Mitigating the Risks of Plant Protection Products in the Environment

MAgPIE

Editors:
Anne Alix, Colin Brown, Ettore Capri, Gerhard Goerlitz, Burkhard Golla, Katja Knauer, Volker Laabs, Neil Mackay, Alexandru Marchis, Véronique Poulsen, Elena Alonso Prados, Wolfgang Reinert, Martin Streloke

MAgPIE

MITIGATING THE RISKS OF PLANT PROTECTION PRODUCTS IN THE ENVIRONMENT

Proceedings of the MAgPIE workshop

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From the two-part SETAC Workshop Mitigating the Risk of Plant Production Products in the Environment

22–24 April 2013

Rome, Italy

13–15 November 2013

Madrid, Spain

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This edition first published 2017 by the Society of Environmental Toxicology and Chemistry.

SETAC Offices: 229 South Baylen St., 2nd Floor, Pensacola, Florida 32502

Av. De la Toison d'Or 67 b 6, B-1060 Brussels, Belgium

For details about the Society of Environmental Toxicology and Chemistry, please visit www.setac.org

ISBN: 978-1-880611-99-9

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SETAC recognizes and thanks the past coordinating editors of SETAC books:

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Preface

Anne Alix, Wolfgang Reinert, and Martin Streloke

"To protect aquatic organisms, respect an unsprayed buffer zone of 3 meters to surface water bodies"

This simple phrase usually appears on the labeling of a pesticide container, which provides a farmer with directions for use, explicitly how to spray his field with this specific product. Although the phrase uses simple wording and provides rather precise instructions, one would be surprised by the number of questions, and requests for clarification that such a phrase triggers in farmers for their agriculture advisers, in agriculture advisers for their regulatory authorities, and between regulatory authorities in different European countries. It sounds simple, yet what is a buffer zone? Is it inside or aside the limits of a field? Does it start with the last spraying nozzle, or at the edge of the spraying cone? Does it take into account the water body bank? Does the phrase also apply if I use spray drift reducing nozzles? Hence, the safety precaution phrases of the European Regulation 547/2011 from which the above phrase is extracted have been implemented in European countries alongside a number of adaptations for them to match with the farming practices, national legal frameworks and in some cases, the definition of what describes a water body on national maps! In the meantime and over the years, European countries have also worked at increasing the level of environmental safety of the pesticides used in agriculture, and developed new tools or risk mitigation measures to complement the set of measures listed in the European regulation. Yet the step towards the implementation of these new measures, by farmers and through pesticide labeling, faced three main hurdles:

- *Is the new measure supported by science?*
- *Is the measure practical enough to be easily implemented by farmers?*
- *Is the measure suitable for neighboring countries and therefore supports mutual recognition of authorizations?*

This book gathers the essence of the extensive discussions that took place over two workshops and 3 years of intensive work and data analysis by 95 experts and regulators from 24 European countries. The richness of the exchanges is reproduced in the main volume and in its equally long appendix that attempts to provide the reader with a comprehensive view on the state of risk reduction and risk mitigation in cultivated landscapes. Gathering 24 countries to reach a consensus on a genuinely diverse, often considered "case-specific," scientific topic that is influenced by local conditions, although challenging, proved to be an unbelievably enlightening journey across European landscapes. We recorded farming practices and their evolution and met the diversity of scientists, technicians, and regulators, all passionate about a common objective: translating science into applicable solutions to farmers for a safer use of pesticides for the environment.

With the publication of this book the first step towards an efficient harmonization of risk mitigation measures is done. The legal implementation of common risk mitigation measures in Europe needs some further efforts of the Member States to create a harmonized risk management system in Europe.

Acknowledgements

This publication was generously sponsored by the following organizations:

ECPA – The European Crop Protection Association
BASF
Bayer
Dow AgroSciences
Dr Knoell
Dupont
National Institute on Agronomy (INIA)
Makhteshim Chemical Works Ltd
Monsanto
The Office for Agriculture Switzerland
RifCon
Syngenta

We gratefully acknowledge the financial support for the workshops from the following organizations:

The European Commission
National Institute on Agronomy (INIA), Spain
OPERA Research
The University of Milan

About the Editors

Anne Alix

Anne Alix is a senior scientist in the area of environmental risk assessment and risk management. She earned a Ph.D. in Biology and Integrated Pest Management in vegetable crops in 2000 at the University of Rennes in France. She joined the French National Institute on Research in Agronomy (INRA) as an ecotoxicologist in 2001, and served as the head of the Environment and Ecotoxicology unit at the French Agency on the Safety of Food (AFSSA, now ANSES). At the French Ministry of Agriculture, Anne linked risk assessment to risk management as the deputy head of the Section for Regulation and Placing Plant Protection Products on the Market, where she lead the implementation of risk mitigation measures for pesticides and post registration monitoring. Anne joined Dow AgroSciences in 2011, as their European Regulatory Risk Management Leader. She has worked with a number of expert groups to develop risk assessment methodologies in diverse environments, some through workshops such as such as ELink, Focus Landscape and Mitigation, and ESCORT 3, and through SETAC groups, such as the MODELINK workshop and the Environmental Monitoring Interest Group on Pesticides.

Colin Brown

Colin Brown is Professor of Environmental Science within the Environment Department at the University of York. He has more than 25 years' experience of research into the fate and effects of pesticides in the environment. Colin has advised the UK government on the environmental fate and behavior of pesticides through membership of the Advisory Committee on Pesticides and chairing its Environmental Panel. He has chaired the DG-Sanco FOCUS working group on Landscape and Mitigation Factors in Ecological Risk Assessment for Pesticides and Chairs the conference on Pesticide Behavior in Soils, Water, and Air held every four years in York.

Ettore Capri

Ettore Capri earned his Ph.D. in Chemistry, Biochemistry and Ecology of Pesticides at Milan University in 1992. That same year he became a scientist in Environmental and Agricultural Chemistry at the Catholic University, and full Professor in Agricultural Chemistry in 2002. His research concerns the ecotoxicology, environmental chemistry, and consumer risk from pesticides, nutrients, heavy metals and trace elements. Ettore's current research is focused on how to integrate the chemical risk from the environment to the human and how to bridge the science to policy. In 2012, the Italian Ministry of the Environment assigned Ettore the responsibility of developing a program for the sustainable development of the wine production sector that included environmental labeling. Since 2009 he has been a member of the Ministry of Agriculture and Forestry on Integrated Food Production. He has also served as a member of the MIUR Commission on Food Education for Expo2015. Other prominent positions include member of the Global Food Ethic Project of The Johns Hopkins Berman Institute of Bioethics (since 2014), member of the Advisory Committee of the University of California Davis Institute for food and Agricultural Literacy (since 2014), formal member of the Panel on Pesticide Risk Assessment of the European Food Safety Authority (2005 – 2015). Ettore has served as Director of the Research Center on Sustainable Development OPERA since 2009, contributes to think tanks in Brussels, and while in Piacenza ideates research projects on education, training, dissemination, and communication. He has published about 230 scientific papers & communications and edited several books. He is an Associate Editor on the scientific journal Science of Total Environment published by Elsevier.

Gerhard Goerlitz

Gerhard Goerlitz studied Chemistry at the University Saarbrücken and went on to earn a Ph.D. at the Institute of Applied Physical Chemistry. Gerhard has worked from 1982 at Hoechst AG and its successor companies Agrevo and Aventis CropScience as an Analytical Chemist, Head of the Product Analysis Group, and Head of Analytics and Quality Management. In 2002 he became Head of Environmental Modeling at Bayer AG - Crop Science Division, located in Monheim, Germany. He started environmental modeling of plant protection products in the late 1980s and has since actively worked in this field. He has participated in several international projects including,

COST66, EUFRAM, and ELINK. Since its foundation in 1994, he has been a member of the FOCUS Steering Committee. Presently, he chairs the ECPA Environmental Exposure Assessment Team (EEAT). He was involved in the EFSA project on emissions from protected crops as a Hearing Expert and participated in several stakeholder workshops on the topic.

Burkhard Golla

Burkhard Golla is a senior research scientist at Julius Kühn-Institute (JKI), Federal Research Centre for Cultivated Plants, Germany. His research focuses on GIS-aided methods to evaluate the risks and benefits of pest and crop management strategies. He is particularly interested in spatially explicit exposure assessment of pesticides at landscape level.

Katja Knauer

Katja Knauer works for the Federal Office for Agriculture in Switzerland and is in charge of the scientific evaluation of dossiers for the authorization of plant protection products and environmental risk management. She is further responsible for the Swiss action plan for bee health and involved in the development of the Swiss action plan on the suitable use of plant protection products. Katja has participated in various SETAC workshops addressing topics such as quality standards for water and soil, ELINK- linking exposure to effects, and AMRAP- aquatic plants in the aquatic risk assessment. She has served as a member of the SETAC Europe Council and is still actively involved in the science committee. Katja received her Ph.D. in Environmental Sciences at ETH Zürich, Switzerland, and conducted a postdoc at the Massachusetts Institute of Technology in Boston and at the University of Geneva. She worked as an environmental risk assessor at Syngenta on the ecotoxicological effects of plant protection products in support of applications for Registration.

Volker Laabs

Volker Laabs currently works for the Crop Protection Division of BASF SE based in Limburgerhof, Germany. He is responsible for the Global Product Stewardship Team and serves his company as water expert. He is a member of the Water Expert Group at the European Crop Protection Association and chairman of the TOPPS Water Protection multi-stakeholder project. Volker received his degree in Geoecology and his Natural Science doctorate from Bayreuth University, Germany. His research interests concern the fate of crop protection products and pharmaceuticals in the environment, and the function of biochar in soil and its influence on soil fertility.

Neil Mackay

Neil Mackay is a senior research scientist in the environmental safety assessment group of DuPont Crop Protection. Neil is active in strategic product development and regulatory exposure and risk assessment activities. His specific interests include aquatic risk assessment and the use and promotion of practical and effective drift mitigation strategies.

Alexandru Marchis

Alexandru Marchis holds a Ph.D. in Agricultural Policies and has an academic background in agricultural economics with two post university degrees in Agribusiness and in Diplomatic International Relations. He has collaborated with Universita Cattolica del Sacro Cuore in Milan since 2010 and is in charge of the research outreach on agriculture and food issues. He has also been the Policy Team Coordinator of the OPERA Research Center agricultural think-tank and is a successful consultant for private entities in the area of food and agriculture policies. Since November 2014, Alexandru has been the coordinator of the UNCCD Soil Leadership Academy project. He previously held the position of Counselor for European Affairs in the Ministry of Agriculture in Romania. In 2005, he was appointed Agricultural Attaché and the Permanent Representation of Romania to the EU.

Elena Alonso Prados

Elena Alonso Prados works in the Plant Protection Unit of The National Institute for Agricultural and Food Research and Technology in Spain. (INIA). Between 2002 and 2010 she worked on the environmental fate and behavior assessments of active substances of plant protection products, participating as an expert in the European peer review process. Nowadays she is team leader responsible for the evaluation of the environmental fate and behavior and ecotoxicology sections of EU and zonal dossiers under regulation 1107/2009.

Véronique Poulsen

Véronique Poulsen has 20 years experience as an ecotoxicologist. She heads the Ecotoxicology and Environmental Fate Unit in the Regulated Products Assessment Department at ANSES (French Agency for Food, Environmental and Occupational Health Safety). She obtained her Ph.D. in conducted research on aquatic microcosms at INERIS (National Institute of Industrial Environment and Risks), France. Her team of 30 ecotoxicologists and environmental risk assessors is in charge of the risk assessment of pesticides prior to their authorization. She has helped organize many EU and international workshops related to pesticide risk assessment methodology, topics that include aquatic macrophytes, bees, endocrine disruptors, non-target terrestrial plants, and ecosystem services and their regulation.

Wolfgang Reinert

Wolfgang Reinert is a Biologist and was trained in Soil Biology. He worked in research and advisory service for plant pathology and plant breeding. In 2002, he joined the unit in charge of approving active substances and placing plant protection products on the market at the European Commission. Wolfgang has led the sector for pesticide market placing since 2014.

Martin Streloke

Martin Streloke is the head of the Department of Plant Protection Products at the Federal Office of Consumer Protection and Food Safety (BVL) in Germany. He completed his Ph.D. in zoology and entomology at Hanover University. Martin has 25 years of professional experience in the field of risk assessment and risk management in the context of authorization procedures for plant protection products in Germany. He participated in the preparation of EU-guidance documents and he chaired expert meetings for the approval of active substances in the EU-regulatory system. He was also taking part in different OECD Working Groups and was a member of the SETAC Europe Council.

Workshop Participants

Participants were assigned to one of the four working groups listed below based on their area of expertise in the different categories of identified risk mitigation. The working group discussion objectives are presented in the introduction of these proceedings, and the outcomes are summarized in the following chapters. The proceedings reflect the input shared by each participant during the workshops, however it does not imply that each participant endorses each and every risk mitigation tool listed, as reflected by the diversity of approaches used in Member States. The workshop participants propose developing state-of-the-art risk mitigation tools to be developed in Member States, and recommend further harmonization and implementation within EU countries.

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List of Abbreviations

AES	Agri-Environmental Scheme (of the CAP)
ALMASS	Animal, Landscape and Man Simulation System
BASIS	Independent standards setting and auditing ertilizern for the pesticide, ertilizer and allied industries
BM	Bee Management
BVL	Biologische Bundesanstalt fur Land- und Forstwirtschaft,ssortenamt unde Chemische Industrie
BZ	Buffer Zone
CA	Conservation Area
CAP	Common Agricultural Policy
CFE	Campaign for the Farmed Environment
CRD	Chemicals Reglation Directorate (Directorate of the Helath and Safety Executive responsible for ensuring the safe use of biocides, industrial chemicals, pesticides and detergents in the UK)
DAFM	Department of Agriculture, Food and Marine
DAR	Draft Assessment Report
DEFRA	Department for Environment, Food and Rural Affairs
DRR	Draft Registration Report
DRN	Drift Reducing Nozzles
DRT	Dust Reduction Technology
EC	European Commission or European Council

ECAF	European Conservation Agriculture Federation in Ireland
ECPA	European Crop protection Association
EFSA	European Food Safety Authority
EU	European Union
GAP	Good Agricultural Practices
GIS	Geographic Information System
IAD	Institut de l'Agriculture Durable
IBM	Individual Based Model
ICM	Integrated Crop Management
INSPIA	European Index for Sustainable Productive Agriculture
IPM	Integrated Pest Management
IVA	Industrieverband Agrar (German Agricultural Industry Association)
JKI	Julius Kuhn Institute
LEAF	Linking Environment and Farming
LERAP	Local Environment Risk Assessment for Pesticides (in the UK)
MASTEP	Metapopulation model for Assessing Spatial and Temporal Effects of Pesticides
MODELINK	Workshop on How to Use Ecological Effect Models to Link Ecotoxicological Tests to Protection Goals
MS	Member State
MSG	Metaldehyde Stewardship Group

NAP	National Action Plan
NFU	National Farmers Union in the UK
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
OP	Organo phosphate
PEC	Predicted Environmental Concentration
PPP	Plant Protection Product
RMM	Risk Mitigation Measure
RMS	Rapporteur Member State
RR	Registration Report
RRMTS	Risk Mitigation Measure Technical Sheet
RSPB	Royal Society for the protection of Birds
SANCO	Health And Consummer Protection Directorate-General, European Commission
SDRN	Spray Drift Reducing Nozzles
SDRT	Spray Drift Reduction Technology
SETAC	Society of Environmental Toxicology and Chemistry
SP-Phrases	Safety Precaution Phrases (of Regulation (EU) 547/2011)
SSSI	Site of Special Scientific Interest
SUD	Sustainable Use Directive (Directive (EC) 2009/128)
TOXSWA	TOXic substances in Surface WAters

VFSMOD	Vegetative Filter Strip Modeling System
WFD	Water Framework Directive (Directive (EC) 2000/60)

1 Executive summary

Environmental risk mitigation measures are a key component in defining the conditions of use of pesticides in crop protection in Europe (EC 2009a, 2011). These risk mitigation measures are derived directly from the evaluation of pesticide products and the risk assessment conducted for each use, and are specific of the type of risk they intend to mitigate. They therefore range from the adjustment of the conditions of use to minimizing transfers to groundwater to the setting of buffer zones at the edge of the crop. Once defined, these measures are reported on the labeling in the form of Safety Precaution Phrases (SP-phrase), according to Regulation (EU) No. 547/2011 (EC 2011) for implementation in European Member States (EC 2015).

In Europe, Member States have developed their own risk mitigation measures, which respond to the agricultural practices in the country, but are also incorporated into legal framework at the national level. Although locally effective, the genesis of a wide variety of approaches proved to raise issues regarding divergence of interpretation and, when access to risk mitigation tools differ between neighboring countries, a potential for concurrence distortion issues.

In this context, a two-part workshop was organized in April and November 2013, under the auspices of the Society of Environmental Toxicology and Chemistry (SETAC) and the European Commission. The goal of the workshop was to develop a toolbox of risk mitigation measures designed for the use on pesticides for agricultural purposes, and thus contribute to better harmonization of their development and use within Europe. Participants included risk assessors and risk managers from 24 European countries, plus experts from Norway and Switzerland, and representing participants from the business sector, academia, and agronomical advisors and extension services.

Workshop discussions started with an inventory of the environmental risk mitigation measures in use in European countries, compiled from a questionnaire survey circulated prior to the meetings. Risk mitigation tools in use for groundwater, surface water (including the protection of aquatic organisms), off-crop areas and in-crop areas were collected and each tool was described with regards to its level of implementation, technical description, regulatory status, inclusion in the good farming practices, economical considerations, options to measure its effectiveness, and finally, options to be taken into account into the regulatory risk assessment. This inventory is summarized in Table 1.1.

Table 1.1: Risk mitigation tools inventoried in European countries, Norway, and Switzerland as a result of the MAgPIE workshop, together with their benefits and related regulatory framework

Type of Mitigation Measure	Risk Mitigation Measure	Benefits	Regulatory Framework
Restrictions or modifications of products' conditions of application	Application rate, application frequency, application timing, and interval between applications	Lower transfers to groundwater and surface water Reduces exposure of organisms in-crop and off-crop	Regulation (EC) No. 1107/2009 and Regulation (EU) No. 547/2011
Application equipment with Spray Drift Reduction Technology (SDRT)	Spray drift reduction nozzles (SDRN), shields, precision treatment, etc.	Reduces exposure of organisms in-crop (precision treatment) and off-crop	Regulation (EC) No. 1107/2009, Directives 2009/1285 and 2009/1276
Buffer zones	Non-sprayed zone at the edge of a crop	Reduces exposure of organisms in-crop and off-crop	Regulation (EC) No. 1107/2009 and Regulation (EU) No. 547/2011, Directive 2000/607, Directive 92/438
Field margins	Vegetated buffer strip	Reduces exposure of organisms in-crop and off-crop, and provides habitat and food resource	Regulation (EC) No. 1107/2009 and Regulation (EU) No. 547/2011, Directive 2000/607, Directive 92/438
	Multifunctional field margin	Reduces exposure of organisms in-crop and off-crop, provides habitat and food resource, and mitigates effects on biodiversity	Regulation (EC) No. 1107/2009 and Regulation (EU) No. 547/2011, Directive 2000/607, Directive 92/438
Compensation areas	Recovery areas (ecological focus	Provides habitat and food resource, reduces exposure of organisms in-	Regulation (EC) No. 1107/2009 and

	areas)	crop, and pending on location in the farmland, may reduce exposure of organisms off-crop	Regulation (EU) No. 547/2011, Directive 2000/607, Directive 92/438, CAP
Dust drift reduction technologies	High quality coating, low dust drillers	Reduces exposure of organisms in-crop and off-crop	Regulation (EC) No. 1107/2009 and Regulation (EU) No. 547/2011
Bee management	Bee hive removal or protection, application periods, information to beekeepers	Managed bees	Regulation (EC) No. 1107/2009 and Regulation (EU) No. 547/2011

This inventory confirmed the diversity of the tools developed and implemented throughout European countries, as well as the number of regulatory frameworks to which they relate or with which they may overlap.

On the basis of this analysis, each tool was then allocated into one of the following categories:

1. Not to be promoted
2. Under development
3. Needs consolidation and research
4. Promising tool implemented in some Member States
5. Well established tool implemented in most Member States

The toolbox was then built to gather the risk mitigation options belonging primarily to the fourth and fifth categories, and the detailed technical data supporting each tool were gathered and discussed in order to provide the users of the toolbox with technical recommendations in view of future implementation. These data are contained in the Risk Mitigation Measure Technical Sheets (RMMTS) for the risk mitigation tools that are already implemented in most Member States, and in Technical Advice Sheets for the most promising tools for which an implementation could be initiated at a broader scale.

In each working group a thorough investigation of Safety Precaution Phrases relevant for protecting the environment of Regulation (EU) No. 547/2011 has shown that some of these phrases might be adjusted to help Member States in setting appropriate risk mitigation measures. Furthermore, it should be considered whether a European guidance document on setting risk mitigation measures should be prepared in order to describe a clear framework for Member States facilitating the use of European-wide, harmonized label phrases. Workshop participants proposed that the core assessment of a product's evaluation, the need for risk mitigation, and the level of risk mitigation need to be reported. Following group discussions, participants felt that in general, the exact level of risk reduction needed was not required, but rather a grouping of risk in classes would facilitate the regulatory work and communication with farmers. Classes of 50, 75, 90 and 95% risk reduction are well established, and in some cases 99% was considered possible if scientifically based. Then these risk classes may call for a single risk mitigation measure or a combination of different risk mitigation measures as illustrated for runoff or spray drift in the proceedings. The existing Safety Precaution Phrases were reviewed in this context, in order to account for the proposed risk mitigation tools. New and revised SPe (SP-phrase specific to the environment) or SPr (SP-phrase specific to mode of action) phrases were drafted to better reflect the diversity of the options offered to users to mitigate risks and improve the clarity of the directions provided.

The workshop also discussed options to optimize the implementation of risk mitigation measures, in particular with regards to possible overlaps among different regulatory texts (e.g., regulatory frameworks relative to plant protection products and the Water Framework Directive), and with regards to the options to further develop the multifunctional aspects of risk mitigation measures, as for field margins. Finally, transversal aspects relative to the protection of biodiversity were discussed.

It is important to note that all data and information made available up to March 2015 were included after it was decided with proceed to the preparation of these proceedings.

1.1 Risk mitigation measures to protect surface water

1.1.1 Runoff mitigation

Abundant scientific evidence has been published regarding the effectiveness of various runoff risk mitigation measures. Consequently, vegetated buffer strips that have been in use for aquatic regulatory risk assessments in several Member States for years and various other runoff risk mitigation measures are now available to be included in a European toolbox. On the basis of our analysis of available data the following basic runoff risk mitigation toolbox is identified, for which general effectiveness values are available:

Table 1.2: Basic toolbox list of runoff risk mitigation measures

Type of Mitigation Measure	Risk Mitigation Measure
In-field	Vegetated filter strip, across slope (5 m width)
	Inter-row vegetated filter strips in permanent crops
	In-field bunds for row crops (e.g., potatoes)
	No-till or reduced tillage
Edge-of-field and off-field	Vegetated filter strip (5 m, 10 m, and 20 m width)
	Artificial wetland or retention pond
	Vegetated ditches
	Edge-of-field bunds

For each of these tools, advice for alternative integration into product-specific modeling approaches were developed, and can be adapted to country-specific conditions, as needed. Many factors influence runoff, and the toolbox herein proposed accounts for the fact that the highest mitigation effectiveness and efficiency is achieved when farmers have the option to select the measure(s) most fitting to their field conditions and crop rotations.

A flexible toolbox approach is the most appropriate way to support European Member States' implementation of runoff mitigation tools. This flexible toolbox first considers the level of runoff risk mitigation needed, as calculated for a product and representative use, e.g., at zonal level. Then Member States are offered the option of implementing the risk mitigation measures of the toolbox at the management level, or after their inclusion into a risk assessment:

- At the risk management level: Based on the runoff mitigation need stated on the label (in %, or transposed into runoff mitigation points), farmers choose a single or multiple measures with defined average effectiveness from an official list to achieve the required effectiveness

- After inclusion into the risk assessment process: Based on the runoff mitigation need, modeling evaluates different measures and combinations thereof to achieve the required overall effectiveness (%). All eligible measures and combinations are then listed for this product on the label

Whatever the preferred approach is to a Member State, there remains a need to establish a list of accepted runoff mitigation measures at the national level, which also details good practices for establishment and maintenance for each measure in order to enable auditing in the field.

1.1.2 Spray drift mitigation

A number of options for spray drift mitigation exist, which include:

- Buffer zones at the edge of fields
- Vegetated buffer zones or strips
- Spray Drift Reducing Technologies (SDRT) including, Drift Reducing Nozzles (DRN), and other machinery equipment such as shield sprayers, tunnel sprayers, band sprayers, and precision sprayers

However, our inventory revealed an uneven implementation of these measures, due to differences in national policies, as well as in the the acceptance of techniques and measurement standards. Overall, this currently limits the opportunities to exploit the efficiency of a harmonized framework of risk mitigations.

These limitations however, may be overcome through a combination of flexible risk assessment options and labeling, allowing the implementation of local policies. A similar approach to the one developed for runoff could be considered. As for runoff, the first step would be to agree on the level of risk reduction that is needed for a specific risk. For example, if a specific risk triggers a 75% reduction exposure to be mitigated, the reduction may be provided by implementating a buffer zone, or with drift mitigation techniques adapted to local policies and standards, and providing the equivalent level of drift reduction.

The development of a basic harmonized basis for the acceptance of spray drift reduction technology (SDRT) efficacy thresholds (e.g., 50%, 75%, 90%, and 95% effectiveness) is then recommended. The extension to measures allowing a 99% drift reduction would stimulate and anticipate further technological advances and allow for options of compounded mitigation.

1.1.3 Drainage risk mitigation

Surface water can be contaminated by pesticides through drainage, which therefore triggers the need for dedicated risk mitigation measures. However, the processes dominating the transport of pesticides into the drainage system are closely related to those determining the leaching into groundwater. Consequently, the participants concluded that almost all the measures discussed for mitigating groundwater risk were also suitable for mitigating exposure via drainage water. These include restrictions on application rate or timing, soil type, band application, restriction of use in vulnerable areas.

As for groundwater, modeling approaches based on approved regulatory models and scenarios can be used to evaluate the effectiveness of a mitigation measure under specific circumstances. If the conditions leading to increased drainage differ from those that increase leaching to groundwater, a separate evaluation may ne needed in order to determine the effectiveness of a mitigation measure under specific circumstances.

Measures such as retention ponds and artificial wetlands were discussed, as well. They may constitute an effective measure at Member State-level where the volume of drainflow is limited, and they often involve large structure. Therefore, the evaluation of their effectiveness was considered premature, as they are not yet sufficiently documented.

1.2 Groundwater protection

The most popular measures in European countries (implemented in more than half of the European Member States) include application restrictions as a function of plant growth stages. Limitations may restrict the maximum number of applications per year or within a two- or three-year period and may be relative to the type of soil or to soil hydrological properties. These risk mitigation measures can be easily taken into account in the risk assessment. Their regulatory, technical, and agronomical feasibility is high and they can be easily enforced. The effectiveness of these measures with regard to groundwater protection can generally be quantified by the use of established regulatory tools, especially leaching modeling.

Measures such as restricting application to certain periods of the year or to a portion (bands) of the cropped area and restricting use in drinking water exclusion areas are also reported to be implemented in 30% to 50% of the Member States. These measures also present a high feasibility and agronomical practicability and they can easily be taken into account in the risk assessment using approved models and scenarios. Restrictions in drinking water abstraction areas are practiced in more than 30% of the Member States, but most often in the context of other legislation and dependant on the interpretation of the set of legislation at national level.

Exclusion of zones with certain hydrogeological properties, e.g., carstic areas, are in use in some Member States and rely on the definition of the corresponding zones in a country. It was suggested that these zones could also be identified and defined jointly with exclusion zones based on vulnerability maps and catchment management plans.

Finally, the use of cover crops during the winter period or inter-row crops as a risk mitigation option for groundwater raised particippants' interest, as the crops may provide additional benefits for soil conservation and for the reduction of nitrate leaching. However, we agreed that the effectiveness and practicability of these options need more investigation before their inclusion in our toolbox.

1.3 Protection of in-crop areas

We considered the groups of organisms common to agricultural areas, such as birds, mammals, bees, non-target arthropods, soil organisms (i.e., earthworms, soil macro- and micro- organisms), and, put in the context of a cropped area, biodiversity when discussing risk mitigation in-crop.

The most popular risk mitigation measures in Member States are those with quantifiable effectiveness: collectable incorporation rates (for sprayed or seed or soil treatments) and reduction in the application rate or of the number of applications.

With regards to birds and mammals, the measures already in use in Member States include the avoidance of spreads for granules and treated seeds and specific precautions to be taken for products presenting toxicological patterns of concern such as rodenticides, molluscicides, and baits. In addition, conditions of use relative to the breeding period, or regarding the rate or frequency of applications are also already in use, and covered by specific Safety Precaution Phrases.

With regards to honey bees, the inventory revealed a widespread implementation of the measures recommended in Regulation (EU) 547/2011 (EC 2011) for example, restrictions of use in flowering crops, management of hives, and specific measures relative to coated seeds. Recommendations regarding the removal of flowering weeds in perennial crops was discussed and further documented through a literature review. The review was unable to conclusively show the benefits of removing flowers in cultivated areas. The main concern was the food limitation stress imposed on pollinating species versus the exposure reduction it theoretically provides.

The measures that address non-target arthropods used by Member States include restriction or modifications of application rates or frequency of applications, to allow recovery in the treated area. Applications on a fraction of the crop have also been recommended, as well as the introduction of unsprayed headlands.

With regards to soil organisms (micro- and macro-organisms), the risk mitigation measures in use in Member States are limited to restrictions of the application rates or frequency, to allow the recovery of the affected taxa.

Additional options to reduce risks to in-crop populations are provided in the list proposed for the off-crop area, particularly in the category of field margins, which provide reservoirs and habitat to an ensemble of organisms in the farmland. Although the effectiveness of these measures at reducing risks is not yet characterized on a quantifiable way, it was agreed that the generation of monitoring data through field studies or monitoring programs could demonstrate their effectiveness through records of limited or non-significant effects of the product, even if the risk reduction cannot be strictly quantified. This is also valid for generic mitigation measures, i.e., those not related to a product, but implemented in the context of agri-environmental measures with an aim to maintain or improve the environmental status of an area, as for example in the context of the Commom Agricultural Policy. These measures include all types of landscape management and as such may provide generic risk mitigation on the area covered. Again, the effectiveness of those measurements can be observed in field studies or field monitoring programs and recommendations were made accordingly.

Finally, special attention was given to compensation measures and their potential to contribute to the reduction of the pressure of in-crop organisms from agricultural practices and pesticides. The survey performed in Member States does not report examples of an implementation of compensation measures in the context of pesticide management, however potential overlap between these farmland management measures and risk mitigation options for pesticides were discussed.

1.4 Protection of off-crop areas

The toolbox for the protection of the off-crop area gathers a diversity of options as summarized in the table below:

Table 1.3: Toolbox for risk mitigation for off-crop organisms

Type of Mitigation Measure	Risk Mitigation Measure	Category of Risks That May Be Reduced
Buffer Zone	No spray zone, wind-dependant no spray zone, bare soil, landscape-dependant buffer zones, aerial treatments	All organisms from exposure to spray drift
Field margin	Vegetated buffer zone	All organisms from exposure to spray drift or runoff Provides habitat and food resource
	Multifunctional field margin	All organisms from exposure to spray drift or runoff Provides habitat and food resource
Compensation areas	Recovery areas (ecological focus areas)	All organisms from exposure to spray drift or runoff (pending on location) Provide habitat and food resource
Spray drift reduction technologies	Nozzles (SDRN), equipped sprayers, directed spray, precision treatments	All organisms from exposure to spray drift
Dust drift reduction technologies	High quality coating, low dust drillers	All organisms from exposure to dust drift
Conditions of application	Application rate and frequency management	All organisms from exposure to drift or runoff

Bee management	Bee hive removal or protection, application periods, information to beekeepers	Bees

The most frequent risk mitigation options used in all Member States are the implementation of buffer zones and non-sprayed zones at the edge of treated crops, besides Spray Drift Reduction Technologies and specific restrictions (or modifications) on the conditions of use of pesticides, already described for groundwater, surface water, or in-crop protection.

Special attention was given to farmland features, such as field margins management, and to their potential as risk mitigation measures as observed in the monitoring studies that investigated their effectiveness in the context of the implementation of agri-environmental schemes. A variety of field margin types have been described, such as natural regeneration areas, grass margins, wildflower margins, pollen and nectar or bird seed mix field margins, annual cultivation areas, and conservation headland. The benefits of these measures are documented in monitoring studies based on abundance and diversity indexes of in-crop and off-crop populations and communities. From these studies, we explored the relative benefits for diverse aspects relative to the group of “organisms of concern” through an evaluation and ranking exercise. We agreed that this first analysis conducted in the context of the workshop was useful to obtain insight to which benefits each feature provides to specific groups of organisms, but that more research was needed to refine the knowledge and allow their inclusion in the risk assessment. The analysis highlighted the importance of developing the multi-functionality of field margins as a way to optimize their land use by the farmers who implement them as risk mitigation measures. It is critical to promote the implementation of these types of field margins in order for the benefits they provide on the groups of organisms and processes listed above to be seen rapidly. As we observed in the available studies, their benefits are more significant at a larger scale, and landscape approaches may be more effective than field-scale implementation. This is important when deciding upon the most appropriate policy level for implementation in individual countries.

Workshop participants agreed that consensual monitoring of the varied approaches is needed to quantify the effectiveness of the measures once implemented. This monitoring, coupled with GIS-based databases, is needed to appreciate the environmental status of a landscape, which helps refine the recommendations in the RMMTS relative to field margins and farmland landscape features to be implemented.

Finally, a discussion of these risk mitigation measures in the broader context of agri-environmental measures that are already implemented within the Common Agricultural Policy will be critical to avoid duplicated efforts by farmers while ensuring the development of optimized farmland management options.

1.5 Recommendations

The inventory undertaken by the different working groups identified the data sources that support the risk mitigation included in the toolbox. The data are collated in the appendices (Volume 2) of this work and identify the major sources of research and development in the area. Further work is indeed needed to 1) accompany the implementation of the risk mitigation measures in countries, 2) consolidate the data sets supporting some of the measures and their potential improvement, and 3) support the development of the risk mitigation identified as promising, but considered as not yet ready.

The needs in terms of actions and development are listed below. Participants shared the hopes that the proposed measures, as well as the measures to be further developed, will provide farmers and regulatory authorities with a fair and practical toolbox, which is important to their acceptance in both parties. These recommendations are more completely listed listed in Chapters 4 – 10.

1. Encourage the implementation of the toolbox in order to benefit of the risk mitigation these tools can already provide and collect further quantification of their effectiveness, as well as on the practicality of their implementation

2. Pursue the development of fair and effective environmental risk mitigation measures easy to implement in the decision making process, e.g., via the Safety Precaution Phrases, and by farmers

3. Develop the multi-functionality of field margins and adapt to Member States conditions in order to optimize the associated benefits

4. Develop a dialogue with the stakeholders involved in the implementation of the measures of the Common Agricultural Practice (CAP) so that the recommendations to farmers allow an optimized use of the land

5. Pursue the development of methods that allow the certification of the risk mitigation measures (e.g., for spray drift reducing technologies or seed mixtures), to facilitate the mutual recognition of the tools between countries and organizations, where relevant

6. Facilitate the integration risk mitigation measure into the risk assessment process where possible (i.e., when their effectiveness is quantified)

7. Pursue the development of technical guidance for ecological and environmental monitoring to better generate relevant data, which will measure the effectiveness of risk mitigation measures, and allow data sharing, extrapolations, and robust databases

8. Pursue the monitoring of pests, diseases, and weeds in farming systems where risk mitigation measures involving non-sprayed zones areas are implemented in order to avoid counterproductive recommendations

9. Pursue the generation of mapping systems such as GIS in support of environmental and ecological modeling tools

10. Pursue the development of ecological and environmental modeling toward tools able to evaluate the effectiveness of risk mitigation measures a priori

11. Develop communication tools, such as the proposed Risk Mitigation Measure Technical Sheets (RMMTS) and declensions in training and stewardship (such as leaflets, applications on mobile devices), to support the transfer of knowledge on the risk mitigation toolbox to farmers and end users

12. Develop networking on the scientific, technical, professional, and legislative and regulatory aspects of the toolbox, to further develop its accuracy and effectiveness

1.6 References

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[EC] European Commission. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Union. L206: 22.7.1992. p. 7.

[EC] European Commission. 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy. Official Journal of the European Union. L 327/1: 22.12.2000.

[EC] European Commission. 2009a. Regulation (EC) No. 1107/2009 of the European Parliament and of the council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. Official Journal of the European Union. L309: 24.11.2009. p. 1.

[EC] European Commission. 2009b. Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009, establishing a framework for community action to achieve the sustainable use of pesticides. Official Journal of the European Union. L 309: 24.11.2009. p. 71.

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2 Introduction

Modern agriculture has to deal with the challenge of producing food and fiber of increasing quality for a growing population while meeting improved human and environmental safety standards. Hence, agricultural practices, and among them plant protection products (or pesticides), must meet these standards, which are embedded in the regulatory framework conditioning market entry (EC 1991, 2009a). This regulatory framework requires that every use of each product is evaluated for the possible risks to humans, consumers, and the environment, according to a thorough assessment of the product's properties and dedicated exposure scenarios that reproduce its conditions for use. If necessary, as an outcome of the risk assessment, risk mitigation measures may be required on a use-basis, which aim at reducing exposure to levels that allow this particular use of a product to meet the regulatory safety standards.

Risk mitigation measures are therefore a key component in defining the conditions of use of pesticides in crop protection (EC 2009a, 2011). These measures are specific to the type of risk they intend to mitigate and for example, may consist of a recommendation for special protections for users while handling the product, or to adjust the conditions of use to minimize transfers to groundwater. Regulation (EU) No. 547/2011 provides a list of the typical phrases to be reported on the labeling to implement these risk mitigation measures. For example, the registration regulation for the active substance spinosad dated 2007 recommends that Member States, in their assessment to authorize plant protection products containing the substance, "*pay particular attention to the protection of aquatic organisms; conditions of use shall include risk mitigation measures, where appropriate.*"

Since the implementation of the regulatory framework for the placing of pesticides on the market, the improvement of the sensitivity of the tools and models used, as well as the definition of worst case exposure scenarios has sharpen the screening capacity of risk assessment processes. This has lead to a recommendation to refine risk assessments and define appropriate risk mitigation measures for an increasing proportion of products. Hence a compilation performed as a preparatory task to the workshop, over the transition period from Directive 91/414/EEC to the new Regulation (EC)No. 1107/2009, concludes that there is a need for risk mitigation for environmental purposes for ca. 95% of the active substances examined at the European level, as shown in Table 2.1:

Table 2.1: Recommendation for risk mitigation measures for the environment as an outcome of the European risk assessment of pesticides. Compilation based on 290 active substances approved, excluding micro-organisms.

Nature of the Risk to be Mitigated	% of Active Substances Concerned
Groundwater	37
Surface water	26
Air	2
Terrestrial vertebrates	29
Non-target arthropods	8
Soil organisms	8
Honey bees	8
Non-target plants	9

The implementation of risk mitigation measures resulted in multiple exchanges between regulatory authorities, where a number of initiatives have been undertaken in order to develop and implement risk mitigation measures and, where possible, take them into account in risk assessment procedures. With these exchanges, networks have been created to further develop risk mitigation tools, as for example in the area of drift reducing nozzles. However, harmonization of the risk mitigation measures implemented among countries is the primary issue, as the measures taken often relate to national policies in first place, as for example in France with the management of spray drift (JORF 2006). National policies also influence the implementation options for risk mitigation measures, which range from incentive measures, flexible for regulators and usually preferred by farmers, to legal enforcement, less flexible, but perceived as more persuasive and therefore efficient in some countries. Finally, experience shows that the interpretation of a recommendation in a regulatory text and on product labeling varies among farmers, as well as in the regulatory population, and more harmonization or clarity was deemed necessary in the wording associated with risk mitigation tools.

The two workshops described in the Executive Summary discussed the tools for the mitigation of environmental risks, i.e., wildlife, including vertebrates and invertebrates, flora and microorganisms, biodiversity, as well as surface and groundwater quality, as identified as protection goals in the European regulation on pesticides (EC 1991, 2009a). The process followed is summarized in Figure 2.1.

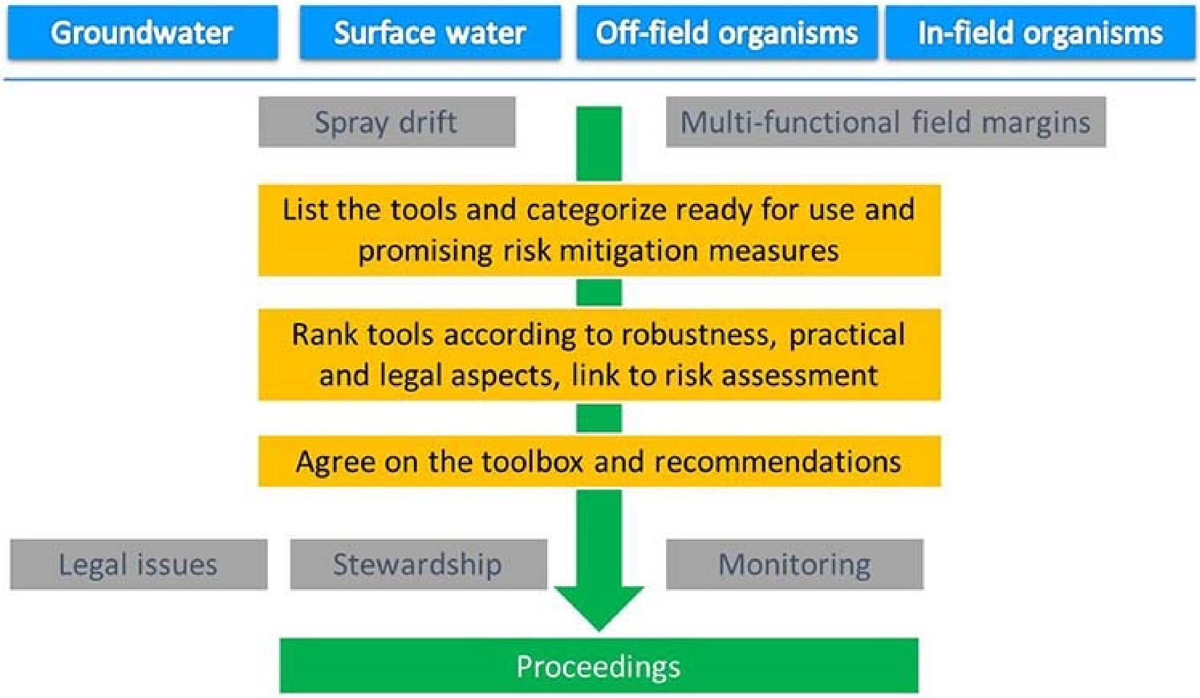

Figure 2.1: Approach followed during the MAgPIE workshops to develop the risk mitigation measure toolbox in the context of Regulation (EC) No. 1107/2009. Details are provided in the text below.

The work was initiated by generating an inventory of the environmental risk mitigation measures in use in European countries. The inventory was compiled from information elicited questionnaires and sent to the participants in preparation of the first workshop. The questionnaires aimed to collect feedback on the risk mitigation tools already implemented, their legal status (i.e., enforced via a dedicated legislative text, incentives, or as part of good practices), and where relevant, the piece of legislation involved (European, national, or both). Additional questionnaires were also sent during the intermediary period between the two workshops, on the basis of the first inventory, in order to gather further information on the risk mitigation approaches recorded. In total, 11 questionnaires were distributed. We also collected feedback from Member States on the success of implementation of the existing tools. Finally, the consultation covered risk mitigation options in development in each country, as well as the risk mitigation measures considered the most promising.

The inventory of risk mitigation measures was presented and discussed in detail during the first workshop. Discussions were organized around the protection of groundwater, surface water (including the protection of aquatic organisms), the off-crop areas, and the in-crop areas.

In addition, discussions on stewardship actions and on regulatory and legal aspects took place in ad-hoc groups and in interaction with the four subgroups.

For each environmental protection area, the tools were classified into categories based on their nature, i.e., related to products' application conditions, application equipment, or farming practices. The benefits they represented were listed and the corresponding legislation was reported. The tools were then discussed and ranked to reflect their importance as a risk mitigation tool currently or for the future. The ranking was performed using the following criteria:

- Implementation and advancement level: From well implemented tools in countries to tools for which insufficient knowledge or confidence are available
- Regulatory aspects: Regulatory status of the tool, from the straight implementation of established legislation to simple good farming practices; possible regulatory hurdles associated with a tool, as well as options to resolve them
- Economic aspects: Costs
- Ability to measure the efficacy of the tool
- Ability to relate to the risk assessment, i.e., to develop a risk assessment that accounts for the risk mitigation tool quantitatively or qualitatively

On the basis of this analysis, each tool was then allocated into one of the following categories:

1. Not to be promoted
2. Under development
3. Needs consolidation or research
4. Promising tool implemented in some Member States
5. Well established tool implemented in most Member States

The results of this classification, evaluation, and ranking process were used to build the toolbox for the different areas of environmental protection.

Detailed technical data on the risk mitigation measures entering the toolbox were gathered during the intervening period between the two workshops. Details on the implementation of risk mitigation measures were requested from Member States through the additional questionnaires. In addition, in order to reach a common understanding on the implementation of the measures, definitions of the terms used were prepared and circulated to participants for comments and adjustments.

Participants reconvened for a second workshop during which they drafted proposals in their respective environmental area and recommendations for the implementation of the measures considered ready for use and for future developments. The options available to measure the effectiveness of the risk mitigation measures were listed for each measure.

A final agreement on the toolbox content and the implementation recommendations were discussed in plenary. In addition, the group discussions aimed to identify measure overlaps and their potential for optimization. In this context, the options for further development of multifunctional field margins were explored, which were based on a dedicated literature review undertaken in the context of the workshop. Overlaps with other regulatory frameworks, including the sustainable use directive (EC 2009b), the water framework directive (EC 2000), the CAP (EC 2013), or the “Habitat Directive” (EC 1992) were discussed in order to derive proposals for optimization practical to farmers. Transversal aspects, such as aspects relative to the protection of biodiversity, were taken into account by preparing practical recommendations on the risk mitigation measures considered “ready to implement,” for which Risk Mitigation Measure Technical Sheets (RMMTS) were drafted. For the most promising tools slated for later implementation, the recommendations were inserted in Technical Advice Sheets. It is important to note that all data and information made available up to March 2015 were included in this analysis.

Finally, participants discussed and drafted the Safety Precaution Phrases as per in Regulation (EU) No. 547/2011, which would support the implementation of the risk mitigation measures listed in the toolbox for further consideration by the European Commission and Member States.

The following chapters summarize the outcome of the workshop and the background information for each of the four subgroups (chapters 4 to 7), as well as for the ad-hoc groups dedicated to legislative aspects (chapter 3), biodiversity (chapter 8), options to measure the effectiveness of risk mitigation measures (chapter 9), and stewardship activity (chapter 10). The proposals amended Safety Precaution Phrases as per Regulation (EU) No. 547/2011 are presented in chapter 3. General conclusions and recommendations are proposed in chapter 11. The RMMTS and Technical Advice Sheets are reported in appendix 1 and supportive information as well as the content of the questionnaires and responses are proposed in all appendices.

2.1 References

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3 Regulatory framework for setting risk mitigation measures under Regulation (EC) No. 1107/2009

Wolfgang Reinert and Martin Streloke

Anne Alix, Burkhard Golla, Gerhard Goerlitz, Volker Laabs, and Veronique Poulsen for the updated set of safety precaution phrases

3.1 Legislative aspects

3.1.1 Regulation (EC) No. 1107/2009 and the placing of plant protection products on the market

Plant protection products (PPP) are recognized as an important tool for producing high quality food in a sufficient amount and at an affordable price. Despite their benefits, their application may also lead to harmful effects on human or animal health or on the environment if the application does not follow the recommended risk mitigation measures (RMM) set out on the label of the applied product. These risk mitigation measures are an important part of Good Agricultural Practice (GAP).

Regulation (EC) No. 1107/2009 defines the legislative framework for the authorization and the placing on the market of PPP in the EU. It is based on the principle of a sequenced pre-marketing authorization: active substances, safeners, and synergists for the use in PPP must be approved at the EU level and placed on a positive list. The PPP themselves are authorized by Member States (MS).

Regulation (EC) No. 1107/2009 reflects the separation of risk assessment and risk management: Approval and authorization are legislative acts based on a scientific assessment of the potential risk from the use of a PPP. Risk assessors and risk managers represent widely separate entities.

According to Article 4(3) of the Regulation, a PPP shall only be authorized if, among other requirements, it is expected that, consequent to realistic conditions of use, there will be:

- No immediate or delayed harmful effects on human health or animal health or on groundwater
- No unacceptable effects on plants

- No unacceptable effect on the environment, under particular consideration of its fate and distribution as well as its impact on non-target species, biodiversity, and the ecosystem

The term “realistic conditions of use” entails two main elements: good practices (e.g., good agricultural practice, good plant protection practice) and risk mitigation measures.

For reasons of efficiency, risks assessment schemes follow a tiered approach. Products that show no risk under a simple set of generic and very conservative criteria are quickly sorted out as “acceptable” and do not have to undergo a detailed and more sophisticated higher-tier risk assessment. Where the lower-tier risk assessment predicts unacceptable risks, this does not necessarily lead to a non-authorization decision. The use of appropriate risk mitigation measures can result in a reduction in the theoretical risk identified following the application to the GAP towards an acceptable level. Clearly, risk mitigation measures may also be applied subsequently to a higher-tier risk assessment.

Risk mitigation measures are mainly risk management tools. However, as they are part of the risk assessment (in order to prove that a risk identified can be effectively mitigated), Regulation (EC) No. 1107/2009 requires that risk mitigation measures are identified in the draft assessment report (DAR) for a PPP made by the rapporteur Member State (RMS) and addressed in the conclusion on the peer review of an active substance by the European Food Safety Authority (EFSA) (Art. 12[2]), for further adaptation and implementation at national level.

As risk mitigation measures are necessary to assure that a PPP is being used according to the requirements of Article 4(3) (i.e., without harmful or unacceptable effects), they are also part of the authorization of a PPP (Article 31[2]). Risk mitigation measures are displayed on the label of the product (Article 65) and users are obliged to apply them (Article 55); Member States shall promote high levels of compliance and, where necessary, prosecute and sentence cases of non-obedience (Articles 72, 73).

Article 65 (1) and (3) of Regulation (EC) No. 1107/2009 refers to different types of phrases to be put on the label of a PPP in order to advise the user on any necessary risk mitigation measures:

- Safety provisions are laid down in Directive 1999/45/EC (transitional until 1 June 2015, afterwards phrases from Regulation (EC) No. 1272/2008 apply). These are common for all chemicals falling under the

REACH Regulation.

- Safety provisions laid down in Annex III to Regulation (EU) No. 547/2011. These provisions are specific for PPPs and are harmonized (SP-phrases, which are reproduced in Chapter 3.2).
- Any additional specific phrase considered necessary by a Member State to protect human or animal health or the environment. Any such additional phrase must be notified, together with an explanation, to the Commission and all other Member States, in order to consider them for an inclusion into Annex III to Regulation (EU) No. 547/2011.

The zonal system of mutual recognition can only work if risk mitigation measures are harmonized between Member States as far as possible. This does not necessarily mean that all Member States must exclusively use the same set of phrases, but the degree of risk reduction needed should be determined at zonal level and a common understanding of the effectiveness of single risk mitigation measures has to be developed. A classification of measures according to their effectiveness would ease their harmonized use. Article 36(3) explicitly recognizes the role of risk mitigation measures, which address specific needs in a certain Member State. The purpose of risk mitigation measures is mitigating the possible risk of PPPs so, that there is no harmful or unacceptable effect from the use of these products. They must be concrete enough to assure that the protection goal is achieved and flexible enough to allow users to apply the right measures in a practical use situation. Member States shall describe the degree of risk reduction expected when using a specific risk mitigation measure.

3.1.2 The Sustainable Use Directive (SUD)

Directive 2009/128/EC on the sustainable use of PPPs is a piece of legislation that is not dealing with the authorization and placing on the market of PPP, but covers the use phase of these products. It provides measures that are complementary to those foreseen in other areas of EU legislation.

The SUD strives to integrate a high level of protection with the principle of sustainable development (recitals 3, 22, 23). With these objectives, it goes beyond the concept of “no harmful or unacceptable effect,” which is the basis for granting authorization and its objectives are the reduction of the impact of PPP use and the promotion of alternatives to conventional phyto-protection practices.

Measures to be taken under this Directive are not related to single products, but follow rather a generic approach to reduce the overall risk and impact of PPP use. Requirements for application machinery, sales of products, or training and licensing of farmers are outlined in this document. Other items like aerial application or use of PPP in specifically protected areas (Water Framework Directive 2000/60/EEC and 2006/118/EC; Biodiversity in Directives 79/409/EEC and 92/43/EEC) are regulated, too. Rules for integrated pest management (IPM) are laid down. A national action plan (NAP) must be implemented by each Member State summarizing all measures to be taken for reducing risks, goals to be reached in a specific period are set, and results must be reported to the European Commission. Ideally, all stakeholders work together to focus their activities and efforts to reach specific goals outlined in the NAP. All these activities must be implemented by the national plant protection acts.

3.1.3 Contribution of industry and farmer organizations

Article 7 of the SUD requires Member States to raise the awareness of the general public about possible risks coming from the use of PPPs. However, as most of the PPPs are applied by professional users, farmers and authorization holders have an important role for the proper implementation of risk mitigation measures. Hence, authorization holders share the responsibility for a safe use of their products. Beside a correct labeling of products, generic awareness-raising campaigns for risks are a risk mitigation measure, and as such must comply or reflect the conditions of approval and use of products. For example, reducing exposure of surface water from point sources is one such important industry project (see references to TOPPS in Chapter 4 and examples of Stewardship actions in Chapter 10). Specific awareness-raising campaigns for company advisers and users of a specific compound are another tool. Companies can refrain from selling products in vulnerable areas (e.g., groundwater protection). Other examples include stewardship projects for specific PPPs. Model projects (farms) are run by a few companies where, for example, farming practices for improving the status of biodiversity or to reduce runoff are demonstrated.

In a few Member States farmer organizations play an important role in finding effective risk mitigation measures. They are most important in awareness-raising and increasing acceptance among practitioners. More support to farmers and farmer organizations would increase acceptance of risk mitigation measures among regulators and subsequently availability of products on the market. Appropriate risk mitigation measures are an important element to be considered in assessing whether there is a “significant difference in risk” between a candidate for substitution and an alternative product (Annex IV to Regulation [EC] No. 1107/2009).

3.1.4 Other regulatory frameworks

Ideally, the measures taken under different legislations and by authorization holders and farmers are harmonized as far as possible to reduce risks in the most efficient way. Furthermore, acceptance of risk mitigation measures by practitioners should benefit from harmonized approaches under different pieces of legislation. Measures to be taken under Directive 2000/60/EC (WFD) to control erosion can have a direct effect on reducing exposure of surface waters by active substances. The articulation of risk mitigation measures to protect non-target terrestrial life, and especially biodiversity, is more complex. Nature conservation and providing habitats in the agricultural landscape does not fall under regulation (EC) No. 1107/2009, but RMM under this regulation may have unintended consequences for nature conservation and habitat provision. As an example, buffer zones applied to hedgerows as a risk mitigation measure to protect insects may prevent laying out new hedgerow habitats, even if money from subsidy programs is available. The more habitats there are in a landscape the higher the resilience of communities and populations against any effects of PPPs. In areas where biodiversity is already low, the remaining species are usually not endangered by the use of PPP. However, indirect effects of using pesticides on biodiversity must be avoided. If the use of insecticides leads to an almost complete eradication of insects in an agricultural landscape because only cropped fields are left – in extreme cases only with one crop – no insectivorous birds can live in this area. The use of PPP should not preclude the recolonization of the aforementioned landscapes. Laying out of new habitats to increase the recovery potential and avoid indirect effects on biodiversity or other risk mitigation measures may be needed to avoid indirect effects at least of products posing highest risks. Balancing these issues against the need for efficient food production is a challenge. Joint actions under Regulation (EC) No. 1107/2009, Directive 2009/128/EC (NAPs) together with an intelligent use of subsidy programs are needed to strengthen the carrying capacities of agricultural landscapes.

3.2 Experience from setting risk mitigation measures in Member States

Over the last twenty years, Member States have used mitigation measures to reduce the risk to the environment for several purposes and in different ways. Specific rules for protecting areas of drinking water abstraction, or honey bees and birds, and stipulating buffer zones to surface waters are well established tools and have been widely used for regulatory purposes. Furthermore, new and more specific, tailor-made measures are in use today – for treated seeds or for new groups of organisms, such as terrestrial invertebrates, for example. In addition, risk mitigation measures are needed where new protection goals are being developed, for example in relation to biodiversity, as this has become important over the last few years.

Under Directive 91/414/EEC rules for Member States existed for setting risk mitigation measures. In part, legally binding label phrases were stipulated under national laws to facilitate enforcement of specific restrictions regarded as very important. The product label is the main communication vehicle by which the user is informed of the requirements for a safe and effective use of a product. The Safety Precautions Phrases (SP-phrases) are among the information that appears on the label, and aim at providing pesticide users with directions for use that effectively mitigate the exposure of and risks to human, animal health, and the environment. These SP-phrases are most often deduced from the conclusions of risk assessments. Details on these risk assessments may be found in guidance documents on the risk assessment, as for example in the EFSA Guidance Document for Birds and Mammals (EFSA 2009), in the SANCO document on terrestrial ecotoxicology (SANCO/10329/2002 rev 2), or guidance documents for non-target arthropods (Candolfi et al. 2002, Alix et al. 2012).

In Annex V of the aforementioned Directive, SP-phrases for protecting the environment were listed and afterwards reproduced in Regulation (EU) No. 547/2011. Table 3.1 reproduces the current SP-phrases with relevance for the protection of the environment, as they may be found in Regulation (EU) No. 547/2011:

Table 3.1: Safety precautions phrases with relevance to the environment as in Regulation (EU) No. 547/2011.

Safety Precaution Phrase	**Criteria for Use of EU 'Safety Precaution' Phrase**
SPe 1: To protect groundwater/soil organisms do not apply this or any other product containing (identify active substance or class of substances, as appropriate) more than (time period or frequency to be	The phrase shall be assigned when an evaluation according to the uniform principles shows that for one or more of the labelled uses such a mitigation measure is necessary.

specified).	
SPe 2: To protect groundwater/effects on aquatic organisms do not apply to (soil type or situation to be specified) soils.	The phrase may be assigned as a risk-mitigation measure to avoid any potential contamination of groundwater or surface water under vulnerable conditions (e.g. associated to soil type, topography, or for drained soils), if an evaluation according to the uniform principles shows for one or more of the labelled uses that risk-mitigation measures are necessary to avoid unacceptable effects.
SPe 3: To protect [aquatic organisms/non-target plants/non-target arthropods/insects] respect an unsprayed buffer zone of (distance to be specified) to [non-agricultural land / surface water bodies].	The phrase shall be assigned to protect non-target arthropods, if an evaluation according to the Uniform Principles shows that, for one or more of the labelled uses, that risk mitigation measures are necessary to avoid unacceptable effects.
SPe 4: To protect [aquatic organisms/non-target plants] do not apply on impermeable surfaces such as asphalt, concrete, cobblestones, railway tracks, and other situations with a high risk of runoff.	Depending on the use pattern of the plant-protection product, Member States may assign the phrase to mitigate the risk of runoff in order to protect aquatic organisms or non-target plants.
SPe 5: To protect birds/wild mammals the product must be entirely incorporated in the soil; ensure that the product is also fully incorporated at the end of rows.	The phrase shall be assigned to plant-protection products, such as granules or pellets, which must be incorporated to protect birds or wild mammals.
SPe 6: To protect birds/wild mammals remove spillages.	The phrase shall be assigned to plant-protection products, such as granules or pellets, to avoid uptake by birds or wild mammals. It is recommended for all solid formulations, which are used undiluted.
SPe 7: Do not apply during bird breeding period.	The phrase shall be assigned when an evaluation according to the uniform principles shows that for one or more of the labelled uses such a mitigation measure is necessary.
SPe 8:	

Dangerous to bees./To protect bees and other pollinating insects do not apply to crop plants when in flower./Do not use where bees are actively foraging./Remove or cover beehives during application and for (state time) after treatment./ Do not apply when flowering weeds are present./ Remove weeds before flowering./Do not apply before (state time).	The phrase shall be assigned to plant-protection products for which an evaluation according to the uniform principles shows for one or more of the labelled uses that risk-mitigation measures must be applied to protect bees or other pollinating insects. Depending on the use pattern of the plant-protection product, and other relevant national regulatory provisions, Member States may select the appropriate phrasing to mitigate the risk to bees and other pollinating insects and their brood.
SPr 1*: The baits must be securely deposited in a way so as to minimise the risk of consumption by other animals. Secure bait blocks so that they cannot be dragged away by rodents.	To ensure compliance of operators the phrase shall appear prominently on the label, so that misuse is excluded as far as possible.
SPr 2*: Treatment area must be marked during the treatment period. The danger from being poisoned (primary or secondary) by the anticoagulant and the antidote against it shall be mentioned.	The phrase shall appear prominently on the label, so that accidental poisoning is excluded as far as possible.
SPr 3*: Dead rodents must be removed from the treatment area each day during treatment. Do not place in refuse bins or on rubbish tips.	To avoid secondary poisoning of animals the phrase shall be assigned to all rodenticides containing anticoagulants as active substances.

*this phrase applies to rodenticide products.

In spite of this regulatory framework, overall the degree of harmonization among Member States is low and that may slow down the process of working through zonal applications under Regulation (EC) No. 1107/2009 considerably. Developing harmonized and standardized risk mitigation measures is an important prerequisite to ease zonal authorizations and mutual recognition of registrations allowing one Member State to employ the same risk mitigation measures used by another Member State. A common terminology about all aspects of risk mitigation measures is needed. If there is a need to use different SP-phrases, regulators should be able to judge on the equivalence of different (national) measures. Networks amongst regulators responsible for decision-making on risk mitigation measures should facilitate the process of coming to harmonized approaches.

3.3 A step towards harmonization across Europe

The analysis of the survey undertaken in Europe in the context of this workshop highlighted a need for a toolbox of risk mitigation measures offering Member States a certain degree of flexibility to adjust for their specific conditions on the one hand, while ensuring a common and consistent approach for the whole EU on the other. A common understanding about the effectiveness of single measures – the degree of risk mitigation expected – must be developed to enable harmonized decisions in zonal authorization procedures. The Commission, in close cooperation with Member States, may wish to keep an official list of risk mitigation measures available where the SP-phrase, together with the degree of effectiveness of the measure and effective alternatives, are outlined. If Member States need such alternatives to ease plant protection under their specific conditions they should propose the degree of risk reduction together with a scientific reasoning to the Commission and Member States. Such a list would facilitate the use of modern risk mitigation measures in all Member States while harmonizing plant protection practices at the same time.

Voluntary measures are preferred because acceptance for such restrictions among practitioners is much higher than legally binding requirements. All attempts should be made to increase acceptance. Therefore, it is important to involve representatives of farmer organizations when developing concepts of risk mitigation measures. Easy to understand text on the label, thorough explanations in training courses, and informational material are important tools when familiarizing farmers with risk mitigation measures. On the other hand, experience has shown that economic pressures reduce acceptance by farmers, especially for any measure leading to loss of soil or area for producing crops or complicating farming practices. Therefore, legally binding risk mitigation measures and a control system are needed to enforce the SP-phrases. Attention must be paid to the enforceability of a risk mitigation measure. The wording must be clear from a legal point of view because in a few situations control actions may end up in court cases.

High quality education and advice for (professional) users is crucial, as an effective implementation of risk mitigation measures is only possible if users are willing to comply. However, no enforcement strategy can go without controls of compliance, as otherwise it will lose its credibility over time. As it is very difficult to control farmers when spraying products it should be possible - for example - to take soil samples in the middle of a field and within the buffer zone. A clear difference of the two soil concentrations may indicate that the label restriction was followed. Other approaches to control the appropriate use of PPP should be developed. It is the responsibility of Member States to decide upon the choice of the most appropriate control methods and whether they are relevant for requirements under the cross compliance system (Regulation (EC) No 1122/2009). Member States must report the results of their controls to the Commission.

In the core assessment of registration reports (RR) it should be clearly stated whether there is a need for risk mitigation for fulfilling the requirements of regulation (EC) No. 1107/2009. Furthermore, the degree of risk mitigation needed should be defined. Participants felt that the exact level of risk reduction needed should not be given, but rather a grouping of risk in classes would facilitate the regulatory work and communication with farmers. Classes of 50, 75, 90 and 95% risk reduction are well established. Also 99% might be an acceptable class if it is scientifically based. Classes may call for a single risk mitigation measure or a combination of different risk mitigation measures; e.g. air-assisted boom sprayer in combination with 90% drift reducing nozzles and end-nozzle.

The reference point or scenario for defining the efficiency of a risk mitigation measure – the degree of risk reduction – should be the same as in the corresponding risk assessment scheme. If runoff PECs are calculated for a field with a length of 100 m the degree of risk reduction should not be determined for one with a length of 10 m. Participants felt that the ongoing use of different exposure models within risk assessments schemes complicates the setting of harmonized risk mitigation measures considerably. Scientific data and a robust scientific reasoning for determining the degree of risk reduction by a single measure is needed, but often complicated by a lack of data and other uncertainties. Furthermore, legal requirements, practicality, acceptance of measures by practitioners, and other non-scientific items are to be considered when setting risk mitigation measures. Therefore, in conclusion, pragmatic approaches need to be found, balancing all important requirements with each other while achieving the legally required safety level.

At least within one zone a common understanding among Member States must be developed regarding the maximum acceptable degree of risk reduction that can be achieved. Otherwise a product or use would be available in one Member State, but not in the other. If a Member State accepts a maximum buffer zone of 100 m to surface waters while another accepts only 20 m, and no other risk mitigation measures are available critical uses can be authorized in the first Member State, but not in the second. For example, in some Mediterranean areas even 500 m could, in principle, be acceptable as there are several crops and uses where no surface waters are around while applying the product.

For all relevant risks (e.g., surface or groundwater, birds and mammals, non-target arthropods, in- and off-crop), exposure routes, and other items, lists can be developed. Such lists might be structured according to the risk reduction class mentioned (e.g., 75%) and, for example, through exposure routes. Member States are free to use and apply the most relevant and suitable measures for their agriculture and conditions. For example, in one Member State spray drift reducing machinery of class 99% is available while in others even 90% is not.

Using class 75% and the exposure of surface waters via runoff as an example, one measure might be a grassed buffer zone of 10 m, and as an alternative, conservation tillage on the field with a soil cover of 70%. Both measures can be implemented for the same use and reduce the risk respectively. A system of risk reduction points was proposed to ease the use of a combination of risk mitigation measures relevant for the same type of risk and exposure route (for details see Chapter 4.1). For communication with farmers it might be best to use only these points. The label would contain only the information that use of this product in a specific crop requires the use of a "point/class/star two measure" which could for example correspond to a risk reduction class of 75%.

From a compliance and enforcement point of view, risk mitigation measures that are not use- or product-specific, but rather need to be established before sowing the crop and are effective for the whole season should be handled differently. A grassed buffer zone for reducing runoff must be established when, for example, cereals are sown. Such risk mitigation measures may be regarded as crop-specific.

3.4 Set of possible SP-phrases reflecting the toolbox developed during the MAgPIE workshop

There is no need to change the basic regulatory system of setting risk mitigation measures at the EU-level. However, the investigation of SP-phrases relevant for protecting the environment of regulation (EU) No. 547/2011 as illustrated above, has shown that some might be adjusted to give Member States more flexibility in setting appropriate risk mitigation measures. Furthermore, it should be considered whether an EU Guidance

Document on setting risk mitigation measures should be worked out in order to describe a clear framework for Member States facilitating the use of EU-wide harmonized label phrases.

It may be difficult to find the text for an SP-phrase describing the risk mitigation measures to reduce a specific risk in a way that can be used effectively in all Member States. Besides language and translational difficulties, agricultural practices are still different, for example the availability of spray drift reducing machinery varies across Member States. The sensitivity of the public towards effects on the environment is different and may lead to different risk management decisions. Therefore, the SP-phrases should allow Member States some flexibility. Specific parts may be even left open for specifications laid down in official national publications which must be notified to the Commission and other Member States.

During this workshop, participants reviewed existing SP-phrases in order to account for upcoming risk mitigation tools to protect the different compartments of the environment. This lead to the proposal of new and revised SPe- or SPr-phrases, so that they better reflect the diversity of the options offered to users to mitigate risks and improve the clarity of the directions provided.

The following table lists these new or revised phrases as deduced from the expert discussions. Where risk mitigation comprises various options, as for example for the reduction of runoff, it is recommended that risk managers communicate with risk assessors in order to implement the options that better reflect their risk management policy.

Workshop participants conducted an initial review of the phrases during the preparation of these proceedings. The wording proposed in these phrases is meant to reflect the diversity of options while reflecting a harmonized language. The proposed SP-phrases have also been reviewed by representative users and farmers and corrected where necessary for more clarity. They are summarized in Table 3.2 below.

Table 3.2: New and revised SPe- and SPr-phrases as deduced from the risk mitigation measures (RMM) toolbox presented in the MAgPIE proceedings. RMM are allocated into the following categories: Buffer Zones (BZ), aimed at reducing exposure of off-crop areas via spray drift; Field Margins (FM) and Compensation Areas (CA), aimed at providing food sources and habitat to off-crop flora and fauna; Spray Drift Reduction Technologies (SDRT), which involve any technology associated to sprayers, nozzles, or spraying techniques that will reduce the drift; Dust Reduction Technologies (DRT),

which involve any technology associated with seed coating, granule manufacture, or drillers to reduce the abrasion of seeds or granules at drilling or to reduce the spread of dust out of the cropped area; Good Agricultural Practices (GAP), which relate to product application (dose and application regime); Crop Management (CM), which relates to agricultural practice in the crop or the field margins aimed at reducing a source of exposure or transfer route; and Bee Management (BM), which relates specifically to measures applied to managed bees to keep them from exposure.

