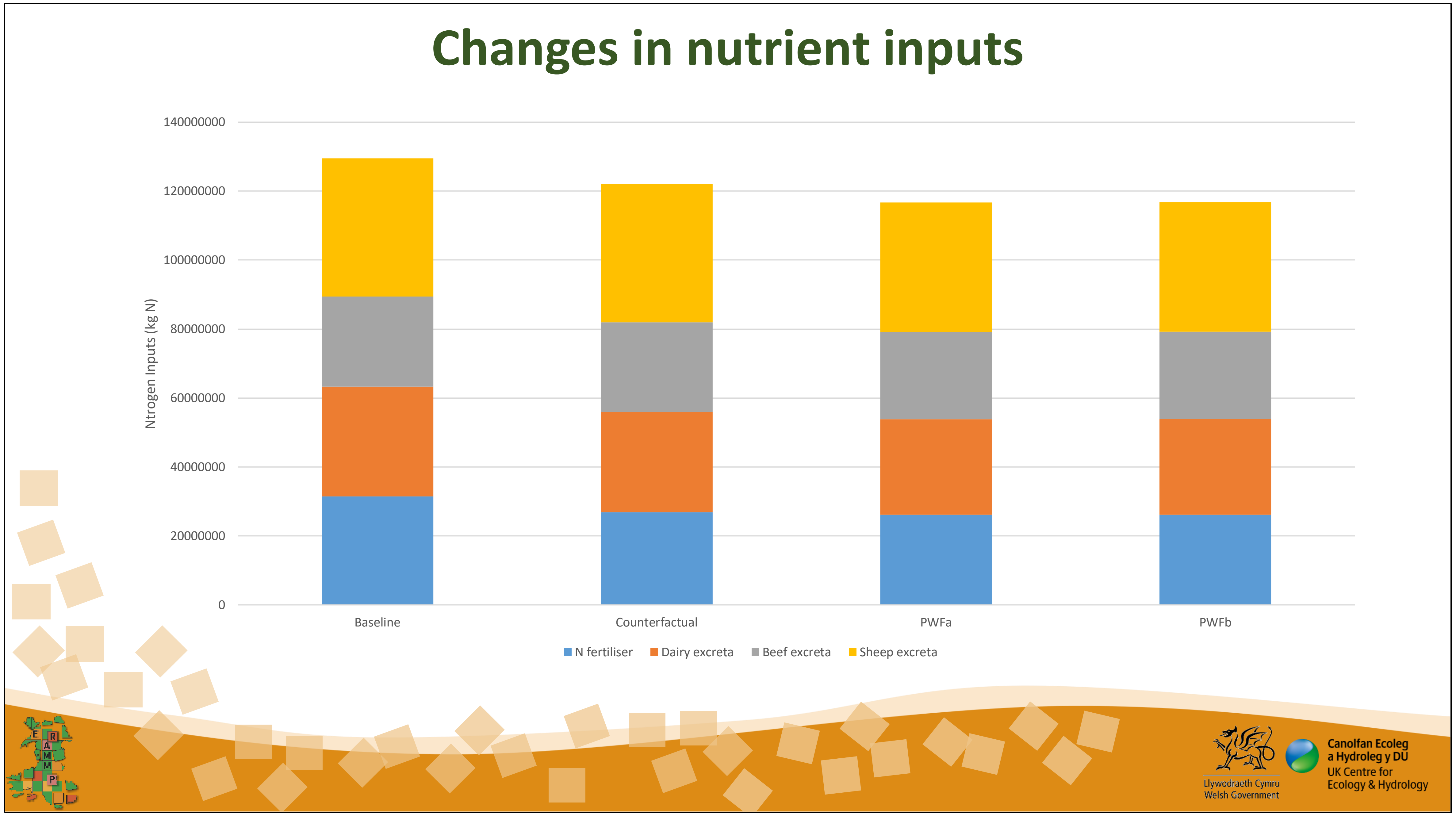
Change or difference in on-farm land use

% change in land use				
	Crop	**Rotational Grass**	**Permanent Grass**	**Rough Grass**
Baseline to Counterfactual	-0.19	0.11	0.00	0.00
Counterfactual to PWFa*	-0.67	-5.28	-1.84	0.00
Counterfactual to PWFb*	-0.66	-5.08	-1.82	0.00
% difference in land use				
PWFa v PWFb	0.01	0.22	0.02	0.00

*this includes land use change due to UA6 – temporary habitat creation on crop, rotational and permanent grass (16,018ha and 15,673ha for PWFa and PWFb respectively). The creation of temporary habitat has been handled differently to a permanent transition."



Baseline to Counterfactual:
The introduction of the CoAP leads to a 14.5% reduction in N fertiliser and 9% reduction in dairy excreta. There is minimal (<1%) reduction in beef excreta and no impact on sheep excreta.
Counterfactual to PWFa:
There is a 2.8% reduction in N fertiliser and a 4.4%, 3.02% and 6.20% reduction in dairy, beef and sheep excreta respectively.
Counterfactual to PWFb:
There is -2.73% reduction in N fertiliser and a 4.23%, 2.99% and 6.19% reduction in dairy, beef and sheep excreta respectively.
PWFa to PWFb:
There is a very minor increase in N fertiliser and livestock excreta from PWFa to PWFb. This is consistent with a small increase in stocking, consistent with lower scheme uptake and subsequently smaller areas removed from production (UA6) and fewer stock reductions associated with UA5.

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Change or difference in nutrient inputs

% change in nutrient input				
	N fertiliser	**Dairy excreta**	**Beef excreta**	**Sheep excreta**
Baseline to Counterfactual	-14.50	-8.99	-0.14	0.00
Counterfactual to PWFa	-2.81	-4.40	-3.02	-6.20
Counterfactual to PWFb	-2.73	-4.23	-2.99	-6.19
% difference in nutrient input				
PWFa to PWFb	0.09	0.18	0.03	0.01

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Baseline to Counterfactual:
The introduction of the CoAP leads to a 14.5% reduction in N fertiliser and 9% reduction in dairy excreta. Reduction in dairy excreta associated with 9% reduction in dairy GLUs as a result of N export limits. There is minimal (<1%) reduction in beef excreta and no impact on sheep excreta.
Counterfactual to PWFa:
There is a 2.8% reduction in N fertiliser and a 4.4%, 3.02% and 6.20% reduction in dairy, beef and sheep excreta respectively. This is associated with stock reductions linked to UA6 and UA5.
Counterfactual to PWFb:
There is -2.73% reduction in N fertiliser and a 4.23%, 2.99% and 6.19% reduction in dairy, beef and sheep excreta respectively. This is associated with stock reductions linked to UA6 and UA5.
PWFa to PWFb:
There is a very minor increase in N fertiliser and livestock excreta from PWFa to PWFb. This is consistent with a small increase in stocking, consistent with lower scheme uptake and subsequently smaller areas removed from production (UA6) and fewer stock reductions associated with UA5.

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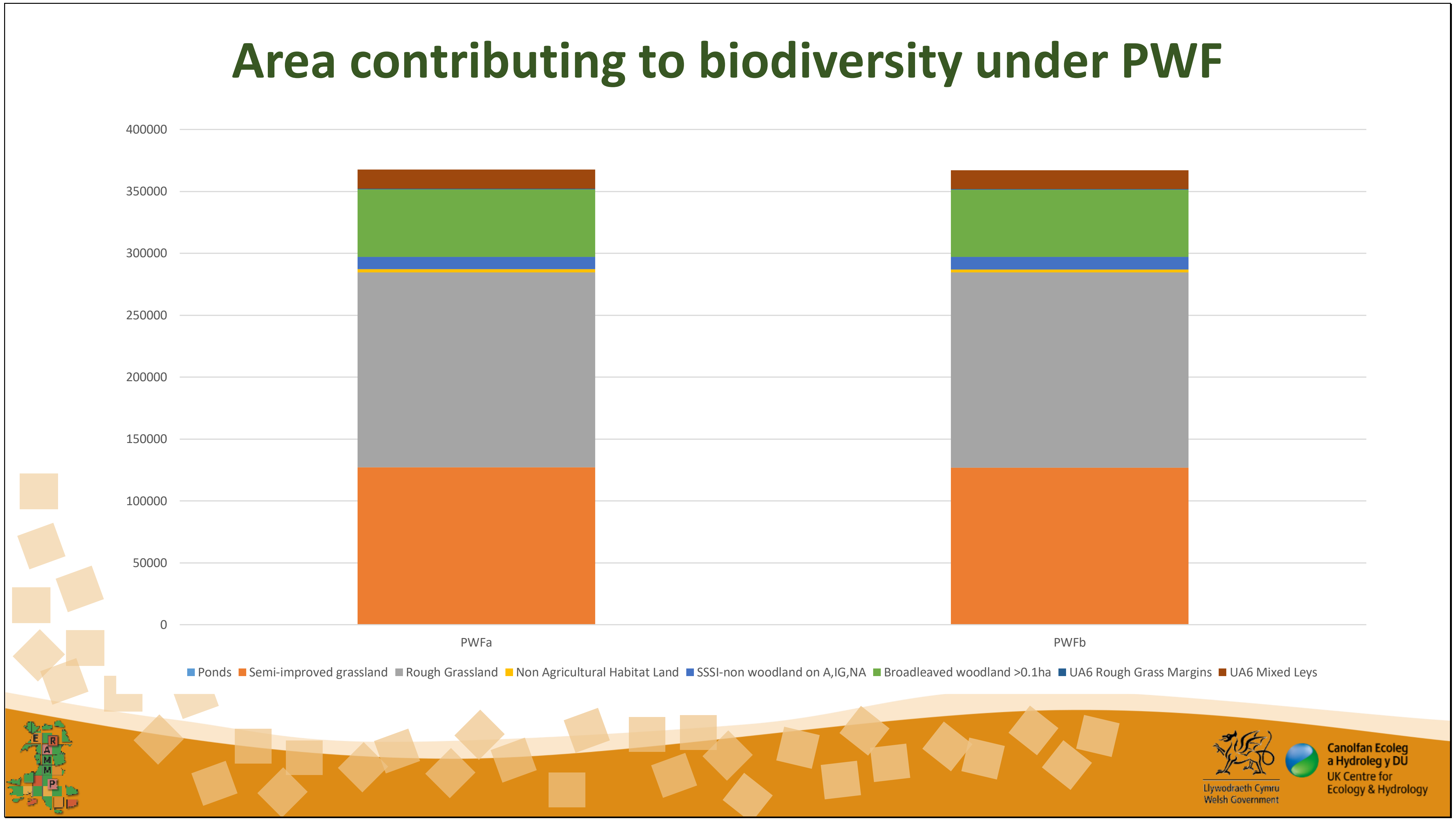

Slide shows the cumulative areas contributing to biodiversity on the simulated farms that adopt the SFS.

There is minimal difference in land contributing to biodiversity between PWFa and PWFb (<-1%).

The main contributors are habitat land within rough grazing or semi-improved areas (PWFa: 284,492ha; PWFb: 284,381ha), broadleaved woodland (PWFa: 54,515ha; PWFb: 54,262ha) and new rough grass margins or mixed leys on improved land (PWFa: 16,019ha; PWFb: 15,673ha).

Whilst representing a small proportion of area contributing to biodiversity overall, the greatest difference in areas contributing to biodiversity is in ponds (-12% reduction). This reflects fewer farms with large ponds entering the scheme as pond management costs are per m2 irrespective of pond size.

SSSI-non woodland on A,IG,NA category = A: arable; IG: intensive grassland; NA: Non-Agricultural

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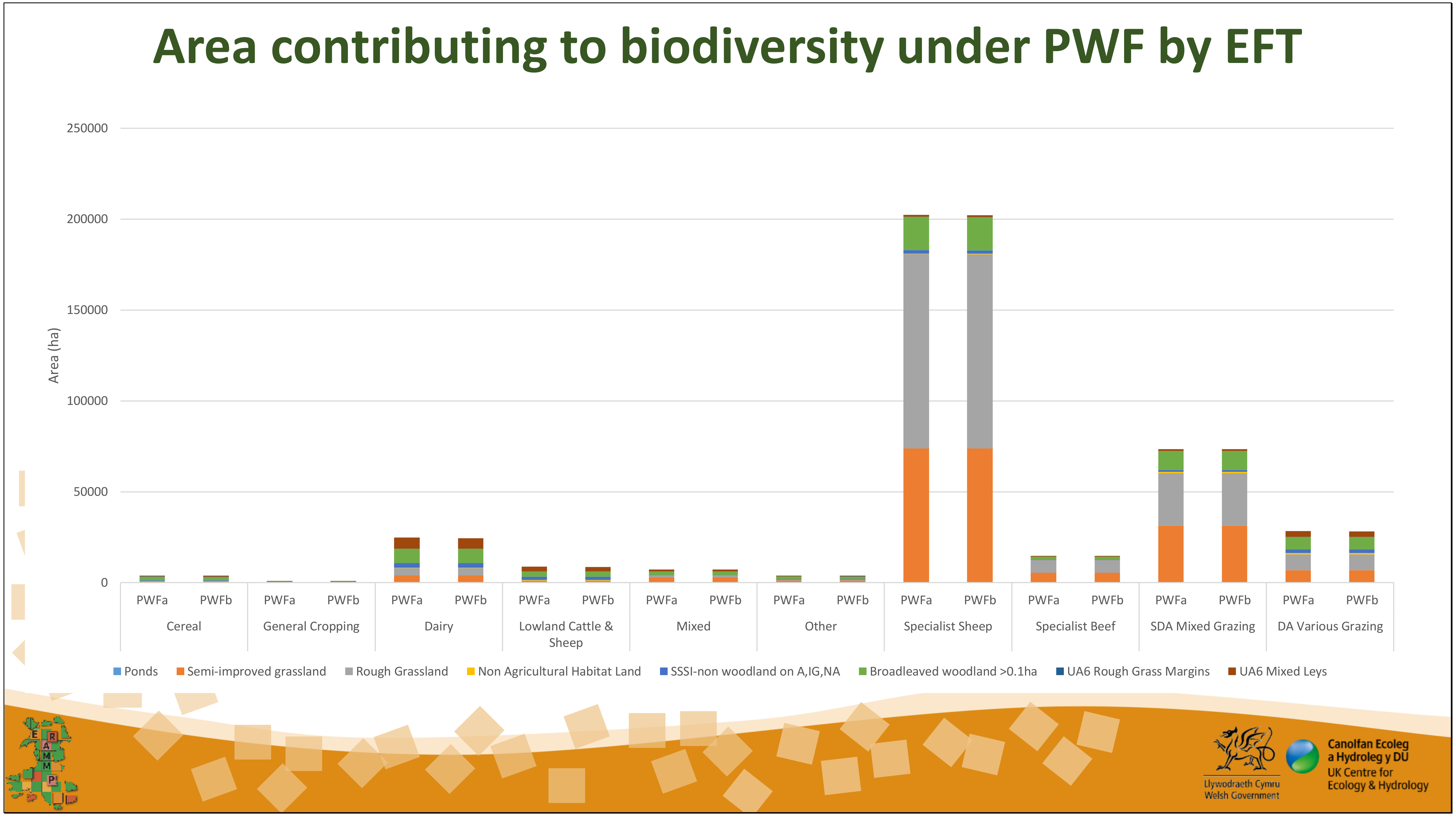

Slide shows the cumulative areas contributing to biodiversity on the simulated farms that adopt the SFS by EFT.

Existing rough grazing/semi-natural is important for specialist sheep, beef, and SDA/DA mixed grazing EFTs. New temporary habitat contributes little to biodiversity on these EFTs.

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PART 2: Forestry and Hedgerows

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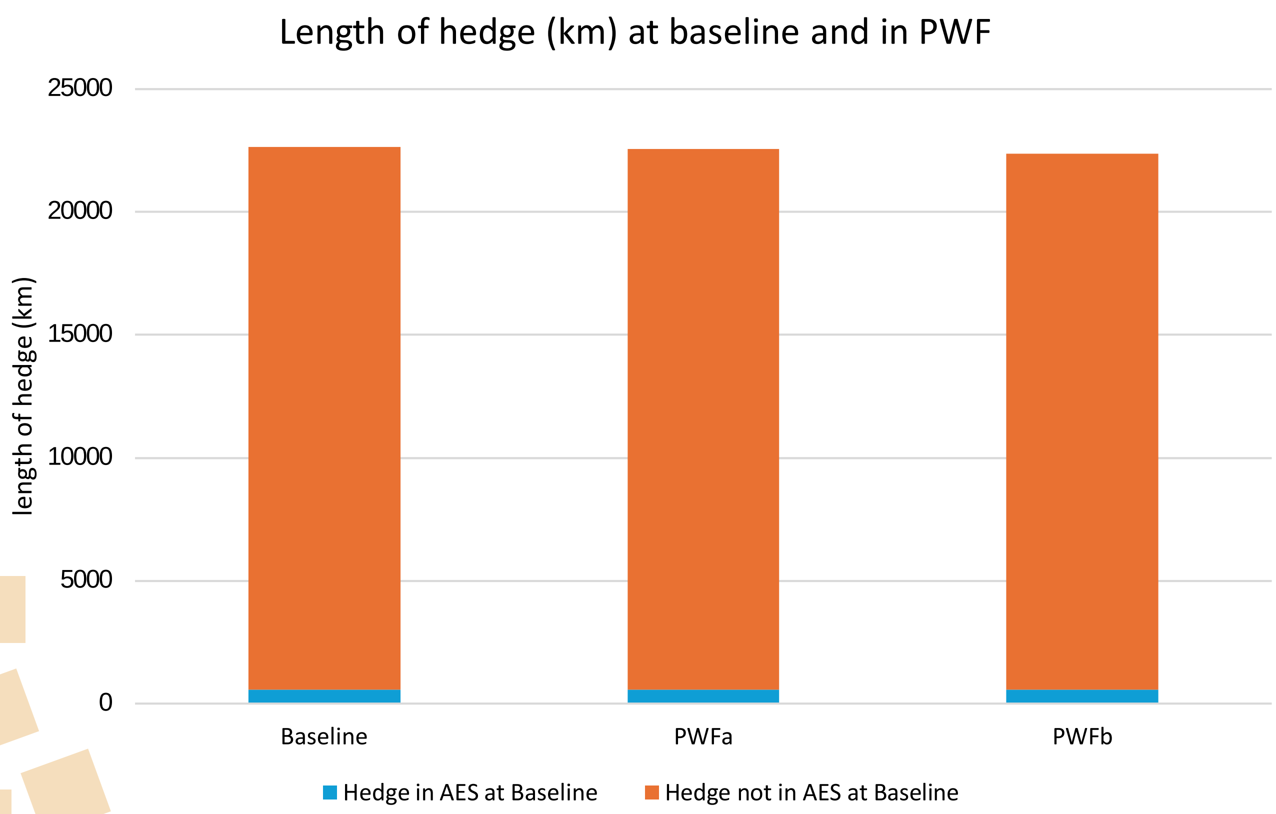
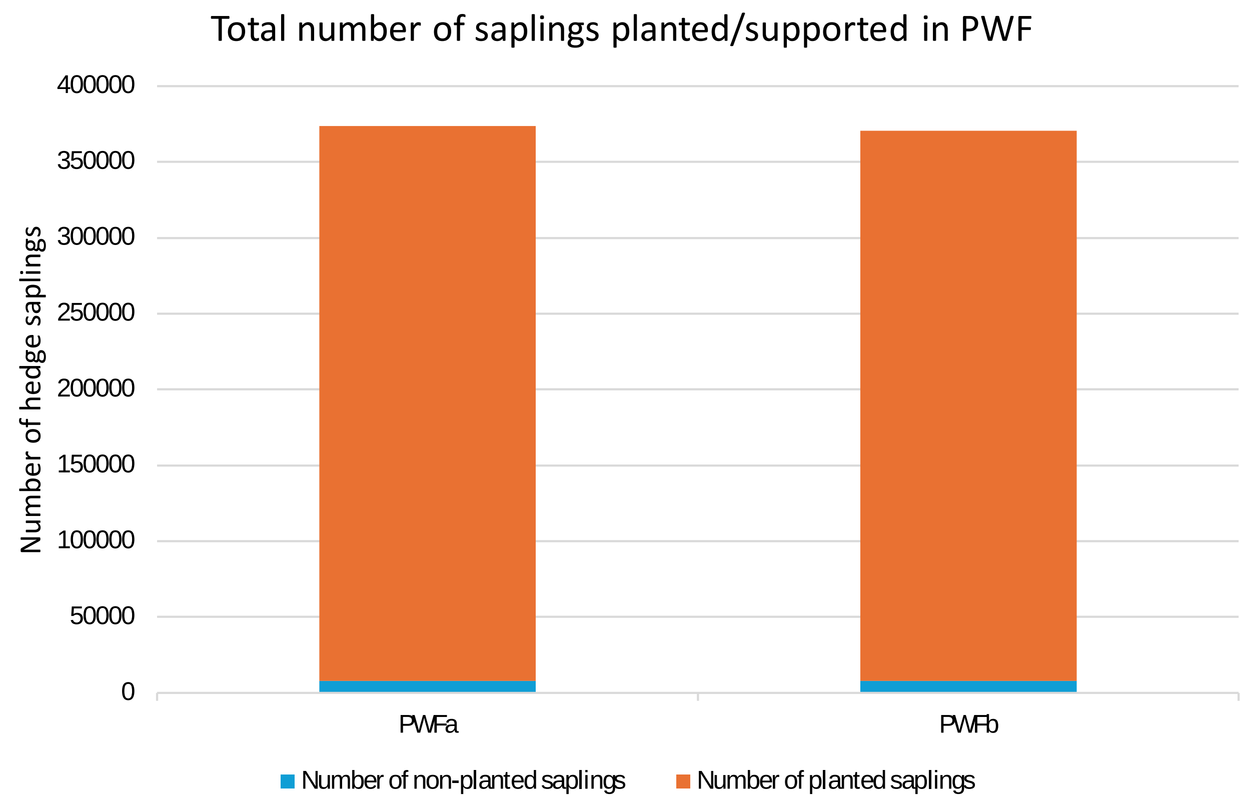
Hedgerow maintenance





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High scheme adoption in both PWF scenarios result in almost all hedges being brought into maintenance (99.6% for PWFa and 98.8% for PWFb).

At baseline 97.5% of hedges are not in AES. It is assumed that hedges not in existing management at baseline will not be able to support natural sapling generation, so a sapling is planted once every 50m. Saplings are assumed to be viable in hedges in existing management at baseline and are left to grow (1 every 50m).

Counterfactual/0% BPS & CoAP not presented as they show no change from baseline.

