# Growing aquaculture in the South West

SWEEP
Applying research to benefit our environment and economy

## ***Future land-use scenarios (for 2050)*** *- affecting water quality, and potential growth of aquaculture in the South West*

Working with stakeholders from across South West England, we explored future land use scenarios for 2050 which could affect the viability of aquaculture growth in the region, through potential effects on water quality. Five possible future rural and urban land use/ management scenarios were identified, along with a set of climate change futures and the current baseline. Scenarios align with those in the UK National Ecosystem Assessment (UK NEA, 2014).

The potential effect of each scenario on the viability of estuary and marine aquaculture in SW England, is being explored through integrated, whole water catchment modelling as part of the SWEEP project 'Water quality management underpinning sustainable aquaculture and its expansion in South West England'. This involves engaging with stakeholders and policy-makers to define and investigate the trajectory and impact of future land use policies.

*Analogous UK National Ecosystem Assessment scenarios are given in parentheses:*

### 1. Business as usual (*Go with the flow*)

The business as usual scenario represents the current expected trajectory of land use change in South West England, based on trends from the past 30 years. Combined Sewer Overflow (CSO) rates follow current trends (CSO rates are modified according to urban development in the following land use scenarios 2-5).

### 2. Extensive regenerative agriculture (*Nature at work*)

Widespread agricultural regeneration includes increased soil quality and extent of best, most versatile agricultural land and reduced agricultural run-off to water courses via best management practices.

### 3. Intensive agriculture (*World markets*)

Intensification of agriculture (indoor livestock rearing and fodder cropping) will create pollution hotspots in lowland areas, compensated for to some extent by land sparing in upland areas. (Pollution hotspots may interconnect via flooding).

### 4. Increased renewable energy capacity (*National security*)

Opportunities to increase renewable energy capacity in South West England include bio-energy crops, solar and wind power, which will require trade-offs in available land use.

### 5. Strategic tree planting (*Local stewardship*)

Increased tree planting across the UK and SW England is a key component of the UK's 25 Year Environment Plan. This scenario considers the resulting changes in land use and hydrology.

### Climate change futures

Climate change is likely to affect the hydro-meteorological conditions governing flow regimes, temperature and runoff in South West England. Scenarios are taken from UKCP18 and superimposed on each of the above land use scenarios (1-5).

# Baseline

**The scenario represents current land use and climatic/ hydrological conditions in South West England. These conditions provide a baseline against which future scenarios can be compared.**

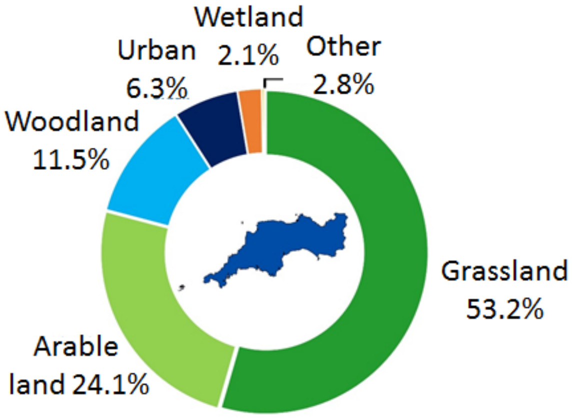
## What are the key features of this scenario?

The baseline scenario represents the South West River Basin District 'as-is'. The breakdown of land use types by % of total area from CEH land cover mapping (2019) is shown below. Baseline Combined Sewer Overflow (CSO) data for 2019 and 2020 are available from Westcountry Rivers Trust (courtesy of South West Water).

## Why is this important?

We have highlighted the key land use breakdown for a baseline scenario to provide a relative comparison versus future land use and land management scenarios.

We have also signposted key baseline data sets below for transparency and informed decision making.