Environmental Area	**Risk Mitigation Measure**	**Category**	**Related SPe-Phrase in Regulation (EU) No. 547/2001**	**Proposed New SPe-Phrase in the Context of Regulation (EU) No. 547/2011**
Groundwater	Dose of product (reduction/limit) Application frequency (reduction), interval between applications Timing of applications (e.g., overnight; before/after flowering)	GAP	**SPe1**	**Existing phrase – no change:** To protect groundwater/soil organisms do not apply this or any other product containing (identify active substance or class of substances, as appropriate) more than (time period or frequency to be specified).
Groundwater	Soil type	GAP	**SPe2**	**Existing phrase – no change:** To protect groundwater/aquatic organisms do not apply to (soil type or situation to be specified) soils.
Groundwater/ drainage	Vulnerable areas	GAP	**None**	**New SPe-phrase:** To protect groundwater do not apply this or any other product containing (identify active substance or class of substances, as appropriate) in vulnerable areas (areas of drinking water abstraction or other vulnerable conditions).
Groundwater/ drainage	Crop management tools	GAP	**None**	**New SPe-phrase:** To protect groundwater the use of this or any other product containing (identify active substance or class of substances, as

				appropriate) is only allowed if specific management conditions e.g. use of cover crops, band application, others (to be specified) are fulfilled.
Surface water (spray drift) Off-crop	No spray zone Buffer zone of bare soil	BZ	**SPe3**	**Adapted from current SPe3:** SPe3: To protect [aquatic organisms/non-target plants/non-target arthropods/ insects] from spray drift respect an unsprayed buffer zone of (distance to be specified) to the edge of the field/surface water bodies]. The edge of the field is either the edge of the crop or, in the presence of a margin strip, the edge of a margin strip (see definition in Chapter 6).
Surface water (spray drift) Off-crop	Wind direction – dependant on spray zone	BZ	**SPe3**	**Additional text to be added to SPe3:** The buffer zone may be adjusted as a function of wind speed, wind direction, and temperature conditions based on available recommendations.
Surface water (spray drift) Off-crop	Drift reducing nozzles (incl. adjusted spray pressure, etc.) Special equipment/machinery (Wings-/Tunnel-/Band sprayer etc.) Directed spraying techniques (one-sided spraying, forward-speed, reflection shield, boom-height adjustment etc.)	SDRT	**SPe3**	**Additional text to be added to SPe3:** The buffer zone may be reduced to (distance to be specified) if a combination of spray drift reduction technologies such as drift reducing nozzles, special equipment to reduce spray drift or directed spraying technique [is/are] used providing at least (% of drift reduction to be specified).
Surface water (runoff) Off-crop	Vegetated buffer strip	FM	**none**	**In countries where a list of runoff risk mitigation measures provided together with an evaluation of their efficacy (into the form of an official guidance or white book), through e.g., a point-system has been developed, the following phrase could be used:** **New SPe X1:**

				SPe X1: To protect [aquatic organisms] only apply to fields [adjacent/within Y m to surface water] where approved mitigation measures(s) with [X% reduction of runoff potential/XY runoff mitigation points] are implemented. The official reference for approved mitigation measures is [detail official reference]. **In countries where recommendations regarding the mitigation of runoff have been derived from modeling or only product-specific mitigation options are intended, the following phrase could be used:** **New SPe X2:** To protect [aquatic organisms/surface water resources] only apply to fields [adjacent /within Y m to surface water] where the following [measure/measure combinations] were implemented: [detail list of appropriate measures or combinations thereof]. **Both phrases could be complemented with the following, to take into account the case of farmlands under a runoff risk diagnosis program, where it is available and accepted by regulatory authorities:** These product-specific runoff mitigation obligations may be superseded by implementing field-specific runoff mitigation measures on the field/farmland, based on the participation in an officially approved national runoff risk diagnosis and management scheme (detail names of officially accepted diagnosis systems). **To tackle the issue of concentrated runoff in agricultural landscapes, the following phrase is proposed:**

				New SPe Y: To protect [aquatic organisms/surface water resources] only apply to fields [within Y m to surface water] where concentrated runoff is prevented by appropriate measures (see [detail official reference or whitebook for concentrated flow mitigation measures]). **This sentence could make the prevention of concentrated runoff more binding in comparison with relying on good agricultural practice only. A control in the field would be done via the traces of concentrated runoff in-fields (erosion rills or gullies and deposited sediment at field edges).**
Surface water (spray drift, runoff) Off-crop In-crop	Multifunctional field margins (e.g., as qualification of a vegetated buffer) Note that in situations where runoff transfers only need mitigation then SPe2-phrases only would be needed	FM	**None**	**New SPe to introduce field margins to protect one or several groups of organisms and mitigate transfers via runoff (multi functional field margins):** To protect [birds/mammals/aquatic organisms/non-target arthropods/non-target plants] and limit risks related to situations of runoff, respect a unsprayed non-cropped vegetated buffer zone of (distance to be specified) to [the edge of the field /surface water bodies] which should consist of [wild bird seed mix/wild flower mix/pollen and nectar mix/sown grass] in order to provide the requested benefits.
Surface water (spray drift,) Off-crop In- crop	Landscape-dependant buffer zones	BZ/CA	**None**	**Additional text to be added to a SPe aiming at introducing field margins to protect wildlife:** An implementation of this buffer zone for the purpose of wildlife protection may not be needed if recovery area that provide a habitat are already present in the farmland and represent

				(percentage to be specified) of the farmland surface.
Surface water (spray drift, runoff, drainage) In-crop Off-crop	Dose of product (reduction/limit) Application frequency (reduction), interval between applications Timing of applications (e.g., overnight; before/after flowering)	GAP	**None**	**New SPe proposing adapted Good Agricultural Practices (GAP) to reduce exposure of wildlife or transfers via runoff:** To protect [birds/mammals/aquatic organisms/pollinators/non-target arthropods/non-target plants/limit risks related to situations of runoff] respect an application rate of maximum (application rate to be specified)/do not apply this product more than (time period or frequency to be specified)/ do not apply during the bird breeding period (dates may be proposed at MS level)/restrict applications to (dates or growth stages to be specified).
Birds/wild mammals	Incorporation of granules and pellets	GAP	**SPe5**	**Current SPe5 – no change:** To protect birds/wild mammals the product must be entirely incorporated in the soil at the end of rows.
Birds /wild mammals	Spillage removal	GAP	**SPe6**	**Current SPe6 – no change:** To protect birds/wild mammals remove spillage.
Birds /wild mammals	Restriction with regards to the timing of application	GAP	**SPe7**	**Current SPe7 – no change:** Do not apply during bird breeding period (dates may be proposed at MS level).
Birds/wild mammals	Caution with regards to application of repellents	GAP		**New SPe-phrase:** Add repellents to formulation in order to avoid ingestion by birds and mammals.
Birds/wild mammals	Caution with regards to the application of rodenticides	GAP	**SPr1**	**Current SPr1-phrase – no change:**The baits must be securely deposited in a way so as to minimise the risk of consumption by other animals. Secure bait blocks so that they cannot be

				dragged away by rodents. Apply baits in confined places in order to avoid non-target organisms' exposure.
Birds/wild mammals	Caution with regards to the application of rodenticides	GAP	**SPr2**	**Current SPr2-phrase – no change:**Treatment area must be marked during the treatment period. The danger from being poisoned (primary or secondary) by the anticoagulant and the antidote against it should be mentioned.
Birds/wild mammals	Caution with regards to the application of rodenticides	GAP	**SPr3**	**New SPr3-phrase:** Dead rodents must be removed from the treatment area each day during treatment. Do not place in refuse bins or on rubbish tips. Remove carcasses in order to avoid secondary poisoning of prey birds and carnivorous mammals.
Migratory birds	Caution with regards to application	GAP	**none**	**New SPe-phrase:** Do not apply the product on migrant birds resting grounds.
Honey bees Pollinators	Remove or cover bee hive Close hives 1 day before spraying Alert beekeepers	BM	**SPe8**	**Adapted from current SPe8:** Dangerous to bees./To protect bees and other pollinating insects do not apply to crop plants when in flower./Do not use where bees are actively foraging./Remove or cover beehives during application and for (state time) after treatment./ Do not apply when flowering weeds are present./ Do not apply before (state time)./ Respect a flowering strip of [width to be specified] at [distance to be specified] of the treated field. Alert beekeepers prior to applying the product to allow adequate mitigation measures to be taken, and avoid bee colonies' exposure.

3.5 From the toolbox to the implementation of a procedure in

Europe

A toolbox or list of risk mitigation measures must be published by the European Commission in close connection with Member States. National orders specifying the measures to be taken in each Member State must be communicated to the Commission and other Member States to facilitate information exchange and subsequent harmonization among Member States. According to Art. 31 (4.a) of Regulation (EC) No. 1107/2009, Member States are still responsible for setting risk mitigation measures.

To facilitate the implementation of the new type of SP-phrases, these may include a reference to legally binding order that is in force at the Member State-level, in which details of the risk mitigation measure can be stipulated in a way appropriate for each single Member State. As an example for spray drift the following phrase was worked out during the workshop:

SPe3 (new)

To protect [aquatic organisms/non-target plants/non-target arthropods/insects] from spray drift, respect an unsprayed buffer zone of (distance to be specified) to the edge of the [field/surface water bodies]. The edge of the field is either the edge of the crop or, in the presence of a margin strip, the edge of a margin strip.

This new SPe3 can be used for different types of risks, which are mentioned in brackets. Furthermore, the distance to surface waters or hedgerows, or a percentage of risk reduction can be stipulated as appropriate. This new type of SP-phrase would clearly lead to greater harmonization of labels than is currently achievable. At the same, time Member States would be able to meet their responsibilities in a flexible and efficient way.

Another example for runoff is given below:

SPe X1 (new):

To protect [aquatic organisms] only apply to fields [adjacent/within Y m to surface water] where approved mitigation measuress with [X% reduction of runoff potential/XY runoff mitigation points] are implemented. The official reference for approved mitigation measures is [detail official reference].

With this option harmonization is promoted through an agreement on the level of reduction that needs to be reached. Such a system would move the regulatory focus from the measure itself and primarily put it on the protection goal. It has the potential to achieve a high level of harmonization of risk mitigation between different Member States without forcing a break with current national risk mitigation approaches.

There are legal, technical, or historic reasons why things are defined slightly differently, but harmonization can be achieved in future. Geographical and climatic conditions will prevail and flexibility will be needed when all other items are fully harmonized. The new type of SP-phrases would allow to agree on common protection goals in different national contexts.

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4 Risk Mitigation Measures to protect surface waters

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4.1 Introduction

Surface water bodies (e.g., rivers, streams, lakes, ponds) need to be protected from unacceptable impacts of crop protection products. Pesticide pollution sources for surface water can be differentiated into point source and diffuse pollution. Point source pollution originates from farmyard operations and spillages or accidents in the field. Point source pollution is not considered during the regulatory risk assessment for pesticides, as it is not a consequence of a proper use of the products and can be avoided by the operator using appropriate management practices (Good Agricultural Practices). Diffuse pollution can originate from correct pesticide applications to fields. Three major potential pollution pathways exist: spray drift, surface runoff, and (subsurface or artificial) drainage. Another indirect diffuse pollution source for surface water may be recharge from groundwater; however, this pathway is in principle separately addressed via the risk assessment for the groundwater compartment (leaching). Wet or dry deposition of pesticides following volatilization from treated surfaces is a further route of entry to surface waters, but mitigation measures to reduce exposure via this route were not discussed at the MAgPIE workshop.

To protect aquatic organisms against unacceptable threats, the EU regulatory risk assessment process for surface water considers all three major diffuse pollution pathways in its FOCUS (FOrum for the Coordination of pesticide fate models and their Use) scenarios (FOCUS 2001). Six scenarios consider entry via artificial drains and spray drift, while the remaining four consider entry via surface runoff and spray drift. In principle, each of these pollution pathways may lead to unacceptable predicted environmental concentrations (PECs) in the receiving water body. Consequently, suitable and accepted mitigation measures for each of the three pollution pathways may be needed in EU Member States in order to achieve successful risk mitigation to protect surface waters.

4.2 Surface runoff

Surface water can be contaminated by pesticides dissolved in the water phase of runoff or carried on sediment particles eroded by runoff. Thus, it is necessary to assess the risks for the regulatory authorization of pesticide uses, and for farmers to manage the risks in their fields in practice.

Fundamentally, runoff is caused by precipitation (or irrigation water) not being able to infiltrate through the soil fast enough, resulting in two types of runoff (see Figure 4.1). The first is due to a low permeability at the soil surface (infiltration restriction), due to its natural properties (heavy soil texture, capping), or soil compaction. The second is due to water flow restrictions below the soil surface – because the subsoil is less permeable than the topsoil. This may occur due to natural reasons, such as heavier textured subsoil, or due to soil cultivation practices, e.g., plough pans and sub-surface compaction. However, runoff occurs in these cases only when topsoil in lower slope positions saturates completely with water (saturation excess) due to water movement accumulating there below the soil surface. Another reason for this type of runoff can be the existence of a very shallow groundwater table. In principle, both types of runoff may occur in the same field, though often one will dominate.

Generally, runoff can be subdivided into two groups: one that tends to move uniformly down the whole or part of a field as diffuse sheet runoff, or one that tends to concentrate into discrete flow channels, either due to localized flow restrictions or channelling at the soil surface (e.g., along tramlines, cropping rows) or due to converging water flow in the larger landscape, following so-called talwegs (or waterways) downslope. Any concentrated runoff and erosion channels in-fields effectively extend the river and stream network into agricultural fields and are potentially the greatest cause of adverse diffuse pollution of surface water by pesticides. Through implementing appropriate Best Management Practices (BMPs) concentrated flow phenomena can be strongly reduced or completely avoided in practice (save for the most extreme precipitation events), thus reducing their potential impact to generally acceptable levels. For example, compaction management of tramlines and orienting tramlines across the slope reduces runoff and erosion from them dramatically (e.g., Deasy et al. 2010). Also, planting grassed waterways in talwegs reduces levels of pesticide in surface water, also acknowledging that pesticides should not be used in these saturated runoff source areas. Concentrated flow is one of the main reasons for cases of low effectiveness of vegetated buffer strips under field conditions (Blanco-Caqui et al. 2006). It can be actively managed through good agricultural practices that also address a range of other environmental issues, primarily soil loss (and hence loss of agricultural productivity), sedimentation of water courses, and nutrient or pesticide transport to surface water.

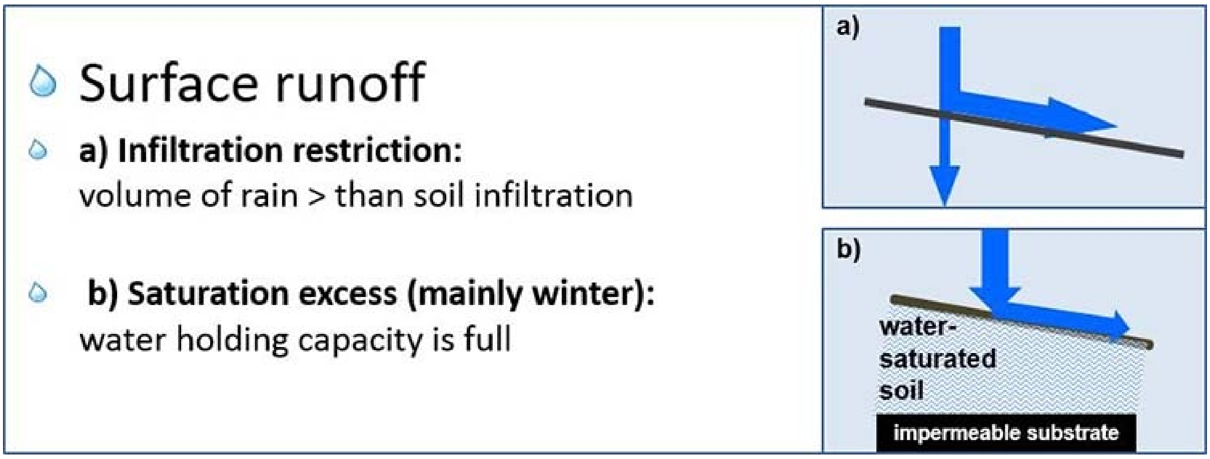

Figure 4.1: Runoff generation types (TOPPS-PROWADIS runoff diagnosis training, www.topps-life.org; modified)

To design a sound regulatory scheme to mitigate risks of runoff, it is important to have insight into how runoff and field erosion affect the amount of pesticide transfered to surface water and how successful buffers are at preventing this transfer. First of all, pesticide transfers from fields are known to increase exponentially as runoff and erosion levels increase. Yet, as the effectiveness of buffers for runoff mitigation is inversely related to the amount of runoff from fields, they generally get more efficient as runoff and erosion levels decrease. This means it is important to have an integrated approach to runoff and erosion management, which combines in-field measures reducing runoff at source (by maximizing water infiltration in agricultural fields), and vegetated edge-of-field strips, which buffer the remaining runoff from fields. In this way, in-field measures and edge-of-field buffering mitigation strategies act in a synergistic way to reduce runoff from agricultural fields. Consequently, farmers should focus on reducing field runoff (and erosion) at source, using a toolbox of known BMPs, and as a second step implement vegetated filter strips (and additional edge-of-field or off-field measures) to cope with the risk of any remaining runoff and erosion.

From a regulatory perspective, using representative field scenarios, it makes sense first to see how much pesticide transfer from field runoff and erosion needs to be mitigated (% of baseline runoff) to avoid unacceptable effects on aquatic organisms (Art. 4(3)e(ii) of Regulation (EC) No. 1107/2009) in edge-of-field surface water. Afterwards, it would be up to national regulators prescribing measures (or combinations thereof) from a toolbox of different in-field (e.g., no-till), edge-of-field (e.g., vegetated buffer strips), or off-field measures to achieve the targeted mitigation effectiveness. This could either be done via higher-tier modeling, or via a combinatory approach using default mitigation effectiveness values listed for the individual measures in official lists (i.e., national runoff mitigation toolboxes).

In summary, the regulatory perspective tends to work from the water body back to the field, while the farmers' perspective works from the field to the water body. A flexible runoff mitigation concept using a toolbox of acceptable in-field, edge-of-field, and off-field measures brings the two different perspectives together, meeting regulators' needs to ensure environmental protection and farmers' needs for practical ways to implement runoff mitigation measures in their fields while farming productively. Taking into account the variability of rainfall-soil-landscape scenarios and thus runoff generation conditions at catchment level, it is important to note that successful water protection depends on achieving the intended mitigation effectiveness on average across all treated fields in catchments, and less on achieving 100% of the mitigation effectiveness target for each individual field.

Another basic consideration is, if runoff mitigation is only to be implemented for fields directly bordering surface water, or if a certain distance (e.g., 100 m) between downslope field edge and next surface water body will be defined for application of surface runoff risk mitigation (or at least for concentrated runoff mitigation – see Chapter 4.2.4 on proposed new safety precaution phrases).

4.2.1 Surface runoff risk mitigation concept

The aim of the proposed mitigation concept is to achieve a specified runoff mitigation goal in the field and at the same time to allow farmers a certain degree of freedom to choose the appropriate mitigation measures that fit best to their cropping system and landscape conditions.

Good agricultural practice on fields is a prerequisite for effective runoff risk mitigation; the prevention of concentrated runoff from e.g., tramlines, rills, and gullies is a baseline activity and should be ensured by appropriate best management practices (such as tramline management schemes, grassed waterways, etc.) in any case as far as possible. Existing concentrated flow phenomena will also make many potential runoff mitigation measures less effective or ineffective (e.g., vegetated buffer strips, no-till), prejudicing the intended runoff mitigation effect of implemented measures. Tables A2.1 and

A2.2 in Appendix 2 list a number of basic mitigation measures to reduce or prevent concentrated flow in agricultural fields. In the multi-stakeholder EU water protection project TOPPS-PROWADIS (www.topps-life.org), there is also a concentrated flow diagnosis, helping the user to select the appropriate measures to mitigate concentrated flow (Runoff BMP booklet). A more binding option would be to prescribe an effective management of concentrated flow via a safety precaution phrase (see proposal in Chapter 4.2.4 – either for all applied products or only for the ones that require runoff mitigation). For regulatory purposes it is important that a control of measures is possible; this would mean the farmer keeping a plan available for inspection with details of mitigation measures for all fields, together with a scientific reasoning from a competent organization for the effectiveness of the measures. Alternatively, mitigation failure could also be observed in the fields (e.g., erosion rills or deposited sediment below field) and documented.

The base case for diffuse runoff risk mitigation in the EU is the use of FOCUS modeling for different EU runoff scenarios in order to calculate surface water exposure concentrations. If a toxicity-exposure ratio (TER) of a representative (or worst-case) scenario is too low, a higher-tier risk assessment needs to be undertaken to demonstrate a safe use. A similar approach is taken by EU Member States that have national modeling approaches established for surface water risk mitigation (based on their specific models, parameterization, and scenarios). By defining only a runoff mitigation target (% mitigation needed based on the model and scenario used) in a first step, zonal rapporteur Member States would leave it up to national registration authorities how to achieve this target. At national level, regulators could define their nationally-approved mitigation toolbox, specifying the applicable measures and, if modeling is not used, the assigned default mitigation effectiveness values for their country.

The proposed basic set of runoff risk mitigation measures (toolbox) is listed in Table 5.1 (all pesticides) and Table A2.3 (differentiated according to hydrophobicity of pesticides, thus considering a predominant solution- or particle-based transport of substances) in Appendix 2. It should be noted that such a list (also at national level) needs to reflect the current state of knowledge. Therefore, the lists should be reviewed and updated regularly to remain flexible and open for new mitigation measures and approaches.

The following process is proposed for a harmonized EU regulatory runoff mitigation concept:

Step 1: Identification of basic runoff risk mitigation need (in % of base case)

The risk assessment outcome (EU FOCUS or national) identifies the necessary runoff reduction effectiveness (e.g., a required reduction of the PEC from 10 µg/L to 1 µg/L equals a mitigation need of 90%), which needs to be achieved in practice by implementing appropriate risk mitigation measures.

Step 2: Define appropriate risk mitigation measures (with defined effectiveness) as toolbox

The toolbox is a list of in-field, edge-of-field, and off-field runoff mitigation measures, which are accepted at national level for reducing runoff risks. Depending on national set-up, either the risk mitigation measures are integrated into higher-tier modeling (i.e., measures are considered via modified model parameters, such as reduction in curve number) or a basic mitigation effectiveness value is assigned to each measure. In Table 4.1, a basic list of runoff mitigation measures and their effectiveness values and integration into modeling is proposed as an EU-wide toolbox.

A basic runoff risk mitigation measure which is already used in several EU Member States (e.g., BE, BG, CZ, DE, ES, FI, IT) and in Switzerland, is the establishment of (permanently) vegetated filter strips between the treated field and surface water bodies. Mostly, filter strips of different widths are accepted (e.g., 5, 6, 10, 20 m) in the regulatory risk assessment, and implementation is easy to control in the field.

Step 3: Provide methodology to calculate overall effectiveness for combinations of risk mitigation measures

As the farmer shall have the flexibility to choose from the toolbox of mitigation measures according to their needs and be able to combine different measures for increased effectiveness, rules must be officially established to dictate (i) which measures may be combined, and (ii) how the overall effectiveness for combinations of measures is calculated.

The use of a simple runoff mitigation effectiveness value per measure (based on evidence from the literature, e.g., choosing a median or x^{th} percentile value of reported results) has the advantage of being easy-to-use and light on regulatory workload; the drawback of this approach is the less accurate approach (ignoring the influence of local environmental conditions) and that a national acceptance for these more simplistic values needs to be ensured.

The effectiveness of vegetated filter strips of different widths, as well as that of several in-field mitigation measures (see Table 4.1), can be modeled e.g., using the PRZM-SWAN-VFSMOD models, meaning that a simulation of overall effectiveness of combinations of measures is also possible. The advantage of the integrated modeling approach is the complete scientific assessment of runoff conditions; the drawback is the higher modeling workload for all integrated measures and intended combinations thereof.

4.2.2 Toolbox of surface runoff risk mitigation measures

There is a multitude of potential and field-tested mitigation measures which can be sorted according to their nature; an overview is provided in Figure 4.2, which was developed by the TOPPS-PROWADIS project based on a multi-stakeholder process and literature review.

Runoff mitigation measures can be allocated to three different classes: (i) in-field mitigation measures, being implemented on the cropped field; (ii) edge-of-field mitigation measures, being implemented right at the downslope edge of the field; and (iii) off-field mitigation measures, being implemented downslope of the field, but not necessarily in direct contact with the field edge.

A survey of existing regulatory runoff mitigation measures (and related information) in EU Member States and associated countries was conducted in the framework of the MAgPIE workshop. The results are summarized in Table A2.4 in Appendix 2. Results of this survey demonstrate that some of these measures are already used for risk mitigation in one or more EU Member States: e.g., vegetated buffer strips (BE, BG, CZ, DE, ES, FI, IT; also CH), edge-of-field bunds (IT), water retention systems (DE), reduced tillage (BG, IT), band spraying (IT), and soil incorporation of product (IT).

Soil management	• Reduce tillage intensity • Manage tramlines • Prepare rough seedbed • Establish in-field bunds	• Manage surface soil compaction • Manage subsoil compaction • Do contour tilling or disking • Increase organic matter
Cropping practices	• Use Crop rotation • Do strip cropping • Enlarge headlands	• Use annual cover crops • Use perennial cover crops • Double sowing
Vegetative buffers	• Use in-field buffers • Establish talweg buffers • Use riparian buffers • Use edge-of-field buffers	• Manage field access areas • Establish hedges • Establish or maintain woodlands
Retention structures	• Use edge-of-field bunds • Establish vegetated ditches	• Establish artificial wetlands or ponds • Build fascines
Adapted use of pesticides and fertilizer	• Adapt application timing • Optimize seasonal timing	• Adapt product and rate selection
Optimized irrigation	• Adapt irrigation technique	• Optimize irrigation timing and rate

Figure 4.2: Overview of available runoff mitigation measures (source: TOPPS-PROWADIS, Runoff BMP booklet, www.topps-life.org)

In order to propose a toolbox of runoff mitigation measures, a number of basic mitigation measures were identified during the initial workshop in Rome and in the following break-out group working phase that are considered to be universally accepted as effective in science and by agricultural stakeholders (see Table 4.1). The table lists proposals for basic mitigation effectiveness per measure, based on MAgPIE literature evaluations and expert judgment. These mitigation effectiveness values are designed to express the reduction in pesticide concentrations in surface water in the field that can be expected to arise from deploying the respective mitigation measure. As they are intended for use on the ground in selecting field measures, they deliberately simplify the mitigation effect into a single value. As an example, vegetated filter strips act to reduce pesticide transfer to water via surface runoff by (i) facilitating infiltration of runoff water and dissolved pesticide as it passes across the strip; and (ii) trapping erosive sediment and any associated pesticide. The mitigation effect of a vegetated filter strip will be different for pesticides primarily in the aqueous or sediment phases. For dissolved-phase pesticide, the reduction in pesticide load reaching surface water will be greater than the reduction in pesticide concentration within the surface water because the volume of runoff entering surface water is decreased as well. These detailed processes associated with vegetated filter strips are simplified in Table 4.1 into a single effectiveness value intended to guide selection and uptake of mitigation measures in the field. Considering the different mitigation effectiveness of measures for predominantly solution- or particle-based transport of substances with runoff water, differentiated effectiveness values are supplied in Table A2.3 in Appendix 2 for hydrophilic (Koc <1000 L Kg^{-1}) and hydrophobic pesticides. The values selected are intended to be representative and relatively precautionary, but not absolutely worst-case. It is recognized that field evidence on mitigation effectiveness continues to grow and that values may need to be refined further in due course within the framework of detailed evaluations at Member State and EU level.

Given that the focus of the basic mitigation effectiveness values in Table 4.1 is field selection and uptake of mitigation measures, there is also a need to incorporate the effect of different measures into the risk assessment for pesticides. The final column of Table 4.1 provides recommendations for how to achieve this integration of mitigation measures into regulatory exposure modeling, as an alternative to using basic mitigation effectiveness values.

Further measures, which were discussed but were not considered ready for integration into the basic toolbox of a regulatory concept are listed in Table A2.1 in Appendix 2. At present, these measures do not have sufficiently robust evidence in the available literature, field data, or knowledge, but each may have a role to play in runoff mitigation where a plan can be developed by a competent authority or organization. A comprehensive overview on all discussed measures and also measures to reduce concentrated runoff, the reasoning for their effectiveness, and the literature references are provided in Table A2.2 in Appendix 2.

A specific measure that is reported in the literature, but has not been included in Table 4.1 is vegetated filter strips with width <5m. Although the literature reports such structures to have some effect in reducing pesticide transfer to surface water in runoff, Reichenberger et al. (2007) note in their review that there is systematic bias in the studies present in the literature. Several studies consider vertisols that are prone to cracking and thus macropore flow that may accentuate infiltration of water under dry antecedent moisture conditions. Other studies on narrow buffers used simulated rainfall or run-on, but without pre-irrigation of buffers; the antecedent moisture content is not actually reported in these studies and so the relative vulnerability of the situation studied is unknown. For these reasons, vegetated filter strips <5m in width are excluded from Table 4.1 and research is required to demonstrate the effectiveness of these structures under a wider range of conditions. It should be noted that narrow buffers are likely to be more acceptable to farmers than wider buffers when applied within the field, and that use of in-field buffers to intercept runoff close to the point at which it is generated is a particularly effective approach in many situations. Ultimately, it remains up to the individual Member States to define the minimum width of vegetated buffer strips that they still consider to be of reliable effectiveness for runoff mitigation under their national conditions.

Table 4.1: Proposed toolbox of basic runoff mitigation measures. The basic mitigation effectiveness provides a generic and representative measure of reduction in pesticide concentrations in surface water that aims to simplify and promote selection and uptake of mitigation measures in the field. The proposed modeling approach provides a recommended method to incorporate the respective mitigation measure into regulatory exposure modelingrisk assessment. More detailed information on references is provided in Table A2.2 in Appendix 2).

Runoff Mitigation Measure	Strength of Scientific Evidence*	Basic Mitigation Effectiveness[1]	Proposed Modeling Tools or Parameter Modifications
Edge-of-field measures			
5 m vegetated filter strip	+++	40%[2]	VFSMOD[14]
10 m vegetated filter strip	+++	65%[3]	VFSMOD
20 m vegetated filter strip	+++	80%[3]	VFSMOD
Edge-of-field bunds	+	40%[4]	Calculation of water retention, infiltration and environmental fate
In-field measures			
No-till / reduced tillage	++	50%[5, 6, 7, 8]	Curve number reduction: -3
In-field bunds (row crops)	+	50%[4]	Curve number reduction: -3[15]
5 m vegetated filter strips	++	50%[9]	Modeling approaches would need to be adapted
Inter-row vegetated strips (in permanent crops)	++	50%[2,4]	Proportionate consideration of curve numbers[16]
Off-field measures			
Artificial wetland and retention pond	+++	75%[10, 11]	Calculation of water retention, infiltration and environmental fate
Vegetated ditches	++	50%[12, 13]	Calculation of water retention, infiltration and environmental fate

* Symbols mean: +: few scientific publications existing; ++: many scientific publications existing; +++: abundant scientific publications existing; see also Table A2.2 in Appendix 2.

[1] Values give broad effectiveness (expressed in % of baseline concentration in surface water due to surface runoff) based on MAgPIE literature evaluations and expert judgement; values may need to be

refined further to reflect more detailed evaluations of efficacy at Member State and EU level; these values are used to derive mitigation points for each measure from respective mitigation point scale (see Table 4.2).

[2] CCPF-Ministero della Salute 2009

[3] Conservative mean of values for high- and low-sorbing pesticides from: (Reichenberger et al. 2007).

[4] Proposal of Swiss regulatory authority for runoff mitigation effectiveness: 50%; according to reference 2: 20%.

[5] UBA 2004

[6] Miao et al. 2004

[7] Deasy et al. 2010

[8] Maetens et al. 2012

[9] Reichenberger et al. 2007. See Fig. 1, and reflecting the fact that buffer strips closer to runoff source have higher efficiency than edge-of-field or riparian buffer strips.

[10] Stehle et al. 2011

[11] Maillard et al. 2012

[12] Gregoire et al. 2009.

[13] Moore et al. 2008.

[14] The regulatory status of VFSMOD in the EU regulatory process is currently uncertain. The model is recommended for use here given its general validation status in the scientific literature and because it is able to reflect changes in buffer efficacy based on e.g. changes in antecedent moisture conditions. Additional work is recommended outside of the MAgPIE process to reach a conclusion on the regulatory acceptability of the model in the EU. A particular issue is evaluation of coupling of the basic VFSMOD code with the regression equation for pesticide transfer across vegetated filter strips reported by Sabbagh et al. (2009).

[15] Bunds are equivalent to terraces: Using the TR-55 curve number (CN) guideline, up to 4 lower CN are recommended; Use a fraction, if the bund only catches part of the runoff (bypassed)

[16] Proportionate calculation means: curve number CN= (% permanent crop area * CN(permanent crop)) + (% vegetated strip * CN(vegetated strip))

In order to achieve an adequate mitigation effectiveness of measures, appropriate environmental conditions and technical aspects of their implementation need to be defined in detail (at national level), as well as – if needed – appropriate activities for maintenance of measures. The technical advice sheets for risk mitigation measures in Appendix 1 provide a first basis for such specifications at an integrated European level.

The basic runoff mitigation effectiveness values provided in Table 4.1 are proposals for average effectiveness (e.g., usually 25th to <50th percentile), derived from available literature data and completed based on expert judgement. The reason for not using a “worst case” approach (e.g., 10th percentile) for measure effectiveness is (i) that an appropriate definition of acceptable implementation conditions (e.g., prohibiting establishment of vegetated filter strips in shallow groundwater areas) and maintenance prevents many cases of low effectiveness (as reported in the literature), and (ii) that the mitigation measures need to achieve their assumed effectiveness on average in an agricultural landscape, thereby making a certain amount of cases with lower effectiveness acceptable. The effectiveness of some measures depends on the sorptive properties of active substances (i.e., high or low Koc), which is reflected in differentiated effectiveness values provided as an alternative in Table A2.3 in Appendix 2.

Obviously, EU Member States should be free to include or discard measures in their national toolbox and to assign different effectiveness values to each measure (reflecting the degree of conservativeness for each measure). This does not prejudice the goal of a harmonized (zonal) runoff mitigation concept, as long as a certain minimum degree of overall runoff mitigation (e.g., 90%) is still possible in each EU Member State.

Control of the appropriate implementation of regulatory risk mitigation measures must be possible in the field. For some (perennial) risk mitigation measures this is straightforward (e.g. via field inspection), while for others an adequate mechanism for documentation (e.g., field-specific records, including photographs) by the farmer, as well as auditable criteria for "good implementation practice" need to be defined and published.

4.2.3 Calculating overall mitigation effectiveness for combinations of measures

All risk mitigation measures that can be integrated into regulatory modeling can also be simulated in combinations, providing a direct mitigation effectiveness output for combinations of measures.

For measures that have been assigned a basic mitigation effectiveness value (e.g., 50% runoff reduction), a methodology must be established to calculate the overall mitigation effectiveness for two or more measures applied to one field. In principle, two standard methods can be used to calculate the overall mitigation effectiveness of combinations of risk mitigation measures: a multiplicative or an additive approach. As a compromise between the relatively less conservative (additive, or linear) and the most conservative (multiplicative, or logarithmic) approach, a hybrid approach may be adopted, providing intermediate protectiveness (see Table 4.2 and Figure 5.3).

In order to provide a simple user interface for farmers and advisors, risk mitigation effectiveness for each measure could be translated into mitigation effectiveness points (e.g., 50% risk reduction equals 30 points, 90% risk reduction equals 100 points, for the multiplicative approach). The farmer just needs to know the number of mitigation points that is required for a product use and can then choose a combination of measures from an official list of measures (whitebook) that adds up to equal or more than the defined points requirement. The whitebook is to be established at national level and lists the acceptable runoff mitigation measures and the mitigation points per measure. As the point scale used reflects the combinatory approach (multiplicative, hybrid, additive), the farmer can always simply sum up the points without having to deal with complicated calculations. In principle, this points system could be applied to all surface water exposure pathways, i.e., also drainage and spray drift.

Table 4.2: Overview on potential combinatory point system scales for calculation of mitigation points.

Mitigation Effectiveness (%)	**Calculated Mitigation Points**		
	Logarithmic scale: Multiplicative effects (most conservative)	Double-exponential scale: Hybrid effects (medium conservative)	Linear scale: Additive effects (less conservative)
40	22	21	20
45	26	25	25
50	30	30	30
55	35	34	35
60	40	39	40
65	46	44	45
70	52	50	50
75	60	56	55
80	70	64	60
85	82	73	65
90	100	86	70

95	130	106	75
99	200	130	79

As can be seen in Table 4.2 and Figure 4.3, there are no large differences in the scale system below a mitigation requirement of 70%; the conservativeness of the different methods shows only for higher mitigation needs. Yet, all of these approaches ignore the potential for synergistic effects of mitigation measures, reflecting their basic conservativeness: in reality, for example, the reduction of runoff water by 50% using no-till would further increase the runoff reduction effectiveness for vegetated filter strips, as they show higher effectiveness for lower runoff water volumes.

EU Member States might want to define an upper limit for possible mitigation to be achieved (e.g., 99%, as in Table 4.2), thereby creating a practical cut-off for products with high mitigation needs. Similarly, Member States may (i) limit the maximum width of vegetated filter strips that they are willing to accept in their regulatory risk mitigation systems or (ii) define a minimum width of vegetated filter strip (e.g., 5 m) that always needs to be established as a basic measure if runoff mitigation is needed.

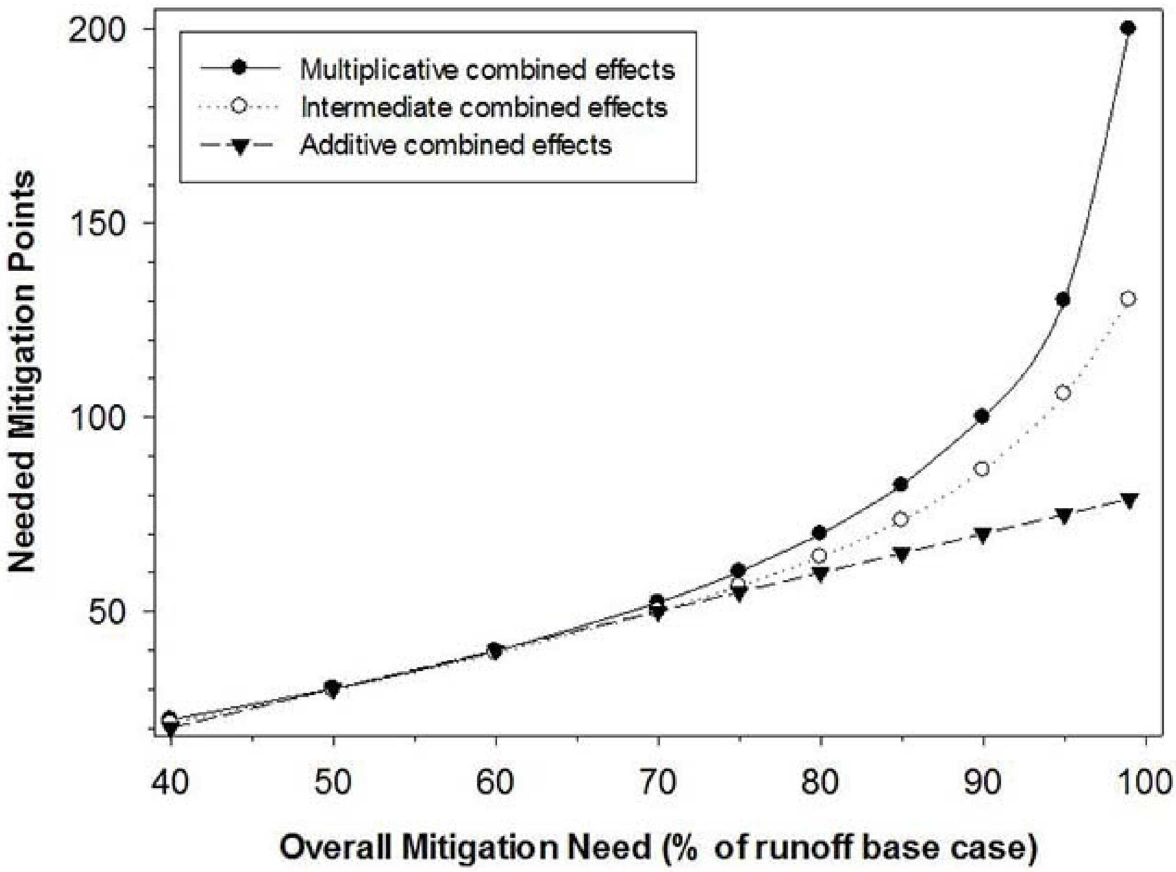

Figure 4.3: Visualization of mitigation points assigned to the overall mitigation need.

Mitigation case example using field evidence-based effectiveness values for measures:

Step 1: Determination of basic runoff mitigation need

Product A needs a reduction of the runoff-induced exposure by 90%. This would translate to
- 100 mitigation points (Table 4.2, logarithmic scale)
- 86 mitigation points (Table 4.2, double-exponential scale)
- 70 mitigation points (Table 4.2, linear scale)

Step 2: Toolbox of measures

The amount of mitigation points per measure is determined in this example by taking the individual mitigation effectiveness value (%) listed in Table 4.1 and reading across the corresponding mitigation points in the different point scale systems (in practice, an official list of measures would only provide the mitigation points per measure). For example, a 10-m vegetated buffer strip is listed with an effectiveness of 65% (Table 4.1), which corresponds to 46 mitigation points in the logarithmic scale, 44 in the hybrid scale, and 45 in the additive scale in Table 4.2.

The farmer checks the available mitigation measures in the official table (e.g., the ones from Table 4.1), which would also list the mitigation points per measure, and can now choose different measures or combinations thereof. Presumably, the farmer will choose the measure(s) that are implemented with the least influence on their cropping system or the least investment regarding time and money (or land) for establishment and maintenance.

Step 3: Assessment of combinatory effects

The farmer adds up the points for the chosen measures and checks if this achieves the necessary amount of mitigation points needed for the application of the product. For this example, the following combinations of measures would qualify:

Logarithmic (multiplicative) scale (100 points needed): e.g.,
→ 20 m vegetated filter strip (70 points) & no-till (30 points): 100 pts
→ 10 m vegetated filter strip (46 points) & no-till (30 points) & vegetated ditch (30 points): 106 pts
→ 5 m vegetated filter strip (22 points) & no-till (30 points) & retention pond (60 points): 112 pts

Double-exponential (hybrid) scale (86 points needed), e.g.,
→ 20 m vegetated filter strip (64 points) & no-till (30 points): 94 pts
→ 5 m in-field vegetated filter strip (30 points) & no-till (30 points) & vegetated ditch (30 points): 90 pts
→ no-till (30 points) & retention pond (56 points): 86 pts

Linear (additive) scale (70 points needed), e.g.,
→ 10 m vegetated filter strip (45 points) & no till (30 points): 75 pts
→ 5 m vegetated filter strip (20 points) & retention pond (55 points): 75 pts
→ 5 m vegetated filter strip (20 points) & no-till (30 points) & vegetated ditch (30 points): 80 pts

Mitigation case example using higher-tier modeling to assess overall mitigation effectiveness

The modeling is done using the appropriate substance parameters, as well as the chosen runoff scenario parameters, based on the (national) risk assessment scheme. An indicative example of the approach that could be taken is provided below. The active substance has the following use conditions and properties:

Use conditions: on maize, applied to soil at 1.0 kg a.s./ha; target date: between 1 April and 1 May.
Physico-chemical propertiesof active ingredient:
- molecular weight 300 g/mol
- water solubility 100 mg/L
- vapour pressure 1 x 10^{-7} Pa
- soil sorption: Koc 100 L/kg, nf 0.9
- soil degradation half-life (at 20°C): 30 d
- water-sediment degradation half-life: 30 d
- degradation half-life on plant surfaces: 10 d

Regulatory acceptable concentration(RAC) in surface water: 7 µg/L

Step 1: Calculation of the basic runoff risk for surface water

Standard FOCUS step 3 modeling is done based on the data above. The risk assessment fails at this step, as the PECmax is determined at 41.4 µg/L in the R4 stream scenario (Table 4.3); for comparison purposes, in order to achieve the RAC this would translate into an 83% mitigation requirement.

Step 2: Integration of toolbox measures into higher tier modeling

Step 4 modeling is carried out using SWAN to include VFSMOD simulations of the effect of a vegetated filter strip (VFS). This demonstrates that e.g., a 20-

m VFS provides the necessary mitigation in all four FOCUS scenarios (PECmax of 5.15 µg/L in the R3 stream scenario), complying with the regulatory acceptable concentration (Table 4.3).

The effect of a minimum tillage mitigation is simulated by re-running standard FOCUS modeling, but with all runoff curve numbers reduced by 3. However, the use of minimum tillage alone does not meet the regulatory acceptable concentration (PECmax of 39.1 µg/L in the R4 stream scenario).

Step 3: Assessing the overall effectiveness for different combinations of mitigation measures

The final modeling step investigates potential combination of runoff risk mitigation measures, for example to allow a reduction in width of the VFS. For instance, a combination of minimum tillage with a 10-m VFS provides the necessary mitigation in all four FOCUS scenarios (PECmax of 6.28 µg/L in the R3 stream scenario).

The modeled regulatory surface water concentrations are summarised for all scenarios and mitigation options in Table 4.3.

Table 4.3: Modeled surface water concentrations using different modeling tiers for mitigation case example

Modeling Step	**FOCUS Scenario**				
	R1 pond	R1 stream	R2 stream	R3 stream	R4 stream
FOCUS Step 3	0.33	16.7	15.3	31.2	**41.4 failed**
Step 4: 20-m VFS	0.09	0.42	0.56	**5.15 ok**	0.42
Step 4: minimum tillage*	0.21	3.62	12.1	17.2	**39.1 failed**
Step 4: min-till + 10-m VFS	0.14	0.81	1.07	**6.28 ok**	0.08

*Note: effectiveness of the VFS is mainly determined by the volume of runoff water leaving the field. Although minimum-tillage has a relatively small effect on the concentration of the pesticide in runoff, it reduces the volume of runoff to a greater extent. Thus a smaller VFS is required to achieve the same net mitigation.

If a modeling approach is used, the product label would need to specify which measures or combinations of measures are required for an acceptable application of this product to a field.

In principle, modeling and field-evidence approaches can also be combined, e.g., by deriving single or overall mitigation effectiveness values from modeled measures or combinations thereof (% mitigation achieved) and then continuing the process as described for the field-evidence based approach for combinations with measures for which no integration into models was achieved.

4.2.4 Resulting label language

The current Safety Precaution phrases according to Regulation (EU) No. 547/2011 (see Chapter 3) do not yet allow to translate a flexible runoff mitigation concept into legal label language. Therefore, the following new SP-phrases are proposed, which are compatible with a flexible toolbox approach to mitigate diffuse runoff:

SPe X1: To protect [aquatic organisms] only apply to fields [adjacent/within Y m to surface water] where approved mitigation measures(s) with [X% reduction of runoff potential/XY runoff mitigation points] are implemented. The official reference for approved mitigation measures is [detail official reference].

The official document, detailing the list of accepted mitigation measures and advice for their implementation and maintenance, needs to be established at national level.

Alternatively, for modeling approaches with specified (combinations of) measures:

SPe X2: To protect [aquatic organisms] only apply to fields [adjacent / within Y m to surface water] where the following [measure / measure combinations] to mitigate runoff are implemented: [detail the list of appropriate measures or combinations thereof].

In practice, farmers will need to determine for each field the maximum runoff mitigation effectiveness needed for the complete group of pesticides (planned to be) used on that field with a given crop rotation. That said, many runoff mitigation measures are perennial (e.g., vegetated filter strips) and cannot or should not be established or dismantled each year.

The selection of mitigation measures by farmers and their implementation would need to be documented for each field, so that an effective control is possible. The official list of accepted mitigation measures will need to detail the correct establishment and maintenance procedures for each measure, together with auditable criteria for adequate measure implementation.

In addition, the new SP-phrases may be complemented by the following sentence for certain products or mitigation effectiveness levels:

These product-specific runoff mitigation obligations may be superseded by implementing field-specific runoff mitigation measures on the field orfarmland, based on the participation in an officially approved national runoff risk diagnosis and management scheme ([detail names of officially accepted diagnosis systems]).

This phrase would enable farmers to switch from product-specific runoff mitigation measures to (officially approved) field-specific runoff risk mitigation (e.g., Aquavallee® diagnosis by Arvalis Institut de Végétal in France, TOPPS-PROWADIS runoff diagnosis scheme), allowing them to achieve equivalent effectiveness but at lower cost. The logic behind this approach is that a field-specific approach would prevent runoff from fields (regardless of products used), using mitigation measures adapted to the specific pedo-climatic and landscape properties.

To tackle the issue of concentrated runoff in agricultural landscapes, the following phrase is proposed:

SPe Y: To protect [aquatic organisms] only apply to fields [within Y m to surface water] where concentrated runoff is prevented by appropriate measures (see [detail official reference for concentrated flow mitigation measures]).

This sentence could make the prevention of concentrated runoff more binding in comparison with relying on “good agricultural practice” only. As for diffuse runoff measures, the choice of mitigation measure(s) by farmers and their implementation would need to be documented for each field, so that an effective control is possible. The official list of accepted mitigation measures will need to detail the correct establishment and maintenance procedures for each measure, together with auditable criteria for adequate implementation of measures. Alternatively, a negative control in the field could be achieved via a diagnosis and documentation of traces of concentrated runoff in fields (erosion rills or gullies and deposited sediment at field edges).

4.3 Spray drift

Spray drift assessments are typical mandatory features of regulatory evaluations of plant protection products at the European level (Annex I assessments), zonal level, and on a country authorization basis. The purpose of this section is to provide a summary of:

- How spray drift is characterized
- What spray drift profiles are used to support regulatory risk assessments
- National options for mitigating spray drift
- Interpretation of labels under usage conditions

Particular emphasis is placed on two specific mitigation strategies: no spray zones and use of spray drift reduction technology. These techniques are also mentioned in Chapter 6, together with other mitigation options to be considered in an off-crop mitigation context. This chapter presents technical and regulatory context surrounding no spray zones and spray drift reduction technologies, which is considered warranted simply because there are sometimes significant differences between Member States when considering:

- Technical drift characterization and representation
- Permissible ranges of no-spray zones for different crops
- Acceptance of spray drift reduction technology as a label mitigation option
- Where accepted, the permissible options of spray drift reduction technology
- Examples where only voluntary implementation is permitted
- Examples of flexible implementation with adaptation of mitigation taking into account local conditions

A brief discussion on the implementation of spray drift reduction technology is proposed, recognizing that in a number of Member States there remain regulatory barriers for adoption or other constraints with users that may limit effective implementation. Possible options to address this are discussed. An illustration of expansion of options with spray drift reduction technology as a flexible strategy for implementation of spray drift mitigation is also provided based upon experiences in Southern Europe. Finally, proposals and recommendations for more practical, flexible, and meaningful spray drift mitigation (and spray drift reduction technology, in particular) are discussed with a view towards more effective harmonization of policy on spray drift mitigation between Member States.

4.3.1 How spray drift is characterized

Spray drift measurements may be performed under reference conditions in the field to assess the amount of applied spray volume blown away downwind of a treated area and deposited on the soil surface next to the treated field. This may be facilitated through the use of a fluorescent tracer to quantify spray deposition. A non-ionic surfactant may be added to mimic a spray solution of a plant protection product. Spray drift deposition is then assessed at a range of distances relative to the edge of the treated zone. Studies may be conducted with a range of different reference conditions (wind speed, nozzle height, temperature, humidity, etc.). Consequently, differences arise between assessments related to the choice of standard reference conditions for tests. This is illustrated in Table 4.4 (Huijsmans and van de Zande 2011).

Table 4.4: Summary of boom sprayer reference conditions (after Huijsmans and van de Zande 2011)

	NL	DE	UK	FR	PL	BE	SE
Nozzle	XR11004	FF 03, 04[a]	FF110/1.2/3.0	FF11002	FF03	FF03	F, M, C
Spray pressure (bar)	3	2.0-5.0	3.0	2.5	-	3	-
Spray volume (l/ha)	300	150-300	Speed dependent	-	-	-	-
Sprayer speed (km/h)	6.5	6-8	6-12 (12, 16)[b]	8.0	-	-	7.2
Boom height (m)	0.50	0.50	0.5 (0.7, 1.0) [b]	0.70	0.5	0.5	0.25, 0.40, 0.60
Sprayed surface	Potato, bare soil	Bare soil, short grass	Short grass, crop	-	-	-	Short grass
Crop height (m)	0.5 / 0.10	0.10	0.05 – 2.0	-	-	-	-
Sprayed width (m)	24	20	48	-	-	-	96
Temperature range (°C)	5-25	10-25	-	-	-	-	10, 15, 20
Wind speed range (m/s)	1.5-5.0	1-5	2.5 (2.5, 3.5)[b]	-	-	-	3,0, 4.5

Wind speed height (m)	2.0	2.0	3	-	-	-	2.0

[a] Basic drift curve contains data from measurements from other flat fan (FF) nozzle types and sizes

[b] Values in parenthesis are recently proposed (not yet adopted) for bystander/residents assessments

With respect to spray drift reduction technology, ISO identifies six classes of drift reducing technologies (ISO 22369-1, 2006) relating respectively to 25, 50, 75, 90, 95, and 99% of drift reduction. The underpinning characterization of drift reduction effectiveness varies and may include full-scale field trials (ISO 22866), wind tunnel tests (ISO 22856), and droplet size characterization (ISO/DIS 25358).

During discussions at the second workshop it was agreed that these differences should be acknowledged, but that harmonization of testing standards beyond ISO 22369 would be more effectively addressed independently via spray physics expert working groups. It was agreed that the workshop delegates should focus on general principles of mitigation – what is used, how it is used, and what opportunities can widen options and build upon regulatory and technical experience.

4.3.2 What spray drift profiles are used to support regulatory risk assessments

In general, the most common basis for representation of spray drift in risk assessments is drift tables presented by Rautmann et al. (2001). This, in turn drew upon the fundation of spray drift data tables established by Ganzelmeier et al. (1995) derived from trials over bare ground and were considered at the time to represent a worst case scenario. The original datset was collected from the late 1980s to the early 1990s, and included a total of 119 trials comprising 16 drift trials for field crops, 21 trials for grape vines, 61 trials for fruit crops, and 21 trials for hops. The 90th percentile values (or overall 90th percentile for multiple applications) derived from the data have remained the mainstay of EU risk assessments ever since (including incorporation into the FOCUS Surface Water modeling framework (FOCUS 2001). There are, however, notable differences in regulatory strategy and these are summarized in Figure 4.4 and detailed below.

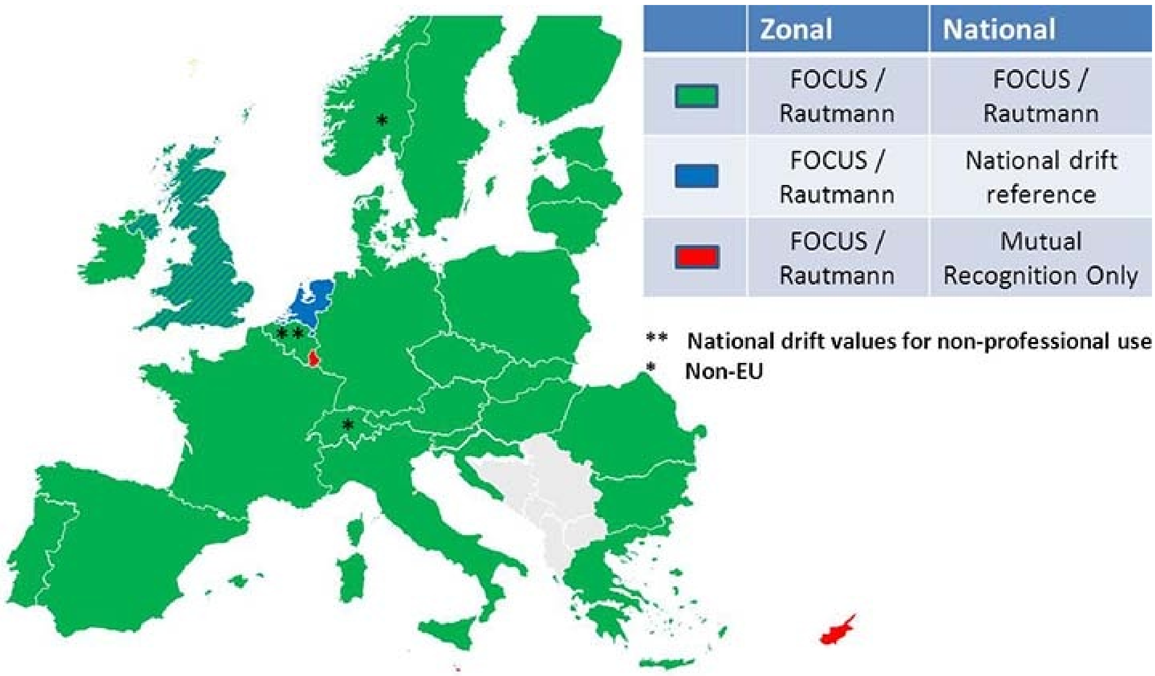

Figure 4.4: Summary of regulatory preferences for drift representation

Two Member States (the Netherlands and the UK) employ spray drift representations that differ from Rautmann et al. (2001) and these are discussed in brief below.

Netherlands

In the Dutch assessment procedure different spray drift curves are used for arable crops (boom sprayers), fruit crops, and nursery trees, all originating from field measurements carried out in the Netherlands based upon reference standards summarized (Huijsmans et al. 1997) in Table 4.4 for boom sprayers. In the Netherlands, the standard reference basis for assessment includes spray of a potato crop and in the near future also for bare soil or small crops (i.e., grass). For boom sprayers, the Netherlands specifies the position of the last nozzle relative to the last crop row. This originates from the experience in measuring spray drift in a crop situation where the nozzle position above the last crop row is fixed while the edge of the canopy varies. In other drift frameworks used in other countries, the edge of field is defined as half a nozzle spacing distance from the last nozzle (ISO 22866 2005). On this basis, and because of differences in reference nozzle standards and wind speed conditions during spray drift measurements, spray drift potential for the Netherlands is higher than represented in FOCUS.

Dutch spray drift profiles are implemented as a component of the Dutch government's policy (Multi-Year Crop Protection, Water Pollution Act, Plant

Protection and Biocide Act, Sustainable Crop Protection I and II; LNV 2004, EZ 2013) that has set goals for the reduction of the emission of pesticides into the environment. A minimum set of agreed measures are mandatory to reduce spray drift deposition in practice based on drift-reducing application techniques and crop-free buffer zones based on the Water Pollution Act (I&M 2012). For example, in arable field crop spraying it is mandatory to use nozzles with at least 50% drift reduction on the outside 14 m of the field (VW and LNV 2001), a maximum boom height of 0.50 m and an end-nozzle on boom sprayers spraying alongside waterways (I&M 2012). For frequently sprayed crops like potatoes, flower bulbs, and onions, a crop-free buffer zone of 1.5 m measured between the center of the last crop row and the start of the ditch bank is obligatory. On the field edge it is also allowed to grow another non-sprayed crop or vegetation to serve as a buffer zone thereby introducing a no spray buffer zone. With higher level spray drift reducing techniques (drift reduction of 50% up to a drift reduction of 95%) the crop-free buffer zone is allowed to be smaller, up to 0.50 m (TC 2014) as long as authorization thresholds of pesticides are not exceeded for surface water (Ctgb 2014). For orchard spraying, specific combinations of spray techniques (Van de Zande et al. 2012) and crop-free buffer zones are mandatory as a first level leading to a minimal drift reduction of 90% at the water surface. Regulations are embedded in both the Pesticide Act and the Water Pollution Act. Based on the spray drift deposition level in surface water, the width of crop-free buffer zones can be set and impacts on the registration process of agrochemicals determined. A general reduction in spray drift to surface water next to the sprayed field can be achieved by improvements in spray application techniques. So in general in the Netherlands there are two levels of implementing SDRT and buffer zones:

1. Protection by general rules of mandatory drift reducing technologies and crop-free buffer zones

2. Wider buffer zones or more drift reducing technologies based on the toxicity of the agrochemical in the authorization procedure. From 2015 onward a minimum drift reduction of 75% is to be used on all fields sprayed with agrochemical irrespective of whether the field is alongside a water course.

United Kingdom

The current UK accepted approach for calculation of PECsw by spray drift is described in a previous Aquatic Guidance document (SANCO/3268/2001) drawing upon drift profiles proposed by Rautmann et al. (2001). This remains the primary basis for evaluation in most cases.

However, the UK authorities (CRD) have recently revised their policy to allow for greater flexibility to consider horizontal boom spray drift reduction technology. In this scheme, uses or products that do not give a satisfactory risk assessment without reliance upon SDRT can be assessed assuming the use of LERAP three star nozzles (HSE 2014), which provide at least 75% drift reduction. Where applicable, spray drift assessments based upon this SDRT framework may then be based upon the van de Zande spray drift dataset (van de Zande and Holterman 2005). The drift model contains the appropriate regression values from van de Zande data to calculate the initial surface water PEC due to spray drift (PECsw) for buffer zones from 5 m to 20 m in 5 m intervals. The basis for this policy revision is detailed in a CRD regulatory update (CRD 2014). It is for this reason that the UK is represented in Figure 4.4 as operating two parallel drift representation schemes.

4.3.3 National options for mitigating spray drift

Typically, where spray drift mitigation is required to support safe use, product labels make reference to no spray zones. In a number of Member States, the maximum width of these no spray zones is constrained by national policy. Certain Member States also permit the use of drift reducing nozzles as an independent or complementary means of mitigating spray drift. Examples of other schemes are summarized in the off-crop mitigation chapter. A summary is presented in the following discussion based upon status quo in mid-2014.

Specific national policies on the role of buffers and spray drift reducing nozzles in mitigating spray drift are summarized in the following tables. Examples for the Northern Zone have been summarized within the Northern Zone guidance document (Northern Zone Work Share Committee 2014) and are reproduced in Table 4.5. A similar assessment has been conducted for the Central Zone by Abu et al., (2013) with results reproduced in Table 4.6 and Table 4.7. Parallel tables including feedback from Member State regulators and companies for the Southern Zone are summarized in Table 4.8 to Table 4.11.

Table 4.5: Possible surface water mitigation measures in the countries of the Northern Zone (based upon Northern Zone Work Share Committee 2014)

Northern zone	Width of No-Spray Buffer Zones (m) to Mitigate Drift Accepted by Northern Zone Member States	Drift Reducing Nozzles

<table>
<tr><th></th><th>2</th><th>3</th><th>5</th><th>10</th><th>15</th><th>20</th><th>25</th><th>30</th><th>35</th><th>40</th><th>45</th><th>50</th><th></th></tr>
<tr><td>Denmark</td><td>FVOB</td><td></td><td></td><td>FVOB</td><td></td><td>FVOB</td><td></td><td>VOB</td><td></td><td></td><td></td><td>O</td><td>NA</td></tr>
<tr><td>Estonia</td><td></td><td></td><td colspan="6">FVOB</td><td colspan="2">OB</td><td></td><td></td><td>NA</td></tr>
<tr><td>Finland</td><td></td><td colspan="5">FVOB</td><td></td><td>OB</td><td></td><td>O</td><td></td><td>O</td><td>Yes[A]</td></tr>
<tr><td>Latvia</td><td></td><td></td><td colspan="6">FVOB</td><td colspan="2">OB</td><td></td><td></td><td>NA</td></tr>
<tr><td>Lithuania</td><td></td><td></td><td colspan="4">FVOB</td><td colspan="4">OB</td><td></td><td></td><td>NA</td></tr>
<tr><td>Norway</td><td></td><td></td><td colspan="2">FVOB</td><td></td><td>FVOB</td><td></td><td>FVOB</td><td></td><td></td><td></td><td></td><td>NA</td></tr>
<tr><td>Sweden</td><td></td><td></td><td></td><td></td><td>FVB</td><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Yes[B],</td></tr>
</table>

F = Field crops, V = Vegetables, O = Orchards, B = Bush & nurseries
NA: Not accepted
[A] 50%, 75%, 90%
[B] No spray buffer zone ("*Hjälpredan*"/"the Helper") is to be used as first option for off-field risk mitigation. If necessary, drift reducing equipment could be used in combination with no spray buffer zones to further reduce the exposure. Arable crops & vegetables: 50, 75, or 90%; Orchards: 25, 50, 75, 90, or 99%

Table 4.6: Summary of surface water mitigation measures currently applied by Member States in the Central Zone for arable crops (based on survey conducted by Abu et al. 2013)

Member State	Maximum No Spray Buffer Zone	Drift Reducing Nozzles	Maximum No Spray + Drift Reduction Combination
Austria	20 m	50%, 75%, 90%	20 m + 90% drift reduction
Belgium	20 m	50%, 75%, 90%	20 m + 90% drift reduction
Czech Republic	50 m	50%, 75%, 90%	90% drift reduction
Germany	20 m	50%, 75%, 90%	20 m + 90% drift reduction
Hungary	50 m	50%, 75%	50 m, No drift reduction
Netherlands	3 m; No maximum set*	50%, 75%, 90%, 95%	95% drift reduction
Poland	No maximum set	50, 75, 90, 95%[B]	95% drift reduction

Ireland	Under review	Under review	Under review
Romania	No information	No Information	No Information
Slovakia	20 m	50%, 75%, 90%	Not specified
Slovenia	20 m	50%, 75%, 90%	Under review
United Kingdom	20 m	LERAP[A]	LERAP[A]

[A] Reduction in buffer width specified on the product label is possible at farm level under the Local Environmental Risk Assessment for Pesticides scheme when drift reducing equipment is used.

[B] Polish authorities are finalizing a legal act in which permissible spray drift reduction technology is defined rather than specifically referring to spray drift reducting nozzles

* In general, crop-free buffer zones are used

Table 4.7: Summary of surface water mitigation measures currently applied by Member States in the Central Zone for fruit crops (based on survey conducted by Abu et al. 2013)

Member State	Maximum No Spray Buffer Zone	Drift Reducing Nozzles	Maximum No Spray + Drift Reduction Combination
Austria	20 m	50%, 75%, 90%, 95%	95% drift reduction
Belgium	30 m	50%, 75%, 90%, 99%	30 m + 90% drift reduction
Czech Republic	50 m	50%, 75%, 90%	90% drift reduction
Germany	20 m	50%, 75%, 90%	20 m + 90% drift reduction
Hungary	50 m	50%, 75%	50 m, No drift reduction
Netherlands	9 m; No Maximum Set*)	50%, 75%, 90%, 95%	95% drift reduction
Poland	No maximum set	50, 75, 90, 95%[B]	95% drift reduction
Ireland	Under Review	Under Review	Under Review
Romania	No Information	No Information	No Information

Slovakia	50 m	50%, 75%, 90%	Not specified
Slovenia	20 m	50%, 75%, 90%	Under review
United Kingdom	20 m	LERAP[A]	LERAP[A]

[A] Reduction in buffer width specified on the product label is possible at farm level under the Local Environmental Risk Assessment for Pesticides scheme when drift reducing equipment is used.

[B] Polish authorities are finalizing a legal act in which permissible spray drift reduction technology is defined rather than specifically referring to spray drift reducting nozzles

* In general, crop-free buffer zones are used

Table 4.8: Possible surface water mitigation measures in the countries of the Central zone (based on survey conducted by Abu et al. 2013)

	Width of No-Spray Buffer Zones (m) to Mitigate Drift Accepted by Central Zone Member States																										Drift Reducing Nozzles
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	25	30	35	40	45	50	100	
Austria	FVOB		FVOB		FVOB					FVOB					FVOB					FVOB								FV: 50, 75, 90% OB: 50, 75, 90, 95%
Belgium		FV	OB		FVOB					FVOB										FVOB		OB						FV: 50, 75, 90% OB: 50, 75, 90, 99%
Czech Republic					FV					FVOB											FVOB							FVOB: 50, 75, 90%
Germany					FVOB					FVOB					FVOB					FVOB								FVOB: 50, 75, 90%
Hungary																										FVOB[A]		FVOB: 50, 75%
Ireland																												No information
Netherlands					FV				OB																			FV: 50, 75, 90, 95% OB: 50, 75, 90, 95%
Poland	FV														FVOB[B]													FVOB: 95%
Romania																												No information
Slovakia								FV				FV			FV			FV		FV				OB				FVOB: 50, 75, 90%
Slovenia																				FV						OB		FVOB: 50, 75, 90%
United Kingdom[C,D]		FV			FVOB		FV[C]			FVOB[C]			FV[C]		FVOB[C]			FV[C]		FVOB		OB		OB		OB		LERAP[D]

F = Field crops, V = Vegetables, O = Orchards, B = Bush & nurseries

[A] Only maximum buffers presented. Smaller buffers may be accepted.

[B] No maximum buffer width is defined

[C] FV buffer zones at 6, 12, or 18 m may also require use of 75% drift reducing equipment to control exposure.

[D] For FV buffer zones 1-5 m, and OB a reduction in buffer width specified on the product label is possible at farm level under the Local Environmental Risk Assessment for Pesticides (LERAP) scheme when drift reducing equipment or other measures are used. Drift reduction classes are 25%, 50%, 75%. For FV buffer zones 5-20 m with standard equipment no reduction is allowed under LERAP

Table 4.9: Summary of surface water mitigation measures currently applied by Member States in the Southern Zone for arable crops (based upon combination of Member State and company feedback)

Member State	Maximum No Spray Buffer Zone	Drift Reducing Nozzles
Bulgaria	100 m	SDRT proposals accepted[C]
Croatia	20 m	No precedent for acceptance
Cyprus[A]	20 m	SDRT proposals accepted[C]
France	20 m	Used at discretion of farmers – cannot be introduced as label requirement
Greece	20 m	SDRT proposals accepted[C]
Italy	30 m	50%, 75%, 90%, 95%, 99%
Malta[B]	20 m	50%, 75%, 90%, 95%, 99%
Portugal	20 m	SDRT proposals accepted[C]
Spain	50 m	50%, 75%, 90%, 95%

[A] Assumes mutual recognition with Greece

[B] Assumes mutual recognition with Italy

[C] No formal guidance available on nozzle effectiveness – subject to negotiation

Table 4.10: Summary of surface water mitigation measures currently applied by Member States in the Southern Zone for fruit crops (based upon combination of Member State and Company feedback)

Member State	Maximum No Spray Buffer Zone	Drift Reducing Nozzles
Bulgaria	100 m	SDRT proposals accepted[C]
Croatia	20 m	No precedent for acceptance
Cyprus[A]	40 m	SDRT proposals accepted[C]
France	20 m	Used at discretion of farmers – cannot be introduced as label requirement
Greece	40 m	SDRT proposals accepted[C]
Italy	30 m	50%,75%,90%,95%, 99%

Malta[B]	40 m	50%,75%,90%,95%, 99%
Portugal	20 m	SDRT proposals accepted[C]
Spain	50 m	50%, 75%, 90%, 95%,

[A] Assumes mutual recognition with Greece

[B] Assumes mutual recognition with Italy

[C] No formal guidance available on nozzle effectiveness – subject to negotiation

Table 4.11: Possible surface water mitigation measures in the countries of the Southern zone (based upon combination of Member State and Company feedback)

	Width of No-Spray Buffer Zones to Mitigate Drift (m)														Drift Reducing Nozzles
	2	**3**	**5**	**9**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**100**	
Bulgaria	?	?	?	?	?	?	?	?	?	?	?	?	?	FVOB	SDRT proposals accepted[C]
Croatia	?	?	?	?	?	?	FVOB								No precedent for acceptance
Cyprus[A]	?	?	?	?	?	?	FV	?	?	?	OB				SDRT proposals accepted[C]
France			FVOB				FVOB								Used at discretion of farmers – cannot be introduced as label requirement
Greece	?	?	?	?	?	?	FV	?	?	?	OB				SDRT proposals accepted[C]
Italy	FVOB[D]														50%, 75%, 90%, 95%, 99%
Malta[B]	?	?	?	?	?	?	FV	?	?	?	OB				50%, 75%, 90%, 95%, 99%
Portugal	?	?	?	?	?	?	FVOB								SDRT proposals accepted[C]
Spain			FVOB		FVOB										50, 75, 90, 95%

F = Field crops, V = Vegetables, O = Orchards, B = Bush & nurseries

[A] Assumes mutual recognition with Greece

[B] Assumes mutual recognition with Italy

[C] No formal guidance available on nozzle effectiveness – subject to negotiation

[D] Exception for maize where maximum drift buffers are typically 5 m due to high density of water bodies in the primary maize production region (Po valley). For compounds requiring buffers for the purpose of run-off mitigation a label restriction is introduced to eliminate use in areas with greater than 2% slope.

? Acceptance of these intermediate widths is currently unknown

4.3.4 Interpretation of label under usage conditions

Requirements for spray drift mitigation based upon no spray zones or SDRT stipulated on the product label must be respected by the user. In selected Member States there is some further flexibility to reduce reliance upon no spray zones through compensatory actions. Examples where this is the case are discussed below.

France

The implementation of SDRT by farmers in France is purely voluntary. However, buffers may be reduced from 20 m to 5 m (or 50 m to 5 m) if the following conditions are met by farmers (JORF 2006):

- Planting of a permanent vegetated strip of 5 m width adjacent to the water body:
    - For high drift uses such as orchards and vineyards the strip must be planted with a hedge of at least equivalent height to the crop;
    - For other uses no height is specified and there is greater flexibility with vegetation.
- Implementation of other means of reducing risk to aquatic life, such as SDRT:
    - This must include approved methods published by the Ministry of Agriculture and Fisheries, which would have the effect of reducing risk to aquatic organisms by at least a factor of 3 relative to normal usage conditions (implicitly this means spray drift reduction must be at least 66.7%);
    - This includes a range of drift reducing nozzles published in the Ministry of Agriculture and Fisheries bulletin (Arrété du 12 Septembre 2006 relatif à la mise sur la marché et à l'utilisation des produits vises à l'article L.253-1 du code rural) (JORF 2006);
- Recording of products used (trade name, dates, and rates used).

United Kingdom – LERAP

Aquatic buffers for products applied by horizontal boom or broadcast air-assisted sprayers in the United Kingdom may be reduced through a legal obligation to carry out and record a Local Environmental Risk Assessment for Pesticides (LERAP; Gilbert 2000). For horizontal boom sprayers it is only possible to reduce buffer zones of 5 m; buffer zones of greater than 5 m cannot be reduced.

A flow chart summarizing the application of LERAPs in the United Kingdom to reduce buffer widths is provided in Figure 4.5.

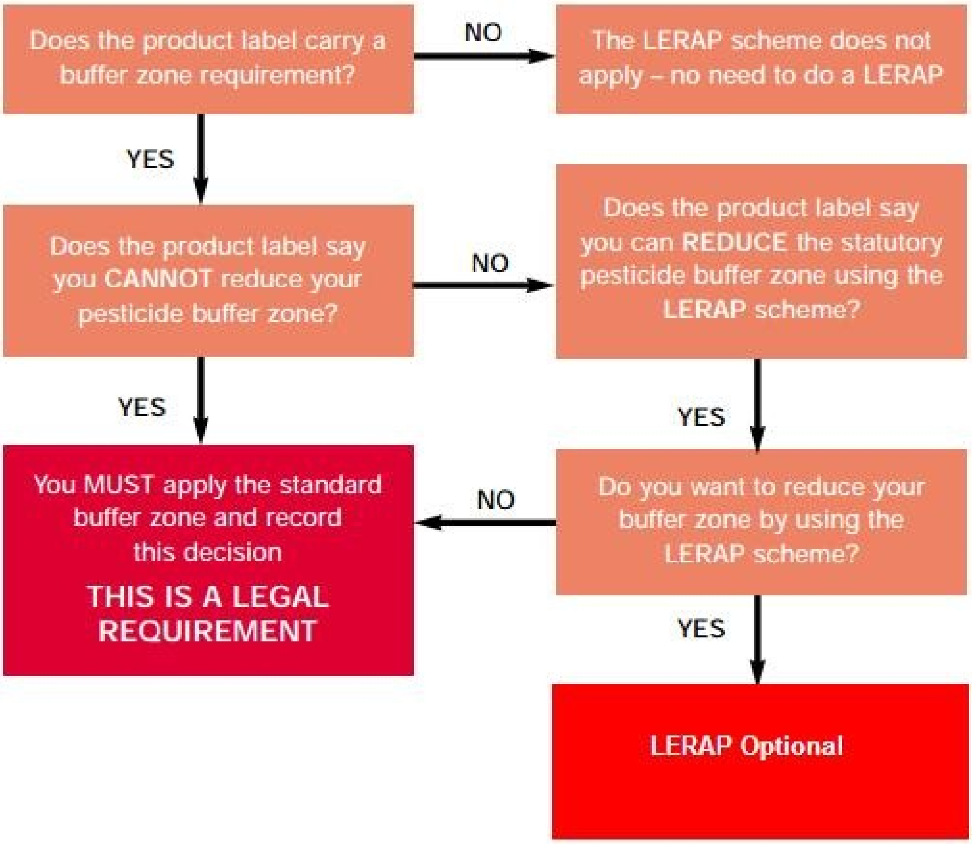

Figure 4.5: Summary of application of LERAP scheme in the United Kingdom

The LERAP procedure to reduce buffer zone widths in the United Kingdom is conducted by first characterizing the local environment and intended spray operation:

- Characterize water bodies adjacent to the spray area (width at narrowest point)
- Record dose rate proposed (e.g., full rate, ½ rate, ¼ rate)
- Decide whether a LERAP spray drift reduction nozzle is proposed to reduce spray drift
- LERAP spray drift reduction nozzle star rates represent 25% spray drift reduction (*), 50% spray drift reduction (**), and 75% spray drift reduction (***)

When considering applications using broadcast air-assisted sprayers there are further refinements. For example, it is possible to take into account living windbreaks fulfilling the following conditions to assist in reducing buffer widths:

- The windbreak is formed from broad-leaved trees or shrubs, not conifers (conifers may deflect spray down onto the watercourse behind them); It is managed to protect the crop from the effects of wind or to minimize spray drift
- It is at least 2 m higher than the crop to be sprayed
- It extends for the full length of the boundary between the treated crop and the watercourse
- It has no gaps over this length including those resulting from systematic stripping of lower branches
- Leaves are visible over its entire length

Those responsible for product application then work out the width of buffer zone for the intended spray operation. Using the information above users can, with the aid of tables provided in LERAP guidance, work out what unsprayed buffer zone reduction may be permitted. If the user intends to use a LERAP low-drift 3-star-rated sprayer (75% spray drift reduction), they may apply a 1 m buffer zone for all horizontal boom sprayer dose rates regardless of the width of watercourse or pond. For broadcast air-assisted sprayers the minimum buffer zones permitted on the basis of reduced doses alone is 7 m for all crops. When including other reduction aspects (e.g., SDRT, living windbreakers), the absolute minimum buffer zone is 5 m. If a ditch is dry at the time of application a 1 m or 5 m unsprayed buffer zone is applied for horizontal boom sprayers and broadcast air assisted sprayers, respectively.