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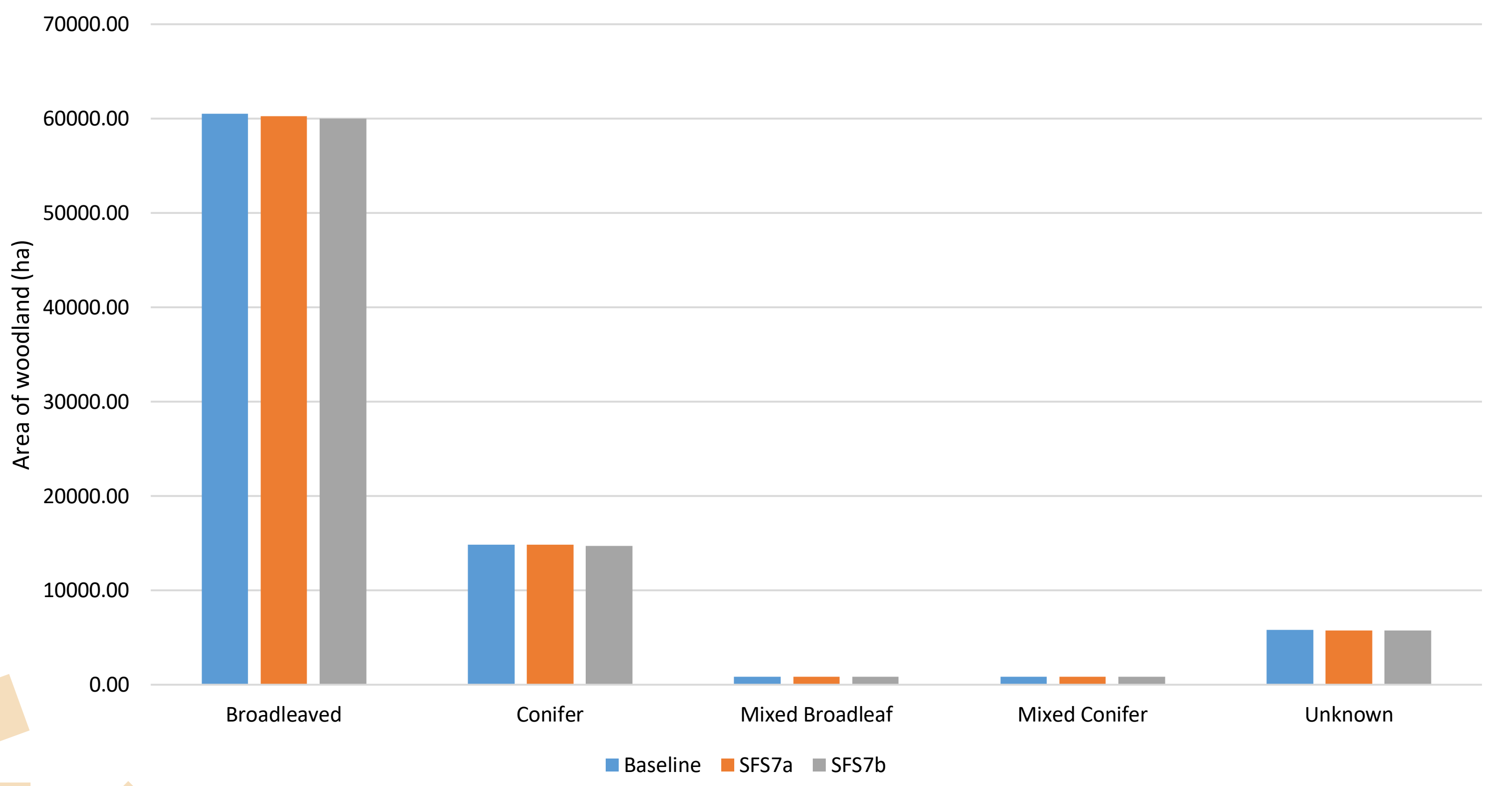
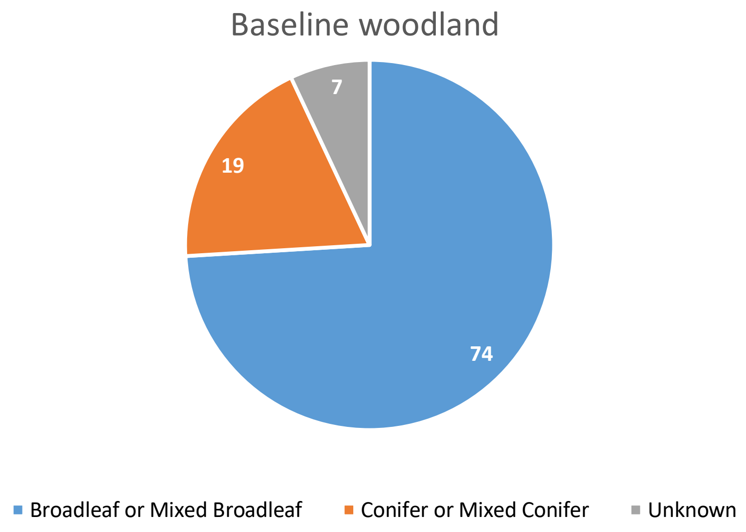
Existing woodland and PWF woodland maintenance





- The total area of woodland at baseline is 82,857ha, of which 74% is broadleaf or mixed broadleaf.
- Almost all woodland is brought into maintenance under PWFa and PWFb.

Slide shows >0.1ha only and excludes conifer woodland >30ha.

There is 82,857ha of on-farm woodland, 74% of which is broadleaf or mixed broadleaf, 19% is conifer or mixed conifer, and 7% is unknown.

High scheme adoption means that almost all baseline woodland is brought into maintenance (99.7% for PWFa and 99.2% for PWFb). % of baseline woodland brought into the scheme is 99.66% for PWFa and 99.17% for PWFb.

Broadleaf = >80% broadleaf species
Conifer = >50% conifer species
Mixed broadleaf = between 50-80% broadleaf species
Mixed conifer = between 50-80% conifer species

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PART 3: Summary of Agriculture, Forestry and Hedgerows

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Summary of Agriculture, Forestry and Hedgerow impacts

	Counterfactual	PWFa	PWFb	Difference (PWFa to PWFb)
Agricultural Income (£m)	299	306	263	-43
Number of farms changing from full-time to part-time	107	52	378	+362
Total WG Payment (£m)	143.51	168.87	124.63	-44.24
Total Livestock (GLU)	939,993	894,806	895,402	+596
Area contributing to biodiversity (ha)	NA	367,760	367,022	-738
Total length of hedge in SFS maintenance (km)	NA	22,570	22,375	-195
Total area of woodland in maintenance (ha)	NA	82,573	82,171	-402

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PART 4: Biodiversity

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PART 4a: Plant biodiversity

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Plant biodiversity: The Counterfactual

- The Counterfactual was not modelled by MultiMOVE and therefore **all change presented in the plant biodiversity slides is from baseline to the PWF scenarios.**
- The Counterfactual was not modelled by MultiMOVE because:
    - The projected land use change is minimal for the Counterfactual as farm transitions were not allowed. The IMP simulated minor (<1%) conversion of cropland to improved (rotational) grass, which will not have an impact on plant biodiversity due to the lack of persistence.
    - MultiMOVE has not been set up to respond to changes in livestock or nutrient inputs when not associated with an intervention. It should also be noted that the livestock changes simulated in the Counterfactual were unlikely to result in increases in plant biodiversity. There was minimal change to sheep and beef GLUs but in contrast a 9% reduction in dairy GLUs, concentrated on improved grassland. A reduction in livestock on improved grassland will have less biodiversity benefit than on rough grazing habitat land.

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Plant biodiversity: PWF scenarios

- Two of the possible 12 UA interventions were modelled to estimate their impact on plant biodiversity. Impact is measured as the number of plant species predicted to significantly increase or decrease in habitat suitability over time. Changes were conveyed as total number of species changing and grouped by indicator type as follows:
  - UA5 'habitat maintenance': Count of Common Standards Monitoring species (positive indicators) for Lowland wetland, Lowland heath and Upland habitats [1].
  - UA8 'Hedge maintenance': Count of nectar plants [2], Ancient Woodland Indicators for Wales [3], Common Standards Monitoring species (positive indicators) for Lowland grassland [1].
- Significant change in mean habitat suitability per species across eligible locations sampled in ERAMMP was inferred where bootstrapped 95% Confidence Intervals from a random effects model did not include zero.
- Note that the model simulates changes in habitat suitability. In reality, projected increases may only be slowly realised if dispersal is slow, while projected decreases in species abundance may exhibit lag effects as slow-growing or high cover perennials persist even under unfavourable conditions.
- The time interval modelled was 20 years for UA8, this being the expected time between laying or coppicing the hedge. For UA5, because there was no requirement to model successional processes on soil change, the time interval over which vegetation responds to the reduction of 1 ewe ha^{-1} is likely to vary. A slower response is expected in dispersal limited places where low fertility and more severe weather slows growth rates.

[1] Based on a collation of CSM indicator lists carried out by the Botanical Society of Britain and Ireland and used in the National Plant Monitoring Scheme (https://www.npms.org.uk/).
[2] List derived from https://www.nature.com/articles/nature16532.
[3] Listed in Glaves, D et al 2009 at https://core.ac.uk/download/pdf/4149223.pdf

Note that hedgerows are modelled over a 20-year time-period when coppicing/laying is assumed. This then re-initiates hedge growth. This also assumes stock are fenced off.

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Plant biodiversity: PWF intervention assumptions

Modelled interventions	**Representation in the MultiMOVE model**
UA5 "Habitat maintenance"	The 1 ewe ha^{-1} reduction was applied by assuming that decreased stocking density drives an increase in vegetation height which changes niche space for plant species promoting some while others are reduced. The relationship between stocking density and height varies by habitat and has high uncertainty and this is reflected in the modelling by making predictions over a range of possible heights associated with each habitat-specific stocking density.
UA8 "Hedge maintenance"	Consistent with an assumed increase in hedge width, the growth of the hedge is modelled as a successional process that drives change in soil conditions (%C, %N and pH) as a response to tree and shrub growth as well as increasing shade as the hedge grows out over a previously unshaded 1m strip next to the existing hedge. Note, the addition of hedgerow trees are not modelled as they do not have a modellable impact plant biodiversity.
Interventions not modelled	**Reason for exclusion**
UA6 "Create temporary habitat"	Option to either create rough grass margins on arable or use mixed leys on permanent or temporary grass. Rough grass margins were not modelled because of the short duration (max 5 years but presumed to usually be not more than 1 year) and the lack of requirement to remove cuttings. From this, it can be inferred that there is a) very little time for community assembly and b) no managed fertility reduction. Mixed leys were also not modelled given their rotational nature and the introduction of commercial seed to provide cover. While beneficial in other respects, because of the temporary nature of the intervention, UA6 is unlikely to have a lasting positive impact on plant biodiversity.
All other SFS UA actions	UA1, UA2, UA3, UA4, UA7, UA9, UA10, UA11, UA12 No impact/modellable impact on plant biodiversity

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UA5 Habitat maintenance assumptions

Stocking rates and canopy height thresholds

Where the observed cover-weighted canopy height was >= the 'UA5 equivalent canopy height' then no change was modelled hence the 1 ewe per hectare reduction was NOT applied. The inference is that the stocking density at these locations does not exceed the UA5 upper limit [1,2].

Broad Habitat	UA5 upper stocking limit (LU ha^{-1})	UA5 equivalent canopy height	Recommended stocking rates (LU ha^{-1})			Vegetation height consistent with recommended stocking rates			Modelled UA5 impacts [3]
			Low	Mid	High	Low	Mid	High	Veg height increase with -1 ewe ha^{-1} (0.08 LU)
Acid Grassland	0.4	2.1	0.15	0.38	0.6	2.1	2.1	2.1	0.22-0.26 [4]
Fen, Marsh & swamp	0.1	4	0.1	0.2	0.4	4	3	2	0.4-0.8
Purple moor-grass dominated	0.1	4	0.1	0.2	0.4	4	3	2	0.4-0.8
Dwarf Shrub Heath	0.1	4	0.02	0.09	0.2	5	4	3	0.4-1.14
Bog	0.05	3.17	0	0.03	0.06	4	3.5	3	1.33
Blanket Bog	0.05	3.17	0	0.03	0.06	4	3.5	3	1.33

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MultiMOVE models UA5 using a relationship between grazing livestock rates and vegetation canopy height. These rates and their associated canopy heights are reproduced here because the relationship between the two was used to derive the change in canopy height estimated to result following a 1 ewe ha-1 reduction in each habitat type.

Recommended stocking rates were compiled from the SFS scheme guidance rates (https://www.gov.wales/sustainable-farming-scheme-2026-scheme-description-html#175207) alongside two conservation grazing documents (https://www.sruc.ac.uk/media/vwsfv2td/tn586-conservation.pdf, https://www.fas.scot/downloads/tn686-conservation-grazing-semi-natural-habitats).

The scaling of average canopy height intervals is as follows:
Vegetation height classes: 1:<10cm, 2: 10.1-30cm, 3: 30.1-60cm, 4: 60.1cm-1m, 5: 1.0-3.0m, 6: 3.1m-6.0m, 7: 6.1-15.0m, 8: >15m.

[1] Evidence for changes in vegetation height following relaxed grazing across habitat land is limited and indicates large uncertainties. These uncertainties are likely to reflect a range of local factors that are mostly not explicitly identified in the published literature nor applied to explain the observed variation in response. The consequence is that our translation of stocking rate to vegetation height will inevitably be imprecise and we reflect this uncertainty by modelling over a larger range of vegetation heights. Also note that we modelled at the level of broad rather than priority habitat given small sample sizes for the latter.

[2] For UA5 the recommended upper limits were agreed between the IMP team and Welsh Government. Note that translation of livestock into LU per ha is taken from https://www.gov.uk/government/publications/countryside-stewardship-cs-mid-tier-and-wildlife-offers-manual-for-agreements-starting-on-1-january-2023/annex-6c-convert-livestock-numbers-into-livestock-units

[3] The conversion of a change in stocking density of 1 ewe ha-1 into a change in canopy height was carried out as follows:
1. We assume that 1 LU ha-1 is 0.08 ewe ha-1 following the guidance in [2] above.
2. We then translate the change in stocking density from Low to High (see cols 4-6 above) into change in number of ewes ha-1. Using Dwarf Shrub Heath as an example this equals (0.2-0.02)/0.08 = 2.25 ewes per ha-1. Given the uncertainties in the relationships between height and stocking density we assume that a move from Low to Mid to High recommended stocking drives a change of roughly 1 unit of cover-weighted canopy height. In the Dwarf Shrub Heath example this would mean that a change from 0.2 LU ha-1 to 0.02 LU ha-1 is assumed to allow a change from a canopy height of 30-60cm to 1-3m, i.e. succession to shrub could occur at the lowest stocking density.
3. A value of 1 unit change in cover-weighted canopy height simplifies the calculation of the amount of change in cover-weighted canopy height that equates with the change in ewe ha-1. In the Dwarf Shrub Heath example this becomes 0.08/(0.2-0.02) = 0.4 and from the Mid value of 0.09 to the Lower value would be 0.08/(0.09-0.02) = 1.14. Note that we ONLY applied a change in cover-weighted canopy height where the baseline observed height (col 3 in the table) was less than the height associated with the UA5 upper stocking limit in col 2 of the table.

[4] These are small estimated changes in canopy height. This is because removing 1 ewe ha-1 has relatively little effect on cover-weighted canopy height. A bigger change in LU ha-1 and therefore canopy height is required to move from the high stocking density typically associated with Acid Grassland to the low stocking levels associated with Dwarf Shrub Heath, and even lower for Bog, that are required to drive vegetation recovery. In essence 1 ewe ha-1 makes a minor contribution to moving the vegetation height associated with Acid Grassland to the levels needed for Dwarf Shrub Heath and Bog.

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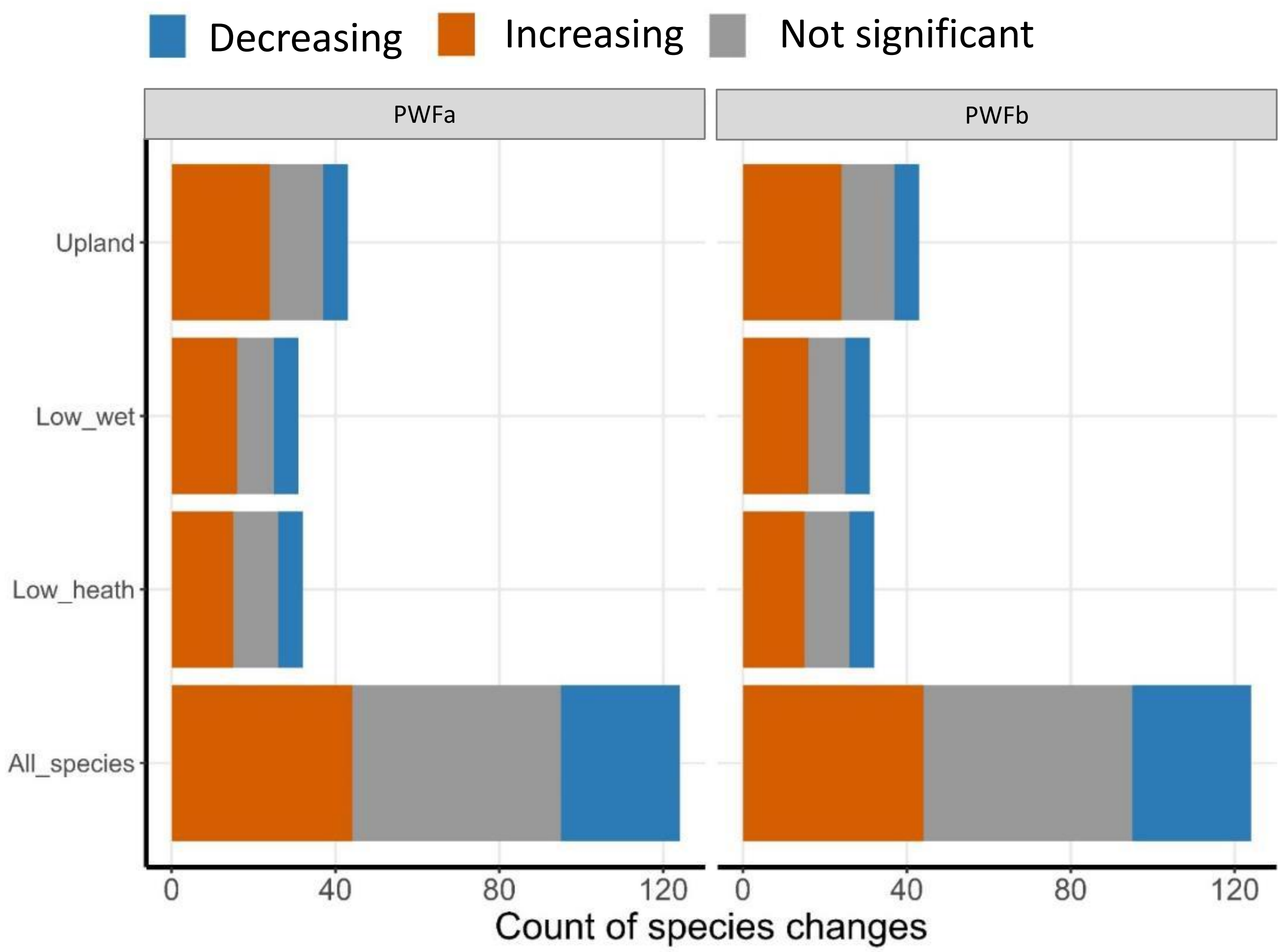
UA5 Habitat maintenance: Results



All species	PWFa	PWFb
Increasing	44	44
Decreasing	29	29
Not significant	51	51

This plot shows the number of species appearing or disappearing on the 2x2m plot location for the UA5 plots.

Increasing species most frequently observed in surveyed plots at baseline across the ERAMMP squares include *Potentilla erecta, Molinia caerulea, Pleurozium schreberi, Vaccinium myrtillus, Calluna vulgaris* and *Erica tetralix*.

Common decreasing species are *Festuca ovina, Nardus stricta, Galium saxatile* and *Juncus squarrosus*.

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Upland = Common Standards Monitoring species (positive indicators) for Upland habitats.
Low_wet = Common Standards Monitoring species (positive indicators) for Lowland wetland.
Low_heath = Common Standards Monitoring species (positive indicators) for Lowland heath.

This plot shows the number of species appearing or disappearing on the 2x2m plot location.
A total pool of around 950 species were modelled across all plots, but in order to determine those species most likely to appear or disappear from the plot we selected only the number of species in each plot such that count of species did not exceed the estimated species richness in each plot. That way we do not consider species that are never likely to be actually encountered in the plots. This means that the species in these figures tend to be the most common species, which is realistic.

