

Guidance for the Assessment of Mitigation Method Implementation

Introduction

Farmscoper Create calculates baseline diffuse pollutant loads for air and water pollutants, before any implementation of mitigation methods is accounted for elsewhere in the tool. The baseline loads are calculated using export coefficients which express pollutant loads as linear functions of fertiliser use, livestock excreta and crop areas, with the information on the farm system (entered by the user) providing the necessary farm management information. The export coefficients were derived from the output of mechanistic models applied to the range of environmental conditions across England and Wales. Input data to these mechanistic models included fertiliser and manure timing and livestock grazing periods, which for v5 were taken from national survey data from 2015 to 2019.

Farmscoper Evaluate calculates the impacts of one or more mitigation methods upon these baseline pollutant loads. This tool allows the prior level of implementation of each mitigation method to be specified, which enables a more accurate calculation of current pollutant losses, which ensures any impacts of future implementation determined with Farmscoper will take account of what is already happening.

A user is able to set the level of prior implementation for each method, but default values are also provided, which represent national average rates. These values are based upon survey data, drawing upon the Defra Farm Practice Surveys (FPS) in particular, with a focus on data between 2006 and 2012, and revisions to these from Defra Project WT1594¹ (Elliot et al., 2019) from farmer surveys and analysis of Agri-Environment scheme data. A simple scoring system (Table 2) was used to estimate the range of uptake as it reflects the uncertainty in mapping farm practice survey questions to the specific mitigation methods. Each mitigation method was assigned an uptake score for free draining and slowly permeable soil types, along with any expected variation in uptake with livestock intensity or location within a Nitrate Vulnerable Zone. The default implementation values are listed in a spreadsheet appendix to this document, along with the data source from which they were derived.

Table 1 Implementation scores used in the Farmscoper mitigation method library, and the uncertainty range associated with the average values.

Category	Implementation (%)	Uncertainty Range	Description
A	-	-	None
B	2	0 to 10	Very Low
C	10	2 to 25	Low
D	25	10 to 50	Moderate
E	50	25 to 80	High
F	80	50 to 95	Very High
G	100	100	Total

¹Defra project WT1594. 2019. A national scale assessment of current and future actions to reduce diffuse pollution of water by agriculture.

The Defra FPS data is from approximately 3,000 farms in any given year, with the data stratified by farm type, and so represents a relatively robust estimate for the national population when estimating mitigation uptake. Assuming that there is no regional bias in method implementation, then Table 2 gives the confidence intervals (95th percentile) on the percentage of farms in a random sample implementing a mitigation method for given percentages of farms nationwide implementing the same method. This table suggests that a sample (i.e. catchment(s)) of at least 50 farms is needed in order for the national data to be representative of the behaviour of the sample.

There are a number of mitigation methods where prior implementation representative of c. 2010 would have been accounted for in the datasets used to create the baseline pollutant losses (e.g. timing of fertiliser applications derived from the British Survey of Fertiliser Practice), and so implementation for these methods is set to zero. These methods are:

- 26. Avoid spreading manufactured fertiliser to fields at high-risk times
- 31. Use clover in place of fertiliser nitrogen
- 32. Do not apply P fertilisers to high P index soils
- 52. Increase the capacity of farm slurry stores to improve timing of slurry applications
- 69. Do not spread slurry or poultry manure at high-risk times
- 72. Do not spread FYM to fields at high-risk times
- 125. Monitor and amend soil pH status for grassland
- 126. Increased use of maize silage

The need for a defined baseline for farm practice means that Farmscoper can only be used to assess the impacts of improvement in farm management from average behaviour, and cannot represent 'below average' practice that must by definition be found on some farms. Although baseline losses in the 'Output' sheet of Farmscoper Create could be modified to reflect poorer management (e.g. increase all surface runoff losses of manure), the specification of the rules for mitigation method impacts (e.g. a 10% reduction due to improved manure timing) may not be so appropriate for such a baseline.