Farmers are obliged to then record the LERAP decision, taking note of the following in sprayer records:

- date of assessment
- type of sprayer, nozzle, and spray pressure used (in particular any LERAP one, two, or three star rating drift reduction nozzle)
- the pesticide product applied
- the dose at which it was applied

- the width of the watercourse
- the result of the LERAP decision (i.e., the width of unsprayed buffer zone set)
- the name of the person who carried out the LERAP

As a result of recent changes in policy in the UK (CRD 2014), some products may be specified for use with spray drift reduction technology (LERAP 3 star low-drift status) and buffer zones of 6, 12, or 18 m (as necessary for each crop) as a condition of authorization for horizontal boom spraying. Authorizations issued under these arrangements also specify a second buffer zone of 30 m, beyond which use of spray drift reduction technology is not required. This is necessary to protect watercourses from higher rates of spray drift arising from use of standard spraying equipment and procedures. These distances cannot be reduced under the LERAP scheme.

Sweden – "Hjälpredan"

Hjälpredan (literally "the Helper") is to be used as a first option for off-field risk mitigation. If necessary, drift reducing equipment could be used in combination with no spray buffer zones to further reduce the exposure. Users first need to measure wind direction, wind speed, and temperature, and together with data on dose rate, spray boom height, and spray quality (fine, medium, coarse; nozzle type), they can calculate the proper safety distances needed taking into account "general" or "specific" areas of concern.

The objective for areas of "general" concern is protection of biodiversity outside the field and neighboring crops downwind of application, while a higher standard of protection exists for areas of "specific" concern downwind of application; these include water courses, areas with vulnerable biodiversity, sensitive crops, organically grown crops, bee-hives, home gardens, playgrounds, and other suburban areas.

The Helper gives the user several options in each spraying situation, which is also an important aspect. The user can reduce the dose rate or choose other spraying techniques, for example nozzles that may allow spraying closer to the field edges. If large safety distances (e.g., >50 m) are required due to particular weather conditions, the user can postpone spraying and come back later when the weather conditions are more suitable for spraying.

If the risk assessment indicates that (fixed) no-spray buffer zones wider than 15 or 20 m are necessary in order to maintain a low risk to non-target organisms, Hjälpredan is not sufficient. Additional risk management measures may then be needed to fulfill the requirement for authorization, such as spray drift-reducing equipment. However, it has to be established that the use of spray drift reducing nozzles does not impair the efficacy of the product.

According to a farmer survey, approximately 50% of all Swedish farmers spraying pesticides report that they use the Helper to determine when to apply safety distances such as buffer zones. KEMI (2012) now sets a demand in all new approvals and re-approvals that the Helper must be used to determine the size of buffer zones. This is a cross-compliance initiative which means that the farmers will need to maintain spray records based on the tool. It is expected that this will reinforce the use of the tool.

More information about the Hjälpredan can be found at: http://sakertvaxtskydd.se/sv/Bibliotek/Mitigating-spray-drift-in-Sweden1/

While tools and options such as the Hjälpredan allow for a relatively high degree of customization of application to reflect the environmental and landscape conditions at the point of application, they require a high degree of compliance, awareness, and acceptance by farmers and applicators. The Hjälpredanis noted here simply as an example of a scheme in which a relatively high degree of responsibility is put in the hands of farmers and applicators to adjust application to reflect local conditions. In most Member States a more rigid framework of recommendations for applications is applied. While this has the disadvantage of constraining the ability to adapt application to local conditions, it has significant labeling advantages in terms of simplicity, ease of communication, and greater potential likelihood of compliance. The Hjälpredan is summarized here as an illustration of how Member States might choose to balance the need for flexibility to adapt an application framework and the need for label simplicity.

4.3.5 Overview of spray drift reductions measures

A compilation of the risk mitigation tools directly intended to manage spray drift that were identified via questionnaires was prepared to support preparation of an inventory of off-crop risk mitigation measures discussed in Chapter 6. These measures are summarized in Table 5.12. As in Chapter 6, the group discussed the following criteria for each tool:

- Efficacy of the tool to appropriately mitigate risks
- Regulatory and legal aspects relevant to the tool. This criterion

considers, for example, the legal status of the risk mitigation tool in the countries where it is implemented. This criterion also considers the possibility to take the risk mitigation measure into account in the risk assessment process

- Implementation aspects, particularly with regards to the acceptability of the tool to farmers

Table 4.12 also lists the mitigation measures identified at Member State level for different groups of species of concern, and characterizes their level of practicality, effectiveness, and enforceability. Based on the expert judgement of the workshop participants, the risk mitigation measures identified were ranked, as explained in the introduction.

The risk mitigation tools identified as promising or well established are further detailed in dedicated Risk Mitigation Measure Technical Sheets (RMMTS) that are provided in Appendix 1.

It is noted that the measures summarized here are limited to those that would be primarily developed to manage spray drift. Other measures summarized in Chapter 6 may have a complementary benefit in reducing spray drift and associated impacts (e.g., vegetated buffer strips, multi-functional field margins), but are not discussed here for the sake of brevity. Readers are directed to Table 6.2 in Chapter 6 where additional spray drift reduction benefits from these measures are highlighted.

Table 4.12: Overview of the risk mitigation measures (RMM) suitable to reduce impact of spray drift. RMM are allocated into the following categories: Buffer Zones (BZ) aimed at reducing exposure of off-crop area via spray drift, Spray Drift Reduction Technologies (SDRT), which involve any technology associated with sprayers, nozzles, or spraying techniques that will reduce drift, and Good Agricultural Practices (GAP), which relate to product application (dose and application regime). Note that mitigation measures associated with field margin management may have a complementary spray drift reduction benefit but are discussed in Chapter 6. The corresponding Risk Mitigation Measure Technical Sheets (RMMTS) are listed in the last column together with their location in the proceedings.

Risk Mitigation Measure	Category	Description	Status[1]	Countries Where Implemented (as Based on the Questionnaires and Further Discussions)	Proposed New SPe Phrase in the Context of Regulation (EU) 547/2001	RMM Taken Into Account in the Risk Assessment	RMMTS
No spray buffer zone	BZ	• No spray buffer zone in the field and/or at the field border to avoid direct spray of off-field area • Usually product-specific • Width typically comprised between 1 and 50 m • Benefits on all off-field area and organisms through spray drift reduction	4	All MS	**Adapted from current SPe3:** SPe3: To protect [aquatic organisms / non-target plants / non-target arthropods / insects] from spray drift respect an unsprayed buffer zone of (distance to be specified) to the edge of the field/surface water bodies]. The edge of the field is either the edge of the crop or, in the presence of a margin strip, the edge of a margin strip (see previous section).	Yes	Not necessary The risk assessment already takes into account spray drift values for no spray buffer zones up to 100 m width
Wind direction – dependant no spray zone	BZ	• No spray zone in the field or at the field boarder to avoid direct spray of off-field area • Product specific, set as a function of wind speed and temperature based on a user guide (Helper) • Benefits on all off-crop area and organisms through spray drift reduction	3	SE	**Additional text to be associated to SPe3:** The buffer zone may be adjusted as a function of wind speed, wind direction and temperature conditions based on available recommendations.	Possible	Yes (RMMTS #1)
Buffer zone of bare soil	BZ	• No spray zone at the field border to avoid direct spray of off-crop area • Generic • Width from 0.25 to 12 m if used with spray drift reduction technology • Benefits on all off-crop area and organisms through spray drift reduction	3	NL, UK	**See SPe 3**	Yes	Yes (RMMTS # 2)
Drift reducing nozzles (incl. adjusted spray pressure, etc.)	SDRT	• Generic or product-specific • Benefits on all off-crop area and organisms through spray drift	3	AT, BE, BG, CH, CZ, DE, ES, FR, HU, IT, NL, PL, SE, SL, UK	**Additional text to be added to a SPe3:** The buffer zone may be reduced to (distance to be	Yes	Yes (RMMTS # 11)

Risk Mitigation Measure	Category	Description	Status[1]	Countries Where Implemented (as Based on the Questionnaires and Further Discussions)	Proposed New SPe Phrase in the Context of Regulation (EU) 547/2001	RMM Taken Into Account in the Risk Assessment	RMMTS
		reduction			specified) if a combination of spray drift reduction technologies such as drift reducing nozzles, special equipment to reduce spray drift or directed spraying technique [is / are] used providing at least (% of drift reduction to be specified).		
Special equipment/machinery (Wings-/Tunnel-/Band sprayer etc)	SDRT	• Generic or product-specific • Benefits on all off-crop area and organisms through spray drift reduction	4	DE, NL	**As for drift reducing nozzles**	Possible	Yes (RMMTS # 12)
Directed spraying techniques (one-sided spraying, forward-speed, reflection shield, boom-height adjustment etc.)	SDRT	• Generic or product-specific • Benefits on all off-crop area and organisms through spray drift reduction	4	CH, DE, IT, NL,SE	**As for drift reducing nozzles**	Possible	Yes (RMMTS #12)
Precision treatment (as sprayers' equipment)	SDRT	• Spray limited to the area of the crop identified as to be treated by the farmer – supported by GPS technology • Used on some crops and depending on the growth stage • Data on use and benefits are needed to propose detailed recommendations	1	-	n.a.	n.a.	Yes (RMMTS # 13)
Dose of product (reduction or limitation)	GAP	• Label language limiting the application rate to a maximum • Derived from the risk assessment • Benefits related to the group of organisms having driven the risk assessment	4	BE, DE, ES, FR, NO, SE, UK	**New SPe proposing adapted Good Agricultural Practices (GAP) to reduce exposure of wildlife and/or transfers via runoff:** To protect [birds / mammals / aquatic organisms / pollinators / non-target	Yes	Not necessary The risk assessment already takes into account modified application regimes where

Risk Mitigation Measure	Category	Description	Status[1]	Countries Where Implemented (as Based on the Questionnaires and Further Discussions)	Proposed New SPe Phrase in the Context of Regulation (EU) 547/2001	RMM Taken Into Account in the Risk Assessment	RMMTS
					arthropods / non-target plants/limit risks related to situations of runoff] respect an application rate of maximum (application rate to be specified) /do not apply this product more than (time period or frequency to be specified)/ do not apply during the bird breeding period / restrict applications to (dates or growth stages to be specified).		necessary
Excluding types of application techniques (e.g., canon application)	GAP	• Label language excluding some application techniques to be used for a specific product • Derived from the risk assessment • Benefits related to the group of organisms having driven the risk assessment	3	-	n.a.	Yes	Not necessary The risk assessment already takes into account modified application regimes where necessary
Forest aerial application - max. 50% area treated, no spray on the forest edges, standard buffer zones Aerial applications	BZ	• Restriction of aerial applications with regards to the surface treated, implementation of in-crop buffer zones • Case-by-case as related to restricted uses • Benefits on all off-field area and organisms through spray drift reduction	3	DE, FR	n.a.	n.a.	Not necessary (see note) Product and use specific and to be managed at the country level based on policy relative to aerial applications
Specific regulation orsuspension of pesticide	Regulatory	• Restriction of uses in the registration certificate/decision notification	4	IT, SI, UK	n.a.	n.a.	No

[1] Status:

1. Not to be promoted
2. Under development
3. Needs consolidation and research
4. Promising tool implemented in some Member States
5. Well established tool implemented in most Member States.

4.3.6 Towards wider implementation and overcoming hurdles

There is a high level of awareness among farmers, risk assessors, and risk managers of both the benefits and constraints surrounding spray drift mitigation employing conventional no-spray buffer zones. Such buffers are easily and flexibly implemented and there is a substantial database of field research to characterize their effectiveness. This research has led to the development of formal spray drift mitigation representations that are readily incorporated into regulatory risk assessments.

Spray drift reduction nozzles (SDRN or DRN) provide an alternative or supplementary means of mitigating drift. SDRN are effective through reducing the production of droplets of diameter of ca.<100 µm, thereby reducing the impact of variables such as wind speed and release height. It is noteworthy that SDRN have a number of important benefits to growers, including:

- SDRN can be used with simple reductions in spray pressure and does not necessitate changes in any other application parameters such as water volume, application speed, use rate, or frequency of application, etc.
- SDRN can easily be substituted for standard hydraulic nozzles for a reasonable price, without any significant technical modification to the sprayer
- The reduction in spray drift also means that in-field buffers may be reduced, thereby helping the grower to maximize the area of production at their disposal

Nevertheless, SDRN remain an under-exploited means of managing spray drift losses in a number of Member States. There are a number of potential reasons for this:

- Grower and applicator constraints
  - Awareness of SDRN options
  - Misconceptions surrounding practicality of implementation
  - Concerns associated with loss of product efficacy
  - Uncertainties surrounding product label interpretation
- Regulatory uncertainties

- SDRN mitigation efficacy in spray drift reduction
- Variability in nozzle classification
- Practicality and extent of grower or applicator implementation
- Representation in risk assessments
- Statement to be able to support the correct selection of drift reducing nozzles by farmers to achieve the drift reduction required by the risk assessment
- Enforceability

Each of these constraints or uncertainties is considered here drawing upon recent initiatives such as the ECPA funded TOPPS-PROWADIS and SDRT info projects and other product stewardship activities.

4.3.6.1 Perception regarding product efficacy

Growers have questioned product efficacy based on the idea that product delivery to target surfaces may be less consistent, but there is no evidence of loss of efficacy if the application equipment is properly calibrated through key parameters like pressure. Farmers are aware of other parameters, which are important for a successful treatment: growth stage of pests and their mobility on the plant, growth stage of crop where particularly important parameters include LAI (Leaf Area Index), and timing of application.

It is noted that the act of transferring nozzles should be accompanied by a recommendation that equipment should be maintained, cleaned, and calibrated at the same time in order to maximize performance and delivery of product spray. It is clear that use of SDRN requires an improvement in the technical background of farmers which is aligned with the principles of the Sustainable Use Directive (Directive [EC] No. 2009/128).

In case of downward placement like herbicide applications, the literature reports that the efficacy can be slightly reduced. It occurs because the application equipment typically used is already for low water volumes, so in these cases it is particularly important to assess the right rate per hectare to ensure that the final spray applied is not less than recommended by the label.

In the Netherlands, an intensive research program has investigated the efficacy of drift reducing technology in order to support its introduction.

Results showed that drift reduction techniques up to 90% drift reduction showed no reduction in biological efficacy in orchard, flower bulb, vegetable, and arable crop spraying (Schepers & Meier 2007). Only two areas were identified as potentially having a small reduction in biological efficacy:

1. Application of herbicides in a low dose system on very small weeds (cotyledon stage) where biological efficacy was guaranteed up to 75% drift reducing nozzles. With an application at a 2-4 leaf stage the problem was already solved
2. Fungicide application in onions gave a reduced biological efficacy using 90% drift reducing nozzles, whereas there were no problems with DRN up to 75%

In general, experience has shown that issues that may be encountered with lesser efficacy may be resolved through slight adjustment of application practices. Examples of options in this case included:

1. Application with additives such as "stickers" may reduce loss of larger droplets (reduces run-off loss down stems)
2. Application with a 75% twin fan nozzle with simultaneous spraying to the front and back with reduced boom height providing an increased coverage with no negative drop size effects (a combination that has the same high drift reduction level)
3. Adaptation of timing of spraying to ensure application when weeds are a little larger in size

4.3.6.2 Practicality of implementation

There are basically two kinds of pesticide sprayers on the market for 3D crops: hydraulic and pneumatic. Hydraulic sprayers already have nozzles so, to reduce drift keeping the same level of efficacy, it is necessary just to replace conventional nozzles with drift reducing nozzles.

Standard hydraulic nozzles can be easily substituted for spray drift reduction nozzles for a reasonable price, without any significant technical modification to the sprayer also considering that new sprayers usually adopt a multiple nozzle body, which has 3 to 5 spray positions for easy change of spray tips. These multiple nozzle bodies can be mounted after-market and on old or basic sprayers. Technologies for drift reduction are quickly improving across Europe and a further contribution from mechanical engineering is expected over the next years, as recommended in the Sustainable Use Directive.

Pneumatic atomizers generate droplets by tearing a spray film at high air speed. These are mainly used in south Europe especially in plantations (orchard, vine, etc.). With the technology available today, it is difficult to change the droplet spectra under practical conditions. Bigger drops will be generated if the airspeed is reduced. On the other hand the airspeed and air volume is important to transport the droplets to the target and to provide the necessary penetration of spray solution into the canopy.

4.3.6.3 Addressing issues with characterizing spray drift reduction effectiveness

As noted earlier in this chapter, a common European classification of drift reducing nozzles would be helpful for harmonization as, for the time being, each Member State refers to local or national criteria to select them. It would be important to refer to the European standard provided by ISO 22369-1, which identifies six classes of drift reduction nozzles relating respectively to 25, 50, 75, 90, 95, and 99% drift reduction. The lack of detailed, agreed, technical standards for characterizing drift reduction effectiveness remains a technical and regulatory constraint to effective harmonization of mitigation standards. For boom sprayers the classification in drift reducing classes is defined in ISO 22369-2. Standard methodologies are still required for orchard sprayers, wind tunnel measurements, test bench measurements, and nozzle spray quality measurements combined with spray drift modeling.

A more fundamental hurdle in some Member States is related to the sometimes sparse availability of information on SDRT options. Until recently there was no European database where technologies and specifications used in each EU Member State were described. In recognition of this problem, ECPA funded an internet-based database (www.sdrt.info) as an inventory for SDR methodologies with the following objectives:

- To enable an EU Member State-by-Member State breakdown of status
- To improve awareness of such technologies and methodologies in those EU Member States that are not (yet) exploiting the benefits of spray drift reduction technology
- To promote a flexible and effective approach to SDRN classification and recognition in those countries currently without formal national SDRN schemes, drawing upon experiences and schemes already in existence

elsewhere in Europe (classification transfer)

- To support sustainable use initiatives already underway (see Chapter 10)
- To help identify further needs for research or development

In this way, this extensive database is intended to provide a resource for:

- Growers and advisors: To understand options available to them in their jurisdiction
- Industry: To understand how spray drift reduction technology may be taken into account when compiling risk assessments
- Regulators: To consider technology transfer or 'classification transfer' from other Member States where well-established SDRN classification already exists

4.3.6.4 Representations in risk assessments

Regulatory concerns may arise when considering practicality of representation in regulatory risk assessments. The representation of the ISO defaults (25, 50, 75, 90, 95, and 99% drift reduction) within formal regulatory risk assessments is very straightforward (simply reducing spray drift percentages versus defaults by appropriate factors). Drift reduction is included as an option within the SWAN software that is capable of post-processing Step 3 FOCUS SW input files (TOXSWA) to more readily represent a range of mitigation options.

4.3.7 Calculating overall mitigation effectiveness for combinations of measures

As noted in the preceding discussion regarding runoff, all risk mitigation measures that can be integrated into regulatory modeling can also be simulated in combinations, providing a direct mitigation effectiveness output for combinations of measures. A point system is discussed that may be applied to address mitigation needs for runoff in a flexible manner that is tailored to local conditions in the agricultural landscape and applicability or availability of risk mitigation measures.

The same basic structure may also be applied to drift mitigation. In many respects, such a system may be more readily adopted for spray drift given the greater simplicity of implementation and quantitative representation of effectiveness of measures. Drift mitigation achieved through the introduction of no-spray buffer zones or via spray drift reduction technology are already both expressed in quantitative forms that may be simply arithmetically compounded. The effectiveness of other factors or features may also be included in a similar manner so that an overall mitigation requirement may be achieved with flexibly through a variety of mechanisms in combination.

4.3.7.1 Product label interpretation

Regulatory concerns may also arise associated with clarity of communication of mitigation needs on labels. Ideally, label language should be concise and transparent and provide options for adoption as measures in their own right or in conjunction with conventional no spray buffers. Correct use of SDRN may be most effective when accompanied by simple and clear implementation schemes readily adopted by growers as aids to customizing application to the agricultural landscape (relationship between field and non-target environments and other landscape features) and application conditions (temperature, wind speed, humidity, etc.). Examples that support these objectives include the UK LERAP and Swedish Hjälpreda schemes. It is noteworthy that as an aid to correct implementation at application, the latter of these schemes also includes an internet tool and tool for facilitating assessments in the field via mobile phone. A similar tool to assist with developing application assessments customized to local conditions and founded on good agricultural practice has been developed under the auspices of the TOPPS-PROWADIS project (TOPPS-PROWADIS Drift Evaluation Tool).

4.3.7.2 Enforceability

When considering risk mitigation policy it is often stated that the enforceability of a measure needs to be considered to allow for practice verification to thereby increase regulatory and public confidence in such measures. It is noted that the enforceability status of SDRN is not significantly different from that of no-spray buffer zones; indeed, SDRN may actually be more readily enforced than no-spray buffer zones because of the dependency on specific equipment that may be verified after application. Formal classification of nozzles through accredited organizations encourages confidence in technical quality and indirectly supports enforceability through a framework of record keeping associated with nozzle selection.

The proper functioning of SDRN in a certain drift reduction class is only guaranteed when used with the correct spray pressure. Therefore, in the Netherlands it is proposed to make spray pressure recording mandatory from 2016 onward using the logging facilities of spray computers or specific pressure recording devices. Record keeping by applicators provides additional supporting evidence tied to subsidies. As no-spray buffer zones are difficult to control in the Netherlands, crop-free buffer zones are introduced as no farmer will spray a non-cropped strip next to the field and a no-crop distance is easy to measure.

4.3.8 Case study: Spray drift reduction in the UK and Italy

Farmer awareness of spray drift reduction technology continues to spread, thanks to farmer education and awareness campaigns (e.g., TOPPS-PROWADIS and other nationally-oriented campaigns). When accompanied by effective product stewardship campaigns, growers' awareness of the need to more effectively manage drift issues for a given product is significantly improved. An example of this is the successful information campaign, for implementation of low-drift nozzles and no-spray buffer zones developed in the UK (Say No To Drift) and in Italy (Miralbersaglio).

The UK information campaign was initiated in October 2011 and involved growers, farmer organizations, and regulatory authorities. The campaign resulted in an increased intention to use low-drift nozzles in the subsequent season from only 7% in 2011 to 91% of users in 2013 (source: 200 Pesticide Usage Survey Group interviews). The main reasons for the initial reluctance to use low-drift nozzles by farmers were a misconception regarding a loss of efficacy and the lack of familiarity with low-drift nozzles. This information campaign showed that technology transfer from companies to farmers can be helpful to significantly improve take-up of drift reducing nozzles and, thus, reduce spray drift more widely.

A similar information campaign was initiated in Italy in 2012 for apple and vine applications in two pilot areas: Emilia Romagna and Trentino Alto Adige. This campaign consisted in technology transfer events from the south to the north of Italy and involved regional extension services for phytosanitary management, growers, experts in ecotoxicology, environmental fate of pesticides, and efficacy from the Pesticide Committee. The main objective of this campaign was to demonstrate to farmers that the use of low-drift nozzles is easy and delivers a real benefit to the environment. It is noted that in Italy the use of drift reducing nozzles and no-spray buffer zones will be linked to subsidies coming through CAP and to the Italian Action Plan as developed under the Sustainable Use Directive. In this context, the campaigns on technology transfer represent highly effective and well-targeted tools for farmers to meet future obligations. The results of this campaign will provide useful comparative indicators of willingness of farmers in Southern Europe to access and employ drift-reducing nozzles.

4.3.9 Recommendations

Development of independent spray drift reduction technology classification schemes for each of the 28 Member States in the European Union is not only impractical but also inefficient and unjustified. It is recommended that Member States may draw upon extensive experience and sound scientific foundation associated with schemes in place in the countries where it is implemented, for recognition and transfer of classification to enable take up of SDRN throughout the European Union. There are precedents for such policies in Member States where there are not specific domestic classification schemes. This is noted in Belgium, for example, where there is acceptance of classification schemes in Germany, The Netherlands, and the United Kingdom. In practice the most stringent of these criteria is followed. Similar strategies for national recognition and acceptance of spray drift reduction nozzle classification would be effective and could be implemented rapidly and easily.

The regulatory role for such mitigation measures varies considerably across the European Union. In some Member States there is no formal role for spray drift reduction technology for a range of reasons explored earlier. In others, SDRN do not have a role in regulatory risk assessments, but adoption is encouraged in local environmental risk assessments conducted by farmers to gain greater flexibility with product use. Finally, a number of Member States allow for formal representation of SDRN in regulatory risk assessments including Austria, Belgium, Finland, Germany, The Netherlands, Poland, Sweden, and the United Kingdom. Harmonizing policies that encourage the adoption of SDRN by farmers would be beneficial. Additional regulatory benefits would include a higher degree of consistency within zonal evaluations where, currently, different policies lead to inefficient presentation of multiple versions of risk assessments customized to local preferences and policies on risk mitigation. Consideration of a harmonized basis for acceptance of basic SDRN efficacy thresholds (e.g., 50, 75, 90, and 95% effectiveness) is recommended to simplify the regulatory process. It is proposed that this would be expanded to allow for up to 99% spray drift reduction, anticipating future technological developments and increased practicality of implementation of current methods with this effectiveness. This recommendation needs to be considered in the context of guidance offered by the FOCUS Landscape and Mitigation Group (FOCUS 2007) nearly 10 years ago that ”a maximum cap of 95% reduction in exposure via spray drift is applied at Annex I. ” Expansion to include the potential to represent 99% spray drift reduction is now suggested as technically feasible.

Finally, as an aid to allowing for greater flexibility for farmers in managing drift in the local application environment, consideration should be given to schemes such as the Swedish Hjälpreda and the TOPPS-PROWADIS drift evaluation tool (http://www.topps-drift.org/). These schemes and tools allow for customizable application strategies to account for local environment and application conditions, and raise farmer awareness of drift issues and strategies for managing drift. Allowing landscape features, such as windbreaks or hedgerows and windbreak shields (nets) is another way to manage spray drift and is a feature of both the UK LERAP scheme and the Dutch spray drift guidance. As noted earlier, the experience gained elsewhere in Europe where options and policies have been tried and tested may present a way forward that can be adopted “as is” or customized to some extent to accommodate local agricultural norms.

The adoption of technological options for managing drift may be constrained by local regulatory policies. Removing barriers and allowing for a greater degree of consistency on policies for recognition and implementation of SDRN would be a significant step forward in improving not only the flexibility of risk mitigation strategies, but also the effectiveness of spray drift management, greater awareness of the issues by farmers of issues and greater attention to the correct setup of application technology. In many cases, other constraints such as cost or impact on efficacy, can be addressed through additional campaigns.

4.4 Drainage

The objective of land drainage is to remove excess water from the soil or land surface. Since the mid-eighteenth century, large-scale attempts have been made to improve subsurface water control through the installation of various underdrainage systems. Early stone drains were followed by baked clay horseshoe tiles and later still by round clay pipes. Many of these old systems, as well as more recent artificial drainage systems, are still effective and are responsible for draining many slowly permeable soils or those with shallow water tables that might not otherwise be cultivated. Artificial drainage is responsible for the transport of significant quantities of dissolved pesticide, particularly when rainfall and subsequent drainage occur shortly after pesticide application.

The design of a drainage scheme is influenced by many considerations, including climate, cropping practice, soils, and slope. Drain depth and spacing are used to control the depth of the water table and the rate of drainage, while the size, type, and gradient of pipe (e.g., slotted plastic pipe, clay tiles) determine how and when water is transported from the soil. Most clay subsoils have saturated hydraulic conductivities of 0.1 m day^{-1} or less, so that effective drainage is mainly confined to the surface horizon. In clay soils, pipe drainage is usually ineffective unless the subsoil properties are modified to increase physically the number and size of cracks and fissures. This can be done by moling or by subsoiling the site. Mole drains are unlined channels that convey water readily through the soil to the pipe drainage system. They are formed by a mole plough consisting of a steel shaft with a circular steel foot or bullet at the base trailing a cylindrical expander behind. Mole drains are normally drawn at 45-60 cm depth, 2-3 m spacing, and at right angles to the primary drainage treatment. Subsoiling is another option in heavy soils and is carried out to break up soil layers, usually below the plough depth, to make the soil less dense and allow water and air entry. Permeable fill is commonly placed in the trench above a drainage pipe to form a permanent connector for moling or subsoiling treatments. The fill may consist of crushed gravel, hard crushed stone, or synthetic material, and serves to ensure that flows of water have easy access to the underlying drain pipe.

Artificial drainage is commonplace in most slowly permeable soils or in areas where shallow water tables limit agricultural production. An analysis by De la Cueva (2006) investigated the extent of drained land in different European countries. Overlay of artificially drained soil mapping units with land cover data suggested that the proportion of agricultural land that is drained ranges from 0.5% in Spain to 93% in Finland (Figure 4.6). Further analysis showed that the proportion of arable land that is drained is generally larger still and exceeds 50% in five countries: Finland (97%), Latvia (85%), Lithuania (65%), Netherlands (87%), and United Kingdom (66%) (De la Cueva 2006).

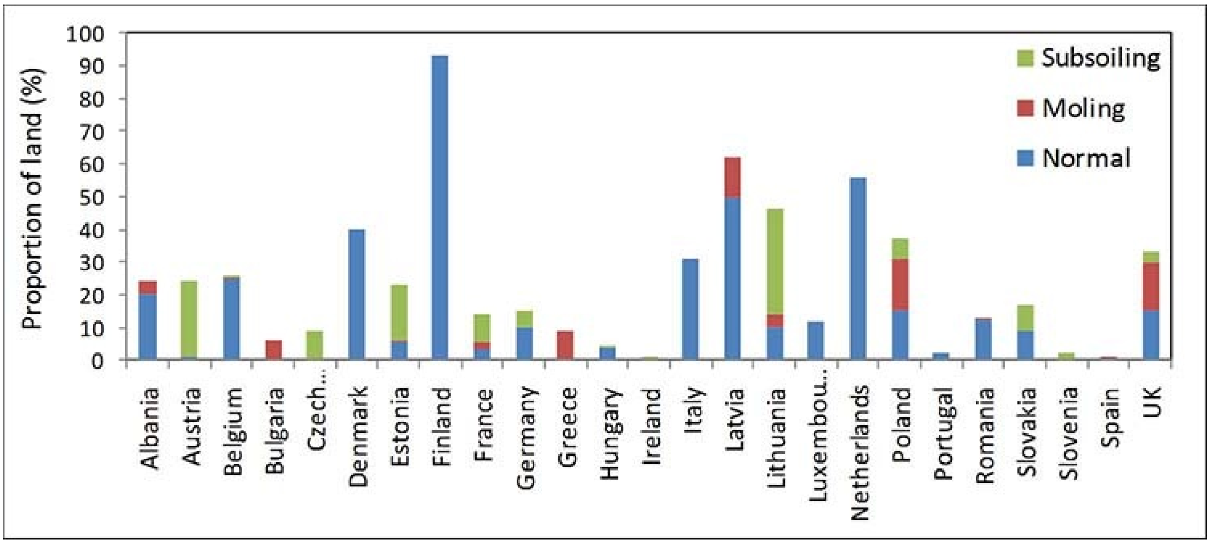

Figure 4.6: Estimated extent of drained land as a proportion of total agricultural land in different European countries. Data were derived by De la Cueva (2006) from analysis of drained soil units within the Soil Geographic Database for Europe and the CORINE Land Cover 2000 database.

While water and pesticide transported via subsurface drains will generally affect surface water quality, leaching through the soil layers that overlie the drains is the first step in transfer to drains. Thus, the processes governing the transport of pesticides via drainage are closely related to those controlling leaching of pesticides to groundwater. Many of the methods to assess, as well as to reduce, loadings to groundwater are in principle also applicable to assess and reduce drainage loadings. Nevertheless, there are some important differences that must be considered. Permeable sandy soils are generally considered as the most vulnerable situation for leaching to groundwater. Consequently corresponding scenarios and matrix flow models were selected for the majority of groundwater assessment schemes (e.g., FOCUS 2009). Transfer via drains in sandy soils with shallow groundwater is also relevant when considering risks to surface water from pesticides. However, subsurface drainage systems are also established in areas with slowly-permeable, fine-textured soils where transport via macropore flow plays a major and sometimes dominant role. The assessment scheme for drainage currently used in the European authorization procedure (FOCUS 2002) defines a number of soil and weather scenarios representing realistic worst case conditions for drainage situations. The scenarios are implemented into the MACRO model, chosen because it simulates both matrix and macropore flow. Specific national scenarios using the MACRO model have been established in the UK (Brown et al. 2004).

4.4.1 Drainage risk mitigation concept

There is a marked contrast between risk mitigation for runoff and that for drainage. Movement of water via runoff is generally deleterious for agricultural systems because it is associated with loss of soil via erosion, saturation of upper soil layers, and potential damage to crops. Subsequently, farmers are already implementing measures to control runoff and erosion as part of best management practices, and risk mitigation measures for pesticides fit well within this existing framework. In contrast, maintaining efficient drainage systems is fundamental to moving excess water out of topsoil layers and to maintaining normal agronomic practices. Thus, risk management for drainage cannot address the pathway of transport per se, and rather, needs to address the use of the plant protection product in situations that present an unacceptable risk.

Since the efficacy of a specific mitigation measure is very dependent on the interaction of substance properties, use pattern, and the properties of the relevant drainage scenario, the efficacy must be specifically evaluated for the individual case. For drainage as for leaching, this can be done most easily using the same simulation models and scenarios that are approved for the authorization process. However, the significantly faster nature of macropore flow compared with matrix flow increases the scope to use monitoring studies as an additional approach to evaluate the efficacy of mitigation measures implemented to reduce surface water exposure via drainage.

The following process is proposed for a harmonized EU regulatory drainage concept:

Step 1: Identification of basic drainage risk mitigation approach

The risk assessment outcome (EU FOCUS or national) identifies an unacceptable risk from transport via drains. It is then necessary to determine whether mitigation is feasible for specific areas at risk (e.g., specific soil types) or whether the same mitigation measure must be applied to all usage areas. This will depend primarily on the legal framework and existing practice within a specific Member State.

Step 2a: Uniform mitigation measure

Mitigation measures applied to all of the usage areas are focused on modifying the rate, timing, or nature (e.g., band spraying) of pesticide applications. In this case, standard risk assessment methods can be modified to incorporate the restriction on application and demonstrate acceptable risk. This approach is simple to communicate via the label, but carries a penalty in restricting use in areas where risk is shown to be acceptable as well as those where risk is considered not acceptable.

Step 2b: Differentiated mitigation measure

Mitigation measures applied only to areas considered to have unacceptable risk include restrictions based on soil type or vulnerability maps. It is necessary to identify the areas with unacceptable risk (e.g., using results of standard risk assessment modeling or higher-tier modeling). Next, the risk mitigation measure to be applied in areas with unacceptable risk needs to be demonstrated through refinement of inputs to the modeling; in practice, the mitigation will be some kind of restriction in application and may range from complete prohibition in use for the most vulnerable situations to restrictions on rate, time, or nature (e.g., band spraying) of applications in situations where this reduces risk to acceptable levels.

4.4.2 Toolbox of drainage mitigation measures

The toolbox of drainage risk mitigation measures has many parallels with those available for mitigating risk of leaching to groundwater. However, some measures applied in the groundwater situation are not applicable. For example, restriction to the number of times a compound can be applied within an arable rotation (e.g., only apply 1 year out of every 3) is not relevant for drainage because of the rapid transfer to surface water relative to rate of leaching to groundwater.

In order to propose a toolbox of drainage mitigation measures, a number of basic mitigation measures were identified during the initial workshop in Rome that are considered as effective by farmers and supported by data (see Table 4.13). The reader is referred to Chapter 5 on groundwater for a more detailed description of the approaches (e.g., restrictions based on soil type or vulnerability maps).

Table 4.13: Proposed toolbox of basic drainage mitigation measures (assessment of current use, technical and practical feasibility, and enforceability is included within Chapter 5 on groundwater)

Drainage Mitigation Measure	Scientific Data Basis*	Proposed Modeling Tool or Parameter Modifications	Comment
Restriction on application timing	+++	Modified application pattern with standard risk assessment models	Can include restrictions based on crop growth stage or dates
Restriction on	+++	Modified application pattern with standard risk assessment	Can include maximum single rate or maximum rate per season

application rate		models	
Band application	++	Simulate the effective application per unit area with standard risk assessment models	-
Restriction based on soil type	++	Purpose-designed modeling drawing on MACRO or other models and potentially incorporating GIS	Soil-based restriction is normally necessary rather than restriction based on presence or absence of drains, as the latter is not always known
Restriction based on vulnerability maps	+	Purpose-designed modeling drawing on MACRO or other models and likely to incorporate GIS	Vulnerability maps could draw on existing catchment management plans or Drinking Water Protection Areas defined under the Water Framework Directive

* Symbols mean: + few scientific publications existing; ++ many scientific publications existing; +++ abundant scientific publications existing

One mitigation measure that can be applied to drainage but not leaching to groundwater is the use of retention structures including detention ponds, natural ponds, artificial wetlands and, potentially, stormwater tanks. The purpose of such structures is to intercept drainflow either before or very soon after entry into surface water; by slowing the movement of water, processes including filtration and sedimentation of suspended sediment and associated pesticide load, sorption of pesticide out of solution and degradation can reduce the total mass of pesticide transferred to the wider surface water network. Artificial wetlands and retention ponds are identified as a mitigation measure for pesticide transfer in surface runoff (Table 4.1). Recent research, particularly in France, has focused on using retention structures to mitigate pesticide transfer via drainage (e.g., Tournebize et al. 2013; Passeport et al. 2014). This research demonstrates that retention structures can be an effective mitigation measure, particularly in areas with silty soils (luvisols) and where (i) either the volume or rate of drainflow entering the retention structure is relatively small or the structure itself is large; or (ii) there is significant loss of water and pesticide during transfer through the structure due to infiltration. Design criteria published in France target a hydraulic retention time of 7 days and suggest that retention structures with an aerial extent of ca. 1% of the drained agricultural area and a depth of 0.8 m will be sufficient to retain 7-mm of drainflow (Tournebize et al. 2015).

Use of retention structures to mitigate pesticide transfer in drainflow from heavier clay soils can be more challenging than for surface runoff. This is because drains in such soils tend to run for extended periods whenever rainfall exceeds evapotranspiration and the volumes of drainflow per unit area of agriculture tend to be larger than for surface runoff (e.g., drainage occurs across the full drained area of land whereas surface runoff is episodic and may only be generated on part of a field). Hydraulic retention times (and thus efficacy) will decrease if the capacity of the retention structure is exceeded or if the structure is either partially or completely full of water at the time drainflow is initiated. Therefore, at the present time, retention structures for reducing pesticide transport in drainflow are considered an important possibility for national mitigation schemes. Further research into broad application to drainflow is required before the measure is suitable for inclusion into the harmonized mitigation scheme proposed by the MAgPIE workshop participants.

4.4.3 Resulting label language

The following safety precaution phrase according to Regulation (EU) No. 547/2011 is applicable for mitigating risk to surface waters from drainflow:

> *SPe 2: To protect groundwater/aquatic organisms do not apply to (soil type or situation to be specified) soils.*

As discussed in Chapter 5.4 on groundwater, an additional standard phrase is proposed to cover the risk mitigation measures that are connected to certain areas (e.g., vulnerability maps):

> *SPe X: To protect groundwater/aquatic organisms do not apply this or any other product containing (identify active substance or class of substances, as appropriate) in vulnerable areas (areas of drinking water abstraction or other vulnerable conditions).*

A further new standard phrase is proposed to cover the remaining risk mitigation measures that are based on specific management options (e.g., band spraying)

> *SPe XX: To protect groundwater/aquatic organisms the use of this or any other product containing (identify active substance or class of substances, as appropriate) is only allowed if specific management conditions (e.g., use of cover crops, band application, others [to be specified]) are fulfilled.*

4.4.4 Acknowledgements

We would like to thank Professor Balsari for his review and suggestions

relating to the drift chapter.

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5 Risk mitigation measures for groundwater

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5.1 Introduction and background

The protection of groundwater ranks very high in European environmental policy. This is clearly expressed in Directive (EC) No. 2000/60 (usually called Water Framework Directive or WFD; EU 2000) and in the related Directive (EC) No. 2006/118 (usually called Groundwater Directive or GWD; EC 2006). With regards to the authorization of plant protection products (PPP), the most important piece of legislation is Art. 4 (3b) of regulation (EC) No. 1107/2009, where the protection of groundwater is as important as human health. Annex II contains the following paragraph:

> *3.10. Fate and behaviour concerning groundwater*
>
> *An active substance shall only be approved where it has been established for one or more representative uses, that consequently after application of the plant protection product consistent with realistic conditions on use, the predicted concentration of the active substance or of metabolites, degradation or reaction products in groundwater complies with the respective criteria of the uniform principles for evaluation and authorisation of plant protection products referred to in Article 29(6).*

The table below shows the quality standards that are used as protection goals in the regulation on the placing of PPP on the market.

Table 5.1: Quality standards to be applied to active substances in pesticides, based on the GWD (EC 2006):

Pollutant	Quality Standards
Active substances in pesticides, including their relevant metabolites, degradation and reaction products[1]	0.1µg/L 0.5µg/L (total)[2]

[1] “Pesticides” means plant protection products and biocidal products as defined in Article 2 of Directive 91/414/EEC and in Article 2 of Directive 98/8/EC, respectively.

[2] “Total” means the sum of all individual pesticides detected and quantified in the monitoring procedure, including their relevant metabolites, degradation and reaction products.

At the EU-level, the term “relevant metabolite” included in Table 5.1 is more precisely defined in the DG SANCO “Guidance Document on the Assessment of the Relevance of Metabolites in Groundwater of Substances regulated under Council Directive 91/414/EC” (SANCO/221/2000, Rev.10, 25 Feb 2003). This guidance is also followed for the national assessment of products by the majority of Member States.

In the subordinate Regulation (EU) No. 283/2013 and Regulation (EU) No. 284/2013 (EU 2013a) that set out the data requirements concerning the approval of active ingredients and authorization of PPP, respectively, the concept of the predicted environmental concentration (PECgw) is established. Experimental (i.e., lysimeter and field leaching studies), as well as modeling methods and monitoring studies can be used to assess the leaching potential of substances. Due to the very high effort in terms of costs and time necessary to perform lysimeter and field leaching studies and the inherently retrospective nature of monitoring studies, simulation models have gained a crucial role in the prospective leaching assessment required for the approval of active substances and authorization of PPP. For the same reasons, simulation models are also uniquely suited to evaluate the effectiveness of proposed mitigation measures and to select measures that achieve the necessary protection of groundwater. However, it needs to be emphasized that experimental and monitoring studies play an important role in validating assumptions made in the modeling approach, assuring that the selected model, scenario, and parametrization of the substance properties result in a realistic representation of the real world. Thus, experimental and monitoring studies may give crucial information to put the modeling results into perspective and to achieve a realistic assessment. On their own they can be used to check if the limit concentration at a representative site is not breached – thus establishing that groundwater is indeed protected.

Detailed guidance on simulation models suitable for the regulatory use, selection of suitable soil, weather, and crop scenarios, as well as the parametrization of substance properties and product application has been developed in three subsequent projects of FOCUS (FOrum for the Coordination of pesticide fate models and their USe) (FOCUS 1995, 2000, 2009), which has been supplemented by several EFSA opinions highlighting specific aspects and reviewing the FOCUS reports (EFSA 2013a, 2013b).

Though the approaches and scenarios developed by FOCUS are now implemented into the European requirements for the approval of active ingredients, some differences exist in the national authorization of products. While all European countries principally follow the approach developed by the FOCUS work group and rely on the same leaching models, there are marked differences, where soil and climate scenarios are considered relevant to achieve protectiveness in different countries. Consequently, some countries have developed specific scenarios and modifications to the FOCUS approach to reflect the national situation. While these shall not be discussed here in detail, it is important to keep in mind that the evaluation of the effectiveness of a certain measure to mitigate leaching needs to be evaluated according to the specific requirements of the country where the authorization of the product is sought. Therefore, the effectiveness of a specific measure may be considered differently among countries, reflecting differences in the environmental conditions, as well as differences in the applicable regulations.

Scientifically, the leaching of a compound through the soil into the groundwater layer is the result of a multitude of interactions driven by the compound properties, environmental conditions, and management practices, including management of the crop and pesticide application.

Among the compound properties, the degradation of the active ingredient and its transformation into metabolites, which can undergo further degradation and transformation, and the adsorption of the active substance and its metabolites to the soil dominate the leaching behaviour. While the compound properties are intrinsic to the compounds (active ingredients or metabolites) of a product and cannot be changed, their specific interaction with certain soil components offers scope for mitigation measures, which will be discussed in the following chapters.

Among the environmental conditions, the weather conditions, namely rainfall and temperature, play a crucial role; rainfall providing the driving force for the leaching process and temperature strongly influencing the transformation and degradation processes. The net water flow to the groundwater table is also dependent on evapotranspiration, which in turn is a function of soil moisture, temperature, and crop, and the impact of these factors can only be judged based on a detailed simulation. The effect on leaching is further complicated by the fact that the speed of transport of the compound through the different soil layers and the degradation of the compound is very specific to a substance and its interaction with the soil. It should be noted, that the seasonality of rainfall and temperature frequently offer scope for mitigation measures by defining appropriate application conditions. These will also be discussed in more detail below.

Management practices, e.g., restricting the application to certain time periods, geographic areas, band applications, considerations on crop rotations, etc. are the natural starting point to implement mitigation measures. These practices are deduced from the knowledge on how compound properties vary with the environmental conditions listed above, modeling can be used to estimate the effectiveness of a measure before to recommend it on the label.

5.2 Aspects relative to drainage

Drainage is one of the major potential entry routes of pesticides into surface water. Whereas risk mitigation measures (RMM) for the protection of surface water are discussed in chapter 4 the processes governing the transport of pesticides through the soil layer into underground drainage systems are closely related to the leaching of pesticides into groundwater. Therefore, many of the methods used to assess, as well as to reduce loadings to groundwater are also applicable to assess and reduce drainage loadings. However, there are some important differences that must be considered; for leaching to groundwater, permeable sandy soils are generally considered the most vulnerable situation. Consequently, corresponding scenarios and matrix flow models were selected for the majority of groundwater assessment schemes (e.g., FOCUS 2009). However, subsurface drainage systems are most commonly established in areas with more heavy cracking clay soils where transport via macropore flow plays a major, and occasionally dominant, role. Furthermore, a major objective of drainage systems is to discharge excess water that would limit suitability of land for arable use into surface water systems. Consequently, the assessment scheme currently used in the European authorization procedure (FOCUS 2001) defines a number of soil and weather scenarios representing realistic worst case conditions for drainage situations. These scenarios are implemented in a specific model (FOCUS-MACRO), which simulates matrix and macropore flow. Similar combinations of MACRO with specific scenarios have been established in the UK (CRD 2012).

Since the efficacy of a specific mitigation measure is dependent on the interaction of substance properties, use pattern, and the properties of the relevant drainage scenario, the efficacy must be specifically evaluated for the individual case. For drainage and leaching, this can most easily be done using the same simulation models and scenarios that are approved for the authorization process. However, the significantly faster nature of macropore flow compared with matrix flow encourages the use of monitoring studies to evaluate the efficacy of mitigation measures implemented to reduce surface water exposure via drainage.

Table 5.2 identifies the risk mitigation measures for groundwater protection that also apply to mitigate drainage loadings. In the discussion of the individual measures a more detailed description of the specific issues concerning the application to mitigation of drainage risks are given.

5.3 Review of the risk mitigation measures for groundwater in European countries

The Member States were asked to provide information about risk mitigation measures for groundwater protection with the purpose to:

- Identify the protection goals in relation to groundwater that is used in Member States
- Clarify some aspects of the risk mitigation toolboxes
- Obtain details on how these risk mitigation measures are implemented and monitored in the different Member States

In total, the group received feedback from 18 countries: 5 from the Southern zone, 8 from the Central zone (including Switzerland), and 5 from the Northern zone (including Norway). The results of the questionnaire are presented in Appendix 3.

Based on this feedback the toolbox for the protection of groundwater consists of:

- Risk mitigation measures based on the conditions of application
- Risk mitigation measures based on agricultural practices
- Risk mitigation measures based on the type of soil
- Risk mitigation measures based on geohydrological properties
- Exclusion zones (geography)
- Vulnerability maps

- Catchment management plans

The content of this feedback is summarized below and in Table 5.2.

5.3.1 Feedback relative to protection goals

With respect to the protection goal, 10 out of 15 answers (3 responses did not address this question) refer to groundwater protection from a precautionary point of view, meaning that groundwater in general is the protection goal. The other Member States consider groundwater used as drinking water to be the protection goal (3/15), whereas 2/15 of them refer to the protection goals defined in article 6 of the WFD, which refers, among others, to groundwater as (potential) drinking water source.

5.3.2 Feedback received on risk mitigation tools

Depending on the degree of consolidation among Member States risk mitigation measures were divided into the following categories (see introduction) for details.

<u>Category 1: Not to be promoted</u>

The group did not identify risk mitigation in this category.

<u>Category 2: Risk mitigation measures that need more research</u>

- Cover crops during winter
- Inter-row crop

“Cover crops during the winter period” or “inter-row crops” are considered to be promising risk mitigation measures for certain situations, however there is currently not sufficient information available to assess the technical feasibility or the agronomical practicability of these measures. Cover crops are requested already by the “nitrate directive” (EC 1991) therefore some Member States are willing to take cover crops into consideration for the risk assessment.

The effectiveness of the measures may vary with the respective situation and this would need further investigation. It is currently also uncertain how the measures could be used in the risk assessment and whether regulatory implementation could be easily done. Additionally, the enforceability of the measure is currently unknown. However, no zonal restrictions are foreseen (measure not limited to any zone). These measures are discussed in greater detail in Chapter 5.4.1.

These measures are currently not covered by the existing SPe-labeling phrases (see Chapter 3).

In principle, these measures may also be used to mitigate drainage risks, however this has not yet been investigated.

Category 3: Well documented risk mitigation measure implemented in few Member States (<30%), that may need more consolidation

Few countries (< 30%) reported to have implemented the following risk mitigation measure:

- Exclusion of zones with certain geohydrological properties (e.g., karstic areas)

This measure is technically feasible and the agronomical practicability at farmer-level considered to be high. The measure can be used within the risk assessment (e.g., within higher-tier risk assessment). The regulatory feasibility will depend on the Member State situation, but in general it should be high. The enforceability may also depend on the Member State situation (e.g., how clearly such zones are defined in each country). The measure is not considered to be limited to any zone.

In principle, this risk mitigation measure can be considered to be covered by the existing SPe2-label phrase of Regulation (EU) No. 547/2011, although more specific wording might be necessary.

The following more sophisticated approaches of this measure (to exclude certain geohydrological conditions) were discussed:

- Exclusion zones based on vulnerability maps
- Catchment management plans

Technically, the use of these measures will require detailed expertise and they can be cost and work intensive. However, these measures are considered to be highly effective tools as their application can lead to a high level of groundwater protection. Thus, the exploration of these measures is considered to be promising.

The “exclusion zones based on vulnerability maps” in a general sense are covered by the existing SPe2-label phrase of Regulation (EU) No. 547/2011, although some clarification would be needed. The risk mitigation measure on “catchment management plans” is not covered by any existing SPe-label phrase so far (see also Chapter 3).

Vulnerability maps and catchment management plans are principally applicable to mitigate drainage risk using similar approaches as described in Chapter 5.4.2 and 5.4.3., but will of course have to be tailored specifically for this purpose.

Category 4: Promising risk mitigation tool, established somewhere in the EU (30-50% of the Member States), and consolidated

The following tools are considered to belong to this category, as they were mentioned by about 30-50% of the countries:

- Application only during certain times of the year (“from [date] to [date]”)

This risk mitigation measure was reported from Member States of the Northern and Central zone only.

- Band application

The term band application refers to applying the product only on a strip of the field (in orchards also called inter-row application). Six countries (FI, IE, UK, ES, IT, and BG) answered positively, whereas LV explained in a more extensive response that they have considered band application in one case in a groundwater assessment. More refined precision farming practices were also mentioned, which could be termed “band application.” These are not considered here and will be discussed under Category 2.

- Exclusion of application in drinking water abstraction areas

The exclusion of application in drinking water abstraction areas is possible either by implementation on the label for a certain product or as a general requirement under water protection legislation. Exclusion can also be considered in this category, since from the responses it emerged that more than 30% of countries are using it, although this may be a restriction under other legislation than PPP.

The technical feasibility and agronomical practicability (at farmer-level) of these measures can be considered to be high. In general, the risk mitigation measures can easily be used in the risk assessment. The regulatory feasibility is high for all measures and they can be easily enforced (e.g., implementation on the product label).

”Band application” and the “exclusion of application in drinking water abstraction areas” can be considered to be highly effective (the latter is directed to the protection of drinking water resources). The effectiveness of “application only during certain time of the year” may vary, but can still be considered to be quantifiable using the accepted regulatory tools, especially leaching models and scenarios. The latter measure seems to be used only in the Northern and Central zone, which is probably due to climatic reasons. According to the responses to the questionnaire, “band application” is preferred in Southern zone countries, although in principle it could be applied in all zones. The risk mitigation measure for “exclusion zones in drinking water abstraction areas” should not be limited to any country or zone, either, and thus, no zonal aspects or limitations are foreseen for this measure. However, some legal aspects may restrict the applicability to groundwater protection in a specific Member State.

From the measures of category 4, the risk mitigation measure on “application only during certain times of the year” is reflected by an existing SPe1-label phrase of Regulation (EU) No. 547/2011 (EC 2011). The other measures from category 4 are not covered by existing SPe-label phrases, however the “exclusion zones for drinking water” are covered by other legislation (WFD).

Except the “exclusion of application in drinking water abstraction areas,” all these measures are equally applicable to mitigation of drainage risks, again with the reminder that their efficacy may differ and needs to be evaluated separately.

<u>Category 5: Well established in the EU, widely used and consolidated (>50% of the Member States)</u>

The following tools are identified within this category:

- Restriction of application to a certain growth stage of crop (mainly used in Member States of the Northern and Central zone; usually implicit part of the GAP)
- Restriction of application to a certain time of the year (e.g., exclusion of application in autumn or exclusion during periods of heavy rainfall)
- Maximum number of applications per year
- Maximum number of applications within a 2- or 3-year period

- Restriction of application for certain soil types or soil properties

These risk mitigation measures can easily be used in the risk assessment. Consequently, the regulatory feasibility is high and they can be easily enforced (e.g., implementation on the product label). No zonal aspects are foreseen for these measures, meaning that they can be implemented in all 3 zones equally.

The category 5 measures are covered by the currently existing label phrases SPe1 or SPe2, as defined in Regulation (EU) No. 547/2011 (EC 2011) (see also Chapter 3).

All risk mitigation measures are considered to apply for a fixed dose rate. However, it is recognized that the application rate is a critical parameter for groundwater leaching, and as a result of the evaluation process the application rate initially proposed in the GAP may eventually be reduced in the label.

The technical feasibility and agronomical practicability (at farmer-level) of these measures can be considered to be high.

The effectiveness with regard to groundwater protection is high for measures such as restriction of maximum number of applications per year, maximum number of applications within a 2- or 3-year period, restriction for certain soil types, or soil properties. On the other hand, the effectiveness of measures such as restriction to certain growth stage of the crop or restriction of application to certain times of the year may vary, depending on the substance properties and situation, but are still considered to be quantifiable (e.g., by groundwater modeling).

Most of these measures are also applicable to the mitigation of drainage risks. However, as explained above, their effectiveness at mitigating drainage risks may be significantly different from mitigating leaching risks. The exceptions are the measures based on a reduction of the number of applications. While leaching is usually a cumulative process, where the rate applied cumulatively over 1 or even 2 or 3 years determines the amount leaching to groundwater, drainage is much more an event driven process where each individual application may cause a drainage event. Therefore, these measures are expected to be significantly less effective to reduce drainage risk than leaching risk. However, generally it should be possible to evaluate their effectiveness and reduce drainage risks using the regulatory approved models and scenarios.

5.3.3 Feedback received on implementation and monitoring

The feedback to the questionnaires clearly shows that in many countries the authority issuing the approval of a PPP is not the same as the one concerned with the enforcement of risk mitigation measures and monitoring programs.

The majority of Member States answered that SPe1 and 2 measures are implemented as a general rule and not in connection to vulnerable locations (in context of WFD).

Quite a number of Member States (12) answered that they have implemented monitoring programs, but in general these are not aimed at targeting the success of risk mitigation measures, but to fulfill other legislations (e.g., WFD).

5.3.4 Overview of the toolbox on risk mitigation measures for groundwater

The resulting toolbox is presented in Table 5.2.

Apart from the categorization already described above, each risk mitigation measure is also characterized according to:

Technical Feasibility: Estimate of the effort needed to implementing the risk mitigation measure.

High: No technical issues with the implementation of the risk mitigation measure.

Low: Significant additional effort necessary to develop and implement the risk mitigation measure.

Effectiveness: Estimate of the effectivity of the risk mitigation measure to reduce risk.

Variable: Effectiveness of the risk mitigation measure depends on the properties of the product (active ingredient) and their interaction with environmental and agronomic factors. Effectiveness of risk reduction can be quantified with methods commonly used and accepted in regulatory risk assessments.

Agronomical Practicability: Fit of the risk mitigation measure into current agronomical practice.

Use in Risk Assessment: Fit of the risk mitigation measure into regulatory risk assessment practices and procedures.

Legal and Regulatory Feasibility: Fit of the risk mitigation measure into the current regulatory and legal framework.

High: No regulatory or legal obstacles to the implementation of the risk mitigation measure.

Low: Major regulatory or legal changes required to implement risk mitigation measures.

Zonal Aspect: Zonal aspects need to be considered for the risk mitigation measure (yes or no).

Enforceability: Use of the risk mitigation measure by the farmer can be enforced and controlled by authorities.

Applicability to drainage: Risk mitigation measure can be applied to mitigate risks to surface water arising from drainage.

Table 5.2 Summary of the risk mitigation measures for groundwater inventoried through the questionnaires and during the workshop, including the feedback on their technical feasibility, effectiveness, practicability, enforceability, and possibility to take into account into risk assessments.

Risk Mitigation Measure	Status[1]	Technical Feasibility	Effectiveness	Agronomical Practicability	Use in Risk Assessment	Legal & Regulatory Feasibility	Zonal Aspects	Enforce-ability	Label Phrase	Comments	Applicable to Drainage
Conditions of application											
Restriction of application to certain growth stage (RMMTS #20)	5	High	Variable	High	Yes	High	No	Yes	SPe 1	Usually implicitly part of the conditions of use (GAP)	Yes
Restriction of application to certain time of the year (RMMTS #18)	5	High	Variable	High	Yes	High	No	Yes	SPe 1		Yes
Application only from (date to date)	4	High	Variable	High	Yes	High	Yes	Yes	SPe 1	Only in Northern and Central Zone	Yes
Max number of applications (RMMTS #17a)	5	High	High	High	Yes	High	No	Yes	SPe 1		Limited

Risk Mitigation Measure	Status[1]	Technical Feasibility	Effectiveness	Agronomical Practicability	Use in Risk Assessment	Legal & Regulatory Feasibility	Zonal Aspects	Enforce-ability	Label Phrase	Comments	Applicable to Drainage
Within 2yr/3yr period (RMMTS # 17b)	5	High	High	High	Yes	High	No	Yes	SPe 1		No
Agricultural Practices											
Band application (RMMTS #21)	4	High	High	High	Yes	High	No	Yes	New SPe X		Yes
Cover crops during winter (RMMTS #22)	2	Medium	Variable (needs investigation)	Unknown	Unknown	Medium	No (MS issue)	Unknown	New SPe X	Considered in some MS (already requested by "nitrate directive") modeling results need validation	Needs investigation
Inter-row crops	2	Medium	Variable (needs investigation)	High	Unkown	Unknown	Yes	Unknown	New SPe X		Needs investigation
Soil Properties											
Soil type, -parameter (RMMTS # 19)	5	High	Variable	High	Yes	High	High	High	SPe 2	Suitable communication in the label	Yes
Geography											
Geohydrological properties (RMMTS #23a)	4	High	High	High	Yes	High depending on MS	No (MS issue)	Medium depending on MS	SPe 2, but needs clarification		No
Exclusion based on vulnerability maps (RMMTS #24)	3	Medium	High	Medium	Yes	Medium review by national authorities	No (MS issue)	Review by national authorities	SPe 2, but needs clarification	Communication of the vulnerability map, differentiation between generic and product specific maps	Yes
Exclusion of drinking water (DW) abstraction	3-4 depending on MS	High	High (drinking water)	High	Depending on MS	High	No (MS issue)	High	Covered in WFD	Depends on the definition of	No
areas (RMMTS #23b)										DW abstraction well or area	
Catchment management plans	4 strongly depending on MS	Medium cost and work intensive	High	Medium (cost and work intensive)	No	Medium	No (MS issue)	difficult	New SPe X	Presently mostly applied to DW catchments	No

Status:

1. Not to be promoted
2. Under development
3. Needs consolidation and research
4. Promising tool implemented in some Member States
5. Well established tool implemented in most Member States

5.4 Proposed risk mitigation measures deserving further investigation

In addition to the risk management measures that are already implemented on a more or less common basis (described in the previous section) there are a number of additional measures identified in the workshops that deserve further investigation.

5.4.1 Cover crops

A cover crop is a temporary vegetative cover that is used to protect the soil and the establishment of plants, particularly those that are slow growing (OECD 2001). Dabney et al. (2010) specified a catch crop as a cover crop that is established to take up plant-available nitrogen in the soil and thereby reduce nitrogen leaching losses. In the following general discussion, the term 'cover crops' subsumes all kinds of cover crops (e.g., catch crops, inter-crops during winter ['intermediate crops'], inter-row cropping in orchards, vines, or other tall-growing crops).

It was demonstrated that cover crops reduced nitrogen leaching (Sieling and Kage 2010, Spiess et al. 2011). In principle, these beneficial effects can be expected for other substances, such as heavy metals or pesticides, too. Therefore, cover crops are being considered as a mitigation measure for pesticide leaching, as well. The effects of cover crops on pesticide behavior in soils are manifold, and vary from clear beneficial aspects, such as pesticide crop uptake or reducing contaminated water leached into the groundwater aquifer, through ambiguous effects that may be substance- or site-specific to adverse effects, e.g., effects, which may be caused by treating cover crops with pesticides, thereby increasing the total applied rate.

Unlike nitrogen leaching, the influence of cover crops on leaching resulting from treatments to the preceding crop has not been studied intensively. The mechanisms for preventing pesticide leaching using cover crops are not always the same with those used to prevent nitrogen leaching, since nitrogen, in the form of nitrate, is a nutrient and therefore generally needed and taken up by plants, whereas pesticides may or may not be taken up easily by plants. In addition to substance uptake, cover crops can influence water balance in a way that further reduces pesticide leaching. Finally, processes such as sorption behavior or biotic and abiotic degradation and dissipation are highly diverse for the environmental fate of pesticides, whereas sorption is not relevant to nitrate leaching and the processes steering the N-cycle (N-transformation), which may be different or have a different weight than those steering degradation and dissipation of pesticides. Nevertheless, in the following chapter, some conclusions are drawn from the well-known research field about cover crop effects on nitrogen leaching. An overview on the potential of cover crops to reduce nitrate leaching was conducted recently in France, and is summarized in Justes et al. (2012, 2013).

5.4.1.1 Benefits of cover crops

Cover crops show several advantages:

1. Reduction of soil erosion and enhancement of the stability of the soil structure

Cover crops protect the soil very well and lead to a reduction of soil erosion. If erosion does occur, it usually follows sowing the cover crop (Prasuhn 2012). Intense rooting of the upper soil levels leads to aggregate and pore stabilization and to the formation of biopores. Both factors reduce the vulnerability to runoff and erosion (Bodner 2012).

Arable land covered by any kind of crop leads to reduced wind erosion compared with fallow land, since the plant cover reduces the wind speed slightly above the soil surface and the rooting system stabilizes the soil structure.

2. Reduction of nutrient losses to ground and surface water (nitrogen and phosphorus)

Catch crops are currently mainly used to minimize nitrogen loss. They can take up large amounts of nitrogen, and reduce the amount available for leaching (Sieling and Kage 2010). Furthermore, the use of cover crops can lead to a significant reduction of the seepage water volume (Spiess et al. 2011). In temperate climate, nitrogen leaching occurs when rainfall exceeds evapotranspiration, which is mainly the case in autumn and winter (van Dam 2006). When cover crops are successfully established they are generally able to reduce nitrate leaching. However, long-term effects may lead to a flush of nitrate when cover cropping is ceased (Stevens and Quinton 2009).

The loss of particulate phosphorus by runoff can be reduced by the use of cover crops. On the other hand, cover crops can lead to an increased loss of the dissolved reactive phosphorus that is biologically available (Stevens and Quinton 2009). The effect on particulate-bound phosphorus is controversial, as other sources show that the use of catch crops has not reduced those losses to any larger extent (Bergstrom 2004).

3. Reduction of pesticide losses to surface and groundwater

Soil adsorption of pesticides generally increases with increasing organic matter content and cation exchange capacity, where the latter is correlated with the soil organic matter content. Cover cropping is generally known to increase soil organic matter either through residues from roots or from whole plants that are incorporated into the top soil. The quality and quantity of organic residues that affect pesticide sorption depends on the type of cover crops. Further, microbial activity may be positively affected by cover cropping leading to additional increased degradation of pesticides. Several lab and field studies investigating the influence of cover crops on pesticides (mainly herbicides) were done on different soils.

The influence of cover crop residues on the sorption of three pesticides (two herbicides and one fungicide) with differing physicochemical characteristics was studied in batch experiments and showed that the type of cover crop and the decomposition level of cover crop residues influenced the mobility of the pesticides (Cassigneul et al. 2013). Another study about the influence of cover crop residues on herbicide sorption corroborated evidence that plant residues can temporarily intercept and retain the herbicide (Reddy et al. 1995). In a laboratory study, the effect of different tillage and cover crop combinations on the behavior of an herbicide was studied with soil from cotton fields (Brown et al. 1994). The results indicated that tillage and cover crop may alter the physical and chemical properties of the soil affecting microbial degradation and bioavailability of the investigated herbicide. Reduced tillage and cover cropping led to increased sorption of the tested substance. A study performed in the southwest of Spain showed that the behavior of an herbicide used in an olive orchard is influenced by soil management (Hermosín et al. 2013). The results indicated that cover crops are not only relevant to decrease the run-off process, but also the herbicide leaching by increasing irreversible adsorption to soil. A study on a loamy soil in the south of France investigated herbicide degradation and leaching in a maize field as a function of tillage and fallow period management (Aletto et al. 2012). The use of cover crops resulted in lower herbicide losses compared with bare soil. In another study on maize fields (sweet corn) in Florida an herbicide and 3 metabolites were measured in shallow groundwater samples collected near the fields (Potter and Bosch 2007). The measurements showed that the concentrations of the herbicide and the degradation products were significantly lower in samples collected beneath cover crop plots compared with fallow plots. In a similar field experiment on maize plots in Florida, the transport of another pesticide and its metabolites to shallow groundwater was studied (White et al. 2009). The concentrations in groundwater were again significantly higher beneath the non-cover cropped plots indicating that cover cropping leads to more rapid dissipation or reduced leaching.

The studies confirmed that, at least for the investigated compounds, the use of cover crops can lead to a reduction of leaching by reducing the available amount for transportation through enhanced degradation or increasing the sorption processes.

The use of cover crops might also increase the plant uptake of the active substance or the metabolites compared with bare soil, which means that a smaller amount of the applied pesticide is available for transport to surface water or groundwater. If the cover crop is not removed from the field but incorporated, at the least part of substance taken up by the cover crops but not metabolized within the plants is introduced to the top soil again. Also, of note this happens at the beginning of the vegetation period, a time when leaching is reduced. Finally, compound residues in cover crops that are afterwards incorporated into the soil may lead to a relocation from deeper soil layers into the upper top soil where microbial activity and organic matter content is highest.

5.4.1.2 Drawbacks of cover crops

The research on the effect of cover crops on pesticides is often linked to the adapted use of pesticides. The amount of pesticide applied might be higher or lower after the introduction of cover crops. For example, herbicide use is decreased if weeds are suppressed by cover crops. However, if cover crops are difficult to control, herbicide use increases (Dabney et al. 2001). Cover crops might affect the development of the next crop by competing for nitrogen or water. Furthermore, there could be toxic effects (“allelopathy”) or the cover crop might serve as host for pests and diseases (Shepherd 1999). Finally, the establishment of cover crops causes additional expenses for the farmers (e.g., sawing or mulching).

Those disadvantages should be kept in mind when suggesting cover crops as a risk mitigation measure for a certain PPP.

5.4.1.3 Legal and economic aspects

In the European Union, there are several directives and regulations that are dealing to a greater or lesser extent with cover crop management:

1. The EU Nitrates Directive

The EU Nitrates Directive was enacted 1991 to protect the quality of ground and surface waters (EC 1991). To decrease the pollution by nitrates from agricultural sources, the Member States are required to designate nitrate vulnerable zones and to establish action programs that apply within designated vulnerable zones or to the whole territory (EC 2013b). One goal of the directive is to establish a series of codes of good agricultural practice that are implemented by farmers on a voluntary basis. Those codes should include, among others, crop rotations, soil winter cover, and catch crops to prevent nitrate leaching and run-off during wet seasons (http://ec.europa.eu/environment/water/water-nitrates/index_en.html.

2. The EU Water Framework Directive

In 2000, the Water Framework Directive (WFD) was adopted by the European Union to manage and protect water based on river basins (EC 2000). The WFD itself does not directly address crop management, but it mentions the promotion of low-water requiring crops as supplementary measures that could be considered by Member States (Henriksen et al. 2011).

3. Common Agricultural Policy

The EU Common Agricultural Policy (CAP) was created 1962 to ensure food security and to enable farmers to make a reasonable living (EC 2013d). Today, more challenges have to be addressed such as food security at a global level, climate change, and sustainable management of natural resources. The CAP is based on four EU regulations concerning rural development (EC 2013c), “horizontal” issues such as funding and controls (EC 2013d), direct payments for farmers (EC 2013e) and market measures (EC 2013f). According to the legislation about the rules of direct payments (Art. 46), farmers shall ensure that at least 5% of the arable land of the holding of the farmer (applies for farms >15 ha arable land) is ecological focus area (EC 2013e). Furthermore, the Member States were to decide by August 2014 which areas are to be considered to be ecological focus area.

One of the possible areas are "(i) areas with catch crops, or green cover established by the planting and germination of seeds (…)." This means that the establishment of catch crops may be more attractive to farmers in the future.

4. Cover crops at Member State-level

According to the Baltic Deal, a flagship project of the EU Strategy for the Baltic Sea Region (from 2010 to 2013), some of the countries around the Baltic Sea are financing measures that include cover crops (Baltic Deal 2013). For example, farmers in Finland can get support for growing catch crops. In Denmark on the other hand, the farmers do not receive any financial compensation for catch crops.

In Germany, the growing of cover crops is eligible for grants in order to protect soil and groundwater, the latter particularly in the context of the implementation of the Water Framework Directive (Landwirtschaftskammer 2013). The federal state of Lower Saxony, for example, explains the subsidies in the following way: "all states of Germany reward the use of cover crops to protect the soil from erosion and export of nutrients, to enhance biological activity and soil structure and to protect groundwater" (Saaten Union 2014).

In France, within the framework of the 4th National Action Program on the Implementation of the Nitrates Directive (91/676/EEC), it was prescribed that in areas classified as "vulnerable zones" the surface of agricultural fields must be covered in autumn and winter: either by winter crops, cover crops, volunteer oilseed rape (before winter cereals in rape – cereal rotations), or finely chopped and superficially incorporated maize stubbles (Ministere 2008). The vulnerable zones are defined as those with a high risk of nitrate pollution of ground and surface water and mainly reflect the areas with high agricultural intensity. They are regularly updated based on surface water and groundwater monitoring results for nitrate and currently cover about 55 % of the agricultural area of France (http://www.developpement-durable.gouv.fr/Directive-Nitrates-les-zones.html, visited 26 October 2015). However, exemptions from the obligation to maintain the soil covered in vulnerable zones can be obtained, e.g., for soils with high clay content (Chambre d'Agriculture de la Region Nord-Pas-de-Calais 2015).

5.4.1.4 Implementation of cover crops as a potential mitigation measure within the groundwater risk assessment of the European authorization system of plant protection products

The groundwater risk assessment within the current authorization system for plant protection products (PPP) in the EU (Regulation [EC] No. 1107/2009; EC 2009) is based on scenario-based modeling including annually repeated cropping and application over an assessment period of 20 years (i.e., monoculture) of the pesticide under investigation. The scenarios are developed for the models PEARL, PELMO, PRZM, and MACRO as defined by the FOCUS groundwater guidance documents (FOCUS 2000, EC 2014). It is suggested that if the beneficial effects of cover crops are intended to be used for reducing substance loads into groundwater, the effectiveness of this mitigation measure may be proven for each use by integrating cover crops into the existing FOCUS groundwater assessment.

The MAgPIE groundwater subgroup dealing with cover crops tested the general feasibility of implementing cover crops into FOCUS-PEARL 4.4.4 and concluded that observations described in the following need to be discussed prior to judging the degree of mitigation cover crops may contribute to within the EU PPP authorization process:

- Decision for which combination of FOCUS groundwater scenario and crop cover cropping can be reasonably parameterized, i.e., development of suitable ‘crop rotations’ between the main crop and the cover crop
- Parameterization of agronomic dates of cover crops (sawing, emergence, harvest, etc.) and possible adjustment of such dates for main crops
- Parameterization of crop factors influencing water balance and subsequent potential substance uptake
- Consideration of the relevance and informational value of the PECgw (as currently defined in FOCUS groundwater) when cover cropping influences the water balance so that PECgw may increase although substance loads are reduced
- Implementation of cover crops into different FOCUS groundwater models and comparison of results
- Validation of the modeling approach based on field experiments

To harmonize the risk assessment and to overcome simplifications of the scenario-based modeling it is concluded that further investigations on how to integrate cover crop systems into regulatory environmental exposure modeling are considered necessary, and a specific guidance on how to implement cover crops into FOCUS groundwater models, as well as on how to interpret the results, is recommended.