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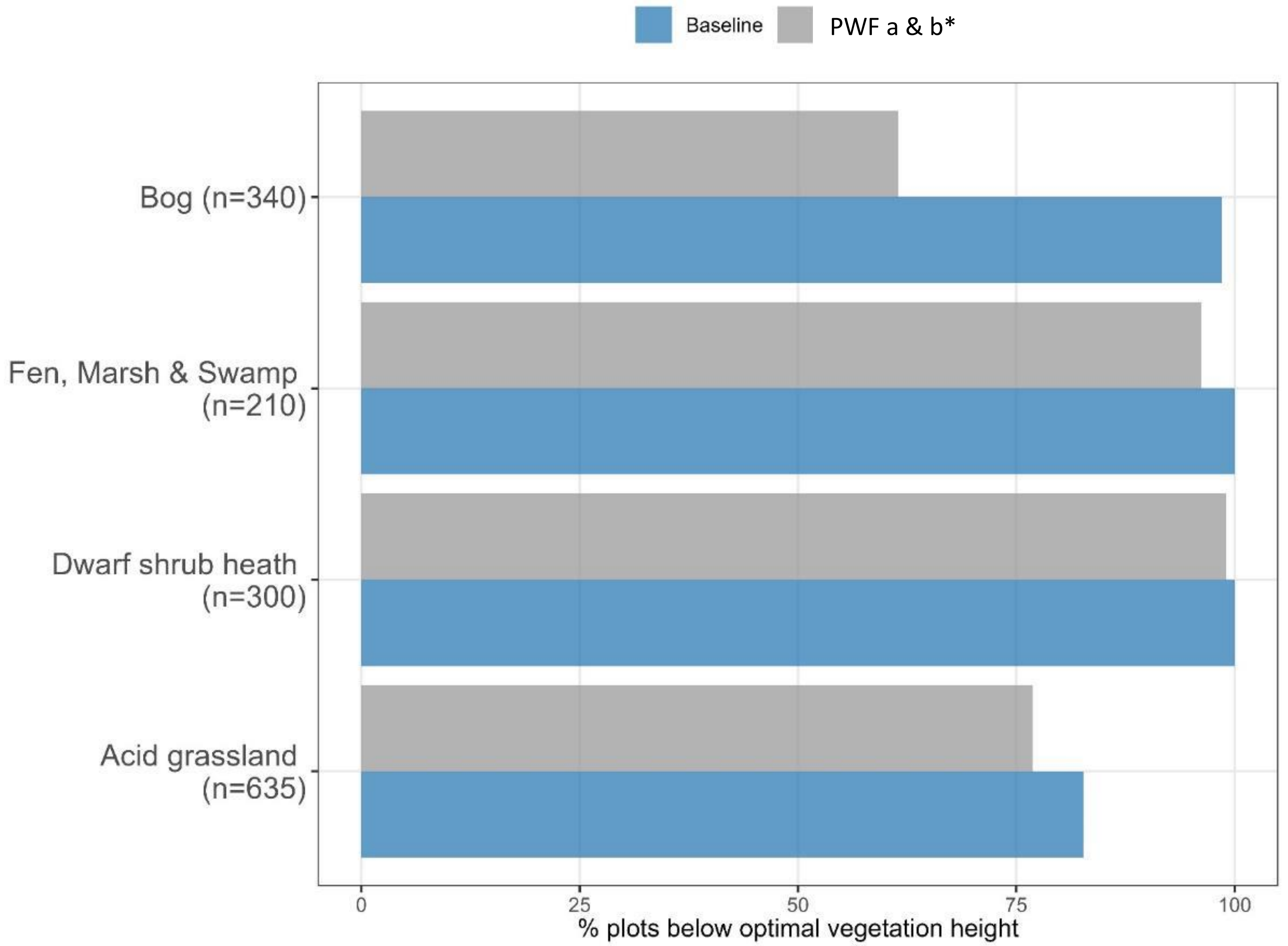
UA5 Habitat maintenance: Results



- The graph shows the percentage of ERAMMP plots where the cover-weighted vegetation height was below the canopy height associated with the UA5 upper stocking limit and therefore where the shorter vegetation height implies *greater* stocking density than optimal.
- In all habitats the effect of the modelled reduction of 1 ewe ha^{-1} stocking is to *decrease* the number of locations in sub-optimal condition.
- The biggest decrease is in Bog because the stocking reduction is associated with a greater potential increase in canopy height.
- The reduction has only minor impacts in other habitat types but is sufficient to drive changes in habitat suitability of plant species (see previous slide).

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* No modelled difference between PWF a and b.

Note that the lower proportion of Acid Grassland plots at sub-optimal vegetation height will in part reflect plots with Bracken present resulting in higher values of observed cover-weighted canopy height.

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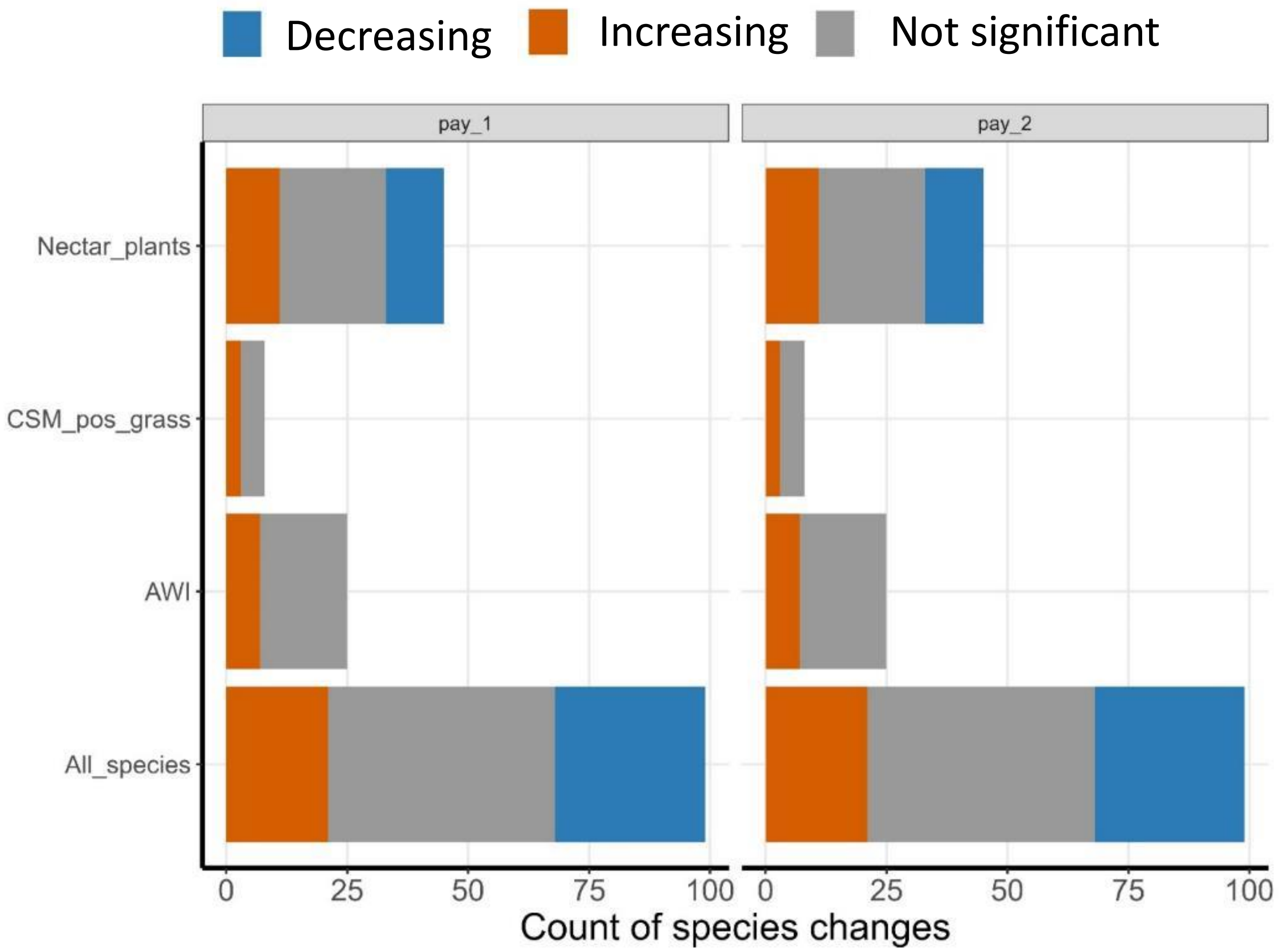
UA8 Hedge maintenance: Results



All species	PWFa	PWFb
Increasing	21	21
Decreasing	31	31
Not significant	47	47

This plot shows the number of species appearing or disappearing on the 1x10m plot location for the UA11 plots.

Increasing species most frequently observed in surveyed plots across the ERAMMP squares include *Silene dioica, Geranium robertianum, Rubus fruticosus agg., Dryopteris filix-mas and Viola riviniana.*

Woodland specialists were also predicted to increase such as *Hyacinthoides non-scripta, Oxalis acetosella and Mercurialis perennis,* but these are much less common across surveyed plots and so may be slow to disperse from small and distant source populations.

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Nectar plants = Count of nectar plants.
CSM_pos_grass = Common Standards Monitoring species (positive indicators) for Lowland grassland .
AWI = Ancient Woodland Indicators for Wales.

This plot shows the number of species appearing or disappearing on the 1x10m plot location for the UA8 plots.
A total pool of around 950 species were modelled across all plots, but in order to determine those species most likely to appear or disappear from the plot we selected only the number of species in each plot such that count of species did not exceed the estimated species richness in each plot. That way we do not consider species that are never likely to be actually encountered in the plots. This means that the species in these figures tend to be the most common species, which is realistic.

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Plant biodiversity: Summary of results for PWF scenarios

- Differences in adoption between PWFa and PWFb: There are no differences in scheme adoption for ERAMMP surveyed locations. Intersecting the ERAMMP surveyed locations with the PWF uptake layer shows the same number of plots are simulated to adopt the SFS. Hence, results for modelled impact of both interventions are the same under both PWFa and PWFb scenarios.
- UA5 "Habitat maintenance": The modelled reduction in livestock (1 ewe ha^{-1}) is assumed to increase vegetation height in all habitats. The intervention results in 11% of modelled plots moving into a favourable potential vegetation height. While relatively modest, this change is predicted to result in significant increases in common dwarf shrubs and other heath and bog species and a decrease in species of grazed acid grassland.
- UA8 "Hedge maintenance": Modelled increases in hedge width and height are applied over field boundary plots next to existing hedges. Changes in soil and light regime over 20 years are projected to increase suitability for common woodland and woodland edge species and drive down species of improved and semi-improved grasslands. Whether these changes will plausibly result from the intervention maybe open to question. Specifically, if there is no reduction in grazing pressure alongside hedges then without factoring in fencing it is less likely that the hedge will widen at the base.

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PART 4b: Bird biodiversity

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Bird biodiversity: The BIMLA model

- The BIMLA model consists of two core components: (i) standardised records of where birds have been seen; and (ii) a spatial summary of the types of landscape composition and management that influence bird breeding conditions.
- Bird observations are collated using data from the BTO/JNCC/RSPB Breeding Bird Survey (BBS) and, newly for this run, survey data from the GMEP survey programme. ERAMMP survey data are also available, but were not used in this run, as those surveys took place at a later date than the land cover data collation. The use of GMEP survey data has improved survey density and species representation, especially in upland and woodland areas.
- Land use data within farm holdings are sourced from the IMP outputs. Land use data outside of farm holdings are derived from a wide range of other spatial datasets (e.g., Land Cover Map).
- All changes between scenario and baseline are based solely on differences within farm holdings, as determined by the IMP. Land not in farm holdings was also included, because birds depend on whole landscapes, not just farmed land.
- Bird counts and land use metrics are summarised at the 1km grid square level.
- BIMLA is composed of species-specific models. Each model is trained on the relationship between species counts and relevant land use and management variables. Only variables with a statistically significant relationship with species counts are utilised.
- The impact of each scenario is assessed by comparing predicted national populations for each species to the baseline using thousands of simulated outcomes. A species is considered likely to change if 89% of these simulations suggest a population shift; a threshold percentage commonly used for balancing confidence in a result with tolerance for natural variability in model simulations.

Bird biodiversity: PWF scenarios

Three approaches are used to apply interventions:

- **Direct replacement** – If the scenario introduces a land cover type already present in the baseline, it directly replaces the existing cover. This same approach applies to changes in stocking levels and farming intensity, which are adjusted by modifying livestock units and yield values, as calculated in SFARMOD.
- **GLASTIR-based management** – A new management baseline has been developed using spatial data on GLASTIR payments and other agri-environment schemes. Where an intervention closely matches a type of management utilised in areas with sufficient bird survey coverage, this is included as an additional variable in the models. The baseline extent of each management type is informed by the new spatial baseline, while scenario areas are derived from LAM outputs. Both baseline and scenario values are combinedif previous management is expected to have long-term effects. Otherwise, scenario management is assumed to be zero unless supported by PWF payments. We attempted to model UA6 with this approach, but sample sizes were insufficient (n=9 for arable, n=11 for improvedgrass).
- **Proxy replacement** – If a land cover or management intervention has no direct match or has insufficient baseline data, the variable with the most similar expected effect on birds is selected as a proxy. The direct replacement approach is then applied using thisproxy.

Direct replacement	Modelled by 'management baseline'	Modelled by proxy	Consistent between scenario & baseline	Not modelled using BIMLA
UA5 – Habitat maintenance modelled as a function of changes in stocking	UA8 - Hedgerow maintenance: Hedgerow is assumed to be maintained in a condition equivalent to that managed in GLASTIR in the baseline	UA6 – Introduction of mixed leys on improved grass: land-cover is assumed to be "rotational grass". UA6 – Introduction of rough grass margins on arable land: land cover is assumed to be "rough grazing"	UA9: Woodland maintenance	UA1, UA2, UA3, UA4, UA7, UA9, UA10, UA11, UA12

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Bird biodiversity: Modelled land use change

Baseline information			IMP land cover changes			BIMLA-specific intervention changes			Total change		
Land use	**Baseline**	**Counter-factual**	**Intervention**	**PWFa**	**PWFb**	**Intervention**	**PWFa**	**PWFb**	**Counter-factual**	**PWFa**	**PWFb**
Rough grass	157,620ha	0		0	0	UA6 – rough grass margins on arable	+91ha	+89ha	0	+91ha	89ha
Winter cereals	31,184ha	-128ha		-92ha	-92ha		-79ha	-77ha	-128ha	-171ha	-170ha
Maize	2,660ha	+90ha		49ha	49ha		-8ha	-8ha	+90ha	+41ha	+41ha
Broadleaf vegetables	2,762ha	-90ha		-81ha	-81ha		0	0	-90ha	-81ha	-81ha
Other crops	24,094ha	-1,112ha		-1,108ha	-1,108ha		-5ha	-5ha	-1,112ha	-1,113ha	-1,113ha
Whole crop & spring cereal	5,324ha	+1,119ha		+1,160ha	+1,160ha		0	0	+1,119ha	+1,160ha	+1,160ha
Permanent improved pasture	956,316ha	0		0	0	UA6 – mixed leys on IG	-1,908ha	-1,888ha	0	-1,909ha	-1,888ha
Rotational grass	114,290ha	125ha		+72ha	+72ha		+1,908ha	+1,888ha	125ha	+1,980ha	+1,960ha
Hedge not in AES	22,086km	0	UA8 – Hedgerow maintenance	-22,006 km	-21,815 km		0	0	0	-22,006 km	-21,815 km
Hedge in AES	564.81km	0		+22,006 km	+21,815 km		0	0	0	+22,006 km	+21,815 km
Livestock	966,745LU	-26,484LU	UA5 – Habitat maintenance	-71,670LU	-71,075LU		0	0	-26,484LU	-71,670LU	-71,075LU

- Rough grass increase for UA6 is a space for time downscaling of the total buffer area to represent rotations.
- Land use areas include data outside the SFARMOD modelled >1FTE farm areas, hence baseline totals can exceed those presented elsewhere in the results (particularly improved grass).

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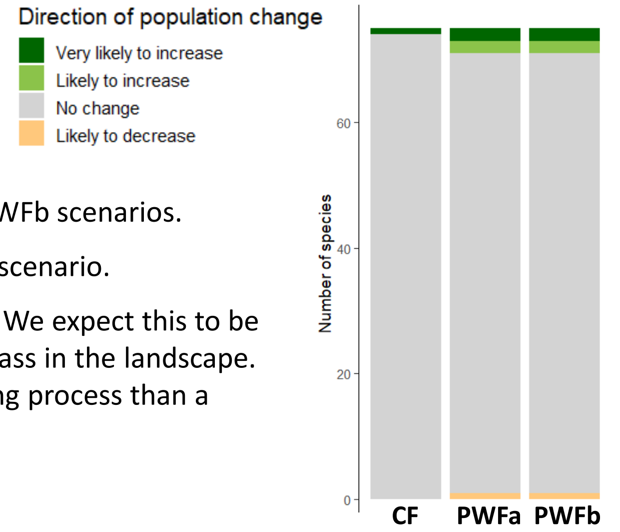
Bird biodiversity: Counterfactual and PWF scenarios



- The vast majority of species exhibit minimal change under either PWFa or PWFb scenarios.
- For all species, the average population change does not exceed 10% for any scenario.
- Four species are predicted as likely to increase under both PWFa and PWFb. We expect this to be linked to changes in arable rotation and the removal of areas of improved grass in the landscape. We suspect these minor increases are more likely an artefact of the modelling process than a genuine ecological response.
- The main intervention we had expected to influence predictions was the increased uptake of GLASTIR-standard hedgerow management. Wider and taller hedgerows are likely to have a small to moderate positive effect on hedgerow-nesting species, including Lesser Whitethroat, Bullfinch and House Sparrow. This effect is not currently reflected in our quantitative predictions, but remains our qualitative expectation if PWF is implemented. We are working on methods to improve our modelling of hedgerow management. Further discussion on this outcome can be found in the slide notes.

Number of species	CF	PWFa	PWFb
Very likely to increase	1	2	2
Likely to increase	0	2	2
No change	79	75	75
Likely to decrease	0	1	1

Several factors may contribute to our model's difficulties in assessing GLASTIR "enhanced" hedgerow. Firstly, the coverage of enhanced hedgerow involves only a small proportion of overall land cover. As a result, surveyors walking non-targeted transects may not encounter them, or may spend too little time sampling them during a typical survey to record enough birds for management effects to be detected, even where effects are occurring. Secondly, the benefits of hedgerow management may not be apparent given the baseline used here. Improvements may have occurred due to historical management, notably under Tir Gofal, such that Glastir payments function to maintain this benefit and bird increases due to Glastir would not be expected to occur. The surrounding landscape context may also be important, as birds will rarely use hedgerows alone, often nesting there but foraging elsewhere, for example, so it is possible that, if GLASTIR-managed hedgerows were situated within less favourable landscapes for the species concerned, enhanced hedgerows may be limited in terms of the benefits that they can deliver in practice. There are also known difficulties with data quality regarding hedgerow, which has been previously hard to distinguish from similar types of linear land-cover like stonewalls.

We have performed an investigative model run where we omit hedgerow management information and focus on the hedgerow area. This run demonstrates that hedgerow-species increase when the hedgerow area is greater. However, by omitting the management effect, this run behaves as if hedgerow is being planted, rather than being grown, because we are only measuring the area. As a result, more species are predicted to decline in the scenario, as key open habitat species respond poorly to the greater area of hedgerow. In practice, this would not occur, as these open habitat species are equally as affected by a small hedge as they would be a marginally larger one. We therefore believe this updated run results in a more problematic overall picture than the submitted version, and BTO therefore recommended to use the original run, and the discussion around the response to hedgerow management.

Both the figure and table reflect the same data (CF = Counterfactual). They summarise the number of species that the model predicts will be affected by the scenarios out of a total of 80 modelled species. For each species, population change is projected as the average from 2000 randomised simulations. The certainty of population change is based on the percentage of simulations where the population change is positive or negative.

Thresholds are selected to reflect different levels of certainty. The 97.5% threshold corresponds to a one-sided 95% prediction interval, where we can be highly confident of the directional outcome. The 89.5% threshold is roughly aligned to that of an 80% prediction interval, flagging results where we have strong directional support, but where factors such as limited sample sizes (e.g. for certain species or land cover types) may constrain the reliability of the model predications.

Dark green (very likely to increase) = Population increases in > 97.5% of simulations
Green (likely to increase) = Population increases in > 89.5% of simulations
Grey (no change) = None of the above are true, so no change is assumed to be projected as a result of the scenario, or confidence in a change is low.
Light orange = Population decreases in > 89.5% of simulations.

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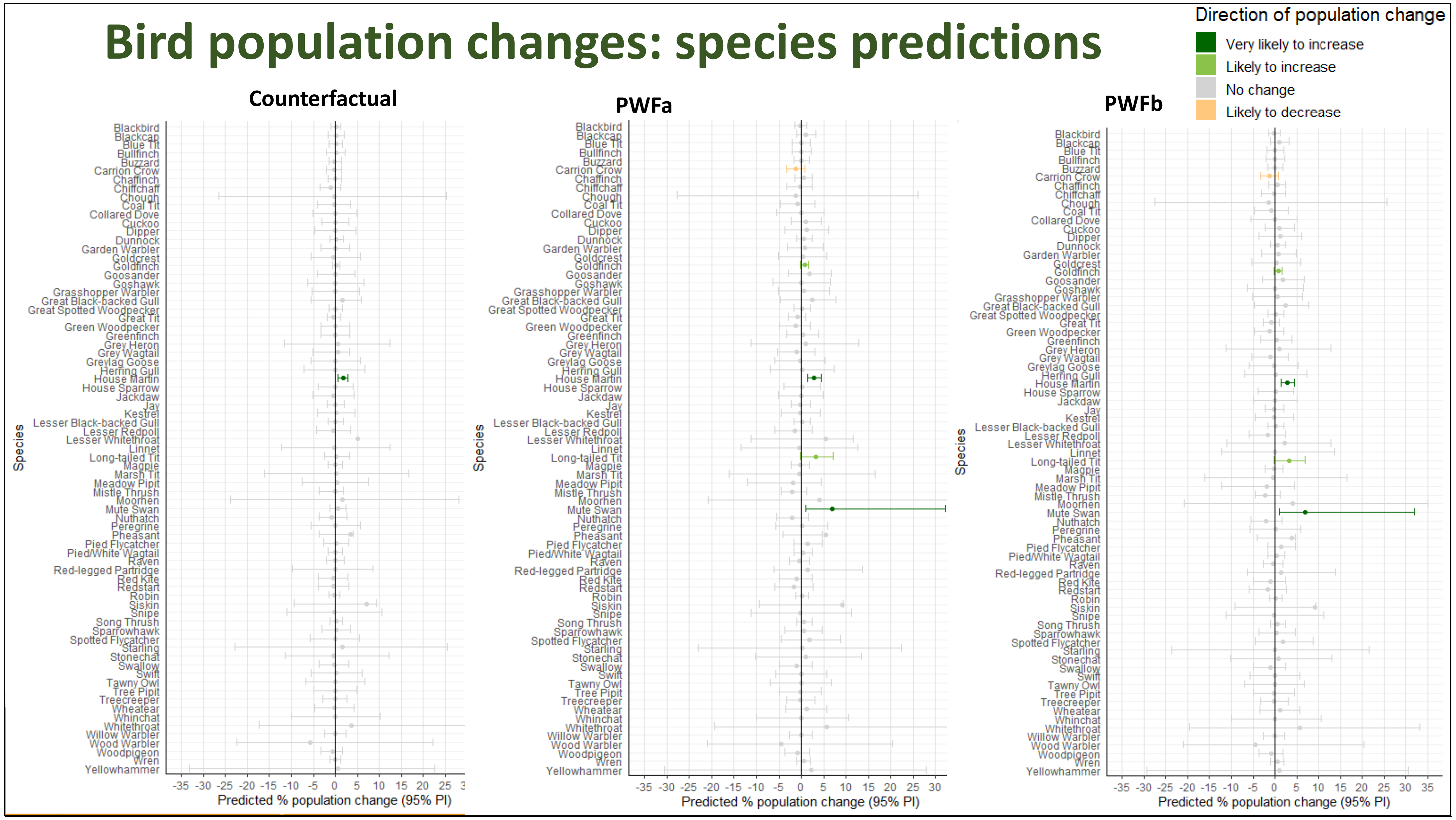

This slide shows the modelled bird population changes per species for the Counterfactual and PWF scenarios. Only 1 species is projected to increase under the Counterfactual, while another 3 species are projected to benefit under the PWFa and PWFb scenarios. However, note that as explained on the previous slide these changes are expected to be linked to artefacts in the modelling process concerning changes in the arable rotation, and the removal of improved grass. See notes on previous slide for a more detailed explanation.