## What evidence underpins this?

Land use is based on the Centre for Ecology and Hydrology 2019 Land Cover maps (CEH, 2019). Specific crop maps are available through the CROME 2019 Crop Maps (DEFRA, 2020) and agri-chemical and slurry application is available through the CEH Land Cover Plus mapping (CEH, 2021), MANURES GIS mapping (Nicholson et al., 2016) and the British Fertiliser Manual PB209 (DEFRA, 2011). Hydrological data is available through the CEH National River Flow Archive (2021) and meteorological data is available through the UK MET Office (2018). Baseline data quantifying CSO spills in 2019 and 2020 are available from Westcountry Rivers Trust (2021).

## How can we practically implement this in decision support?

Models and decision support tools can be applied using the data specified above. These data have been used in the first instance to parameterise Integrated Catchment models: INCA – Pathogens (Whitehouse, 2016); INCA – Metals (Wade, 2021); INCA –N (Wade 2015; and also a catchment-based wash-off model for pesticide risk assessment (Webber et al., 2021).

# References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UK National Ecosystem Assessment (2014) The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, LWEC, UK. URL (accessed December 2020): http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

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Wade (2021) INCA-Metals: INCA Versions and Applications URL (accessed May 2021): https://www.reading.ac.uk/geographyandenvironmentalscience/research/INCA/ges-INCA-versions-applications.aspx

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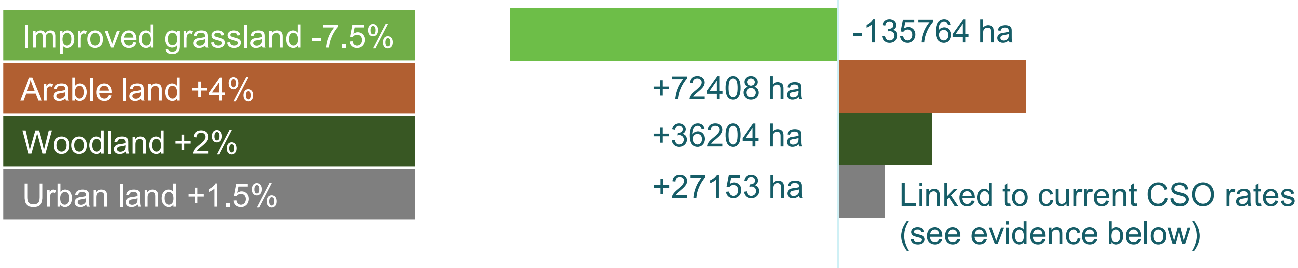
# 1. Business as usual

**The business as usual scenario represents the current expected trajectory of land use change in South West England, based on trends from the past 30 years. Combined Sewer Overflow (CSO) spill rates follow current trends.**

## What are the key features of this scenario?

Expected changes in % of total land cover across the SW River Basin District :




## Why is this important?

Analysis of current trends highlights a continued loss in agricultural grassland to be replaced by increasing arable land, woodland and urban areas. This will continue to affect the range and quantity of pollutants impacting watercourses in South West England. This scenario aligns with ‘Go with the flow’ under the UK National Ecosystem Assessment (UK NEA, 2014).

## What evidence underpins this?

Changes in land use are based on extrapolation from historic changes in the CEH land cover mapping (1990-2019) projected forward (CEH, 2019). The projected change in (sub)urban land cover (6.3-7.8%) is in line with the ~20% population increase (projected by South West Water for 2039) (SWW, 2019). CSO spill rates will remain at current levels (WRT, 2021), assuming adequate storm water capacity will be provided for new developments.

## How can we practically implement this in decision support?

Business as usual can be implemented through changing land uses, in line with changes in land cover specified above.

Land management is not expected to change significantly from current levels and extent of engagement (37% of farmland managed under Countryside Stewardship – employing Catchment Sensitive Farming practices).