5.4.1.5 Conclusion

There are many environmentally beneficial aspects of implementation of cover crops that led to their promotion within the EU CAP system and other national programs. Agronomic recommendations on environmental and economic effective cover cropping systems should be developed to assist farmers in setting up most efficient management systems to reduce pesticide leaching. Such recommendations should take into account other environmental impact of cover cropping (e.g., potentially reduced N-fertilization, reduced erosion).

Cover crops, as a promising mitigation measure, could also be implemented in the PPP authorization process at Member State-level. Since the effect of cover crops on the reduction of pesticide leaching may depend on several factors, such as soil climatic conditions, agronomic conditions of cash and cover crops, as well as substance properties, it is suggested to use appropriate computer modeling techniques to assess the expected effect on pesticide leaching. Since FOCUS groundwater models and scenarios are currently not parameterized for cover crops, it is recommended that a guidance for good modeling practice applied to cover crops should be developed in which the respective adjustments to existent FOCUS parameterization are explained.

5.4.2 Groundwater vulnerability maps

5.4.2.1 What is groundwater vulnerability?

No generally accepted definition of groundwater vulnerability exists; however, the concept describes the relative ease with which groundwater resources could be contaminated from surface activities and result in a degradation of water quality (Liggett and Talwar 2009). Groundwater vulnerability to contamination was defined by the US National Research Council as “the tendency or likelihood for contaminants to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer.”

In this section we only focus on pesticides as potential contaminant although other organic, inorganic, or biological contaminants exists (e.g., fertilizers, landfills, chemical spills, and septic systems).

The literature proposes two concepts of “groundwater vulnerability” exist and have to be distinguished, cf. Focazio et al. (1984) and Zwahlen (2003): intrinsic vulnerability (or aquifer sensitivity, intrinsic susceptibility) in a broader sense and specific vulnerability (or only groundwater vulnerability) in its literal sense. Intrinsic vulnerability of a groundwater system depends on the geological, hydrological, and hydrogeological characteristics of an aquifer and overlying material, but is independent of the nature of the contaminant and its sources. Intrinsic susceptibility assessments therefore do not target specific natural or anthropogenic sources of contamination, but instead consider only the physical factors affecting the flow of water to, and through, the groundwater resource. Specific vulnerability of groundwater also accounts for the transport and fate properties of a particular pesticide within the unsaturated zone in addition to the physical characteristics of the environment.

In this context, the breakout group proposes the following definition of groundwater vulnerability to pesticide leaching:

Groundwater vulnerability is the likelihood that under prevailing pedoclimatic conditions the concentrations in groundwater of an active ingredient or relevant metabolites exceeds relevant trigger values. The assessment is related to the area of use of a PPP. As vulnerability is spatially dependent it may relate to regional subunits of the area of use.

5.4.2.2 Mapping groundwater vulnerability

Groundwater vulnerability assessments often result in a map of areas where the groundwater is vulnerable to contamination from PPP. The objective of mapping groundwater vulnerability is therefore the delineation of areas in which the concentrations of a substance of interest in groundwater are likely to exceed relevant trigger values. Based on these maps areas can be prioritized for further investigation, monitoring, and protection if the need is identified.

In the “problem formulation” stage for each mapping project there is a need to define the “environmentally relevant type of concentrations” under consideration including a definition of what is meant by “groundwater” and its temporal and spatial variability. The relevant “trigger values” that should not be breached also have to be provided. The definition of “likelihood for exceedance” deserves some further attention and it should be made clear if this is expressed in quantitative terms (“model output shows concentrations > 0.1 µg/L “) or in relative terms (“relatively more vulnerable than …”).

5.4.2.3 Types of groundwater vulnerablity maps

Taking the definitions of the different concepts of groundwater vulnerability into account different types of groundwater vulnerability maps have to be distinguished.

- Maps of intrinsically vulnerable areas

  In this context maps will give information on the intrinsic vulnerability of an area for pesticide leaching to groundwater. The intrinsic vulnerability is typically expressed in relative categories of vulnerability (e.g., low, medium, and high). A combination of different maps of relevant pedoclimatic and hydrologic properties determine the extent of generic vulnerable areas.

- Substance-specific groundwater vulnerability maps

  Substance-specific vulnerability maps represent the graphical representation of a spatial leaching risk assessment for a given substance. This could vary from a simple and qualitative indexing or overlay assessment to complex, quantitative numerical assessments of groundwater concentrations using leaching models.

- General exclusion zones

  In addition to these two types of vulnerability maps there exist some areas that can be considered as vulnerable, not because of their intrinsic vulnerability, but are determined by legal or other frameworks that may originate from e.g., general hygienic considerations for the protection of abstraction wells.

5.4.2.4 Mapping approaches for groundwater vulnerability

A number of methods to generate vulnerability maps were identified in the breakout group and a list has been compiled (see Appendix 4). The mapping approaches described here can be divided into three major groups: process-based methods, statistical methods, and index methods. Detailed information on the different methods can be found in more comprehensive review studies (Gogu and Dassargues 2000, Focazio et al. 1984, Zwahlen 2003).

Spatially distributed process modeling is based on the use of process-based groundwater leaching models. A large number of scenarios with input parameters relevant to specific locations are calculated with these models and the results are presented as a map. The advantage of this approach is that it provides a quantitative estimation of groundwater vulnerability. However, the models require detailed soil descriptions and high resolution meteorological time series data, which can be difficult to obtain and the approach is computationally intensive. Examples of process based models are EuroPEARL (European level), SuSAP-PELMO, or GeoPEARL (national or regional level).

Vulnerability mapping using statistical methods is based on the correlation between the pedoclimatic conditions that control leaching and the occurrence of pollutants in groundwater. These models can be process-based regression models (e.g., MetaPEARL, the metamodel of the PEARL leaching model), or more sophisticated purely statistical approaches such as Bayesian methods or fuzzy logic approaches. These methods are easily applicable to GIS data, however, they are very dependent on the quality of the input data.

Index methods combine data in a GIS using simple logical rules and corresponding arithmetic rules (mostly linear combination of attributes or parameters) to yield a vulnerability index. Weights can be assigned to different attributes in terms of the sensitivity of individual parameters to leaching (FOCUS 2009). The advantage of index methods is their relatively simple usage. They can easily be integrated in a GIS environment and use data that is readily available. The drawback, however, is the arbitrary selection of weights for the different model parameters. This makes these approaches difficult to reproduce. The most prominent example of an index method is the DRASTIC model (Aller et al. 1987). Index methods can be used to map intrinsic vulnerability and compound-specific vulnerability.

- Generic Approaches

  When developing generic approaches for groundwater vulnerability mapping a differentiation can be made if substance properties are considered for defining areas that are, or not vulnerable.

1. Substance independent ("areas with increased potential of leaching to groundwater") - i.e., intrinsic vulnerability
2. Substance- or product-specific vulnerability maps

Components for groundwater vulnerability mapping

The components required for a groundwater vulnerability assessment that are site-specific or substance-independent are the environmental conditions, hydrology management, and the generic use areas. The substance related components, depicted in Figure 5.1, encompass the application scenario and the compound properties.

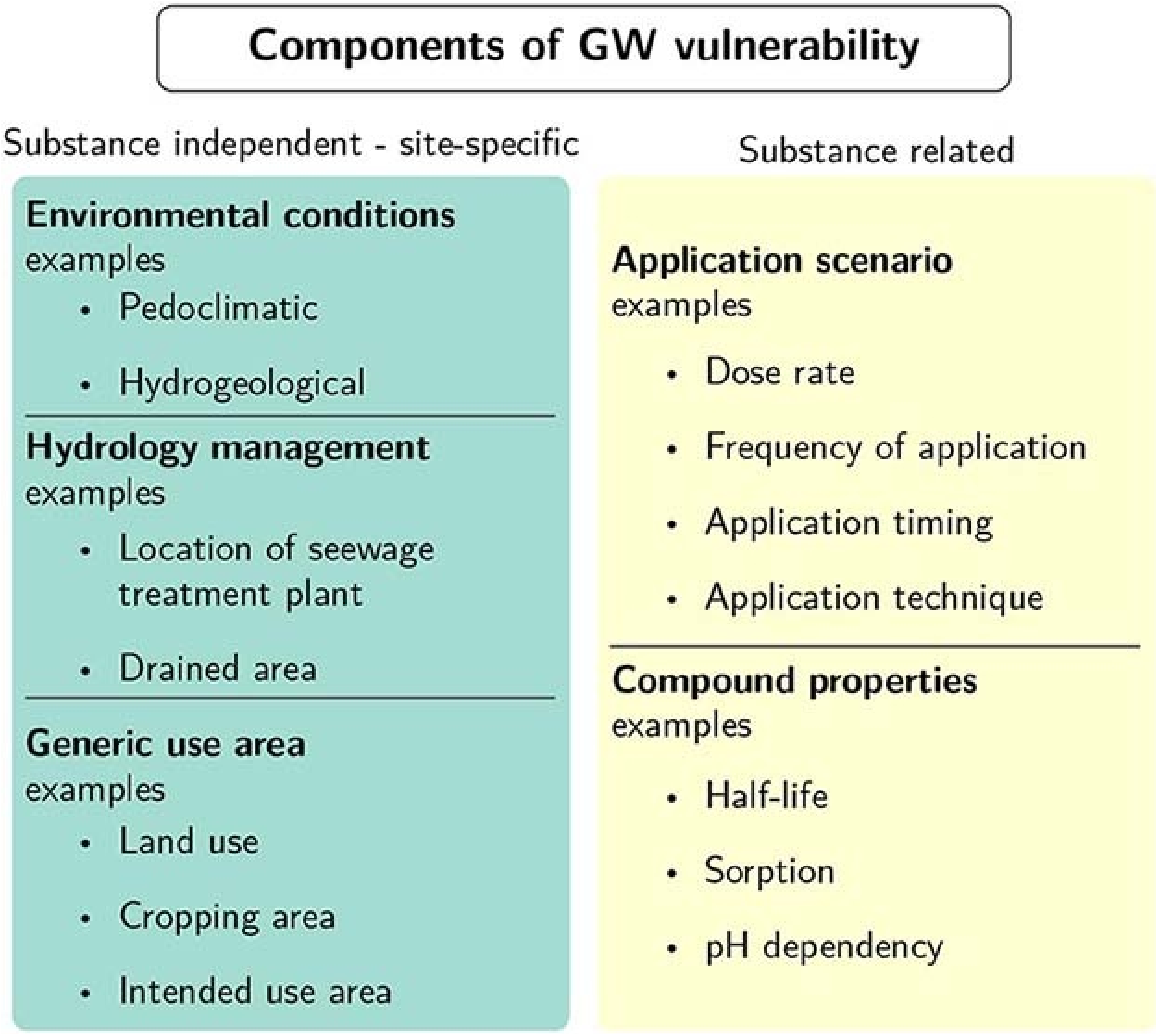

Figure 5.1: Components of groundwater vulnerability

5.4.2.4.1 Approach 1: Mapping of intrinsic vulnerability, independent of substance properties

To delineate areas with increased potential of leaching to groundwater "independent of substance properties" (approach 1) the agricultural area of interest has to be overlayed with a vulnerability index based on a combination of different data layers in a GIS. The crucial point is how the relevance for leaching of environmental parameters can be defined.

Subsequently, an overlay with spatial hydrogeological information, such as drinking water protection areas, 5 year upstream contribution areas for drinking water abstraction wells, or other relevant information that is not considered by the vulnerability index, will further improve the generic mapping of vulnerable areas independent of substance properties. The procedure is outlined in Figure 5.2.

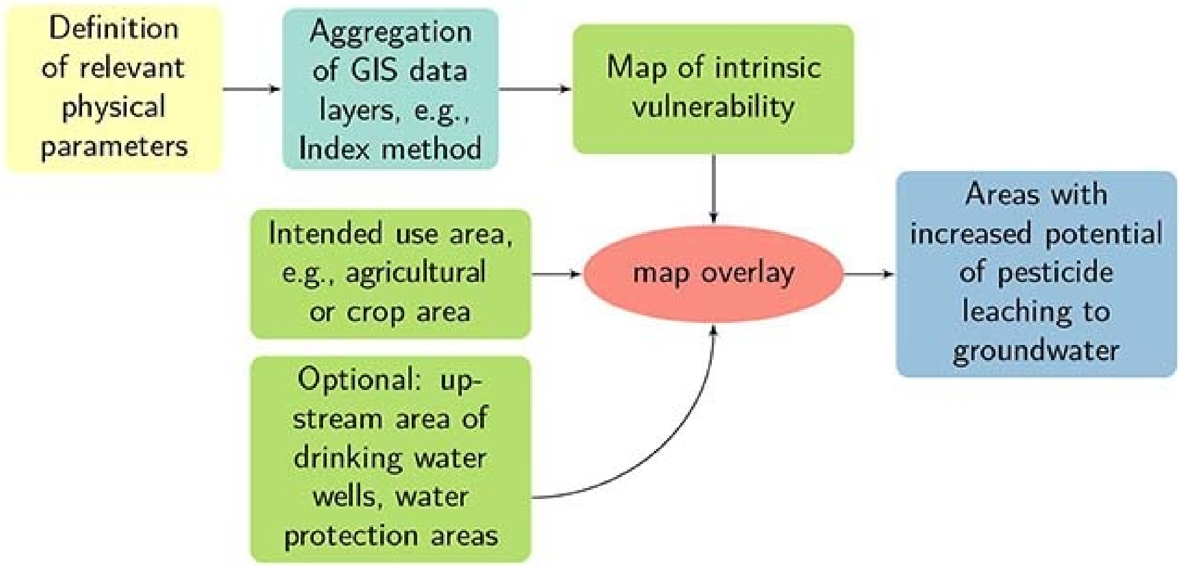

Figure 5.2: Mapping of areas with increased potential of leaching to groundwater, independent of substance properties (approach 1)

5.4.2.4.2 Approach 2a/2b: Specific vulnerability mapping considering substance properties

Two methods are presented for considering substance specific information in vulnerability mapping (approach 2), of which one will be recommended as a preferred option.

The first method (approach 2a) allows to include non-linear processes, which are important factors in the leaching assessment in the creation of substance specific vulnerability maps.

The core of this method is a process-based, spatially explicit model, which is fed with substance independent information on the intended use area and environmental conditions, and combines these with substance related information about the application scenarios and compound properties. The result is a substance specific vulnerability map, which would require a verification step such as ground truthing with regional specific additional information before use in practice. The procedure is outlined in Figure 5.3. Where the data are available, approach 2a is the preferred option.

If sufficient data are available the process-based, spatially explicit model could be a fully physically based model such as Geopearl, which is used in the national authorization in the Netherlands. However, as detailed data are missing for significant areas of the EU it is advisable to revise the ambitions and also consider as a start a process-based statistical metamodel that mimics the full physical model, but requires less spatial data (approach 2b).

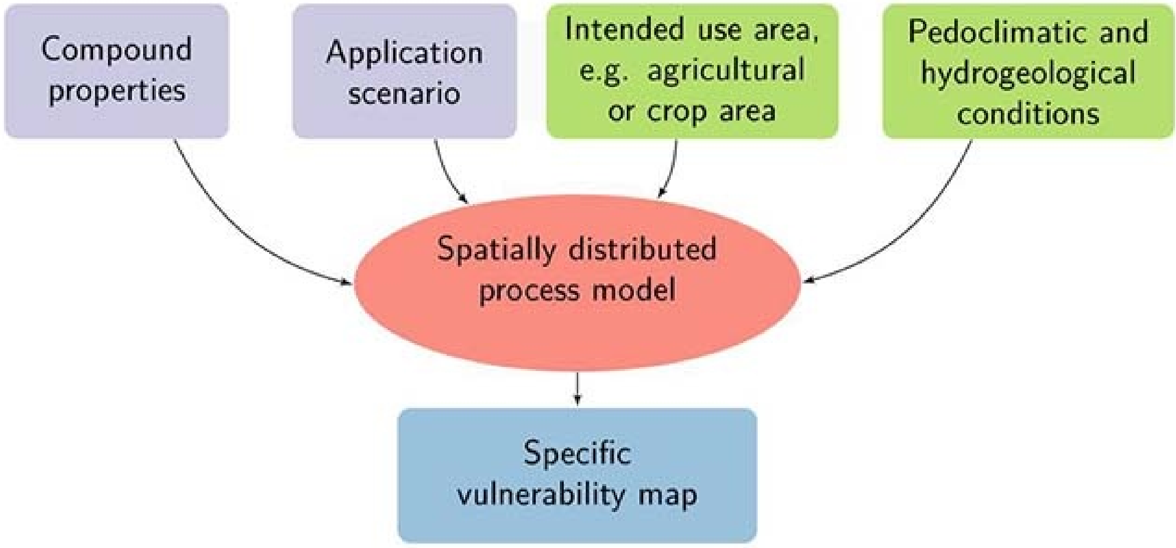

Figure 5.3: Mapping of areas with increased potential of leaching to groundwater (dependent of substance properties) (approach 2a).

Approach 2b is appropriate for linear combinations and is shown in Figure 5.4.

Based on an analysis of the sensitivity of compound properties and key environmental parameters for leaching to groundwater are determined.

As there is insufficient information available to cover the whole intended area of use it is recommended to select a limited number of scenarios that are known to be from the use area. A sensitivity analysis has to be conducted on the results of modeling performed using a process-based leaching model and is used to characterize how the calculated leaching concentrations are affected by varying the environmental parameters (within reasonable ranges). In this way different weights can be attributed to environmental properties with which the pesticide parameters interact or which have a significant impact (e.g., time of rainfall). The difference to approach 2a is that the sensitivity is determined generically, not taking into account knowledge of the intended use area. Alternatively to the weighting approach or in addition one or more substance specific GIS layers could be generated, e.g., a layer of spatially varying Freundlich values calculated with a pedotransfer function. Subsequently, the information is combined with key GIS data in a form of index method and results in a compound-specific vulnerability map for the whole region of interest. An overlay with the potential use area of the compound results in a vulnerability map that considers substance-specific information (compound properties and use pattern).

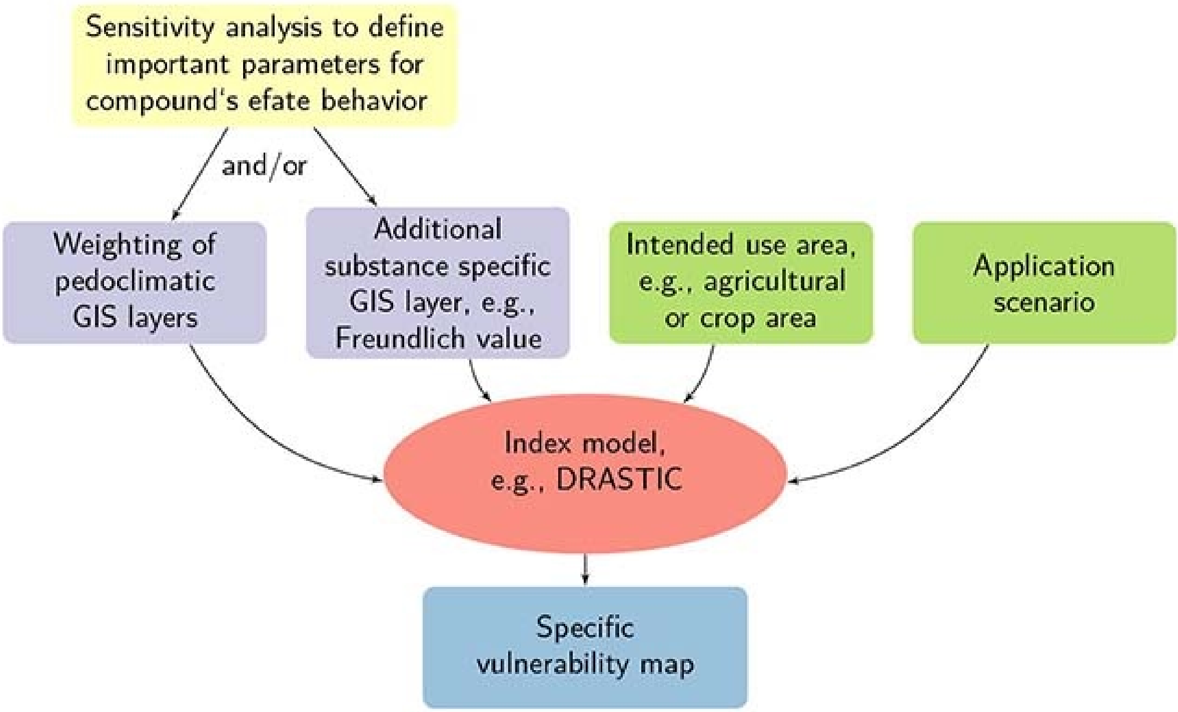

Figure 5.4: Mapping of areas with increased potential of leaching to groundwater (dependent of substance properties) (approach 2b).

It should, however, be noted that vulnerability mapping may be only the first step in the definition of vulnerable areas. A further refinement could be the detailed analysis of the hydrogeology of areas defined as vulnerable (e.g., the absence of unconfined aquifers may mitigate the problem). Appendices 5 and 6 provide further details on GIS data available in Member States for vulnerability mapping.

5.4.3 Groundwater catchment management plans (case study in England)

5.4.3.1 Introduction

Some Member States consider drinking water abstraction directly within their approvals process, for example in the Netherlands where modeled GeoPEARL 90th spatial percentile predicted environmental concentrations >0.01 µg/L, but <0.1 µg/L, and products may be registered for use with exclusion in drinking water protection areas. Other Member States, e.g., the UK Chemicals Regulation Directorate (CRD), do not consider drinking water protection areas explicitly within their groundwater risk assessments, as they do not allow authorization with a label restriction to exclude use in drinking water protection areas.

On occasion, the active ingredients of PPP authorized for use may be found in groundwater. In some instances this is a result of poor agricultural practice and in others it results from vulnerable real world catchment conditions, both of which may be addressed by catchment management approaches as a post approvals activity. Water Framework Directive (WFD) failures are increasingly putting pressure on authorizations made under the PPP directive (1107/2009/EC), however, the groundwater areas that are affected by WFD failures are generally small and limited to a few currently registered active ingredients. Of the 304 groundwater bodies in England and Wales, 16 (just over 5%) failed WFD 'good status' because of substances that have been (11 groundwater bodies) or are still being used (5 groundwater bodies) as pesticides (currently bentazone and mecoprop-P) according to the Pesticides Forum annual report (2012). Detection of an active ingredient in groundwater, and specifically drinking water, may be dealt with through a post-approvals process in the first instance. Since such management plans are dependent on the specific issue that needs to be managed, as well as the legal and institutional preconditions, the current regulatory mechanisms and context in England are described in this chapter as a case study. It is not intended to be a definitive review of catchment management and its effectiveness and is a work in progress.

5.4.3.2 Regulatory Background

In accordance with the Water Framework Directive article 7, England has defined groundwater bodies that comprise drinking water protected areas (See Figure 5.5), being bodies of groundwater:

i. used, or planned to be used, for the abstraction of water intended for human consumption; and

ii. providing, or planned to provide, a total of more than 10 cubic metres of water per day on average, or serving, or planned to serve, more than 50 people (UKWFD 2009).

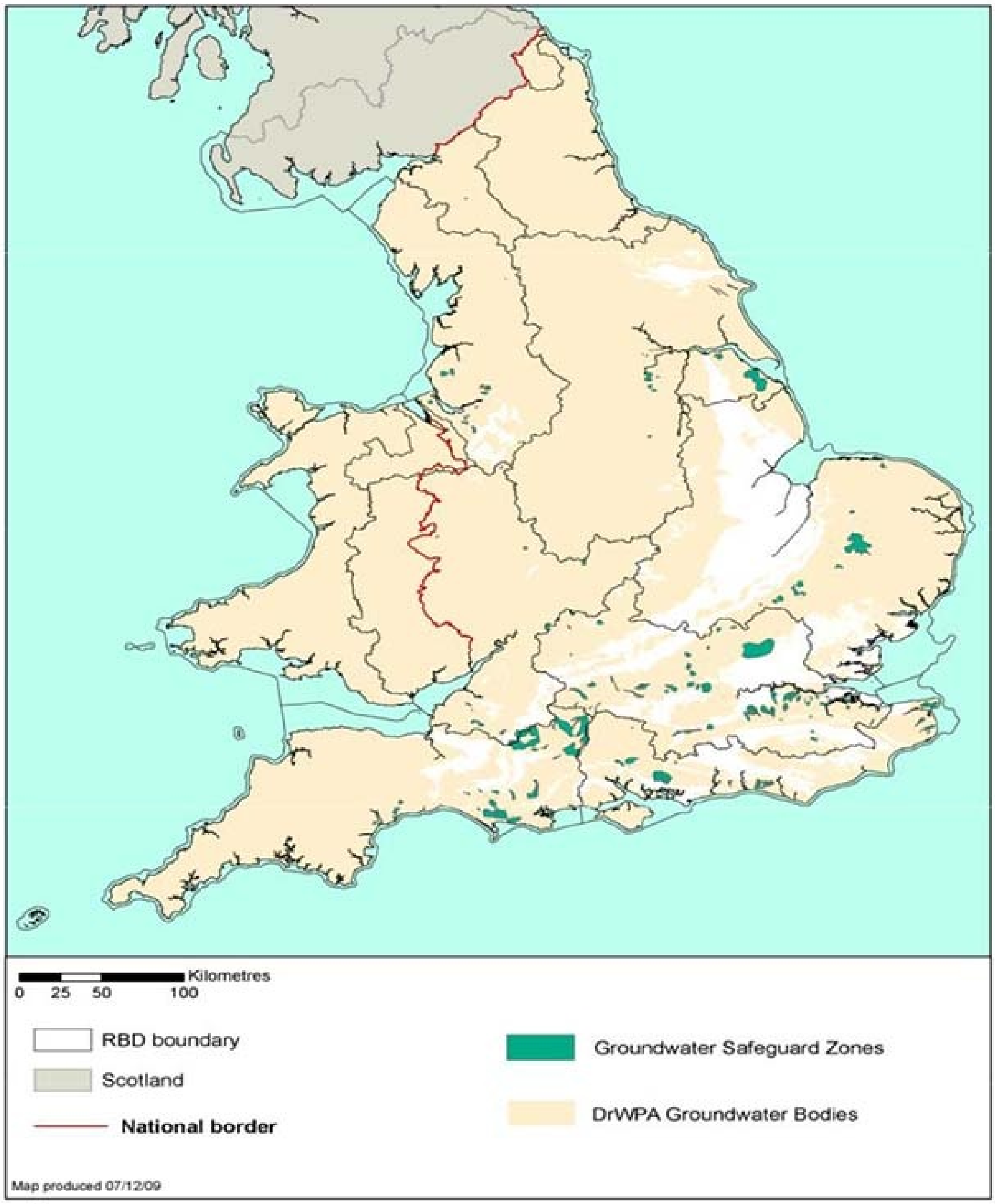

Figure 5.5: Illustration of ground water protected areas and safeguard zones defined in England using 2008 datasets (EA 2013b).

Much of England is designated as a drinking water protected area (DrWPA), approximately ~81% of land. Within these, safeguard zones are defined where the DrWPAs are "at risk" of requiring additional water treatment (See Figure 5.6). These non-statutory safeguard zones allow for specific targeted measures to reduce the deterioration of groundwater quality and the need for additional water treatment. Safeguard zones are an initiative between the Environment Agency (EA) and water companies and make use of existing source protection zones for their delineation, typically the outer protection zone. The EA have defined Source Protection Zones (SPZs) for more than 2,000 groundwater sources, which occupy ~22% of land, such as wells, boreholes, and springs used for public drinking water supply (See Figure 5.7). These typically comprise 3 zones (EA 2013a):

SPZ1 – Inner protection zone (~1% of land): Defined as the 50 day travel time from any point below the water table to the source. This zone has a minimum radius of 50 m.

SPZ2 – Outer protection zone (~6% of land): Defined by a 400 day travel time from a point below the water table. This has a minimum radius of 250 or 500 m around the source, depending on the size of the abstraction.

SPZ3 – Source catchment protection zone (~15% of land): Defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source. In confined aquifers, the source catchment may be displaced some distance from the source. For heavily exploited aquifers, the final Source Catchment Protection Zone can be defined as the whole aquifer recharge area where the ratio of groundwater abstraction to aquifer recharge (average recharge multiplied by outcrop area) is >0.75. There is still the need to define individual source protection areas to assist operators in catchment management.

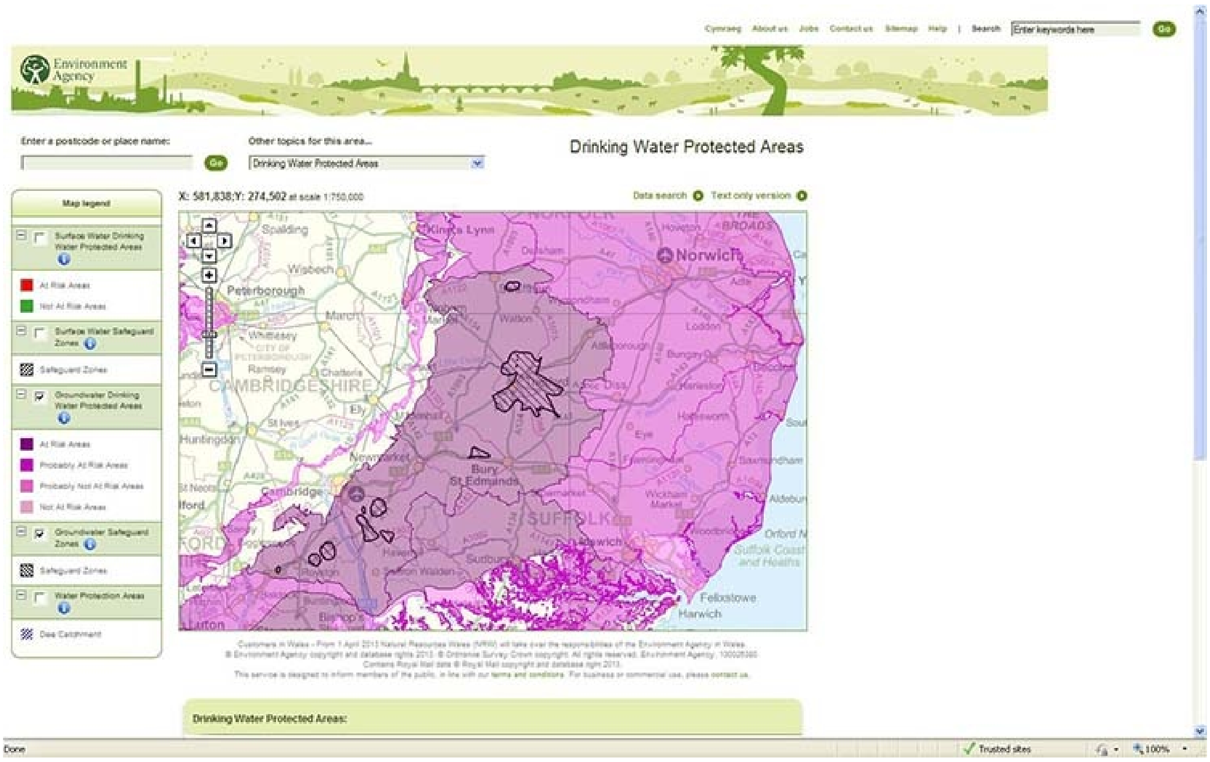

Figure 5.6: Illustration of the safeguard zones defined within drinking water protected areas that are “at risk” from requiring extra drinking water treatment (EA 2013c).

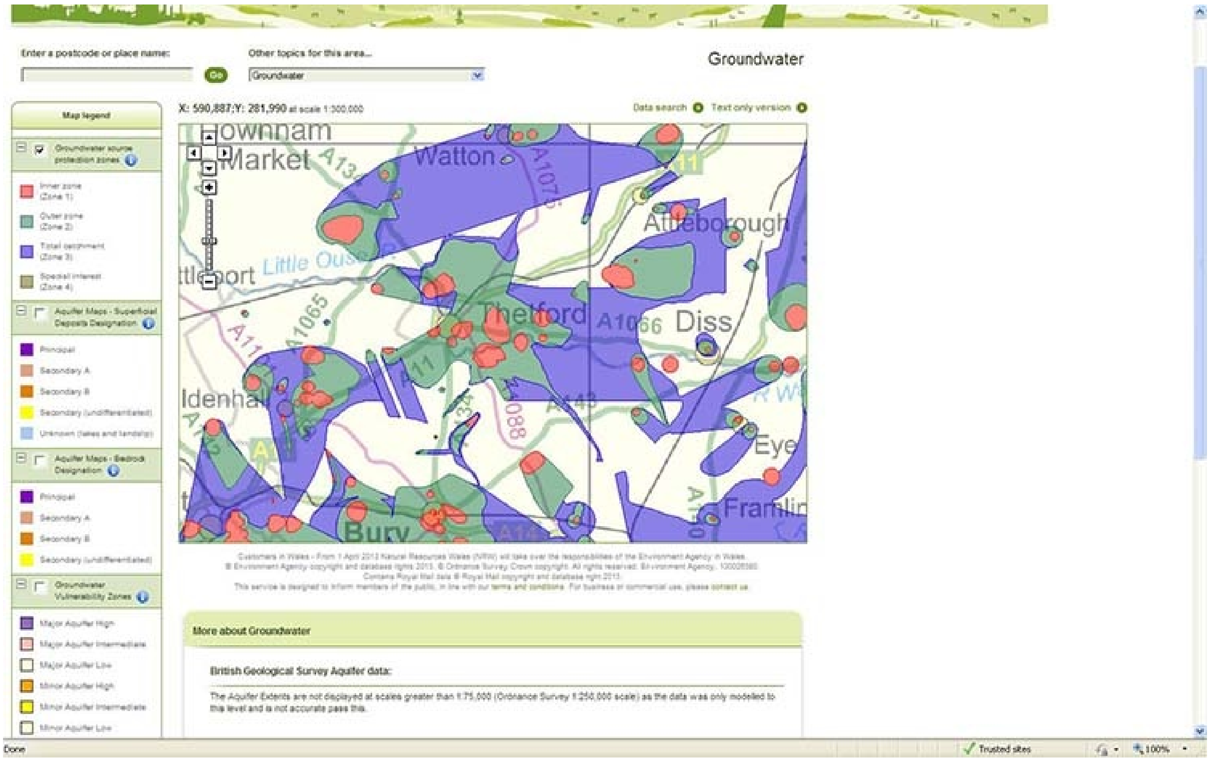

Figure 5.7: Illustration of the source protection zones defined by the Environment Agency to protect groundwater sources (EA 2013d).

In addition, water quality at the tap must also meet the standards set out under the Drinking Water Directive. For pesticides, this means no individual substance must reach tap water above 0.1 µg/L and total concentrations must not exceed 0.5 µg/L. Where the Drinking Water Inspectorate (DWI 2013) considers a failure to meet the required water supply standards, as laid out in the Water Supply Regulations, is likely to recur, the water company must put in place a legally binding program of work to improve the quality of the water to the required standard. This may involve a range of measures, including monitoring, stakeholder engagement, and catchment management.

Where safeguard zones fail to protect drinking water the EA could decide to reclassify the safeguard zone as a water protection zone. Water Projection Zones (WPZs) are intended as a regulatory mechanism to address water pollution that will lead to failure of WFD objectives. Additional powers within a defined geographical area will allow the use of measures to manage or prohibit activities that cause or could cause pollution of water, such as prohibiting the use of certain products or the growing of certain crops (EA 2009). So far, the EA have only used the existing legislation for WPZs once, on the River Dee (Wales) in 1999 to control point sources of industrial chemical pollution. It is also possible that CRD would review product's authorization for use in the case of continued detections in drinking water or the environment of a specific active ingredient.

5.4.3.3 Catchment management options

Groundwater catchment management with respect to pesticide active ingredients is limited to a similarly small suite of mitigation options that are currently available within the regulatory risk assessment process and largely centers on (i) reductions in application rate, (ii) changes in application timing, (iii) limitation of usage to low vulnerability areas, and (iv) the removal of point sources, in addition to (v) advice programs.

i. Reductions in application rate may be achieved by lowering the rate of an existing product in line with label recommendations or agronomic advice; using an alternate product that contains a lower concentration possibly as part of a mixture; spot treatment with the product in difficult areas only, i.e., limiting the spatial extent of the usage; complete reduction through substitution of an alternate product that does not contain the active ingredient that is causing concern, or possibly even complete withdrawal of all compounds within extremely vulnerable groundwater catchments.

ii. Changes in application timing range from changes in monthly or seasonal use, achieved possibly through application at a different growth stage or a switch in-crops, e.g., from winter to spring oilseed rape through to the frequency of use between years, possibly through alteration of the crop rotation.

iii. Limitations on use range from restriction to soils with higher organic matter content to those with lower leaching potential owing to soil properties or lower boundary conditions.

iv. Removal of point sources comprises the upgrade of storage, handling, and wash down areas to avoid the transfer of spills and discharge from machine washoff areas to groundwater.

v. One-to-one advice of best practice coupled with good communication of risks and arising water quality issues.

Successful catchment management in groundwater safeguard zones given the size of these catchments requires engagement with a smaller number of land managers and consensus on best practice and implementation of mitigations.

5.4.3.4 Catchment management in England

Prior to the 2009 price review conducted by OFWAT (the Water Services Regulation Authority), catchment management schemes were not common practice in water company asset management plans. However at the 2009 price review, OFWAT supported water company proposals to spend £60 million on more than 100 catchment management schemes and investigations. These were a major departure for OFWAT and were largely designed to engage with catchment stakeholders to address water quality through changes in practice (OFWAT 2013). Prior to this, catchment management initiatives to address surface water quality related specifically to pesticides and were centred on 5 Catchment Sensitive Farming (See Figure 5.8) and 6 Voluntary Initiative (See Figure 5.9) These are pilot catchments, although some water companies have been exploring catchment management options for many years.

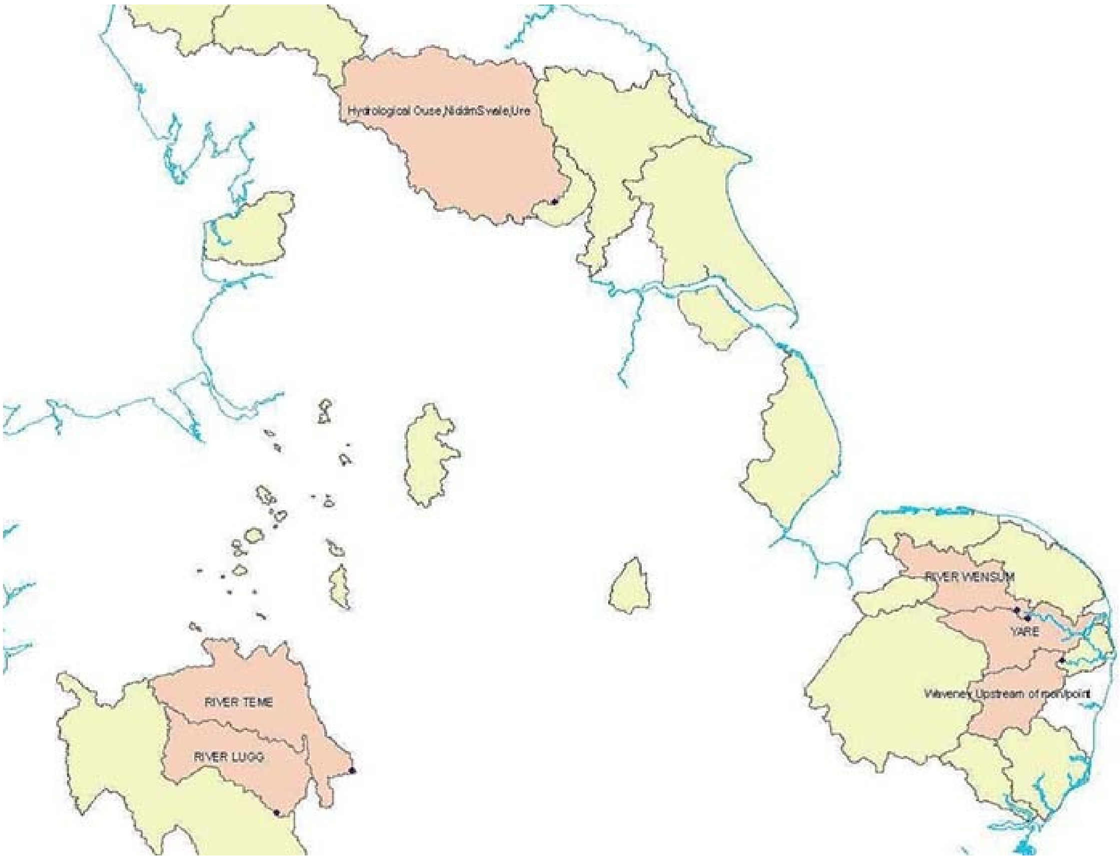

Figure 5.8: Map of the six Catchment Sensitive Farming test surface water catchments (CSF 2012).

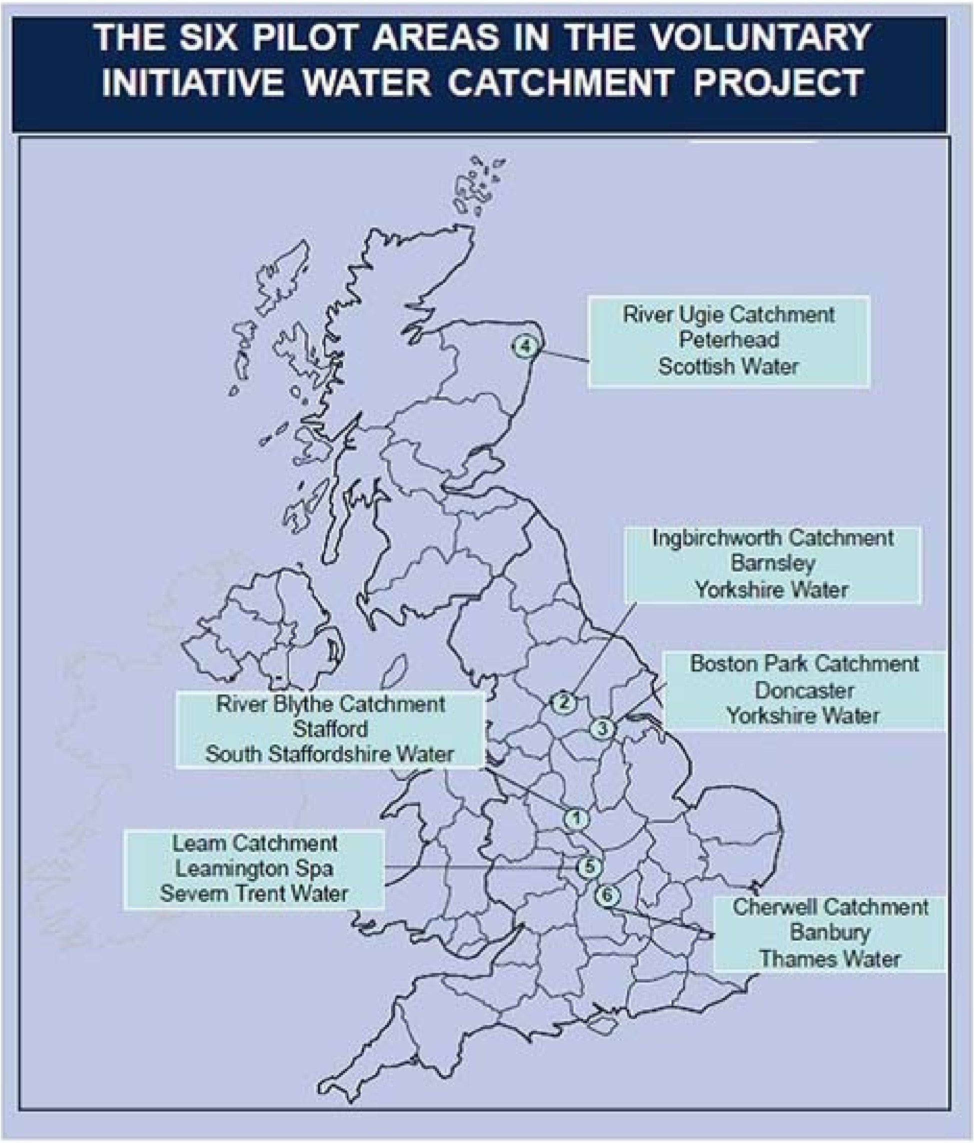

Figure 5.9: Map of the six Voluntary Initiative surface water catchments (VI 2007).

A few examples of catchment management options designed to illustrate the options outlined above, applied by water companies in England are detailed below [NOTE: Examples published on the internet were preferred for inclusion in this document]. Not all are groundwater examples or relate to pesticides but serve to illustrate how these approaches have been used and might be useful with respect to groundwater:

i. Wessex Water negotiated a complete cessation of all pesticide applications on 160 ha of arable land in the Friar Waddon groundwater catchment in 2005 (Wessex Water 2011), as this source was a key supply for Weymouth and Portland. This agreement has been extremely successful and had been extended in 3 year agreements until 2014.

ii. The Voluntary Initiative (www.voluntaryinitiative.org.uk) and the metaldehyde Get Pelletwise campaign (www.getpelletwise.co.uk) provides examples of tools and guidance to restrict usage to less vulnerable periods. Severn Trent Water (2013a) have commissioned scenario-based modeling to explore the impact of changes in timing of applications, for example converting winter oilseed rape to spring oilseed rape, as a means of improving surface water quality in the Avon and Leam catchment.

iii. Farmers in the Staunton Harold surface water catchment were more supportive of complete product substitution as opposed to a partial substitution on risky parcels of land, as they felt this was a better solution should their payments be linked to water quality monitoring (Severn Trent Water 2013b).

iv. Wessex Water (2011) aided the construction of a purpose built vehicle wash down facility and implementation of a farm yard pesticide management plan in the Friar Waddon groundwater catchment to remove a key source of pesticide contamination entering this key water supply source. South West Water (2013) similarly, use 20 year covenant agreements to improve farm infrastructure through capital grant support of up to 70% of project cost to reduce pollutants getting into water.

v. A range of water companies have seen the benefits of providing one-to-one agronomic advice to farmers with either a complete solution to the water quality problem or a reduction in the problem that water treatment systems could cope (e.g., South West Water 2013, Wessex Water 2011, Bristol Water 2012).

5.5 SPe phrases

5.5.1 Existing phrases

Risk mitigation measures for protecting the environment can be implemented by adding standard phrases to the label of a PPP as defined by Commission Regulation (EU) No. 547/2011 (EC 2011). The phrases are listed in Annex III “Standard phrases for safety precautions for the protection of human or animal health or to the environment” and are part of the subchapter 2.2 “safety precautions related to the environment (SPe) .”

As stated in Chapter 3, the following two standard phrases are applicable for groundwater:

SPe 1: To protect groundwater/soil organisms do not apply this or any other product containing (identify active substance or class of substances, as appropriate) more than (time period or frequency to be specified)

SPe 2: To protect groundwater/aquatic organisms do not apply to (soil type or situation to be specified) soils

The standard phrase SPe 1 covers some of the above discussed risk mitigation measures related to the application of a PPP. The restriction to a maximum number of applications per year and the permission to use a PPP or an active substance only every second or third year can be described by SPe 1. The restriction to a certain time of year (e.g., only spring applications) or to a certain timeframe (e.g., from April 1 to June 30) can only be implemented by adapting the standard phrase SPe 1.

The standard phrase SPe 2 uses the expression "soil type or situation to be specified." The situation specified might be the soil type (e.g., sandy soil) or geohydrological properties (e.g., karstic soil).

A comparison of the SPe 2 versions in the different languages showed certain variations. In most of the languages (e.g., Spanish, German, Italian) the wording is the same as in the English version meaning that "soils" is not inside the parentheses (only "soil type"). Technically speaking, the phrase can thus only be used to restrict the application depending on soil properties. However, in some languages (e.g., Danish, Estonian, French, and Swedish) only the term "soil type" is used and placed inside the parentheses. Therefore, the SPe 2-phrase could theoretically be interpreted differently depending on the Member State.

5.5.2 Recommendations for SPe phrases

To cover the risk mitigation measures that are connected to certain areas (cf. previous sections) an additional standard phrase is proposed:

SPe X: To protect groundwater do not apply this or any other product containing (identify active substance or class of substances, as appropriate) in vulnerable areas (areas of drinking water abstraction or other vulnerable conditions).

This new standard phrase can be used for the implementation of exclusion zones for drinking water, vulnerability maps, or catchment management plans. Drinking water catchments can also be defined by the Water Framework Directive (WFD) as "waters used for the abstraction of drinking water" (Article 7). Member States may establish safeguard zones for those bodies of water to avoid deterioration of the water quality.

A further new standard phrase is proposed to cover the remaining risk mitigation measures that are based on specific management options (see Chapter 3):

SPe XX: To protect groundwater the use of this or any other product containing (identify active substance or class of substances, as appropriate) is only allowed if specific management conditions (e.g., use of cover crops, band application, others [to be specified]) are fulfilled.

It is proposed to leave such a SPe-phrase open for the development of further measures.

5.6 Conclusions and research needed

Overall, a broad spectrum of tools exist from which regulators and practicioners can choose to mitigate the risks to groundwater. These tools comprise measures that can already be implemented directly on the label (such as restricting the maximum applicable rate, number of applications, etc.) and measures that are covered by the two existing SPe phrases 1 and 2 (e.g., to measures that would restrict the use of the product to specific frequencies or time periods [SPe 1] or to specific soil types or situations [SPe2]. Additionally, proposals for two additional SPe phrases that would restrict the use of a product to certain management practices or exclude it from specific areas are proposed by the group. The working group concluded that the scientific and technical prerequisites for these two SPe phrases are sufficiently developed for their implementation into the regulatory framework to be initiated.

The working group identified a number of additional measures, for example the use of cover crops, which would offer multiple benefits outside of mitigation leaching risk, but for which evidence regarding their efficacy to reduce risk to groundwater is not yet sufficient. However, the working group felt that these measures certainly merit a further intensive investigation due to the multiple benefits for agriculture and environment that they represent, and recommends that further research into these is undertaken. In a class on its own, catchment management plans were deemed as certainly very effective, especially with regards to the protection of drinking water. However, catchment management plans must be well adapted to the specific environmental, legal, and organizational circumstances of the individual catchment to be protected, and hence the group found it difficult to derive general recommendations and instead opted for the description of programs which were successfully implemented in England.

On a more general level, the group noticed that the acceptance of risk mitigation measures is very different amongst Member States of the European Union. This is sometimes justified by differences in the agricultural and environmental conditions in the Member State, but it seems to be also caused by differences in the legal and regulatory systems, or related to a lack of information. Hopefully, this report can be used as a basis for further communication and harmonization.

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6 Risk mitigation measures for the off-crop environment

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6.1 Introduction

Risk assessments often refer to the “off-field areas,” which may be defined as all the farmland areas that are not cultivated, as well as the areas that are not part of fields. It is not always clear how to define off-field areas compared with areas that are not cultivated or “off-crop,” and the boundary between “off-field” and “off-crop” areas has been explored in previous workshops (see for example Alix et al. 2011). For the benefit of a full understanding between risk managers and further harmonization, definitions were checked by participants and the outcome is proposed in this chapter.

More practically, off-field areas can be managed or unmanaged, non-sprayed, vegetated strips, wildlife corridors, habitat patches, conservation buffers, and greenways outside, but in a certain proximity (spatial relation) to the agricultural fields (Figure 6.1). As non-cultivated area, all of them implicitly represent a higher level of biodiversity than the crop area with regards to flora and fauna, although research to quantitatively appreciate these differences remains limited, as for example for non-target arthropods (de Lange et al. 2012). These areas are therefore thought to contribute to the environmental status of an agroecosystem in providing area for recovery of the agroecosystem wildlife, be a source of recolonization of the in-field areas, and contribute to ecologically stable agricultural landscapes. The latter is of special interest for agricultural production, as these landscapes provide additional functional services supporting integrated pest control. When implemented to reduce pesticide or fertilizer transfers from the cropped area (such as vegetated strips or wind breaks, for example), they also help reduce the exposure of off-field organisms. Together with other tools aimed at reducing transfers during application and adapted application strategies, these measures enter in the toolbox of risk mitigation measures that were identified during the workshop to mitigate risks to off-crop or off-field area and ecosystems. Their inherent benefit to the environmental status of agroecosystems is also reflected in the recommendations of the “Common Agricultural Policy” (CAP) and more particularly the listing of measures identified in the greening concept (EC 2013).

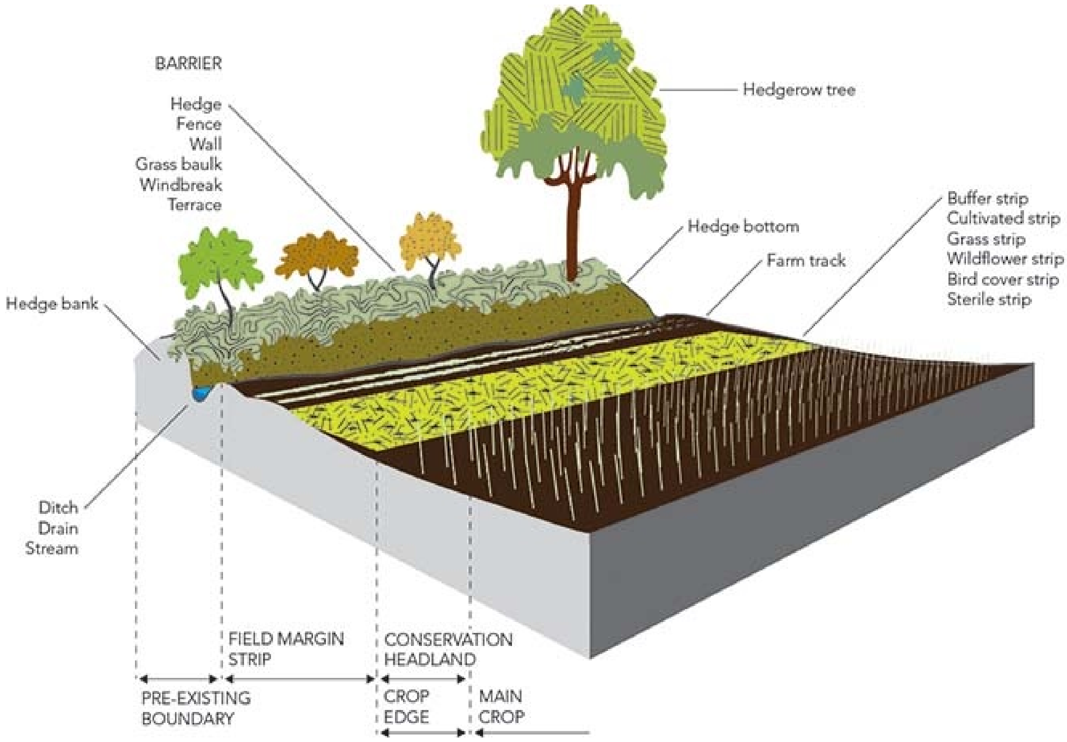


Figure 6.1: The main components of an arable field margin (after Hackett and Lawrence 2014).

The development of a toolbox implies agreement or at least a common understanding of the terminology relating to non-target areas. A questionnaire was circulated to regulatory authorities, offering definitions for a range of terms referring to agriculture area and commonly used in the regulatory process. The feedback received is reproduced in Appendix 7. The series of definitions proposed in Table 6.1 result from this consultation and reflect the feedback of regulatory authorities. The compilation of the feedback received is proposed in Appendix 8.

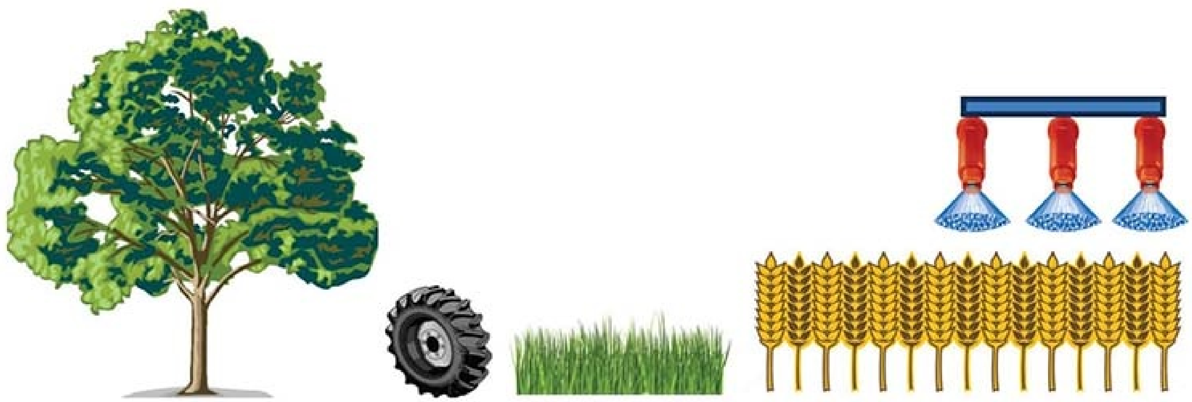
Regulatory authorities agreed on a definition of the ”field“ that corresponds to the “crop.” Hedges and boundaries may be either managed or not, therefore their status may not be defined a priori. As a consequence in terms of protection of the off-field areas, a similar level of protection was considered for all off-crop areas as long as they do not belong to the farmer, since then their status is not known a priori.

The definitions in Table 6.1 were approved with the recommendation that all areas of land not under the control of the farmer (i.e., not owned or rented land) should be considered as off-field area. Therefore in terms of risk management, off-crop and off-field areas may represent the same area when the off-crop area does not belong to the farmer.

Figure 6.2 provides an illustration of the set agriculture areas used in the regulatory process.

Table 6.1: Definitions of the agriculture area commonly used in the regulatory process, as agreed by workshop participants.

Term	**Definition**
In-crop area	Area sown with the crop plants, including the space between the crop rows
Sprayed crop area	Area of crop or soil sprayed with pesticides
Unsprayed crop	Area of crop plants left unsprayed with pesticides
Off-crop area	Area starting at the edge of the cropped area, which is not over sprayed with pesticides
Field margin (off-crop area)	Area in the field that is not planted with crop plants
Farm track	Area used for transport of farm machinery or vehicles
Field boundary	Trees, hedges, fences, walls, ditches (including planted wind breaks) at the border of the field area. This area is an off-crop area and may be in the field of the farmer but may also be off-field
Margin strip	Any area of bare soil or grass or wildflower area left untreated with pesticides
In-field area	Cropped area plus the field boundaries, any farm track, and any margin strip (planted or bare soil). For risk management purposes at the level of a farmland, the in-field area therefore corresponds to the farmland area, which is owned by the farmer
Off-field area	Area surrounding the in-field area, excluding neighboring in-field areas



Field boundary	Farm track	Margin strip	Unsprayed crop area	Sprayed crop area

Off-crop area	In-crop-area

Off-field area	In-field-area

Or, when the farmers own or manages the land off-crop:

Off-field area	In-field-area

In-field-area

Figure 6.2: Illustration of the agriculture areas used in the regulatory process.

There was therefore an agreement that all the off-crop and off-field should a priori be protected similarly, with no distinction (e.g., between roads, farm tracks, and vegetated strips). Similarly, managed boundaries, or boundaries created for risk management purposes (i.e., wind break), would be a priori equivalent to non-managed natural boundaries. The reason for this is that if the purpose of these areas is not known by the farmer, in cases where he is not in charge of their management, he should avoid any spray drift onto them. Where these areas respond to specific functions and needs known by the farmers or under his responsibility then their protection will de facto be ensured for them to meet the expected needs.

The off-crop area also contains landscape features that need to be protected. These landscapes features provide habitat and food resource and the benefits to species and functions (such as pollination and biological pest control, for example) that we foresee in using them as risk mitigation. Landscape elements at distance of the field may get residues from airborne sprays or drift. Recent studies by FERA in the UK funded by the Department for the Environment, Food and Rural Affairs (DEFRA) have generated data for airborne drift up to a height of 2m at distances up to 20m from the sprayed crop area (DEFRA 2008, Glass et al. 2010). Therefore, a point is made in this chapter to appropriately protect non-target plants, i.e., the vegetation in the field margins or at the vicinity of the crops that is not targeted by treatments, but further consideration with regards to the extrapolation to landscape elements will be needed in future. It should also be noted, that farmers' motivation to voluntarily implement landscape structures such as vegetated buffer strips (e.g., under the CAP), or as risk mitigation measures, would be strongly impacted if additional requirements were imposed to protect these structures as pristine areas (e.g., in-field buffer zones to protect these in-field structures). This is partly solved when the ownership or land management is taken into account, as areas not directly owned or managed are to be protected as off-field areas, while the function of the off-crop land being owned or managed is well known and to be protected as such.

Section 2 of this chapter lists these measures and implementation recommendations. Section 3 discusses the aspects relative to the implementation of the measures proposed in the tool set as well as specific monitoring issues and related stewardship. Section 4 proposes recommendations for the development and implementation of this toolbox in future. The Risk Mitigation Measure Technical Sheets (RMMTS) that provide practical details, benefits, and possible constraints on the tools that may be implemented in European countries are reported in Appendix 1.

6.2 Risk mitigation measures to protect the off-crop area

Three questionnaires have been prepared in order to collect experience in European Member States with regards to risk mitigation options to protect off-field area. These questionnaires focused on:

- An inventory of the risk mitigation options already implemented or considered as promising in future as well as an inventory of the Safety Precaution phrases (Regulation (EU) No. 547/2011) implemented in European Member States (questionnaire #1)
- A consultation on experience with managed and natural recovery areas as off-field risk mitigation tools in farmlands (questionnaire #2)
- A consultation on the terminology used in the area of environmental risk mitigation (questionnaire #3)

The responses to questionnaire # 1 are reported in Appendix 7. The responses to questionnaires # 2 and # 3 are reported in Appendix 8.

The following table proposes a compilation of the risk mitigation tools identified through these questionnaires and additional information provided by the working group with regards to general aspects and the developments proposed for each of these tools in future. For each tool the group discussed the following criteria:

- Efficacy of the tool to appropriately mitigate risks
- Regulatory and legal aspects relative to the tool. For example, this criterion considers the legal status of the risk mitigation tool in the countries where it is implemented. This criterion also considers the possibility to take the risk mitigation measure into account in the risk assessment process
- Implementation aspects, and more particularly with regards to the acceptability of the tool to farmers

Each tool has then been ranked as explained in the introduction.

The risk mitigation tools identified as promising or well established are further detailed in dedicated Risk Mitigation Measure Technical Sheets (RMMTS). Where no specific recommendation from the group was considered necessary (risk mitigation measure already well established) the measure is simply described in this table and in the following notes.

Table 6.2: Overview of the risk mitigation measures (RMM) suitable to reduce environmental risks in the farmland. RMM are allocated into the following categories: Buffer Zones (BZ) aimed at reducing exposure of off-crop areas via spray drift; Field Margins (FM) and Compensation Area (CA) aimed at providing food sources and habitat to off-crop flora and fauna; Spray Drift Reduction Technologies (SDRT), which involve any technology associated to sprayers, nozzles, or spraying techniques that will reduce the drift; Dust Reduction Technologies (DRT), which involve any technology associated with seed coating, granule manufacture, or drillers to reduce the abrasion of seeds or granules at drilling or to reduce the spread of dust out of the cropped area; Good Agricultural Practices (GAP), which relate to product application (dose and application regime); Crop Management (CM), which relates to agricultural practice in the crop or the field margins aimed at reducing a source of exposure or transfer route; and Bee Management (BM), which relates specifically to measures applied to managed bees to keep them from exposure. The corresponding Risk Mitigation Measure Technical Sheets (RMMTS) are listed in the last column together with their location in the proceedings.

Risk Mitigation Measure	Category	Description	Status[1]	Countries Where Implemented #	Proposed New SPe Phrase in the Context of Regulation (EU) No. 547/2001 – see also Chapter 3	RMM Taken Into Account in the Risk Assessment	RMMTS
No spray buffer zone	BZ	See Chapter 4.3	4	All	**Adapted from current SPe3**	Yes	Not necessary - See Chapter 4.3
Wind direction – dependant no spray zone	BZ	See Chapter 4.3	3	SE	**Additional text to be associated to SPe3**	Yes - See chapter 4.2	Yes (RMMTS #1) – see Chapter 4.3 and Appendix 1
Buffer zone of bare soil	BZ	See Chapter 4.3	3	NL, UK	**See SPe 3**	Yes	Yes (RMMTS #2) – see Chapter 4.3 and Appendix 1
Vegetated buffer strip	FM	• Introduction of a managed orsemi-managed vegetated strip at the field margins to provide food source and habitat to a group of organisms, or to offer wind screen or runoff management • Generic or product-specific • Potentially from 5 to 50 m • Benefits on all off-field area and organisms through spray drift reduction • Additional benefits related to the purpose of the vegetated buffer strip (e.g., pollen and nectar seed mix, bird seed mix, runoff mitigation etc.)	3	BE, CH, DE, NL	**New SPe introducing vegetated strips to mitigate transfers via runoff (see Chapter 4.2)**	Yes for spray drift and runoff reduction. For beneficial effects on wildlife and biodiversity observed in monitoring studies, they do not yet translate into percentage risk reduction for a product	Yes (RMMTS # 3 to 9) in Appendix 1
Multifunctional field margins (e.g., as qualification of a vegetated buffer)	FM	• Introduction of a managed or semi-managed vegetated strip at the field margins to provide food source and habitat to one or several group(s) of organisms, or to offer wind screen or runoff management • Product specific or generic • Potentially from 5 to 50 m • See above: defined to present several of the benefits listed for vegetated buffer strips	3	-	**New SPe to introduce field margins to protect one or several groups of organisms and mitigate transfers via runoff (multi functional field margins):** To protect [birds / mammals / aquatic organisms / non-target arthropods / non-target plants] and limit risks related to situations of runoff, respect an unsprayed non-cropped vegetated buffer zone of (distance to be specified) to [the edge of the field / surface	Yes for spray drift and runoff reduction. For beneficial effects on wildlife and biodiversity observed in monitoring studies, they do not yet translate into percentage risk reduction for a product	Yes (RMMTS # 3 to 9) in Appendix 1

					water bodies] which should consist of [wild bird seed mix / wild flower mix / pollen and nectar mix/sown grass] in order to provide the requested benefits.		
Presence of recovery area in the farmland and Ecological focus areas	BZ/CA	• Introduction of recovery area in the farmland • Benefits on species in providing food source and habitat	3	DE, IE	n.a.	Beneficial effects on wildlife and biodiversity observed in monitoring studies, but do not yet translate into percentage risk reduction for a product	No, see note
Landscape-dependant buffer zones	BZ/CA	• No spray zone at the field border to avoid direct spray of off-field area, as a function of the presence of recovery area in the farmland, which indicate on the level of resilience of the farmland • Benefits on species in providing food source and habitat	3	DE	**Additional text to be added to a SPe aiming at introducing field margins to protect wildlife:** An implementation of this buffer zone for the purpose of wildlife protection may not be needed if recovery area such as semi-natural habitats are already present in the farmland represents (percentage to be specified) of the farmland surface.	Yes for spray drift and runoff reduction. For beneficial effects on wildlife and biodiversity observed in monitoring studies, they do not yet translate into percentage risk reduction for a product	Yes (RMMTS #10) in Appendix 1
Drift reducing nozzles (incl. adjusted spray pressure, etc.)	SDRT	See chapter on spray drift	3	AT, BG, CH, CZ, DE, ES, FR, HU, IT, NL, BE, PL, SE, UK	**Additional text to be added to a SPe3**	Yes	Yes (RMMTS #11) - see Chapter 4.3 and Appendix 1
Special equipment or machinery (Wings-/Tunnel-/Band sprayer etc.)	SDRT	See chapter on spray drift	4	DE, NL	**Additional text to be added to a SPe3**	Yes in these countries, therefore there is a possibility to harmonize	Yes (RMMTS #12) - see Chapter 4.3 and Appendix 1
Directed spraying techniques (one-sided spraying, forward-speed, reflection shield, boom-height adjustment, etc.)	SDRT	See chapter on spray drift	4	CH, DE, IT, SE, NL	**Additional text to be added to a SPe3**	Yes in some of these countries, therefore there is a possibility to harmonize	Yes (RMMTS #12) - see Chapter 4.3 and Appendix 1
Precision treatment (as sprayers' equipment)	SDRT	See chapter on spray drift	1	-	n.a.	n.a.	Yes (RMMTS #13) - see Chapter 4.3 and Appendix 1
Dose of product (reduction or limit)	GAP	• Label language limiting the application rate to a maximum • Derived from the risk assessment • Benefits related to the group of organisms having	4	BE, DE, ES, FR, NO, SE, UK	**New SPe proposing adapted Good Agricultural Practices (GAP) to reduce exposure of wildlife and/or transfers via**	Yes	Not necessary The risk assessment already takes into account

		driven the risk assessment			**runoff:** To protect [birds / mammals / aquatic organisms / pollinators / non-target arthropods / non-target plants/limit risks related to situations of runoff] respect an application rate of maximum (application rate to be specified) /do not apply this product more than (time period or frequency to be specified)/ do not apply during the bird breeding period / restrict applications to (dates or growth stages to be specified).		modified application regimes where necessary
Application frequency (reduction), interval between applications	GAP	• Label language defining application regime • Derived from the risk assessment • Benefits related to the group of organisms having driven the risk assessment	4	BE, DE, ES, FR, NO, UK	As for reduced application rate	Yes	Not necessary The risk assessment already takes into account modified application
							regimes where necessary
Timing of applications (e.g., overnight; before or after flowering)	GAP	• Label language defining application regime with regards to crop growth stages • Derived from the risk assessment • Benefits related to the group of organisms having driven the risk assessment	4	BE, CH, DE, ES, FR, EL, HU, NO, NL[2], UK	As for reduced application rate	n.a.	Not necessary The risk assessment already takes into account modified application regimes where necessary
Excluding types of application techniques (e.g., canon application)	GAP	• Label language excluding some application techniques to be used for a specific product • Derived from the risk assessment • Benefits related to the group of organisms having driven the risk assessment	3	-	n.a.	Yes	Not necessary The risk assessment already takes into account modified application regimes where necessary
Treated seeds - low wind speed	DRT	• Restriction of the drilling period to favourable wind conditions • Generic • Benefits on all off-field	3	DE, FR	In the scope of SANCO 10553/2014	n.a.	In the scope of SANCO 10553/2014

		area and organisms through dust reduction					
Treated seeds - high quality of treatment and drillers	DRT	• Implementation of high quality criteria to drillers and seed coating quality in order to reduce abrasion of seeds and granules to a minimum during drilling and during all the steps of seeds and granule handling • Generic • Benefits on all off-field area and organisms through dust reduction	4	DE, FR	In the scope of SANCO 10553/2014	In the scope of SANCO 10553/2014	In the scope of SANCO 10553/2014
Forest aerial application - max. 50% area treated, no spray on the forest edges, standard buffer zones Aerial applications	BZ	See chapter on spray drift	3	DE, FR	n.a.	n.a.	Not necessary (see note) Product and use specific and to be managed at the country level based on policy relative to aerial applications
Remove or cover bee hive, close bee hive	BM	• Physical protection of the hives during spraying	3	UK	**Adapted from current**	n.a.	-
1 day before spraying		activities • Implies an information of the beekeeper prior to applications			**SPe 8:** Dangerous to bees./To protect bees and other pollinating insects do not apply to crop plants when in flower./Do not use where bees are actively foraging./Remove or cover beehives during application and for (state time) after treatment./ Do not apply when flowering weeds are present./ Do not apply before (state time)./ Respect a flowering strip of [width to be specified] at [distance to be specified] of the treated field.		
Close hives 1 day before spraying	BM	• Physical protection of the hives during spraying activities • Implies an information of the beekeeper prior to applications	3	EL	See SPe 8		-
Permission by bee-	BM	• Implies an information	3	FI, DE	An alert of beekeepers	n.a.	

keeper needed		of the beekeeper prior to applications			is recommended		
Removal of flowering weeds	BM	• Removal of flowering weeds prior to applications in order to limit the exposure of pollinators • Potential conflict with preservation of biodiversity in cropped lands	3	BE, CZ, ES, HU, IT, UK	n.a.	n.a.	Not necessary – a note proposing a risk-benefit analysis is included below
Specific regulation or suspension of pesticide	Regulatory	• Restriction of uses in the registration certificate or decision notification	4	IT, SI, UK	n.a.	n.a.	No

as based on the questionnaires and further discussions

[3] Status:

1. Not to be promoted
2. Under development
3. Needs consolidation or research
4. Promising tool implemented in some Member States
5. Well established tool implemented in most Member States.

[4] In fruit crops (e.g. before / after 1st of May)

6.2.1 Buffer zones and field margins

6.2.1.1 Generic buffer zones

Generic buffer zones, not wind or temperature related [5], are the most common risk mitigation measures implemented in the EU. Buffer zones have first been set for the management of transfers to surface water via spray drift in almost all countries in the EU. Later on they were progressively used to protect non-target plants and non-target arthropods (13 countries reported the use of buffer zones and of the related SPe3 phrase for that purpose).

Buffer zones usually start at the edge of the field and are a defined width (1 to up to 100 m were mentioned). One country reported that the buffer zone could be located in-field cropped ("crop are allowed"), but defined them at the edge of the crop. Buffer zone widths are usually pesticide-specific. Buffer zones present the advantage of being easily used in the risk assessment and easily reported on product's label. However, farmers report the lack of flexibility with regards to the width to be applied, which is fixed regardless of the way farmers manage their field margins. In France, it is possible to reduce the width of the buffer zone recommended on the label (e.g., from 50 m to 20 or 5 m, or from 20 m to 5 m) if the farmer uses additional spray drift reduction tools such as drift reducing nozzles or wind breaks (JORF

2006, see also Chapter 4.3). The width reduction depends on the number of measures the farmer applies to mitigate spray drift. The economic impact of buffer zones on growers (wheat, oil seed rape, and apple) was assessed for German conditions in Kehlenbeck et al. (2014).