Predicted population change in 80 species between the scenarios & baseline, reported as a percentage of the baseline population. For each species, the predicted population change, averaged from 2000 randomised simulations, is represented by a point. The range of predicted population changes for the lowest and uppermost prediction intervals of all simulations (2.5% and 97.5% respectively) is also presented. The certainty of population change is based upon the percentage of simulations where the population change is positive or negative.

Thresholds are selected to reflect different levels of certainty. The 97.5% threshold corresponds to a one-sided 95% prediction interval, where we can be highly confident of the directional outcome. The 89.5% threshold is roughly aligned to that of an 80% predictive interval, flagging results where we have strong directional support, but where factors such as limited sample sizes (e.g. for certain species or land cover types) may constrain the model's ability to express higher certainty.

Dark green (very likely to increase) = Population increases in > 97.5% of simulations
Green (likely to increase) = Population increases in > 89.5% of simulations
Grey (no change) = None of the above are true, so no change is assumed to be projected as a result of the scenario, or confidence in a change is low.
Light orange = Population decreases in > 89.5% of simulations.

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PART 5: Ecosystem Services

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Interpreting the data

- These slides compare the Counterfactual (a scenario with 100%BPS and the CoAP regulations in place) and the PWF scenarios (where BPS is 0%, replaced with PWF funding and CoAP regulations are in place).
- To understand these differences we need to know how Ecosystem Services provision has changed between the modelled baseline (which doesn't include the CoAP) and each of these modelled scenarios (Counterfactual and PWF). Thus, results are presented as comparisons of absolute values and/or comparative changes from baseline.
- It is not possible to model change in Ecosystem Services from the Counterfactual to the PWF scenarios directly because, within the Counterfactual run, modelled CoAP has not been in place long enough for carbon stocks and water quality to reach equilibrium (which can take many decades for some outcomes). Instead scenarios are modelled as change from the baseline run, which is modelled as at an assumed equilibrium, is used.
- Note: Within the Counterfactual and the PWF scenarios some of the absolute values for changes in land use are very small. Likewise, differences in ecosystem service outcomes between PWFa and PWFb are very small. It is important to note that in some cases, impacts and differences may be smaller than the uncertainty in the modelling. Output data have been provided to facilitate interpretation and comparison to facilitate the reader's interpretation.

Interpreting the data

Data group	Interpretation and calculation
Projected	Raw model outputs: the absolute value for the baseline or scenario, in relevant units (ha, kg, GLU etc)
Difference from Counterfactual	Difference between projected value for PWF scenario and projected value for Counterfactual scenario Supplied in original relevant units (ha, kg, GLU etc) Calculated as: PWF scenario – Counterfactual scenario
% Difference from Counterfactual	Difference between projected value for scenario and projected value for Counterfactual as a proportion of the counterfactual value Supplied as % of Counterfactual Calculated as: ((PWF scenario – Counterfactual) / Counterfactual)*100
% Difference from Baseline	Difference between projected value for scenario and projected value for baseline as a proportion of the baseline value Supplied as % of baseline Calculated as: ((scenario – baseline) / baseline)*100

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Difference from Counterfactual is Calculated as: scenario – Counterfactual so positive numbers mean increase, and negative mean decrease
% Difference from Counterfactual is calculated as: (scenario – Counterfactual) as % of Counterfactual so again positive numbers mean increase, and negative mean decrease
% Difference from Baseline is similar. No change equivalent for this.

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Interpreting the data

- Note there is a very small discrepancy in farmed area between the modelled scenarios. The national total sum of cropland and grassland areas increases for the Counterfactual (+6ha) and decreases for PWF (-2ha).
- This is because of differences in areas allocated by Sfarmod at the DMU level, which are very small at parcel level and amount to < 0.001% of modelled area overall. This is well below any reasonable assumed confidence in model outputs.
- In almost all cases, this has a very small impact on all modelled Ecosystem Services outputs but can be considered negligible. This is not noticeable at the level results are presented and will not have any effect on the overall message or interpretation.
- However, there are two exceptions where there is a noticeable impact on the results. This occurs for Ecosystem Services outputs where change is driven only by land use change, since there was virtually no modelled land use change for these scenarios. Specifically, it impacts the results for:
    1. LULUCF carbon change for the Counterfactual.
    2. Change in sediment loss for the Counterfactual and PWF.
- Since there was virtually no modelled change in drivers of these outputs, the small discrepancy has a large proportional impact on the results.
- Given the very small magnitude of modelled change for this scenario, it would be appropriate to interpret the Counterfactual Scenario as having no impact on soil and biomass carbon stocks, and all scenarios as having virtually no impact on sediment loss.
- This issue and recommended interpretation is noted alongside all relevant outputs

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1) LULUCF carbon change for the Counterfactual.
LULUCF carbon change is driven by change between major land use classes
Whilst there was some (minimal) change between rotational improved grass and arable, rotational grass applies the same carbon coefficients as arable, due to frequent disturbance
Whilst the same artefact may be present in the PWF, the modelled impacts of hedge maintenance changes on carbon mean that the small discrepancy does not have a large proportional impact on results.

2) Change in sediment loss for the Counterfactual and PWF.
This is driven only by change between the major land use classes in all modelled scenarios. Although change between rotational grass and arable would affect this outcome, the total national level modelled change in these areas is not sufficiently greater than the discrepancy in modelled areas that the results should be considered reliable.

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PART 5a:
Land use and livestock change

To aid interpretation of the ecosystem service results

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Summary of land use change

Group	Scenario	Cropland (ha)	Improved Grass (ha)	Rough Grass (ha)
Projected	Baseline	61,543	633,258	157,629
	Counterfactual	61,428	633,380	157,629
	PWFa	61,473	633,326	157,629
	PWFb	61,473	633,326	157,629
Difference from Counterfactual	PWFa	45	-54	0
	PWFb	45	-54	0
% Difference from Counterfactual	PWFa	0	0	0
	PWFb	0	0	0
% Difference from Baseline	Counterfactual	0	0	0
	PWFa	0	0	0
	PWFb	0	0	0

Note these changes do not include areas converted for temporary habitat action UA6, due to the single year scheme commitment and temporary nature of the habitat actions. Temporary habitat creation is not modelled as affecting Ecosystem Services.

Projected land use change is minimal for the Counterfactual and the PWF scenarios due to limited interventions and no modelled farm type change.

Compared to baseline, the Counterfactual and both PWF scenarios show:

- More improved grass, and less cropland; reflecting near zero (<0.1%) conversion of cropland to improved grass.
- No change for rough grass.

Comparing the PWFa and PWFb scenarios to the Counterfactual shows:

- Both show slightly more cropland and less improved grass.
- % Difference in areas from Counterfactual is minimal (~0%).

Note there is a very small difference in farmed area between the modelled scenarios, i.e. the national total sum of cropland and grassland areas increases for Counterfactual scenario (+6ha) and decreases for PWF scenarios (-2ha). This is because of differences in DMU level areas allocated by Sfarmod, which are very small at parcel level and amount to < 0.001% of modelled area overall. This is well below any reasonable assumed confidence in model outputs. This will have a very small impact on all modelled Ecosystem Services outputs, but will not have any effect on the overall message or interpretation. Where the modelled change in drivers is very small, this minor discrepancy makes up a greater proportion of modelled change, as noted in the slides where relevant.

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Summary of livestock change from baseline

Group	Scenario	N fertiliser (kt N)	P fertiliser (kt P)	Beef (GLUs)	Dairy (GLUs)	Sheep (GLUs)
Projected	Baseline	31.45	13.63	261,637	293,860	411,249
	Counterfactual	26.89	13.37	261,348	267,383	411,262
	PWFa	26.14	13.09	253,442	255,618	385,746
	PWFb	26.16	13.09	253,528	256,085	385,789
Difference from Counterfactual	PWFa	-0.76	-0.28	-7,905	-11,765	-25,516
	PWFb	-0.73	-0.27	-7,820	-11,298	-25,473
% Difference from Counterfactual	PWFa	-2.81	-2.09	-3	-4	-6
	PWFb	-2.72	-2.05	-3	-4	-6
% Difference from Baseline	Counterfactual	-14.50	-1.94	0	-9	0
	PWFa	-16.91	-3.99	-3	-13	-6
	PWFb	-16.83	-3.95	-3	-13	-6

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Compared to the baseline, the Counterfactual and both PWF scenarios show:

- Projected reductions for beef, dairy and N and P fertiliser, and reductions for sheep under both PWF scenarios but not the Counterfactual.
- Reductions were proportionally larger than land use change.

Comparing the PWF scenarios to the Counterfactual shows:

- PWF drives further reductions. PWFa with higher payment and uptake leads to slightly more reductions than PWFb.
- Both show more reduction in fertiliser, with 2-2.8% less inputs than the Counterfactual.
- Both PWF scenarios show 6% reductions for sheep, whilst the Counterfactual shows a negligible (<0.01%) increase.
- Both PWF scenarios show greater decreases for dairy (13%) than the Counterfactual (9%).
- Decreases for beef are an additional 3% of the baseline change, on top of change for the Counterfactual.

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PART 5b i: Carbon & GHG emissions
- Overview

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Changes in carbon stocks and carbon/GHG emissions

- The next slides show the data for carbon stocks and carbon/GHG emissions together to represent the combined impact on atmospheric GHG.

Contents:

- Methods
- Cumulative change to 2030 in KtCO2eq and as percentage change of baseline values, for all scenarios.
- Cumulative change to 2030, 2050 and 2100 to illustrate potential longer-term impacts, for the counterfactual, then the two PWF scenarios.

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Changes in carbon stocks and carbon/GHG emissions

These data have 2 separate components:

1. Carbon stocks and change for soils and biomass. Modelled for non-organic soils (to 1m), agricultural biomass and new woodland vegetation.
    a) Modelled using LULUCF coefficients for agricultural land use and change, and CARBINE-ESC for woodland creation.
    b) Modelled for hedge soil and biomass using bespoke coefficients to represent management assumptions.
2. Annual GHG emissions and change in emission of greenhouse gas from:
    a) Peat/wetland soils. Modelled using LULUCF wetland supplement coefficients (methane, CO_2 & direct N_2O emissions).
    b) Agricultural land management (livestock and fertiliser) in the form of N_2O; agricultural land management (livestock) in the form of methane. Modelled using FARMSCOPER coefficients.

- Soil carbon stock and change (1) are only calculated for non-organic soils, whilst peat GHG emissions and change (2a) are only calculated for organic soils. The carbon stocks and flows are relevant for different soil types, so there is no spatial overlap.
- Agricultural land management GHG emissions of N_2O (2b) are also not calculated for peat soils, since losses from peat soils are better represented by the wetland coefficients (2a). These are relevant for different soil types, so there is no spatial overlap.
- Therefore, total change for carbon stocks and both agricultural and wetland GHG must be summed to understand the net carbon impacts of the scenario.
- Because carbon stocks and GHG emissions flows are distinct, the baseline values cannot be added up, hence, the data are provided separately to allow us to calculate % change from baseline.
- Carbon stock change (1) is calculated based on non-linear rates of change over time, whilst GHG (2) is an annual average, multiplied by the number of years to get a cumulative value
- Both (1) & (2) are modelled at DMU scale, for parcels represented by SFARMOD and the LAM.
- Agricultural GHG (2b) are modelled for farms <1FTE (applying small farm averages for land use and livestock) and commons (rough grass only). These numbers are only included for QA of national totals, since no change is modelled on these parcels.

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Summary of change in carbon stocks and GHG emissions to 2030

Cumulative change in carbon stock and GHG **2023 to 2030**					
Note: negative numbers indicate sequestration or avoided emissions which equates to reduction in atmospheric GHG		1) Change in carbon stocks for soils and biomass: Losses from carbon stocks in a) land use change and forestry + harvested wood products b) Hedge maintenance	2) Change in emission of greenhouse gas: Additional emissions from		Total
Group	Scenario		a) Wetlands/ peat GHG	b) Agricultural GHG	
Cumulative change in emissions from baseline to 2030 **(KtCO2eq)**	Counterfactual	0.78	-0.81	-1,796	-1,796
	PWFa	-92.34	-0.81	-3,112	-3,205
	PWFb	-91.53	-0.81	-3,086	-3,178
Cumulative change from baseline to 2030 as: **% of baseline stock** (losses from carbon stocks) or **% of baseline GHG emissions** (agricultural and wetland GHG)	Counterfactual	0	-0.1	-5.53	
	PWFa	-0.02	-0.1	-9.57	
	PWFb	-0.02	-0.1	-9.49	

- **Overall, there are marginally greater modelled benefits for PWFa for all outcomes, but they should be considered equivalent for carbon and GHG outcomes**

For the Counterfactual and both PWF scenarios:

- Reduction in agricultural GHG (2b) delivers most of the carbon benefits to 2030.
- Minimal land use change led to minimal reduction in wetland GHG (2a).

Comparing the PWF scenarios to the Counterfactual:

- For carbon stock in soils and biomass (1), due to minimal land use change, there is negligible change for the Counterfactual which should be treated as zero. However, both PWF scenarios show benefits due to hedge maintenance (see here).
- The Counterfactual represents a 6% reduction in baseline agricultural GHG, and the PWF an additional ~ 4% (see here).

This slide is a summary of the carbon stock change and GHG changes together, in terms of change in atmospheric GHG. Note, these data represent a change over time.

- The table shows values in terms of increased atmospheric GHG relative to baseline for the Counterfactual and PWF scenarios, from different sources: losses of carbon stock; wetland GHG; agricultural GHG.
- Values are cumulative for 2023 (start) to 2030 (end).
- Values are negative to indicate reduction in atmospheric GHG.
- It is not possible to calculate an overall cumulative % change from baseline to 2030 because it is not appropriate to add up a % of stock (for losses from carbon stocks) and a % of flow (baseline GHG emissions from agricultural and wetland/peat sources).

Summary of these changes, as explained by the Top of Chain changes:

- For all scenarios, change in agricultural GHG flux delivers most of the carbon and GHG benefits to 2030 due to livestock and fertiliser changes.
- For all scenarios, very limited benefit from reduced wetland/peat GHG flux, due to minimal land use change, largely not on peat/wetland.
- For change in carbon stock in soils and biomass there was negligible benefits for the Counterfactual (limited land use change).
  - The modelled agricultural land use changes are all between rotational grass and cropland, which affects biomass carbon but not soil carbon.
  - The negligible modelled change in LULUCF carbon for the Counterfactual should be thought of as zero, given the effects of the small discrepancy in combined arable and grass area between the baseline and scenarios. Note that this very small discrepancy for soil carbon is only noticeable in the absence of real change for these scenarios.
- Comparatively, both PWF scenarios showed benefits for carbon stock in soils and biomass due to hedge maintenance.

- The Counterfactual shows comparatively large benefits of the modelled representation of CoAP for change in agricultural GHG flux (~1,800kt which was ~7% reduction from baseline).
- These changes are in line with the projected reduction in dairy (9%) & N fertiliser (14.5%) with 5.8% reduction in total N inputs, as well as adjustment of Farmscoper coefficients to match modelled representation of CoAP implementation.
- Both PWF scenarios show an additional reduction in agricultural GHG flux compared to the Counterfactual scenario (additional ~4% of baseline agricultural GHG), due to additional reductions on top of the Counterfactual scenario changes. Additional (to Counterfactual scenario) reductions were: ~2-2.8% of baseline fertiliser inputs; ~3% beef; 4% dairy; 6% sheep.

Changes were calculated as follows (as explained on previous slide):

1) Losses from carbon stocks in land use change and forestry + harvested wood products

These data are carbon stock changes for soils and biomass, calculated based on non-linear rates of change over time, which result from:

a) changes in land use (these were minimal), modelled using LULUCF coefficients.

b) for the PWF scenarios also from changes in hedge maintenance, modelled using bespoke coefficients developed to represent the specific maintenance assumptions.

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2a) Additional wetland/peat GHG emissions

Changes in GHG emissions from wetlands result from land use changes on peat (these changes were minimal).
Modelled as an annual average, which is multiplied by the number of years to get a cumulative value to end 2030.

2b) Additional agricultural GHG emissions
These agricultural GHG changes result from changes in livestock and fertiliser, with impacts modelled using Farmscoper coefficients. These coefficients were also adjusted to represent impacts of CoAP.
Modelled as an annual average, which is multiplied by the number of years to get a cumulative value to end 2030.

Note there is a very small difference in farmed area between the modelled scenarios, i.e., the national total sum of cropland and grassland areas increases for Counterfactual scenario (+6ha) and decreases for PWF scenarios (-2ha).
This is because of differences in DMU level areas allocated by SFARMOD, which are very small at parcel level and amount to < 0.002% of modelled area overall, which is well below any reasonable assumed confidence in model outputs.
Rotational grass has the same soil carbon coefficients as cropland, due to frequent disturbance, and no time to accumulate carbon. However, the small modelled area discrepancy leads to some modelled sequestration or loss of soil carbon; this is negligible and should be ignored.

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Breakdown of carbon stock and GHG emissions over time: Counterfactual

Inventory category (Note: Negative numbers indicate sequestration or avoided emissions)		**Increased emissions or losses of carbon by the year:**		
		2030	**2050**	**2123**
1) Change in carbon stocks for soils and biomass	a) Losses from carbon stocks in Land use change and forestry + harvested wood products (LULUCF 4 A,B,C & G) (KtCO2eq)	1	0	-1
	b) Losses from carbon stocks in hedge management (non LULUCF coefficients) (KtCO2eq)	0	0	0
2) Change in GHG emissions - Additional emissions from	a) Wetlands/peat GHG (4D) flux (KtCO2eq)	-1	-3	-10
	b) Agricultural GHG flux (KtCO2eq)	-1,796	-6,286	-22,676
Total		**-1,796**	**-6,289**	**-22,688**

- For the Counterfactual, given very little projected land use change, there is very little change for carbon stocks or wetland emissions.
- For LULUCF carbon (4 A,B,C & G) modelled change is smaller than uncertainty in the modelling, given impacts from the small land cover discrepancy.
- Comparatively there are larger benefits for avoided agricultural GHG emissions, representing ~6% reduction in annual agricultural GHG emissions. This component delivers the vast majority of the projected carbon and GHG benefits in all time periods, due to reduced N inputs and management adjustments.

This slide shows breakdown of carbon stock & peat and agricultural GHG over time for the Counterfactual. Results show:

- For the Counterfactual, given very little projected land use change, there is virtually no change in carbon stocks in soils and biomass:
  - Minor (~1kt) loss from intensive grass/arable change to 2030, presumably from biomass loss.
  - Largely offset by 2050 due to sequestration in soils, with minor (~1kt) sequestration by 2123.
- Similarly, in the absence of land use change there is virtually no projected change in peat GHG, although minor benefits accumulate over time up to 10Kt avoided over 100 years.
- Comparatively large benefits of the modelled representation of CoAP for avoided agricultural GHG; these accumulate linearly over time.

Drivers:

- 1a) "LULUCF carbon (4 A,B,C & G)" data represent carbon stock changes for agricultural soils and biomass, which result from changes in land use, modelled using LULUCF coefficients (the changes were minimal) and woodland modelled using ESC and CARBINE for woodland creation (no change, because no woodland creation).
- 1b) For the PWF scenarios, "Losses from carbon stocks in hedge management" data also represent changes for soils and biomass, from changes in hedge maintenance, modelled using bespoke coefficients developed to represent the specific maintenance assumptions.
- 2a)"Additional emissions from wetlands (4D)" data represent changes in peat GHG resulting from land use changes on peat (these changes were minimal).
- 2b)"Additional agricultural GHG " data represent Agricultural GHG changes resulting from changes in livestock and fertiliser, with impacts modelled using Farmscoper coefficients. These coefficients were also adjusted to represent impacts of CoAP.

Note there is a very small difference in farmed area between the modelled scenarios, i.e., the national total sum of cropland and grassland areas increases for Counterfactual scenario (+6ha) and decreases for PWF scenarios (-2ha). This is because of differences in DMU level areas allocated by SFARMOD, which are very small at parcel level and amount to < 0.002% of modelled area overall, which is well below any reasonable assumed confidence in model outputs. Rotational grass has the same soil carbon coefficients as cropland, due to frequent disturbance, and no time to accumulate carbon. However, the small modelled area discrepancy leads to some modelled sequestration or loss of soil carbon; this is negligible and should be ignored.

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Breakdown of carbon stock and GHG emissions over time: PWF

Inventory category (Note: Negative numbers indicate sequestration or avoided emissions)		**Increased emissions or losses of carbon by the year:** 2030 PWFa	2030 PWFb	2050 PWFa	2050 PWFb	2123 PWFa	2123 PWFb
1) Change in carbon stocks for soils and biomass	a) Losses from carbon stocks in Land use change and forestry + harvested wood products (LULUCF 4 A,B,C & G) (KtCO2eq)	2	2	3	3	2	2
	b) Losses from carbon stocks in hedge management (non LULUCF coefficients) (KtCO2eq)	-94	-93	-611	-606	-1,815	-1,799
2) Change in GHG emissions - Additional emissions from	a) Wetlands/peat GHG (4D) flux (KtCO2eq)	-1	-1	-3	-3	-10	-10
	b) Agricultural GHG flux(KtCO2eq)	-3,112	-3,086	-10,892	-10,801	-39,289	-38,961
Total		**-3,205**	**-3,178**	**-11,503**	**-11,407**	**-41,112**	**-40,768**

- For the PWF, given very little projected land use change, there is virtually no change in LULUCF carbon stocks (1a) or wetland emissions (2a).
- For agricultural LULUCF carbon (4 A,B,C & G) (KtCO2eq) modelled change is smaller than uncertainty in the modelling, given impacts from the small land cover discrepancy.
- Carbon sequestration is projected for hedge maintenance (1b, see here).
- Comparatively, there are larger benefits for avoided agricultural GHG emissions (2b) , representing ~10% reduction in annual agricultural GHG emissions. This component delivers the vast majority of the projected carbon and GHG benefits over all time periods, due to reduced N inputs and management adjustments, including livestock reductions for UA5 Habitat Maintenance.

