Water Friendly Farming: long-term catchment-scale evaluation of measures to improve water quality

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Introduction

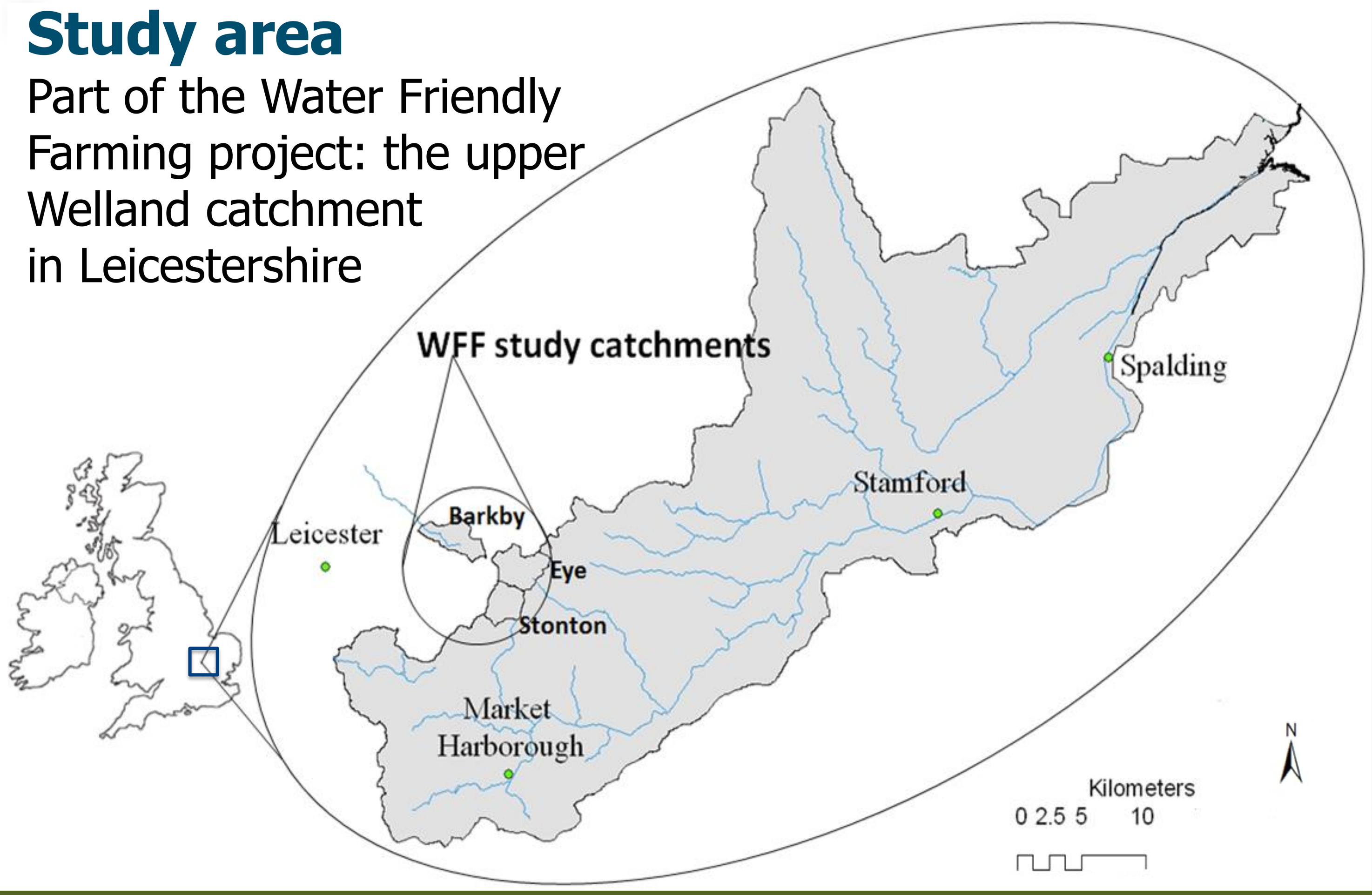
- Mitigation measures are known to reduce agricultural pollutants in water at field-scale, but their effect on chemical and ecological quality of water at catchment-scale is poorly characterised.
- The Water Friendly Farming (WFF) project is a Before-After-Control-Impact experiment with a two year baseline in three 10-km^2 catchments with heavy clay soils and extensive drainflow.
- Monitoring shows subsurface drainage is the dominant route of pesticide loss to water with smaller contributions via surface runoff. Mitigation measures for subsurface drainage are very limited (primarily modifications to rate and/or timing of application or use of alternative products).
- Modelling is a useful tool to predict transport of agricultural pollutants and to assess the effects of mitigation measures. The focus of the current study is on the **Stonton Brook catchment**.