No Member State reported specific buffer zones to protect landscape features such as hedgerows, flower strips, or wind breaks that the farmers plant themselves in-field for risk mitigation purposes. One Member State reported that no buffer zone applies to those features in order not to prevent farmers to establish them. When needed for the proper functioning of the feature itself, risk mitigation measures should be included in implementation directions, as for example in the UK (Natural England 2013). With the establishment of ecological focus areas (EC 2013) in or at the edge of the field, the landscape features above mentioned may gain additional interest to farmers, allowing them to manage specific requirements related to the use of products in compliance with the implementation of the greening aspects of the CAP.

The Directive "Natura 2000" (EC 1992) also recommends that the environmental protection of specific vulnerable areas and a variety of other areas may be defined at the national level, such as area used for drinking water supply, hospitals, etc. The protection of these areas involves diverse and country-specific approaches. Beside specific precautions regarding the use of the land in protected areas, some dedicated protections may be defined as, for example, specific buffer zones around houses, hotels, etc. Where the same level of protection is to be considered for all off-field areas, countries do not distinguish these areas from others (which are to be protected anyway). Member States did not specify the use of a no-spray zone, a buffer zone, or other, to explicitly protect biodiversity.

Overlaps were mentioned with measures implemented to prevent transfers of fertilizers. Overlaps with other legislation as, for example, in the context of the regulation on biocide products (EC 1998 and 2012) were reported in the only case where biocides are considered as part of pesticides (one country). Overlaps with measures being implemented for the protection of drinking water abstraction area where reported for one country. In some countries NAPs give buffer zones to areas used by population, as schools, hospitals, city parks, etc. (e.g., Italian NAP).

[5] Note that Good agricultural practices state a general maximum temperature and wind speed for spraying of PPPs

6.2.1.2 No spray zones based on local conditions

No spray zones based on local conditions have been reported in Sweden. This option provides more flexibility to farmers since they may adapt the recommendation to the current weather conditions, as well as to the rate of product they actually use. A user guide provides precise recommendation on the treatment conditions (Sakertvaxtskydd 2013). Since the level of risk reduction is available from the abacus provided in the guide, such measures may in principle be taken into account in the risk assessment in keeping the same risk reduction categories. The corresponding RMMTS may be found in Appendix 1.

6.2.1.3 Bare soil buffer zones (RMMTS #2)

Bare soil buffer zones (uncultivated buffer zones) are being used in the UK and in the Netherlands. As these buffer areas remain non-cultivated, their implementation becomes easier to verify than the previous types of buffer zones. However their popularity is affected by the fact they offer no filter or screen to drift, and do not represent a flexible option. The corresponding RMMTS may be found in Appendix 1.

6.2.1.4 Vegetated buffer strips (RMMTS #3 to 9)

Vegetated buffer strips have various functions and have been reported for the purpose of runoff management in some countries. Vegetated buffer strips dedicated to the protection of non-target arthropods or non-target plants are used in two countries so far. The advantages reported include the filter function they provide towards spray drift, and their easy implementation and verification in the field. The main disadvantage reported is again the lack of flexibility from farmers' point of view, since these vegetated strips are product-related and in theory offer little flexibility with regards to their width. An economic evaluation of buffer zones in Germany showed that for some crops a vegetated buffer strip can be economically more feasible than a no- spray buffer zone (Kehlenbeck et al. 2014). Also, when located in the field margin, they have shown diverse benefits over years.

The primary role of field margins was stock fencing and delimiting areas of ownership (Marshall and Moonen 2002). In addition, they can provide shelter for stock in adverse weather (heat, snow, wind), as well as windbreaks, and they are useful for preventing surface water flow and particulate water movement. They provide suitable habitat including for overwintering species that move into arable crops and are thought good place to locate beehives. They may also act as barriers to the movement of some pests between fields, but may also act as a source of pest in other cases. Since the 1990s, such field margins have been implemented in national plans as part of ecological compensation areas, as for example in Switzerland (see for example http://www.agroscope.admin.ch/oekologischer-ausgleich/index.html?lang=en).

In order to gather a more comprehensive views on the possible benefits to be expected from field margins and landscape features, a review of field margins management and of their potential as risk mitigation measures suggested in the feedback provided by monitoring studies that investigated their effectiveness in the context of the implementation of Agri-Environmental Schemes. A variety of field margin types have been described such as natural regeneration areas, grass margins, wildflower margins, pollen and nectar or bird seed mix field margins, annual cultivation areas, and conservation headland. The benefits of these measures are documented in monitoring studies based on abundance and diversity indexes of in-crop and off-crop populations and communities. From these studies, the relative benefits for diverse aspects relative to the group of "organism of concern" was explored through an evaluation and ranking exercise reported in the table below:

Table 6.3: Evaluation and ranking of multiple benefits of different field margin types (NR = natural regeneration, GR = grass sown, WF = wildflower sown, P&N = pollen and nectar mix, WBS = wild bird seed mix, AC = annual cultivation, CH = conservation headland)

Environmental Benefit	**Attribute**	**NR**	**GR**	**WF**	**P&N**	**WBS**	**AC**	**CH**
Birds	Overall	2	2	2	1	3	3	1
	Summer - Seed & plant food	2	2	3	1	3	3	2
	Winter - Seed & plant food	1	1	1	1	3	3	2
	Invertebrate food	3	2	3	2	2	3	2
Mammals	Diversity	2	3	2	2	2	3	1
	Abundance	2	3	2	2	2	3	1
Pollinators	Food sources	2	2	3	3	1	2	2
	Species richness	2	2	3	3	2	2	1

	Abundance	2	2	3	3	2	2	1
	Hibernation sites	3	3	2	1	0	0	0
Non-target arthropods	Spiders	3	3	2	1	2	2	1
	Beetles	2	3	2	2	2	2	1
	Parasitic wasps	2	2	3	2	1	1	1
	Soil invertebrates	3	3	2	2	1	1	1
Plants	Overall	2	1	2	1	1	3	3
	Annual arable weeds	1	-1	-1	1	2	3	3
	Perennial wildflowers	3	2	3	1	1	1	1
Aquatic	Aquatic invertebrates	3	3	2	1	1	1	1
	Plants	3	3	2	1	1	1	1
Pest management	Weeds	1	3	2	1	1	1	1
	Invertebrate	2	3	3	2	1	1	1
Run-off	Pesticides	3	3	2	2	1	1	0
	Sediment	3	3	2	2	1	1	0
	Phosphorus	3	3	2	2	1	1	0
	Nitrogen	3	3	2	1	1	2	2
Spray drift	Pesticides	3	3	3	2	2	2	2
Soil	Soil erosion	3	3	3	2	2	1	1

It was agreed that this first analysis conducted in the context of this workshop was useful to obtain a first insight on the benefits each type of feature provides to specific group of organisms, but that more research was needed to refine the knowledge and allow their inclusion in the risk assessment. The importance to also develop the multi-functionality of field margins and thus optimize the land use by the farmers who implements them as risk mitigation measures was highlighted. Promoting the implementation of these types of field margins will be critical to rapidly observing the benefits they provide on the groups of organisms and processes listed above. As observed in the available studies, their benefits are more significant at a larger scale and landscape approaches may be more effective than field-scale implementation. This observation is important in deciding upon the policy level that is the most appropriate for their implementation in individual countries.

6.2.1.5 Multifunctional field margins

A possible way forward is the promotion of multifunctional field margins (MFFM), which would provide farmers a clear benefit as they address the types of risks where their farms show vulnerability. As an example, the use of insecticides on plots vulnerable to runoff could trigger the implementation of field margins, with an aim to stop runoff transfers and at the same time provide refuge, habitat, nectar, and pollen resources to pollinators and non-target arthropods. Recommendations exist regarding the implementation of effective field margins for the purpose of wildlife protection (Aschwanden et al. 2007, Askew et al. 2007, Burn 2003, Hoffmann et al. 2013, Macdonald et al. 2007, Shore et al. 2005, Vickery et al. 2009), invertebrate fauna (Blake et al. 2011, DEFRA 2007, Pywell et al. 2011b), including pollinators (Blaauw and Isaacs 2014; Carvell et al. 2007, 2011; DEFRA 2007; Osgathorpe et al. 2012; Pywell et al. 2005, 2006, 2008, 2011a, 2011b), non-target vegetation (DEFRA 2007, Marrs et al. 1992, Marshall and Arnold 1995, Pywell et al. 2011b) and soil organisms (DEFRA 2007), but also biodiversity (Berger and Pfeffer 2011, de Snoo et al. 1999, DEFRA 2007, Kleijn et al. 2001, 2006, Thomas and Marshall 1999), or to limit the transfer of pesticides via spray drift (Brown et al. 2004, Burn 2003, de Jong et al. 2008, de Snoo and van der Poll 1999, Longley et al. 1997, Miller et al. 2000, Wenneker and van de Zande 2008, van de Zande et al. 2000, 2004, 2010) or runoff (see Chapter 4.2), which may be adapted to provide multiple benefits (Marshall and Moonen 2002, Stoate et al. 2009, Hacket and Lawrence 2014). RMMTS #3 to 9 provide further recommendations for the implementation of multifunctional field margins. Appendix 9 proposes additional recommendations as regards flowering strips.

6.2.1.6 Landscape-dependant buffer zones (RMMTS #10)

Landscape-dependant buffer zones, developed in Germany, constitute an option to account for the landscape features in deciding about the risk mitigation measures to be implemented in the farmland (Gutsche et al. 2002, Golla et al. 2003, Enzian et al. 2004). With this option, farmers evaluate if their farmlands are in an area where semi-natural habitats are present, and if this is the case, they may apply more flexible risk mitigation (e.g., only SDRT without buffer) than if their farmlands do not fulfill the semi-natural habitat pre-requisites where, for example, SDRT and a no-spray zone is required. Flexibility is perceived as a clear advantage by farmers. However, only habitats, that may house the same species or provide the same benefits as managed field margins should be considered. In addition, the implementation of this option requires the generation of a robust and updated GIS-supported database and its access to farmers in real time.

6.2.1.7 Ecological focus areas

Ecological focus areas bring benefits for the environment, improve biodiversity, and maintain attractive landscapes (such as landscape features, buffer strips, afforested areas, fallow land, areas with nitrogen-fixing crops, etc.).

Ecological focus areas are a higher level option in landscape management proposed in the CAP (EC 2013). This option is described in the CAP, using Germany as an example, and consists of implementing ecological focus areas (e.g., land lying fallow, buffer strips) at farm level, which can serve as additional recovery areas in the landscape where these are not considered as sufficiently present. Although they do not represent a risk mitigation option strictly speaking, the benefit of implementing recovery area in the landscape is obvious and may represent more flexibility to farmers who need to compensate for specific vulnerability in their farmland.

As previously mentioned, this option relates to the CAP and may also be considered in a more targeted way with the implementation of multifunctional field margins (see above), provided that the latter are designed as permanent measures.

In Ireland, the presence of recovery area in the farmland is appreciated using a set of characteristics, which help compensate for in-field effects and safeguard biodiversity, as for example in Ireland (box below):

Characteristics of the farmland landscape in Ireland that support ecosystem resilience and biodiversity:

1. Overall land-use pattern - a high proportion of Irish agriculture is low-input grassland farming, with very low levels of PPP use.
2. Large areas of monoculture are not a feature of Irish agriculture. The reasons for this are as follows:

   2.1. Small average farm size.

   2.2. Small average field size.

   2.3. A high degree of fragmentation of farm holdings.

2.4. Widespread short-term renting of land.

Large areas of contiguous land are very unlikely to be treated with the same PPPs. Land treated with any given PPP is very likely to be adjacent to land not treated with that, or any, PPP. This greatly increases the potential for recovery of populations of non-target species.

3. The Irish landscape is characterized by an abundance of hedges, and in particular large volume hedges, which serve as habitats for many species.

Several countries report that recovery areas in the farmland may not be sufficiently represented, as for example in intensive cropping area. In the Netherlands, an option proposed in the context of the Sustainable Crop Protection (2013-2023) to revert the situation is to stimulate farmers to grow flower strips, on a voluntary basis and if possible, with financial compensation from the common agricultural policy (EC 2013). In the Czech Republic it is intended to use tools proposed in the context of the CAP to improve the level of environmental protection in farmlands.

6.2.2 Spray drift reduction technologies

Spray drift reduction technologies (SDRT) correspond to a range of equipment and machinery that aim to target sprays on the crop and limit losses via spray drift. The benefits of their use is generally easy to verify, and they represent a range of options to farmers who may use them on a generic way once they are equipped. In some cases, they may compensate the implementation of buffer zones as for example in France, Germany, and the Netherlands (TCT 2014). Many of these equipments (drift reducing nozzles, reflection shields, boom height adaptation) are cost-effective, though others such as tunnels or band sprayers, still represent an expensive investment. Drift reducing nozzles are being used in 13 European countries so far and the level of drift reduction achieved by these nozzles is being determined on a certified basis (http://sdrt.info/). Advice for farmers is needed for these SDRT tools, either through training or information leaflets. More details on the efficacy of these tools at reducing spray drift may be found in Chapter 4.3 (RMMTS # 11 and 12, in Appendix 1). Each tool associated to quantified drift reduction rates may be used in the risk assessment.

Precision treatment represents an option that allows the farmer to restrict applications to the sole area of the crop that can receive the treatment. This option is supported by GPS and sensor technologies incorporated into the sprayers. The sprayer is then automatically set up to perform precision applications. In addition to the benefit of saving application volumes this option may offer flexibility to the farmer and be used in a generic way. The related costs need further investigation (further details are provided in

Chapter 4.3).

6.2.3 Adaptation of the conditions of use

The adaptation of Good Agricultural Practices (GAP) associated with a product (doses, timing, frequency, period of application) represents a set of options that are easy to implement on the labeling and the benefit of which can be taken into account in the risk assessment. In many countries, GAPs are adapted for the purpose of reducing risks to non-target arthropods, pollinators, and non-target plants, with preferences for an adaptation of the application period (9 countries), application frequencies (6 countries), or doses (7 countries). The benefit to farmers is a reduction of treatment costs and the flexibility related to other risk mitigation measures. The compliance is generally less easy to verify compared with SDRT and vegetated buffer strips and MFFM. However, advice to farmers is needed as modification of the recommendations related to a product may result in the development of resistance of pests or diseases, which need to be taken into account.

6.2.3.1 Adaption of the application dose

In the interests of reducing exposure to products in the environment, it is important to ensure that only the minimum dose is applied to achieve the desired effect. In order to establish the minimum effective dose, it is necessary to conduct trials that show whether doses lower than the recommended dose provide an inferior level of effectiveness compared with the higher dose, an inferior persistence of effect compared with the higher dose, or a control less than that intended or desirable for the target pest. In addition, the potential for resistance, the safety of the product to the crop, and other aspects of efficacy are also considered, e.g., yield. The minimum dose resulting from the efficacy evaluation is compared against the maximum dose rate that can be used safely by humans and in the environment. The authorized product label will specify the maximum dose that can be used in any particular situation or crop. A maximum number of treatments or maximum total dose may also be specified and this will restrict the total amount of product that may be applied to a specific crop or situation per crop or year.

6.2.3.2 Adaptation of the application frequency and interval between applications

Risk assessments may indicate that some non-target populations are initially affected by a product use, but that the population quickly recovers to pre-spray levels. In these instances it is possible for the regulatory authority to specify an application frequency or a minimum interval between applications.

6.2.3.3 Adaptation of the application timing or period of application

Specific application timings may correspond to the latest timing at which a product may be applied to a specific crop or situation, in which case it is often driven by consumer risk assessment. However, application timing may also be adjusted to fit outside the reproductive period of birds or outside the flowering period, in which case it is driven by the outcome of the risk assessment. It may be specified as a date (usually specified as 'in the year of treatment' 'or 'in the year of harvest'), the crop growth stage or as a number of days or weeks before harvest, or other as appropriate.

6.2.3.4 Exclusion of some application techniques

The exclusion of some application techniques, such as cannon applications, for example, is a specific situation where such restrictions are recommended after a dedicated risk assessment. These restrictions usually relate to a product and appear on the label. This is also linked to the labeling instructions regarding application methods and reduction of spray drift via spray drift technologies.

6.2.4 Risk mitigation tools for seed treatments

With regards to seed treatments, recommendations have been developed that define conditions of use for seeds coated with pesticides and of granule formulations that limit the amount of seed dusts being produced and spread out of the cropped area (SANCO 2014). Recommendations relate to the conditions of drilling and to the preparation and handling of coated seeds and granules so that the amount of dust to be expected at drilling is reduced to a minimum. Such measures are being used in several countries already and a guidance document of the European Commission is being developed to further harmonize the conditions of use of coated seeds in the EU (SANCO 2014).

6.2.5 Risk mitigation measures for aerial applications

With regards to aerial applications, general concerns have been raised in European countries about the pressure exerted on the environment resulting from applications via aircraft and helicopters. These application techniques usually respond to a specific demand (use of products on forests to control specific caterpillars presenting a threat to populations, or difficulty to apply products in certain area due to the slope, as observed in certain vineyards, for example) or to the height of the crops (maize, sugarcane, banana, for example). In this context, the use of aerial applications is restricted to situations where there is no alternative treatment device that can provide a lower level of risk (EC 2009). National authorities have developed additional precautionary measures limiting the area to be sprayed and sparing forest edges, as for example in the case of forests in Germany (see chapter on spray drift). These measures correspond to a generic approach to reduce application volumes and related pressure on the environment. More dedicated measures are not proposed in this manuscript since the level of management that is deemed necessary in European countries will remain country-specific, as it applies on a practice being already regulated.

6.2.6 Risk mitigation measures to protect pollinators

With regard to the protection of pollinators, and more specifically, to managed bees such as the honey bee, Regulation (EU) No. 547/2011 provides a set of risk mitigation measures aimed at reducing the exposure during and following sprayed treatments (SPe8 phrases) (EC 2011). The option to restrict applications out of the flowering period, which is being used in most European countries, is potentially beneficial to other pollinating species and is directly deduced from the risk assessment. The SPe8 phrase also contains options to remove or cover hives during the treatment, or close the hive one day before the treatment in order to keep bees from foraging on the treated crop. The latter being reported in 2 countries and implies the involvement of beekeepers who keep their apiaries in the farmland during the treatment process.

Finland reported an agreement with the beekeeper as a pre-requisite to proceed to an application. Similar agreements are reported for Germany. Within a radius of 60 m around a bee hive, dangerous pesticides may be applied within the period of daily bee flight only with agreement of the beekeeper. For compliance reasons, such a measure requires a communication between farmers and beekeepers, and more particularly that farmers inform beekeepers about the treatments that are planned on the farmland and that beekeepers inform farmers on the location of their apiaries. Tools can help support this communication, e.g., via internet or SMS (see Chapter 10).

Information on applications is promoted so that beekeepers may implement protection measures (cover hives, etc.) through communication leaflets. As an example, the British Beekeepers Association recommends to inform beekeepers directly or to contact the local beekeeping association 48 hours before applications (British Beekeepers 2010). In France, informing beekeepers of upcoming applications is recommended through a leaflet prepared by a collective work of all stakeholders (AFPP 2010). In Germany, communication between farmers and beekeepers is supported via an internet tool (BLE 2014). General communication to the public may be requested for specific cases such as aerial applications for sanitary reasons as recommended by the FAO (2001).

The early provision of information to beekeepers about applications is critical to help them implement the appropriate protection measures (cover, remove hives, or any other measure they wish to implement) and thus respect the precautionary recommendations of the SPe8 phrase that involve beekeepers (EC 2011). In turn, measures that may help farmers to be informed of the presence of apiaries in the vicinity of their farms would facilitate this communication. Local contacts or in future the availability of GPS localization of apiaries (of registered beekeepers in a national registration database, for example) would provide assistance in this respect.

Another option, which may also limit the exposure of other species, consists of the removal of flowering weeds under the crop to be treated (e.g., in orchards or vineyards) or in the field margins (all crops). This practice is reported in 5 countries, but remains controversial since the removal of flowers may in turn directly influence the frequency of occurrence of pollinators and other invertebrates in farmland and therefore affect biodiversity. Further considerations on this option are proposed in a note below.

6.2.7 Note on flower removal before pesticide application (pollinator protection)

The removal of flowering weeds in order to limit pesticide exposure to bees and other pollinating insects is one of the options proposed in the safety phrase 8 of Regulation (EU) No. 547/2011 –relevant for the protection of pollinators:

SPe 8:

Dangerous to bees./ To protect bees and other pollinating insects do not apply to crop plants when in flower./ Do not use where bees are actively *foraging./ Remove or cover beehives during application and for (state time) after treatment./ Do not apply when flowering weeds are present./* ***Remove weeds before flowering****./ Do not apply before (state time).*

This option may apply to understory flowers in perennial crops as orchards or vineyards, but has also been mentioned in field margins (for all crops) and its implementation on product labeling is reported in 5 countries.

This measure remains controversial, since the removal of flowers may affect populations of pollinating insects as well as other flower visitors and therefore affect biodiversity. In an attempt to gather further details on the relationship between the presence of flowers on the farm and the presence of pollinators, an analysis of monitoring studies undertaken to describe the influence of farmland management was performed to look at the impact of the presence of non-cropped area, dedicated field margins such as wild flower sown mix or nectar and pollen sown mix, on pollinator populations or communities. The inventory captured studies published between 2000 and 2014 and covered 12 different countries.

No study describing the effects of flower removal as a risk mitigation measure in conventional crops on pollinators could be found. Rather, monitoring studies generally describe the effects, and in all cases the benefit of non-cropped land and diverse types of dedicated field margins involved in Agro-Environmental Schemes (AES) on pollinators as observed in studies on the benefits of AES on pollinator species richness (DEFRA 2007, Kleijn et al. 2001, 2006). In honey bees, benefits of surrounding features were highlighted through food shortage events that were reported between crop flowering events where these features are absent or under represented, as crops may not be sufficient to provide food resource over the whole season (Odoux et al. 2014). In bumble bees, the presence of flowers in field margins and natural regeneration strategies was an effective strategy for providing habitat (DEFRA 2007, Pywell et al. 2005). Higher species richness and forager density were recorded on conservation flower mixture patches than on existing non-crop control habitats. The proportion of arable land in the surrounding landscape was also found to influence bumble bee presence (Carvell et al. 2011). Open herbaceous vegetation proved to be valuable in conserving long-tongued species (Kells et al. 2011). Track edges and road verges with presence of flowering plants were shown to provide an important source of forage (Osgathorpe et al. 2012). In butterflies, positive effects of wildflower strip were recorded on communities (Haaland and Bersier 2011). Looking at pollination services, isolation from natural habitat appeared potentially to be more important to native bees than that of management where organic and conventional farms were compared (Kremen et al. 2002). In a recent study in cider apple orchards in the UK, flowering strips resulted in increased pollinator visits to the apple blossom compared with orchards without flowering strips (Campbell et al. 2013). Similar benefits towards wild bees were observed when forage habitat was provided adjacent to pollinator-dependent crops (Blaauw and Isaacs 2014).

The relationship between bee species abundance or richness and plant coverage seems to be species-dependent and not necessarily linear, thus indicating that other elements of the landscape interact, such as crops (Calabuig 2000), latitude, local land use intensity, connectivity, and geographical location of study fields (Conception et al. 2012a, 2012b). A strong influence of connectivity and corridors on species richness is observed, but effects are habitat dependent. Even small patches of dispersed natural habitat may support high abundance in honey bees and wild bees, in landscape with a low proportion of natural habitat (Winfree et al. 2008). A study comparing the effects of AES in landscapes of different categories with regards to diversity indicated that positive effect of flower abundance observed in hoverflies and bees based on richness and abundance criteria, may be more intense in landscapes with few semi-natural habitats, as in diverse landscape the species richness and abundance are higher and less sensitive to the implementation of AES (Kleijn and Van Langevelde 2006). For some species like eumenid wasps, landscape that permits access to a multiple set of resources was critical to their maintenance (Klein et al. 2006).

On the other hand, the benefit of flower removal on the reduction of pollinator exposure to pesticides is, although intuitive, not fully established. In a review on the aspects determining the risk of pesticides to wild bees, the contribution of in-crop flowering weeds to pollinator exposure has been reported in one of three countries where data or feedback was recorded, and limited to apple orchards (Van der Valk and Koomen 2013). Effects of weeds removal, mechanically or by herbicide applications on pollinators were reviewed by Nicholls and Altieri (2013). Effects on wild bees, but also Coleoptera and Lepidoptera have been reported, and relate to the reduction of nectar sources, larval food sources, and safe sites. The magnitude of effects for pollinating species is related to the length of its seasonal flight period. Effects have also been reported on biocontrol agents such as predators and parasitoids, relating to the availability of floral resources. Weed removal through grazing intensity was found to result in differences in composition of insect-pollinated plants and therefore of bees species richness (Batary et al. 2010).

In view of the observations reported above, flower removal therefore could not be considered to be an appropriate measure to protect pollinators, as this creates gaps in foraging resources. The maintenance of flowering weeds or implementation of flowering margins is instead to be preferred, according to a management plan that does not affect crop yields where relevant (see Nicholls and Altieri 2013). The benefits are reported even for crop monocultures when surrounded by (semi-) natural habitats (Nicholls and Altieri 2013). The presence of flowering weeds in cropped fields also benefits wild bees and other insect pollinator communities (Nicholls and Altieri 2013). In addition, care should be taken to provide a continuous supply of nectar and pollen through the season (i.e., spring to autumn). With regards to flowering weeds in field margins, the introduction of wildlife seed mixtures has the potential for providing the best foraging habitat for as long as preferred forage species are introduced (DEFRA 2007, Pywell et al. 2005). Long-term management may also allow the formation of tussocks, which make nesting sites, as observed for *Osmia* spp, for example (Benedek 2008), and could be used as larval habitat for several species, provided the time span between sowing and ploughing of a strip was adequate (Haaland and Bersier 2011). Further details on dedicated field margins are presented in this chapter.

6.2.8 Risk management through regulatory decisions

Regulatory decisions that may involve restrictions of uses or product withdrawals remain an option for regulators. These options are not in the scope of this workshop and are not discussed further.

6.3 Additional recommendations to promote the implementation of risk mitigation measures in the farmland

The key to a successful implementation of risk mitigation tools by farmers relies on the capacity to deliver clear messages about their efficacy at fulfilling their function(s), their availability, and also on how these tools relate to the overall regulatory framework. This section proposes additional recommendations with regards to the appreciation and measurement of the risk mitigation measures tools' efficacy and side-effects, as well as ways to improve the implementation of these tools in the future.

6.3.1 Demonstrated efficacy and benefits of the risk mitigation measures

tools

The demonstration of the efficacy of risk mitigation measures tools to reduce risks and present benefits for the environment is critical in their acceptance and implementation by farmers and all stakeholders. It is, however, easier to establish this efficacy in the case of risk mitigation measures tools that involve a technology or practice aiming to reduce exposure, such as spray drift reduction tools including SDRT, adapted GAP, or even buffer zones (vegetated or not) than for landscape features aimed at promoting wildlife and biodiversity. Indeed the efficacy of such a technology or practice can only be measured through appropriate trials, or through a certification process, as for low spray drift nozzles or sprayers (ISO 22866 2005, BBA 2000, CIW 2003), for example, whereas the efficacy of a flower strip to promote a group of organism requires dedicated monitoring strategies.

As stated earlier a number of studies have attempted to quantify the benefit of landscape features such a field margins and usually confirm positive effects. A review for flowering strips has been proposed by Dicks et al. (2013), which is reproduced in Table 6.4:

Table 6.4: Outcome of 80 studies on the effects of flowering strips on wildlife and biodiversity, adapted from Dicks et al. (2013). Sixty-four studies showed some benefits to one or more wildlife groups. Note that numbers do not sum up as effects could be positive, negative, or neutral on different species or groups in the same study:

Wildlife Group	**Number of Studies Demonstrating Positive, Neutral, or Negative Effects of Landscape Features as in AES on Wildlife and Biodiversity**			**Parameters Monitored**
	Positive Effects	**Neutral Effects**	**Negative Effects**	
Invertebrates (65 studies)	50	6	15	Abundance, species richness/diversity Foraging, flower visits
Plants (21 studies)	17	4	4	Plant cover, number of flowers, diversity, species richness
Birds (7 studies)	4	2	1	Abundance, density, species richness
Small	5	-	-	Abundance, density,

Mammals (5 studies)				species richness
Biodiversity (22 studies)	19	3	3	Indices of biodiversity

As shown in Table 6.4, the presence and implementation of field margins and recovery areas exert positive effects on all groups of organisms as well as on biodiversity, provided that some recommendations with regards to their implementation are respected (see for example, Pe'er et al. 2014, Stoate et al. 2009). These recommendations may relate to the geographical scale at which the measures are implemented as well as on the time scale needed for the benefits to be actually observed (Pe'er et al. 2014).

Using pollinators as an example, it was observed that both landscape- and local-scale factors influence wild bees assemblages and may interact (Kennedy et al. 2013). Habitat diversity and field-level diversity both promote abundance and richness, and at landscape-scale, the diversity of habitats at bee foraging ranges is a driver of bee abundance and diversity.

Landscape parameters are also critical in the efficacy of a mitigation measure to exert the expected effects. Beneficial effects of AES were more effective in landscapes with intermediate levels of heterogeneity, as previously described in Stoate et al. (2009) and Tscharntke et al. (2012). Similar observations were reported by Kennedy et al. (2013), Kleijn and van Langevelde (2006), Oppermann and Hoffmann (2012), Scheper et al. (2013), and Winfree et al. (2008). Also, habitat fragmentation as compared with the scale at which landscape features are implemented is critical, as observed for example for pollinators, which implies to consider both pollen and nectar resources and nesting habitat for an optimized effectiveness of the measures implemented (Wright et al. 2015).

The implication of the influence of spatial-scale on the efficacy of AES is that although recommendations on their implementation are useful at the farmland scale (i.e., as for example in the recommendations provided in RMMTS #3 to 9 for field margins), an additional level of verification is necessary at a larger scale in order to adjust these recommendations at the relevant local or regional scales. Similar recommendations have been published by Dicks et al. (2013), on the basis that landscape-related factors are implicated in the level of environmental status and biodiversity that is expected in first place, and, therefore, to be promoted or preserved. This was reflected in the outcome of studies AES implementation and efficacy as a function of landscape heterogeneity reported above. GIS-supported landscape descriptions that are in development in some European countries could be a basis for such recommendations as they could help define the relevant scale at which a specific risk mitigation measure may be implemented on a specific way (e.g., field margins of a specific length or width, or of a specific type).

Time-scale effects have finally been reported. The percentages of food plant species being useful to butterflies and birds were found to increase with the age of set-aside fields, and this was accompanied with an increase in the percentage of bird and butterfly species for which larval food plants were present (Stoate et al. 2009). The rapidity with which effects are observed depends on growth traits and competitiveness between the species in an assemblage. The recommendations published in the UK thus propose a multi-year management of field margins in order to promote long lasting effects on wildlife and biodiversity (Natural England 2013). In Switzerland, further work has lead to the development of “improved field margins” (Jacot et al. 2007). These field margins are a species-rich mixture designed to establish a long-lasting, floristically diverse and flower-rich vegetation, which provides multiple benefits to the typical fauna of crop-dominated landscapes, such as shelter, food, or suitable microclimate and they are managed as (semi) permanent landscape features.

Thus, in spite of the difficulty to quantify the level of risk reduction achieved through the implementation of a dedicated field margin for the purpose of risk mitigation issues, it is possible to appreciate the benefit of specific field margins on groups of organisms or on the factors driving the abundance of these groups (e.g., food resource, hibernation sites) through the use of indices (see RMMTS #3 to 9 in section 3) (Hackett and Lawrence 2014). Approaches to quantify the effectiveness of natural areas at mediating effects of harmful pesticides on non-target species are just being initiated as for wild bees for example, which showed a buffering effect providing that the surface represented by these natural areas compared with the cropped surface is important enough (Park et al. 2015).

The benefits of AES measures on wildlife and biodiversity are assessed via monitoring studies, comparing abundance and diversity in one or several groups of organisms in agricultural systems (measured in-crop and off-crop) presenting diverse degrees of implementation of these measures. These studies have been reviewed in several meta-analyses and confirm positive effects of AES measures on all groups of organisms, even in conventional farming, thus demonstrating compensating effects on the overall reduced biodiversity that occurs in intensive systems where no or limited AES are implemented (DEFRA 2007, Dicks et al. 2013, Kennedy et al. 2013, Scheper et al. 2013, Stoate et al. 2009, Schneider et al. 2014). Using pollinators as an example, a review of 39 studies investigating the impact of landscape- and local-scale factors revealed that vegetation diversity in conventional crop fields had similar effect on abundance as organically managed fields with low vegetation diversity, which indicates a potential for compensation mechanisms through the availability of refuges, habitat, and food resource (Kennedy et al. 2013). Similar conclusions were reported by DEFRA (2007), Park et al. (2015), Scheper et al. (2013), Stoate et al. (2009), and Winfree et al. (2008). Kennedy and collaborators (2013) suggested that with a 10% increase in the amount of high-quality habitat in a landscape, wild bee abundance and richness may increase on average by 37%. Even narrow margins (<3 m) are reported to be beneficial to wildlife as for arthropod predators or butterflies (Hahn et al. 2014). However, as stated above, the implementation of farmland features needs to account for diversity in habitat and habitat scale and for an optimizised effectiveness on biodiversity (Kleijn et al. 2015, Park et al. 2015, Wood et al. 2015, Wright et al 2015).

There is a need to develop monitoring strategies that are able to appreciate the benefits of field margins implemented on the groups of organisms concerned (Pe'er et al. 2014). Existing studies use ecological indices such as species richness, abundance, and density indices, but also foraging or visits and plant cover to quantify the effects induced (see Table 6.4). Metrics to inform about species biodiversity in cultivated areas are developed and tested for their capacity to provide useful measurement of the contribution of a farm or a group of farms to the overall biodiversity of an area (Luscher et al. 2014). Recommendations on the spatial- and time-scales to be respected in ecological monitoring would be useful and are under development in the Society of Environmental Toxicology and Chemistry (SETAC) advisory group Environmental Monitoring of Pesticides interest group (http://www.setac.org/group/SEIGPest). Examples of monitoring in birds, invertebrates, or pollinators are available (Hoffmann et al. 2013, see also more references in the introduction to RMMTS #3 to 9 in section 6.3), as well as stewardship initiatives reported in the related chapter. For some species, food resource may also be used as reliable indicator of their presence as for birds, invertebrates, and pollinators, for example Marshall et al. (2001). In addition, the efficacy of a nectar and pollen strip to fill the needs of pollinators may be estimated in calculating the food resource they provide, as for example in Lemoing and Pasquet (2011) (see Appendix 9).

Besides studies that would provide detailed feedback on the effect of risk mitigation measures on the different groups of organisms, simple tools designed to be used by farmers to appreciate the results of their management work would be very useful. This recommendation rejoins previous recommendations to provide farmers with ecological training (Pe'er et al. 2014). Simple indices have been developed for plants (Abadie et al. 2008) and butterflies, (see PROPAGE, developed by the French national museum of natural history [http://propage.mnhn.fr/]), which allow for a fast appreciation of the flora or fauna frequenting fields. Limitations of these indices compared with comprehensive taxonomical monitoring have been pointed out (see for example, Krell 2004; Ward and Stanley 2004), however, they are valuable for global comparisons of trends in space and time and do not require the involvement of a scientist. This level of monitoring is critical as it presents the double benefit of a tool that may be implemented at a large scale together with an easy mean for self appreciation of mitigation results.

6.3.2 Controlling weeds and pests

The presence of field margins can influence the crops they are boarding through diverse processes (Marshall and Moonen 2002). In principle they may:

- Constitute a reservoir of seeds and contribute to the spread of weeds into the crop
- Create microclimate conditions or compete for light, moisture, and nutrients
- Constitute a habitat for pests; but also for beneficial insects, with consequences to the crop that depend on the balance between the two groups

With regards to weeds, studies on the location of plants at arable field edges show four distribution patterns for plant species: (1) limited to the crop area, (2) some ability to spread into the crop, (3) limited to the off-crop area, and (4) highest density in crop edges, or in headlands (Marshall and Moonen 2002). The ability of plant species to spread into the crop would be more limited in Northeastern Europe than in other areas. In warmer Mediterranean conditions, the flora may behave very differently to the moist Atlantic areas, where competitive exclusion by perennial species in general reduces annual weeds.

Among species presenting a propensity to spread are annuals *Anisantha sterilis*, or *Bromus sterilis* and *Gallium aparine*, perennials such as *Elytrigia repens* (current name *Elymus repens*), and biennials such as *Heracleum sphondylium.*

A comparison of the hedge-bottom vegetation of two neighboring farms in Wiltshire, UK gave insight on the influence of field margins on the presence of some grass species (Moonen and Marshall 2001). One farm was sown with 2–20m wide grass strips and the other farm was sown with 0.5m wide sterile strips. The abundance *of B. sterilis* in the hedge-bottom was significantly reduced where grass strips were present. The mechanism is believed to be a protection from disturbance afforded by the introduced grass margins. This is in line with further observations from a review that the disturbance of the field margin and removal of perennials species may promote annual species capable of colonizing the field (Marshall and Moonen 2002).

Another outcome of the above study was that sown grass strips had a positive influence on species richness (Moonen and Marshall 2001). Grass and wildflower strips can prevent spread of *B. sterilis*. Other studies also showed that sown perennial grasses can significantly reduce the growth and spread of rhizomes of *E. repens*, a perennial weed of field edges (Marshall and Moonen 2002). A variety of weeds, including *H. sphondylium*, *Urtica dioica*, *B. sterilis,* and *Cirsium arvense* have been observed to be significantly reduced by sowing grass or grass and flower mixes. Overall, data indicate that where a field margin contains less desirable plant species at the outset, these are likely to increase where natural regeneration is used to create extended margins. Sowing will reduce these species although they might not eliminate them.

With regards to pests, the presence of field margins with diverse flora is theoretically expected to favor pest abundance and thus increase pest pressure in the crops. However, few examples of this phenomenon are described in the literature, as such. Certain pest species are associated with plant species in the field margin, as for example black bean aphids and the shrub *Euonymus europaeus* (Marshall and Moonen 2002). The spread of molluscs has also been observed into crops consecutively to the implementation of field margins (Marshall and Moonen 2002). Field margins may also be as a source of damage from zoophytophagous predatory bugs in species who may survive by feeding on the crop.

Vegetation diversity may however have a suppressive effect on pest abundance through bottom-up mechanisms that disrupt the pest’s ability to locate or access the host plant (Marshall and Moonen 2002). In a study comparing sown flower strips to semi-natural habitats, sap sucking insects were found to be more abundant in flower strips, although crop damage was found to be lower suggesting that flower strips may act as trap-crop (Balzan and Moonen 2014).

But the most described mechanism by which vegetation diversity influences pest presence is the promotion of natural enemy populations. In their study, Balzan and Moonen (2014) observed that the presence of flowers increased the parasitism rate in aphids in the crop, and a lower rate of damage related to Lepidopteran was observed. Lower level of crop damage was observed early in the season when semi-natural strips were present suggesting a role of crop colonization by natural enemies.

It has also been suggested that the presence of field margins with diverse flora would increase the abundance of natural enemies and thus lead to a better regulation of pest populations. Sown flower strips may enhance the abundance of parasitoids and generalist predators such as Coccinelidae, Nabidae, Syrphidae, Thomisidae (Marshall and Moonen 2002, Balzan and Moonen 2014). Indeed, natural enemy populations may be promoted by an adequate choice of flowers: most hymenopteran parasitoids and many predators have short mouthparts and feed on accessible sugar sources such as exposed floral and extra floral nectar (Marshall and Moonen 2002, Balzan and Moonen 2014). Thus, significant reductions in aphid populations have been recorded in cereal crops boarded with grass and flower strips in Germany, which confirm the potential to promote biological control agents (Marshall and Moonen 2002).

It is therefore possible to design field margins in a way to get the most positive effects related to the functions of field margins. Their size, composition, and management, as well as additional considerations relative to crops and the region may help limiting their impact on pests or grass spread into the cropped area while providing a suitable reservoir for wildlife and biodiversity, as well as providing protection functions of the off-crop area.

6.3.3 Build the confidence in risk mitigation measure's efficacy through the development of certified systems

Besides the generation of data through monitoring or dedicated studies, the promotion of certification systems may contribute to building awareness and confidence in the efficacy of a risk mitigation measure. As an example, sprayers and spray drift reducing nozzles may be verified through standardized methods such as ISO methods (ISO 22866 2005, ISO 22369 2006) so that their efficacy is guaranteed by manufacturers. Later on technical controls may be planned in order to verify the compliance with initial specifications, as recommended for sprayers for example (EC 2009). Most of spraying technologies could benefit of such systems. Similarly for sown field margins, seed mixtures fit for purpose could be standardized and a certification process could be developed, which would contribute to facilitate their implementation.

6.3.4 Provide clear messages: Link to the regulatory framework of the Common Agricultural Policy

As previously mentioned field margins also appear as a farmland management tool of the ecological focus area described in the CAP Greening concept – see also below (EC 2013). The ecological focus area as proposed by the CAP represents at least 5% of the arable area of the holding for farms with an area larger than 15 hectares (excluding permanent grassland) – i.e., field margins, hedges, trees, fallow land, landscape features, biotopes, buffer strips, afforested area. This figure will rise to 7% after a Commission report in 2017 and a legislative proposal.

Some of these tools have been implemented in European countries since the 1990s. Grass margins, the most common of these risk mitigation measures, were for example implemented in Finland and in the UK as part of the AES, with a primary goal to mitigate erosion and pesticide drift into watercourses, although with a recognized added value to preserve biodiversity (Stoate et al. 2009). The benefits of field margins entering in AES programs in other countries have since been reported and published as described above (see for example, Conception et al. 2012a or b, Dicks et al. 2013, Kleijn and Van Langelvelde 2006, Kleijn et al. 2006, Pontin et al. 2006, Pywell et al. 2005, Stoate et al. 2009). Thus, these tools are already implemented in some countries as part of AES. It was therefore important to ensure that the recommendations regarding field margins proposed in this manuscript are practical to farmers in the context of the implementation of these AES and aligned with the Greening concept laid down in the CAP. The field margins and recovery areas described in the RMMTS above may be part of the 5% of the arable land dedicated to ecological focus areas while fulfilling their role of buffering chemical transfers and supporting biodiversity.

6.3.5 Promote the availability of risk mitigation measures to farmers

Beside the lack of awareness on a risk mitigation measure or confidence in the efficacy of the measure, the non availability of the technology involved or financial issues associated with gaining access to this technology are often reported as reasons for not implementing a risk mitigation measure.

With regards to financial implications, participants to the workshop agreed to also include and promote in their inventory the risk mitigation measures that involve expensive technologies. For example, some sprayers with special high-tech equipment may enter in this category, and are thus not evenly distributed in European countries. However, the group considered the efficacy of a technology as a priority criteria, before financial implications for the reason that if that technology would represent a significant benefit in environmental protection, then it should be recommended as such to European authorities for them to consider the ways to facilitate the access to this technology in future. A similar reasoning was agreed with regards to measures that are not yet available in some countries.

6.3.6 Education and training

The lack of experience or practice with a risk mitigation measure may also prevent their implementation. Education and training are critical to communicating the correct messages about risk mitigation measures and building farmers' practice. Education and training with regards to the use of pesticides are part of the recommendations of the Directive of the sustainable use of pesticides (EC 2009).

However, training on the implementation of AES is less often reported, although stewardship initiatives proposing educational booklets, dedicated websites, and applications for mobile phones exist (see chapter on stewardship for further details). In addition, training to use dedicated technology, like spray drift reducing nozzles, may be easier than training to implement specific field margins, because the capacity of farmers to self-evaluate the efficacy of their work is easier with a technology than when ecological aspects are at stake. Recommendations to provide farmers with the minimum level of ecological expertise have already been made in relation to the CAP (Pe'er et al. 2014). This expressed need in education and training has consequence on the acceptance of these tools by farmers and thus their implementation. Examples of dedicated training may be found in Chapter 10.

The acceptance of risk mitigation measures by farmers may be assessed via questionnaires where farmers rank the attractiveness of risk mitigation measures and explain their responses. An example study has been undertaken by Jacot and collaborators (2007) with the aim of collecting farmers' opinions on the implementation of AES. Farmers' acceptance of field margins was observed to be related to crop yields and to the costs relative to the value of the crop. Flexibility in the implementation was also reported as a preferred criterion as for example, the possibility to adjust the width of the unsprayed edges. But encouragingly, the capacity to appreciate an increased biodiversity in the cultivated landscape was also a factor of acceptance of field margins by farmers (Jacot et al. 2007). Finally, the authors report that "the more species-rich a plant community is, the more it appealed to people" (Jacot et al. 2007). Intuitively, the capacity to appreciate the benefits of a management feature like a field margin on the mitigation of erosion or run-off, or on the frequentation of the farmland by butterflies or beneficial organisms, constitutes a convincing argument in favor of a practice, and the development of self-evaluation tools is considered as a priority among educational tools. Such tools could be simple ecological indices, such as those previously developed for flora or butterflies, which may be linked to more academic ecological indices in future. It is believed that a wide spread use of such basic tools would represent an important step forward to better awareness of the environmental dimension in a farmland, as well as to a better appreciation of its status within time.

6.4 Conclusions and recommendations

The toolbox for the protection of the off-field area contains a number of tools in the categories of buffer zones, field margins, spray and dust drift reduction technologies, and good agricultural practices. A total of 15 tools have been identified, 13 of which are further described in RMMTS to ease their implementation. Most of the risk mitigation tools we describe here and in the RMMTS above are well developed and many of them are already implemented in European countries (see Table 6.2 for details). Some of them, particularly when based on drift reduction practice (buffer zone) or technology (spray drift reduction technique), are already taken into account in the risk assessment, as the related reduction of risk through reduced transfers may be quantified and standardized. For risk mitigation measures related to field management features such as field margins or recovery areas, benefits have been described and may be quantified through indices and appropriate indicators or ecological modeling approaches, implying the implementation of dedicated monitoring. However their implementation should not be restrained as their contribution to compensate for potential effects of pesticides in conventional agriculture is significant, as indicated by current knowledge.

Although the toolbox offers a set of measures that present a significant potential impact, it is acknowledged that the key to sustainable environmental protection relies on the implementation of the tools (see van der Valk and Koomen 2013 for pollinators). For example, the implementation of field margins does not prevent the use of spray drift reducing technologies and combined effects are expected. In addition, it is often recommended to look for risk mitigation tools that allow a reduction of exposure in the first place, rather than concentrating efforts on compensatory tools only. A selection of complementary measures may help to achieve significant results soon after implementation and could be a way to include these measures into the standard practice in future.

Recommendations for future development are listed below, in order to complete the development or further improve the risk mitigation toolset for off-field protection. They complete the set of recommendations listed in Chapter 11 for the purpose of off-crop protection:

- Promote the implementation of buffer zones (bare soil buffer zones, wind or temperature dependant buffer zones) and field margins in Europe in order to improve their benefits at a larger scale
- Further develop the multi-functionality of field margins and adapt to Member States conditions in order to refine the related RMMTS and optimize associated benefits
- Further develop the standardization of seed mixtures used to implement field margins and develop related certification systems
- Promote the implementation of spray and dust drift reducing technologies through measures to encourage their use by farmers and their development by manufacturers
- Develop guidelines for monitoring in the farmland in order to get a set of tools to measure the ecological benefits of risk mitigation measures and refine them – in line with the SETAC Environmental Monitoring of Pesticides interest group
- Develop an abacus of spray drift reduction provided by the different types of field margins, as well as of combined spray drift reduction measures

- Develop simple indices to measure the benefits of risk mitigation measures in the farmland, by farmers and develop the communication tools for education and training
- Develop GIS-based databases to appreciate the environmental status of a landscape in order to be able to refine the recommendations in the RMMTS relative to field margins and farmland landscape features to be implemented
- Develop scenarios to be applied in ecological modeling approaches to quantify benefits of (combinations of) risk mitigation measures for an extended understanding and optimization
- Develop a mapping of apiaries e.g., through national inventories and record of honey bee colonies, so that GPS coordinates would become available to farmers
- Develop a cooperation system (preferably web-based) for farmers and beekeepers to exchange relevant information (e.g., location of apiaries, insecticide treatment) while respecting data privacy among the partners
- Enable and promote the link to the regulatory framework of the CAP

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7 Risk mitigation measures for in-crop organisms and functions

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7.1 Introduction

This chapter relates to risk mitigation measures for the in-crop or in-field populations of non-target organisms including vertebrates, invertebrates, soil organisms, and biodiversity.

For the purpose of this document and judging the ways in which the mitigation measures can be used in further informing risk assessment, we can distinguish between several categories of risk mitigation measures:

- risk mitigation measures which effectiveness at reducing risks from a pesticide to organisms or functions are quantifiable
- risk mitigation measures which effectiveness at reducing risks from a pesticide to organisms or functions are not quantifiable but may be appreciated qualitatively
- generic risk mitigation measures

7.2 Overview of existing risk mitigation measures

7.2.1 Risk mitigation measures with quantifiable effectiveness

Quantifiable risk mitigation measures are measures for which the risk reduction potential can be used for risk assessment refinements. Unfortunately, data regarding their effectiveness in terms of risk reduction (e.g., incorporation rates) are available only for a few of them, and are used to refine the risk assessment, as for measures involving modifications of the conditions of product applications (frequency or number of applications or application rate).

The necessary data may be generated in field studies and their results included in the risk assessment (e.g., modifaction of the size of granules to reduce exposure of birds, effectiveness of precision drilling). These studies are compound-specific; hence, it may be difficult to draw a general conclusion about the effectiveness of some of these measures in risk reduction.

In order to get a better and more valuable input in the risk assessment process, and to better relate it to the realistic field conditions, generic studies assessing the effects of such mitigation measures should be made available for general use to the risk assessors and managers.

7.2.2 Risk mitigation measures that reduce the risks but the level of reduction is not quantifiable

In this case, field studies, or monitoring programs can be used to monitor the occurrence of incidents when the risk mitigation measure is applied. However, in many cases the results in terms of exposure reduction or risk reduction cannot be expressed in a way to be directly taken into account as a number in the risk assessment.

The results of these studies may be used in a weight of evidence approach. Monitoring and ecological modeling approaches can be utilized in this process to translate such measures into percentage risk reduction (see Chapter 9.3). Until then, it is preferable to include such non-quantifiable mitigation measures at the time of registration, for example with indications on the label for their application.

7.2.3 Generic risk mitigation measures related to the landscape

These risk mitigation measures can be part of landscape management and should be considered as part of risk management process when authorizing products. For such measures, it is mostly difficult to quantify the degree of risk reduction precisely. Most of the participants considered these risk mitigation measures as neither quantitative, nor related to the risk mitigation of a certain product. However, they compensate for effects of other pesticides and of other agricultural stressors.

These risk mitigation measures can be integrated into landscape management and should be considered as part of risk management process. The effectiveness of those measurements should be confirmed in field studies or in-field monitoring programs or be analyzed by employing ecological modeling approaches (Chapter 9.3).

There is a large number of measures available and several single activities can be combined to a management program to e.g., increase biodiversity within agricultural areas. As an example, typical measures to support birds and mammals in agricultural areas and to minimize impacts from modern agricultural production (including effects from pesticide uses) are:

- Planted hedgerows or small woodlands
- Uncultivated field margins
- 'Skylark-plots,' i.e., patches in arable fields without crops
- Flowering strips or flowering plots
- Nestboxes or other support for nesting
- Set-aside areas or fields and crop rotation
- Maintenance of stubble fields over winter
- Non-crop single trees in orchards

Besides the general improvement of biodiversity in agricultural areas, these measures may also be used in a more targeted way to compensate for the effects of specific cultivation processes. For instance, a cropping regime requiring intensive use of herbicides may have secondary effects on food availability for birds and their offspring. Therefore, the implementation of uncultivated areas (like field margins or set-aside fields) may compensate for these indirect effects and provide sustainable resources for potentially affected bird species. The majority of participants were of the opinion that these measures would be more preferably included in national or regional action plans. However, some participants also suggested that it was technically possible for such measures to be implemented in the registration process of individual pesticides, which would be their prefered option. The generation of monitoring data further documenting the risk reduction provided by these measures will support their implementation and their inclusion in the registration process.

Table 7.1 lists the mitigation measures identified at Member State-level for each group of species of concern, and characterizes their level of practicality, effectiveness, and enforceability. Based on the expert judgement of the participants to the MAgPIE workshops, the risk mitigation measures identified were ranked, as explained in the introduction.

Table 7.1: Overview of the risk mitigation measures (RMM) suitable to reduce environmental risks in farmland. RMM are allocated into the following categories: Good Agricultural Practices (GAP), which relate to

product application (dose and application regime); Crop Management (CM), which relates to agricultural practice in the crop or the field margins aimed at reducing a source of exposure or transfer route; Bee Management (BM), which relates specifically to measures applied to managed bees to keep them from exposure; Buffer Zones (BZ) aimed at reducing exposure of off-field area via spray drift; Field Margins (FM) and Compensation Area (CA), aimed at providing food sources and habitat to off-field flora and fauna; and Seed Treatments and Granules (STG), which involve any technology associated to seed and granule applications. The corresponding Risk Mitigation Measure Technical Sheets (RMMTS) are listed in the last column together with their location in the proceedings

Risk Mitigation Measure	**Category by PPP Application Method**	**Description and Use**	**Status[1]**	**Countries Where Implemented#**	**Proposed New SPe Phrase in the Context of Regulation (EU) No. 547/2001 – see also Chapter 3**	**RMM Taken Int Account i the Risk Assessme**
Application Frequency (reduction), interval between applications	GAP	• Label language defining application regime • Derived from the risk assessment • Benefits related to the group of organisms having driven the risk assessment	4	AT, BE, DE, DK, ES, FR,HU, IT, NL, NO, PL, UK	**New SPe proposing adapted Good Agricultural Practices (GAP) to reduce exposure of wildlife and/or transfers via runoff**	Yes
Avoid the breeding period of vertebrates	GAP	• Label language defining application regime • Derived from the risk assessment • Benefits to birds	3	AT, DK, ES, FI, FR, HU, IT, NL, NO, PL, SE	**SPe7**	Yes

		and mammals				
Avoid applications on migrant birds resting grounds	GAP	• Label language defining application regime • Derived from the risk assessment • Benefits to migrant birds	4	DE	**New SPe phrase:** Do not apply the product on migrant birds resting grounds	No except in some specific cases it is taken into account
Applications on patch and avoidance of ecological hot spots (nesting sites, burrows)	GAP	• Label language defining application regime • Derived from the risk assessment • Benefits to birds and mammals, invertebrates	3	-	Label restriction in the GAP table	No except in some specific cases it is taken into account
Apply baits under cover to avoid exposure of non-target organisms	GAP related to rodenticides	• Label language defining application regime • Derived from the risk assessment • Benefits to birds and mammals	4	-	**SPr1**	No except in some specific cases it is taken into account
Remove carcasses	GAP related to rodenticides	• Label language defining application regime • Derived from the risk assessment • Benefits to birds and mammals	3	-	**New SPr3 phrase:** Dead rodents must be removed from the treatment area each day during treatment.	No except in some specific cases it is taken into account

					Do not place in refuse bins or on rubbish tips. Remove carcasses in order to avoid secondary poisoning of prey birds and carnivorous mammals.	
Avoid tillage to decrease impact on earthworm population and soil macro-organisms	CM	• Label language defining application regime • Derived from the risk assessment • Benefits to earthworms and soil macro-organisms	3	-	Label restriction in the GAP table	No except in some specific cases it is taken into account.
In-crop buffer zones	BZ	• Non-spray areas at the edge of the field i. in-crop buffer zones at the edge of the crop ii. conservation headlands • Benefits to flora and fauna	3	All	**Adapted from current SPe3:** SPe3: To protect [aquatic organisms / non-target plants / non-target arthropods / insects] from spray drift respect an unsprayed buffer zone of (distance to be specified)	Yes

					to the edge of the crop.	
Vegetated buffer strips, multifunctional field margins and off-crop compensation areas (includes grass strip, set aside, flower mix, pollen, and nectar mix, etc.)	FM/CA	• Introduction of a managed or semi-managed vegetated strip at the field margins to provide food source and habitat to one or several groups of organisms, and/or to offer wind screen or runoff management • Product specific or generic • Potentially from 5 to 50 m • See above: defined to present several of the benefits listed for vegetated buffer strips	3	-	**New proposed – see Chapter 6**	Beneficial effects on wildlife an biodiversit observed i monitorin studies, they do nc yet translate into percentag risk reduction for a product
Do not apply during flowering or during bee flight	BM	• Label language defining application regime • Derived from the risk assessment • Benefits to honey bees and other pollinators as implies a check for the presence of bees	3	AT, BE, CH,DK, ES, FI, FR, GR, HU, IT, LV, NL, NO,PL, SE, UK	**SPe8**	n.a.
Removal of flowering weeds	BM	• Removal of flowering weeds prior to	3	CZ, ES, FR, HU, IT, UK	n.a.	n.a.

		applications in order to limit the exposure of pollinators • Potential conflict with preservation of biodiversity in cropped lands, therefore not in use in some MS.				
Information of beekeepers before treatments	BM	• Implies an information of the beekeeper prior to applications	3	FI, DE, LV	**Addendum to current SPe8:** Alert beekeepers prior to applying the product to allow adequate mitigation measures to be taken, and avoid bee colonies' exposure.	n.a.
Provide alternative water sources to honey bees to limit exposure to crop water (e.g., guttation droplets)	BM	• Label language defining application regime • Derived from the risk assessment • Benefits to honey bees	2	-	**Addendum to current SPe8:** Provide colonies with a source of clean water. Liaise with the farmer or grower to define the duration of this measure.	Yes
Restrict applications to uses in	BM	• Label language defining	4	-	Label restriction in the GAP	Yes

greenhouses and protected crops: benefits all non-target organisms		application regime • Derived from the risk assessment • Benefits to honey bees and other pollinators			table	
Soil incorporation and precision drilling	STG	• Label language defining application regime • Derived from the risk assessment • Benefits to birds and mammals	4	AT, BE, CH, DK, DE, ES, FI, FR, GR, HU, IT, LV, NL, NO, PL, SL, UK	SPe5	No, unless specific data available
Remove or avoid spillage	STG	• Label language defining application regime • Derived from the risk assessment • Benefits to birds and mammals	4	AT, BE, BG, CH, DE, DK, ES, FI, FR, GR, HU, IT, LV, NL, NO, PL, SL, UK	SPe6	Yes
Use of repellents in the formulation or as extemporaneous adjuvants	STG	• Label language defining application regime • Derived from the risk assessment • Benefits to birds and mammals	3	Industry	-	Yes

as based on the questionnaires and further discussions

Status:

1. Not to be promoted

2. Under development

3. Needs consolidation and research

4. Promising tool implemented in some Member States

5. Well established tool implemented in most Member States

7.3 Existing risk mitigation measures - Strengths and limitations

7.3.1 Birds and mammals

Standard risk assessment procedures have been developed for a large range of scenarios under common agricultural practice including different crops and different types of pesticide uses. In these scenarios, it is considered that birds and mammals may be exposed to pesticides residue via dietary exposure i.e., via the consumption of contaminated food items, including contaminated prey or water, contact exposure through dermal adsorption, or inhalation exposure (in case of high volatile active substances). Even though in some cases risks are not covered by the standard risk assessment procedures, because several different local factors are involved.

For example, for typical spray applications, we have identified 2 case studies where these factors can be the spray liquid itself or coincidence of application and irrigation practice. In the first case, the spray liquid itself created an attractive, humid microclimate for birds in a dry environment. The full cover application of an insecticide with high water volume in old orchards resulted in direct and lethal contacts of birds with the spray solution in wet trees. The second case relates to simultaneity between an insecticidal application and the activity of a drip irrigation system. In this circumstance the irrigation created small pools at the time of application with critical pesticide loadings after the spraying event.

For both examples, risk mitigation measures were developed, communicated to farmers, and accompanied with field monitoring. In the first example only, the application technique was modified from a full cover to a bait-application, with a significant reduction of the exposure to only small spots in each tree without using high water volumes and thus creating an attractive microclimate. In the second example, the irrigation system was shut down early enough before the application so that no pools or areas of shallow water were present during the pesticide spray. The effectiveness of both mitigation measures was again verified by subsequent field observations.

With regards to granular formulations, the theoretical risk evaluation might demonstrate a potential risk for birds and mammals from the granular formulation itself. The risk can be due to the carrier material or granule size, which overlaps with preferred grit particle size for small granivorous birds. Possible risk mitigation measures, such as adoptions of the granular material or size are then to be verified by field investigations. Such studies can be very focused effect studies, evaluating the likelihood of adverse effects in the field, exposure studies assessing the availability of particles on relevant soil types, or (post-registration) monitoring-programs investigating application techniques, exposure, and the presence of vulnerable bird and mammal species in a larger scale.

As mentioned before generic risk mitigation measures (i.e., not linked to a specific product) may benefit from field monitoring. Structures in the agricultural landscape may support farmland birds and mammals (like plots in arable fields to provide nesting ground for birds like skylarks or yellow wagtails), but it is also very important to accompany those measurements by field investigations to avoid "ecological traps," which may not support species in a sustainable way.

The following risk mitigation measures are already used in Member States to reduce the risks for birds and mammals (see Table 7.1):

a. Granules and treated seeds:

- **Soil incorporation and precision drilling**
- **Remove spillage and avoid spillage of seeds and granules**

These mitigation measures present the advantage to avoid treated seed consumption by birds and mammals and ensure a reduced risk for granivorous and omnivorous species in freshly drilled fields. However, concerns were raised on the applicability in practice of these measures due to the fact that seeds or granules cannot be seen by the farmer when drilling or spreading (i.e., when he is sitting on the tractor). Therefore, developments in the area of application equipment might be needed to improve incorporation and prevent spills. Precision drilling techniques are already in place for crops such as maize, for example. The question remains whether such techniques are applicable for crops such as cereals.

b. Rodenticides:

- **Buried application**
- **Addition of repellent substances in granules**

- **Remove dead carcasses to avoid secondary exposure of pray birds and mammals**
- **Restrictions of use in migrant birds resting grounds**

These mitigation measures are used by some Member States following the risk assessment, as precautionary measures, or by industry as proposals for conditions of use (e.g., use of repellent). These measures are necessary to avoid consumption of baits by non-target birds and mammals, and protect birds of prey and mammalian predators from secondary poisoning. However, some of these measures may be time-consuming (e.g., carcasses removal), and imply a regular control of area where the product has been applied. Moreover, questions were raised concerning the effectiveness of repellents to protect birds. Repellents are known to be very effective on mammals, but the experts wondered if they were as effective on birds.

c. Mollusquicide baits

- **Include repellent substances**

This mitigation measure was proposed by industry as proposal for conditions of use. It is intended to avoid consumption of baits by non-target birds and mammals. However as for repellents used with rodenticides, the question of its effectiveness on birds was raised.

d. restricted or no use in protected habitats (e.g., Natura 2000)

Such mitigation measures are not product-specific and are applied at national level, as for example in the context of NAPs or emergency use decisions, in order to preserve biodiversity and protected areas or landscapes.

e. Reduced frequency or number of application, reduced application rate

These mitigation measures are widely used in Member States to reduce exposure of non-target organisms when risks are identified as too high after the risk assessment. They are also easy to implement as they are product-specific and directly connected to the GAPs, and are therefore reported on the product label. They should however be in line with results of efficacy trials in order to ensure sufficient efficacy of the product.

f. Restrictions to apply during breeding period

This mitigation measure is used by some Member States to avoid the exposure of birds during a sensitive period. It can be applied when a specific sensitive period is identified during the risk assessment process. When the whole cycle of birds is equally sensitive or when the product is only intended to be applied during spring, no authorization can be granted.

This measure is not applicable to mammals as reproduction period of small mammals lasts for a large part of the year.

g. Applications on patch

Finally, patch applications may help to avoid direct spray on vertebrate habitats and nests or on ecological hot spots. Details of this risk mitigation measure may be found in Appendix 1(RMMTS #14: "Applications on patch and avoidance of ecological hot spots (nesting sites, burrows)."

7.3.2 Bees

Bees represent a particular group of organisms in cropped area due to their pontentially close interactions with crops. Within this group honey bees have been given increasing attention in the regulatory process and a considerable amount of data have been generated to better understand the conditions for a healthy maintainance in crops. In this context, studies, in particular multifactorial studies, set the light on the factors involved in honey bee losses, as illustrated in Figure 7.1. Beside pesticides, habitat loss, climate change, diseases, beekeeping practices, and invasive species have been involved in losses (see e.g., AFSSA 2009 and OPERA 2012, 2013).

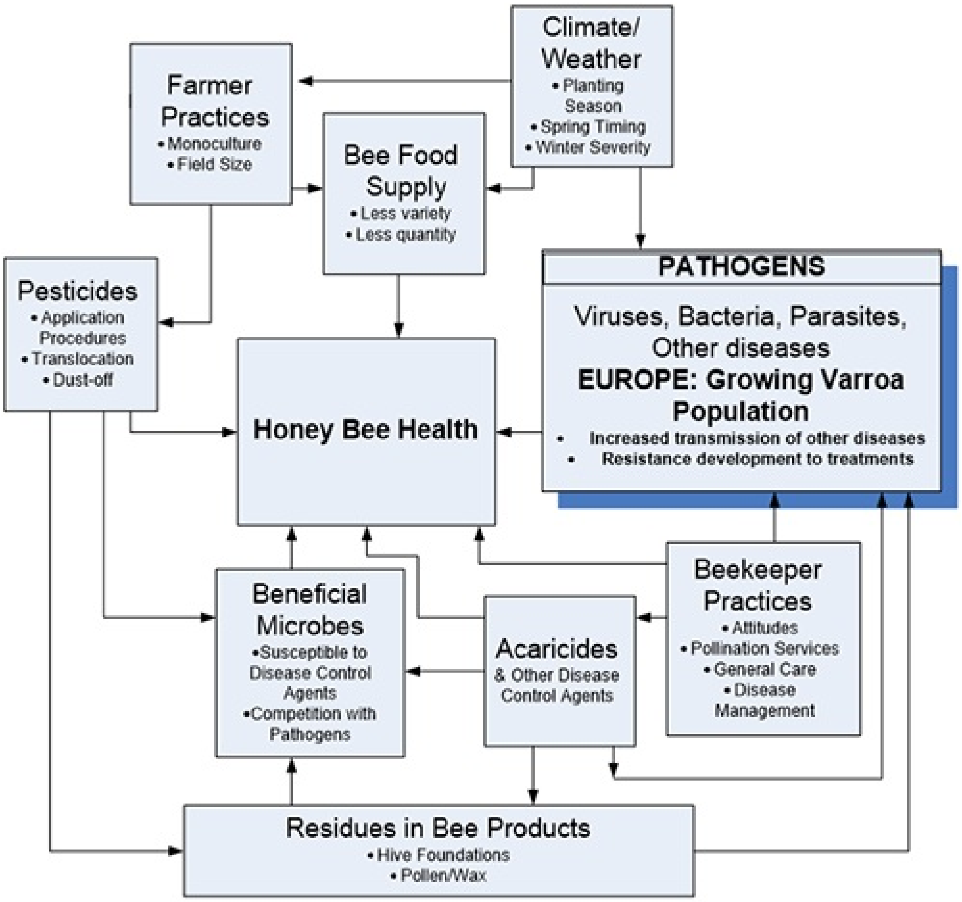

Figure 7.1: Interrelationship of bee health stressors (Adapted from Le Conte et al. 2010)

In this context, the role of pesticides is most often recorded through single events of poisonings by spray applications. The causes of adverse effects of pesticides on bees is usually due to misuse of products resulting from ignorance of product label statements by farmers, combined with poor communication with beekeepers or disregard by the latter for good beekeeping practices (see e.g., AFSSA 2009; Barnett et al. 2007, Seefeld 2008, Thompson & Thorbahn 2009). In this context, it is important to note the misuse of products.

Beside incidents, sublethal effects of pesticides alone or in association to other factor's effects have often been mentioned in the literature, but remain difficult to demonstrate in the field, where effects other than losses of colonies are rarely reported and also because their presence in hive products is not always associated with losses (AFSSA 2009). Sublethal pesticide residue concentrations found in nectar, pollen, and, bee bread are frequently considered a potential factor resulting in delayed adverse effects on bee health. However, the available results of studies completely or partly dedicated to this topic show no correlation between sublethal-level residues of pesticides in bee hives and colony mortality (e.g., AFSSA 2009, Bernal et al. 2010, Genersch et al. 2010). Thus, the availability, quantity, and quality of nectar and pollen throughout the season are major factors for bee health. Bees feeding on a mixture of pollen from different plants are healthier than those fed only one type of pollen. Areas with high biodiversity are more likely to provide sufficient nutrition throughout the year, thus ensuring food provision. Changes in land-use, agricultural crop management, land abandonment, as well as the loss of traditional farming and forestry practices, which have previously generated rich habitats, are some of the major causes for biodiversity loss (see OPERA 2012, 2013 for reviews).

The quality of pollen during colony development is important in determining the sensitivity of bees to pesticides. Bees fed with high quality pollen appear less sensitive to pesticides than those fed on lower quality or inadequate amounts of pollen or pollen substitute during development (Wahl and Ulm 1983). This observation suggests that nutrition may affect the development of enzyme activities at specific life stages, with both the amount and the quality of pollen ingested in the first days of life affecting the sensitivity of both young and older adult bees.

For wild bees, habitat loss and fragmentation are of special importance. Many different wild bees are particularly dependent on special habitats and special wild plants compared with managed honey bees, which fly longer distances and forage on a wider number plant species. Little information is available on how local management practices influence agricultural pollination (Richards et al. 2001).

Habitat loss is one of the main factors inducing bee declines (Brown and Paxton 2010). To maintain health, foraging bees need a variety of sources of natural nectar and pollen to prevent nutritional deficiency and to strengthen immune defences (Brodschneider and Crailsheim 2010; Alaux et al. 2010; Pederson and Omholt 1993). The increased numbers of large farms that grow one type of crop have resulted in reduced variety, quality, and quantity of pollen for bees. Bee foraging is further compromised by efforts to "neaten" landscapes by eliminating wild flowers and weeds in places such as lawns, parks, and farm boundaries.

Exposure of Bees to Pesticides and Pesticide Side Effects to Bees

The exposure of bees to pesticides is determined by different factors, for instance timing and type of application and attractiveness of the treated crop to bees. Exposure can be excluded when according to the type of application bees are not likely to come into contact with the applied product. For example, winter applications when bees are not active, pre-emergence use of herbicides, wound treatments, rodenticide baits, indoor uses, use in greenhouses (where pollinators are not released), products for dipping bulbs, etc., are likely to lead to negligible exposure of bees, and in such cases a risk assessment is not required.

A second point to consider is the attractiveness of the cultivated plant. In general, a crop is not attractive to bees when harvested before flowering. In this context, it has to be considered that attractiveness of a crop may be influenced by factors other than the intrinsic attractiveness of its blossoms (e.g., flowering weeds in the crop, honeydew-producing aphids).

The most important route of exposure to pesticides, and by far most important cause for poisoning incidents, is the exposure to direct overspray of bees in a treated crop and the uptake of contaminated nectar and pollen from flowering crops.

Another path of exposure is via the dust from seed coatings that may be emitted, in particular when vacuum-pneumatic drillers are used for sowing. In certain crops (e.g., sugar beets), potential exposure to dust is due to coating techniques and to size of the seeds a priori low to negligible, in others (e.g., maize) measures have to be taken to minimize dust emission. The level of exposure can vary depending on the quality of the seed coating (the better the seed treatment quality, the less dust is formed) and on the use of devices reducing dust emission, e.g., deflectors. Technical solutions for effective risk mitigation of dusts exist and are in place in many Member States with positive results (for a case study in Austria see Chapter 9.1).

The exposure of bees via uptake of guttation water containing residues of systemic insecticides has been discussed in the scientific community in the last years. Recent research data (Keppler et al. 2010; Pistorius et al. 2012) have demonstrated that the issue of guttation is of comparably low importance compared with spray applications and indicate that in certain circumstances only small numbers of bees in a hive may be intoxicated, even if colonies are placed directly next to crops. The risk has been shown to decrease rapidly within a few m distance of the colonies to treated crops. The conditions of occurrence of guttation dropplets are not fully elucidated, and therefore, the possibilities to reproduce these experimentally remain unclear (EFSA 2012).

The following risk mitigation measures are already used by Member States for bees:

a. Restrictions for use in flowering crops:

- Time of treatment or avoid exposure (out of bee flight): Flowering and pre-flowering restrictions or use only during the night
- PPP should not come in contact with flowering plants

These mitigation measures are widely used by Member States to reduce exposure of honey bees and other pollinators that forage during daylight. However, spraying at night does not prevent exposure of solitary bees and bumble bees that fly at night or nest in the field or its near vicinity. Compensation might be put in place if any damages are observed for pollinators.

b. Only uses in greenhouses allowed

This mitigation measure is used in some Member States in order to avoid exposure of bees and other pollinators. This involves the management of pollinators voluntarily introduced in the greenhouse for crop pollination.

c. Cut flowering plants in the vicinity of the field

During the expert debates on the use of the measures, it was highlighted that there may be contradictions between mitigation measures. Indeed, cutting weeds to protect bees reduces diversity, habitat, and food source (see Chapter 6). Mitigation measures such as spraying at night may not fully prevent exposure of solitary bees and bumble bees, which may be seen flying at night or in the early morning. Hence, we can conclude that the applicability of some of the measures and their efficiency in reducing the risks for pollinators depends very much of the protection goal sought by its application.

d. Risk management package in order to enable safe use of seed treatments:

- **Reduce dust drift**

It is the opinion of the experts that mitigation measures as those establishing quality standards for treated seeds need to be widely implemented due to their efficiency in reducing the risk of exposure through certain routes. A seed industry initiative has proposed a stewardship approach for treated seeds. A general mitigation measures could be to restrict the use of industrial treated seeds, and forbid seeds treated on farm.

The seed sowing process can contribute to mitigating risks (e.g., use of deflectors, use seed quality standards). A SANCO guidance document is under preparation at EU-level (SANCO/10553/2012). The purpose of this guidance document is to provide for a harmonized implementation of the different provisions of Regulation (EC) No. 1107/2009, which are related to the treatment of seeds with plant protection products. Firstly, it intends to harmonize the implementation of the provisions of Regulation (EC) No. 1107/2009 on the placing on the market and the labeling of treated seeds. Secondly, it intends to also provide guidance for the performance of the risk assessment and the application of the criteria for the purpose of authorization of plant protection products for seed treatment, in particular risks related to exposure to dust.

