# LM0308: Catchment Management for Water Quality

**Case Study 1:** Multiple pollutant and ecosystem services responses to land management policies and agri-environment interventions at the farm to catchment scale.

**Lead:** Jack Cosby (CEH); Richard Gooday (ADAS)

**Purpose:** To examine potential trade-offs and co-benefits for a suite of ecosystem services at the farm to catchment scale that may be potential 'by-products' of an agri-environment scheme designed to reduce total multi-pollutant loads entering watercourses.

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| Policy driver(s) | Water Framework Directive (Good Chemical Status), Farm Payment Schemes (Countryside Stewardship, Glastir, SRDP), Climate Change Abatement Agreements, Conservation Targets, Flood Risk Mitigation |
| Enduser(s) | Government Agencies (DEFRA, EA, NRW), Catchment Managers, Conservation Agencies, Local Authorities, River Trusts |
| Pollutant(s) | Nitrate, Phosphorous, Sediment, Fecal Indicator Organisms (FIO), Flood Potential, Carbon loss (and Sequestration), Biodiversity Loss |
| Measures | Case study based in Wales (as exemplar) so measures are derived from Glastir and Glastir Advanced agri-environment schemes in Wales. For farm to catchment scale applications in England or Scotland, measures derived from Countryside Stewardship or SRDP would be used. |
| Scenario if appropriate | Long term impact of the implementation of mitigation methods representing major / common options within Glastir and Glastir Advanced. These include reduction of fertilizer application, change in stocking density, woodland edge expansion, streamside corridor tree planting, and bracken control. Economic assessment of these options where possible. |
| Outcome / output | Percentage change in total pollutant load to the catchment watercourses resulting from applied agri-environment interventions (including FIO delivery to the estuary). Evaluation of co-occurring effects on selected ecosystem services expressed as percentage of areas within the catchment: 1) losing or gaining C; 2) prone to sediment losses; 3) providing flood mitigation; 4) with suitable habitat connectivity (including assessment of areas within the catchment where effects are antagonistic or complementary). Cost-benefit analysis if data and methodology are available. |

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| Scale / Location | Catchment Scale; Conwy catchment in Wales<br>520 $km^2$; sea level to 1000 m elevation; climate gradient; all major Welsh soils and landuse; peats, forests, unimproved and improved grasslands; dairy, cattle, sheep, mixed livestock; shellfish industry in estuary. |
| Risks | Availability of datasets for inclusion in the platform as inputs to the models and for access by endusers. Of particular concern is a robust soils database for LUCI that can be used on the platform without IPR restrictions on use as input data or IPR restrictions on use of platform outputs derived from models using the soil database. Other required databases (above) should be available. |
| Risks | Availbility of a suitable FIO model that can be included on the platform without IPR restrictions (and that can be sourced through the community funding pot and be made available in a suitable timeframe for the case study)<br><br>Difficulty in translating Glastir, Countryside Stewardship or SRDP agri-intervention options into suitable inputs for the models. This includes the possibility that some policy options may involve interventions in processes or land use changes that cannot be addressed by the models because the bio-physical basis of the intervention is not included in either LUCI or Farmscoper. |

**Background / Narrative:**

The New Environmental Land Management Scheme (Countryside Stewardship), the successor to Environmental Stewardship (ES), will be a key package in delivering the Government's sustainable agriculture and rural policies and is likely to form a substantial part of the Rural Development Programme for England (RDP) 2014 -2020. Countryside Stewardship will contribute to Defra strategic priorities for sustainable development, natural resource protection, supporting sustainable farming and food, and sustainable rural communities. While covering cover soil and water issues, Countryside Stewardship also focuses on other ecosystem services such as biodiversity, the historic environment, genetic conservation and educational access, plus measures to address climate change such as reducing greenhouse gas emissions and carbon storage. Agri-environment schemes in Wales (Glastir) and Scotland (SRDP) are similarly focused on sustainable land management and the simultaneous delivery of environmental goods and services.

In these multi-targeted schemes, there is a need to examine potential tradeoffs and/or co-benefits in terms of reductions and or enhancements of ecosystem services (ES) provided in the catchment as a result of the targeted actions to reduce water pollution to the streams. In that interventions to control multi-pollutant runoff are likely to be applied at farm and field scales, the evaluation of potential changes in ES should be evaluated at similar scales.

It is likely that the effects of interventions and their knock-on effects on ES will vary spatially within a single catchment. A key aspect of this case study will be to identify areas within the catchment where: 1) trade-offs occur, i.e. areas where some ES are either enhanced or unaffected while others are seriously degraded; and 2) where co-benefits are derived, i.e. all ES are either unaffected or enhanced. Knowledge of this spatial pattern in response to interventions will allow more efficient and cost-effective implementation of agr-environment policy.

**Basic approach:**

The intention of this case study is to link the agri-environment interventions used to produce changes in agricultural pollutant loads as predicted by the Farmscoper model for a given scenario with the LUCI ecosystem services tool to evaluate the effects of those interventions on other ecosystem services in a catchment. The most recent version of Farmscoper incorporates a catchment-based calculation that operates at Water Management Catchment (WMC) scale. The LUCI tool can also be applied at a catchment scale, but has a 5m spatial resolution allowing evaluation of the effects of agri-interventions implemented at the farm to field scale on ecosystem service provision. The use of the two models will allow analysis of the spatial patterns of trade-offs and/or co-benefits for ES that accompany the changes in agricultural pollutant loads.