There are also two mitigation methods where prior implementation (or the need for future implementation) can also be accounted for when creating farm(s). These methods are:

- 76. Fence off rivers and streams from livestock
- 77. Construct bridges for livestock crossing rivers/streams

The effect of / need for implementation of these can be achieved by specifying whether livestock have access to water either when grazing or travelling to the yard. This can be done in both Farmscoper Create (by selecting the appropriate 'Grazing' option on the 'Farm' sheet) and Farmscoper Upscale (by setting the appropriate options on either the 'Manure' or 'Farm Results' sheet).

Table 2 Confidence intervals (95th percentile) on the percentage of farms in a random sample implementing a mitigation method for given percentages of farms nationwide implementing the same method.

	Percentage of farms implementing mitigation method					
		2%	10%	25%	50%	80%
Number of farms in sample	5	0-14	0-41	0-59	0-89	49-100
	10	0-10	0-30	0-54	21-92	45-96
	50	0-4	1-18	10-41	35-66	62-92
	100	0-4	3-14	12-37	33-61	57-100
	200	0-4	4-15	12-35	31-65	64-92
	500	0-3	4-14	14-32	31-63	59-95

Estimation of Current Implementation Rates

When estimating prior implementation rates, it is important that the rate is calculated as a percentage of the land or livestock to which the method is applicable. For example, the implementation rate for cover crops should be estimated as a percentage of the spring cropping area. The appropriate data to use for this normalisation at a catchment scale are listed in the spreadsheet appendix to this document. At farm scale it may be appropriate to use different normalisation data as more detailed calculations may be possible, for example an estimate of the percentage of the yard area that had been roofed (as opposed to catchment normalisation as a percentage of farms who had roofed their yards). Note that even where implementation of a mitigation method is required by regulation, current implementation is unlikely to be 100%.

The following approaches can be used to estimate implementation rates for one or more catchments.

Surveys

Implementation of mitigation methods can be due to a wide variety of reasons, including regulation, agri-environment schemes, farm assurance schemes, good practice, technological advancements and peer encouragement. The simplest way to determine the net impacts of all these different factors is through a survey of farm managers.

As well as determining implementation rates, such a survey could also be used to obtain information on livestock numbers, crop areas, manure management and fertiliser use which can be used to help inform the input data within Farmscoper Create (on the 'Farm' sheet) or Farmscoper Upscale (on the 'Census' or 'Farm Results' sheet).

The Farmscoper method library contains approximately 100 mitigation methods, some of which have limited or no impact on some of the pollutants modelled within Farmscoper, or may have limited impact within the catchment(s) under consideration. Therefore it is sensible to limit a survey on method implementation to those methods that have a significant impact on the pollutant(s) of interest. The simplest way to determine the most important methods is to use Farmscoper to 'Evaluate Methods Individually', assuming zero current implementation for all methods, and then rank the methods in terms of effectiveness. Such an evaluation can either be done on a farm by farm basis or using for the catchment as a whole using Farmscoper Upscale.

Stakeholder Workshop

An understanding of land management and current and potential future implementation of mitigation methods could be obtained through a workshop of farmers, farm advisors and other stakeholders. Such an approach could potentially allow for all causes of mitigation implementation (e.g. regulation, agri-environment schemes) to be investigated.

Catchment Visit

For some mitigation methods, implementation can be determined from a catchment visit, although it is important to normalise any observations against all land visited where implementation may have been possible – for example, what length of the river bank was fenced compared with the total length of riverbank in the catchment that is next to grassland fields. The timing of a catchment walk within a year may mean that not all instances of method implementation are captured (for example if cover crops were late sown) or not all instances recorded where a farm practice occurs intermittently throughout a year (e.g. placement of manure heaps).

A catchment visit may also provide some evidence to help determine input data within Farmscoper Create (on the 'Farm' sheet) or Farmscoper Upscale (on the 'Census' or 'Farm Results' sheet, although this is likely to be limited to crop area information).