Objective

- To use modelling to explore mitigation measures aimed at reducing diffuse pollution by pesticides.
- To investigate the viewpoints of farmers on proposed mitigation measures.

Study area

Part of the Water Friendly Farming project: the upper Welland catchment in Leicestershire



Methods

- **Water samples** were collected at the catchment outlet every two days over four successive winter seasons and **analysed for metaldehyde and propyzamide**.
- The Soil & Water Assessment tool (**SWAT**) (Arnold *et al.*, 1998) was calibrated then used to study the fate and transport of pesticides in the catchment (Grijalvo-Diego *et al.*, 2015). Modelling results were evaluated against measured pesticide concentrations.
- The calibrated model was used to assess the impact of **mitigation measures** and to propose changes to pesticide usage to farmers in order to reduce diffuse pollution by pesticides. **Changes to pesticide usage** included: i) coordinating and splitting applications spatially and/or temporarily during the crop year to avoid applying the full label dose on the same day across the whole catchment; and ii) reducing OSR area to limit propyzamide applications and so reduce concentrations in water.
- A **stakeholder workshop** was held with farmers in June 2017 under Defra's Sustainable Intensification Research platform (www.siplatform.org.uk). The workshop transcript was analysed using an inductive approach to identify commonly-occurring themes across participants (Morris and Jarratt 2016).

Results & Discussion

Metaldehyde & Propyzamide

- Metaldehyde and propyzamide detected in stream flow at up to 3.3 and 1.3 µg/L, respectively (Fig. 1).
- SWAT successfully simulated behaviour with maximum annual concentrations generally predicted within a factor of two (Fig. 1).