The case study will focus on the Conwy catchment in Wales which consists of areas involving a number of different agricultural activities (dairy, improved and semi-improved grazing, etc.) and areas of environmental concern (peatlands, wetlands, forests, etc.). The Conwy River drains to an estuary that is home to a commercially important shellfish industry, a concern for both pollutant loading to the river as a result of upstream activities as well as potential loss of ES in the near-marine environment of the catchment.

The agri-environment interventions implemented in this case study will be derived from the Galstir and Glastir Advanced schemes in Wales, using a number of intervention options appropriate to the Conwy catchment in Wales. The case study is an exemplar to demonstrate the improved decision making capability and added value that result from the use of a multiple model, multi-pollutant, combined water quality and ecosystem services approach to assessing the effectiveness of land-use policy. The modelling approach and procedures demonstrated by this exemplar are readily transferable to other catchments in Wales (where different Glastir options may be appropriate) or to catchments in England or Scotland (using appropriate measures from Countryside Stewardship or SRDP).

Case studies 1 and 2 are similar in that the consequences of land management policies and agri-environment intervention schemes to reduce multi-pollutant runoff are being examined. Both studies consider catchment scale responses as a starting point and evaluate co-occurring effects on ES. However, the case studies differ in their approaches for incorporating integrated modelling to address broader aspects of the topic.

Case study 2 starts at the catchment scale using Farmscoper, but then combines Farmscoper with SAGIS to extrapolate to larger scales providing assessments for thousands of catchments from regional to a national scale using Countryside Stewardship scenarios for England. As the scale increases, information about the linkages among interventions and ES (both occurring at field or farm scale) is potentially obscured, but a broader more-policy relevant perspective is obtained (effectiveness at national scale).

This case study (1) also starts at the catchment scale using Farmscoper but combines Glastir interventions in Wales with the LUCI modelling tool to disaggregate to smaller scales, evaluating the effects on ES at the scale of implementation (field or farm). Because of the greater spatial detail, this case study is implemented here in a single catchment, the Conwy River in Wales, as an exemplar. At this smaller scale of resolution, the broader effectiveness of the policy at the national scale is potentially lost, but it becomes possible to evaluate effects on a range of ES and to identify trade-offs and co-benefits operating at the scale of uptake and implementation of the interventions.

This can provide feedback to development of the next policy initiative and/or help to target specific local instances of implementation that enhance co-benefits and minimize trade-offs.

Case studies 1 and 2 are thus complementary in the added information they provide through an integrated modelling framework. Case study 1 highlights the increased spatial information that can be derived from ensemble models which can be used for more efficient targeting and evaluation of agr-environment interventions. Case study 2 demonstrates the ability to extrapolate from ensemble models to regional and national scales to provide policy relevant evidence and information.

**Models to be used:**

- Farmscoper
- LUCI
- Model of FIO mobilization and transport – to be identified (see other requirements)
- Economic analysis by Defra

**Data to be used:**

- Inputs
    - Agricultural census by WMC
    - Robust Farm Type counts by WMC
    - DEM data (5m resolution)
    - Landuse cover
    - Climate data
- Outputs
    - Agricultural pollutant reductions at WMC scale
    - Cost of scheme implementation at WMC scale
    - Soil carbon stocks and change
    - N, P and FIO's in streams
    - Flood mitigation potential
    - Sediment and erosion potential
    - Green House gas emissions
- Validation
    - Harmonized Monitoring Scheme data

**Other requirements:**

- Model of fate and transport of FIO's that can be run on catchment scale and includes delivery to estuarine shellfish beds. This can be a stand-alone model that can run in ensemble mode with Farmscoper and LUCI or a module that can be inserted in LUCI. This may have to be sourced from the community funding pot.
- Contact Chris Burgess to identify possible synergies
- Economic requirements to be identified in consultation with Defra

**Workplan:**

- Scenario simulation with Farmscoper to determine reduction in the agricultural load at WMC scale, applied to Conwy catchment.
- Convert Farmscoper scenario to equivalent changes in land use or land management for input to LUCI.
- Scenario simulation with LUCI using translated interventions, applied to Conwy catchment.
- Mapping of individual ES and their changes in the Conwy catchment and identification of areas of trade-off and co-benefit.
- Document the linkage between Farmscoper and LUCI and develop as tool for Integrated Modelling Platform
- Document ES analysis procedure for trade-offs and co-benefits and develop as tool for Integrated Modelling Platform
- Develop protocol and documentation to assist platform end-users in repeating the modelling and procedures demonstrated by this exemplar in other UK catchments.

**Milestones:**

- Scope out Case Study (Feb 2015)
- Develop model documentation for the Platform (March 2015)
- Identify and source FIO model/module (April 2015)
- Start conditioning and ingestion of data and models with documentation into Platform including model input and outputs (June 2015)
- Completion of first model application outputs and testing with Community Forum (Nov 2015)
- Start conditioning and ingestion of external data and models into Platform (June 2016)
- Iteration to identify benefits of model coupling (Nov 2016)
- Final report (Mar 2017)

**Link to Enduser Questions:**

**Effectiveness of measures / mechanisms**

- Capture uncertainty in effectiveness of measures – understanding timescales of response and implications for economics.
- What is the combined impact of multiple pressures, biological response, and the effectiveness of measures

**Evidence of outcome**

- Can models help to target measures and provide an estimate of the level of confidence that they will work – no point in investing customers money if uncertainty high

**Integration / focus / scaling**

- Integration of models across receptors / objectives to identify co-benefits and trade-offs; to help justify / prioritise action depending on local objectives, priorities and characteristics

**Uncertainty, confidence and communication**

- What is the uncertainty associated with modelling the different effectiveness of measures?