*Extent of farm engagement and stewardship across WFD River Basin Districts*

## References

Centre for Ecology and Hydrology (2019). CEH Land Cover maps. URL (accessed May 2021): https://www.ceh.ac.uk/ukceh-land-cover-maps

SWW (2019). Final Water Resources Management Plan 2019. URL (accessed May 2021): https://www.southwestwater.co.uk/siteassets/document-repository/environment/sww-bw-wrmp19---finalplan_aug2019.pdf

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Westcountry Rivers Trust (2021). Raw Sewage in our Rivers – Sewage Map. URL (accessed May 2021): https://www.theriverstrust.org/what-we-do/sewage-in-rivers/

# 2. Extensive regenerative agriculture

**Extensive regenerative agriculture will promote increased soil quality and extent of best, most versatile agricultural land and reduced agricultural run-off to water courses via best management to practices. CSO spills will be prevented for new developments and reduced by 50% for existing urban areas.**

## What are the key features of this scenario?

Extensive regenerative agriculture includes changes to land use resulting in increased soil quality and extent of best most versatile (BMV) agricultural land and reduced agricultural runoff and pollution of water courses through regenerative and precision farming practices.

Expected changes in % of total land cover across the SW River Basin District:


## Why is this important?

The key elements of this scenario align with UK Government priorities to manage and enhance land use through Environmental Land Management Schemes (ELMS) and Nature Recovery Networks. This scenario is consistent with the 'Nature at work' scenario outlined in the UK National Ecosystem Assessment (UK NEA, 2014).

## What evidence underpins this?

Regenerative and/or Catchment Sensitive Farming practices are anticipated to extend across 80% of farmland in SW catchments: e.g. cover cropping, no-tillage, waste recycling, integrated nutrient and pest management, integrating crops with trees and livestock, natural flood management . Uptake will be enabled through ELMS and Nature Recovery Networks (DEFRA, 2018; HM Gov, 2018a,b; HM Gov 2020) and by propagating best practice, profiled for farms in SW England (Agricology, 2020). This scenario (2) is a highly optimistic scenario. For example, the increase in woodland (+3%) exceeds (1) Business as usual scenario (+2%) and (5) Strategic tree planting scenario (+0.5%).

## How can we practically implement this in decision support?

Land use changes can be input into decision support tools through spatially explicit or aggregated means. Soil health can be represented through adjusting soil organic carbon, hydrology and sediment parameters. Impact of Best Management Practices can be incorporated through adjusting variables representing hydrological flows, land run-off and contaminant inputs to watercourses using tools such as FarmScoper or trade-off analysis for all land use options (e.g. SW Regional Assembly, 2005). .

## References


Agricology (2020). Farmer profiles. URL (accessed December 2020): https://www.agricology.co.uk/field/farmer-profiles

DEFRA (2018). Health and Harmony: the future for food, farming and the environment in a Green Brexit, February 2018. URL (accessed December 2020): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/684003/future-farming-environment-consult-document.pdf

HM Government (2018a). A Green Future: Our 25 Year Plan to Improve the Environment. URL (accessed February 2020): https://www.gov.uk/government/publications/25-year-environment-plan

HM Government (2018b). The Future Farming and Environment Evidence Compendium. URL (accessed February 2020): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/683972/future-farming-environment-evidence.pdfHM Government (2020). Policy paper: Nature Recovery Network (updated 26 November 2020). URL (accessed December 2020): https://www.gov.uk/government/publications/nature-recovery-network/nature-recovery-network

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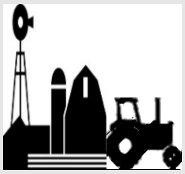
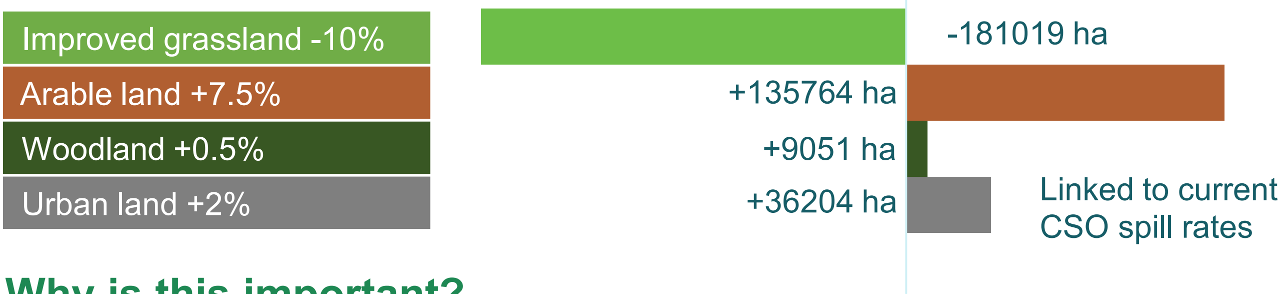
# 3. Intensive Agriculture