Scheme Data

There are a number of current and recently closed agri-environment schemes in England and Wales, each of which have numerous different options that can be implemented on farm. Many of these options have little or no impact on diffuse pollution, but there are others that require changes in practice analogous to the mitigation methods in Farmscoper and some options that require changes in livestock numbers, fertiliser use or land use (representation of these latter options within Farmscoper is described in the following section).

For some scheme options, there is an obvious mitigation method in Farmscoper that can be used to represent it. For other options, it is necessary to compare the details of the scheme prescription with information on what the mitigation methods entail from the Mitigation Method User Guide (Newell-Price et al., 2011) and the Farmscoper Cost tool in order to decide if any mitigation method within Farmscoper is appropriate. Note that a number of options within a scheme may map to the same Farmscoper method – this is typically true for buffer strip options, where scheme prescriptions specify a number of different potential widths, but Farmscoper only has one method, and for a variety of scheme options that are best represented by the 'in-field grass buffer strip' mitigation method. When assessing the impacts of scheme options, consideration should be given to the fact that some options that could be of benefit for water quality (e.g. buffer strips) may have been implemented for other benefits (e.g. biodiversity) and so the full potential water quality benefit may not be realised.

The 'Method List' sheet in Farmscoper Evaluate contains a list of the mitigation methods that can be mapped to options in the following schemes and regulations, which can be used a filter/initial screening tool for any evaluation of a policy mechanism. These are not intended to be definitive guides to scheme options and the methods for representing a scheme should be reviewed when doing a comprehensive analysis of a scheme.

- **FRfW (Required)** Measures required by the Farming Rules for Water
- **FRfW (Reasonable)** Measures that could be considered reasonable precautions to take under the Farming Rules for Water
- **SSAFO** - Storing Silage, Slurry and Agricultural Fuel Oil regulations

- **NVZ** Cross compliance Statutory Management Requirement 1: Reduce water pollution in Nitrate Vulnerable Zones
- **CS** Countryside Stewardship (which can be used as a surrogate for previous environmental stewardship schemes). Note: some options are aimed at biodiversity, but have water quality benefits.
- **CSF** Catchment Sensitive Farming programme of supportive measures such as farm advice, training and capital grants targeted at priority catchments to help reduce soil erosion and nutrient and pesticide losses to water.

The complete scheme data provides details on the extent of implementation of each option, which is typically the count, length or area of option implemented. In order to utilise such data, it is necessary to know the number of fields of the main land uses (i.e. arable, grass, spring cropping) within the catchment of interest, which can either be obtained from official field boundary datasets, or derived from the census data included within Farmscoper Upscale and typical field sizes.

Given the number of times an option has been used, an implementation rate can be derived by dividing this number by the appropriate number of fields within the catchment (i.e. arable fields, for an arable option, spring cropping fields for a cover crop type option).

Given the total length of option implemented (e.g. for a buffer strip), an implementation rate can be derived by dividing this length by the product of total number of appropriate fields and the typical field width (which if fields are assumed to be square, can be taken from the square root of the field area). For example, if there was 400m of buffer strips in 10 fields with a total area of 50 ha, the average field would be 5 ha and so 224 m long if square, so the implementation rate would be $(400 / (224 * 10)) = 18\%$. Note that this assumes the feature is along one edge of a field only, so it may be appropriate to reduce the implementation rate if this is not actually thought to be case.

Given an area of option implementation, an implementation rate can be derived by dividing this area by the total area of appropriate fields. Note that in this scenario, it is necessary to account for the typical area of a field covered by the scheme option. For linear features (e.g. buffer strips), this can be taken from the typical field length and the typical width of a feature. For other options, scheme prescriptions may specify the typical or maximum area within a field or farm that can be devoted to the option. Where multiple scheme options are being mapped to a single Farmscoper method, it may be appropriate to manipulate the scheme data first and then combine the separate implementation rates that have been derived.