This slide shows breakdown of carbon stock & peat and agricultural GHG over time for the PWF scenarios. Results show:

- For the PWF, given very little projected land use change, there is virtually no change in carbon in agricultural soils and biomass, and no change for woodland carbon (1a; LULUCF categories 4 A,B,C & G).
- For agricultural LULUCF carbon (4 A,B,C & G) (KtCO2eq) modelled change is smaller than uncertainty in the modelling, given impacts from the small land cover discrepancy.
- Sequestration for hedge maintenance (1b) modelled as non-linear change over time.
- Because the hedge gets wider and sequestration in soils is ongoing, relatively high sequestration rates are maintained.
- In the absence of land use change there is virtually no projected change in peat GHG (2a), although minor benefits accumulate over time up to 10Kt avoided over 100 years.
- Comparatively large benefits of the scheme changes plus modelled representation of CoAP for avoided agricultural GHG (2b); these accumulate linearly over time.

Drivers:

- 1a) "LULUCF carbon (4 A,B,C & G)" data represent carbon stock changes for agricultural soils and biomass, which result from changes in land use, modelled using LULUCF coefficients (the changes were minimal) and woodland modelled using ESC and CARBINE for woodland creation (no change, because no woodland creation).
- 1b) For the PWF scenarios, "Losses from carbon stocks in hedge management" data also represent changes for soils and biomass, from changes in hedge maintenance, modelled using bespoke coefficients developed to represent the specific maintenance assumptions.
- 2a)"Additional emissions from wetlands (4D)" data represent changes in peat GHG resulting from land use changes on peat (these changes were minimal).
- 2b)"Additional agricultural GHG " data represent Agricultural GHG changes resulting from changes in livestock and fertiliser, with impacts modelled using Farmscoper coefficients. These coefficients were also adjusted to represent impacts of CoAP.

Note there is a very small difference in farmed area between the modelled scenarios, i.e., the national total sum of cropland and grassland areas increases for Counterfactual scenario (+6ha) and decreases for PWF scenarios (-2ha). This is because of differences in DMU level areas allocated by SFARMOD, which are very small at parcel level and amount to < 0.002% of modelled area overall, which is well below any reasonable assumed confidence in model outputs. Rotational grass has the same soil carbon coefficients as cropland, due to frequent disturbance, and no time to accumulate carbon. However, the small modelled area discrepancy leads to some modelled sequestration or loss of soil carbon; this is negligible and should be ignored.

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PART 5b ii: Carbon & GHG emissions

- Carbon stocks in soils and biomass

The next section covers Carbon stocks and change for biomass and non-organic soils.

Modelled for non-organic soils (to 1m), agricultural biomass and new woodland vegetation.

Two components:
A) Modelled using LULUCF coefficients for agricultural land use and change, and CARBINE-ESC for woodland creation.
B) Modelled for hedge soil and biomass using bespoke coefficients to represent management assumptions.

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Changes in carbon stocks in soils and biomass

- The next slides show the data for carbon stocks in soils and biomass to interpret the contribution to overall GHG balance change.

Contents:

- Methods
- Carbon stock changes 2023 to 2030 and 2023 to 2050, for all scenarios.
- Carbon stock changes from hedge maintenance 2023 to 2030 and 2023 to 2050, for PWF scenarios.
- Further breakdown of the Carbon stock changes from hedge maintenance for all time periods, to see the contributions from soil and biomass, and contribution from in hedge trees.
- Map of change in carbon stocks in soil and biomass

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Carbon stocks in soils and biomass: Background information & caveats

- For both (a) LULUCF carbon and (b) hedge maintenance carbon, the following are modelled:
  1. Total stocks in the soil and biomass pool for baseline (where possible);
  2. Total stocks in the soil and biomass and harvested wood pool for the scenario in the year 2030, 2050 and 2123 calculated accounting for non-linear rates of change from the baseline;
  3. Change in the total stocks in the soil and biomass and harvested wood pool from baseline to scenario by year 2030, 2050 and 2123 (difference between values 1 and 2);
  4. Change in the total stocks as CO2 equivalent, representing the change in atmospheric GHG due to net carbon transfer between the soil/biomass/wood and the atmosphere (value 3 converted to CO2 equivalents).
- For carbon stocks ((a) LULUCF carbon, (b) hedge carbon), changes occur non-linearly over time in response to a change in the system. Change therefore occurs in response to land use or management change, or hedge maintenance; if these do not change, then no net emissions or sequestration is assumed.
- The change represents a transfer of carbon from being stored in the soil and biomass “pool” to the atmospheric “pool” (or vice versa).
- Because of the non-linear rates of change, numbers are reported only as a total change to a specific year, rather than as an annual average.
- All coefficients are based on average values and will therefore be less robust at small scales than regionally/nationally.

This slide explains the methods for carbon stock and change calculations.
Note that:
- Estimated baseline stock for the soil and biomass pool for agricultural land (i.e., grassland and arable) has been calculated.
- However, baseline estimates cannot be calculated for hedges and existing woodland due to poor data on species, condition and management.
- For consistency, projected ongoing carbon sequestration from existing hedges is not included in the hedge carbon estimates. Hence, we are only modelling the benefits of changes due to the scheme.
- Change for woodland maintenance carbon is not calculated due to lack of data on baseline management to allow robust assumptions about change. Representation of no change for carbon is in line with representation of costs (no change).

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Carbon stock changes

Carbon stock changes 2023 to 2030 and 2023 to 2050		Counterfactual	PWFa	PWFb
2023 to 2030	Carbon stock change (ktCO2e)	0.78	-92.34	-91.53
	Carbon stock change (%)	0.00	-0.02	-0.02
2023 to 2050	Carbon stock change (ktCO2e)	0.19	-608.34	-603.10
	Carbon stock change (%)	0.00	-0.12	-0.12

- For the Counterfactual, there is a negligible projected (<1kt) loss in carbon stock to 2030.
  - This reflects change in biomass carbon from small areas of conversions between arable and rotational improved grassland.
  - There is a +6ha (< 0.002% of modelled area) discrepancy in modelled agricultural area, which largely offsets the biomass carbon loss by 2050, and this effect should be ignored. This is negligible and is only noticeable because there is no real modelled impact.
  - Modelled change is smaller than uncertainty in the modelling, and this should be stated in any use of the results.
- For both PWF scenarios, there is a projected increase in carbon stock to 2030:
  - This is dominated by carbon sequestration from hedge maintenance.
  - There is slightly greater sequestration for PWFa than PWFb, due to greater scheme adoption, but the difference is negligible.
  - Additionally, there are impacts from biomass carbon change from small areas of conversions between arable and rotational grassland, and a small (2ha) discrepancy in modelled area. This contributes minor net emissions over both time periods, but does not affect the overall modelled outcomes, due to larger scale of overall carbon change.

This slide shows Carbon stock changes in soils and biomass for 2023 to 2030 and 2023 to 2050. More detailed breakdown of this in the next slides.

Changes were calculated as follows (as explained on previous slide):
Carbon stocks and change for soils and biomass are modelled for non-organic soils (to 1m), agricultural biomass and new woodland vegetation.

- Modelled using LULUCF coefficients for agricultural land use and change, and CARBINE-ESC for woodland creation.
- Modelled for hedge soil and biomass using bespoke coefficients to represent management assumptions.

Change therefore occurs in response to land use or management change, or hedge maintenance. No net emissions or sequestration is assumed if there is no change in these.

Note there is a very small difference in farmed area between the modelled scenarios, i.e., the national total sum of cropland and grassland areas increases for Counterfactual scenario (+6ha) and decreases for PWF scenarios (-2ha). This is because of differences in DMU level areas allocated by SFARMOD, which are very small at parcel level and amount to < 0.002% of modelled area overall, which is well below any reasonable assumed confidence in model outputs. Rotational grass has the same soil carbon coefficients as cropland, due to frequent disturbance, and no time to accumulate carbon. However, the small modelled area discrepancy leads to some modelled sequestration or loss of soil carbon; this is negligible and should be ignored.

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Additional carbon sequestration from changes in hedge maintenance

Carbon stock changes 2023 to 2030 and 2023 to 2050		PWFa	PWFb
2023 to 2030	Carbon Hedge maintenance stock change (ktCO2e)	-78.59	-77.91
	Carbon Hedge tree stock change (ktCO2e)	-15.35	-15.22
2023 to 2050	Carbon Hedge maintenance stock change (ktCO2e)	-365.18	-362.01
	Carbon Hedge tree stock change (ktCO2e)	-245.67	-243.59

Hedge maintenance

- For both PWF scenarios, there is a projected increase in carbon stock in hedges and hedge trees to 2030 and 2050.
- To 2030, hedge maintenance carbon is around 5 times that from hedge trees.
- By 2050, hedge trees are projected to sequester around 70% as much carbon as hedges.
- There is slightly greater sequestration for PWFa than PWFb, due to greater scheme adoption.

Assumptions in slide notes

This slide shows Carbon stock changes from hedge maintenance and new trees in hedges from 2023 to 2030, and 2023 to 2050.
The split to soil and biomass is shown in the next slide

Changes were calculated as follows
Carbon stocks and change for soils and biomass. Modelled for non-organic soils (to 1m), agricultural biomass and new woodland vegetation.

- Modelled for hedge soil and biomass using bespoke coefficients to represent management assumptions.

The modelled carbon sequestration represents the following maintenance for all existing hedgerows on farms entering the SFS.

Unmanaged hedgerows (not in an existing AES at baseline):

- Increase by 5cm every 2 years from a baseline size of 1m x 1m to width 3m, height 2m.
- One native tree sapling is planted every 50m.

Managed hedgerows (in an existing AES at baseline):

- Increase by 5cm every 2 years from a baseline size of 2m x 2m to width 3m, height 2m.
- One native tree sapling is supported to grow every 50m.

Trees modelled separately from hedges, and assumed to be next to the hedge (not overlapping)

Although agreements are for 1 year, we model this maintenance regime projected to continue to 2123.

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Breakdown of additional carbon sequestration from changes in hedge maintenance

Category (Note: Negative numbers indicate sequestration or avoided emissions)	**Increased emissions or losses of carbon (KtCO2eq) by the year:**					
	2030		**2050**		**2123**	
	PWFa	**PWFb**	**PWFa**	**PWFb**	**PWFa**	**PWFb**
Hedge Biomass	-74	-73	-321	-318	-598	-592
Hedge Soil	-5	-5	-44	-44	-511	-507
Tree Biomass	-9	-9	-223	-221	-603	-598
Tree Soil	-7	-7	-23	-23	-103	-102
Total	-94	-93	-611	-606	-1,815	-1,799

- For the Counterfactual, there is no projected hedge maintenance or associated benefit.
- The PWF scenarios hedge maintenance leads to very similar trajectories of projected carbon sequestration through time.
- To 2050, the majority of benefits are from biomass rather than soils for both hedges and hedge trees.
- For hedges by 2123, soil has around similar cumulative carbon sequestration to biomass due to ongoing accumulation in the soil reflecting turnover, including from death of fine roots in response to frequent trimming.
- Conversely, trees accumulate more biomass, so the majority of benefits are still in biomass by 2123.
- Benefits were similar, but slightly greater for all pools in PWFa than PWFb.

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Changes were calculated as follows

Carbon stocks and change for soils and biomass are modelled for non-organic soils (to 1m), agricultural biomass and new woodland vegetation.

- Modelled for hedge soil and biomass using bespoke coefficients to represent management assumptions.

The modelled carbon sequestration represents the following maintenance for all existing hedgerows on farms entering the SFS.

Unmanaged hedgerows (not in an existing AES at baseline):

- Increase by 5cm every 2 years from a baseline size of 1m x 1m to width 3m, height 2m.
- One native tree sapling is planted every 50m.

Managed hedgerows (in an existing AES at baseline):

- Increase by 5cm every 2 years from a baseline size of 2m x 2m to width 3m, height 2m.
- One native tree sapling is supported to grow every 50m.

Trees modelled separately from hedges, and assumed to be next to the hedge (not overlapping)

Although agreements are for 1 year, the modelling assumes this maintenance regime will continue to 2123.

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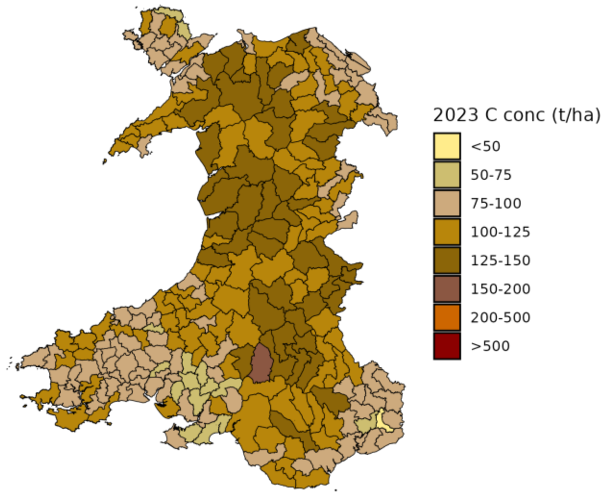
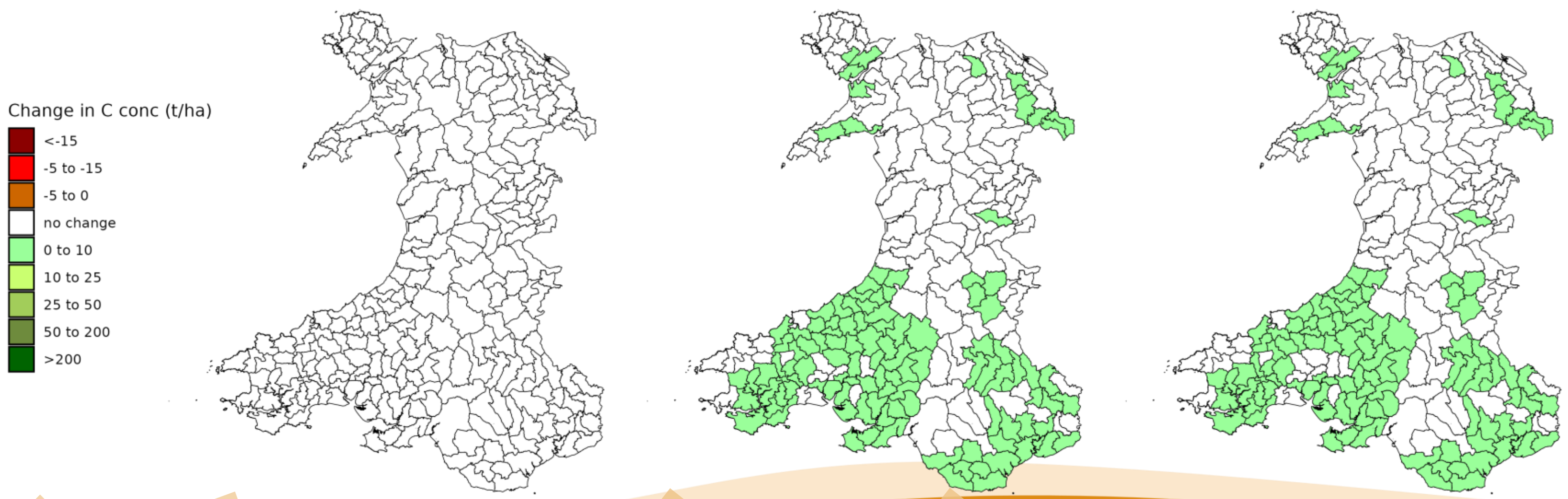
Carbon change

- For the Counterfactual, there is virtually no change in soil and biomass carbon stocks, resulting in no visible change in the map.
- For both PWF scenarios, there is a small amount of sequestration in a lot of regions, driven by presence of hedges and associated carbon sequestration on farms that adopt the SFS.
- The spatial patterns of change are very similar between the PWFa and PWFb scenarios, due to very similar patterns and extent of scheme adoption.

Baseline



Counterfactual | **PWFa** | **PWFb**



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This slide shows spatial pattern of carbon stock changes for soils and biomass

Changes result from changes in land use, modelled using LULUCF coefficients (these were minimal) and for the PWF scenarios also from changes in hedge maintenance, modelled using bespoke coefficients developed to represent the specific maintenance assumptions.

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PART 5b iii: Carbon & GHG emissions

- GHG emissions

This section shows the data for GHG emissions change to understand the separate components and trends over time. GHG emissions and change in emission of greenhouse gas from:

- Peat using LULUCF wetland supplement coefficients (methane, CO_2 & direct N_2O emissions);
- Agricultural GHG emissions by combining the Sfarmod outputs for land use, livestock and fertiliser with coefficients from Farmscoper for:
  - Agricultural land management (livestock and fertiliser) in the form of N_2O;
  - Agricultural land management (livestock) in the form of methane.

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GHG emission changes (wetlands/peat, livestock and land use)

- The next slides show the data for wetland/peat and agricultural GHG emissions to interpret the contribution to overall GHG balance change.

Contents:

- Methods
- Breakdown of annual GHG emissions changes, to see the contributions from wetland/peat and agricultural GHGs, which are further broken down into N_2O and methane, which helps to relate back to drivers of fertiliser and livestock.
- Maps of change in agricultural GHG
- Maps of change in wetland/peat GHG

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GHG emission changes (wetlands/peat, livestock and land use): Background information & caveats

For agricultural and wetland/peat GHG emissions change, the following are modelled:

1. Annual emissions for baseline;
2. Annual emissions for scenario;
3. Change in the annual emissions from baseline to scenario (difference between values 1 and 2);
4. Cumulative change in emissions to years 2030, 2050 and 2123 (value 3 multiplied by 8, 28 and 101 respectively).

- Note: Annual emissions for agricultural GHG and wetland/peat GHG are modelled, and then cumulative change over time is calculated by multiplying by the number of years. That is because these systems, broadly speaking, create GHG emissions each year and have a direct relationship between management and average annual emissions.
- All coefficients are based on average values and will therefore be less robust at small scales than regionally/nationally.
- The modelling assumes that changes for agricultural GHG and wetland/peat GHG occur immediately in response to changes in land use and agricultural management. A consistent rate is assumed for baseline and scenario (i.e. steady state with long term persistence of emissions rate).
- Wetland/peat GHG emissions using LULUCF coefficients are only calculated for DMU which are peat dominated. Conversely, for DMU which are peat dominated, the agricultural N_2O are omitted from the FARMSCOPER modelling. This is to avoid double counting, since the emissions are already represented by the LULUCF coefficients, which are more appropriate in the context of peat.
- Methane emissions represented by the peat LULUCF coefficients are primarily due to anaerobic processes in soil, rather than livestock emissions, hence the FARMSCOPER methane emissions are not omitted.

This slide explains the methods for carbon stock and change calculations.

•Annual emissions for agricultural GHG and wetland GHG are modelled, separately for baseline and each scenario.

•Difference between these gives us change due to modelled representation of CoAP (Counterfactual scenario) or CoAP + Scheme (PWF scenarios).

•Then cumulative change over time is calculated by multiplying this change by the number of years.

Method:

- Wetland/peat GHG using LULUCF wetland supplement coefficients (includes methane, CO_2 & direct N_2O emissions);
- Agricultural GHG emissions by combining the SFARMOD outputs for land use, livestock and fertiliser with coefficients from FARMSCOPER for:
    - Agricultural land management (livestock and fertiliser) in the form of **N_2O**;
    - Agricultural land management (livestock) in the form of **methane**

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GHG emissions: Wetland/peat and agriculture

Annual change in GHG emissions for: a) wetland/peat GHG flux; and b) agricultural (fertiliser & livestock) flux				Breakdown of b) agricultural GHG flux	
Group	**Scenario**	**a) Wetlands (4D) flux (KtCO2eq/yr)**	**b) Agricultural GHG flux total (KtCO2eq/yr)**	**Agricultural GHG flux as N2O (KtCO2eq/yr)**	**Agricultural GHG flux as methane (KtCO2eq/yr)**
Projected	Baseline	509	4,063	658	3,405
	Counterfactual	509	3,838	571	3,268
	PWFa	509	3,674	552	3,122
	PWFb	509	3,677	553	3,124
Difference from Counterfactual	PWFa	0	-164	-19	-146
	PWFb	0	-161	-18	-143
% Difference from Counterfactual	PWFa	0	-4	-3	-4
	PWFb	0	-4	-3	-4
% Difference from Baseline	Counterfactual	0	-6	-13	-4
	PWFa	0	-10	-16	-8
	PWFb	0	-9	-16	-8

This slide shows the annual GHG for peat and agricultural GHG.

Comparing annual wetland/peat and agricultural GHG for the Counterfactual and both PWF scenarios shows:

- Very limited benefit from reduced wetland/peat GHG due to minimal land use change, which is largely not on peat/wetland.
- Agricultural GHG delivers most of the annual GHG benefits. Decreases in annual agricultural GHG reflect the changes in land management, livestock and associated pollutants.

Comparing avoided agricultural GHG emissions for the PWF scenarios to the Counterfactual:

- The Counterfactual shows comparatively large benefits of the modelled representation of CoAP for change in agricultural GHG flux (~1,800kt which was ~7% reduction from baseline).
- These changes are in line with the projected reduction in dairy (9%) & N fertiliser (14.5%) with 5.8% reduction in total N inputs, as well as adjustment of Farmscoper coefficients to match modelled representation of CoAP implementation.
- Both PWF scenarios show an additional reduction in agricultural GHG flux compared to the Counterfactual scenario (additional ~4% of baseline agricultural GHG), due to additional reductions on top of the Counterfactual scenario changes. Additional (to Counterfactual scenario) reductions were: ~2-2.8% of baseline fertiliser inputs; ~3% beef; 4% dairy; 6% sheep.
- Benefits were marginally greater (3 KtCO2eq/yr) for PWFa than PWFb, reflecting marginally greater reductions in fertiliser and livestock (<1%);
    - 3kt is very small as % of annual emissions, the 1% difference in % change from baseline shown in the table reflects rounding of figures included in the table.

Comparing the breakdown of agricultural GHG:

- The magnitude of reduction from methane was greater, but proportionally more reduction was from N2O (13-16% compared to 4-8%).
- When looking at the added benefits from the PWF, proportionally more of this was from methane.

Changes were calculated as follows:

- Peat/wetland GHG changes result from land use changes on peat.
- Agricultural GHG changes result from changes in livestock and fertiliser, with impacts modelled using FARMSCOPER coefficients. These coefficients were also adjusted to represent impacts of CoAP.