**Intensification of agriculture (indoor livestock rearing and fodder cropping) will create pollution hotspots, compensated for to some extent by land sparing. (Pollution hotspots may interconnect via flooding). Combined Sewer Overflow (CSO) spill rates follow current trends.**

## What are the key features of this scenario?

Expected changes in % of total land cover across the SW River Basin District:




## Why is this important?

This scenario is the antithesis of extensive regenerative agriculture – here ecosystem services including natural flood management and carbon capture are secondary to food production. Agriculture will intensify in the most productive lowland areas creating pollution hotspots, while less productive upland areas will be spared/neglected and allowed to re-wild. High productivity areas also include riparian areas (which could otherwise support tree planting to reduce flooding and diffuse pollution). This scenario aligns partially with the 'World markets' scenario outlined in the UK National Ecosystem Assessment (UK NEA, 2014)

## What evidence underpins this?

The UK's food security is currently highly reliant on international imports (McKay et al., 2019). The vulnerability of these supply chains was highlighted following EU Exit, potentially driving growth in domestic food production. One solution is to continue to intensify agricultural production in the UK including SW England, but this has yet to be achieved in a sustainable way and current agroecosystems continue to degrade water, soil and air quality, and biodiversity (McKay et al., 2019).

## How can we practically implement this in decision support?

The intensive agriculture scenario can be implemented through changing land uses, in line with changes in land cover specified above. Agriculture is expected to intensify in the most productive lowland areas, which include floodplains and riparian corridors. Upland areas are likely to be spared, neglected and potentially re-wilded. Tree felling in existing woodland will be compensated by planting of new trees; there will be a marginal increase in woodland cover to compensate for green house gas emissions and historical habitat losses. Land management is not expected to change significantly from current levels (with 37% of farmland employing Catchment Sensitive Farming practices).

## References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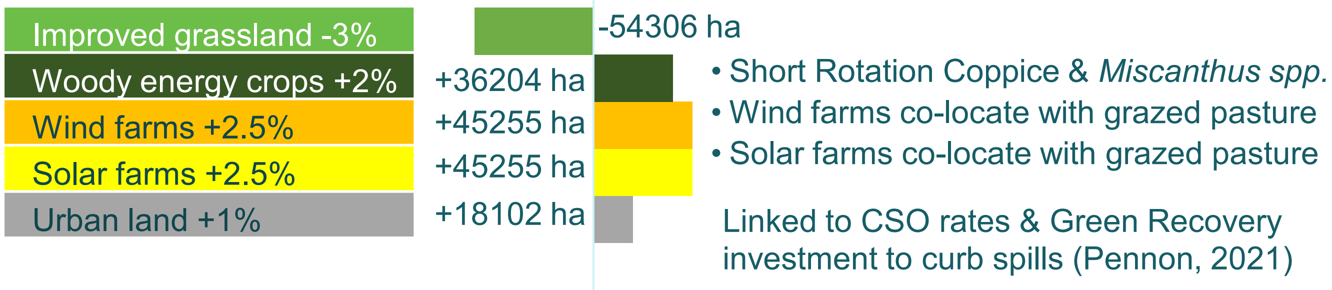
UK National Ecosystem Assessment (2014) The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, LWEC, UK. URL (accessed December 2020): http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

# 4. Increasing renewable energy capacity

**Opportunities to increase renewable energy capacity in South West England include bio-energy crops, solar and wind power, which will require trade-offs in terms of available land use. CSO spills will be prevented for new developments and reduced by 50% for existing urban areas.**

## What are the key features of this scenario?

Expected changes in % of total land cover across the SW River Basin District:




## Why is this important?

Significant growth in renewable energy is required to meet the UK's goal of achieving net zero greenhouse gas emissions by 2050. Key growth areas include: carbon neutral perennial biomass/energy crops; wind farms; solar farms. This scenario aligns with the 'National security' scenario outlined in the UK National Ecosystem Assessment (UK NEA, 2014) and the 'Mixed renewables scenario' from the RSPB's 2050 energy vision.