This document includes generic risk mitigations measures which are meant to be on the label of seed packages, as for example the use of certified deflectors in order to reduce dust drift, or the seed treatment quality standards defined using Heubach test. To facilitate the free circulation of seeds, these mitigation measures should be harmonized into a set of standard phrases. National agricultural practices and environmental conditions need to be considered. There is therefore a need for implementation of recommendations into regulatory (enforcement) in order to have harmonized and recognized treated seeds for selling.

Application rates should also better be harmonized among Member States, as there are many differences on seed sowing GAPs between Member States. In this case, economic impacts have to be taken into account in order to balance environmental risks and benefits for farmers.

Simultaneously, the sustainable directive requires that equipment be certified since 2015 and this provision can be used for the implementation of this risk mitigation measure.

e. Cover static hives or remove hives

In terms of the applicability, experts highlighted that some measures can only be taken into account if other administrative actions are taken. For example when mitigation measures are proposed for bees (e.g., remove hives or cover static hives), there should be an obligation by the farmer to alert local beekeepers.

The implementation of other measures can generate other undesired effects. For example, covering hives may cause problems with colony viability. There is therefore a need for coordination between beekeepers and farmers.

In order to reduce bee exposure to guttation droplets, water sources could be supplied next to the hives (in-field or off-field). However, exposure to guttation droplets is still under discussion and questions are raised as whether to consider it as an issue. In the framework of the International Commission on Plant-Pollinators Relationships (ICP-PR) studies, one study out of 20 recorded a high mortality in individuals. Also, this mitigation measure must be implemented with care to avoid possible disease transfer via alternative water sources. Product specific post-authorization monitoring might be put in place where doubts persist regarding the risks generated by the use of certain products. Using the data collected in such post authorization monitoring and development of new monitoring programs is paramount in order to conclude on risk mitigation effectiveness.

The use of flowering strips might be considered as compensatory mechanisms for farmers' field losses, biodiversity reserve, and pollinator food source and habitat (see dedicated Chapter 6).

7.3.3 In-crop non-target arthropods

The protection of non-target arthropods in-field considers the protection of arthropod communities as regards biodiversity aspects as well as thir role as food source for birds. The off-field area is identified in protection goals as a source for potential recolonization. It is therefore needed to consider harmonization of size of the buffer zone related to the field size.

In addition, in-field vegetated "buffer" strips can serve as a substitute habitat and allow for recolonization of non-target arthropods when a sufficient off-field area is not available. The potential of such strips of hosting crop pests and diseases, which could increase pest pressure and thus the number of pesticide applications (see Chapter 6), might trigger risk mitigation adaptation at the farm scale.

The following risk mitigation measures are already used in Member States for non-target arthropods:

a. Restriction of use based on GAPs

- **Reduced dose or frequency or intervals of applications**
- **Timing of applications (crop stage)**

These mitigation measures are widely used in Member Sates to reduce exposure of non-target organisms when risks are identified as too high after risk assessment. They are also easy to be applied as they are product-specific and directly connected to the GAPs, and are therefore reported on the product label. They should however be in line with results of efficacy trials in order to ensure sufficient efficacy of the product.

b. Restricted spatial use: 50% of surface

This is another way to reduce exposure of non-target arthropods. It is particularly relevant for permanent crops (i.e., orchards and vineyards) with vegetative areas between rows in which the product can be applied on the raw only. They are consistent with agricultural practices of these crops and are therefore not considered as restrictive for their implementation.

c. Temporal restrictions (e.g., only 5 applications within 10 years) in order to enable recolonization

This measure is another way to allow recolonization of in-field, non-target arthropod populations with off-field populations. A good product management by the farmer is necessary, and the respect of the measure is difficult to control.

d. Mitigate the risk to protect specific areas

- **No application on the edge of a forest (25 m buffer zone)**
- **No application in nature protected areas**

These mitigation measures are intended to prevent exposure of specific off-field areas. They are currently not widely used in Member States, and may be part of landscape management national policies.

e. Unsprayed headlands

This measure is equivalent to in-field, non-sprayed buffer zones. It is widely used in Member States in order to avoid exposure of off-field areas and allow recolonization of in-field, non-target arthropod populations.

7.3.4 Soil organisms

It is known that agricultural practices influence earthworm populations. Moreover, recovery is difficult but is however required when addressing long lasting effects. A step forward would be to address recovery within 1 year taking into account several applications of different PPP.

The following risk mitigation measures are already used by Member States for soil organisms:

a. Restriction of use based on GAPs

- **Annual restrictions (e.g., every 2nd year)**
- **Reduced application rate or number of applications**
- **Spot applications; crop growth stage**

As for other non-target organisms, these mitigation measures are widely used in Member States to reduce exposure of non-target organisms when risks are identified as too high after risk assessment. The same considerations related to the product efficacy should be taken into account.

b. In greenhouse only

This mitigation measure is used in some Member States in order to avoid exposure of soil-dwelling organisms, as soils in greenhouses may be highly disturbed, or crops may even be grown in pots containing artificial soil or growing media.

7.3.5 Compensation measures for managing in-crop effects of plant protection products

While direct effects on species and communities in off-field areas can in principle be considered as being covered by current EU regulatory risk assessment and management methodology for PPPs, and approaches do exist for assessing and managing impacts on some parts of the in-field fauna (but not plants), indirect effects on biocenoses (in particular farmland birds) are not yet addressed.

However, direct effects on in-field, non-target organisms, such as arthropods might indirectly lead to significant impacts on individual farmland species, as well as to overall biodiversity in the agricultural landscape. Even though the endangerment of farmland invertebrate and vertebrate species is known to be a multifactorial problem, it is obvious that the effects of pesticide use on the availability of insects as a food source can be a limiting factor to the viability of farmland bird populations. The state of knowledge regarding such indirect effects of pesticide use on the populations of farmland birds and mammals has been reviewed recently in a comprehensive report by Jahn et al. (2014). As indirect effects of PPP on vertebrates derive mainly from their direct effects on lower trophic levels caused in-field, a risk management of indirect effects on farmland bird species has to target the protection of in-field, non-target plants and arthropods on a functional level. In the following, we provide an overview of the current knowledge regarding the availability and suitability of measures to compensate in-field effects.

7.3.5.1 Compensation measures as risk management option

The current risk mitigation of PPP mainly relies on measures reducing the exposure to non-target species within their habitat. When it comes to mitigating in-field effects, though, this principle reaches its limits as reducing exposure in-field would mostly be incompatible with the intended plant protection effect, i.e., effectively eliminating competing weeds and other pest species. Thus, regarding in-field effects it appears necessary to expand the range of risk mitigation options. In principle, two options are available:

1. Compensating indirect effects by measures integrated into the agricultural system, and
2. In specific cases of broad spectrum pesticides for which effects at several trophic levels in non-resilient habitats have been demonstrated, mitigating indirect effects by e.g., increasing the proportion of low pesticide-input agriculture in order to reduce impact on the potentially affected species.

Although not yet established in a regulatory scheme, comprehensive practical experiences with potential compensation measures exist in the context of landscape conservation and species protection in the EU countries. Prospects of their use as a tool for the management of PPP-related in-field effects have been discussed i.e., by DEFRA (2004) and Jahn et al. (2014).

The DEFRA report is focused on the risk to the wider biodiversity arising from the use of pesticides, including weed and arthropod species and their function as “chick food.” Regarding compensation measures, the DEFRA report emphasizes the following options:

- Conservation headlands (the outer few meters of cereal crops on which a modified pesticide regime is implemented, with only selective herbicides permitted)
- Undrilled patches (also known as “skylark scrapes”)
- Beetle banks (banks around 0.5 m high and 2–3 m wide, normally positioned across the center of large fields, and sown with tussock-forming grasses)

Besides the compensation effects of those measures, DEFRA (2004) estimates their costs, their impact on production, and the ease of implementation.

Jahn et al. (2014) evaluate comprehensively the options for the compensation of indirect effects of PPPs on birds and mammals regarding their ecological suitability and the prospects of their practical implementation in Germany. According to this study, the most effective compensation measures for the risk management of farmland bird species include:

- Creation of extensive field crops without application of pesticide and with reduced sowing density and fertilization (comparable to conservation headlands as discussed by DEFRA [2004]), and very similar to the creation of sparsely sown cereal crops
- Creation of flowering areas or strips
- Keeping stubble fields with self-greening and as appropriate with maintenance measures
- Creation of road, water, and bank verges with extensive grassland
- Creation of biotope networks (e.g., sowing of wild herbs from autochthonous seeds)

Generally, these 5 measures can be implemented in almost all arable countryside within the EU. In their report, Jahn et al. (2014) also discuss the minimum extent of ecological compensation areas needed to sustainably secure the populations of many farmland species. The kind and extent of necessary compensation measures are essentially dependent on the affected species and the given ecological and agricultural conditions. For instance, the population relevance of indirect effects will be more severe in intensive agricultural landscapes with a scarcity of suitable refuge habitats. Thus, no recommendations for concrete risk management schemes in Member States can be provided in these intensive production situations. Rather, the concrete risk assessment with regard to indirect effects, as well as the derivation of suitable risk mitigation strategies for their management should be done in single Member States.

Table 7.2: Overview on possible compensatory measures for mitigating the risk to farmland birds caused by PPP-related alteration of the food web.

Risk Mitigation	**Principle**	**Explanation and References**

Measure		
Creation of flowering areas or strips	Providing alternative habitats for arable plants and arthropods and accordingly additional food sources for farmland birds	Flower plots or strips are created by different sowing flowering mixtures available on sale. They also support populations of pollinating insects, in particular bee and butterfly species. If placed as a buffer zone between in- and off-field area they can additionally reduce off-field exposure. Reference: DEFRA 2004, Jahn et al. 2014
Establishment of whole-field set-aside	Providing alternative habitats for arable plants and arthropods and accordingly additional food sources for farmland birds	Positive effects of whole-field set-aside on the diversity and abundance of the arable flora as well as species on higher trophic levels have been demonstrated by various studies (Jahn et al. 2014). However, positive effects of rotational (1 or more years) set-asides for both arable plants and higher trophic levels such as farmland birds depend on the management of the set-asides itself as well as the general landscape context. References: DEFRA 2004; Anonymous 2008, Jahn et al. 2014, Tscharntke et al 2011
Creation of sparsely sown cereal crops with restriction of application of PPP	Providing alternative habitats for arable plants and arthropods and accordingly additional food sources for farmland birds Furthermore habitat quality especially for birds such as skylark is improved due to the reduction of the density of crop	Sparsely sown areas or strips are created during the sowing of cereal crops by closing individual coulters of the seed drill. Reference: Huber et al. 2008 and NABU 2010 in Jahn et al. (2014) Undrilled patches as proposed in DEFRA (2004) basically follow a similar approach with the focus mainly on provision of appropriate nesting habitats for birds such as skylark
Non-spray areas at the edge of the field a) in-field buffer zones to adjacent off-field areas b) conservation headlands	Providing alternative habitats for arable plants and arthropods and accordingly additional food sources for farmland birds	Conservation headlands represent the outer few meters of crops on which a modified pesticide regime is implemented, with restricted use of herbicides, e.g., with no use or only selective herbicides permitted. Conservation headlands effectively provide alternative habitat for arable plant species of high conservational value. If placed as a buffer zone between in- and off-field area they can additionally reduce off-field exposure Reference: DEFRA 2004, Jahn et al. 2014
Preservation of over-wintered	Providing alternative habitats for arable plants and arthropods and	According to Jahn et al. (2014) the keeping of stubble fields does not only benefit farmland birds and mammals, but also have an enormous ecological significance.

stubble with self-greening and as appropriate with maintenance measures	accordingly additional food sources for farmland birds	
Reduce the use of broad spectrum products in areas of low environmental resilience	Restrict the use of these PPP use by means of other/non-chemical plant protection, thus reducing effects on in-field plants and arthropods and accordingly increasing food sources for farmland birds	In specific cases of broad spectrum pesticides for which effects at several trophic levels in non resilient habitats have been demonstrated, mitigating indirect effects by e. g., increasing the proportion of low pesticide-input agriculture in order to reduce impact on the potentially affected species
Patch application (spray)	Reducing in-field exposure will decrease risk for non-target plants, especially species of high conservational value, and does consequently increase the food availability for higher trophic levels	Methods of spatially selective weed management based on geo-referenced information on the occurrence of pest species which enable an appropriate application due to higher precision. By such a differentiated weed control only those in-field areas with a critical abundance of pest species are treated. Scientific background and applicability with agricultural practice are discussed in detail in DEFRA 2004
Restriction of application of PPP in ecological hot spots (nesting sites, burrows)	Reducing or restricting in-field exposure in ecologically sensitive patches within the field counteracts the habitat loss for e.g., breeding birds by full area herbicide applications	The use of spatially explicit methods may also be used for selectively restricting spaying in ecological hotspots such as nesting sites as proposed by Jahn et al. 2014

7.4 Conclusions and further development

The toolbox dedicated to the protection of in-field and in-crop organisms shows a diversity of options that goes beyond the conditions of application of pesticides. Indeed, beside modifications of the GAPs, adaptation of cropping practices and farmland management can exert significant impact on the overall environmental sustainability of the cropped area. Measures in the cultivated area such as tillage practices and buffer zones have proven to be effective, and associated with an increased awareness on the organisms to be protected, they constitute tools for a greater agility in farmers to compensate potential effects. Off-crop and farmland management measures as described for the mitigation of risks off-crop also have beneficial effects in the cultivated area itself, when implemented at appropriate spatial and time scales. Indeed, except for groups of organisms of limited mobility, monitoring studies having addressed the effectiveness of farmland management options often measures the effects at the farmland scale, with little distinction between cropped and non-cropped areas. Again, it is crucial that these farmland features are defined for the purpose of providing habitat, food resource, and buffer to exposure in a dedicated way, and more data involving monitoring or ecological modeling may be necessary before a proper inclusion of these risk mitigation measures in the risk assessment. However, as for other risk mitigation measures not yet to be used in a quantitative risk assessment, it is recommended that their implementation is encouraged for the benefits they may provide as well as to initiate data generation on their quantitative effectiveness.

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8 Developing harmonized risk mitigation measures to protect non-target terrestrial life covering the new protection goal “biodiversity”

Martin Streloke and Katja Knauer

8.1 Biodiversity as a protection goal

The protection of non-target species was a protection goal in Directive 91/414 (ECC) and remains as such in Regulation (EC) No. 1107/2009. In this context, the data provided on a product must be sufficient to permit an assessment of the impact on non-target species. Both acute and chronic exposure testing are conducted on most non-target species including birds, fish, aquatic invertebrates, algae, sediment-dwelling organisms, aquatic plants, bees and other arthropods, earthworms and other soil macro- and micro-organisms, non-target plants, and organisms involved in sewage treatment biological methods. All these groups of organisms are to be protected at the population level, off-crop, and for terrestrial vertebrates and invertebrates and soil organisms, in-crop, as well. For some vertebrates species, the level of protection may be the individual as for birds and mammals species for which populations may be very limited in size and it is not desirable to observe mortality in fields, for example.

Over the last 10 years Member States have set risk mitigation measures (RMM) to protect non-target terrestrial life when authorizing plant protection products (PPP). As an example use restrictions for granules and treated seeds could be set in order to protect bees and birds. Buffer zones may be set to protect terrestrial habitats like hedgerows or grassed biotopes in order to protect non-target insects and plants. Specific additional pieces of legislation were also developed at the national level as for the protection of honey bees, for example.

The protection of birds and mammals, bees and other arthropods, and plants dwelling outside cropped fields contributes considerably to the protection of biodiversity in agricultural landscapes. Whereas the protection of non-target species was already a requirement under the Directive 91/414/EEC, Regulation (EC) No. 1107/2009 has introduced biodiversity as a new protection goal: according to Article 4 (3e) of regulation (EC) No. 1107/2009 (i) “unacceptable effects on the environment” and (ii) specifically “impact on non-target species…“ and (iii) “impacts on biodiversity and the ecosystem” must be avoided. "Biodiversity" is defined as "variability among living organisms and the ecological complexes of which they are part; this variability may include diversity within species, between species and of ecosystems" (Art 3 [29]). It is not known whether this implies to consider an additional level of protection on top of the existing protection goal of no-effect on species populations, as described above.

The "variability of living organisms" in the agricultural landscape as part of the biodiversity definition in the regulation suggests a typical variety of species and, as a prerequisite for this, different habitats and niches are needed. The "ecological complexes" point to typical food webs and food chains of agricultural landscapes, including crop and non-crop biotopes. On the other hand, this variability is to be put in the context of agricultural areas where agricultural production, plant health, and food production are important targets in Regulation (EC) No. 1007/2009, whereas measures for nature conservation do not fall in the remit of this regulation. Also, the diversity of the landscape itself is critical in environmental protection. Indeed, the higher carrying capacity of diverse landscapes to compensate for potential effects of pesticide use on the treated fields has been recognized, in the context of Integrated Pest Management (IPM), for example. Hence, in diverse and well-structured agricultural landscapes, where food chains and food webs are being present and supported, resilience and self regulation are observed so that the benefits of additional risk mitigation measures to protect biodiversity from effects of pesticides are not significant (see also Chapter 6). Thus, in diverse landscapes, recolonization of areas is more likely, in general, and the biodiversity protection goal is easily met. In contrast, in landscapes where one type of habitat is present as the crop itself (extreme cases), pesticide use and more especially products with a high potential of risk to non-target life that require important risk mitigation measures, could contribute to effects on biodiversity, and to situations where "ecological complexes" cannot be established. Indirect effects on biodiversity due to the lack of food chains and food webs may occur. The lower the number of habitats the lower the carrying capacity of agricultural landscapes against effects of pesticide use, and the more likely there will be indirect effects on biodiversity. However, pesticides are not the only reason for such effects (see below).

If effects of pesticide use on biodiversity are considered as important for regulatory decision-making, a risk assessment scheme should be developed. Subsequently, a workshop was organised by EFSA on this topic. At the moment, there are no clearly defined specific protection goals (or endpoints to be measured) for biodiversity, and the way and scale to measure biodiversity (m², field, farm, landscape, region) in the regulatory context of a risk assessement are not defined. As mentioned in Chapter 6, the benefits of some of these risk mitigation measures to reduce exposure and risks to non target-organisms are not quantified in risk assessments yet. Until the benefits of risk mitigation measures are estimated quantitatively for each of them, mitigation proposals for that purpose might remain general and abstract. In the meantime, Member States are free to already undertake mitigation measures in order to prevent further loss of biodiversity and in the medium-term a clear and quantitative chain of reasoning from the risk assessment to risk mitigation measures protecting biodiversity needs to be established.

8.2 Example of the Swiss approach - Federal office for agriculture (FOAG) (updated February 2014)

In Switzerland, a scheme that involves direct payments with the aim of promoting biodiversity on farmland was introduced in 1993 and extended in 2001, in order to enhance the eco-quality of compensation areas, and promote biodiversity and habitat diversity in the agricultural landscape (in German: Biodiversitätsförderflächen). Direct payments represent economically attractive incentives for farmers and they contribute towards preserving the environment. Farmers can voluntary participate in the program. This program is not linked to the Swiss regulation for pesticides and requests additional risk mitigation measures for product safety.

The key elements of proof of ecological performance are i) an appropriate share of ecological compensation areas to enhance biodiversity in the agricultural landscape (a minimum of 7% of the agricultural land), ii) well adjusted fertilizer balance, iii) compulsory crop rotation, iv) measures for soil protection, and v) restricted and targeted use of plant protection products and animal welfare standards. Linking direct payments to these conditions has resulted in almost all farmland in Switzerland (98% of Swiss farms receive direct payment) being used in a more “environmentally friendly” way. Ecological direct payments support specific compensation areas. These measures list:

- Extensive meadowland
- Less intensive meadowland

- Extensive grassland
- Reed beds
- Hedges, copses, and wooded river banks
- Flowery meadows
- Rotated fallow fields
- Natural field margins
- High-stem fruit trees
- Vineyards with natural species composition
- Species-rich grassland and meadows in the region of the alp and canton Jura “Sömmerungsgebiet”
- Regional-specific areas to enhance biodiversity

Payments are also linked to the quality of the compensation areas and the interlinking of compensation areas (http://www.admin.ch/opc/de/classified-compilation/19983379/).

All direct payments have been based on stringent proof of ecological performance (cross-compliance). This ensures that ecological measures are used throughout the country. Through direct payments, the aim is to ensure a vital and environmentally friendly agricultural sector is achieved. Furthermore, Switzerland has set up a monitoring scheme that includes the use of specific indicators to evaluate the current state and development of the agricultural ecosystems.

8.3 Example of approach under discussion in Germany

In the EU, direct payment-related measures meant to promote biodiversity have recently been established in the course of the “Greening” of the Common Agricultural Policy (CAP). However, these measures are not yet as extensive and ambitious as in Switzerland. In Germany, a concept for implementing risk mitigation measures to protect biodiversity in the authorization of PPP is under discussion. Safety phrases on the label to protect non-target arthropods and plants have been in use for more than 10 years. Buffer zones to biotopes like hedgerows or use of spray drift reducing machinery are important elements of these risk mitigation measures. To achieve recolonization potential of the surrounding agricultural landscape (and to avoid disproportionate burdens for those farmers taking care of natural habitats or even establishing new ones), a GIS-based inventory of natural habitats was established at the national level and each agricultural landscape of a village having enough carrying capacities is listed in the federal gazette. When using products in these areas, buffer zones to terrestrial habitats do not need to be kept.

This system is a working system and will be adjusted in the near future. An important part of the discussion is the integration of the new protection goal of biodiversity into the future system. Depending on the product risk (toxicity, mode of action, time of use, application technique, etc.) and the type of use, the existing mitigation measures to protect off-crop life could be supplemented by in-crop measures where the recolonization potential and the carrying capacity of the agricultural landscape is too low or – in extreme cases – not existing at all. The identification of appropriate measures will in part rely on the inventory of risk mitigation measures that were investigated 20 years ago when more demanding approaches of IPM were developed. Other risk mitigation measures are still in use in ecological farming. Quantifying the effectiveness of these tools and the proportion of the landscape needed for ecological complexes existing in a sustainable way will need resources and no final decisions have been taken so far. In particular, a broadly harmonized approach among Member States would be important on this aspect.

8.4 Conclusions

Even though Regulation (EC) No. 1107/2009 contains the requirement to protect biodiversity from adverse effects of pesticides, it is important to note that other factors such as the use of fertilizers or removing hedgerows and other habitats may contribute to the loss of biodiversity. Some of these agricultural stressors are regulated under other laws and provisions, and related measures undertaken to mitigate risks related to those stressors can, in terms of a spin-off benefit, mitigate pesticide-related risks, as well. Therefore, from an overall regulatory perspective it is difficult to decide on which legal basis and which type of regulatory decisions risk mitigation measures needed to protect biodiversity should be made. This is critical as, when deduced from a risk assessment performed in the context of an individual plant protection product, the necessary mitigation measures need to be undertaken and their effectiveness to be measured. It is not the responsibility of MAgPIE participants to decide upon political questions, but arguments in both directions are outlined above. However, it is recommended that this aspect is taken into account in defining the indicators and scale to be used to measure the effectiveness of risk mitigation measures on non-target organisms and biodiversity in agricultural areas and in the context of pesticide management, in order to make sure that the measures retained are proportionate and match regulatory expectations.

8.5 References

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9 Options to measure risk mitigation measures' effectiveness

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9.1 The use of monitoring data in the registration and post-registration process of plant protection products

According to Annex points 7.5 of Regulation (EU) No. 283/2013 and Annex point 10.8 of Regulation (EU) No. 284/2013, monitoring studies may be required in authorization procedures for Plant Protection Products (PPP) when there is a need to confirm that predictive environmental assessments covered all the risks related to the use of a single product under practical conditions. In order to fulfill these objectives, monitoring studies should be designed to allow an investigation of the potential for exposure and effects that cannot be fully ruled out in the predictive risk assessment for a specific substance. Before a new product can be placed on the market, uncertainties and risks have to be well characterized. No authorization can be granted if unacceptable risks are predicted, since this would clearly contradict the uniform principles or conditions of approval of products, i.e., one of the aims of pesticide regulation to ensure a high level of protection of both human and animal health and the environment.

The effectiveness of risk mitigation measures under practical use conditions may be investigated in conducting monitoring studies. Residues in surface waters adjacent to fields, where a specific product was used, and with a grassed buffer zone in between can be measured and the results can be compared to predicted concentrations. A comparable monitoring study can also measure the effectiveness of specific measures to mitigate intake by spray drift into surface waters. However, as model assumptions in the risk assessment schemes usually cover "reasonable worst case" situations, it can be difficult to find monitoring sites that will provide data directly comparable to risk assessment output.

To date, guidance on how to perform monitoring studies meeting these objectives is missing, or is at best, highly variable in terms of scope and depth. There is therefore a need to define criteria and circumstances under which these studies can be requested, as well as a need to develop clear and issue-focused, but sufficiently flexible guidance to conduct of monitoring studies. Also, rules are needed for the evaluation of these studies and their use into to consistent and transparent regulatory decisions.

This chapter summarizes the current knowledge on the use of monitoring studies in the development of risk mitigation measures. More detailed recommendations on the development of monitoring protocols and on the use of monitoring data in decision making are worked out in the SETAC Environmental Monitoring Interest Group on Pesticides.

9.1.1 Monitoring data

Two types of monitoring data are currently being undertaken in European countries: national monitoring programs, which are looking at the presence of active substances in respect to water quality criteria, and dedicated field-scale or watershed-scale monitoring of specific active substances in support of their registration.

9.1.1.1 National monitoring programs

National monitoring programs to survey the environment and describe the environmental status of compartments such as, surface water, groundwater, drinking water, and soil, and specific indicator species are widespread in Europe. These programs are performed on a regular basis and as a result, a tremendous amount of monitoring data are available. Data are often summarized in national reports and are the basis for surveillance of water quality indices and a subsequent range of regulatory actions.

National environmental agencies are responsible for implementation under the auspices of a range of legislation including the Water Framework Directive (WFD) 2000/60/EG, Habitat directive (FFH-D) 92/43/EEC, the EU Biodiversity Strategy, the Birds Directive 2009/147/EC, and the Drinking Water Directive 98/83/EC.

Usually, these generic monitoring programs are not directly relevant for decision-making on single PPP or active substances in the regulatory procedures. The reason for this is that they are not designed to identify risks related to a specific use of PPP on field level. However, if relevant water quality criteria are frequently not achieved for an active substance, this may trigger further actions as a revision of risk assessment and the conditions of use, and eventually the authorization of the products containing the active substance of concern.

9.1.1.2 Field-scale monitoring studies for the registration of plant protection products

Monitoring data generated in field-scale studies are designed in such a way that exposure levels or effects can be monitored in relation to products' registered uses, and are thus most appropriate for regulatory decision-making under (EC) No. 1107/2009.

In most cases, these studies are performed by industry to support the registration of products and as components of product stewardship programs. In these studies, specific questions are addressed that are related to critical properties of substances, such as the potential to leach to the groundwater (leaching studies), the potential to adversely affect pollinators in areas close to or in the crop, or birds in-field crops, for example. Often these monitoring efforts also investigate the effectiveness of a specified risk mitigation measure put into place to protect an environmental compartment or species at risk.

Field monitoring studies are available for various compartments and organisms, such as groundwater, surface water and aquatic organisms, soil organisms and earthworms, honey bees and other pollinators, birds and small mammals (wood mice, hares, etc.), and in some cases amphibians and terrestrial plants.

9.1.2 Value of monitoring data

In principle, the expectations on monitoring data for regulatory purposes are the same as for highly standardized studies like OECD-type tests. Data must be valid in the light of current scientific and technical knowledge and relevant for a decision on whether it can alter groundwater quality (e.g., concentration above the regulatory limit of 0.1 μg/L) or if unacceptable effects on non-target life are to be expected. Monitoring data may also help to improve the regulatory assessment schemes as done in previous years for the bee risk assessment, where monitoring studies and corresponding residue analysis in various countries in Europe revealed that the exposure of bees to specific neonicotinoid products used as seed treatments could occur and that specific risk mitigation measures such as the use of treated seeds with low dust content and of drillers equipped with deflectors enhanced the safety of the use of the related products.

9.1.3 Limitations of monitoring data

As mentioned above, the interpretation of monitoring data generated in generic (i.e., national or non-product-specific) monitoring programs is typically not straightforward. In the case of water quality monitoring for example, the following questions may help to determine the appropriateness of the data in a regulatory context:

- Did the monitoring program include the product in question and how frequently?
- Were the analytical methods appropriate to allow the identification and quantification of the product or were they generic screening methods? Could the method employed screen for true and false positives and negatives?
- Are the usage and landscape context described?
- Were there any attempts to track and identify causes for large-scale detections or effects, if any (i.e., point source contamination etc.)?
- In the case of surface water monitoring programs, was the size and type of water bodies (e.g., flowing or stationary) appropriate? How were populations of sampling points selected? Are data comparable over time?
- In surface water monitoring, what sampling strategy was employed in the monitoring program and how does this take into account the primary route of entry via spray drift, run-off or drainage, for which risks are to be mitigated?

This final point needs to be considered with great care when making use of data from water monitoring programs. This defines not only the spatial frequency of sampling, but also the temporal frequency and any response to hydrological change. For example, if the primary route of concern is drainage or run-off, monitoring programs including a rainfall-response sampling strategy make the interpretation of data much easier. It must be recognized when interpreting existing databases that this aspect may not be included in the program design as sampling strategy is often more simplistic or too generic.

If monitoring studies are performed for organisms, such as e.g., honey bees or mammals, landscape and different resources than the crops have to be taken into account, which influence the sampling methods.

Unfortunately, it is difficult to answer all of these questions with historical databases with certainty. This can limit the interpretation of the data to the sole frequency of occurrence of effect or quality threshold exceedance in generic monitoring based on sampling at random. However, these limitations are well known, and the availability and quality of data are constantly improving. New spatial techniques are providing tools to assist in the interpretation of this information. Where robust and detailed databases exist, a very effective use of this information to provide practical demonstrations of actual exposure potential associated with real usage situations becomes possible. Where sufficient water quality and hydrology data are available, monitoring exercises can also provide a useful database for estimating parameter ranges required for modeling predictions and facilitating comparisons with other (real or simulated) systems.

9.1.4 Protection goals and regulatory action in the case of risk

Protection goals in Regulation (EC) No. 1107/2009 are defined as "no… harmful effect…on groundwater" and "no unacceptable effects to the environment" (Regulation [EC] No. 1107/2009, article 4 [2a and b]) and are further defined in the uniform principle as criteria of acceptability of risks).

Groundwater should be protected in general and not only in specific areas that are used for drinking water abstraction. Further background on the use of monitoring to support leaching evaluations is provided in Chapter 5. This has also been the subject of recent reviews and is explored in detail in the recommendations of the FOCUS Groundwater Group (FOCUS 2009). For other protection goals including surface water, vertebrates (birds, mammals), or invertebrates (e.g., pollinators), soil organisms, plants, or any other organism like amphibians and reptiles, monitoring studies should be designed in order to establish that the level of protection aimed at under the conditions of pesticide use is reached including, where necessary, risk mitigation measures. Trigger values and quality criteria do not have the same status with regards to regulatory decision-making.

In groundwater, for active substances and relevant degradation products, the limit of 0.1 µg/L is established in the approval criteria for plant protection products or "Uniform Principles" (Regulation [EU] No. 546/2011). For non-relevant degradation products, a trigger value of 10 µg/L is proposed in the EU guidance document (SANCO 2000), which is not legally binding and and used in Member States as a function of their interpretation. Thus, specific trigger values may be used in European Member States based on national policy frameworks.

In the case of surface water, criteria for decision-making are set under the Water Framework Directive and may differ from the criteria determined under Regulation (EC) No. 1107/2009, which are defined based on a risk assessment approach. Although protection goals are comparable in the two regulatory contexts, regulatory implications might be different. However, in the case where measured residues in surface waters even in generic monitoring studies, are found to exceed quality criteria, this triggers a need to further consider the risk assessments for the products and this may lead to regulatory actions (Art. 44 [1] of Regulation [EC] No. 1107/2009).

9.1.5 Risk management

When evaluating monitoring data, the number of critical findings, the duration and frequency of exceedance (return period), the peak magnitude, and the objective of protection are important parameters for regulatory decision-making. Wherever possible, reasons for exceedances and effects should be thoroughly investigated and identified to allow informed decisions. For surface water, for example, it is important – wherever possible – to assess whether exceedances may arise as point sources (e.g., through misuse or poor mixing, loading, or cleaning practices in farmyards) or as non-point sources (e.g., drift, run-off, and drainage events that may be subject to further mitigation or management in some cases) from uses according to the principles of Good Agricultural Practice (GAP), because the regulatory actions to be taken are different. Indeed, point sources contaminations are an item for awareness campaigns and enforcement actions, whereas entry via non-point sources contaminations is often additionally regulated by adjustments of the conditions of use or of the approval.

As a general rule, authorization holders should be involved in the evaluation of monitoring data and should be allowed to make proposals for actions to be taken to investigate, characterize, and potentially reduce the observed risk through stewardship actions, which may include enhanced farmer education and awareness campaigns, local vulnerability assessment, and associated risk management programs. The share of experiences, especially from other regions and countries is important. Trials or surveys to reveal the reasons for critical findings should be examined for a proper causal-link analysis. Stakeholder involvement is needed for effectiveness taking into account the principle of transparency.

In the case of incidents reporting (e.g., bird kills), an independent office or agency, like an extension service (giving official advice to farmers on how to use PPP), may register the incidents and analyze the results in a transparent manner. For an immediate and effective collection of relevant data, Member States may request input from authorization holders, which are generated in the frame of stewardship programmes accompanying authorizations of their products. All relevant information is supplied to the responsible regulatory bodies in order to decide whether further regulatory actions should be considered. As a consequence, it may be warranted to consider a specific, customized monitoring study to determine if a clear cause-and-effect relationship is to be expected. Design and scope of such studies should be the subject of discussions between registrants and competent authorities to ensure such studies are meaningfully focused and may address the specific risk concerns.

If monitoring data are acceptable from a methodological point of view, it should be further considered whether a misuse of the products, for example inappropriate cleaning operations on machinery, led to critical findings. In such cases, legal action or administrative fines may be warranted depending on local legislation. In the case where the critical findings are found to be connected to incorrect use of the products, this information is also useful to understand the reasons behind the disregard of the conditions of use.

In the case where critical findings are considered harmful or unacceptable in terms of scale, frequency (spatio-temporal), or duration, further product stewardship discussions are warranted and more advice to farmers should be given. If it is established that the product was used in accordance with good agricultural practice, there may be a need to adjust regulatory risk assessment schemes or risk mitigation measures.

When incident or survey schemes indicate critical findings or when generic monitoring studies indicate recurrent exceedance of environmental quality criteria, the following steps depend on the situation where the records were made:

- Were the records expected based on the conclusions of the risk assessment without risk mitigation measures (for e.g., no risk mitigation of drainage entry to surface water)?

  If yes:

  Were risk mitigation measures recommended?

  Are other risks mitigation measures susceptible to reduce transfers or effects?

  If no, further regulatory actions are necessary.

As an example, if residues occur in wells for drinking water abstraction and are restricted to specific locations, health authorities may close the wells according to their regulations. When during the enquiry, evidence becomes available that local vulnerabilities are not well addressed or represented by regulatory risk assessment schemes, adjustments may be needed to refine both risk assessments and risk management plans – these may subsequently necessitate modifications of existing authorizations. If uncertainties remain regarding the most effective measures to be taken, it may be necessary to require specific studies from the authorization holder. In most cases, typical findings in generic monitoring studies (e.g., measured residues in surface water) are not immediately linked to a regulatory action for the respective products in the authorization procedure. However, if after thorough investigation there is clear evidence from a generic monitoring study that groundwater quality may be affected or that there are unacceptable effects to non-target organisms, the withdrawal of a product from the market may be justified. A specific monitoring may be required in order to determine causality relationship. Setting more effective risk mitigation measures for authorized products may not lead to immediate responses from the exposed system. This is especially true for groundwater where aquifer response may be relatively slow. Monitoring design should be defined accordingly.

Finally, data from monitoring studies serve as a rough reality check for risk assessment schemes used for regulatory purposes. Fortunately, a number of monitoring data are available today that show no or acceptable effects on those entities to be protected. Even if effects were observed or residues were measured, sometimes the magnitude was not as high as predicted by regulatory risk assessments or effects did not prevail as long as expected. However, in several cases unexpected or critical effects or residues were measured that led to regulatory actions. The most valuable aspect of monitoring studies may be that they are the only tool available to observe effects that are not – or only to a certain extent – predicted by usual risk assessment tools or even anticipated by scientists. For example, this has been the case for effects on honey bees due to seed dust, residues of metabolites such as DMS for tolylfluanid in groundwater in strawberry fields, or residues of metabolites of chloridazon in groundwater under sugar beet fields.

9.1.6 Case studies

Examples of monitoring studies that have been used to define risk mitigation measures are given below.

9.1.6.1 Development of risk mitigation measures to protect the groundwater from entries of a herbicide in Germany

A widely used herbicide was detected frequently in the generic groundwater monitoring that is performed routinely to assess the state of groundwater bodies. The results showed exceedances of the limit value of 0.1 µg/L to an extent that gave cause for concern.

Authorities required the authorization holders of the PPP containing this active substance to elucidate the causes of the exceedances, and additionally, to perform a targeted monitoring study to help confirming the specific reasons that led to the groundwater entries.

On the basis of the output of these monitoring studies, the authorities issued the following targeted risk mitigation measures for all products containing this herbicide:

i. not to be used before 15 April in each calendar year;

ii. not to be used on the following soils: pure sand, slightly silty sand, and slightly clayey sand; and

iii. not to be used on soils with an organic carbon content under 1%. The use of products in periods or on soils prone to leaching was no longer allowed.

   To avoid bank infiltration another restriction was stipulated:

iv. between treated areas and surface waters including periodically, but excluding occasionally water-bearing surface waters, there must be a buffer zone under complete plant cover. The buffer zone's protective function must not be impaired by the use of working equipment. It must be at least 5 m wide. This buffer zone is not necessary if sufficient catching systems are available for the water and soil transported by run-off, which do not flow into surface water or are not connected with the urban drainage system or the product is used for conservation or no-tillage methods.

9.1.6.2 Implementation of risk mitigation measures to protect surface water from entries of pesticides in Switzerland

Surface waters near agricultural fields may receive pesticides due to drift during the application of pesticides or after rain events due to run-off and drainage systems. In a small river in the canton of Geneva, Switzerland located near vineyards, pesticide concentrations were much higher than the accepted value of 0.1 µg/L in the Swiss water protection law. Therefore, a program was set up by the canton and financially supported by the federal office for agriculture and environment to reduce the entries into surface water in this region. Specific risk mitigation measures were taken and the efficiency was controlled via monitoring of pesticide concentration in the river. The specific measures taken were the installation of a washing station for sprayers, planting a grass cover in the vineyards to reduce run-off, and where possible, using pheromones instead of pesticides for pest control. The monitoring data demonstrated that the concentrations of pesticides were strongly reduced after the set of risk mitigation measures were implemented.

9.1.6.3 Development of risk mitigation measures to protect birds and mammals in orchards in Greece

Wild birds and mammals are frequent in cultivated areas and may therefore inhabit areas where PPP are used and may be exposed via contaminated food or even direct contact, e.g., when getting over-sprayed or entering a sprayed field directly after treatment. Field monitoring data may be helpful to detect a ”critical use,” to derive risk mitigation measures from the observations in the field and, again, to evaluate the success of the risk mitigation measures under practical use conditions.

As an example, in the mid-90s an organophosphorous (OP) insecticide was registered for the use against the olive fruit fly (*Dacus oleae*), which damages olives in the Mediterranean area. The OP used had a high intrinsic acute toxicity to birds and a risk assessment based on oral exposure via food items indicated a potential risk for lethal effects from the uses recommended on the label. Therefore, the applicant decided to perform a field monitoring under practical use conditions according to the product label. The study was performed in a major olive growing area in Greece, where due to the height and density of the olive trees the application was made as a full-cover application with a high water volume. As the application was performed in a dry Mediterranean environment, the overall spray of an olive orchard created a relatively cool and damp environment, which was so attractive to birds that they entered a sprayed orchard immediately after the sprayer was not causing disturbance any more, but before the spray solution was dry. The monitoring team detected a significant number of sublethal or lethally intoxicated song birds within a few hours after the application was made. Most likely, birds were exposed to the compound not (only) by consumption of contaminated food items, but also from direct contact to the spray solution by pathways like drinking (droplets or from puddles), oral uptake via preening of contaminated feathers, or direct dermal exposure.

As these observations were not in line with the intention of the applicant, neither for an environmental safe use nor with the conditions for the registration of PPP in the EU, agronomists and ecotoxicologists in the Member State where the product was approved developed a risk mitigation concept for the use of the insecticide against the olive fruit fly. From previous research, a bait substance was known that could effectively attract olive fruit flies, and it was added to the formulation of the OP. In addition, the treatment could be reduced to a single spot in each tree with a much lower water volume instead of the “full cover” spraying usually performed in olive orchards. The bait attracted the pest organisms to this treatment-spot and they came in contact with the insecticide.

Within the following growing season the use of the ‘spot-application’ technique was used under practical use conditions in olive orchards and was accompanied by a field monitoring study. The study revealed no intoxicated birds and no bird carcasses were found within the treated orchards.

This case gives a good example how field monitoring activities, their results, and intelligent risk mitigation measures can form a toolbox to improve the use of PPP for wild birds and mammals.

9.1.6.4 Development of risk mitigation measures to protect bees from pesticides in Austria

The project “Investigations in the incidence of bee losses in corn and oilseed rape growing areas of Austria and possible correlations with bee diseases and the use of insecticidal plant protection products” (acronym: “MELISSA”) was carried out in the years 2009 – 2011 on behalf of the Federal Ministry of Agriculture, Forestry, Environment, and Water Management and the Austrian federal provinces. The aim of the project was to identify possible correlations between the incidence of honey bee losses in production areas of maize and oilseed rape, and bee diseases or the use of plant protection products on the basis of field data.

Within the project, incidents of suspected bee poisoning reported during the years 2009 – 2011 were recorded. Different materials from bee hives were provided by beekeepers or sampled by AGES (Austrian Agency for Health and Food Safety) staff members during on-site inspections and analyzed for honey bee pests and parasites and for residues of insecticidal seed dressing substances. Sowing conditions, including details on maize and oil pumpkin seed used, were collected on a voluntary basis via a questionnaire addressed to farmers in selected areas where residues of insecticidal seed dressing materials had been detected in bees and bee bread. Furthermore, for selected areas wind speed conditions were collected retrospectively.

The data collected in the group of hives where incidents were suspected indicated a significant reduction in the percentage of bee hives positively tested for insecticidal seed dressing substances between 2009 and 2011. The percentage of bee samples showing residues decreased significantly for clothianidin, thiamethoxam, and fipronil. In contrast, a significant increase was observed for imidacloprid.

In the group of hives part of the monitoring, the number of monitoring bee hives in which insecticidal seed dressing substances were detected was significantly reduced from 2009 to 2010. No monitoring bee yards were under observation in 2011. Altogether, the number of bee yards with residue detections was significantly lower in the monitoring group than in that with suspected bee poisoning.

The median residue concentrations in bee samples showed a significant decrease over the 3 years for clothianidin, thiamethoxam, and fipronil. In contrast to these findings, the median concentrations significantly increased for imidacloprid.

The results of the MELISSA-project gave evidence that in Austria, regional clustered bee damages had occurred in the years 2009 – 2011, which were frequently associated with the use of maize (and partly oilseed pumpkin) seeds coated with insecticides, on the basis of the outcome of residue analysis. The strong local component and the accumulation in areas with small-scale structured agriculture indicated special environmental conditions resulting in an increased exposure of honey bees to the identified insecticidal plant protection substances in the affected areas.

Regulatory risk mitigation measures to prevent honey bee losses due to the exposure of bees to insecticidal seed dressing substances have been progressively implemented in the meantime and significantly improved the situation. However, repeatedly observed incidences of honey bee mortality in defined regions suggest their systematic correlation with local factors contributing to increased exposure of bees. In addition to considering environmental factors, the following additional recommendations were made:

- Further improvement in quality of seed dressings
- The use of a sowing with pneumatic seed drills exclusively at low risk of drift and wind speeds of maximal 5 m/s according to the approval
- The optimization of seed drill equipment to largely prevent the disposal of abrasive dust, particularly with regard to the application of seeds with insecticidal dressing
- The use of insecticidal seed dressings solely based on a given risk in plant production

These measures to reduce and minimize the risk of honey bee losses due to insecticidal seed dressings could be directly derived from the results of MELISSA.

A new series of monitoring programs was performed during 2012 and 2013, which focused on reported incidents. Samples of bees, bee bread, and pollen were collected and analyzed for clothianidin, thiamethoxam, imidacloprid, and fipronil. The main symptoms observed were dead or weakened hives, high winter mortality, or single dead bees with stretched proboscis. From 69 samples (38 bee samples, 31 beebread samples) collected in spring and summer 2013, 28 samples showed residues with one of the 4 substances. Residue analyses were positive in 51% of the apiairies (around 600 concerned hives). All 4 substances were detected with clothianidin being the most frequently active substance found.

In the samples collected in spring and summer 2013, residues were detected in 14 out of 74 apiaries (around 1,500 hives), corresponding to one of the substances (7 for clothianidin, 3 for imidacloprid, 4 for fipronil). Residue levels were quite low. The source of contamination could not be determined (spray treatment, biocide use, other). These samples were also analyzed for other pesticides and in several samples fungicides, insecticides, and acaricides were detected.

Compared to 2009-2011, there was a reduction of the number of apiaries exposed to neonicotinoids or fipronil in 2012 and 2013. This is interpreted as a positive signal as regards the effectiveness of risk mitigation measures. In 2014, the number of suspected bee poisoning incidents was further reduced (results not available yet).

The following set of risk mitigation measures to be implemented in Austria from 2012 was therefore proposed:

- Equipment of pneumatic sowing machines with drift reducing equipment or deflectors - list of admissible machines is available (decree of BMLFUW) – only these may be used
- Strict avoidance of dust drift into adjacent flowering vegetation during sowing
- Interdiction of sowing of treated seed when wind speed > 5 m/s (18 km/h)
- Obligatory use of licensed adhesive agent for the seed treatment of corn
- Proper seed coating (upper Heubach limit set to 0.75 g dust/100.000 kernels) and labeling
- Risk mitigation measures concerning handling of treated seed
- Avoidance of mechanical stress of the seeds
- Proper disposal of seed bags
- General restriction of seed treatment authorizations of neonicotinoids in maize to control Diabrotica and wireworm only
- Obligatory crop rotation after 3 years of maize
- Sowing of treated seeds against Diabrotica in the first year of maize on an area (first time maize or after crop rotation) is not allowed
- Extensive quality control
- Measures of information and control

9.2 Environmental modeling as a tool to assess the effectiveness of risk mitigation measures

Gerhard Goerlitz and Colin Brown

9.2.1 Introduction

Exposure modeling has already been used for a long time in environmental risk assessment. It gained a special importance in the European authorization process for active substances under Directive (EEC) 91/414 where the Uniform Principles (Council Directive [EC]97/57, Annex IV to

Directive [EEC] 91/414) stipulated the use of simulation models to calculate predicted environmental concentrations in groundwater, surface water, soil, and air. For example, for groundwater:

… using a suitable calculation model validated at Community level, the concentration of the active substance and of relevant metabolites, degradation and reaction products that could be expected in the groundwater in the area of envisaged use after use of the plant protection product according to the proposed conditions of use.

In the following years, the commission established the "Forum for the Co-ordination of Pesticide Fate Models and their Use" (FOCUS) as a stakeholder organization to propose suitable models and to develop a framework that allowed their use in a regulatory setting. The results of this cooperation consist of a set of simulation models in the form of computer programs and associated data files defining scenarios for their application, as well as documentation, which gives detailed information on how the models were selected, on modifications that were necessary to achieve harmonization between models, and on how environmental scenarios were selected and parameterized. Furthermore, the efforts to improve validation by comparison with available experimental data are documented. Finally, the documentation gives detailed advice about how substance properties can be derived from experimental study results as input data for the models, and together with models and scenarios, environmental concentrations can be predicted in a way that is scientifically correct and acceptable from a regulatory perspective.

All the models, data files, and documentation can be downloaded from http://focus.jrc.ec.europa.eu/index.html. While the FOCUS system is used as a basis in the European authorization of active ingredients and to a large extent in the zonal registration procedure for PPP, it is not universally accepted in the Member States. Therefore, apart from subsets of the FOCUS defined models and scenarios, national systems exist, which cover specific regulatory or environmental requirements of the Member States. As far as these are relevant in the context of risk mitigation, these are referenced in the individual chapters, especially regarding groundwater and surface water risk mitigation. Additionally, specific models have been developed to support individual risk mitigation measures (e.g., VFSMOD for the simulation of vegetated buffer strips [see Chapter 4.2]), modeling approaches for spray drift (see Chapter 4.3). Since all these models and approaches are described in much detail in the individual chapters, the information is not repeated here.

In the context of mitigation, exposure modeling offers a unique opportunity to predict the effect of many mitigation measures, which affect a risk reduction by reducing the emission of a pesticide from the treatment area into the surrounding environment. By a variation of the respective input parameter, e.g., increasing the distance between application and an adjacent non-target area or changing the date of application, the effect of a mitigation measure on exposure can be directly determined for a given scenario and substance. By variation of additional scenario- or substance parameters, the robustness of the risk mitigation measure can be investigated, as well as, whether the effect is specific for a given substance or scenario, or whether it is applicable to a broader range of substances or scenarios. This can then help decide how the measures can be implemented in regulatory measures and labels. Thereby, the good integration of the FOCUS system of models, as well as comparable national systems, make them especially suitable for this last objective.

While the high flexibility of computer models allows the fast evaluation of the effects of a mitigation measure, the need for validation, either via experimental studies on a field-scale or via monitoring of concentrations observed under “real life” application and environmental conditions must not be forgotten. This is especially important if the mitigation measure is outside of the validation range of the model or scenario accepted for regulation. More details may be found in the chapters on individual mitigation measures in much detail and therefore are not repeated here.

9.3 Ecological modeling as a tool to assess the effectiveness of risk mitigation measures

Andreas Focks, Christopher John Topping, and Matthias A. Becher

9.3.1 Introduction

In the context of the environmental risk assessment of chemicals, ecological modeling approaches have been utilized in previous years in refined risk assessments, to overcome some of the limitations met with deterministic approaches using experimental tools with regards to time and space and the number of exposure or ecological scenarios that may be experimented (Schmolke et al. 2010; Forbes et al. 2011).

In some pioneering examples, ecological modeling approaches were applied in the context of risk assessments for terrestrial or aquatic non-target organisms. The ALMaSS approach, a spatially explicit model developed for the terrestrial domain (Topping et al. 2003), was for example, used to analyze the impact of dynamic spatial factors on the effects of an insecticide on a carabid beetle population (Topping and Lagisz 2012). Another case studied how the area of pesticide application and environmental half-life affect the assessment of recovery at the plot scale for a spider and a beetle population (Topping et al. 2014). In the aquatic domain, Van den Brink et al. (2007) used an individual-based modeling (IBM) approach to simulate the response of water lice to pesticide stress in aquatic systems, mimicking exposure scenarios being used for the registration of pesticides in the EU (FOCUS 2001). An adapted version of the MASTEP model was also used to assess the influence of the timing of pesticide stress in the year and landscape connectivity on recovery times of the water louse (Galic et al. 2012), and, coupled with simulation results from a landscape-scaled chemical fate and exposure model, could also be used to assess the effects of real-world exposure patterns on aquatic macroinvertebrate populations (Focks et al. 2014).

Increasing interest in ecological modeling and at the same time the increasing demand for higher-tier risk assessment tools led to several activities to foster development and applications of ecological models on the European scale: the formation of a SETAC advisory group on mechanistic effect models was established (Preuss et al. 2009), and an EU research project on the development of mechanistic effect models was funded (Grimm et al. 2009). Most prominently, ecological models are also mentioned in the recently published aquatic guidance document of the European Food Safety Authority (EFSA 2013), and EFSA also published a scientific opinion on good modeling practice (EFSA 2014). Ecological modeling therefore constitutes a possible tool in support of risk assessment and decision making in the EU.

Mathematical or simulation models are per definition capable of producing model dynamics for any scenario of interest that may be defined. Therefore, it is reasonable to consider ecological models as a tool to check the effectiveness of mitigation measures, providing that specific risk mitigation measure of interest would translate into a set of simulation scenarios. Risk mitigation measures as described and worked out in these proceedings can be divided into a number of basic categories (confer also Table 6.2 in Chapter 6):

1. Risk mitigation measures aiming at *reducing exposure via spray drift*

(Spray Drift Reduction Technologies in general, Buffer Zones for off-field areas) or *via dust* (Dust Reduction Technologies for seed coating)

2. Risk mitigation measures aiming at *improving the habitat quality for non-target flora and fauna* (Field Margins and Compensation Areas)
3. Good Agricultural Practices (GAP), which relate to product application (*dose and application regime*)
4. Crop Management options (CM), which relate to agricultural practice in the crop or the field margins aiming at reducing a source of exposure or transfer route
5. Bee Management tools (BM), which relate specifically to *measures applied to managed bees* to keep them from exposure

At least for risk mitigation measures of the 1st through-3rd, and 5th categories, respective scenarios can be formulated, hence exploratory simulation studies employing existing ecological modeling approaches seem to be achievable with relative little effort. Most of the ecological modeling approaches developed in previous years are individual based models (IBMs), and consider explicitly spatial dimensions, per definition. Working in a spatially-explicit simulated environment is a very useful, if not mandatory, ingredient for ecological modeling to be capable of the evaluation of risk mitigation measures, for those that have a spatial component (buffer zones, off-field areas, field margins, etc.).

This chapter explores, through examples, whether ecological models may be used to assess the contribution of specific mitigation measures at reducing exposure and risks. This discussion will be based upon three exemplary modeling approaches that have already been used in the context of environmental risk assessment for pesticides.

9.3.2 Example 1: ALMaSS

ALMaSS (Topping et al. 2003) has been developed over the last 10 years into a large simulation system comprised of many interacting agent-based models. ALMaSS models are all agent-based and simulate entities primarily in agro-ecosystems at landscape scale (e.g., 40 x 40 km) and in great detail (e.g., map resolution is usually 1 x 1 m). Documentation for ALMaSS under the ODdox format (Topping et al. 2010), combining model description with “doxygen code documentation” (van Heesch, 1997) is available on the internet (Aarhus Universitet. 2014), and a short overview follows.

ALMaSS is comprised of two main components, the environment and its associated classes and the animal representations (classes) (http://ccpforge.cse.rl.ac.uk/gf/project/almass/). The environment contains a map of the landscape to be simulated together with individual landscape elements, such as fields, hedges, roads, and woodlands. Farms are simulated based on real farm data on ownership or management information from municipal or EU-farming subsidy sources. Each farm simulates the detailed management of its fields, dependent upon its farm type, the weather, soil type, and past history of management. There is a degree of stochasticity in farmer decisions, and hence the result is a dynamic pattern of farm management across the landscape. Hence, farmers with the same farm type, growing the same crops make similar but not identical decisions. However, once differences occur, they propagate as decision history becomes part of decision-making information used by the farmer. All vegetated landscape elements (crops and non-crops) undergo type-specific daily vegetation development based on weather, and fertilizer inputs as drivers. Farm management events (e.g., spraying, harvest, ploughing) directly interact with vegetation height and biomass, providing a dynamic picture of changing landscape conditions as a result of both environmental and anthropogenic processes and factors. These events may affect animals directly (e.g., ploughing related mortality) or indirectly (e.g., herbicide removing insect food; Topping and Odderskær 2004).

All animals are modeled as individuals and are affected by environmental variables, vegetation structure, and by direct interaction with other agents or farm management. Each animal has its own behavioral rules and ways to interact with its environment. Animals can sense the characteristics of their environment (habitat type, vegetation structure, temperature, etc.), management events, and their own physiological condition. Hence, animals exposed to management will choose behavior suitable for that management, their current location, and physiological state. Animals will also interact with each other in a variety of ways ranging from simple local-density dependent interactions (e.g., beetles; Bilde and Topping 2004) to complex behavioral messaging (e.g., roe deer; Jepsen and Topping 2004) depending upon animal type and current activity. The overall result is highly realistic simulations of populations of animals in space and time, with each animal making decisions that result in movement, breeding, and mortality as close as possible to the way the real animals would act.

ALMaSS-based simulations can address spatio-temporal dynamics and non-equilibrium properties of agro-ecosystems aspects in a risk assessment.

ALMaSS handles pesticide application to the landscape in a realistic way in terms of both the spatial and temporal pattern of applications and environmental fate. The resulting distribution of pesticide and its effects will emerge from the particular landscape and farming combination simulated. By manipulation of the map, pesticide, or farm management inputs, scenarios may be developed to evaluate impacts of pesticides or changes in pesticide use on both the impact on non-target populations, but also in terms of distribution of pesticide residues in space and time. The efficacy of field-margin management to reduce exposure in off-field areas could thus be assessed by adding suitable field margins to the map and recording changes pesticide residues in time and space. Also, the influence of the size of field-margins may be studied, as a function of landscape structure and farming practices. The development of landscape scenarios is no longer difficult. The increase in availability and accessibility of farm management and landscape mapping data make it possible to generate simulations of real landscapes with real farming conditions for most European countries and thus place the risk assessment directly into the context of landscape situation where the pesticides are used.

9.3.3 Example 2: BEEHAVE

BEEHAVE simulates the dynamics of a single honey bee colony, the foraging activities of workers, and the population dynamics of varroa mites. It is an integrated model combining and extending existing models (Becher et al. 2013, Becher et al. 2014). It is freely available (http://beehave-model.net/) and implemented in the open modeling platform Netlogo (Wilensky 1999). The model is fully described and documented in a standard format (Grimm et al. 2006, 2010).

In the model, a colony is comprised of eggs, larvae, pupae, and adult bees, distinguishing between workers and drones. Adult workers show age polyethism, with younger bees acting as in-hive bees, responsible for the care of brood, and foragers collecting nectar and pollen. While all in-hive stages (including adult drones) are represented by age cohorts, foragers are implemented as super-individuals in an agent-based foraging module. Although the maximal egg-laying rate of the queen is imposed, the actual number of eggs produced, as well as the survival of the brood depends on the number of bees contributing to nursing and the amount of pollen or protein available in the colony. The onset of foraging (i.e., the age when in-hive bees develop into foragers) is variable and influenced by the colony structure and demands (honey and pollen stores, ratio of brood to nursing bees, ratio of in-hive bees to foragers).

The foraging module is based on a general framework of collective foraging (Sumpter and Pratt 2003), with the activities resting, searching food patches, collecting nectar or pollen, recruiting or being recruited. Foragers mortality depends on the time spent on the foraging trip and foraging decisions are based on energetic efficiency for nectar foraging (Seeley 1994) or temporal efficiency for pollen foraging. Weather conditions are implemented via the amount of time bees are allowed to forage on each day. Foraging takes place in a dynamic landscape with a number of food patches, defined by their distance to the hive and the amount of nectar and pollen they provide every day. Sugar concentration of the nectar, handling times to collect a full load of nectar or pollen, and the probability of the food patch to be detected by a searching scout also influence the forging activity and success of the bees. An external landscape module (Becher et al. 2014) may soon allow the translation of maps of food sources into input files for BEEHAVE and calculation of the detection probabilities of identified food patches.

In the BEEHAVE model, colonies can die on the last day of each year, akin to winter mortality of bee hives, if the number of adult workers is below a threshold (4,000 bees) or any time during the year, if the honey stores are depleted. Depleted pollen stores result in increasing larval mortality up to the point where no brood can be raised successfully anymore. The model also contains a varroa mite module (Martin 1998, 2001), where varroa mite infestation leads to increased mortality. BEEHAVE closely follows the relevant biological processes and is complex enough to provide testable hypotheses.

Although the current version of BEEHAVE does not contain a specific pesticide module, some effects of pesticide applications could be considered in the model. Becher et al. (2014) simulated the impact of a doubled foraging mortality, as a consequence of pesticide exposure over 30 days (Henry et al. 2012), showing that not only the timing of exposure, but also the food availability in the landscape may affect colony survival. In a similar way, the impact of increased brood mortality (Zhu et al. 2014) or a reduced egg laying rate (Dai et al. 2010) can be simulated. Also sub-lethal effects like changes in the age of first foraging, reduction in foraging efficiency, or accuracy of waggle dances (Eiri and Nieh 2012) can be implemented with relatively little changes to the model.

There are a number of mitigation measures that can be, directly or indirectly, analyzed with the model. Improvement of habitat quality, e.g., by providing compensation areas, can be directly included into the models' foraging landscape by adding additional food sources. The effectiveness of these areas to reduce risks could be simulated at diverse distances to the treated crops. Effects of such measures on the risk for the bee hive could be quantitatively determined by model simulations. The model could also simulate different application dates, since the model ignores patches that do not provide food. Lower product doses can reduce the negative effects on exposed bees (resulting in e.g., a reduced mortality), whereas spraying only under low wind conditions or allowing for bare soil buffer zones will limit the pesticide application to the treated crop fields and avoid contamination of close-by food patches.

Beekeeping practices are already part of the model and include, among others, additional feeding of the colony with nectar or pollen. Both practices can reduce the foraging activities of the bees and might hence offer some protection. Also, closing the hive, i.e., not allowing any foraging activity in the model on the day of pesticide application, can be simulated and contribute to mitigating exposure via direct spraying.

The BEEHAVE model may thus simulate, at least to some degree, the impact of lethal and sub-lethal effects as they may occur after pesticide exposure. It can also consider some mitigation measures, which either reduce the number of bees exposed to a pesticide or reduce the negative effects on those bees that were exposed.

As mentioned above, pesticides are not explicitly implemented in the model yet, so all effects caused by pesticide exposure have to be defined in advance and triggered by certain events, e.g., a doubled foraging mortality for each visit of a forager on a contaminated field. To overcome this gap, a specific pesticide module for BEEHAVE is currently developed at the Exeter University. This module will allow the user to simulate the presence of chemicals in the bees and the colonies' stores where relevant for example, and the subsequent effects on behavior and mortality of the bees, based on empirical dose-response curves.

9.3.4 Example 3: MASTEP and related

The MASTEP (Metapopulation model for the Assessment of Spatio-Temporal Effects of Pesticides) model concept links population dynamics of an organism with exposure to pesticides within a spatio-temporal context, applied to aquatic invertebrates. It can take into consideration the variability of population dynamics and pesticide effects in space and time for the calculation of effects and population recovery in exposed organisms.

The IBMs being used in the MASTEP context simulate the life cycle of individuals of an aquatic macroinvertebrate species. All relevant life stages are simulated in the IBM, e.g., individuals of the water louse *Asellus aquaticus* are considered to be juvenile or adult (Van den Brink et al. 2007). All modeled processes are formulated in dependence of the life stage, and being simulated on an individual basis: growth in length, movement, reproduction, and mortality that can be natural, density-dependent, or pesticide induced. The parameterization is mainly done based on species traits such as e.g., size at time of first reproduction, maximum number of offspring, or dispersal range. The population dynamics are emerging from the individual processes, and population density and voltinism can be compared with observations from mesocosm experiments or field monitoring. The regulation of the population densities is density-dependent, as a result of intraspecific competition for habitat space and food and other interactions and density-dependent mechanisms, such as mortality or limitation of growth in length, have been directly implemented in the model. Current effort is going into the implementation of new model versions that consider explicit nutrient availability, individual uptake, and consecutive energy flows based on dynamic energy budget theory (Jager and Zimmer 2012; Jager et al. 2013).

In addition to natural or density dependent mortality, exposure to pesticides can lead to individual death in the model. The level of detail of the interface between exposure and effects is quite flexible. Pesticide induced mortalities can be based on average death rates, meaning simply that certain percentage of a population dies (Galic et al. 2012), or calculated by dose-response curves that translate water concentrations into mortalities (Focks et al. 2014), or can even be based on toxicokinetic-toxicodynamic processes that simulate internal concentrations and consequent effects for each and every individual (Baveco et al. 2014).

IBMs such as MASTEP are organized in a spatially-explicit, grid-based way. The environment in MASTEP consists of so called “patches,” which are discrete spatial units forming a regular grid within the simulated landscape. Individuals are located based on 2 coordinates that specify a position in the simulated landscape for an individual and hence a certain patch. Pesticide exposure concentrations, being calculated in a spatially explicit way, can also be associated to a certain patch, and in this way spatial links between pesticide exposure of individuals and subsequent effects is realized. Because individuals take unique trajectories through the simulated landscape and cross over patches with different pesticide concentrations over time, unique "exposure life-histories" are created and evaluated in such simulations.

A number of studies adapted the MASTEP concept for different purposes, for example for assessing effects and recovery in reaction to FOCUS surface water scenarios in edge-of-field systems (Van den Brink et al. 2007), for assessing the influence of the timing of pesticide stress in the year and landscape connectivity on recovery times (Galic et al. 2012), for linking landscape-level pesticide fate modeling results with population dynamics (Focks et al. 2014), and for assessing recovery of spatially structured populations after chemical exposure that varies in time and space using IBMs coupled with toxicokinetic–toxicodynamic equations (Baveco et al. 2014).

Basically, models such as MASTEP can be employed following two different approaches. On the one hand, general aspects of environmental risk assessment can be investigated, like for example the influence of landscape connectivity or habitat quality on the recovery of populations from chemical effects. On the other hand, when equipped with an appropriate dose-response interface and being parameterized for a specific substance, MASTEP models can be employed to calculate effects for this specific substance for quite detailed spatio-temporal emission and exposure patterns and the subsequent recovery of the population.

Being spatially explicit, MASTEP may allow to consider the effect of any mitigation measures that contains spatial aspects, such as buffer zones, off-field areas, or field margins. In the spatially explicit environment in MASTEP, simulations can consider different properties of landscape patches, e.g., habitat quality, food availability, substrate type, exposure or non-exposure, etc. Examples for such analyses have been given by evaluating effects of landscape connectivity (Galic et al. 2012) or of permeability of buffer strips for flying insects (Galic et al. 2013) on population effects and recovery.

Further on, MASTEP can be directly applied to evaluate all risk mitigation measures that aim to reduce exposure, because changing emissions and exposure patterns can be considered and simulated for pesticides by software packages such as Focus TOXSWA (Adriaanse 1996) or STEPS (FOCUS 2001). Simulations with such chemical fate models typically result in spatio-temporal concentration tables of water dissolved compound, but also of other fractions such as sediment concentrations or fractions bound to organic matter in water. By considering detailed spatio-temporal chemical exposure information, MASTEP models can translate reduced emissions into changes in population effects and mortalities. An example for such simulations was already performed for the case of the application of a pyrethroid insecticide, where effects as resulting from exposure via spray drift and subsequent recovery dynamics were investigated for two different levels of spray drift input (Focks et al. 2014).

Simulations of effects of reduced exposures could be combined with other mitigation measures. In a reverse engineering approach, it would even be possible to define a desired levels of protection at the population level and then to identify the level and type of risk mitigation measures being necessary to reach that with a certain probability. All such exercises can be performed on real landscape structures, if desired, because IBM models can work on data from geographical information systems (GIS).

9.3.5 Conclusions and perspectives

The usage of ecological modeling approaches for assessing the effectiveness of risk mitigation measures appears attractive for different categories of risk mitigation measures. Because current (meta-)population models can use spatially and temporally differentiated exposure concentrations as calculated by chemical fate and exposure models, effects of all risk mitigation measures aiming at reduced exposures can with little effort be translated into reduced individual mortalities and population risk. Also, risk mitigation measures that relate to dosing and application regimes (good agricultural practices) can be tested on their effects on the survival of non-target species in off-field areas. Thus, more ecological factors can be taken into account for the assessment of effects of risk mitigation measures, and hence the ecological realism of such approaches would increase. It is obvious that when ecological realism is increased by using ecological modeling approaches, risk assessment and risk mitigation would move towards a landscape management of pesticide applications; an approach that might give a new perspective for risk assessment and mitigation in the future.

Ecological modeling approaches may also quantify effects of risk mitigation measures aiming at improving the habitat quality for non-target flora and fauna in form of field margins and compensation areas (Jepsen et al. 2005). The inclusion of such measures into the formal framework of risk assessment is not straight forward because the benefit they provide to species and environmental functions does not directly translate into percentage risk reduction for a specific product. Nevertheless, the benefits related to habitat refugia, and food supply provided by these risk mitigation measures to non-target species, can be calculated and simulated by ecological modeling. Ecological models may thus provide the opportunity to quantify endpoints like the risk posed by pesticide applications for a local population representing an indicator species, for scenarios with and without compensation areas in the surroundings.

The examples above illustrate the state of the art for 3 models having already been used in risk assessment and parameterized for this purpose. Some of them and other models are currently also evaluated in the scope of the SETAC MODELINK workshop with focus on their applicability to link ecotoxicological tests to protection goals. Examples for more candidate ecological modeling approaches are given for small mammals (Liu et al. 2013, 2014), fish (Hazlerigg et al. 2014) or for birds (Kułakowska et al. 2014). In general, many of the mentioned models are more or less directly applicable to specifically account for habitat, and food resources as provided in field margins and recovery or compensations areas (Table 9.1).

Table 9.1: Ecological models per group of organisms and related risk mitigation options that could be simulated.

Group of Organism	Model Available	Risk Mitigation Option That May Be Simulated	Currently Available Model Species
Birds	ALMaSS Kulakowska et al. 2014	a, b, c, d, e a, b, c, d	*Aluada arvensis, Perdix perdix* *Columba palumbus*
Mammals	ALMaSS Liu et al. 2013	a, b, c, d, e a, b, c, d	*Microtus agrestis, Lepus europeaus, Capreolus capreolus* *Apodemus sylvaticus*
Aquatic Organisms – Fish	Hazlerigg et al. 2014	b, f	*Danio rerio*
Aquatic Organisms – Invertebrates	MASTEP	b, c, d, f	*Asellus aquaticus, Gammarus pulex, Chironomus riparius, Mayfly*
Terrestrial Non-Target Arthopods	ALMaSS	a, b, c, d, e	*Bembidion lampros, Erigone atra, Oedothorax fuscus*

a) Habitat management (beetlebanks, unsprayed margins, buffer strips, etc.), b) Alternate application regimes, c) Spatially or temporally restricted use, d) Habitat creation, e) Other field managements (e.g. mowing, no-tillage), f) Reduced exposure.

It is important to note that landscape-scale population approaches also imply that the traditional separations between in-crop and off-crop become less visible, and recovery issues become subsumed under the long-term population impacts. Another consequence is that the focal biological unit is very different from traditional risk assessment approaches, so new measurement endpoints may be needed to assess changes not just in population size, but in its spatial distribution. This may be achieved using a consideration of occupancy and abundance, the AOR-Index (Abundance Occupancy Relationship Index) (Hoye et al. 2012). This metric can explicitly describe the effect of pesticide use or mitigation measures on the population's distribution in the landscape.

Ideally, the application of ecological modeling may go along with monitoring campaigns that focus on the effectiveness of risk mitigation measures, which will provide data at landscape scales. In this way, ecological modeling approaches can prove their validity by testing model predictions with real-world data and enabling feedback between model simulations and real-world dynamics.

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10 Risk mitigation measures and Stewardship

Anne Alix and Janet Williams

10.1 Inventory of current and past stewardship activities and initiatives

Stewardship activities related to pesticide use in agriculture aim to make the use of crop protection products more efficient and safe for human health and the environment. This brief chapter highlights the diversity of initiatives ongoing throughout Europe at different scales and with diverse levels of focus. These initiatives involve a number of stakeholders, including government bodies, extension services, pesticide manufacturers, NGOs, and international research and development organizations. They are often voluntary activities. Each activity identified in this review is reported in Table 10.1 below and further in a dedicated summary, in Appendix 10.

Table 10.1 provides a compilation of on-going stewardship activities and initiatives inventoried in the context of this workshop.

Table 10.1: Examples of existing stewardship initiatives and activities in Europe. The focus area describes the purpose or protection objective of the activity, within one of the following category: general farming practices, protection of biodiversity, protection of pollinators, and protection of water quality. Initiative or activities may provide various services organized here as advice, education, training, information, mapping tools, or funding. The main audience is often farmers however, the information is public and accessible to all.

	Focus Area / Objective of Protection	Category of Service	Name of the Initiative or Activity	Owner	Service Proposed	Language	Website Link
1	General farming practices	Training/ Advice	National Action Plans	Government	Training, ICM & Water (UK example)	English	https://www.go
2	General farming practices	Training	BETA Training	BASIS	Environmental training for advisors	English	http://www.bas
3	General farming	Advice	Campaign for the Farmed	CFE	Advice on risk mitigation	English	http://www.cfe

	practices		Environment		measures for farmers		
4	General farming practices	Advice	Voluntary Initiative (VI)	VI	Risk mitigation sheets for products; water and wildlife protection advice	English	http://www.vol
5	General farming practices	Advice	LEAF	LEAF	Advice on risk mitigation measures for farmers	English	http://www.lea
6	General farming practices	Education/ Information	IPM Guidance Notes & Checklist	DAFM	Booklet	English	http://www.pcs
7	General farming practices	Funding	Common Agricultural Policy (CAP) Greening	DEFRA	Funding	English	https://www.go
8	General farming practices	Funding	Environmental Stewardship Schemes (Natural England)	DEFRA	Funding	English	http://www.nat
9	General farming practices	Mapping	SSSI	DEFRA	Mapping of sites of scientific interest and advice	English	http://www.nat
10	General farming practices	Advice	Hope Farm	RSPB	Advice on birds and wildlife	English	http://www.rsp
11	Water	Advice	Local Environment Risk to Pesticides (LERAP)	CRD	Risk management scheme	English	http://www.pes assessment-for
12	Water	Advice	Every Drop Counts and H2OK	VI	Advice on water stewardship	English	http://www.vol
13	Water	Advice	TOPPS and TOPPS-PROWADIS	ECPA	Advice on avoiding point source and minimizing diffuse source water pollution	English	http://www.top

14	Water	Advice	Water stewardship: Protect water to preserve your plant protection tools and meet society's needs	BASF	Guidance booklet, summarizing general recommendations to reduce point and diffuse pollution sources	English and others	http://www.agı Internet/en/fur
15	Water	Advice	Say No to Drift Campaign	Dow AgroSciences, Headland and Makhteshim-Agan	Specific advice on water and chlorpyrifos	English	http://www.say
16	Water, off-target	Advice	On-target Application Academy (OTAA)	BASF	Advice on optimized application, using best practices and newest technologies to reduce spray drift	English	http://www.agı http://www.agı
17	Water and biodiversity	Advice	Spray Drift Reduction Technology	Industry	To demonstrate to farmers that the use of low-drift nozzles is easy and allows to ensure a real benefit to the environment	English	http://www.top
18	Water	Advice	Focus on Pesticides	LRF, Jordbruks Verket, Naturvards Verket, KEMI, Lantmannen and Svenskt Vaxtskydd	Short videos giving practical advice	Swedish (English subtitles)	http://www.you
19	Water	Advice	Bentazone Water Stewardship	BASF	Specific advice on responsible bentazone use to protect groundwater	English	http://www.agı http://www.agı
20	Water	Advice	Get Pelletwise	MSG	Specific advice on water and metaldehyde	English	http://www.get
21	Water	Education/ Information	Biobeds	JTI	Advice on disposal of waste pesticide	English	http://biobeds.