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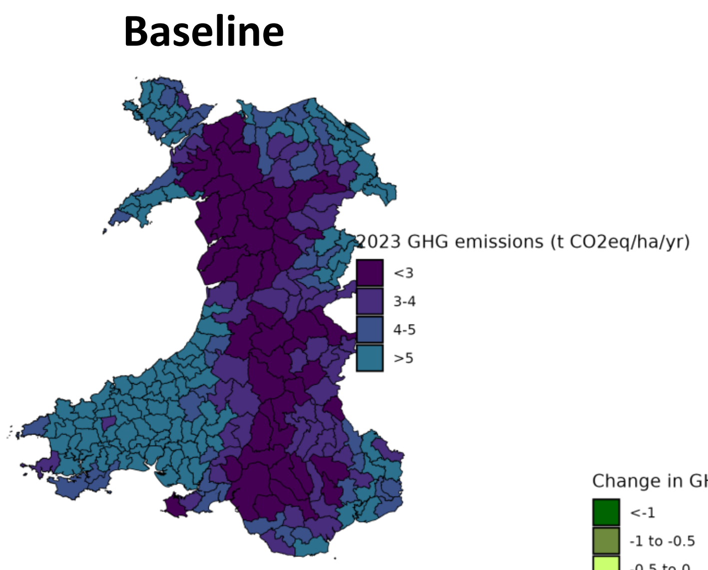
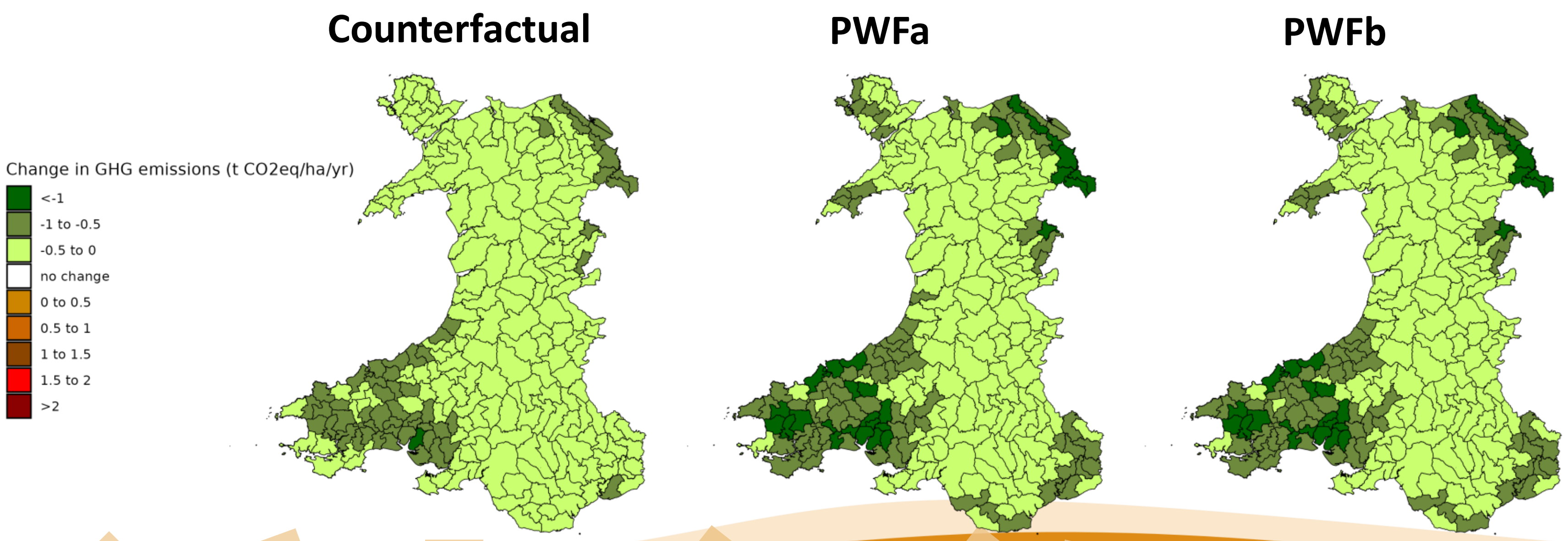
Agricultural GHG emission change

- For the Counterfactual and PWF scenarios, the projected regional pattern of agricultural GHG emissions (fertiliser and livestock) shows decreases in all regions, with greater decreases in some regions.
- The spatial patterns of change are very similar between the PWFa and PWFb scenarios, whilst less area shows improvement for the Counterfactual.
- Higher benefits in the PWF are projected in areas with greater reduction in dairy.





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This slide shows spatial pattern of agricultural GHG changes.
Changes result from changes in livestock and fertiliser, with impacts modelled using FARMSCOPER coefficients. These coefficients were also adjusted to represent impacts of CoAP.

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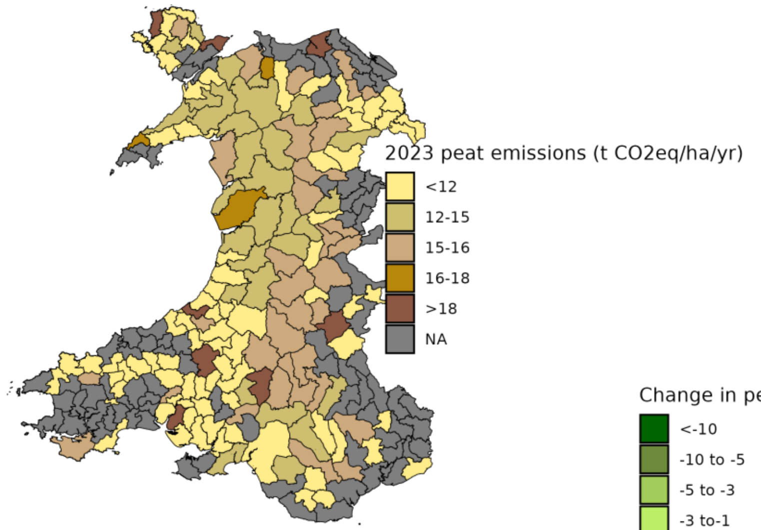
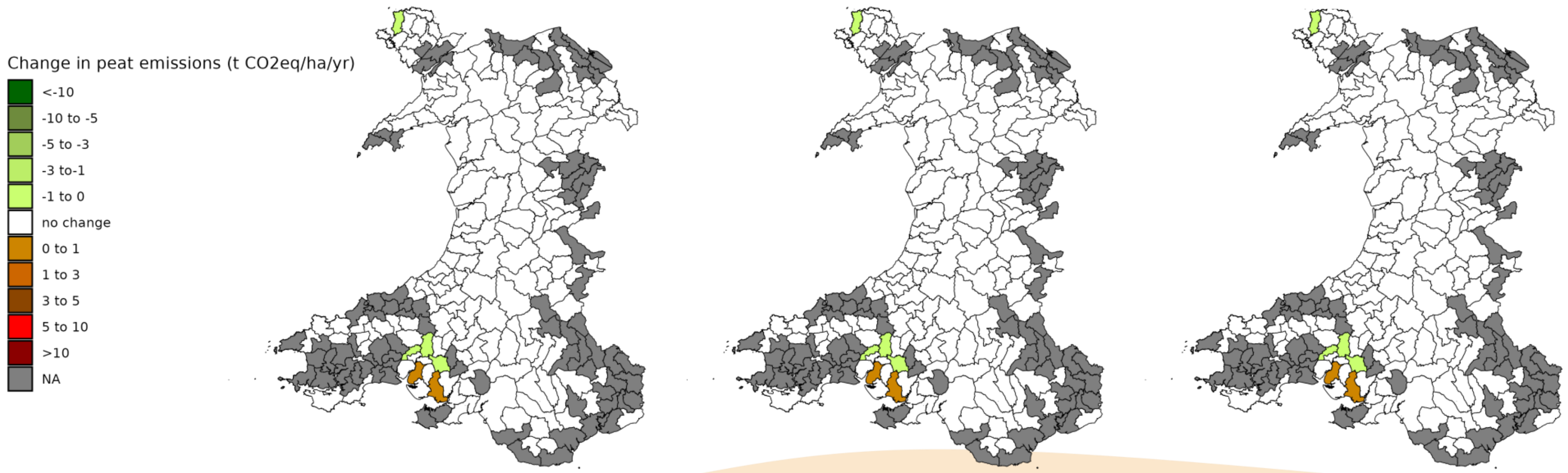
Wetland/peat GHG emission change

- As would be expected given minimal land use change and minimal associated change in peat GHG, most regions do not show change.

Baseline



Counterfactual **PWFa** **PWFb**



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This slide shows spatial pattern of peat/wetland GHG changes.
Changes result from land use changes on peat, which were minimal.
N/A means no modelled agricultural peat in that region

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PART 5c: Water quality

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Water Quality: Background information

- Pollutant loads for N, P and sediment are calculated for each DMU by combining the SFARMOD outputs for livestock, fertiliser and land use with coefficients from FARMSCOPER.
- 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.
- Non-agricultural sources of pollutants, as well as estimates of pollutants for farms not modelled by the IMP (<1 FTE) and commons, are added.
- The modelling then accounts for flow (and nutrient) accumulation to downstream catchments, and for stream flow to calculate concentration for N and P.
- Data for N and P are processed to units reflecting the relevant thresholds used in water quality assessment: 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. As a result, we do not calculate concentrations for sediment, and validation of these outputs is more difficult.

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This slide explains the methods for the water quality modelling.
Pollutant loadings are calculated at DMU scale by combining the SFARMOD outputs for livestock, fertiliser and land use with coefficients from FARMSCOPER.
Farms<1FTE are represented by assuming average land use and stocking, whilst commons are represented as rough grass only, assuming livestock are accounted for on the relevant farms.

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Water Quality: Background information

- The water quality analyses are based on the counterfactual and PWF scenarios being applied to farms >1 FTE only.
- Farms <1 FTE and commons are accounted for in all calculations of concentration and status, but the contribution is static (i.e. does not respond to the scenario).
- 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: the modelling does not account for time lags in the nitrogen system.
- Predicted loads are based on average climate data (1981-2010).
- 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).
- The results presented here are for a point in time after which equilibrium has been reached, which in practice could take 10+ years.

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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.
The scenario outputs assume these changes have already occurred.

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Change in N, P and sediment load

Most of the benefit for N and P load is delivered by the modelled representation of CoAP regulations, with some additional benefit delivered by additional reductions in fertiliser and livestock under the PWF scenarios. The added benefits had greater impact on status with 4 more catchments improving in PWF.

Group	Scenario	Nitrate load kt NO3 N /yr	Phosphorus load kt P /yr	Sediment load kt Z /yr
Projected	Baseline	23	0.41	148
	Counterfactual	21	0.38	147
	PWFa	21	0.37	147
	PWFb	21	0.37	147
Difference from Counterfactual	PWFa	-1	-0.01	0
	PWFb	-1	-0.01	0
% Difference from Counterfactual	PWFa	-3	-1.70	0
	PWFb	-3	-1.67	0
% Difference from Baseline	Counterfactual	-7	-7.15	0
	PWFa	-10	-8.73	0
	PWFb	-10	-8.70	0

- The Counterfactual scenario shows comparatively large benefits of the modelled representation of CoAP for avoided N & P loadings (~7% difference from baseline).
- Both PWF scenarios show ~10% reduction in N & P loadings from baseline due to additional fertiliser and livestock reductions on top of the modelled representation of CoAP changes.
- For the Counterfactual and both PWF scenarios, there was less reduction in sediment loss (<1%), and no real difference across scenarios, in line with expectations considering minimal land use change, and less effect from the modelled representation of CoAP regulations.

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This slide shows change in N, P and sediment loading.
Changes result from changes in livestock and fertiliser, with impacts modelled using FARMSCOPER coefficients. These coefficients were also adjusted to represent impacts of the CoAP in the Counterfactual scenario.

The **Counterfactual** shows comparatively large benefits for avoided N & P loadings (~7% difference from baseline):

- These changes are in line with the projected reduction in dairy (9%) and fertiliser (14.5% N; 1.9% P), with 5.8% reduction in total N inputs, as well as adjustment of FARMSCOPER coefficients to match modelled representation of CoAP implementation.

Both **PWF scenarios** show ~10% reduction in N & P loadings compared to baseline:

- These changes reflect livestock and fertiliser reductions on top of the Counterfactual scenario changes.
- Additional (to Counterfactual scenario) reductions were: ~2-2.8% of baseline fertiliser inputs; ~3% beef; 4% dairy; 6% sheep.
- PWFa with higher payment and higher scheme adoption leads to a slightly greater reduction for fertiliser and livestock than PWFb, with very slightly greater benefits for N and P losses.

For the **Counterfactual and both PWF scenarios**, there was less reduction in sediment loss (<1%):

- This is in line with expectations considering that limited land use change is projected, and less impact would be expected from the CoAP regulations specification, compared to N and P.
- The slightly greater reduction in sediment for the PWF scenarios than the Counterfactual is very small (<1kt) and relates to small differences in modelled land use change, and negligible parcel level modelled area discrepancies which led to ~8ha less modelled arable + grassland total area nationally in the PWF scenario than the Counterfactual scenario.
- There was virtually no modelled change in drivers of sediment losses, hence this very small discrepancy has a noticeable proportional impact on the results. However, given the very small magnitude of modelled change for this scenario, it would be appropriate to interpret all scenarios as having no impact on sediment loss, with some very minimal reduction expected from the modelled representation of CoAP regulations.

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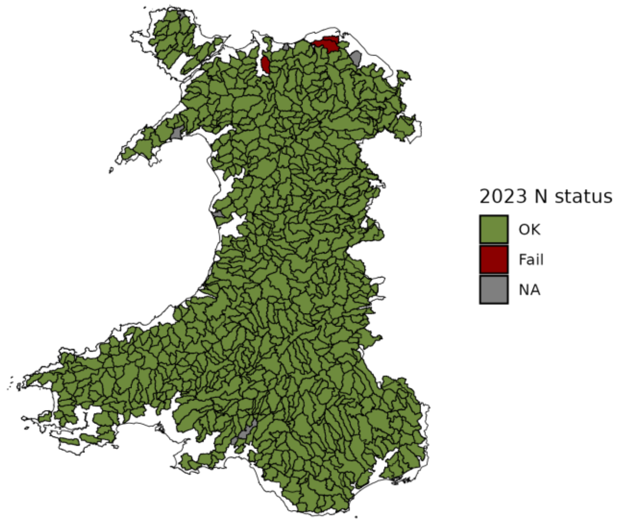
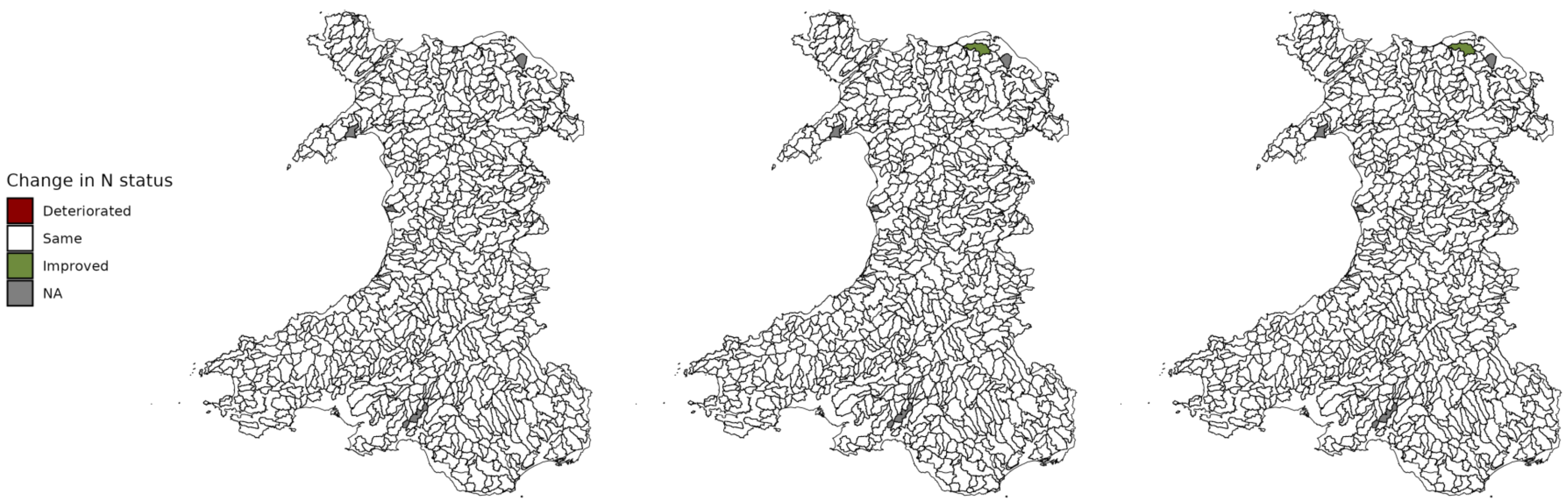
Drinking water N status change

- For the Counterfactual, no catchments are projected to improve or deteriorate.
- For both PWF scenarios, one catchment is projected to improve; this equates to 20% as a proportion of the number of catchments modelled as failing in the baseline.

Baseline



Counterfactual **PWFa** **PWFb**



Nitrate status is based upon EU Nitrate Directive target of 50 mg l^{-1} Nitrate, or 11.3 mg l^{-1} NO_3-N

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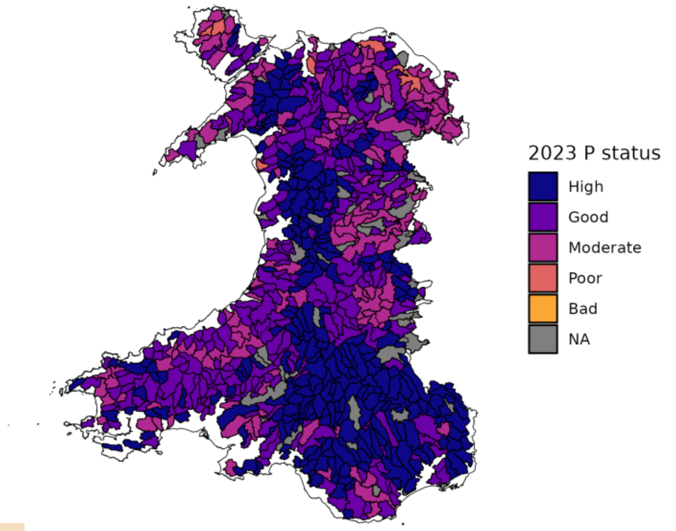
WFD P status change

- For the Counterfactual and both PWF scenarios several catchments are projected to improve, with none deteriorating.

Baseline



Counterfactual **PWFa** **PWFb**

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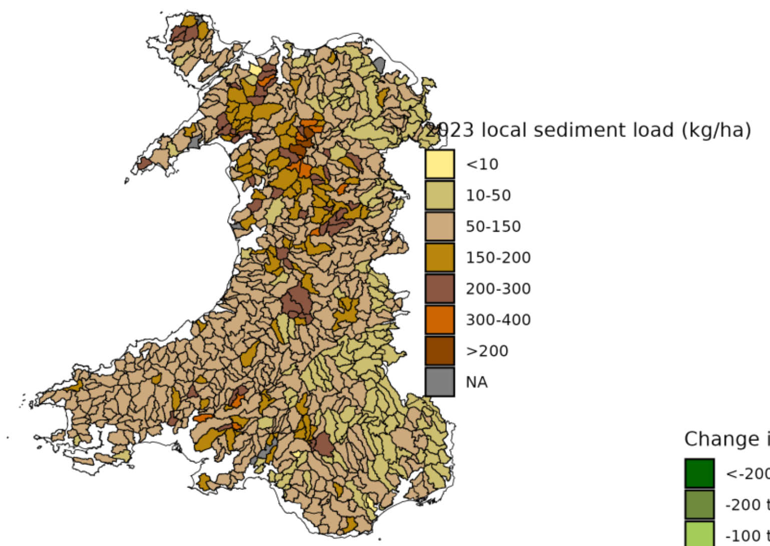
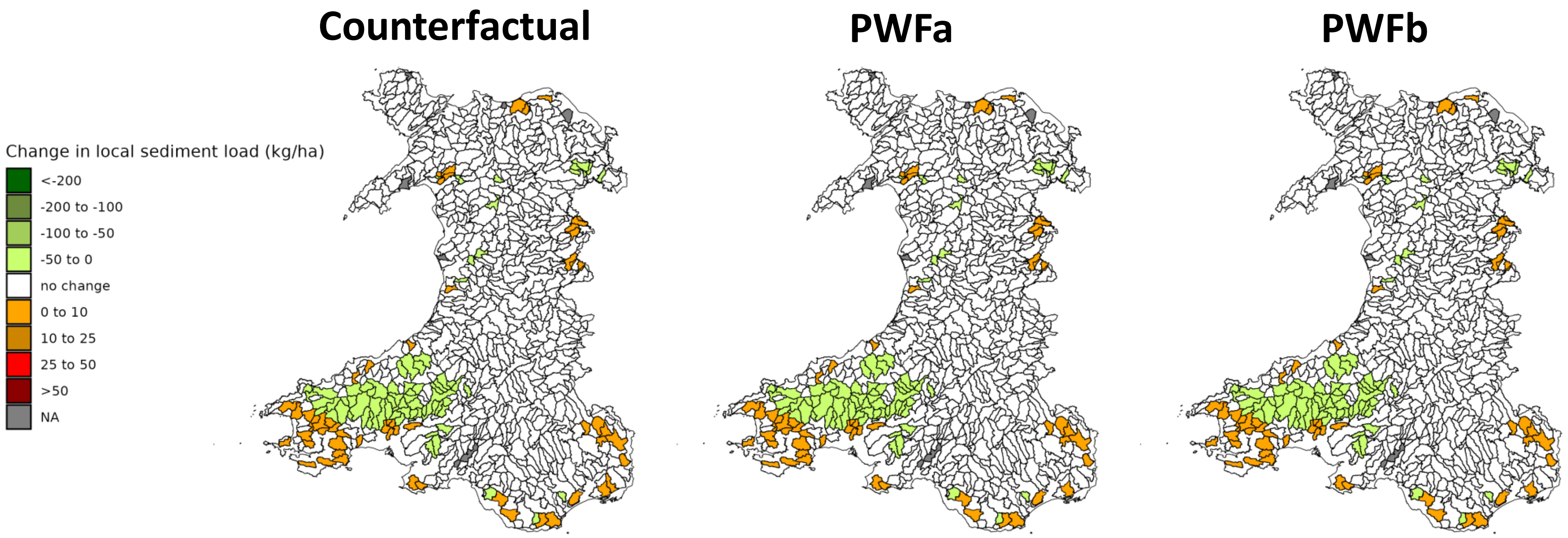
P status is assigned using catchment-specific thresholds based upon altitude and alkalinity.

Change in sediment load

- For the Counterfactual, the small net simulated reduction in sediment loading nationally shows a pattern of increases in some areas and decreases in others. Trends correspond with changes in arable area; increased arable leads to increased sediment loss.
- The slightly greater (<1kt) net reduction in sediment load projected for the PWF scenarios is not noticeable in the maps.