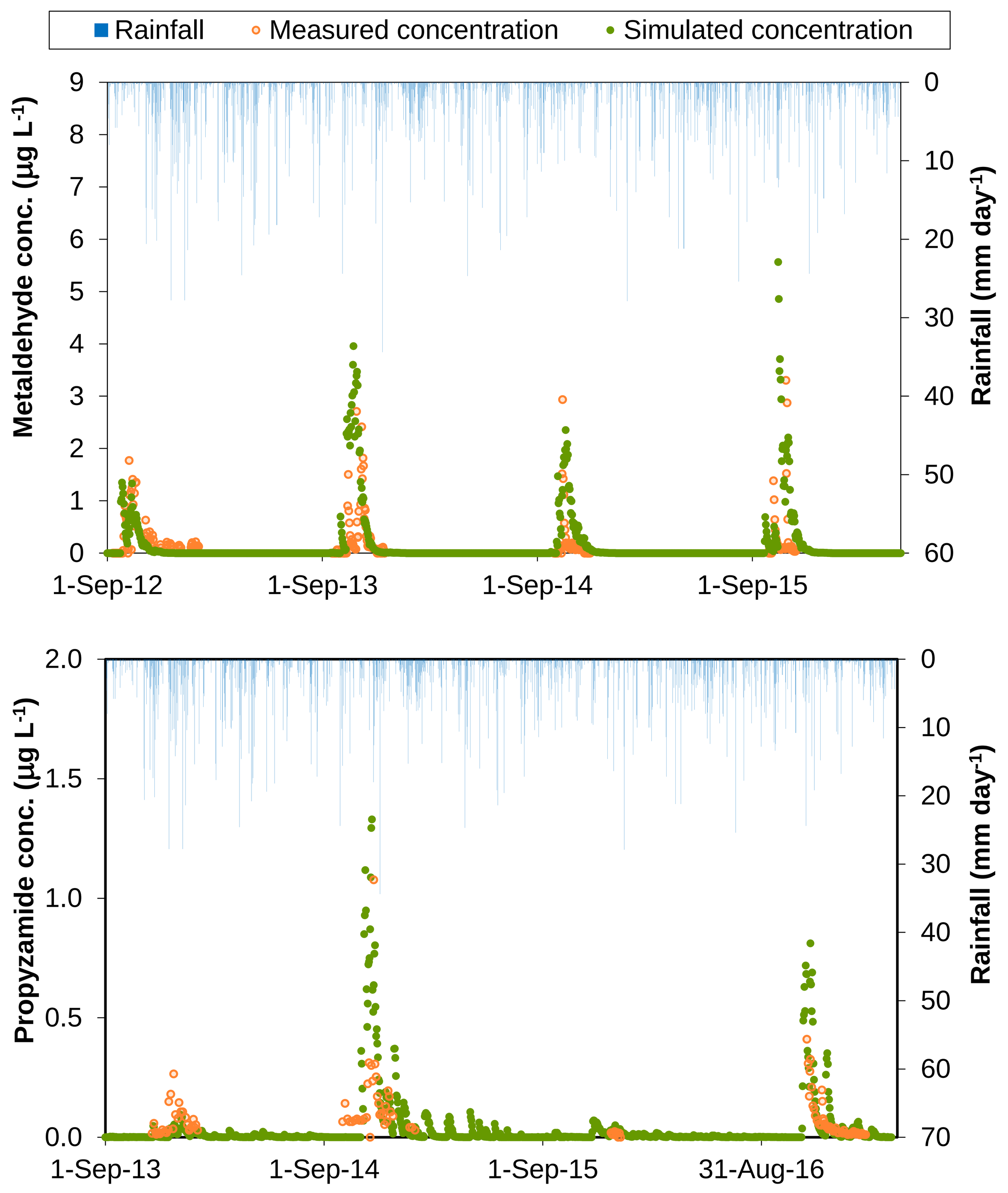


Figure 1 Measured and simulated concentrations of metaldehyde (top) and propyzamide (bottom) in Stonton Brook.

Coordinated/split applications

- Split (2 x 50% dose) applications of metaldehyde to all arable land reduces stream concentrations by an average factor of 1.4 compared to a single (full-dose) application (Fig.2).
- Coordinated application of propyzamide to OSR (50% fields treated in November, 50% in December) would reduce maximum concentrations by 30%. Application timing had little impact as drains flow throughout the window.