22	Biodiversity	Advice	BASF network of farm cooperations (UK, FR, CZ, PL, IT and DE)	BASF	Advice on biodiversity and resource protection, best management practices crop protection	English	http://www.agr Internet/en/fur
23	Biodiversity	Education/ Information	Pesticides and Biodiversity	ECPA	Booklet	English	http://issuu.cor
24	Biodiversity	Education/ Information	Soil Biodiversity and Agriculture	ECPA	Booklet	English	http://www.ecp
25	Biodiversity	Education/ Information	Biodiversity centers	Bayer	Booklet	English	http://www.bay
26	Biodiversity	Advice	INSPIA	ECAF, IAD and ECPA	Website	English	http://www.ecp
27	Biodiversity	Advice	Biodiversity and Diversity of Habitats	IVA	Website	German	http://www.iva http://www.iva http://www.iva
28	Pollinators	Advice	Risk Management of Pesticides	OECD	Website	English	http://www.oe
29	Pollinators	Education/ Information	Pollinators and Agriculture	ECPA	Booklet	English	http://issuu.cor
30	Pollinators	Education/ Information	Pollinator Station	ECPA	Website	English	http://www.po
31	Pollinators	Advice	Operation Pollinator	Syngenta	Recommendations on flowering margins	English	http://www.op
32	Pollinators	Advice	Bayer Beecare program	Bayer	Recommendations on pollinators	English	http://beecare.
33	Pollinators	Education/ Information	Bayer Beecare website and centers	Bayer	Website and scientific communication platform	English	http://beecare.
							http://beecare.

34	Pollinators	Education/ Information	gEo-BEE	GisEO; JKI; LIB; BtS and DELPHI IMM	Open and participative information platform for protecting and promoting wild bees and honey bees	English and German	http://www.fisa
35	Pollinators	Advice	Honey Bee care	Bayer	Booklet providing advice for farmers on bees	English	http://beecare.
36	Pollinators	Education/ Information	Toby and the Bees	Bayer	Children's book	English	http://beecare.
37	Pollinators	Advice	Netzwerk Blühende Landschaften	Mellifera e. V.	Website and print material with information about pollinators and concrete measures how to create and connect habitats	German	http://www.blu
38	Pollinators	Advice	Apolo Observatorio de Agentes Polinizadores	Asociación Española de Entomología, Jardín Botánico Gijón, CIBIO, Ministry of Agriculture and Environment	Website and print material with information about pollinators. Teaching and extension material	Spanish	http://apolo.en
39	Pollinators	Advice	Seed Drilling Guides	Bayer	Advice on use of treated seeds and prevention of dust	English	http://www.bay
40	Pollinators	Advice	Farming for Bees	NFU	Leaflet providing advice for farmers on bees	English	http://www.nfu
41	Pollinators	Advice	Bee Safe Bee Careful	Farmer Unions	Booklet providing advice for farmers on bees	English	http://www.cro
42	Pollinators	Education/ Information	BeeConected	CropLife	App for notification of plant protection and beekeeping	English	http://www.cro

					activities		

National Action Plans are implemented in every European country in accordance with the principle of the Directive on the Sustainable Use of Pesticides (2009/128/EC). The related actions have a national or, within a country, regional scale and aim to a better control of the use of pesticides in crop protection and more particularly with regards to their utilization, application techniques, and integration into IPM or ICM programs (see ref 1 in Table 10.1). These plans involve training, associated certification of farmers, technical control of application devices, etc.

Training aspects of farmers related to the implementation of the Directive (EU) 128/2009 are part of the implementation of National Action Plans (NAP) (see 2-6 in table 10.1). These trainings may come together with demonstration farms to provide farmers with help to drawing a plan to protect crops, e.g., a LEAF audit or an integrated protection management plan (IPMP). The use of chemical protection comes together with the use of appropriate crop rotations, different varieties of crop, cultivation methods, or fertilizers. Farmers receive advice and support to take into account the importance of habitats for wildlife and wild plants when planning to use pesticides, especially where such sensitive areas such as hedges, waterways and ditches, and areas rich in different plants and wildlife are present. Laboratory tests or in-field test kits are available to identify a range of crop diseases, or a trap to help monitor insect pests, for an improved control. These methods help growers to decide whether a pesticide is needed, which one to use, and the best time to use it.

The development of landscape management features, also described as Agro-Environmental Schemes (AES) complements the set of measures at the scale of the farm in the European Union. As indicated in Chapter 6, non-cropped areas such as permanent grass margins, while providing a habitat for wildlife (including beneficial insects) and protecting hedgerows and water courses, may prevent weeds moving into the crop. These are in-line with the recommendation for the implementation of ecological recovery areas of the revised CAP (see ref. 7). In the UK, the Entry Level Stewardship Scheme offered farmers financial incentives to establish field margins for example (see ref. 8). In Germany, a similar voluntary scheme has fostered the establishment of an estimated 2 million kilometres of field margins. The use of “beetle banks” (vegetated mounds favored by beetles), uncut field margins, and a permanent conservation area have demonstrated the valuable role that on-farm biodiversity can play in enhancing efficiency, and thus economic viability. More practically, off-field areas can be managed or unmanaged non-sprayed vegetated strips, wildlife corridors, habitat patches, conservation buffers, and greenways outside, but in a certain proximity (spatial relation) to the agricultural fields. As non-cultivated areas, all of them implicitly represent a higher level of biodiversity than the crop area with regards to flora, and are considered to represent a higher biodiversity level with regards to fauna, for non-target for example (see Chapter 6). When implemented to reduce pesticide or fertilizer transfers from the cropped area (such as vegetated strips or wind screens, for example) they also contribute a reduction of the exposure of off-field organisms. A mapping system is available to locate the sites of interests for special protection (see ref. 9). These tools may also provide more specific advice, as illustrated by the advice provided to implement areas for food resource and nesting for birds in the farmland, proposed by the RSPB (see ref. 11).

Initiatives aimed at protecting water quality are also recorded (see actions 11-21). The EU Water Framework Directive, introduced in 2000, has driven a number of these actions (EC 2000). This directive aims to achieve a 'good status' for all waters in 2015 and sets a threshold of 0.1 μg/L in drinking water. Advice regarding the use of products and the implementation of risk mitigation measures is provided by governmental bodies, industry, and voluntary initiatives (see refs. 11-14). They address the various aspects of these transfers i.e., spray drift, run-off, and drainage. Dedicated advice relative to spray drift is also increasingly provided through initiatives aimed at promoting the use of drift reducing nozzles and equipment (see refs. 15-17) and involves demonstration session at farms, training, and documentation. In Sweden, this advice is supported by easily accessible videos (see ref. 18). Some of these stewardship activities have also been developed by specific products and may serve as models for other case studies in future (see refs. 19-20). Finally, stewardship covers life cycle aspects through advice regarding the disposal of waste products using dedicated tools (see ref. 21).

Information and advice regarding the protection of biodiversity in farmlands is available in booklets or websites, developed by associations and industry (see refs. 22-27). A further step is being undertaken through a network of farms where measures are implemented, and which can provide useful training support (see ref. 22). These measures are in line with AES recommendations described above in the context of the CAP and therefore provide demonstrated benefits to biodiversity at the farm level, the efficacy of which is further discussed in Chapter 6.

Finally, a number of initiatives have been developed to improve communication on the protection of pollinators in the farmland (see refs. 28 to 39). The economic importance of honey bees for honey production, as well as pollination explains this effort. These efforts consist of communication tools, such as leaflets and booklets or websites targeting farmers, beekeepers, and the public audience. Industry (refs. 29-33, 36, and 37) provides information toolkits for a wide audience, but also specific recommendations to farmers for the implementation of AES dedicated to pollinators (see refs. 31 and 32). Some risk mitigation options may be relayed on the labeling, as reviewed by OECD (ref. 28). Multiple stakeholder initiatives demonstrate the possibility of ambitious plans of work, such as gEo-BEE, involving databases and networking possibilities (ref. 34). Finally, some initiatives come from farmers themselves providing practical advice on pesticide use regarding bee protection (refs. 38 and 39).

10.2 Conclusions

The initiatives listed in this chapter try to illustrate the approaches developed so far to promote the implementation of improved practices, and may serve as a basis for further implementation, using the proposed risk mitigation toolbox as a source of information for a harmonized implementation. With regards to stewardship related to general farming practices, some improvement is still possible through a more harmonized implementation of AES measures throughout Europe. As an example, NAPs are in place in many countries, but the actual training activities remain under-reported and probably still need to be implemented on a wider scale. The "greening measures" under the Common Agricultural Policy (CAP) are a good way to fund improved training and advice to farmers. Training is also required and encouraged under the Sustainable Use Directive (SUD) and the National Action Plans (NAP) provide for adoption of Integrated Crop Management (ICM) and improvements in risk mitigation. Both legislations converge towards the improvement of the ecological dimension in farmlands, and schemes such as that proposed by Natural England is a good example of approaches to link them. The proposals made in these proceedings for dedicated field edges and farmland features to mitigate risks for in-crop and off-crop organisms are hopefully a step forward in this direction.

With regards to stewardship activities focused on water quality, a number of generic and product-specific activities are reported, which relate to the implementation of the Water Framework Directive (EC) 2000/60. It is recommended that in future, water stewardship activities could be also implemented via the river basin management activities still in accordance with this Directive. Indeed, according to this legislation, water protection shall be organized via a river basin-based structure (key tool: River Basin Management Plans; Art. 15), and concrete measures to be taken are listed in the Programme of Measures (Art. 11). For instance, awareness raising campaigns, identification of vulnerable areas, dissemination and training on BMPs, and implementation of riparian vegetated buffer strips could be rolled out in a structured way across river basins, using the organizational structure and funding possibilities created under the Water Framework Directive. Diffuse pollution stemming from agriculture is identified as a major pressure in many River Basin Management Plans and therefore synergies could be realized here.

For groundwater the focus is on drinking water catchments and incidents management for other sources the frame is given by the WFD. It is very often focused on specific active substances. Initiatives aimed at locating and analyzing vulnerable areas would benefit of a parallel analysis of stewardship activities as it would help understanding their effectiveness and promoting their implementation.

With regards to stewardship activities with benefits to flora and fauna (in-crop and off-crop), including biodiversity, a wider implementation of appropriate AES, as described above, is recommended. The success of these measures is indeed reinforced by their implementation at a broad scale. In addition, all aspects of biodiversity need to be considered in order for the agroecosystem to fully benefit. Measures that benefit different groups may be combined in order to achieve highest benefit for the total agroecosystem (e.g., measures for Non-Target Plants, Non-Target Arthropods, and pollinators).

Communication support tools such as booklet, leaflets, and websites, are available, but the link to the target audience may often be missing, and feedback on how readers and users understand and apply the messages is rarely available. We should actively solicit feedback on the efficacy with which messages are understood and applied, where relevant.

Generalization of farm surveys and accompaniment is seen as a possible way to reach this target. Diagnosis tools similar to the tools that were developed for river basins, targeted to farm elements of biodiversity, may help in the implementation of these surveys. Links with monitoring and dedicated indicator species need to be done in order to recommend the most appropriate tools allowing to get this feedback with available practical and economical means. Finally, dedicated training on the implementation of AES measures would gain to be generalized and harmonized throughout Europe.

Overall, stewardship activities and initiatives contribute significantly to making pesticide use more responsible and environmentally acceptable. Stewardship has proven to be a successful and effective implementation tool, especially in areas where detailed advice, complex practices, or outreach to many stakeholders is required. Despite the fact that many stewardship activities are voluntary, they enhance legal compliance by users by going beyond regulatory standards and constantly reminding users of baseline activities for responsible use of crop protection products. The initiatives reported in this chapter may serve as a basis for further inspiration for their implementation and harmonization throughout Europe.

10.3 References

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11 General conclusions and recommendations

11.1 Diversity of the risk mitigation options

The inventory and review of the existing measures to mitigate environmental risks related to pesticide applications throughout Europe revealed the diversity of the tools developed, beyond restrictions on the conditions of applications of products.

Restrictions and modifications of the conditions of application of product may concern the application rate, number, frequency, and interval between applications. These measures are used in all Member States and remain the easiest way to reduce exposure in all environmental compartments. A modification of the conditions of use may be directly taken into account in exposure models, and hence, it is possible to check if a simple change would be sufficient to mitigate risks. Such measures may, however, lead to reductions in the product's efficacy, or compromise resistance management, which need to be verified in first place. In addition, they do not constitute the best responses to all risk situations, as for example where transfer routes are driven by more influent parameters related to vulnerability of the soil or local hydro-pedological conditions. In such cases, restrictions relative to soil nature, hydrology (drainage), the water table depth, may be more effective, and are often preferred by Member States, as they reflect the conditions under which risks are likely to occur and thus allow a more adapted mitigation of these risks. A broader implementation of site-specific conditions of application would be possible provided that vulnerability conditions can be realistically determined from risk assessment and modeling. The generalization of vulnerability maps, as for example for groundwater and drainage, and their accessibility through web-based information systems or applications for mobile devices, would also facilitate their implementation by farmers.

Beyond these measures, the optimization of the accuracy of pesticide applications has generated an increasing interest and led to significant improvements. Most manufacturers have developed drift reducing nozzles, directed spraying techniques, and reflection shields and deflection systems, which allow a significant reduction of transfers to off-crop areas. Excepted for drift reducing nozzles, the level of drift reduction provided by the SDRT is not reported in such a way that it could be used in risk assessment models, or in support of buffer zone determination by risk managers or farmers. The generation of these databases requires, as for drift reducing nozzles, to agree on measurement methods and an involvement of manufacturers when defining the standards in the level(s) of reduction to be achieved to account for technical feasibility. The experience gained in the case of drift reducing nozzles shows that a broader implementation may be achieved under the condition that their effectiveness is verified and reproducible (e.g., via certification systems) and is accessible to farmers. Again, the involvement of manufacturers to improve accessibility is necessary. The gain in confidence in the effectiveness of these tools may be supported through a dedicated networking on the development of consensual measurement methods and their implementation by certified organisms or processes so that mutual recognition of these SDTR becomes possible among countries.

At the farmland scale, the implementation of non-sprayed zones and edge-of-field land management is widespread in Member States, and as “buffer zones” or non-sprayed zones a common risk mitigation measure reported on product’s labeling. These measures constitute a relatively easy to implement and effective way to reduce, or avoid the exposure of, off-crop areas. Buffer zones are defined during the evaluation process of pesticides according to Regulation (EC) No. 1107/2009, and are thus product-specific, defined for the different uses and use rates of the product by a quantitative risk assessment, which correspond to fixed buffer zone widths (e.g., 10, 20, 50 m). Although largely implemented at the regulatory level as accompanying precaution phrases reported on products’ labeling, buffer zones may raise discontentment in farmers. The main reasons are the complexity of implementation where several buffer zones appear on the label, as for example for the protection of different groups of organisms (e.g., aquatic organisms and non-target arthropods), anticipation or observation of yields losses resulting from the implementation of a non-sprayed and non-cropped area, and when the non-sprayed zone or buffer zone is to be respected inside the crop due to anticipated side-effects with regards to potential pests or weeds’ proliferation. Further monitoring to confirm the current observations of limited promotion of pests and weeds would be a first recommendation to build the confidence of farmers in these mitigation options. From a practical point of view, recommendations for buffer zones may be defined in a way to optimize their implementation in the cases where multiple buffer zones are recommended. Proposals are enclosed in these proceedings on how this could translate in the Safety Precaution Phrases as per in Regulation (EU) No. 547/2011 (see Chapter 3). Additional optimization may be achieved with the implementation of the Common Agricultural Policy (CAP) in cases where farmers are to keep 5% of their land off-crop. In these cases, this portion of land may be used as buffer zone, since it responds to the condition of not receiving direct sprays. Similar recommendations are also proposed when these buffer zones are also vegetated, such as vegetated strips and other vegetated field margins. Indeed, these field margins may be implemented into the form of simple vegetated strips, hedges, headlands, etc., and are similar to the ecological areas defined in the CAP (EC 2013). The dedication of 5% of the land as recovery area, i.e., non cultivated and thus non-sprayed, as recommended in the CAP, in contributing to an improved ecological resilience in the farmland, including to potential effects of pesticides, may also facilitate the acceptance and implementation of product-specific buffer zones as they may simply overlap. Further dialogue with the stakeholders involved in the implementation of the CAP at national level will help to communicate on the options to optimize the joint implementation of the two pieces of regulation. Overlaps with the protection of specific organisms or environmental compartments as defined in the Habitat Directive (Directive 92/43/EEC) and the Water Framework Directive (Directive 2000/60/EC) are already in place in Member States, which also illustrates how optimization may be done, to provide farmers with fair and flexible options to meet their objectives of environmental protection.

11.2 Increasing knowledge on the effectiveness of the measures proposed

This inventory and analysis have also revealed an increasing knowledge on how these risk mitigation tools work in the farmland.

The risk mitigation measures selected to enter our toolbox are supported by data documenting their effectiveness at reducing the risks for which they were implemented, and where available by technical guidance on how to optimize their effectiveness. Data collected through the literature review, technical reports, and web-based data resources are collated in these proceedings and in the appendices, in an attempt to identify the major sources of research and development in the area.

The need for further monitoring of the effectiveness of these risk mitigation measures has been identified in all expert groups. Monitoring data will help stakeholders become familiar with the mitigation techniques involved and with the reality of the farmland as a landscape element. Additional confidence would be achieved with the development of consensual monitoring protocols, since they would allow the generation of relevant data, facilitate their interpretation, and where possible, their extrapolation among different situations. Progress in monitoring and data sharing would result in the building of more robust databases. Working groups dedicated to monitoring, such as the SETAC Environmental Monitoring of Pesticides interest group, may provide support in the development of guidance to monitoring in diverse areas, such as groundwater, for example.

The collection of data via monitoring is also beneficial to the development of environmental (exposure) and ecological modeling, as valuable tools able to predict the effectiveness of risk mitigation measures. Environmental modeling tools are more advanced in their development than ecological models, having been used in risk assessment for a decade in Europe, and now being adapted to take into account risk mitigation options and estimate their effectiveness. An example of such an application for runoff is provided in Chapter 4.3. Ecological modeling tools are in increasing development, and options to use them to predict benefits of risk mitigation measures may in future involve joint modules with environmental models.

The availability of monitoring and modeling capacity as routine tools could allow to rapidly estimate the potential effectiveness of risk mitigation measures, and increase the agility in their implementation.

11.3 Fairness, proportionality, and practicality in the acceptance of risk mitigation measures by farmers

Exchanges with experts from extension services, agricultural advisors, and farmers' representatives highlighted the importance of ensuring that the risk mitigation measures to be promoted are fit for purpose and easy to implement. For farmers, taking measures to accompany the application of plant protection products comes on top of additional conditions related to the CAP (EC 2013) and the Directive of the Sustainable Use of Pesticides (EC 2009b), and is often perceived as an additional constraint not fully justified with regards to the environmental objectives.

Meeting these expectations is critical for the acceptance and implementation in the field of risk mitigation options. Fairness and proportionality of a measure requires parameterizing a risk mitigation measure with accuracy, i.e., if a 10 m buffer zone is recommended one can trust that 10 m were actually required to meet environmental protection objectives, which a 5 m buffer zone would not have achieved. The analysis of data supporting the risk mitigation measures proposed in the toolbox confirmed that in most cases accuracy can only be reached through complex models or data analysis. The challenge relies on the subsequent re-simplification of the outcome of these models or data analysis so that is easy to translate as a risk mitigation measure and understood by users. An illustration of this is provided in the example of runoff reduction, where a thorough analysis of complex data systems quantified the capacity of the diverse options for mitigation at reducing transfers to the expected level, which is thereafter transposed into a point system easy to implement risk mitigation options, as illustrated on Figure 11.1.

Data collection and analysis

Runoff Mitigation measure	Strength of scientific evidence	Basic Mitigation Effectiveness
Edge-of-field measures		
5 m vegetated filter strip	+++	40%
10 m vegetated filter strip	+++	65%
20 m vegetated filter strip	+++	80%
Edge-of-field bunds	+	40%
In-field measures		
No-till / reduced tillage	++	50%
In-field bunds (row crops)	+	50%
5 m vegetated filter strips	++	50%
Inter-row vegetated strips (in permanent crops)	++	50%
Off-field measures		
Artificial wetland / retention pond	+++	75%
Vegetated ditches	++	50%

Double-exponential scale point system (=intermediate conservative)

Mitigation Efficiency (%)	Mitigation Points
40	21
50	30
60	39
70	50
75	56
80	64
90	86
95	106
99	130
Max. 99%	130+

Farmers' choice to manage risks at field level: in field edge of field

- **Winter wheat** (56 mitigation points needed)
  - Field 1 (Farmer X): 10 m VBS 60 pts

  - Field 2 (Farmer Y): no-till & 3-m in-field VBS 60 pts

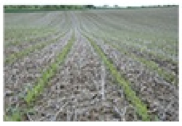 + 

Figure 11.1: Approach used for the development of the risk mitigation toolbox specific to runoff (from chapter 5.1).

Ultimately, the risk mitigation options may be directly read from product's labeling, using the Safety Precaution Phrases of Regulation (EU) 547/2011 (EC, 2011), as illustrated in Chapter 3.

Feedback from stewardship activities and National Action Plans confirm that training and educational programs are effective at getting farmers up-to-date with regulatory developments and their technical implications with regards to the management of their farm, and will be critical to accompany the transfer of knowledge of the risk mitigation measures proposed in the toolbox to farmers and end users.

11.4 Recommendations

Further work is needed and the priorities are listed below. They complete more specific recommendations already listed in the dedicated chapters above.

1. Encourage the implementation of the toolbox in order to benefit of the risk mitigation these tools can already provide and collect further quantification of their effectiveness as well as on the practicality of their implementation

2. Pursue the development of fair and effective environmental risk mitigation measures easy to implement in the decision making process e.g., via the Safety Precaution Phrases and by farmers

3. Further develop the multi-functionality of field margins and adapt to Member States conditions to optimize associated benefits

4. Develop a dialogue with the stakeholders involved in the implementation of the measures of the CAP so that the recommendations to farmers allow an optimized use of the land

5. Where relevant, pursue the development of methods allowing the certification of the risk mitigation measures (as, for example, for spray drift reducing technologies or seed mixtures), to facilitate the mutual recognition of the tools between countries and organizations

6. Where a quantitative appreciation of the effectiveness of a risk mitigation measure is possible, facilitate their integration in the risk assessment process

7. Pursue the development of technical guidance for ecological and environmental monitoring for the generation of relevant data allowing to measure the effectiveness of risk mitigation measure and allow data sharing, extrapolations, and robust databases

8. Pursue the monitoring of pests, diseases, and weeds in farming systems where risk mitigation measures involving non-sprayed zones areas are implemented in order to limit counterproductive recommendations

9. Pursue the generation of mapping systems such as GIS in support of environmental and ecological modeling tools

10. Pursue the development of ecological and environmental modeling

toward tools able to evaluate the effectiveness of risk mitigation measures a priori

11. Develop communication tools, such as the proposed Risk Mitigation Measure Technical Sheets (RMMTS) and declensions in training and stewardship (such as leaflets, applications on mobile devices), to support the transfer of knowledge on the risk mitigation toolbox to farmers and end users

12. Develop networking on the scientific, technical, professional, and legislative or regulatory aspects of the toolbox, to further develop its accuracy and effectiveness

11.5 References

[EC] European Commission. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journals of the European Union. L 206: 22.7.1992. p. 7.

[EC] European Commission. 2009a. Regulation (EC) No. 1107/2009 of the European Parliament and of the council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. Official Journals of the European Union. L 309: 24.11.2009. p. 1.

[EC] European Commission. 2009b. Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009, establishing a framework for Community action to achieve the sustainable use of pesticides. Official Journals of the European Union. L 309: 24.11.2009. p. 71.

[EC] European Commission. 2011. Commission Regulation (EU) No. 547/2011 of 8 June 2011 implementing Regulation (EC) No. 1107/2009 of the European Parliament and of the Council as regards labeling requirements for plant protection products. Official Journals of the European Union. L 155: 11.06.2011. p. 176.

MAgPIE

MITIGATING THE RISKS OF PLANT PROTECTION PRODUCTS IN THE ENVIRONMENT

Proceedings of the MAgPIE workshop - Appendices

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Appendix 1 Risk Mitigation Measures Technical Sheets

This appendix proposes Risk Mitigation Measure Technical Sheets (RMMTS) that provide practical details on the tools that may be implemented in European countries, together with indication on their benefits and possible constraints, where relevant. Users may find practical details on their implementation and management, as well as supportive literature. Where indicated details on implementation are taken as example from a Member States and may need adaptation for other member States. Details regarding the integration in a risk assessment or decision making are also provided. Finally each file contains recommendations as regards the evaluation of the efficacy of the risk mitigation measure and possible related monitoring.

1.1 RMMTS

1.1.1 Risk Mitigation Measure Technical Sheet (RMMTS) # 1 – No spray zones based on local conditions

RMMTS # 1 – No spray zones based on local conditions	
Description	Spray drift reduction on a vulnerable area can be obtained by keeping distance between the sprayed area and the vulnerable area (see also #2). Instead of fixed buffer zones, no spray zones (safety distances) can be based on local conditions. In this RMMTS the Swedish “Hjälpredan” (engl. ‘The Helper’) is used as an example. It considers weather/climate conditions such as wind direction, wind speed and local temperature as well as used application technology and the dose of PPP. National regulation issued by the Swedish EPA requires all professional users of plant protection products to calculate and observe proper spray drift related safety distances based on local conditions (SNFS 1997:2)
Beneficial for[1]	Birds Mammals Pollinators Non-target arthropods Plants Aquatic organisms
Negative effects on	Farmers’ productivity as it takes some more time (2 – 5 min.) at beginning of each field. Some more data in spray records for traceability is needed. Note that implementation is only required for field in sensitive areas (what TOPPS

	refers to as "zone of awareness")
Estimated risk reduction potential	The risk reduction can be estimated through the reduction of transfers of spray drift. Depending on the equipment used a 25, 50, 75, 90 or 99% drift reduction is possible (Nilsson J, et al. 2006). Various classification systems for equipment exist but the thresholds summarized here are commonly used benchmarks.
Implementation and management	Guidance on implementation is given by the Hjälpredan booklet. In tabular format it covers three different temperatures (10, 15 and 20°C) and three different wind speeds (1.5, 3 and 4.5 m/s). Each combination of temperature and wind speed (nine combinations) constitute a set of two pages, one intended for general and one for special concern. In the table columns there are entries for the different spray droplet sizes and the DRT. The different boom heights can be found in the table rows. 1. Once the temperature and wind speed have been measured, the matching two paged spread of the Helper can be chosen. 2. Next step is to decide on the proper level of acceptable spray drift by identifying whether the area in the wind direction requires general or special concern to be applied. Guidance is given by the Helper. 3. Continue to identify the proper safety distance by selecting your matching boom height (25, 40 or 60 cm), spray droplet size (Fine, Medium or Coarse) and the used dose (1/1, ½ or ¼ off full dose). If, for example the area in the wind direction requires general concern, the boom height is 40 cm, the spray droplet size is categorised as medium and the used dose is the recommended dose (1/1), the proper safety distance to the field edge need to be set at 3 m (under condition that no particular DRT is used). However, if instead special concern is needed, the proper safety distance need to be set at 26 m. If nozzles with e.g. 50% drift reduction are used, a safety distance of 2 or 8 m respectively can be applied.
Constraints	How to use the Hjälpredan is an important element in mandatory training courses and it also forms a part of written exams.
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	While the Hjälpredan allows for a relatively high degree of customization of application to reflect the environmental and landscape conditions at the point of application, they require a high degree of compliance, awareness and acceptance by farmers/applicators. Implementation must be accompanied by appropriate measures to assure compliance.

1.1.2 RMMTS # 2 – buffer zone on bare soil

RMMTS # 2 – Buffer zone on bare soil	
Description	Spray drift reduction on a vulnerable area can be obtained by keeping distance

<table>
<tr><td></td><td>between the sprayed area and the vulnerable area. This buffer zone can be a non-cropped and therefore non-sprayed area and kept as a bare soil surface to prevent weeds entering the cropped area.</td></tr>
<tr><td>Beneficial for[2]</td><td>Birds
Mammals
Pollinators
Non-target arthropods
Plants
Aquatic organisms
Pest management
Runoff
Spray drift</td></tr>
<tr><td>Negative effects on</td><td>No negative effects are foreseen.</td></tr>
<tr><td>Estimated risk reduction potential</td><td>The risk reduction can be estimated through the reduction of transfers of spray drift, which may be up to more than 99% drift reduction.</td></tr>
<tr><td>Implementation and management</td><td>Implementation of non-cropped and non-sprayed bare soil buffer zones is easy to control, as it is a bare soil strip between the vulnerable area and the crop. The width of the buffer zone is also easy to determine as the distance between the edge of the vulnerable area and the last crop row. The effect on spray drift can be determined from the used spray drift curve as spray drift deposition outside the sprayed field decrease with increasing distance. Spray drift from spraying a crop can be different from spraying a bare soil surface or short crop.

For a crop situation spray drift reductions of different crop-free buffer zones and DRTs are:

Drift reductions of different crop-free buffer zones and DRTs based on basic drift values (Rautmann et al. 2001; FOCUS 2001), alone and with 50, 75, 90, and 95% drift reduction:
<table>
<tr><td>[m]</td><td>1</td><td>3</td><td>5</td><td>10</td></tr>
<tr><td>standard</td><td>49</td><td>74</td><td>83</td><td>90</td></tr>
<tr><td>DRT50</td><td>75</td><td>87</td><td>91</td><td>95</td></tr>
<tr><td>DRT75</td><td>87</td><td>94</td><td>96</td><td>98</td></tr>
<tr><td>DRT90</td><td>95</td><td>97</td><td>98</td><td>99</td></tr>
<tr><td>DRT95</td><td>97</td><td>99</td><td>99</td><td>100*</td></tr>
</table>
This shows that a 1m bare soil surface buffer zone has a reduction in spray drift deposition at a 1 m evaluation zone of at least 50%, a 3 m zone at least 75%, a 5 m zone around 90% and a 10 m zone around 95%.</td></tr>
</table>

	* rounded value, actually 99.9…%
Constraints	None. Keep the buffer zone clean of plant growth. Note that this requires additional effort for farmers and require mechanical maintenance. Grassed strips may be more easily managed and have additional efficacy for drift reduction.
Recommendations on implementation	It is recommended to link decreasing steps in width of bare soil buffer zone with classes of increasing drift reducing spray equipment. For spraying a bare soil surface/short crop or a crop situation spray drift can be different and therefore the bare soil buffer zone width to obtain a similar level of drift deposition can be different. In situation vulnerable to run-off preference should be given to MFFM (see RMMTS # 3 to 9). Further details may be found in Ganzelmeier and Rautmann (2000), Groot et al. (2012) and Van de Zande et al. (2000, 2005, 2014 a & 2014b).

1.1.3 RMMTS # 3 to 9 – Vegetated buffer strip/ Multifunctional field margins (e.g. as qualification of a vegetated buffer)

Field margins (also called interstitial elements as in Stoate et al. (2009)) may be divided into two groups: permanent and temporary (Marshall and Moonen, 2002):

- permanent field margins, which include sown strips such as sown grass strips, sown grass and wild flower strips, and set-aside margins. These are created by natural regeneration of the flora or are sown to perennial grass and/or wildflower mixtures and can include beetle banks across fields;

- temporary strips, which include uncropped wildlife strips made of arable flower margins, sown wildlife mixtures (strips or blocks) and conservation headlands (which consist in uncropped but cultivated edges), and strips sown to bird cover crops or flowers.

Permanent field margins are important for species that do not disperse in the landscape, notably most plant species. For the farmer they require extra work because they cannot be treated as a crop within the field, but they may facilitate access or be sited to control weeds. Temporary strips can be integrated in the normal crop management but will only be beneficial for those species that are adapted to regularly cultivated crop areas or have the ability to move freely in the landscape.

The biological value of managed and set-aside field margins has been confirmed in a number of studies across Europe – for a review see for example Marshall and Moonen (2002 and Stoate et al. (2009) as well as DEFRA (2007) for an example of study protocol. More details are provided below for each type of field margins, together with recommendations with regards to the possibilities to extend their benefits to the environment.

References cited in these RMMTS may be found at the end of this chapter.

RMMTS # 3 Natural regeneration field margin	
Description	These field margins are existing (established) or newly installed vegetated strips that will be further managed so that they fulfil the purpose for which they have been maintained or installed. Their location in the farmland is dependent on the primary benefit that is aimed at (*e.g.* runoff management, spray drift management, other…).
Beneficial for[3]	Birds (2 on seeds, plants and food in summer and 1 in winter, 3 on invertebrate food); Mammals (2 on abundance and diversity); Pollinators (2 on food resources, species richness abundance and 3 on hibernation sites); Non-target arthropods (2 on parasitic wasps, 3 on spiders, 2 on beetles, 3 on soil invertebrates); Plants (1 on annual arable weeds, 3 on perennial flowers, 2 overall); Aquatic organisms (3 on invertebrates and plants); Pest management (1 on invertebrates, 2 on weeds); Runoff (3 on pesticides, sediment, phosphorus and nitrogen); Spray drift (3 on pesticides); Soil (3 on soil erosion).
Negative effects on	None reported
Estimated risk reduction potential	Risk reduction is a function of the reduction of drift and runoff as well as influenced by the benefit of the field margin to the flora and fauna, as it provides habitat and food resource. Also this type of buffer zone may connect different (semi-)natural habitats and therefore enlarge refuges. As regards drift: the risk reduction is proportional to the width and height of the buffer. Spray-free buffer zones of the same height as the sprayed crop (50-70 cm) can at the zone 1-5 m distance from the edge of the crop be classified in three different drift reduction classes: 3 m spray-free buffer zone in >75%, 14 m spray-free buffer zone in >90% and 24 m spray-free buffer zone in >95% spray drift reduction (Zande et al., 2010). For vegetation at the spray-free buffer zone of 50 cm higher than the sprayed crop, spray drift reduction at 1-5 m behind the vegetated buffer strip is 80%, and for vegetated strips 1 m higher than the sprayed crop 90% (Zande et al., 2000). For vegetated buffer zones lower (<20 cm) than the sprayed crop the spray drift reduction is comparable to that of a crop-free buffer zone (RMMTS#1). As regards runoff: only buffers at the down slope edge of the field will be effective; the ability to infiltrate runoff water and retain eroded soil material is expected be lower than for grassed buffer strips (estimation: 50 to 75% of default mitigation efficiency for grassed buffers), which are explicitly designed for optimized runoff mitigation. However, as soon as good soil coverage and rooting vegetation is established, runoff mitigation will be an additional benefit to consider for this type of buffer strip.

Implementation and management	Establishment and management Based on the UK ELS handbook (Natural England, 2013), the establishment and management guidance for the option which applies to grass seed mix and natural regeneration area is as follows: <u>EE1 (2 m), EE2 (4 m), EE3 (6 m) Buffer strips on cultivated land</u> For these options, you must comply with the following: - Establish or maintain a grassy strip during the first 12 months of your agreement, either by sowing or, ideally, by natural regeneration. Remove any compaction in the topsoil if you need to prepare a seedbed, except on archaeological features. - Regular cutting in the first 12–24 months may be needed to control annual weeds and encourage grasses to tiller. Avoid cutting when the soil is moist, to prevent further compaction. Do not apply any fertilisers or manures. - Only apply herbicides to spot-treat or weed-wipe for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort) or invasive non-native species (e.g. Himalayan balsam, rhododendron or Japanese knotweed). - After the first 12–24 months of your agreement, cut buffer strips only to control woody growth, and no more than once in every 2 years. - Do not use buffer strips for regular vehicular access, turning or storage. There should be no tracks, compacted areas or poaching. Placement of buffer adjacent to watercourse In-field and edge of field buffers, rather than riparian buffers, which break up the flow of runoff or alternative buffer features, which match the flow path of runoff, are more effective and efficient when concentrated flow is an issue. Edge-of-field buffers which are separated from the water feature are generally more efficient for reducing runoff transfer than riparian buffers. Positioning buffer strips nearest to vulnerable fields is usually the most effective strategy for mitigation, as flowing runoff water tends to form channels of concentrated flow within the field, as rivers and streams already do within the landscape, as it passes downhill. This would suggest that in-field and non-riparian edge-of-field buffer strips may be most efficient use of land area. EE1 (2 m), EE2 (4 m), EE3 (6 m) can also be used adjacent to watercourse features with the following additional requirements from the ELS handbook: <u>EE9 6 m buffer strips on cultivated land next to a watercourse:</u> EE9 should always be used when a 6 m buffer on cultivated land is placed alongside a watercourse. For this option, you must follow the management for options EE1/EE2 and in addition comply with the following: - After the first 12–24 months of your agreement, cut the 3 m next to the crop edge annually after mid-July. Only cut the other 3 m to control woody growth, and no more than once every 2 years. <u>EE9 12 m buffer strips for watercourses on cultivated land:</u>

	This option aims to reduce the risk of transport of potential pollutants, such as sediment, nutrients (principally phosphate) and pesticides, to watercourses. This option is intended for land adjacent to ditches, rivers or streams where it can intercept and remove sediment, organic material, nutrients and chemicals carried in runoff water. These buffer strips must not overlap with the cross compliance requirement not to cultivate land within 2 m of the centre of a hedgerow or watercourse (and within 1 m of the top of the bank of a watercourse). This option is only available on arable or rotational land that has been identified (and recorded on your Farm Environmental Record FER) as at risk of soil erosion or runoff. For this option, you must comply with the following in addition to the requirements of EE1, EE2 or EE3: - The width of the strip may vary between 12 m and 24 m along its length but must not be less than 12 m wide at any point. - Do not apply any fertilisers or manures. - After the first 12–24 months, cut the 6 m next to the crop edge annually after mid-July. Only cut the remainder to control woody growth, and no more than once every 2 years. - Do not graze the buffer strip.
Constraints	Natural regeneration is favourable over grass mix due to the lower initial cost of establishment. Natural regeneration can also produce a diverse fauna on lighter (non-clay) soils where there is a diverse local seed bank (Marshall, 1998). However, if there are existing issues with weeds in field boundaries this will affect uptake and long term management of margins (Marshall, 1998). As perennial options natural regeneration area and grass mix require reduced input and management once established. They may require intensive mowing in first two years to reduce weed pressure. However, beyond this management requirements can be minimal. The ease of management and extended life of these margins are likely to promote uptake.
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	The implementation of natural regeneration areas is country specific. It may be driven by the risk assessment where the implementation of vegetated field margins is recommended as a risk mitigation measure accompanying a product as well as generically in the context of the implementation of the CAP. Natural regeneration areas are part of perennial risk mitigation measures the benefits of which increase with time, thus they should be considered generically independently of the nature of the products used in the farmland. Their benefits may be multiplied if they take into account recommendations relative to other types of field margins so please also consult RMMTS #4 to 9 in this chapter. Their benefits are further reinforced when implemented at a larger scale. Additional recommendations are provided in section 6 of this chapter as well as in the associated references relative to practical aspects.

RMMTS #4 Grass sown mix (similar to natural regeneration area except for benefits)	

Description	These field margins are existing (established) or newly installed vegetated strips that will be further managed so that they fulfil the purpose for which they have been maintained or installed. Their location in the farmland is dependent on the primary benefit that is aimed at (*e.g.* runoff management, spray drift management, other…).
Beneficial for[4]	Birds (2 on seeds, plants and food in summer and 1 in winter, 2 on invertebrate food); Mammals (3 on abundance and diversity); Pollinators (2 on food resources, species richness abundance and 3 on hibernation sites); Non-target arthropods (2 on parasitic wasps, 3 on spiders, 3 on beetles, 3 on soil invertebrates); Plants (2 on perennial flowers, 1 overall); Aquatic organisms (3 on invertebrates and plants); Pest management (3 on invertebrates, 3 on weeds); Runoff (3 on pesticides, sediment, phosphorus and nitrogen); Spray drift (3 on pesticides); Soil (3 on soil erosion)
Negative effects on	-1 on annual arable weeds
Estimated risk reduction potential	Risk reduction is a function of the reduction of drift and runoff as well as influenced by the benefit of the field margin to the flora and fauna, as it may provide habitat and food resource. As regards drift: mostly risk reduction according to the width and height of the buffer. For vegetated buffer zones lower (<20 cm) than the sprayed crop like grass strips the spray drift reduction is comparable to that of a crop-free buffer zone (RMMTS#1). As regards runoff: only buffers at the down slope edge of the field will be effective; similar runoff mitigation as for grassed buffer strips can be assumed (see section on runoff).
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	Establishment and management Based on the UK ELS handbook (Natural England, 2013), the establishment and management guidance for the option which applies to grass seed mix and natural regeneration area is as follows: <u>EE1 (2 m), EE2 (4 m), EE3 (6 m) Buffer strips on cultivated land</u> For these options, you must comply with the following: - Establish or maintain a grassy strip during the first 12 months of your agreement, either by sowing or, ideally, by natural regeneration. Remove any compaction in the topsoil if you need to prepare a seedbed, except on archaeological features. - Regular cutting in the first 12–24 months may be needed to control annual weeds and encourage grasses to tiller. Avoid cutting when the soil is moist, to prevent further compaction. Do not apply any fertilisers or manures.

- Only apply herbicides to spot-treat or weed-wipe for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort) or invasive non-native species (e.g. Himalayan balsam, rhododendron or Japanese knotweed).
- After the first 12–24 months of your agreement, cut buffer strips only to control woody growth, and no more than once in every 2 years.
- Do not use buffer strips for regular vehicular access, turning or storage. There should be no tracks, compacted areas or poaching.

Placement of buffer adjacent to watercourse

In-field and edge of field buffers, rather than riparian buffers, which break up the flow of runoff or alternative buffer features, which match the flow path of runoff, are more effective and efficient when concentrated flow is an issue. Edge-of-field buffers which are separated from the water feature are generally more efficient for reducing runoff transfer than riparian buffers.

Positioning buffer strips nearest to vulnerable fields is usually the most effective strategy for mitigation, as flowing runoff water tends to form channels of concentrated flow within the field, as rivers and streams already do within the landscape, as it passes downhill. This would suggest that in-field and non-riparian edge-of-field buffer strips may be most efficient use of land area.

EE1 (2 m), EE2 (4 m), EE3 (6 m) can also be used adjacent to watercourse features with the following additional requirements from the ELS handbook:

<u>EE9 6 m buffer strips on cultivated land next to a watercourse:</u>

EE9 should always be used when a 6m buffer on cultivated land is placed alongside a watercourse.

For this option, you must follow the management for options EE1/EE2 and in addition comply with the following:

- After the first 12–24 months of your agreement, cut the 3 m next to the crop edge annually after mid-July. Only cut the other 3 m to control woody growth, and no more than once every 2 years.

<u>EE9 12 m buffer strips for watercourses on cultivated land:</u>

This option aims to reduce the risk of transport of potential pollutants, such as sediment, nutrients (principally phosphate) and pesticides, to watercourses.

This option is intended for land adjacent to ditches, rivers or streams where it can intercept and remove sediment, organic material, nutrients and chemicals carried in runoff water. These buffer strips must not overlap with the cross compliance requirement not to cultivate land within 2 m of the centre of a hedgerow or watercourse (and within 1 m of the top of the bank of a watercourse). This option is only available on arable or rotational land that has been identified (and recorded on your Farm Environmental Record FER) as at risk of soil erosion or runoff.

For this option, you must comply with the following in addition to the requirements of EE1, EE2 or EE3:

- The width of the strip may vary between 12 m and 24 m along its length but must not be less than 12 m wide at any point.

	- Do not apply any fertilisers or manures. - After the first 12–24 months, cut the 6 m next to the crop edge annually after mid-July. Only cut the remainder to control woody growth, and no more than once every 2 years. - Do not graze the buffer strip.
Constraints	Sowing with grass seed mixtures is recommended where weeds are already an issue (Marshall, 1998). However, sowing grass seed is not favourable in situations where rare or locally important annual species are present. As perennial options grass mix require reduced input and management once established. They may require intensive mowing in first two years to reduce weed pressure. However, beyond this management requirements can be minimal. The ease of management and extended life of these margins are likely to promote uptake.
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	The implementation of natural regeneration areas is country specific. It may be driven by the risk assessment where the implementation of vegetated field margins is recommended as a risk mitigation measure accompanying a product as well as generically in the context of the implementation of the CAP. Natural regeneration areas are part of perennial risk mitigation measures the benefits of which increase with time, thus they should be considered generically independently of the nature of the products used in the farmland. Their benefits may be multiplied if they take into account recommendations relative to other types of field margins so please also consult RMMTS #3 to 9 in this chapter. Their benefits are further reinforced when implemented at a larger scale. Additional recommendations are provided in section 6 of this chapter as well as in the associated references relative to practical aspects.

RMMTS #5 Sown wildflower seed mix	
Description	Wildflower seed can be incorporated in as an additional component of buffer options relevant to natural regeneration margins and grass sown margins, including 6 m buffers adjacent to watercourses (EE1-EE3, EE9).
Beneficial for[5]	Birds (3 on summer seeds, plants and food, 1 on winter seeds, plants and food, 3 on invertebrate food); Mammals (2 on abundance and diversity); Pollinators (3 on food resources, species richness abundance and 2 on hibernation sites); Non-target arthropods (3 on parasitic wasps, 2 on spiders, beetles, soil invertebrates); Plants (3 on perennial flowers, 2 overall); Aquatic organisms (2 on invertebrates and plants); Pest management (3 on invertebrates, 2 on weeds); Runoff (2 on pesticides, sediment, phosphorus and nitrogen); Spray drift (3 on pesticides);

	Soil (3 on soil erosion)
Negative effects on	Plants (-1 on perennial wildflowers)
Estimated risk reduction potential	Risk reduction is a function of the reduction of drift and runoff as well as influenced by the benefit of the field margin to the flora and fauna, as it provides habitat and food resource. Also this type of buffer zone could bridge gaps in pollen and nectar resources for pollinators and enhance population. As regards drift: mostly risk reduction according to the width and height of the buffer. Spray-free buffer zones of the same height as the sprayed crop (50-70 cm) can at the zone 1-5 m distance from the edge of the crop be classified in three different drift reduction classes: 3 m spray-free buffer zone in >75%, 14 m spray-free buffer zone in >90% and 24 m spray-free buffer zone in >95% spray drift reduction (Zande et al., 2010). For a vegetation at the spray-free buffer zone of 50 cm higher than the sprayed crop, spray drift reduction at 1-5 m behind the vegetated buffer strip is 80%, and for vegetated strips 1 m higher than the sprayed crop 90% (Zande et al., 2000). For vegetated buffer zones lower (<20 cm) than the sprayed crop the spray drift reduction is comparable to that of a crop-free buffer zone (RMMTS#1). As regards runoff: only buffers at the down slope edge of the field will be effective; an almost similar runoff mitigation as for grassed buffer strips can be expected for this type of buffer if perennially established. Maybe a slightly less efficient runoff infiltration and sediment retention will be caused by the less intensive root systems that non-grass species will develop (estimation: -80% of runoff mitigation as compared with grassed buffers).
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	Wildflower seed can be incorporated as an additional component of buffer options relevant to natural regeneration area and sown grass seed mixtures, including 6 m buffers adjacent to watercourses (EE1-EE3, EE9). Establishment and management Based on the UK ELS handbook (Natural England, 2013), the establishment and management guidance is as follows: <u>EE12: Supplement to add wildflowers to field corners and buffer strips on cultivated land</u> The aim of this supplement is to create flower-rich areas on cultivated land that will provide valuable sources of food for invertebrates and birds, and a greater diversity and structure of vegetation compared to grass only areas. This supplement can be used with field margin options for sown grass seed mixture and natural regeneration (EE1-EE3, EE9). It must not be used to sow wild flowers into established buffer strips, field corners and in-field grass areas unless the areas are present at the start of the agreement and will be managed to ensure successful flower establishment in the first year. You must follow the management for the base option except the sowing and cutting requirements and in addition comply with the following: - By the end of the first 12 months of the agreement, establish a mix or maintain existing areas containing fine-leaved grasses (such as crested dog's tail, chewings fescue, slender red fescue, smooth-stalked meadow grass and common bent) and flowers (such as knapweed, bird's-foot trefoil, self-heal, oxeye daisy, yarrow, wild red clover and wild carrot).

	- Where sown, the flower component must be included at a minimum seed rate of 1.0 kg/ha. - Do not sow tussock-forming grasses such as cocksfoot, meadow foxtail and meadow fescue, as these can swamp the wild flowers. - By the beginning of year three, there must be at least five flower species (excluding injurious weeds) and three fine-leaved grass species present frequently across the flower-rich area. Maintain this floristic area for the duration of your agreement. - Regular cutting and removal of cuttings in the first 12 months after sowing may be needed to ensure successful establishment of sown species. - After establishment, cut the whole area to 10 cm between 1 August and 30 September, removing cuttings to avoid patches of dead material developing. If excess vegetation threatens to suppress the flowers, cut again the following March or April providing no birds are nesting in the flower-rich area.
Constraints	Wildflower field margins allow for additional income to be generated from natural regeneration and sown grass seed mix options under UK AES options based on similar management. The Wildflower field supplement also ensures that a wildflower component is incorporated which can benefit a wider variety of biodiversity. This may be particularly important where sown grass seed mix is required to help control weeds. The additional supplement provided when Wildflower field margin is established under Entry Level Stewardship (ELS6) ensures that additional costs (higher seed prices and more intensive initial and ongoing management), compared to natural regeneration and grass sown strips, are rewarded. In an assessment of the economic value of AES field margin options studied as part of the Farm4Bio project, Wildflower field, as Floristically Enhanced Grass mix, was calculated as the most valuable option based on gross margin earned over a five year AES period (Holland et al., 2013).
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	The implementation of natural regeneration areas is country specific. It may be driven by the risk assessment where the implementation of vegetated field margins is recommended as a risk mitigation measure accompanying a product as well as generically in the context of the implementation of the CAP. Natural regeneration areas are part of perennial risk mitigation measures the benefits of which increase with time, thus they should be considered generically independently of the nature of the products used in the farmland. Their benefits may be multiplied if they take into account recommendations relative to other types of field margins so please also consult RMMTS #3 to 9 in this chapter. Their benefits are further reinforced when implemented at a larger scale. Additional recommendations are provided in section 6 of this chapter, in Appendix 10 as well as in the associated references relative to practical aspects.

RMMTS #6 Sown pollen and nectar mix	
Description	These field margins are made of pollen and nectar producing species and the composition of which may be adapted based on the fauna to be sustained. Their location in the farmland is dependent on the benefit that is aimed at (*e.g.*

	provide pollen and nectar and provide runoff management, spray drift management, other…).
Beneficial for[6]	Birds (1 on summer and winter seeds, plants and food, 2 on invertebrate food); Mammals (2 on abundance and diversity); Pollinators (3 on food resources, species richness abundance and 1 on hibernation sites); Non-target arthropods (1 on parasitic wasps, 2 on spiders, beetles, soil invertebrates); Plants (1 on annual weeds and perennial flowers, 1 overall); Aquatic organisms (1 on invertebrates and plants); Pest management (1 on invertebrates, 2 on weeds); Runoff (2 on pesticides, sediment, phosphorus and 1 on nitrogen); Spray drift (2 on pesticides); Soil (2 on soil erosion)
Negative effects on	None reported
Estimated risk reduction potential	These field margins can provide habitat pollinators and therefore contribute to a reduction of the exposure to the crop in providing an alternative food resource and refuges. The efficacy may be function of a good protection from sprayed residues. They may also provide a reduction of drift and runoff as follows. As regards drift: mostly risk reduction according to the width and height of the buffer. Spray-free buffer zones of the same height as the sprayed crop (50-70 cm) can at the zone 1-5 m distance from the edge of the crop be classified in three different drift reduction classes: 3 m spray-free buffer zone in >75%, 14 m spray-free buffer zone in >90% and 24 m spray-free buffer zone in >95% spray drift reduction (Zande et al., 2010). For a vegetation at the spray-free buffer zone of 50 cm higher than the sprayed crop, spray drift reduction at 1-5 m behind the vegetated buffer strip is 80%, and for vegetated strips 1 m higher than the sprayed crop 90% (Zande et al., 2000). For vegetated buffer zones lower (<20 cm) than the sprayed crop the spray drift reduction is comparable to that of a crop-free buffer zone (RMMTS#1). As regards runoff, only buffers at the down slope edge of the field will be effective; less efficient than grassed buffer strips for runoff mitigation, when established year by year in new locations (estimation: 50% of mitigation efficiency of grassed buffer strips).
Implementation and management	Establishment and management Based on the UK ELS handbook (Natural England, 2013), the establishment and management guidance is as follows: EF4 Nectar flower mixture: This option is available on arable land or temporary grassland (sown to grass for less than five years).

Sowing an area of flowering plants into the farmed landscape will boost the availability of essential food sources for a range of nectar-feeding insects, including butterflies and bumblebees. This option provides valuable benefits to wildlife at a landscape scale and is ideally suited to larger blocks and small fields.

This option is a 'rotational option'. This means that it can move around the farm within the normal rotation, but the same total hectarage must be maintained each year. Relocating these blocks or strips will help to avoid the build-up of weeds or soil borne disease and can be rotated with EF2 Wild bird seed mixture to utilise any residual fertility left behind.

For this option, you must comply with the following:

- Remove any compaction in the topsoil if you need to prepare a seedbed, except on archaeological features.

- Sow a mixture of nectar-rich plants (e.g. red clover, alsike clover, bird's-foot-trefoil, sainfoin, musk mallow, common knapweed), with no single species making up more than 50 per cent of the mix by weight. Phacelia is also a preferred source of pollen and nectar and has been reported to assist in egg maturation in some aphidophageous species (Pontin et al., 2006). The minimum number of plant species should be defined so that it privileges native species and provides food resource and refuge/habitat for a wide range of pollinating species. The option to privilege mixture of several species is currently the best compromise, since the cultivation of a single flower which will minimise the risk of non-target effects may be too restrictive to sustain biodiversity over time, while the cultivation of a wide range of species will allow. Also changes in floral attractiveness by individual pollinators might occur over day and over a growing season even if it remains constant over a single foraging bout (Pontin et al., 2006). A minimum of 3 plant species that bloom at any given time during the growing season (spring, summer and fall) is recommended (Nicholls and Altieri, 2012). Combinations of annuals and perennials are preferred, which combine a variety of colours and shapes to attract different pollinator species. Plants in clumps may be more attractive than isolated plants. More advice as regards plant species are available in Marshall et al. (2001) and Lemoing and Pasquet (2011), which are reported in Appendix 10.

Also for honey bees the need in food resource may be estimated and used to design the composition and surface of the flowering strips (Lemoing and Pasquet, 2011).

- Sow in blocks and/or strips at least 6 m wide in early spring or late summer.

- Re-establish the mix as necessary, to maintain a sustained nectar supply (this is typically after three years).

- Regular cutting and removal of cuttings in the first 12 months after sowing may be needed to ensure successful establishment of sown species.

- Only apply herbicides to spot-treat or weed-wipe for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort) or invasive non-native species (Himalayan balsam, rhododendron or Japanese knotweed). Non-residual, non-selective herbicides may be applied prior to sowing, to help re-establishment.

- Do not apply any other pesticides, fertilisers, manures or lime.

- To stimulate valuable late flowering to meet the peak demand from bees,

	cut half the area to 20 cm between mid-June and the end of the first week of July. Do not cut if ground-nesting birds are present. - Cut the whole area to 10 cm between 15 September and 31 October, removing or shredding cuttings to avoid patches of dead material developing. - Do not graze in the spring or summer. Late autumn/early winter grazing of areas is allowed and will benefit legumes, but take care to avoid poaching damage and compaction, particularly when conditions are wet. - Do not use the area for access, turning or storage. The strips should be sown with the purpose to provide pollen and nectar during the whole period when pollinators are present and more particularly during the periods of food shortage when the crop is not flowering (Nicholls and Altieri, 2012). Finally nesting locations can be provided in the farmland, such as patches of bare soil, piles or hedges of stone and clump forming grasses (Nicholls and Altieri, 2012).
Constraints	Pollen and nectar margins generally require greater ongoing management and repeated cultivation compared to more perennial and robust margins such as wild flowers, grass mix and natural regeneration. Similar non-grass flower mixes are available under Swiss and German AES (Haaland et al., 2011). Greater than 30 species can be included in these seed mixes (Haaland et al., 2011). Pollen and nectar are designed to produce a period of highly abundant pollen and nectar supply based primarily on clovers and other legumes common to agriculture. The value of these field margins as pollen and nectar source options generally declines with age (Natural England, 2013). From research, pollen and nectar margins are observed to decline in flower abundance over time due to short life span of mixture species and competition from grasses (Pywell et al., 2007, 2008 and 2011). Consequently their value as a source of pollen and nectar may be reduced over time and, generally, this margin type must be re-established after 3 years. The short life-span of pollen and nectar margins is a trade-off for their high value benefit as nectar and pollen sources. Therefore, pollen and nectar margins must be reestablished every few years thus reducing its economic value compared to more permanent options. As a rotational option it is possible to rotate this with other more short term options.
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	The implementation of natural regeneration areas is country specific. It may be driven by the risk assessment where the implementation of vegetated field margins is recommended as a risk mitigation measure accompanying a product as well as generically in the context of the implementation of the CAP. Natural regeneration areas are part of perennial risk mitigation measures the benefits of which increase with time, thus they should be considered generically independently of the nature of the products used in the farmland. Their benefits may be multiplied if they take into account recommendations relative to other types of field margins so please also consult RMMTS #3 to 9 in this chapter. Their benefits are further reinforced when implemented at a larger scale. Additional recommendations are provided in section 6 of this chapter, in Appendix 10 as well as in the associated references relative to practical aspects.

RMMTS #7 Sown wild bird seed mix	
Description	These field margins are species that will provide seeds and habitat to birds. The composition of which may be adapted based on the fauna to be sustained. Their location in the farmland is dependent on the benefit that is aimed at (e.g. provide habitat and seeds and provide runoff management, spray drift management, other…).
Beneficial for[7]	Birds (3 on winter and summer seeds, plants and food, 2 on invertebrate food); Mammals (2 on abundance and diversity); Pollinators (1 on food resources, 2 on species richness abundance and 0 on hibernation sites); Non-target arthropods (1 on parasitic wasps, 2 on spiders, 2 on beetles, and 1 on soil invertebrates); Plants (2 on annual weeds and 1 on perennial flowers, 1 overall); Aquatic organisms (1 on invertebrates and plants); Pest management (1 on invertebrates, 2 on weeds); Runoff (1 on pesticides, sediment, phosphorus and 1 on nitrogen); Spray drift (2 on pesticides); Soil (2 on soil erosion)
Negative effects on	None reported
Estimated risk reduction potential	These field margins can provide habitat to birds and therefore contribute to a reduction of the exposure to the crop in providing an alternative food resource and refuges. The efficacy may be function of a good protection from sprayed residues. They may also provide a reduction of drift and runoff as follows. As regards drift: mostly risk reduction according to the width and height of the buffer. Spray-free buffer zones of the same height as the sprayed crop (50-70 cm) can at the zone 1-5 m distance from the edge of the crop be classified in three different drift reduction classes: 3 m spray-free buffer zone in >75%, 14 m spray-free buffer zone in >90% and 24 m spray-free buffer zone in >95% spray drift reduction (Zande et al., 2010). For a vegetation at the spray-free buffer zone of 50 cm higher than the sprayed crop, spray drift reduction at 1-5 m behind the vegetated buffer strip is 80%, and for vegetated strips 1 m higher than the sprayed crop 90% (Zande et al., 2000). For vegetated buffer zones lower (<20 cm) than the sprayed crop the spray drift reduction is comparable to that of a crop-free buffer zone (RMMTS#1). As regards runoff: only buffers at the down slope edge of the field will be effective; an almost similar runoff mitigation as for grassed buffer strips can be expected for this type of buffer if perennially established.
Implementation and management () here we give practical	Establishment and management Based on the UK ELS handbook (Natural England, 2013), the establishment and

recommendations that are meant to be adapted in MS / Zone	management guidance is as follows: EF2 Wild bird seed mixture: This option is available on arable land or temporary grassland (sown to grass for less than five years). This option will provide important food resources for farmland birds, especially in winter and early spring, on arable and mixed farms. The aim is to maximise the production of small seeds suitable as bird food in either annual or annual/biennial mixtures, while also providing a source of invertebrates for birds. This option is a 'rotational option'. This means that it can move around the farm within the normal rotation, but the same total hectarage must be maintained each year. Relocating these blocks or strips will help to avoid the build-up of weeds or soil-borne disease. Rotating them with EF4 Nectar flower mixtures makes use of any residual fertility from that option. For this option, you must comply with the following: - Sow a balanced combination of at least three small-seed bearing crops chosen from barley, triticale, kale, quinoa, linseed, millet, mustard, fodder radish and sunflower. No single species should make up more than 70 per cent by weight of the mix and the combination must cover a range of crop groups to minimise any pest and disease impacts. Large-seeded crops (maize) and game covers (giant sorghum or sweet clover) are not allowed. - Sow in blocks and/or strips at least 6 m wide at the edges of fields. Both should be between 0.4 ha and 3 ha in size. Ensure that the strips or blocks are well distributed across your farm and that food is always available for seed-eating birds. - In the first year, sow at the optimum time for the chosen species mixture, which may be autumn or spring, ensuring that any areas of soil compaction are removed prior to establishment, except on archaeological features. Avoid sowing too early in the spring, when seedbeds may be dry, cold and of poor quality. - To help with weed and pest management, the seed can be sown in separate drill widths or blocks within the option area. - On sandy soils, strips must be sown along contours. - Retain the crop mixture until at least 1 March before re-establishment in spring, which could be annually or every other year (biennial crops), to maintain sufficient seed production to feed birds during the late autumn/early winter. - Fertilisers or manures (but not within 10 m of watercourses) and seed treatments may also be used to aid establishment and ensure sufficient seed production during that period. - Only apply herbicides to spot-treat or weed-wipe for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort) or invasive non-native species (e.g. Himalayan balsam, rhododendron or Japanese knotweed). - Non-residual, non-selective herbicides may be used prior to sowing to help re-establishment. - Apply environmentally sympathetic insecticides during establishment

	where there is a strong risk of crop failure due to severe pest attack (identified through monitoring and use of thresholds). Advice must be taken from a British Agrochemical Standards Inspection Scheme (BASIS) professional before any insecticides are used. - Do not use the area for access, turning or storage. - Do not graze.
Constraints	Similar to pollen and nectar mix, wild bird sown margins require repeated cultivation. They are essentially annual or biennial crops for which the cropping season is extended to provide a winter supply of seed for birds. A large variety of seed mix options are available and these can be targeted to promote particular species. Annual and biennial mixtures are available. This option is likely to be favourable to farmers, as similar management techniques employed in the main crop can be used to control weed and pest species if required (Natural England, 2013).
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	The implementation of natural regeneration areas is country specific. It may be driven by the risk assessment where the implementation of vegetated field margins is recommended as a risk mitigation measure accompanying a product as well as generically in the context of the implementation of the CAP. Natural regeneration areas are part of perennial risk mitigation measures the benefits of which increase with time, thus they should be considered generically independently of the nature of the products used in the farmland. Their benefits may be multiplied if they take into account recommendations relative to other types of field margins so please also consult RMMTS #3 to 9 in this chapter. Their benefits are further reinforced when implemented at a larger scale. Additional recommendations are provided in section 6 of this chapter as well as in the associated references relative to practical aspects.

RMMTS #8 Cereal conservation headland	
Description	Conservation headlands are crop edges where no herbicide or insecticide application is performed. They are a normal part of agricultural practice in many countries and are be used as a mitigation measure to noticeably reduce pesticides spray drift to off-crop areas.
Beneficial for[8]	Birds (1 on summer and winter seeds, plants and food, 2 on invertebrate food); Mammals (1 on abundance and diversity); Pollinators (2 on food resources, 1 on species richness and abundance and 0 on hibernation sites); Non-target arthropods (1 on parasitic wasps, 1 on spiders, 1 on beetles, 1 on soil invertebrates); Plants (3 on annual weeds and 1 on perennial flowers, 1 overall); Aquatic organisms (1 on invertebrates and plants); Pest management (1 on invertebrates, 1 on weeds); Runoff (0 on pesticides, sediment, phosphorus and 2 on nitrogen);

	Spray drift (2 on pesticides); Soil (1 on soil erosion)
Negative effects on	None reported
Estimated risk reduction potential	Conservation headlands contribute to reduce transfers via spray drift. No significant runoff mitigation will result from this measure, as yearly establishment and reduced seeding rate will not lead to higher infiltration rates and sediment retention as compared with the cropped areas. Their contribution to a reduction of risks to flora and fauna is proportional of the effect on spray drift, and benefits on bird species such as the grey partridge, pheasants, blue-headed wagtails and small mammals such as the wood mouse as well as chick-food arthropods and butterflies have been observed (Marshall et al., 2001) which are attributed to an improved food resource in the area not being oversprayed. Spray-free buffer zones of the same height as the sprayed crop (50-70 cm) can at the zone 1-5 m distance from the edge of the crop be classified in three different drift reduction classes: 3 m spray-free buffer zone in >75%, 14 m spray-free buffer zone in >90% and 24 m spray-free buffer zone in >95% spray drift reduction (Zande et al., 2010). For low crop situations and low vegetated buffer zones lower (<20 cm) than the sprayed crop the spray drift reduction is comparable to that of a crop-free buffer zone (RMMTS#1).
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	Establishment and management Based on the UK ELS handbook (Natural England, 2013), the establishment and management guidance is as follows: EF9 Unfertilised cereal headland: This option provides an important food supply for birds, and habitat for arable plants and insects, within any arable field during the cropping year. It will deliver most benefit when sited next to a buffer strip, stubble or area planted for wild bird seed or nectar flower mixtures. Unfertilised cereal headlands can be difficult to manage where grass weeds are a problem, particularly where herbicide resistance is present. If an unexpected weed infestation occurs and becomes unmanageable, select a less weedy location in following years. This is a 'rotational option'. This means that the headlands can move around the farm within the normal arable rotation, but the same total hectarage must be maintained each year. The headlands can also remain in the same place in the field. This will be especially beneficial where scarce arable plants are present. For this option, you must comply with the following: - Do not apply fertilisers or manures to the headland between harvest of the previous crop and resuming normal management. - Sow and manage a 3 m–24 m wide cereal headland along the edge of an arable crop. - Do not apply insecticides between 15 March and the following harvest. - For grass weeds control please refer to Natural England (2013). - Where weed growth threatens harvest, you may use a pre-harvest desiccant, unless you plan to use this area as overwintered stubble.

	- Sow and manage a 3 m–24 m wide cereal headland along the edge of any arable crop, ensuring that any areas of soil compaction are removed prior to establishment, except on archaeological features. An additional option (EF10) which allows leaving the crop unharvested through winter is also available for cereal headlands under Entry Level Stewardship (ELS6). Leaving the crop unharvested can provide additional benefits for biodiversity for birds and annual weeds and invertebrates due to the extended undisturbed period and potentially supply food resources in winter similar to sown Wild Bird Seed mix (WBS). EF10 Unharvested cereal headlands for birds and rare arable plants: This option provides a year-round food supply for birds, and habitat for arable plants and insects, within any arable field over two cropping years. It will deliver most benefit when sited next to a buffer strip, stubble or area managed for wild bird seed or nectar flower mixtures. Unharvested cereal headlands can be difficult to manage where grass weeds are a problem, particularly where herbicide resistance is present. If an unexpected weed infestation occurs and becomes unmanageable, select a less weedy location in following years. This is a 'rotational option'. This means that the headlands can move around the farm within the normal arable rotation, but the same total hectarage must be maintained each year. The headlands can also remain in the same place in the field. This will be especially beneficial where scarce arable plants are present. For this option, you must comply with the following: - Do not apply fertilisers or manures to the headland between harvest of the previous crop and resuming normal management. - You can sow the headland in either autumn or spring (do not leave as bare ground over the winter) and leave it unharvested until the following spring (1 March), before resuming normal management. - Sow and manage a 3 m–24 m wide cereal headland along the edge of any arable crop, ensuring that any areas of soil compaction are removed prior to establishment, except on archaeological features. - Sow a cereal or cereal mixture at a reduced seed rate, to encourage a more open headland structure. On more difficult or weedy sites, conventional seed rates can be used. - Do not apply insecticides between 15 March and the following harvest. - For details on the herbicides that may be applied please refer to Natural England (2013).
Constraints	Conservation headlands involve limiting or complete restriction of insecticide and herbicide as well as manure and fertilizer inputs to a specified width of crop edge. This is generally used to allow broad leaved weeds and associated insects to survive in cereal crop edges (Marshall, 1998). As an option this is favourable as it does not fully remove the land from production and direct income from the crop can still be earned. For unharvested headlands (EF10) this advantage does not apply, however, this option can greatly enhance the benefit of a conservation headland option for biodiversity. It is a highly

	favourable option for rare annual arable plants which may not be promoted under long term margins (Marshall, 1998). Use of conservation headlands in combination with other field margin features is likely to enhance both features as buffering of off-field areas is increased. This also results in increased greater diversity of management methods being used.
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	The implementation of natural regeneration areas is country specific. It may be driven by the risk assessment where the implementation of vegetated field margins is recommended as a risk mitigation measure accompanying a product as well as generically in the context of the implementation of the CAP. Natural regeneration areas are part of perennial risk mitigation measures the benefits of which increase with time, thus they should be considered generically independently of the nature of the products used in the farmland. Their benefits may be multiplied if they take into account recommendations relative to other types of field margins so please also consult RMMTS #3 to 9 in this chapter. Their benefits are further reinforced when implemented at a larger scale. Additional recommendations are provided in section 6 of this chapter, in appendix 6 as well as in the associated references relative to practical aspects.

RMMTS #9 Uncropped cultivated margins for rare plants	
Description	These margins provide beneficial management for rare arable plants, insects and foraging sites for seed-eating birds. It is better to avoid locating these margins where there is a grass weed problem. Where runoff is a problem, a grass buffer should be considered. The option will provide greatest benefits on sandy, shallow, chalky or stony soils.
Beneficial for[9]	Birds (3 on summer and winter seeds, plants and food, 3 on invertebrate food); Mammals (3 on abundance and diversity); Pollinators (2 on food resources, species richness abundance and 0 on hibernation sites); Non-target arthropods (1 on parasitic wasps, 2 on spiders, 2 on beetles, 1 on soil invertebrates); Plants (3 on annual weeds and 1 on perennial flowers, 3 overall); Aquatic organisms (1 on invertebrates and plants); Pest management (1 on invertebrates, 2 on weeds); Runoff (1 on pesticides, sediment, phosphorus and 2 on nitrogen); Spray drift (2 on pesticides); Soil (1 on soil erosion)
Negative effects on	None reported
Estimated risk reduction potential	These margins provide habitat for some plant species, insects and birds. They may provide a drift reduction function of the width and height of the buffer; check the data provided by Jan; as regards runoff, the yearly establishment and open character of this buffer will not lead to significant runoff mitigation in comparison with normal cropped areas. In the case they are perennially

	established, see natural regeneration strips.
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	Establishment and management Based on the UK ELS handbook (Natural England, 2013), the establishment and management guidance is as follows: <u>EF11 Uncropped cultivated margins for rare plants:</u> These margins will provide beneficial management for rare arable plants, insects and foraging sites for seed-eating birds. It is better to avoid locating these margins where you have a grass weed problem. Where runoff is a problem, a grass buffer should be considered. The option will provide greatest benefits on sandy, shallow, chalky or stony soils. For this option, you must comply with the following: - Cultivate an arable field margin annually in either spring or autumn to a depth of about 15 cm (6 inches). - Varying the depth and time of cultivation may help prevent the build-up of undesirable weeds, but should always be managed according to the requirements of the target species. - Margins should be 3 m–6 m wide. They can be relocated within the same field to avoid the build-up of pernicious weeds.
Constraints	Uncropped annual cultivation is likely to be favourable as an option due to low inputs required and ease with which these margins can be incorporated into existing field management operations. Uptake is likely to be lower where problem weeds are already present in existing boundaries and the field crop.
Further recommendations with regards to an implementation in risk management/decision making and with regards to risk assessment	The implementation of natural regeneration areas is country specific. It may be driven by the risk assessment where the implementation of vegetated field margins is recommended as a risk mitigation measure accompanying a product as well as generically in the context of the implementation of the CAP. Natural regeneration areas are part of perennial risk mitigation measures the benefits of which increase with time, thus they should be considered generically independently of the nature of the products used in the farmland. Their benefits may be multiplied if they take into account recommendations relative to other types of field margins so please also consult RMMTS #3 to 9 in this chapter. Their benefits are further reinforced when implemented at a larger scale. Additional recommendations are provided in section 6 of this chapter as well as in the associated references relative to practical aspects.