Baseline





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- The slightly greater reduction in sediment simulated for the PWF scenarios than the Counterfactual is very small (<1kt) and relates to small differences in modelled land use change, and negligible parcel level modelled area discrepancies which led to ~8ha less modelled arable + grassland total area nationally in the PWF than the Counterfactual.
- There was virtually no modelled change in drivers of sediment losses, hence this very small discrepancy has a noticeable proportional impact on the results. However, given the very small magnitude of modelled change for this scenario, it would be appropriate to interpret all scenarios as having no impact on sediment loss, with some very minimal reduction expected from the modelled representation of CoAP regulations.

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N drinking water status: Number of catchments at each status

Modelled N drinking water status comparison between scenarios			
Group	**Scenario**	**OK**	**Fail**
Projected	Baseline	872	5
	Counterfactual	872	5
	PWFa	873	4
	PWFb	873	4

- For the Counterfactual, no change is projected in number of catchments failing, in spite of ~7% reduction in loading. This may be because little or no loading reductions are modelled in the few (5) catchments modelled as failing in the baseline.
- For both PWF scenarios, one catchment is projected to improve, although there is only 3% greater reduction in N pollutant load than the counterfactual. Most of the N load reduction benefit is still being delivered by the modelled representation of CoAP component of the PWF.

This slide shows number of catchments with status OK vs failing for N drinking water status.

Nitrate status is based upon EU Nitrate Directive target of 50 mg l^{-1} Nitrate, or 11.3 mg l^{-1} NO_3-N

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WFD P status: Number of catchments at each status

Modelled WFD P status comparison between scenarios						
Group	**Scenario**	**High**	**Good**	**Moderate**	**Poor**	**Bad**
Projected	Baseline	279	264	131	7	0
	Counterfactual	287	269	118	7	0
	PWFa	290	266	118	7	0
	PWFb	290	266	118	7	0
Difference from Counterfactual	PWFa	3	-3	0	0	0
	PWFb	3	-3	0	0	0
% Difference from Counterfactual	PWFa	1	-1	0	0	NA
	PWFb	1	-1	0	0	NA
% Difference from Baseline	Counterfactual	3	2	-10	0	NA
	PWFa	4	1	-10	0	NA
	PWFb	4	1	-10	0	NA

- For the Counterfactual, several catchments are projected to improve, leading to a reduction (13) in the number of catchments with moderate status and an increase with good (5) and high (8) status.
- Both PWF scenarios had the same number of catchments improving from moderate status as the Counterfactual, but the PWF scenarios show more catchments increasing to high status (11) and less with good status (2). This suggests the additional reductions in fertiliser and livestock are occurring in catchments already modelled as improving due to the modelled representation of CoAP.
- No scenarios show improvement for the 7 catchments with poor status.

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This slide shows number of catchments at each WFD P status for each scenario.

P status is assigned using catchment-specific thresholds based upon altitude and alkalinity.

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PART 5d: Air quality

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Change in ammonia emissions

Group	Scenario	Ammonia emissions (kt NH3 N /yr)	Change in ammonia emissions (kt NH3 N /yr)
Projected	Baseline	16	0.00
	Counterfactual	14	-1.06
	PWFa	14	-1.59
	PWFb	14	-1.58
Difference from Counterfactual	PWFa	-1	-0.53
	PWFb	-1	-0.52
% Difference from Counterfactual	PWFa	-4	50
	PWFb	-4	49
% Difference from Baseline	Counterfactual	-7	
	PWFa	-10	
	PWFb	-10	

For the Counterfactual:

- There is comparatively large projected benefits for avoided ammonia emissions (~7%).
- These changes are in line with the projected 9% reduction in dairy, 14.5% reduction in N fertiliser and adjustment of FARMSCOPER coefficients to match CoAP implementation.

For both PWF scenarios:

- An additional ~4% improvement is projected compared to the Counterfactual reflecting additional reductions in fertiliser and livestock.
- This additional improvement is ~50% of the Counterfactual change
- Very slightly more (~0.01 kt) reduction is seen for PWFa.

- The ~7% reduction for the Counterfactual is in line with the projected reduction in dairy (9%) and N fertiliser (14.5%) with 5.8% reduction in total N inputs, as well as benefits represented by adjustment of FARMSCOPER coefficients to match modelled representation of CoAP implementation.
- Both PWF scenarios show ~10% reduction in ammonia emissions.
- The additional benefit is slightly higher for PWFa due to higher scheme adoption, but there is very little difference.
    - These changes reflect livestock and N fertiliser reductions on top of the Counterfactual scenario changes.
    - Additional (to Counterfactual scenario) reductions were: ~2-2.8% of baseline N fertiliser inputs; ~3% beef; 4% dairy; 6% sheep.

NOTE the following are deliberately not supplied for change in ammonia emissions in the table, for the reasons specified:

- % Difference from Baseline: There is no change for baseline.

Method

- Annual agricultural ammonia emissions from land management (livestock and N fertiliser) are calculated for each DMU by combining the SFARMOD outputs for livestock, fertiliser and land use with coefficients from FARMSCOPER.
- Health impacts of changes in ammonia and changes in woody cover are calculated using the EMEP4UK metamodel (results in next slides) to allow for valuation.

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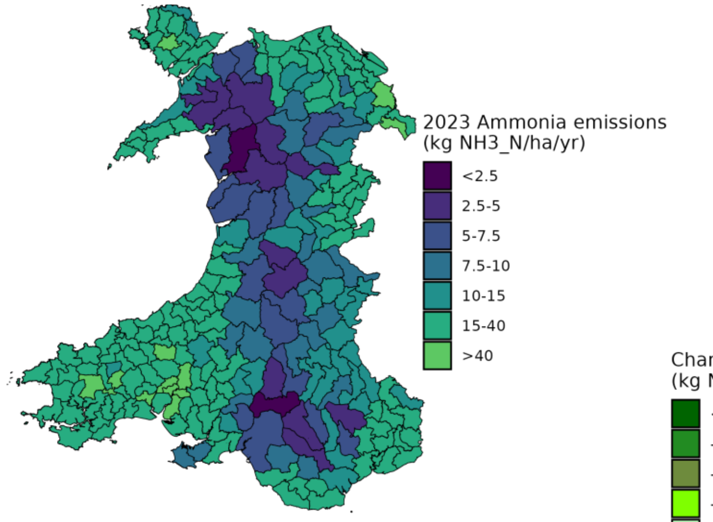
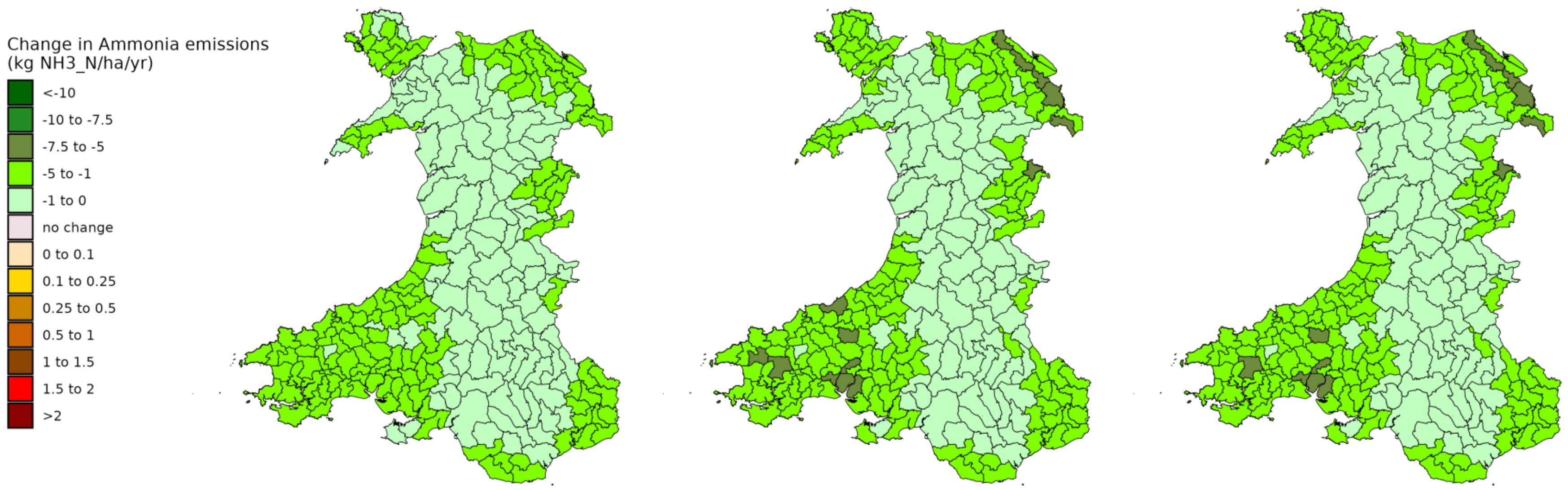
Change in ammonia emissions

- For the Counterfactual, the small net simulated reduction in ammonia nationally shows a pattern of higher reduction in regions with more baseline loading.
- The PWF scenarios project a similar basic pattern, with the greatest additional reductions occurring in regions with higher baseline loading.

Baseline



Counterfactual **PWFa** **PWFb**



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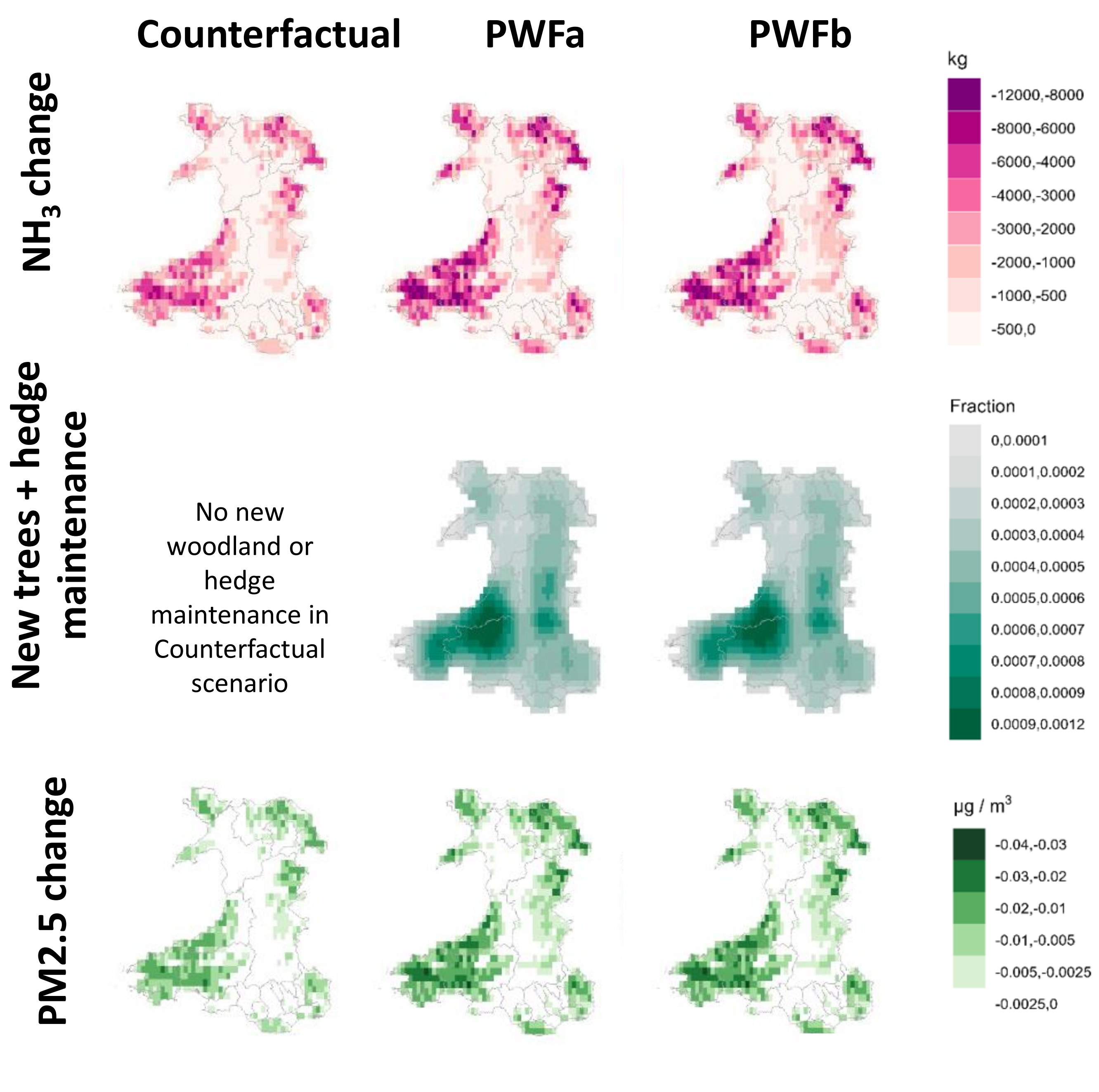
Change in air quality

- In all scenarios decreases in PM2.5 concentrations largely follow the pattern of ammonia (NH3) emissions decrease.
- Additional trees and expansion of hedge width and height contribute to greater PM2.5 removal in the PWF scenarios compared to the Counterfactual.



For the PWF scenarios, the modelled changes in PM2.5 represent a timepoint when the trees and hedges are fully grown. The component of benefits relating to removal by vegetation would not be fully delivered before this.

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Additional assumptions for in hedge trees:
Tree height: Height is assumed to be 20m. This may be an over-estimate for trees outside of woodland, however, canopy exposure will be greater for single trees.
Canopy width: Canopy area was calculated on a basis of square of 3.5 by 3.5m. This is based on the assumption of hedges being 3m width in UA8 Hedgerow maintenance at the end of the period, an estimated range of 2m-6m for in hedge trees (based on expert judgement) and some assumed constraints to hedge width area.
Trees are modelled separately from the hedge and assumed to be next to the hedge (i.e. all areas of soil/biomass/canopy are additional).

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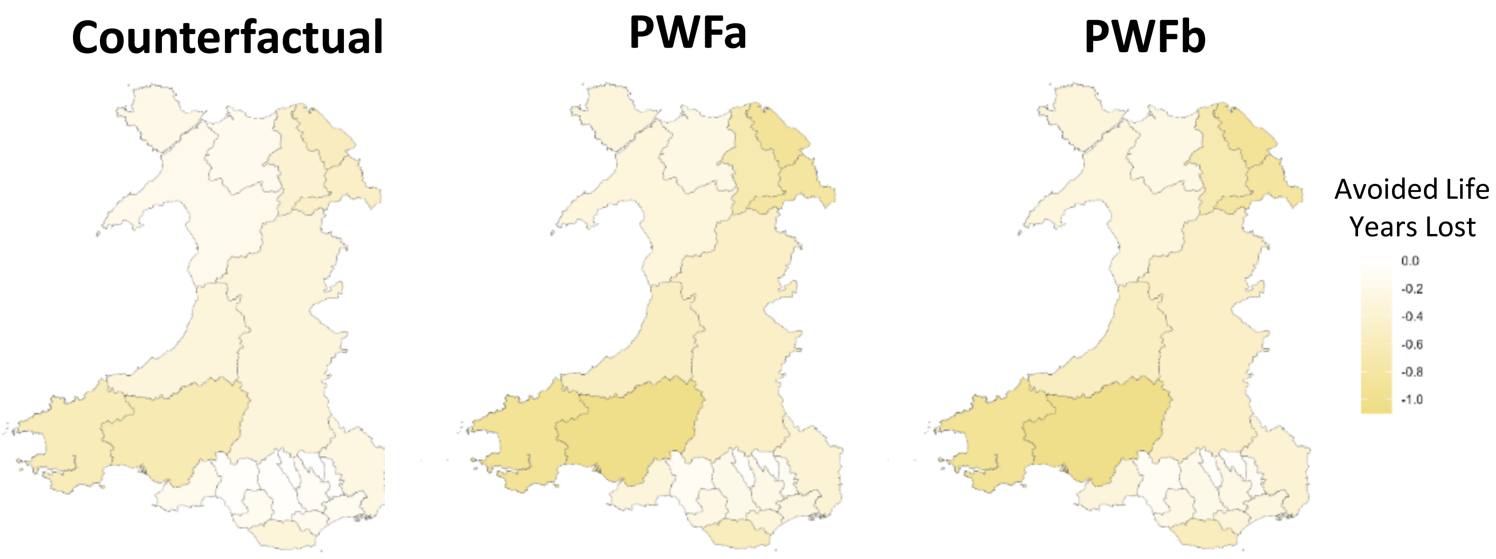
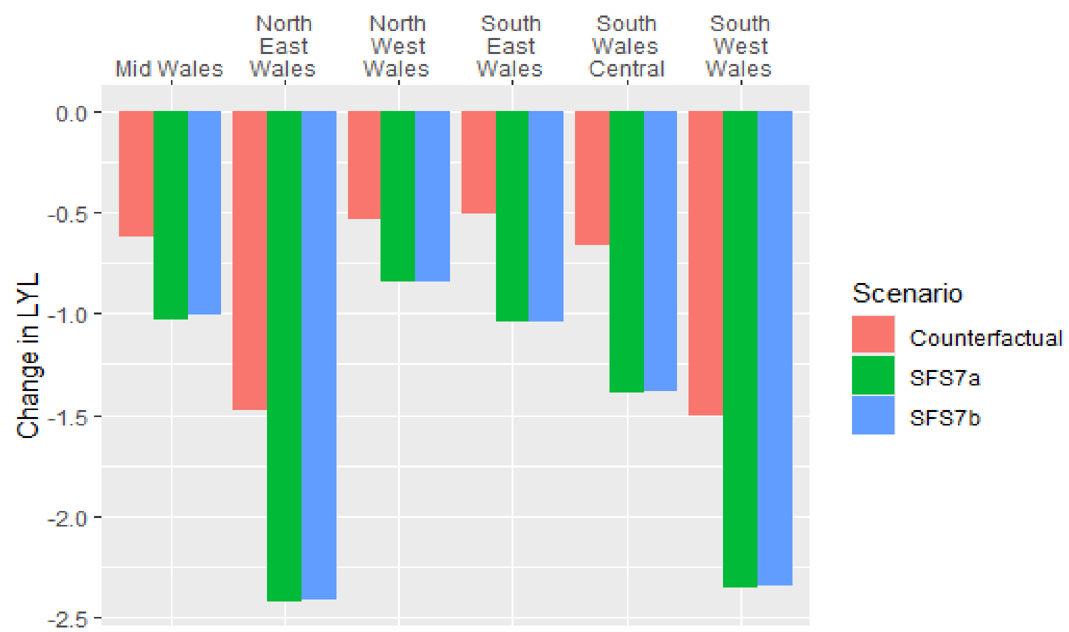
Change in air quality



Scenario	Average pop weighted change in PM2.5 concentration	Life Years Lost (LYL)
Counterfactual	-0.003	-5.3
PWFa	-0.0051	-9.08
PWFb	-0.0050	-9.02



- Health outcomes are a function of change in exposure to PM2.5 of the population.
- All scenarios project net positive benefit in 'avoided Life Years Lost'. Greatest benefits occur in North East Wales and South West Wales.
- In comparison to the Counterfactual, the PWF scenarios project around a third more 'avoided Life Years Lost'.

For the PWF scenarios, the modelled changes in PM2.5 and LYL represent a timepoint when the trees and hedges are fully grown. The component of benefits relating to removal by vegetation would not be fully delivered before this.

Life Years Lost (LYL): corresponds to years that the population is short from an age benchmark. Similar to life expectancy which is measured in years, LYL refers to the years lost due to premature death (Andersen et al., 2013; Andersen, 2013; Erlangsen et al., 2017).

For context: avoided LYL accruing from ALL vegetation in Wales = 1,258 (Jones et al., 2017; Engledew et al., 2019).

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PART 6: Valuation

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Valuation results: Background information

- Price year: 2023
- Baseline year: 2023
- Time horizons:
  - 8 years (2023-2030)
  - 28 years (2023-2050)
  - 101 years (2023-2123)
- Appraisal approaches and assumptions are HMT Green Book compliant (e.g., 3.5% declining discount rate/ health discount rate for air quality)

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Summary of public goods values for 2050: Counterfactual

Benefits	Physical measure	Units	Present value, 28 yrs, £m	Type of value
Air Quality	5.3	Life Years Lost (LYL) each year	3.6	Reduction in costs of health impacts from air pollution (Jones et al. Modelling for ONS)
Water Quality	21 Improve, 0 Deteriorate	Expected changes in WFD status due to changes in P and N	12.4	Benefit to people from knowing of/ enjoying higher quality freshwater environments (NWEBS values from Metcalfe, 2012 and updates)
GHGs	Decrease of 6.289m tCO_2e	Net change in atmospheric TCO2eq over 28 years	1,393	Benefit of reducing atmospheric GHG concentrations from non-traded sources (DESNZ, 2023)

- The figures are an estimate of the value of the change in the well-being to people over a period of 28 years (2050) under this scenario.
- Figures indicate order of magnitude of values of expected changes in the Welsh Environment.

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Summary of public goods values for 2050: Counterfactual and PWF scenarios

	Counterfactual		PWFa		PWFb	
Benefits	**Physical measure**	**Present value, 28 yrs, £m**	**Physical measure**	**Present value, 28 yrs, £m**	**Physical measure**	**Present value, 28 yrs, £m**
Air Quality	5.3 LYL	3.6	9.08 LYL	8.58	9.02 LYL	8.53
Water Quality	21 Improve, 0 Deteriorate	12.4	25 Improve, 0 Deteriorate	13.4	25 Improve, 0 Deteriorate	13.4
GHGs	Decrease of 6.289m tCO_2e	1,393	Decrease of 11.503m tCO_2e	2,542	Decrease of 11.407m tCO_2e	2,520

- The figures are an estimate of the value of the change in wellbeing to people over a period of 28 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 value over time: Counterfactual

Benefits	Present value, £m			Type of value
	2030	2050	2123	
Air Quality	**0.84**	**3.59**	**12.05**	Reduction in costs of health impacts from air pollution
Water Quality	**4.8**	**12.4**	**20.2**	Benefit to people from knowing of/ enjoying higher quality freshwater environments
GHGs:				Benefit of reducing GHG sources:
Agriculture	477	1,392	3,072	Agricultural sources (livestock and inputs)
Land use	-0.22	-0.11	0.07	Land use changes
Wetlands	0.21	0.62	1.38	Wetland sources (peatlands)
Total GHGs	**477**	**1,393**	**3,075**	Benefit of reducing atmospheric GHG concentrations from non-traded sources

- Reduction in dairy, reduction in fertiliser inputs and change in management assumptions to match CoAP implementation (represented by adjustment of FARMSCOPER coefficients) delivers the following benefits for the Counterfactual:
  - Air quality benefits from avoided ammonia emissions.
  - Water quality benefits from catchments improving for P status.
  - Agricultural GHG benefits from reductions in methane and N_2O.
- Land use and wetland GHG emissions changes are driven by (limited) change in land use.
- Avoided GHG emissions for agriculture exceed those of Land Use change and Wetlands by several orders of magnitude.