Changes in livestock numbers, fertiliser use and land use

Agri-environmental schemes can include specific options that require land use change, restrictions on livestock intensities or reduced use of fertiliser. Comparable methods are not included in the Farmscoper mitigation method library since the impacts of such options can be represented in Farmscoper through modification of the initial input data. If agricultural census data is assumed to represent current practice, and you want to understand the reduction achieved by uptake of these scheme options then it is necessary to alter this data to represent the situation before the scheme was in place.

If the area of land use change is known, then relevant crop areas can simply be increased (decreased) in either the 'Farm' sheet in Farmscoper Create or the 'Census' or 'Farm Results' sheets in Farmscoper Upscale), ensuring that an appropriate land use is decreased (increased) if that land use is also agricultural. Most scheme options restricting fertiliser rates have a maximum rate allowable, which can be differenced from the current overall average application rate (or the rate on land receiving fertiliser) and the net change calculated based upon the area of land under the options and the area not under options. For example, if the average fertiliser rate was 100 kg ha⁻¹, and 20 ha are

restricted to only 50 kg ha⁻¹, then the overall rate would drop to 90 kg ha⁻¹. Scheme options restricting livestock often have an assumed change in stock intensity used in the calculation of scheme payments, which can be used to determine a change in stock. However, there are a variety of issues that can complicate such calculations, including:

- arable reversion to grassland may result in more grazing livestock within the catchment (with the possibility that the livestock are not owned by the farm);
- reductions in fertiliser use should result in reduced forage production and thus decrease the amount of livestock that can be supported;
- options with maximum fertiliser rates may be on land where fertiliser rates were already below this level;
- stock restrictions in specific fields may simply result in the livestock being located elsewhere on farm and not actually change the amount of stock.

One approach to overcoming these obstacles is by asking, as part of a survey, explicitly what changes in stock numbers and/or fertiliser use have occurred as a result of scheme membership.

Estimation of Future Implementation Rates

As well as providing information on current implementation, surveys and stakeholder workshops can also be used to inform the methods that could be used in any scenario analysis, and the likely maximum implementation rate of those methods.

Even where a mitigation method is required by current or some potential future regulation, an assumption of 100% compliance with the regulation may not be appropriate.

Setting Up Implementation Rates in Farmscoper

Farmscoper Evaluate allows for the implementation rate of each mitigation method to be specified. There are three potential ways that this can be done, described below.

Using the 'Method List' sheet

Implementation rates can be entered directly into the 'Method List' sheet in Farmscoper Evaluate.

Using the 'Settings-Priors' sheet

If 'Use Prior Implementation Rates' is selected on the 'Method Settings' sheet in Farmscoper Evaluate, the default national rates are used, which are specified as a function of soil type, inside/outside NVZ and farm intensity. The rules for setting the default national rates can be viewed on the 'Settings-Priors' sheet, which is made visible within 'Farmscoper Evaluate' by selecting 'Show Prior Implementation Rates'. The rules for any mitigation method can be edited (changing the initial score by soil type, or altering the NVZ or farm intensity modifier) to make them more appropriate for a catchment being modelled.

Using the 'FarmSummary.csv' file (Farmscoper Upscale only)

When one or more catchments are created with the Farmscoper Upscale tool, a list of all the Farmscoper Create files made for the different catchment-farm-NVZ-climate-soil combinations within those catchments is placed in the root of the specified working directory.

When these catchments are then run through Farmscoper Evaluate from the Upscale tool to determine the impacts of mitigation implementation, it reads this 'FarmSummary.csv' file to know which Farmscoper Create files it needs to open. The 'FarmSummary.csv' file also contains a

TRUE/FALSE column which allows for only selected Farmscoper Create files to be passed through Evaluate. Using this functionality allows for different parts of a catchment to utilise different copies of Farmscoper Evaluate, and thus the two approaches outlined above to be applied. After each part of a catchment is run through Farmscoper Upscale, the data from the 'Output Evaluate' sheet will need to be copied into a separate workbook and the various parts joined together when all have been processed.