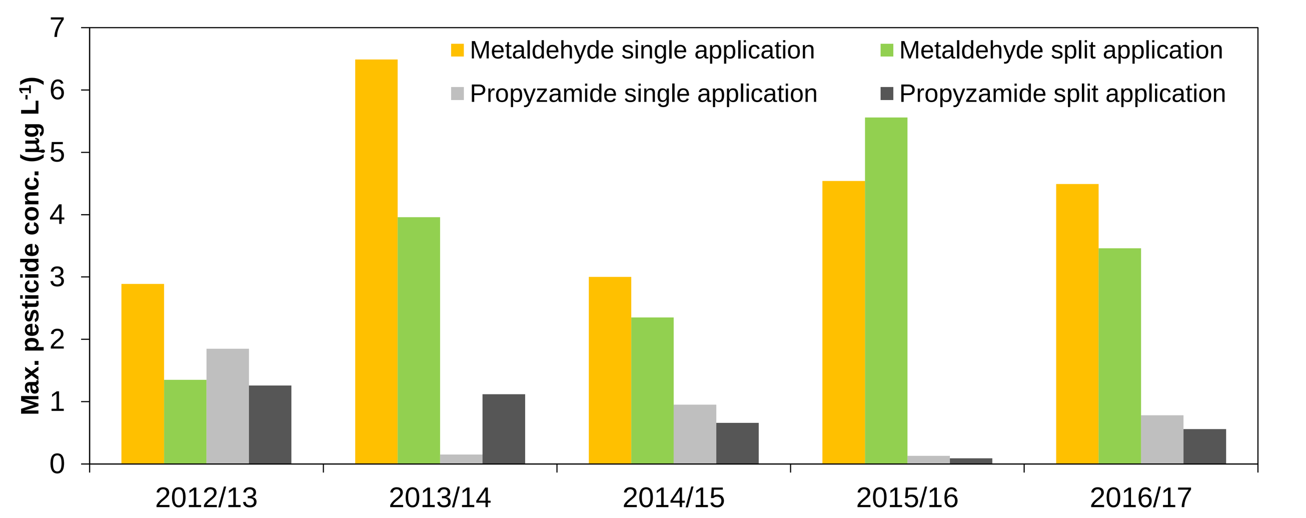


Figure 2 Simulated maximum metaldehyde and propyzamide concentrations following single and split pesticide applications.

Reducing crop area

- OSR area would need to be reduced to ca. 2.0% of total land area to ensure concentrations in the stream did not exceed 0.1 µg/L at any point across the season (Table 1).

Table 1 Estimated OSR area that would ensure concentrations of propyzamide in the stream did not exceed 0.1 µg/L using monitoring and model data compared to the actual measured crop area between 2012/13 and 2016/17.

	2012/13	2013/14	2014/15	2015/16	2016/17
Area of OSR (ha)	229	33	209	26	57
Area of OSR (%)	29.8	4.3	27.2	3.4	7.5
Area of OSR to deliver 0.1 µg/L (% of the catchment area)					
Based on measured data	n/a	1.6	2.5	n/a	1.8
Based on model data	1.9	4.8	2.0	4.9	0.9

Stakeholder workshop

- Farmers felt that the drinking water limit of 0.1 µg/L had been set based on analytical limits rather than established by research as safe limits for human health or the environment.
- Coordinated application of propyzamide was not regarded as viable (lower efficacy).
- A catchment scale limit on the area of OSR grown requires farmers to cooperate by coordinating their rotations:
  - Rotations are set to reduce blackgrass resistance not product usage;
  - Rotations cannot be modified without compromising profitability;
  - The price of OSR will influence the crop area that farmers grow.
- Data showing when field drains are running were not considered useful as it would be too late to make decisions about propyzamide application once drains were flowing.

Conclusions

- SWAT successfully forecast pesticide concentrations in this drained agricultural catchment with heavy clay soils. Modelling results are useful to estimate the effects of the mitigation measures within the WFF project.
- Metaldehyde is applied to both dominant crops in the catchments (winter cereals and winter OSR) and concentrations and the compound was consistently present in the stream from October through to January each year. Split applications help to reduce concentrations in surface water to some extent.
- Mitigation strategies were developed for propyzamide based on coordinated approaches with differentiated application timings or reductions in overall area of OSR. The strategies were not regarded as viable because of economic drivers, impacts on product efficacy and limitations to the levels of collaboration that can be delivered between neighbouring farms.

References: **Arnold *et al.* (1998).** *J. Am. Water Resour. Assoc.* 34(1):73–89. **Grijalvo Diego, I**; Brown, C; Biggs, J; Hawczak, A; Stoate, C; Szczur, J. 2015. Modelling pesticide contamination in two small agricultural catchments using SWAT. Pesticide conference, Piacenza. **Morris, C. and Jarratt, S. 2016.** *SIP-Sustainable Intensification Research Platform.* University of Nottingham.

Acknowledgements: This project has been funded by the Environment Agency, DEFRA, Anglian Water and Dow AgroSciences