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

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Breakdown of public goods values over time: Counterfactual and PWF scenarios

Benefits	Counterfactual Present value, £m			PWFa Present value, £m			PWFb Present value, £m		
	2030	2050	2123	2030	2050	2123	2030	2050	2123
Air Quality	**0.84**	**3.59**	**12.05**	**1.94**	**8.58**	**23.28**	**1.93**	**8.53**	**23.14**
Water Quality	**4.8**	**12.4**	**20.2**	**5.21**	**13.40**	**21.88**	**5.21**	**13.40**	**21.88**
GHGs:									
Agriculture	477	1,392	3,072	827	2,411	5,323	820	2,391	5,278
Land use	-0.22	-0.11	0.07	25	130	253	24	128	251
Wetlands	0.21	0.62	1.38	0.22	0.63	1.39	0.22	0.63	1.39
Total GHGs	**477**	**1,393**	**3,075**	**851**	**2,542**	**5,577**	**844**	**2,520**	**5,531**

- Higher air quality benefits in PWFa and PWFb are due to increased hedges and hedge trees, and woodland maintenance.
- Water quality benefits are the same in PWFa and PWFb but are slightly higher than the Counterfactual due to additional livestock and fertiliser reductions on top of the modelled representation of CoAP changes.
- Land use change benefits are minimal due to small areas of projected land use change. Hedge maintenance carbon benefits are included in this category, leading to slightly higher values for PWFa and PWFb.
- Agricultural benefits show the largest changes in values for PWFa and PWFb due to decreases in livestock stocking rates and decreases in fertiliser inputs.

All figures are based on simplifying assumptions of change over time.
It should be noted that the relative values of the air quality and water quality effects change over time up to 2123 for the PWF. This is due to the lag effect applied in the valuation of the physical air quality benefit modelled, to reflect that the physical values are representative of the timepoint when the trees and hedges are fully grown. This is 5 years for benefit delivered by hedgerows and 40 years for benefit delivered by trees, during which time the benefit increases to its full potential, and after which it remains stable.

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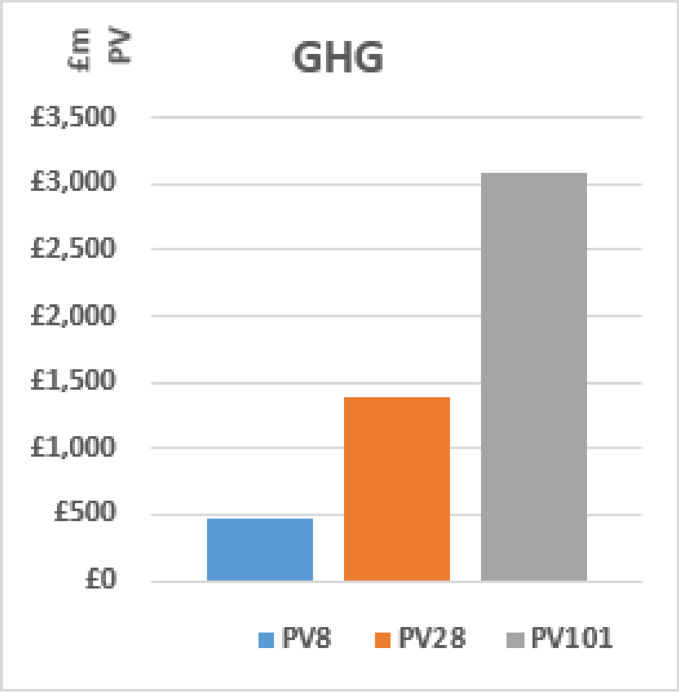
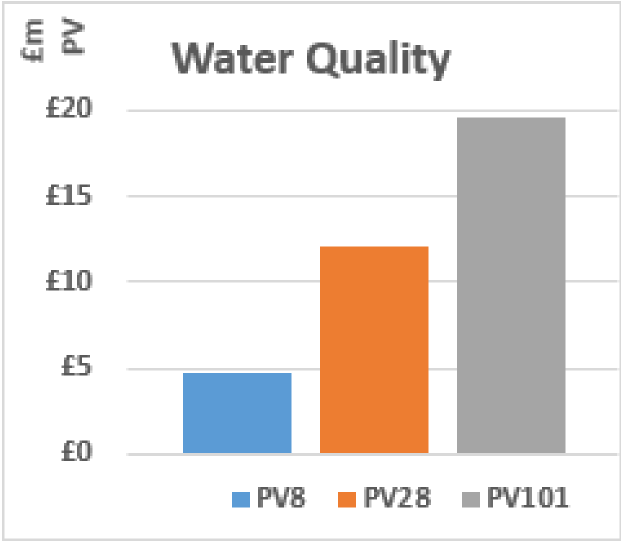
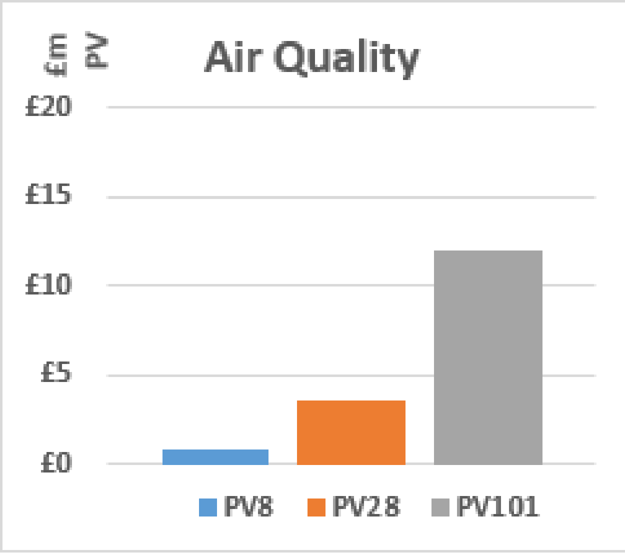
Public Goods Values for different time horizons: Counterfactual







- Note the differences in the vertical axes.
- The changes in all three benefits reflect the reductions in N fertiliser input and reductions in stocking rates.

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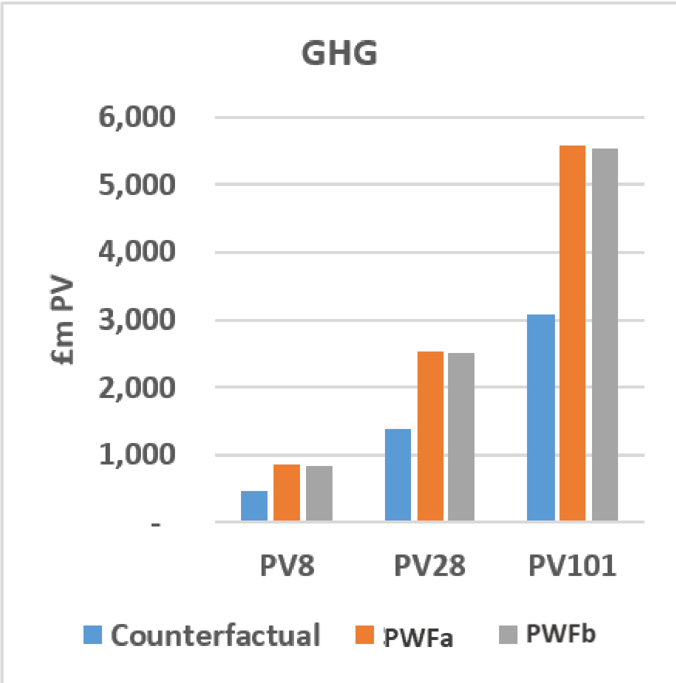
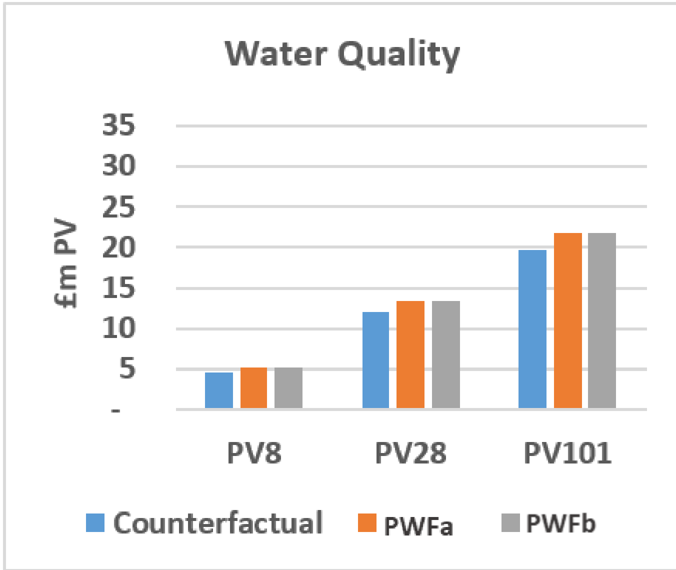
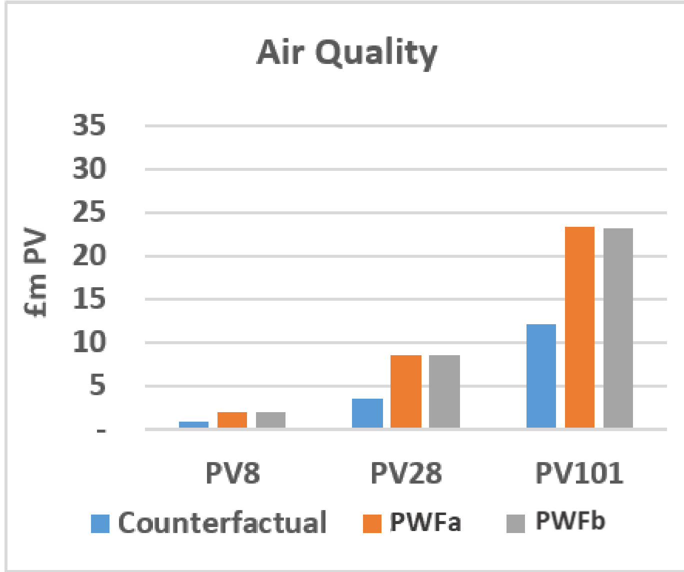
Public Goods Values for different time horizons: Counterfactual and PWF scenarios







- Note the differences in the vertical axes.
- Water quality benefits in the Counterfactual always exceed air quality benefits, whilst in PWFa and PWFb, air quality benefits exceed water quality benefits by 2123 (PV101). This is due to the increasing air quality benefit over time, provided by maturing hedges and trees in those scenarios.

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Clarification of differences in scope and assumptions between the IMP and eftec report (110)

- ERAMMP report 110 and the Integrated Modelling Platform (IMP) universal PWF modelling run (PWF) both provide projections for Ecosystem Services delivery and valuation.
- These will differ due to differences in system boundaries (i.e., what is or isn't represented) and assumptions about scheme activities.

System boundaries:

- The IMP models only benefits resulting from changes in agriculture due to the PWF and CoAP, whereas report 110 aims to also capture aspects of the delivery of benefits from existing on-farm habitat and woodland.

Assumptions about scheme activities:

- The IMP does not model benefits for carbon or biodiversity from temporary habitat creation action UA6 due to the single year scheme commitment and temporary nature of the habitat actions. For UA6, IMP assumes rotational rough grass margins on arable land and herbal leys on improved grass. There are no significant carbon or biodiversity benefits of herbal leys which can be represented in IMP. For rough grass margins, any carbon sequestration or plant biodiversity from a single year would be lost when the land was ploughed to go back into production. For bird biodiversity, some benefits might be delivered on a landscape scale, even if the margins did not have fixed location, however given the scale of arable land in Wales, minimal impacts could be expected.
- Note that ERAMMP report 110 is being extended and this new work may also make updates which more closely align assumptions.

PART 7: Glossary and Context

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Glossary: Key Acronyms (I)

- 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

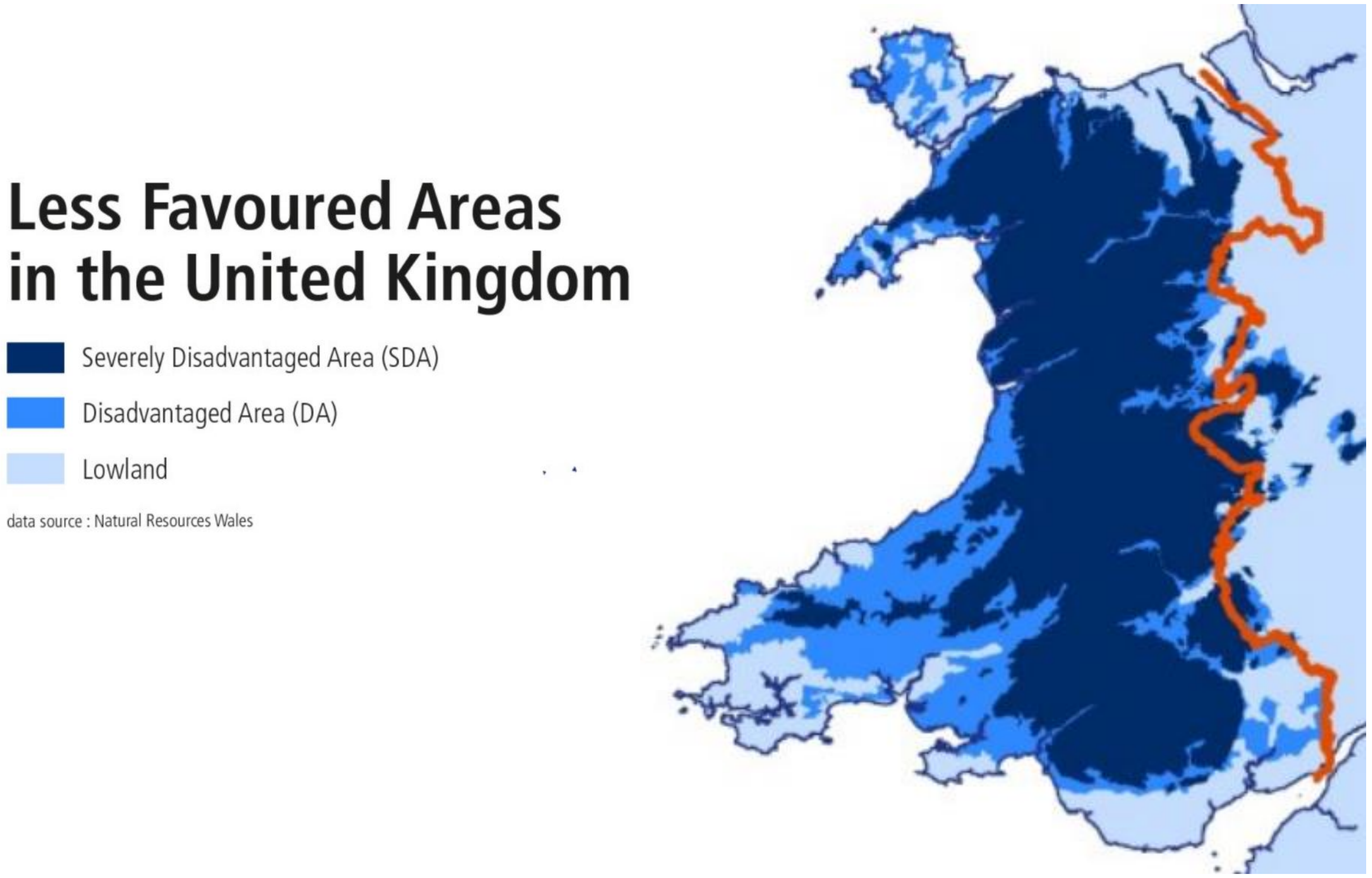

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Image from https://gov.wales/sites/default/files/statistics-and-research/2019-05/farm-incomes-april-2018-to-march-2019-forecasts-938.pdf

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Glossary: Key Acronyms (II)

- CoAP: Control of Agricultural Pollution Regulations (2021)
- 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 .
- GAEC: Good Agricultural & Environmental Conditions
- PWF: Preferred Way Forward
- 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.
- UA: Universal Action
- Names and acronyms for models within the IMP: SFARMOD; ESC; CARBINE; LAM; FARMSCOPER; BTO; MULTIMOVE; EMEP4UK; Valuation (see following slide)

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Glossary: Key Acronyms (III)

- 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 producing this 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 module
    - FARMSCOPER: Farm emissions
    - BTO: Biodiversity impacts (bird species)
    - MULTIMOVE: Biodiversity impacts (plant species)
    - 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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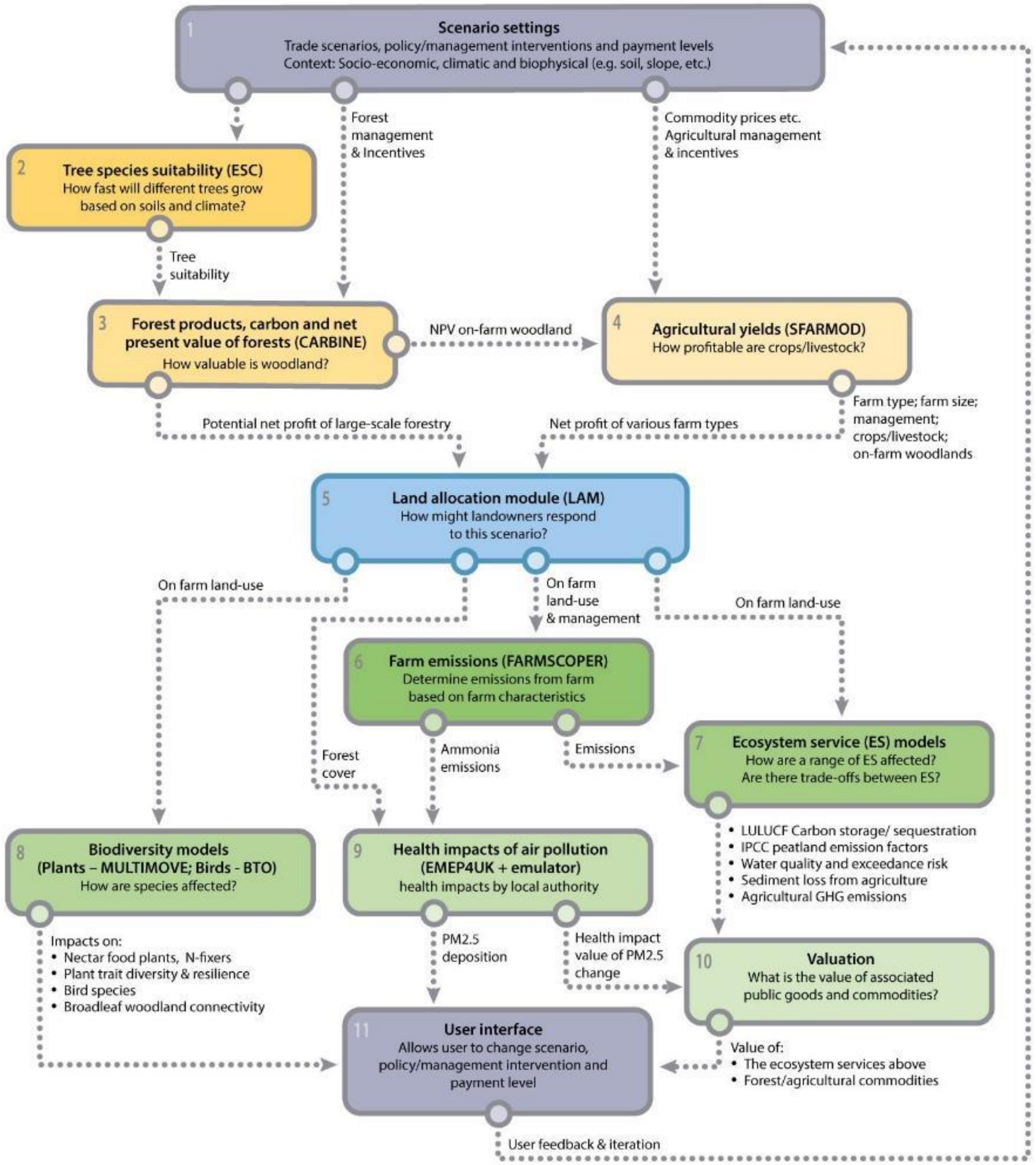
Integrated Modelling Platform schematic



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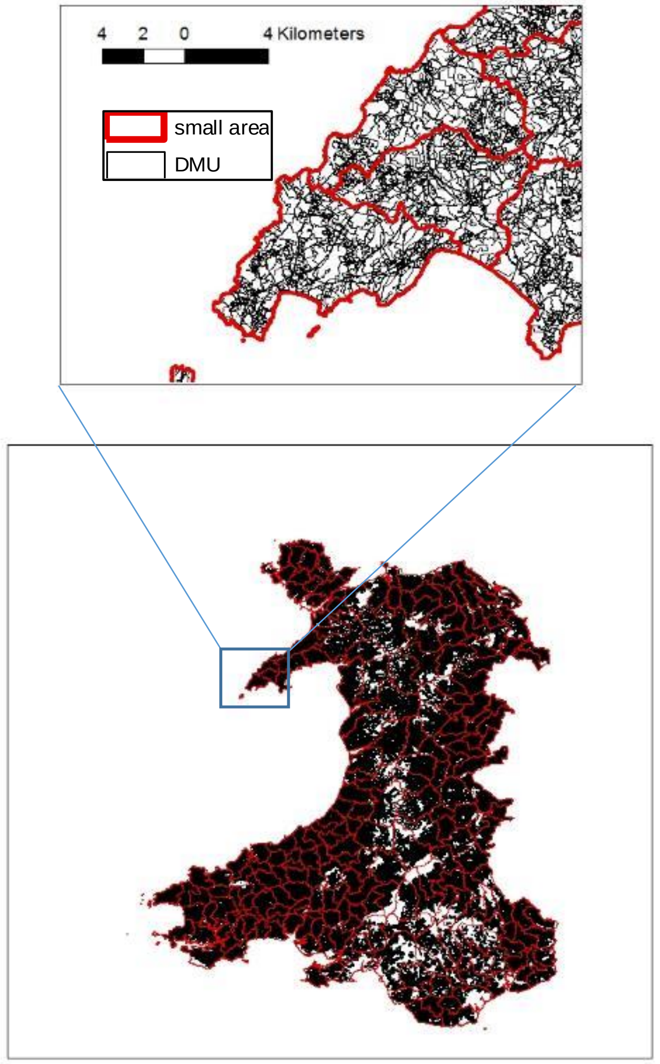
IMP modelling scales



- 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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