## What evidence underpins this?

The UK's draft integrated National Energy and Climate Plan (NECP) calls for expansion and increased renewable energy production from onshore (and offshore) wind farms and solar farms in the next 10-30 years (BEIS, 2019; Easy, 2011; Defra, 2019). Biomass crops (mostly imported) currently generate ~50% of renewable electricity and ~80% of renewable heat in the UK. Maize is the largest domestic energy crop with 31% of UK maize (64000 ha) being grown in SW England (Defra, 2020). However, maize cultivation causes soil erosion and has a net positive carbon footprint with or without tillage. Current cultivation of perennial biomass crops elephant grass (*Miscanthus* spp. ~1500 ha) and short rotation coppice (poplar and willow ~600 ha) have significant potential to expand on low grade agricultural land and can help mitigate flood risk (Defra, 2019).

## How can we practically implement this in decision support?

The renewable energy generation scenario can be implemented through changing land uses, in line with changes in land cover specified above. The geographical location of wind farms, solar farms and bioenergy crops will be dictated by exposure, aspect and soil quality respectively, which are captured in opportunity mapping targeted for each renewable energy option (SW Regional Assembly (2005). Existing woodland will be complemented (in hydrological terms) by woody energy crops; leading to an effective increase in woodland cover. Land management is expected to increase moderately from current levels (to 50% of farmland employing ELMS and CSF practices).

## References:


BEIS, Department for Business, Energy & Industrial Strategy (2019). Digest of United Kingdom Energy Statistics, 2019. https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

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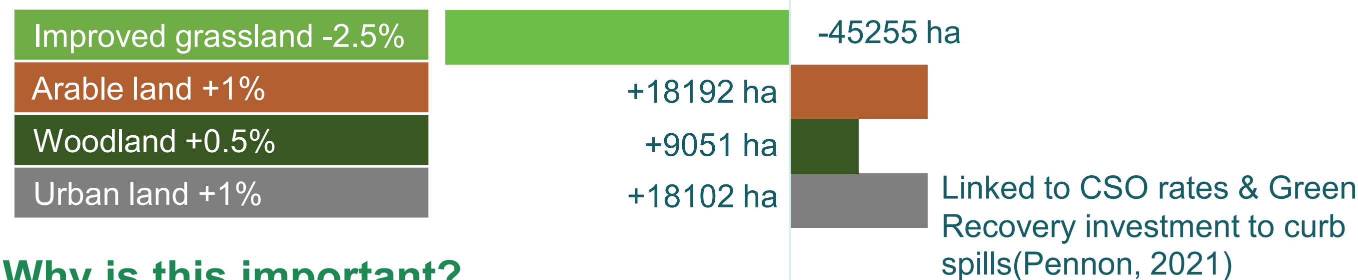
# 5. Strategic tree planting for water management

**Tree planting across the UK and SW England is a key component of the UK's 25 Year Environment Plan. This scenario considers strategic tree planting for flood control and water quality management. CSO spills will be prevented for new developments and reduced by 50% for existing urban areas.**

## What are the key features of this scenario?

Expected changes in % of total land cover across the SW River Basin District:




## Why is this important?

The UK's 25 Year Environment Plan (HM Gov, 2018) commits to natural woodland restoration and planting of up to 30,000 hectares of trees per year by 2025 across the UK. Furthermore, by 2050, there will be at least 12% woodland in England, according to the England Tree Action Plan (HM Gov, 2021). Strategic tree planting will contribute significantly to flood control and water quality management, as well as national efforts to promote biodiversity and reach net zero carbon emissions by 2050. This scenario aligns with the 'Local stewardship' scenario outlined in the UK National Ecosystem Assessment (UK NEA, 2014)

## What evidence underpins this?

SWW aims to plant 1 million trees by 2030 as part of their Upstream Thinking Strategy (SWW, 2020). The Woodlands4Water will plant an additional 30,000 trees in three areas: the Taw Torridge catchment including the North Devon Biosphere; the Camel catchment in Cornwall; the Otter, Sid and Axe catchments and the Blackdown Hills Area of Outstanding Natural Beauty (AONB) in East Devon. This is part of the Forestry Commission and Environment Agency's £1.4 million 'Woodlands for Water' programme to protect around 160 km of river from flooding and impaired water quality by reducing surface run-off (HM Government, 2020). This scenario (5) assumes this level of strategic tree planting will increase to 2050

## How can we practically implement this in decision support?

Strategic tree planting aims to contribute to flood protection and sustainable agriculture, as well as nature conservation and carbon sequestration. Based on opportunity mapping for woodland creation to meet water objectives (Forest Research, 2020), tree planting will be targeted in riparian corridors, including critical source areas (for flood control) in the uplands, lower grade farmland (identified by DEFRA, 2020) and also urban areas. A 0.5% increase in woodland cover (11.5% to 12%) across the SW River Basin District equates to +9300 ha (208860 in 2019 to 218160 ha in 2050) (CEH, 2019). Based on the Forestry Commission minimum density for native mixed woodland (1600 trees /ha), the 0.5% increase in woodland area will require a minimum of 15 million trees. Land management is expected to increase moderately from current levels (to 50% of farmland employing ELMS and CSF practices).

## References


Centre for Ecology and Hydrology (2019). CEH Land Cover maps. URL (accessed May 2021): https://www.ceh.ac.uk/ukceh-land-cover-maps

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# Climate change futures

**Climate change is likely to affect the hydro-meteorological conditions governing flow regimes, temperature and runoff in South West England. Scenarios are taken from UKCP18 and superimposed on each of the above land use scenarios (1-5).**

## What are the key features of this scenario?

- RCP 8.5: business as usual - emissions continue to rise throughout the 21st century.
- RCP 2.6: requires that carbon dioxide (CO2) emissions start declining by 2020 and go to zero by 2100.

Expected changes in % rainfall and temperature in summer and winter (50th percentile) across the entire SW England region by 2050:

**RCP 8.5**

| |
|---|
| Summer rainfall -20% |
| Winter rainfall +10-20% |
| Summer temperature +2°C |
| Winter temperature +1°C |

**RCP 2.6**

| |
|---|
| Summer rainfall –10 to 20% |
| Winter rainfall +10% |
| Summer temperature +2°C |
| Winter temperature +1°C |

## Why is this important?

Observations for the UK show that the most recent decade (2008-2017) has been on average 0.3 ° C warmer than the 1981-2010 average and 0.8 ° C warmer than 1961-1990. All of the top ten warmest years have occurred since 1990. In the past few decades there has been an increase in annual average rainfall over the UK. These and future changes will impact upon viability of agriculture and aquaculture in the UK.

## What evidence underpins this?

The UK Climate Projections 2018 provides a set of high-resolution spatially-coherent future climate projections. UKCP18 climate projections consist of: updated probabilistic projections, giving estimates of different future climate outcomes; a new set of global climate model projections, comprising simulations from both the latest Met Office Hadley Centre climate model and global climate models from around the world; and a set of regional climate model projections on a finer scale (12km) for the UK and Europe.

## How can we practically implement this in decision support?

We can use these projections to plan land use changes and aquaculture operations in areas less impacted by extreme climate changes. The geographical location of managed realignment should take sea level rise into account, while the location of wooded areas and aquaculture will be dictated by rainfall and temperature anomalies.

UK MET Office (2018). UK Climate Projections 2018 (UKCP018). URL (accessed May 2021): https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/about