1.1.4 Landscape-dependant buffer zones (RMMTS #10)

RMMTS # 10 – landscape-dependant buffer zones	
Description	The German approach 'Index of regional proportions of ecotones (IRPE)' serves as example for landscape-dependant buffer zones. The GIS-based inventory IRPE helps to access, if agricultural landscapes are sufficiently equipped with off-field areas to compensate for effects of

	pesticides to non-target arthropods and plants. Since 2002 the IRPE is used in Germany as a prerequisite for risk mitigation measurements (SDRT and/or no-spray buffer zones). Buffer zones are adjusted for regional differences according the amount of off-crop habitats and agricultural intensity. The GIS-based inventory classifies municipalities according to inventory of natural (NH) and semi-natural habitats (SNH) of open farmland. Only habitats, that that may house the same species or provide the same benefits as managed field margins are considered as NH and SNH in the IRPE context (e.g. forest, grassland >1 ha are excluded). The approach is based on the ecological concepts of recovery and recolonisation. The requirement for risk mitigation depends on the provision of an adequate amount of SNH in a specific agricultural landscape. This shall also ensure that farmers in small structured landscapes are not undue handicapped compared to farmers in areas with little structures in the agricultural landscape. For several reasons the system is under revision and will have to be adjusted in near future. One of the reasons is to discuss the integration of the new protection goal 'biodiversity' (see chapter Biodiversity5). For details on the technical implementation of the GIS database see Enzian and Gutsche (2004), Golla et al. (2003) and Gutsche and Enzian (2002).
Beneficial for	The measure is beneficial to off-field non-target organisms and biodiversity. RMM are focused on landscapes which are not sufficiently equipped with off-field areas to compensate for in-field effects and to safeguard biodiversity (i.e. landscapes with intensive cropping systems).
Negative effects on	None reported
Estimated risk reduction potential	Up to 90%
Implementation and management	The technical implementation of such a GIS based inventory require the availability of reliable geodata, in order to - at least quantify (better also qualify) – the amount of natural and semi-natural habitats (NH and SNH) in a given landscape. If data is available the implementation of such an inventory is feasible. More difficult is to define the proportion of the landscape, which is needed to compensate for negative effects. The acceptance and feasibility of such definitions is best to be assisted by a technical and scientific board. The result needs to be published in a proper way, which is easy accessed and understood by farmers and extension services. Giving the users (farmers/municipalities etc) the opportunity to provide more detailed/additional data on SNH is a plus for the acceptance of such an approach.
Constraints	Requires the (GIS-based) mapping of agricultural landscapes.
Further recommendations with regards to an implementation in risk management/decision	This tool relies on quantitative data and allows putting the risk assessment conclusions in perspective based on an accurate description of the landscape composition (proportion of habitats). In nature this tool is at the edge between risk assessment and risk management and provides options for decision making.

making and with regards to risk assessment	It is linked with labelling and tools to communicate/train farmers (web-based register/web map).

1.1.5 RMMTS # 11 – Drift reducing spray nozzles

RMMTS # 11 – Drift reducing spray nozzles	
Description	Instead of standard nozzle types (like flat fan nozzles of types XR, LU, etc.) nozzles a spray quality to reduce spray drift. Efficacy is benchmarked against reference nozzle (standard flatfan nozzles with defined pressures and flow rates). Special nozzle type the drift vulnerable fraction of drops smaller than 100 µm in the spray fan (like nozz AVI, etc.) maintaining similar flow rates as standard nozzle types. The drift reducing spray pressure dependent and can be classified in drift reducing classes (e.g. 50%, 7
Beneficial for	Spray drift reduction
Negative effects on	Negative effects are suggestedd on biological efficacy of the PPP, however little evic s known to have a small decrease effect (less than 25%) when spraying herbicides w small weeds (cotyledon stage - Low Dose System weed control; spraying at first leav was gone) and spraying fungicides on onions (can be compensated adding a sticker
Estimated risk reduction potential	For drift: up to more than 95% drift reduction
Implementation and management	The implementation of spray drift reduction nozzles is best combined with the widt buffer zones. This leads to exchangeability of technical measures that cost money (l yield (sellable product, income). The best way to implement therefore is to classify spray drift reduction following the ISO22369 standard (25%, 50%, 75%, 90%, 95%, 9 to a reference nozzle. In general the reference nozzle is as specified in ISO22866 (FF threshold nozzle or equivalent). Drift reduction of nozzles can be measured by mea (ISO22866), wind tunnel measurements (ISO22856) or drop size measurements (ISC spray drift modelling. Examples of classified spray drift reducing nozzles are present website, the UK LERAP site and the NL helpdeskwater site.
Constraints	There is a need for protocols to measure drift reducing effect of spray nozzles, a cer the presented reports for following the protocol and evaluation of the outcome anc to publish and maintain the list of drift reducing nozzle – pressure combinations in c A constraint on drift reducing effect of spray nozzles is that it is strongly related to t means also that for the use in the correct drift reducing class the spray pressure is ii therefore be controllable and recorded/logged in spray computer or with spray pre (manometer). Differences in reference standards for nozzle effectiveness testing may create differ response; consequently the spray drift reduction classes may not be read as being e reduction classifications.
Recommendations on implementation	It is recommended to link classes of increasing drift reducing nozzle types with step buffer zones. Controllability depends on logged/recorded spray pressures during application.

	Further details may be found in Ganzelmeier and Rautmann (2000), Southcombe et (2004), Van de Zande et al. (2000, 2005, 2014 a& 2014b). Lists of drift reducing nozzles may be found on the following links: German list with drift reducing spray equipment: http://www.jki.bund.de/no_cache/de/startseite/institute/anwendungstechnik/gera pflanzenschutzgeraete.html NL list with drift reducing nozzles: http://www.helpdeskwater.nl/onderwerpen/emi veeteelt/open-teelt/driftarme-doppen/@3575/lijst-driftarme/ UK list with drift reducing nozzles: https://secure.pesticides.gov.uk/SprayEquipmen

1.1.6 RMMTS # 12 – Special equipment to reduce spray drift

RMMTS # 12 – Special equipment to reduce spray drift	
Description	Spray drift reduction can not only be achieved with drift reducing nozzle types but also with special equipment. Boom sprayers can be equipped with air assistance, shielding, low boom height (control devices, Släpduk, Wings sprayer), tunnels, band sprayers etc. including the additional effect of drift reducing nozzles on this special equipment and can be classified in drift reducing classes (e.g. 50%, 75%, 90%, 95%, 99%) relative to reference spray equipment. Other systems may also be relevant here such as tree and bush sprayers equipped with cross systems, radial fans, sensor sprayers for detection of green foliage etc.)
Beneficial for	Spray drift reduction
Negative effects on	No negative effects are known.
Estimated risk reduction potential	For drift: up to more than 99% drift reduction
Implementation and management	The implementation of special drift reducing equipment is best combined with the width of spray free or crop-free buffer zones. This leads to exchangeability of technical measures that cost money (buy new spray equipment) and crop yield (sellable product, income). Best way to implement therefore is to classify the special drift reducing equipment in classes of spray drift reduction following the ISO22369 standard (25%, 50%, 75%, 90%, 95%, 99% drift reduction) relative to a defined reference sprayer (ISO22369-2). In general the reference boom sprayer is defined as specified in ISO22866 (boom sprayer with a boom height of 50 cm above crop canopy or soil surface, a flat fan nozzle FF110/1.2/3.0; the BCPC F/M threshold nozzle or equivalent, and a driving speed of 6-8 km/h). Drift reduction of special drift reducing equipment can be measured by means of field measurements (ISO22866). Examples of classified spray drift reducing equipment are presented on the German JKI website and the NL helpdeskwater site.
Constraints	There is a need for protocols to measure drift reducing effect of special drift reducing spray equipment, a certification body to evaluate the presented reports for following the protocol and evaluation of the outcome and an official publication body to publish and maintain the list of drift reducing equipment in

	classes.
Recommendations on implementation	It is recommended to link classes of increasing drift reducing spray equipment with steps in decreasing width of buffer zones. Controllability depends on sprayer settings during application (e.g. amount of air assistance, boom height, etc.. Further information may be found in Wenneker and van de Zande (2008) and Wenneker et al. (2014). Further advice can be found via TOPPs to support a drift risk analysis before spraying in vulnerable areas (www.TOPPS-drift.org).

1.1.7 RMMTS # 13 – Precision treatment

RMMTS # 13 – Precision treatment	
Description	Global Positioning System (GPS) supported spraying technology is part of precision agriculture (PA) and is generally known to manage inter field variability in crops. During the second MAgPIE workshop an additional aspect to this technology was identified, which makes it interesting as a future tool for a safer application of pesticides to protect non-target areas – in and off-field. As an example from Germany the research and development project "Pesticide Application Manager (PAM) -Decision support in crop protection based on terrain-, machine-, business - and public data" develops such an approach. The project consortium develops tools to automate and optimize the processes for planning, implementing and documenting pesticide application. The overall aim is to make pesticide application less error-prone. Key parts of the project are: *1. Solutions for a practical mapping of sensitive landscape areas* The process starts with the mapping of sensitive landscape areas adjacent to the field. The project promotes a GPS-RTK based approach. It allows the farmer to map the applicable landscape elements during a tractor ride using an off-set method. *2. Develop a web service to automatically generate machine-readable application maps that include legal buffer zones* In the scope of the PAM-project different web services are being developed. One example is a tool that automatically creates machine-readable application maps using the non-proprietary ISO-XML format. These application maps include legal buffer zones depending on pesticide and application unit. Databases from different public institutions in Germany are included to access the necessary information. *3. Develop an electronic system to read bar-code-labels of crop protection product (CPP) containers and connect to different public and private databases to get related information* Information about crop protection products is mostly only readable by humans. An example is labels on CPP-containers. This poses the risk, that information is not considered at all or not in the right way. Manual transfer into Farm Management Information Systems (FMIS) can also be error-prone. Using electronically readable crop protection product information helps users to avoid errors and make sure all relevant information is being considered. In the PAM-project a system for

	electronically readable bar-code-labels is being developed in cooperation with the chemical industry and agricultural engineering businesses. By connecting different private and public databases product specific information is being made accessible on site. Examples are: Information about miscibility of different crop protection products or information about legal regulations (e.g. legal no-spray zones). Open interfaces are being developed to include these services in Farm Management Information Systems (FMIS) and to automate spraying. *4. Documentation* Landscape sensitivity maps and application maps together with Differential Global Positioning System (DGPS) track recordings support the farmer's business management processes such as documentation and reporting commitments to supervisory authorities or customers.
Beneficial for	Spray drift reduction
Negative effects on	No negative effects are foreseen.
Estimated risk reduction potential	For drift up to 99% drift reduction possible
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	Implementation requires field mapping of pest occurrences or off- and in- field vulnerabilities translated into GPS format as input to in-cab GPS connected to spray machinery to ensure delivery of product to desired targets. This strategy requires investment in GPS devices and associated linkage with machinery and a degree of technical sophistication to support IT requirements. This strategy allows for flexible product delivery crop-by-crop, season-by-season in response to pest pressures and considering non target areas with a number of significant advantages to farmers/applicators (more direct record keeping, no further direct investment or specific maintenance of GPS equipment is needed beyond occasional IT upgrades, reduced product use and expense etc…).
Constraints	Primary constraints surrounding uptake by farmers are expense related to the equipment, technical sophistication and equipment compatibility. No field constraints are envisaged. Efficacy as a drift reduction strategy will be variable dependent upon degree of pest pressure, location of pest pressure relative to edge of field, off- and in- field non target areas and equipment used to support application (e.g. choice of nozzle etc.)
Recommendations on implementation	While precision application can potentially allow for a relatively high degree of customization of application to reflect occurrence of pest pressures and thereby reduce the overall quantity of product applied, the impact in terms of risk reduction may be variable in practice as pest density-dependent. Furthermore, if implemented within a drift reduction strategy this tool would require a high degree of compliance and awareness by farmers/applicators to adapt to local conditions whilst achieving joint objectives of pest and drift management. Recent technological developments implemented in research projects aim at automatically assisting the farmers/applicators in this respect. It is recommended that with increased take up of precision spraying by farmers further support for a role within drift mitigation strategies should be investigated to support clear, effective and reliable implementation for this purpose.

1.1.8 Application on patch / avoidance of ecological hot spots (RMMTS # 14)

The following technical sheet summarises the advantages, limitations, and conditions of applicability of the mitigation measure #14: “Applications on patch / avoidance of ecological hot spots (nesting sites, burrows)”.

RMMTS #14 - Applications on patch / avoidance of ecological hot spots (nesting sites, burrows)	
Description	In order to reduce bird exposure during breeding period, application of PPP can be limited to patches in field. It should be noted that patch spraying is only relevant to herbicide application, as weeds are non-mobile and so can be mapped. Plants in fields can occur in patches, as a result of soil variation, unintended spatially variable applications in the past, other previous non-uniform agricultural operations and general variability in plant distributions. Patch spraying provides an opportunity for two contrasting biodiversity enhancing approaches. If fields contain discrete patches of noxious unwanted species, the technology can be used to focus application to these patches. Spatially selective weed management has considerable potential for allowing managing populations of species to be protected to achieve a balance between production and conservation objectives. The main barriers to wider uptake at present are the capital costs of the equipment and the time involved in producing weed maps. Weeds for which treatments are required should grow large enough to be readily identified, without prejudicing control if required, and allow for producing maps. The use of spatially explicit methods may also be used for selectively restricting spaying in ecological hotspots such as nesting sites, especially for sensitive species.
Beneficial for	Birds
Negative effects	Possible reduced pest control at untreated spots/sites
Estimated risk reduction potential	Significant reduction of exposure possible, especially for vulnerable life stages (e.g. chicks)
Implementation and management (to be adapted in zone / EU MS)	On member state/local level, often restricted to specific areas, regions and crops
Constraints	Needs detailed knowledge of species and their ecology/distribution
Recommendations on implementation	Collaboration with competent institutions (e.g. RSPB in the UK) necessary

Recommendations on monitoring	Monitoring by competent institutions required

1.1.9 Risk Mitigation Technical Sheet: In-field vegetative filter strips (RMMTS # 15)

RMMTS # 15 - Risk Mitigation Technical Sheet: In-field vegetative filter strips	
Description	• In-field vegetated filter strip (VFS) to infiltrate runoff water and reduce erosion
Beneficial for	• Infiltrates runoff water and catches sediments • Overall reduction of erosion in a landscape • Reduction of losses of PPP and nutrients to surface water • Increasing biodiversity in agricultural landscapes by providing non-cropped habitats
Negative effects	• Basically it reduces the field size with negative effects on economic land management; Farmer may perceive VFS as a loss of land for production
Estimated risk reduction potential	• In field VFSs have a high level of efficacy as they are located near the runoff source. • Compared with riparian VFSs their water infiltration capacity is generally higher (not directly influenced by water body) • VFS size and location is critical for their efficacy. (Test Le Boug Dun FR showed for 3 m buffer a 81% reduction of erosion out of wheat / 6 m buffer showed a 98% reduction)
Implementation and management (to be adapted in zone / EU MS)	• Non treated, perennial grassed zone in a cultivated field, in a position to intercept runoff • Plant local and adapted species that should exhibit stiff leaves / stems in order to resist water flow • Position VFSs across the steepest part of slope or in mid-field. • Do not fertilize or spray buffer zones • Do not create short-cuts for water through the VFS • Maintain VFS (mowing once or twice per year necessary for grass buffer; grass should not be higher than 25 cm) • Avoid driving on the VFS, avoid soil compaction

	• If sediments accumulate, spread sediments across the VFS.
Constraints	• Acceptance of infield VFSs by farmers may be low due to working operations. VFSs require additional maintenance work and are often seen by farmers as a loss of their land.
Recommendations on implementation	• VFSs should be positioned/sized after a catchment and field audit (see TOPPS). • Infield VFSs (near runoff source) are generally more efficient than riparian VFSs (higher probability of high soil moisture). • Combination between different VFSs (in-field + riparian) will be more efficient and will require less land area.
Recommendations on monitoring	• Efficacy of runoff reduction needs to be monitored regularly and VFSs need to be maintained for optimum long-term efficacy.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.1.10 Risk Mitigation Technical Sheet: Vegetative filter strips in talwegs (in-field) (RMMTS #16)

RMMTS#16 -Risk Mitigation Technical Sheet: Vegetative filter strips in talwegs (in-field)	
Description	• Vegetated filter strips (VFSs) located in talweg position on slope, typically within a field (talweg: linear form, where two slopes come together to form a potential water pathway in fields).
Beneficial for	• Infiltrates runoff water and catches sediments • Overall reduction of erosion in a landscape (talwegs are often starting points for heavy rill / gully erosion) • Reduction of losses of PPP and nutrients to surface water • Increasing biodiversity in agricultural landscapes by providing non-cropped habitats
Negative effects	• Basically it reduces the field size with negative effects on economic land management; Farmer may perceive VFSs as a loss of land for production • Field parts to be cultivated have uneven shapes.

Estimated risk reduction potential	• Talweg VFSs have a high level of efficacy as they are located where runoff/erosion starts. • Compared with other VFSs their water infiltration capacity is generally higher (not directly influenced by water body). • VFS size and location is critical for their efficacy; effectiveness is judged to be ≥70% for 25 m long VFS (Reichenberger et al., 2007).
Implementation and management (to be adapted in zone / EU MS)	• Plant local and adapted species that should exhibit stiff leaves / stems in order to resist water flow • Do not fertilize or spray VFSs • Avoid driving on the VFS, avoid soil compaction • Do not create short-cuts for water through the VFS • If sediments accumulate, spread sediments across the VFS. • Maintain VFS (mowing once or twice per year necessary for grass buffer; grass should not be higher than 25 cm) • If appropriate, use a catchment audit to position VFSs and determine optimum size per field
Constraints	• Acceptance of talweg VFSs by farmers may be low due to less optimal working operations. • VFSs require additional maintenance work and are often seen by farmers as a loss of their land.
Recommendations on implementation	• Talweg VFSs should be positioned/sized after a catchment and field audit. • See also basic edge-of-field VFS advice • Talweg VFSs are generally more efficient (less water saturation) as riparian VFSs. A combination of infield + riparian VFSs will be more efficient and will require less land area.
Recommendations on monitoring	• VFS needs to be monitored and maintained regularly to achieve optimum long-term efficacy.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org) • Reichenberger et al., 2007

1.1.11 Risk Mitigation Technical Sheet: restriction of the number of

applications (RMMTS # 17)

Name	Restriction of the maximum number of applications per year or Restriction to use the product with a maximum number of applications (maximum dose rate) only within a 2-year or 3-year time period
Description	The product is allowed to be used only for a maximum number of applications per year or The product is restricted to be used with a maximum number of applications (corresponding to a maximum dose rate) within a 2-year or 3-year time period
Beneficial for	Groundwater but also for other areas (e.g. aquatic organisms, soil organisms)
Negative effects on	None foreseen
Estimated risk reduction potential	High
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	To be implemented on the label (SPe 1)
Constraints	Needs to be supported with efficacy data
Recommendations on implementation	Part of the approved use of the product
Recommendations on monitoring	The effectiveness of the measure may be assessed via dedicated monitoring.

1.1.12 Risk Mitigation Technical Sheet: restriction of use to certain time of the year (RMMTS # 18)

Name	Restriction to use the product only at a certain time of the year
Description	The product is allowed to be used only during a certain time period (e.g from May to August) or the use under certain conditions or the use within certain seasons or months are excluded (no autumn use, no use from 1 November to 31 March)
Beneficial for	Groundwater

	but also for other areas (e.g. aquatic organisms via drainage pathway)
Negative effects on	None foreseen
Estimated risk reduction potential	Variable (can be estimated using regulatory-approved models and procedures)
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	To be implemented on the label (SPe 1)
Constraints	Use limitation of products, exclusion of certain uses
Recommendations on implementation	Part of the approved use of the product
Recommendations on monitoring	The effectiveness of the measure may be assessed via dedicated monitoring.

1.1.13 Risk Mitigation Technical Sheet: restriction of use as a function of soil type (RMMTS # 19)

Name	Restriction of application for certain soil types or soil properties
Description	The product is not be used for certain soil types respectively on soils with certain properties (pH, org. C, texture)
Beneficial for	Groundwater but also: Drainage (aquatic organisms)
Negative effects on	Non foreseen
Estimated risk reduction potential	Variable (can be estimated using regulatory-approved models and procedures)
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	To be implemented on the label (SPe 2)
Constraints	Product cannot be used under certain conditions
Recommendations on implementation	i.e. link with labelling and tools to communicate/train farmers
Recommendations on monitoring	The effectiveness of the measure may be assessed via dedicated monitoring.

1.1.14 Risk Mitigation Technical Sheet: restriction of use to specific crop

growth stages (RMMTS # 20)

Name	Restriction to use the product only at certain growth stage of crop
Description	The product is allowed to be used only from certain growth stages onwards (e.g. post-emergence > BBCH 20)
Beneficial for	Groundwater but also for other areas (e.g. aquatic organisms)
Negative effects on	Implications regarding risks for areas like bird/mammals or NTAs
Estimated risk reduction potential	Variable (can be estimated using regulatory-approved models and procedures)
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	To be implemented on the label
Constraints	Use limitation of products, exclusion of certain uses
Recommendations on implementation	Part of the approved use of the product
Recommendations on monitoring	The effectiveness of the measure may be assessed via dedicated monitoring.

1.1.15 Risk Mitigation Technical Sheet: band applications (RMMTS # 21)

Name	Band applications
Description	Apply the products only in bands (rows), e.g. in orchards and vineyards
Beneficial for	Groundwater but also others (e.g. surface water by drainage entry pathway)
Negative effects on	None foreseen
Estimated risk reduction potential	High
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	To be implemented on the label
Constraints	Only applicable under certain agricultural conditions (mainly

	orchards)
Recommendations on implementation	Part of the approved use of the product
Recommendations on monitoring	The effectiveness of the measure may be assessed via dedicated monitoring.

1.1.16 Risk Mitigation Technical Sheet: cover crops (RMMTS # 22)

Name	Cover crops
Description	Crop cover to reduce periods of fallow land – especially during winter.
Beneficial for[10]	Reduction of Nitrogen leaching (2). Reduction of erosion (both, via water and via wind) and run-off (2 on pesticides, sediment, phosphorus and nitrogen; impact of run-off and erosion for pesticides is variable due to substance properties. Soil organic carbon (1-2). Soil structure (1).
Negative effects	Availability of water for the cash crop may be negatively affected; this effect is expected to be regionally highly diverse since it depends on the general availability or scarceness of water. Availability of nutrients for the cash crop could be negatively affected – highly depending on the cover crop type and the agricultural management. Total pesticide loading on a site might be increased if the cover crops themselves are treated with additional pesticides. Potential allelopathic effects might have negative impact on the cash crop. Potential that cover crop serves as a host for pests.
Estimated risk reduction potential	Variable and most likely dependent on substance properties as well as on the geographical and agronomical scenario. The possibility to determine the efficacy of this measure using regulatory-approved procedures and models needs further investigation.
Implementation and management	Cover crops should be implemented using the agricultural advisory system to weigh the clear benefits against potential negative effects and to discuss strategies to reduce/avoid negative impact.
Constraints	Additional management measures lead to additional costs reducing farmers added value in the short run; it is noted that the beneficial effects may overrule a temporary reduction of added value in the long run since soil fertility can be improved, nitrogen fertilisation may be reduced and soil loss by erosion is reduced when a more sustainable cropping system is introduced; furthermore, subsidies may compensate for reduced added value.
Recommendations on implementation	Cover crops could play a role in the PPP authorisation process at member state level. However, as discussed in much detail in chapter 7.4.1 a more detailed investigation of their benefits regarding leaching is required before they can be generally recommended.
Recommendations on monitoring	The effectiveness of the measure may be assessed via dedicated monitoring.

1.1.17 Risk Mitigation Technical Sheet: exclusion areas (RMMTS # 23)

Name	Exclude the application of product under certain conditions
Description (brief)	a) Exclude the application under certain geohydrological conditions (e.g. carstic areas) b) Exclude the application in drinking water abstraction areas
Beneficial for	Groundwater
Negative effects on	None foreseen
Estimated risk reduction potential	High, however c) only reduces risk to drinking water and is not applicable to general groundwater protection.
Implementation and management () here we give practical recommendations that are meant to be adapted in MS / Zone	To be implemented on the label (SPe 2) Exclusion from specific areas (such as carstic areas) can be relatively easily implemented and the exclusion from drinking water abstraction areas should not pose any major practical issues.
Constraints	
Recommendations on implementation	Part of the approved use of the product
Recommendations on monitoring	The effectiveness of the measure may be assessed via dedicated monitoring.

1.1.18 Risk Mitigation Technical Sheet: Exclusion of application based on vulnerability maps (RMMTS # 24)

Name	Exclusion of application based on vulnerability maps
Description	Identification of areas where the groundwater is vulnerable to contamination of plant protection products
Beneficial for	Groundwater But also drainage
Negative effects on	None foreseen
Estimated risk reduction potential	high
Implementation and management () here we give practical recommendations that are meant to be adapted in MS	- Agreement on GIS data and vulnerability-mapping approaches - Differentiation between generic and compound specific vulnerability maps

/ Zone	- Where sufficiently detailed (regional, catchment scale) GIS data is not available, EU scale data should be used as guidance until appropriate data are available
Constraints	Product cannot be used under certain conditions
Recommendations on implementation	Vulnerability mapping may be only the first step in the definition of vulnerable areas. A further refinement could be the detailed analysis of the hydrogeology of areas defined as vulnerable (e.g. the absence of unconfined aquifers may mitigate the problem).
Recommendations on monitoring	Vulnerability mapping should be part of the decision making for the location of groundwater monitoring wells but should be used in conjunction with other information (geology, hydro-geology, detailed land use)

1.2 Risk Mitigation Measure Technical Advice Sheets (RMMTAS)

1.2.1 Technical advice sheet: Edge-of-field (incl. riparian) vegetative filter strips

RMMTA#1 - Edge-of-field (incl. riparian) vegetative filter strips	
Description	• Edge-of-field vegetated filter strip (perennial grass, shrubs, trees) located at the downslope edge of fields to infiltrate runoff water and stop erosion
Beneficial for	• Infiltrates runoff water and catches sediments • Overall reduction of erosion in a landscape • Reduction of losses of PPP and nutrients to surface water • Increasing biodiversity in agricultural landscapes by providing non-cropped habitats • Riparian VFSs: stream bank protection, ecosystem enrichment and connectivity. • Edge-of-field VFSs also provide a safety buffer to adjacent ecosystems/protected areas (e.g. reducing spray drift)
Negative effects	• Basically it reduces the field size with negative effects on economic land management; Farmer may perceive VFSs as a land loss for production
Estimated risk reduction	• Efficacy of VFSs can vary according to soil properties (texture, structure),

potential	actual soil moisture, incoming amount of water, VFS width, maintenance of VFSs, etc. Literature data indicates efficacy of VFSs between close to zero and 100% for runoff reduction, with average values mostly in the range from 50 to 90%.
Implementation and management	• Non treated zone with perennial vegetation (e.g. grass) at the downslope edge of a cultivated field • Plant local and adapted species that should exhibit stiff leaves / stems in order to resist water flow; establish permanently. • Do not fertilize or spray VFS zones • Do not create short-cuts for water through the VFS • Maintain VFS (mowing once or twice per year necessary for grass buffer; grass should not be higher than 25 cm) • Avoid driving on the VFS, avoid soil compaction • If sediments accumulate, spread sediments across the VFS. • Do not establish VFSs in locations with shallow groundwater (<1 m below soil surface), as this will strongly reduce efficacy
Constraints	• VFSs require additional maintenance work and are often seen by farmers as a loss of their land.
Recommendations on implementation	• If appropriate, use a catchment audit to position VFSs properly and determine an optimum width for each field. • Infield VFSs (near runoff source) are generally more efficient than riparian VFSs (higher water saturation). • Combination of different VFSs (in-field + riparian) will be more efficient and will require less land area.
Recommendations on monitoring	• Runoff reduction efficacy needs to be monitored regularly and VFSs need to be maintained for optimum long-term performance.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org>) • Reichenberger et al., 2007

1.2.2 Technical advice sheet: Artificial wetlands / retention ponds

RMMTA#2 - Artificial wetlands / retention ponds

Description	• Artificial wetlands / retention ponds are established along the pathway of storm runoff from fields, slowing down, infiltrating, and retaining runoff water, thereby also retaining and degrading pesticide residues.
Beneficial for	• Retains and evapotranspirates/infiltrates runoff water in agricultural catchments, reducing storm runoff peaks and local flooding incidents • Can also be used to retain drainage water • Sediments and pollutants are retained • Organic pollutants are degraded and fertilizer immobilized, if retention time is sufficient • Potential new habitat contributing to biodiversity
Negative effects	• Wetlands / ponds use up agricultural land.
Estimated risk reduction potential	• Wetlands are effective to retain sediments and runoff water and to mitigate water pollution with pesticides. Mitigation effect for pesticides depends on substance properties and varies typically between 50 and 90%. • Maintaining dense vegetation in the ponds (as well as vegetation residues) enhances the retention of pesticides.
Implementation and management	• Position wetland/pond properly to capture all runoff water • Size wetlands adapted to expected runoff: • Volume: Ratio of artificial wetland/contributory watershed area in a range of 0.4 to 1 % (ideally 2 to 5 mm runoff from contributing area; 1 mm = 10 m^3/ha) • Depth: when full, water depth in the range of 0.2 to 1 m with an average of 0.5 m (using a weir to regulate max depth) • Length: maximize water flow pathway in wetland/pond • If appropriate limit/control water exchange between artificial wetland /pond and groundwater (e.g. using a clay layer as basis) • Vegetation in the retention structure increases sedimentation and pesticide degradation: the seeding of local plant species (non-invasive), which are resilient to irregular flooding and drought, should be preferred • Remove sediments regularly to maintain water storage capacity (e.g. every 1 to 3 years)
Constraints	• Legal status of wetlands/pond must be clarified: if it provides a habitat for

	protected species, it may fall under legislative protection, preventing its further use for runoff mitigation • Organisation to construct wetlands/ponds requires in most cases higher investments and/or participation of a group of farmers, if several fields contribute to runoff generation (more complex engagement process).
Recommendations on implementation	• If water cannot be kept in the fields, the implementation of wetlands is a measure to keep the water at least in the upper catchment part
Recommendations on monitoring	• Regular control during runoff events and maintenance is necessary to ensure long-term efficacy.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org) • Reichenberger et al. 2007; Stehle et al. 2011; Gregoire et al. 2009, Vallee et al. 2014

1.2.3 Technical advice sheet: Vegetated Ditch

RMMTA#3 - Vegetated Ditch	
Description	• Vegetated ditches are established at the downslope edge of the field (or off-field) to capture runoff; besides infiltration and evapotranspiration of runoff water, also degradation and sorption of pesticide residues occurs.
Beneficial for	• Retains and evapotranspirates/infiltrates runoff water in agricultural catchments • Sediments and pollutants are retained • Organic pollutants are degraded and fertilizer immobilized, if retention time is sufficient • Potential new habitat for biodiversity
Negative effects	• Vegetated ditches use agricultural land.
Estimated risk reduction potential	• Vegetated ditches have proven effective to retain sediments and runoff water and to mitigate water pollution with pesticides • Mitigation effect for pesticides depends on runoff event and substance properties (typically between 20 and 70%). • Maintaining dense vegetation in the ditches (as well as vegetation residues)

	enhances the retention of pesticides.
Implementation and management	• Position ditches at critical locations in catchments where runoff probabilities are high (between fields, between field and road, between field and surface water) and linear structures are needed • Size ditch adapted to expected runoff: • Volume: The ditch should ideally be able to capture 2 to 3 mm of runoff from the contributing area (1 mm = 10 m^3/ha) • Depth in the range of 0.5 to 1 m, with not too steep banks (escape route for animals) • The ditch should have dead ends, i.e. no connection to water bodies or concentrated flow pathways, or overflow weirs. • Limit quick exchange between ditch and groundwater by coating the ditch surface with topsoil material (loamy and finer, if possible) • Vegetate the ditch banks and bottom using local plant species (non-invasive), which are resilient to irregular flooding • Remove sediments when needed to maintain water storage capacity
Constraints	• Legal status of vegetated ditches must be clarified: if it provides a habitat for protected species, it may fall under legislative protection, preventing its further use for runoff mitigation
Recommendations on implementation	• If water cannot be kept in the field, the implementation of ditches is a measure to stop the water at the field edge or off-field.
Recommendations on monitoring	• Regular control during runoff events and maintenance is necessary to ensure long-term efficacy.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org) • Gregoire et al. 2009; Moore et al. 2008, Vallee et al, 2014

1.2.4 Technical advice sheet: Edge-of-field bunds

RMMTA#4 - Edge-of-field bunds	
Description	• Edge of field bunds are established from soil material as small embankment/dam along the downslope edge of the field.

Beneficial for	• Retains runoff water and facilitates infiltration at field edge. • Retains eroded soil close to field
Negative effects	• If dam breaks due to too much runoff, concentrated flow may be induced at breaking point.
Estimated risk reduction potential	• Measure helps to manage moderate amounts of runoff from fields; efficacy depends on runoff event.
Implementation and management	• Create small dam (30 to 50 cm wide and high) at the downslope edge of the field. • Follow the contour line with the dam to minimize chance for breakthrough of water at lowest point of dam. • Works best with heavier textured soils (dam stability)
Constraints	• Dam may intefere with working of the field
Recommendations on implementation	• To ensure that not too much water needs to be retained, consider also in-field measures to reduce runoff load (e.g. in-field buffer, reduced tillage)
Recommendations on monitoring	• Regular control during runoff events (dam stability and height), as well as maintenance is necessary to ensure long-term efficacy.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org) • CCPF-Ministero della Salute 2009

1.2.5 Technical advice sheet: Reduced tillage intensity (no-till, conservational tillage)

RMMTA#5 - Reduced tillage intensity (no-till, conservational tillage)	
Description	• Reduced tillage intensity increases infiltration capacity for water in soil (improved soil structure and pore system continuity), while reducing the rain-splash erosion and capping of soils by increased crop residues on the soil surface.

Beneficial for	• Increased biodiversity, biological activity and organic matter content in top layer of soil • Less nitrogen mineralization and leaching in soil during winter compared with ploughed soil in autumn • Reduced tillage requires less energy (diesel) consumption than conventional till, thereby improving the CO_2 footprint
Negative effects	• Reduced tillage may need additional weed control and can in general increase the weed pressure • Crop residues on the soil surface can create phytosanitary problems, e. g. increased populations of snails and fungal diseases
Estimated risk reduction potential	• The effectiveness of adapted tillage to mitigate run-off/erosion is high, if the risks are mainly caused by poor soil management (e.g. capping). Reduced tillage can reduce run-off >50% and erosion by >75%. • About 3 to 5 years of minimum tillage or no tillage management can be necessary to reach the full positive effects on soil water; yet, conflicting information on long-term effects of reduced tillage on runoff mitigation exists (Maetens et al. 2012).
Implementation and management	• No-till / reduced tillage requires special soil working and seeding machinery. • Depending on the crop rotation, use of no tillage may not be applied as the only method of soil management. After some years of no-till, it might be necessary to reuse the plough. • Clay soils need a certain amount of light tilling to reduce the amount of soil cracks formed during the summer and to avoid soil compaction. • Fields with an artificial drainage network may need some form of tillage to reduce the preferential water flow through the topsoil to the drains (especially for cracking soils)
Constraints	• No-till / reduced tillage is not compatible with all soil-crop rotation combinations; in some instances, infrequent (e.g. every 3 to 5 yrs) ploughing may be necessary to optimize soil and pest management.
Recommendations on implementation	• Efficacy of no-till / reduced till depends to a large degree on maintaining a good soil surface cover with crop residues (best >30% coverage) • Reduced tillage systems need a few years to develop optimum soil structure, organic matter content and infiltration capacity • Regulations exist in some EU countries to reduce tillage intensity for erosion protection (ploughing only allowed in spring), certain slopes (>10%) make

	reduced tillage obligatory.
Recommendations on monitoring	• Regular monitoring of runoff situation and weed/pest pressure necessary to ensure economic and environmental benefits.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org) • Soane et al. 2012; Maetens et al. 2012

1.2.6 Technical advice sheet: Inter-row Vegetated Filter Strips

RMMTA#6 - Inter-row Vegetated Filter Strips	
Description	• VFSs between rows in perennial plantations (e.g. vine, orchards) minimize runoff and erosion by effective water infiltration and sedimentation of eroded soil particles even on steep slopes
Beneficial for	• Runoff and erosion prevention in perennial crops / plantations • Additional non-cropped habitat
Negative effects	• Competition for water and nutrients may in some situations influence crop yields or quality
Estimated risk reduction potential	• Perennial cover crops can mitigate runoff / erosion on gentle slopes up to 100%. Reduction on steep soils may only reach an effectiveness of ca. 50%.
Implementation and management	• Chose cover crop (e.g. grasses, grasses and clover) according to pedo-climatic conditions. • Mow vegetation regularly to keep erect stems (<25 cm)
Constraints	• Perennial cover crops require regular maintenance (e.g. mowing)
Recommendations on implementation	• In cases where competition for water plays a role, implement cover crops only in every other row, or desiccate grassy vegetation at end of rainy season.
Recommendations on monitoring	• Regular monitoring of runoff situation necessary to ensure efficacy of soil

	cover.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)> • CCPF-Ministero della Salute 2009

1.2.7 Technical advice sheet: In-field bunds (row crops)

RMMTA#7-In-field bunds (row crops)	
Description	• Create bunds in the field (row crops)
Beneficial for	• Reduce runoff by providing space and time for infiltration of water in the field.
Negative effects	• None foreseeen
Estimated risk reduction potential	• Can be substantial in row crops with ridges (e.g. potatoes), based on field evidence (FR, BE) • However, usually this measure is less effective for steep slopes (high water runoff speed and pressure)
Implementation and management	• Inter-ridge bunds are established using special machinery during/after planting • The height and distance of the bunds need to be adapted to the site properties (soil texture, slope, typical rain events).
Constraints	• It might be necessary to invest in special machines / devices
Recommendations on implementation	• Key for measure effectiveness is the correct spacing of the bunds
Recommendations on monitoring	• Bunding is especially useful in row crops (e.g. potato), where rows cannot be oriented across slopes. • Effectiveness of the measure should be regularly monitored after rainfall events (→ spacing of bunds for next season)
References	

	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.8 Technical advice sheet: Crop rotation

RMMTA#8-Crop rotation	
Description	• Optimized crop rotation for improvement of soil properties
Beneficial for	• Reduction of runoff and erosion (crop rotations can have positive impact on soil structure and water holding capacity of soils) • Improved integrated pest management (IPM) • Increased crop (and weed) diversity at landscape level
Negative effects	• Less profitability of farming may occur in the short-term.
Estimated risk reduction potential	• An appropriate crop rotation can minimize the runoff generation substantially in vulnerable seasons/fields (e.g. winter crops)
Implementation and management	• For each field a crop rotation should be implemented that provides maximum soil coverage at critical rainfall periods and in vulnerable situation. • A coordination of crop rotations with neighbours across slopes/the catchment may lead to an alternation of winter and summer crops on slopes, helping to implement strip cropping approaches.
Constraints	• Profitability evaluations for crops.
Recommendations on implementation	• Planning of crop rotations at catchment level should be done together with a runoff catchment audit, to maximize effectiveness. • Row crops should not dominate on sloped land and vulnerable soils. • Alternation of winter and summer crops, as well as row crops and broad seeded crops along slopes.
Recommendations on monitoring	• Runoff monitoring at catchment level is recommended to assess the effectiveness of crop rotations for runoff reduction.

References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.9 Technical advice sheet: Intercrops (annual cover crops)

RMMTA#9- Intercrops (annual cover crops)	
Description	• Intercrops are planted in the time between two commercial crops to cover the soils surface and improve soil properties
Beneficial for	• Reduction of runoff generation and erosion, by reducing rainsplash erosion and reducing the capping/crusting of the soil surface • Increases the crop (and weed) diversity at landscape level • May increase biodiversity
Negative effects	• Additional investment of resources may be needed (time, seeds, gasoline)
Estimated risk reduction potential	• In vulnerable situations, intercrops (e.g. mustard) can reduce erosion by >95% (FR field data)
Implementation and management	• Intercrops can be established by sowing into a ripening crop, or by drilling after harvest (e.g. into the stubbles) • Sowing conditions should allow for a fast and dense establishment • Before the next cropping cycle, intercrops can be desiccated or partly worked into the soil, leaving plant residues on the soil surface to reduce erosion
Constraints	• Intercrop residues may influence a good preparation of the seedbed for the next main crop • Increased pest/disease pressure may be caused for the next crop • Slower drying and warming of soil in spring may delay crop establishment
Recommendations on implementation	• The longer the time for intercrops in fields, the better the effects on runoff reduction
Recommendations on monitoring	• The effectiveness of the measure may be assessed via dedicated monitoring.

References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org) • Reichenberger et al. 2007

1.2.10 Technical advice sheet:Strip cropping

RMMTA#10-Strip cropping	
Description	• Fields with different crops (winter vs. summer; row vs. broadcast) are positioned across the slope, leading to alternating strips of crops along the slope.
Beneficial for	• Reduction of runoff and erosion due to infiltration of runoff water in fields/strips with high-density crops along the slope • Increased crop (and weed) diversity at landscape level
Negative effects	• None foreseen
Estimated risk reduction potential	• Reduction of runoff (diffuse and concentrated) especially for long slopes under cultivation
Implementation and management	• Along slopes a coordinated spatial rotation of crops needs to be achieved: to this aim fields need to be established in strips across the slopes (along the contour lines) and alternating crops need to be established each season. • In case the whole slope belongs to one field, a breaking up of the slope into different fields needs to be considered
Constraints	• In some cases, a repositioning of fields is needed (strips across slopes) • At times, smaller field sizes on long slopes will result.
Recommendations on implementation	• Measure is especially effective for long slopes. • Implementation best coordinated at catchment scale
Recommendations on monitoring	• Effectiveness of strip cropping needs to be evaluated regularly during the seasons.

References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.11 Technical advice sheet:Double sowing (in strips, in talwegs)

RMMTA#11- Double sowing (in strips, in talwegs)	
Description	• Double sowing is done in field areas where diffuse runoff is generated, thereby increasing soil roughness, water evapotranspiration, and root density.
Beneficial for	• Reduced runoff, due to increased infiltration and evapotranspiration of water
Negative effects	• May cause partially reduced yields or harvesting variability
Estimated risk reduction potential	• Suitable for fields where moderated diffuse (→ strips) or concentrated runoff (à talweg) occurs
Implementation and management	• Second sowing process (or double sowing density) in critical field areas (steepest slope, talweg) • Double sown strips should be positioned across the slopes; number and spacing dependent on severity of runoff generation
Constraints	• Crop density variability in field may impact harvesting practices
Recommendations on implementation	• Double sowing may be more attractive to farmers than vegetated in-field / talweg buffer strips; this measure may therefore serve as first attempt for in-field runoff mitigation
Recommendations on monitoring	• Runoff situation should be regularly monitored to assess effectiveness (à spacing, width) of double sown areas
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.12 Technical advice sheet:Enlarged headland

RMMTA#12 - Enlarged headland	
Description	• In headlands, crops are drilled across the main working direction: doubling the working widths in headlands at slope bottoms may therefore infiltrate runoff water generated upslope in the field
Beneficial for	• Reduction of runoff by slowing water flow and increasing water infiltration in headlands
Negative effects	• None foreseen
Estimated risk reduction potential	• In fields where a downslope working direction cannot be avoided (e.g. due to multiple slope angles), enlarged headlands will provide buffer capacity for runoff and trapping of eroded soil. • Risk reduction depends on the shape of the headland (concave slope) and efficacy directly influenced by the width of the headland
Implementation and management	• Easily implemented in daily routine of farmers • Only recommended, if an across slope (contour) working direction is not feasible
Constraints	• Working comfort reduced because tramways are cut by headland
Recommendations on implementation	• To be gathered
Recommendations on monitoring	• Assess runoff mitigation effectiveness during the season to optimize the width of headland (and the sowing density → double sowing).
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.13 Technical advice sheet:Contour tilling

RMMTA#13-Contour tilling	
Description	• Tilling of fields is done along the contour lines, thereby effectively increasing soil surface roughness in the downslope direction

Beneficial for	• Reduction of runoff and erosion, due to increased water infiltration and reduction of water flow speed
Negative effects	• None foreseen
Estimated risk reduction potential	• Significant reduction of runoff (10 to 50%, USDA) possible, especially in combination with other soil management measures (e.g. reduced tillage intensity)
Implementation and management	• In part special machinery needed to follow the contour lines during tilling (e.g. via GPS systems) • Especially useful for low to medium steep slopes; for steeper slopes crawler/caterpillar machinery may be necessary
Constraints	• Contour tilling is not yet well accepted in Europe, probably due to smaller field sizes, limiting the freedom to e.g. resize fields on slopes
Recommendations on implementation	• Contour tillage is recommended on fields with rather uniform slopes between 2 and 10% steepness. Slope length should be between 35 and 120 m.
Recommendations on monitoring	• The effectiveness of the measure may be assessed via dedicated monitoring.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.14 Technical advice sheet:Rough seedbed preparation

RMMTA#14 - Rough seedbed preparation	
Description	• Prepare a rough seedbed
Beneficial for	• Reduced runoff and slow down of runoff water (reduced erosion), due to preparation of a rough seedbed with larger soil clods; this effectively increases the infiltration of water into the soil.

Negative effects	• Potential for reduced yield, if germination of crops impacted too much.
Estimated risk reduction potential	• A rough seedbed reduces runoff at the vulnerable time of vegetation-free soil surface; depending on soil type the tendency for soil crusting is reduced and the overall surface roughness is increased.
Implementation and management	• Using appropriate machinery, a rough seedbed is prepared before seeding, maintaining as many coarse aggregates/clods as possible. • Do not roll over after seed drilling.
Constraints	• Rough seedbeds may have a negative influence on the germination of specific crops.
Recommendations on implementation	• Use of this measure especially recommended for capping (crusting) soils and for summer crops (soil surface with poor vegetation cover at late spring/early summer)
Recommendations on monitoring	• Effectiveness of measure needs to be verified for each field.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.15 Technical advice sheet: Reduced application rate via band spraying

RMMTA#15- Reduced application rate via band spraying	
Description	• Reducing the overall application rate per ha is effectively reducing the potential for runoff and erosion transport of pesticides
Beneficial for	• Reduction of runoff and erosion
Negative effects	• None foreseen
Estimated risk reduction potential	• Proportionate to reduction of overall application rate
Implementation and management	• Special spraying machinery needed (e.g. GPS steered)

	• Band properties dependent on crop type • Herbicides (non-selective) may be applied in between rows • Fungicides/insecticides applications can be focused on rows
Constraints	• Not applicable to broadcast crops
Recommendations on implementation	• To be gathered
Recommendations on monitoring	• The effectiveness of the measure may be assessed via dedicated monitoring.
References	-

1.2.16 Technical advice sheet:Fascines

RMMTA#16-Fascines	
Description	• Across-slope constructions (fascines) are installed to disperse concentrated runoff in existing water flow pathways
Beneficial for	• Reduction of concentrated flow runoff and sedimentation of eroded soil
Negative effects	• Fascines may represent an obstacle to vehicle traffic • Considerable investments and maintenance needed
Estimated risk reduction potential	• Fascines can be highly effective in locations where runoff occurs concentrated and is highly erosive.
Implementation and management	• Typically fascines are constructed from bundles of branches/twigs in the form of a low fence across concentrated flow pathways • Between two rows of low fence posts, bundles of branches/twigs are inserted, ensuring good contact to the underlying soil • Maintenance needs to be done at least every 2 to three years, replacing rotten sections of the fascines
Constraints	

	• Labour intensive measure, mainly useful for hotspot locations with severe erosion problems
Recommendations on implementation	• The fascines can be combined with a mini-dam (30cm high); in general, fascines should be permeable for water (lowering flow rate)
Recommendations on monitoring	• Regular inspection of fascines during/after rain events is necessary to ensure effectiveness and optimize their design and location
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

1.2.17 Technical advice sheet: Tramline management

RMMTA#17- Tramline management	
Description	• Tramlines are oriented across the slope (if feasible) and managed to minimize runoff in them
Beneficial for	• Minimizing concentrated runoff and erosion in fields
Negative effects	• None foreseen
Estimated risk reduction potential	• Optimized tramline management can greatly reduce the runoff and erosion from fields in comparison with downslope tramlines or compacted ones: Reduction of runoff by >80% can be achieved, based on field evidence (AREAS experiments, northern FR)
Implementation and management	• Whenever possible, orient tramlines across the main slope direction • Reduce soil compaction in tramlines by (i) reducing tyre pressure, (ii) avoiding in-field driving at moist soil conditions, (iii) achieving plant coverage or increase surface roughness (e.g. small bunds) by using special machinery
Constraints	• Machinery constraints may limit across-slope positioning • Controlled traffic farming (precision agriculture) may result in fixed tramlines for several years

Recommendations on implementation	• Alternate the tramline positions each season to avoid long-term build-up of compaction in these soil zones
Recommendations on monitoring	• The efficiency of tramline management should be regularly evaluated after heavy rainfall • Runoff water in tramlines can partly be re-infiltrated at the basis of the slope, if the headland (running across the slope) is increased to e.g. two working widths (see measure: Enlarged headland)
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org) • Deasy et al. 2010

1.2.18 Technical advice sheet:Hedges (edge-of-field)

RMMTA#18- Hedges (edge-of-field)	
Description	• Edge-of-field (downslope) and riparian hedges infiltrate runoff water and retain eroded soil sediment
Beneficial for	• Reduction of losses of PPP and nutrients to surface water • Infiltrates runoff water and catches sediments • Overall reduction of erosion in a landscape • Windbreak: reducing wind erosion and spray drift • Increasing biodiversity in agricultural landscapes by providing habitats • Riparian hedges: stream bank protection, ecosystem enrichment and connectivity.
Negative effects	• Basically, hedges reduce the field size with potential negative effects on economic land management • May represent a source of crop pest and diseases • Significant resources needed for establishment and maintenance
Estimated risk reduction potential	• Efficacy of hedges for runoff reduction, if planted on a grassed strip, similar to grassed filter strips of comparable width.
Implementation	• Choose native, robust wooden species, which provide food/nesting habitats

and management	for native fauna and do not negatively impact cropping practices (e.g. host plant for pests, diseases) • Maintain to ensure a dense, multiple stalk hedge (regular cutting, especially in first years, necessary) • Position hedge in the middle of grassed strip (minimum 2 m wide), across slope • Plant local and adapted grass species that should exhibit stiff leaves / stems in order to resist water flow; establish permanently. • Do not create short-cuts for water through the hedge • If sediments accumulate, spread sediments across the grassed margins
Constraints	• Establishment and maintenance of hedges requires significant resources.
Recommendations on implementation	• If possible, position hedges based on a catchment audit to maximize benefits (runoff, spray drift, biodiversity, stream bank protection, etc.) • Check for funding possibilities via CAP 2nd pillar funds or national agri-environmental programs
Recommendations on monitoring	• Runoff reduction efficacy should be monitored regularly and hedges and adjacent grassed strips maintained for optimum long-term performance.
References	• TOPPS-prowadis Runoff BMP Booklet (www.topps-life.org)

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[1] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[2] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the + - environmental benefit

[3] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[4] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[5] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[6] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[7] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[8] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[9] -1 = Negative impact for the environmental benefit ; 0 = No positive impact for the environmental benefit ;1 = Some benefits for the environmental benefit; 2 = Major benefits for the environmental benefit; 3 = Most beneficial of all field margin types for the environmental benefit

[10] -1 = Negative impact for the environment ; 0 = No positive impact for the environment ; 1 = Some benefits for the environment; 2 = Major benefits for the environment

Appendix 2. Surface Water protection-Runoff

Table A2.1: Overview on further runoff risk mitigation measures, not considered in proposed basic EU toolbox

Runoff Mitigation measure	**Scientific Data Basis***	**Average Mitigation Efficiency for total peak pesticide losses**	**Mitigation type**	**Consideration in modeling possible?**
Edge-of-field measures				
Hedges	O	similar to vegetated buffer strips, if grassed margins	Diffuse flow	?
In-field measures				
Reduction of application rate[1]	+++	Dependent on rate reduction	All (no specific runoff mitigation)	Yes (reduction of rate)
Contour tillage/cropping[2]	++	65 to 75 %[3]	Diffuse flow	?
Rough seedbed preparation	O	Field evidence	Diffuse flow	Yes (curve number modification)
Intercrops	+	Depending on time of application of CPPs	Diffuse flow	Yes
Crop rotation	O	Case-specific	Diffuse flow	?
Double sowing across slope	O	Field evidence	Diffuse flow	Yes (curve number modification)
Enlarge headland	O	Field evidence	Diffuse flow	Yes (curve number modification)
Strip cropping	+	Depending on set-up	Diffuse flow	Yes (if whole slope modeled)
Tramline management	*+*	*70 to 95%[3]*	*Concentrated flow*	-
Grassed talweg/waterway	*+*	*Highly efficient*	*Concentrated flow*	-
Double sowing in talweg/waterway	*O*	*Field evidence*	*Concentrated flow*	-

Off-field measures				
Fascines	*O*	*Case-specific*	*Concentrated flow*	-

* Symbols mean: O: limited information available; +: few scientific publications existing; ++: many scientific publications existing; +++: abundant scientific publications existing.

1 Already considered in most regulatory systems in EU member states; in part novel techniques like band spraying would need to be considered under this measure.

2 Already considered as good agricultural practice in FOCUS surface runoff modeling.

3 Deasy, C. Quinton, J.N., Silgram, M., Bailey, A.P., Jackson, B. and Stevens, C.J. 2010. Contributing understanding of mitigation option for phosphorus and sediment to a review of the efficacy of contemporary agricultural stewardship measures. Agricultural Systems 103, 105-109.

Table A2.2: Reasoning for effectiveness and literature references for all evaluated runoff risk mitigation measures (diffuse and *concentrated flow* runoff).

Mitigation Measure (MApPIE efficiency proposal)	**Mitigation function, reasoning for effectiveness, and literature findings**	**Literature base**
In-field		
Reduced tillage (All pesticides: 50% Pesticides with Koc<1000 L Kg^{-1}: 50%	Reduced-/minimum-/no-tillage reduces runoff from fields because of (i) an increased water infiltration capacity of soil, due to a stable macropore system and better soil aggregation, and (ii) a lower vulnerability of the soil surface for crusting, due to higher soil aggregate stability and an increased amount of plant residues on the soil surface (mulch). (see also review from Soane et al., 2012 and Armand R., Bockstaller, C., Auzet, A.-V., Van Dijk P., 2009. Runoff generation related to intra-field soil surface characteristics variability - Application to conservation tillage context, Soil Tillage Res., 102, 27-37.)	
Pesticides with Koc>1000 L Kg^{-1}: 75%)	Average reduction of pesticide runoff, including herbicides with high mobility, was 70% for no-till, 69% for chisel ploughing, and 42% for ridge till.	RS Fawcett, BR Christensen and DP Tierney 1994. The impact of conservation tillage on pesticide runoff into surface water: a review and analysis. J. Soil Water Conserv. 49: 126-135
	Runoff losses of herbicides were compared for minimum tillage and conventional mouldboard tillage. Differences not given in Tables, but shown in Figures for both water and sediment fractions. Figures show that majority of the loss was in the water fraction. It is estimated that the loss was 20 times higher for conventional moldboard compared to minimum till on a loam soil (i.e. 95% reduction of	Z Miao, A Vicari, E Capri, F Ventura, L Padovani and M Trevisan 2004. Modeling the effects of tillage management practices on herbicide runoff in northern Italy. J Environmental Quality. 33: 1720-1732.

	runoff losses).	
	Evaluation of the influence of mulch and direct seeding on erosion and export of pesticides from fields. Mulch seeding led to reductions of 71 to 90%, direct seeding to 100% reduction of transport of selected herbicides in corn (metolachlor, terbuthylazine, pendimethalin) – see Table 9 on page 16.	UBA, 2004. Bodenschutz und landwirtschaftliche Bodennutzung - Umweltwirkungen am Beispiel der konservierenden Bodenbearbeitung. Gemeinsame Fachveranstaltung der Gesellschaft für konservierende Bodenbearbeitung (GKB e.V.) des Umweltbundesamtes (UBA) und der Bundesforschungsanstalt für Landwirtschaft (FAL), 27 to 28 October, 2003. Braunschweig, Germany.
	Minimum tillage led to reduction of water losses (4 to 81%) and sediment losses (37 to 98%) from fields (for sand, silt, clay) – see Table 1.	Deasy, C. Quinton, J.N., Silgram, M., Bailey, A.P., Jackson, B. and Stevens, C.J. 2010. Contributing understanding of mitigation option for phosphorus and sediment to a review of the efficacy of contemporary agricultural stewardship measures. Agricultural Systems 103, 105-109.
	In order to achieve a significant reduction of erosion in maize fields in southern Germany, a minimum coverage of the soil surface by mulch of 10% is necessary; best results for erosion mitigation at ≥30% surface cover (page 48).	LfL, 2013. Wirksamkeit von Erosionsschutzmaßnahmen – Ergebnisse einer Feldstudie. Schriftenreihe der Bayerischen Landesanstalt für Landwirtschaft (LfL), Freising-Weihenstephan, Germany.
	The paper reviews the effects of no-till/conservational tillage in Europe. Erosion reductions from 70 to 90% are cited from various EU countries, and runoff reduction by 40% from France.	BD Soane, BC Ball, J Arvidsson, G Basch, F Moreno and J Roger-Estrade, 2012. No-till in northern, western and south-western Europe. A review of the problems and opportunities for crop production and the environment. Soil Tillage Res. 118, 66-87.
	In this review paper a large number of publications are cited with contradictory results, regarding tillage effects on pesticide transfer in runoff. While the majority of studies reports a reduction of pesticide transfer with runoff under reduced/no tillage, a number of studies reports equal or even greater runoff transport of pesticides under reduced/no tillage regimes. The authors conclude that “in a	Alletto, L., Coquet, Y., Benoit, P., Heddadj, D., Barriuso, E. 2010. Tillage management effects on pesticide fate in soils. A review. Agron. Sustain. Dev. 30, 367-400.

	general way, conservation tillage is more efficient in reducing runoff than leaching", based on the fact that reduced tillage leads to higher aggregate stability and soil surface roughness (mulch residues).	
	This review paper assigns a runoff reduction effectiveness of 25 to 70% to no-till, and 5 to 30% to reduced tillage (only cases with n>2 considered). Interestingly, the runoff reduction efficiency decreases with time since establishment of the conservational tillage system (contradicting textbook knowledge on this topic). Erosion reduction effectiveness is reported to be always >90% for no-till systems, and in the range from 70 to 95% for reduced tillage systems, with no time effects apparent.	Maetens W., Poesen, J., Vanmaercke, M. 2012. How effective are soil conservation techniques in reducing plot runoff and soil loss in Europe and the Mediterranean?. Earth Sci. Rev. 115, 21-36.
Bunds for row crops (50%)	Due to the establishment of small earth bunds in-between rows (e.g. potatoes), runoff water is prevented from channeling in-between rows.	
	Proposal of Swiss regulatory authority: 50% effectiveness	
	Field experience and data from France prove effectiveness for runoff and erosion prevention (Arvalis Institute); field evidence from Belgian TOPPS-prowadis catchment also positive.	
5-m vegetated buffer strips (50%)	Vegetated buffer strips may be established in-field to break up long slopes within fields and infiltrate runoff water (and deposit any sediment) exiting the upper part(s) of the field. The efficiency of buffer strips near the source of runoff is known to be greater than further downslope, as a potential concentrated flow of runoff water is thus prevented to a larger degree (see also review by Reichenberger et al., 2007).	
	Based on a literature review, for all pesticides the following efficiencies for pesticide load reductions were found (Figure 1): 5 m width: Median ca. 70%, 25th perc. ca. 50%.	Reichenberger S., Bach M., Skitschak A., Frede H.G. 2007. Mitigation strategies to reduce pesticide inputs into ground-and surface water and their effectiveness; a review. Science of the Total Environment 384: 1-35.
	Erosion severity depends very much on field size, and therefore in first approximation slope length. Strip cropping (i.e. alternating winter and summer crops, row and cereal crops, along a slope) or breaking up of slopes by buffers therefore is effective to reduce runoff and erosion (pages 61 to 65)	LfL, 2013. Wirksamkeit von Erosionsschutzmaßnahmen – Ergebnisse einer Feldstudie. Schriftenreihe der Bayerischen Landesanstalt für Landwirtschaft (LfL), Freising-Weihenstephan, Germany.
Cover crops	Vegetation as ground cover in perennial crops (e.g. orchards, vineyards) reduces the	

in perennial crops (50%	runoff generation and erosion by maximizing water infiltration and keeping topsoil covered and rooted.	
	While for reduction of runoff volume not always effective, erosion was reduced by 53 to 98% by vegetated ground in olive groves and vineyards in the Mediterranean area (France, Spain).	JA Gomez, C Llewellyn, G Basch, PB Sutton, JS Dyson and CA Jones. 2011. The effects of cover crops and conventional tillage on soil and runoff loss in vineyards and olive groves in several Mediterranean countries. Soil Use and Management doi: 10.111/j.1475-2743.2011.00367.x
	Proposal for runoff reduction efficiency (Table 3, page 12): 40% for vegetated interrows downslope. 50% for vegetated interrows across slope.	CCPF-Ministero della Salute, 2009. Misure di mitigazione del rischio per la riduzione della contaminazione dei corpi idrici superficiali da deriva e ruscellamento. Documento di orientamento. 27 pp, CCPF/MitRis/Finale- 20 July 2009, Italy.
	Proposal of Swiss regulatory authority: 50% runoff reduction.	
Reduction of application rate (variable)	All measures, leading to a predictable reduction of the effective rate (e.g. band spraying, precision spraying, overall rate reduction), will also reduce the resulting concentrations/load of pesticides in runoff water and eroded sediment. The reduction efficiency depends on the achieved overall rate reduction per ha.	
Tramline management *(conc. flow)*	*Concentrated flow and erosion is often starting in tramlines, where soil is compacted and a channel structure is provided. Establishing tramlines across the slope and/or covering tramlines by vegetation is an effective way to minimize the generation of concentrated flow in fields.*	
	On a sand and loam soil, management of the tramlines led to a major reduction in the losses from the field – runoff (69 to 97%), eroded soil (75 to 99%) – see Table 1.	*Deasy, C. Quinton, J.N., Silgram, M., Bailey, A.P., Jackson, B. and Stevens, C.J. 2010. Contributing understanding of mitigation option for phosphorus and sediment to a review of the efficacy of contemporary agricultural stewardship measures. Agricultural Systems 103, 105-109.*
Grassed talweg *(conc. flow)*	*Grassed talwegs are effective to reduce surface runoff in the natural potential waterways forming in fields during strong rainfall events. They are therefore often more effective than a large downslope buffer at the edge of the field, as they prevent the formation of concentrated flow in the field along talwegs.*	

	Recommendation for efficiency to be used in modelling, 25 m length (see Table 5 of reference): *Pesticides with Koc<1000 L Kg^{-1}: 70%* *Pesticides with Koc>1000 L Kg^{-1}: 90%*	*Reichenberger S., Bach M., Skitschak A., Frede H.G. 2007. Mitigation strategies to reduce pesticide inputs into ground-and surface water and their effectiveness; a review. Science of the Total Environment 384: 1-35.*
Double sowing in talweg *(conc. flow)*	*Double sowing of crops in talweg positions leads to higher root density, providing a higher resistance to water flow and erosion; in addition the increased evaporation will reduce the water content in soil, also reducing the probability of runoff generation.*	
Edge-of-field		
Vegetated buffer strips (All pesticides:	Vegetated buffer strips established edge-of-field infiltrate water (and deposit sediment) exiting the field at its lower edge. Grassed filter strips are more effective than cropped buffers, as the dense grass root system enhances water infiltration in buffers and grass stems slow water flow and filter sediment. The efficiency of buffer strips near the source of runoff is known to be greater than further downslope, as a potential concentrated flow of runoff water is thus prevented to a larger degree.	
5 m: 40% 10 m: 65% 20 m: 80% Pesticides with Koc<1000 L Kg^{-1}: 5 m: 40% 10 m: 60% 20 m: 70% Pesticides with Koc>1000 L Kg^{-1}: 5 m: 50% 10 m: 75% 20 m: 90%)	Based on a literature review, for all pesticides the following efficiencies for pesticide load reductions were found (Figure 1): 3 m width: Median ca. 70%, 25^{th} perc. ca. 50% 5 m width: Median ca. 70%, 25^{th} perc. ca. 50% 10 m width: Median ca. 90%, 25^{th} perc. ca. 75% 20 m width: Median ca. 95%, 25^{th} perc. ca. 50% Based on a literature review, for pesticides with Koc<1000 L Kg^{-1} the following efficiencies for pesticide load reductions were found (Figure 2): 3 m width: Median ca. 70%, 25^{th} perc. ca. 45% 5 m width: Median ca. 60%, 25^{th} perc. ca. 45% 10 m width: Median ca. 80%, 25^{th} perc. ca. 70% 20 m width: Median ca. 90%, 25^{th} perc. ca. 35% Based on a literature review, for pesticides with Koc>1000 L Kg^{-1} the following efficiencies for pesticide load reductions were found (Figure 3): 3 m width: Median ca. 75%, 25^{th} perc. ca. 65% 5 m width: Median ca. 75%, 25^{th} perc. ca. 55% 10 m width: Median ca. 95%, 25^{th} perc. ca. 90%	Reichenberger S., Bach M., Skitschak A., Frede H.G. 2007. Mitigation strategies to reduce pesticide inputs into ground-and surface water and their effectiveness; a review. Science of the Total Environment 384: 1-35.

	20 m width: Median ca. 99%, 25th perc. ca. 95% Recommendations for reduction efficiency to be used in modelling – buffer strips at edge of field (Table 5): For pesticides with Koc<1000 L Kg^{-1}: 5 m width: 50% 10 m width: 70% 20 m width: 80% For pesticides with Koc>1000 L Kg^{-1}: 5 m width: 60% 10 m width: 85% 20 m width: 95%	
	Summary of EU data on buffer strip efficiencies for aqueous phase of runoff: 5 m width: Range 10 to 98%, mean 62% 10 m width: Range 2 to 100%, mean 77% 15 m width: Range 33 to 100%, mean 88% 20 m width: Range 14 to 98%, mean 86% Summary of EU data on buffer strip efficiencies for sediment phase of runoff: 5 m width: Range 11 to 97%, mean 66% 10 m width: Range 86 to 99%, mean 95% 15 m width: Range 43 to 100%, mean 89% 20 m width: Range 93 to 100%, mean 97% (detailed technical review report, pages 57/58). Recommendations based on 90th percentile worst case of literature data (summary report, page 33): 10 to 12 m width: 60% (water), 85% (sediment) 18 to 20 m width: 85% (water), 95% (sediment)	FOCUS, 2007. Landscape And Mitigation Factors In Aquatic Risk Assessment. Volume 1&2. Report of the FOCUS Working Group on Landscape and Mitigation Factors in Ecological Risk Assessment, SANCO/10422/2005 v2.0.
	For pesticides, many studies were reviewed on buffer zones and constructed wetlands. For buffer zones of 5 to 20 m width, the average reduction in mass loss was 65% (see Table 3), and varied from 30 to 100%. Buffer size effectiveness was reported to be similar at smaller area ratios (buffer to drained area of e.g. 1:30) to the one of e.g. 1:15.	P Kay, AC Edwards and M Foulger. 2009. A review of the efficacy of contemporary agricultural stewardship measures for ameliorating water pollution problems of key concern to the UK water industry. Agricultural Systems 99: 67-75
	For fields with <4% slope the following runoff reductions were defined: 3 m: 40%	CCPF-Ministero della Salute, 2009. Misure di mitigazione del rischio per la riduzione della

	5 m: 50% 10 m: 90%.	contaminazione dei corpi idrici superficiali da deriva e ruscellamento. Documento di orientamento. 27 pp, CCPF/MitRis/Finale- 20 July 2009, Italy.
	A reduction effectiveness of 90% for pesticide load in runoff was recorded for a 6 m vegetated buffer strip for corn herbicides in Italy.	Milan, M., Vidotto, F., Piano, S., Negre, M., Ferrero, Al. 2013. Buffer strip effect on terbuthylazine, desethyl-terbuthylazine and S-metolachlor runoff from maize fields in northern Italy. Environ. Technol. 34, 71-80.
(conc. flow)	*The mitigation efficiency of vegetative filter strips at the edges of fields is low if water and sediment flows across them in a concentrated manner – from 20% to 10% in this experiment on a silt loam soil. When grass barriers were added, 90% of the soil and >50% of the nutrient losses were mitigated.*	*H Blanco-Canqui, CJ Gantzer and SH Anderson. 2006. Performance of grass barriers and filter strips under interrill and concentrated flow. J Environ. Quality 35: 1969-1974.*
Edge-of-field bunds (40%)	By establishing edge-of-field bunds across the slope, runoff water is collected and infiltrated at the location of bunds. In case of bund overflow, a sheet flow is again initiated at its lower edge (assuming conformity of its lower rim with isohypes).	
	Proposal of Swiss regulatory authority: 50% effectiveness	
	This measure is called a temporary "runoff ditch" at the edge of the field with at least 40 cm depth, maintained until 45 d after application: An effectiveness of 20% for runoff reduction is defined.	CCPF-Ministero della Salute, 2009. Misure di mitigazione del rischio per la riduzione della contaminazione dei corpi idrici superficiali da deriva e ruscellamento. Documento di orientamento. 27 pp, CCPF/MitRis/Finale- 20 July 2009, Italy.
Hedges (see vegetated filter strips)	Not detailed literature data available; similar efficiency as vegetated filter strips assumed, if hedges are established with grassed margins.	
Off-field		
Artificial Wetlands (all pesticides: 75% Pesticides	Constructed wetlands capture runoff water downslope of fields/sub-catchments, before it enters natural surface water bodies. A significant reduction of pesticide peak concentrations is already achieved via dilution of the first peak of substances in the first runoff volume within the larger wetland before any overflow is produced. In addition, pesticides are retained in wetlands via adsorption to plant/sediment surfaces, or sedimentation of eroded soil particles in the wetland. Last but not least, pesticides are	

with Koc<1000 L Kg^{-1}: 60%	degraded in the water and sediment phase of wetlands with time. A dense vegetation and adequate hydraulic retention time of runoff water (i.e. size of the wetland tailored to expected runoff water volume). – see also Stehle et al, 2011.	
Pesticides with Koc>1000 L Kg^{-1}: 90%)	The paper reviewed 24 scientific articles on constructed wetlands and pesticide retention, including findings from the European ArtWET project. Overall, the majority of the constructed wetlands retained >70% of the pesticides entering them. The paper also studied parameters which influenced the retention of pesticides. Four main factors were identified: the pesticide Koc, the water phase DT50, the overall plant coverage in the wetland, and the residence time for the water flowing through the wetland.	Stehle, S., Elsaesser, D., Gregoire, C., Imfeld, G., Niehaus, E., Passeport, E., Payraudeau, S., Schäfer, R.B., Tournebize, J., Schulz, R. 2011. Pesticide risk mitigation by vegetated treatment systems: A meta-analysis. J. Environ. Qual. 40, 1068–1080.
	Review on the effects of buffer zones and constructed wetlands on pesticide load reductions in runoff water. For constructed wetlands, the average reduction in mass loss was 80% (cf. Table 5), and varied from 25-100%.	P Kay, AC Edwards and M Foulger. 2009. A review of the efficacy of contemporary agricultural stewardship measures for amelioriating water pollution problems of key concern to the UK water industry. Agricultural Systems 99: 67-75
	Recommendations for efficiency to be used in modelling (Table 5): For pesticides with Koc<1000 L Kg^{-1}: 60% For pesticides with Koc>1000 L Kg^{-1}: 90%	Reichenberger S., Bach M., Skitschak A., Frede H.G. 2007. Mitigation strategies to reduce pesticide inputs into ground-and surface water and their effectiveness; a review. Science of the Total Environment 384: 1-35.
	Summary of literature data on retention effectiveness of artificial wetlands or vegetated ditches (page 68): Runoff reduction (conc.): Range 77 to >99% Runoff reduction (load): Range 83 to >99.9%	FOCUS, 2007. Landscape And Mitigation Factors In Aquatic Risk Assessment. Volume 2. Detailed technical review report of the FOCUS Working Group on Landscape and Mitigation Factors in Ecological Risk Assessment, SANCO/10422/2005 v2.0.
	The paper studied the removal rates of 9 fungicides, 6 herbicides and 1 insecticide. Removal rates varied from 39% to 100%. More than 88% of the suspended solids were trapped, demonstrating the ability of these wetlands to trap pesticides adsorbed to particles via sedimentation.	Maillard, E. Payraudeau, S., Faivre, E., Gregoire, C., Gangloff, S. Imfeld, G. 2011. Removal of pesticide mixtures in a storm water wetland collecting runoff from a vineyard catchment. Sci. Total Environ. 409, 2317-2324.
	Reduction of concentrations of pesticides and their	Maillard, E., Payraudeau, S.,

	metabolites (17 substances) ranged in two different experimental years from 50 to 100 percent. Load reduction ranged from 26 to 100%, averaging 81 and 92% for the two years.	Ortiz, Fl. Imfeld, G. 2012. Removal of dissolved pesticide mixtures by a stormwater wetland receiving runoff forma vineyard catchment: an inter-annual comparison. Intern. J. Environ. Anal. 92, 979-994.
	For 13 measured substances, flux reduction efficiencies of 16 to 100 % were found; for two substances (chlortoluron, iprodione) a negative retention efficiency was recorded. Average load reduction efficiency was cited with 45 to 54%.	Tournebize, J. , Passeport, E. Chaumont, C. Fresneau, C., Guenne, A, Vincent; B. 2013. Pesticide de-contamination of surface waters as a wetland ecosystem service in agricultural landscapes. Ecol. Engin. 56, 51-59.
	Load reductions of 45 to 96% were achieved using an artificial wetland for runoff mitigation in a tile-drained catchment (16 substances).	Passeport, E., Tournebize, J., Chaumont, C. Guenne, A., Coquet, Y. 2013. Pesticide contamination interception stragegy and removal efficiency in forest buffer and artificial wetland in a tile-drained agricultural watershed.
	The authors demonstrated that the presence of plants and organic material in the retention system optimized the retention of pesticides, which is especially effective for more hydrophobic active substances.	Vallee, R., Dousset, S., Billet, D., Benoit, M. 2014. Sorption of selected pesticides on soils, sediment and straw from a constructed agricultural drainage ditch or pond. Environ. Sci. Pollut. Res. 21, 4895-4905
Vegetated ditches (50%)	As a special form of artificial wetlands, vegetated ditches collect runoff water from a field and enhance infiltration. They are of a permanent nature and the vegetation enhances water infiltration, evaporation and pesticide sorption and degradation in the ditch.	
	In this review, a mitigation efficiency of densely vegetated ditches with low flow rate (<0.3 m/s) is estimated at 60% for herbicides and 90% for insecticides.	Gregoire, C. , Elsaesser D., Huguenot, D., Lange, J., Lebeau, T., Merli, A., Mose, R., Passeport, E., Payraudeau, S., Schütz, T., Schulz, R., Tapia-Padilla, G. Tournebize, J., Trevisan, M., Wanko, A. 2009. Mitigation of agricultural nonpoint-source pesticide pollution in artificial wetland ecosystems. Environ. Chem. Lett. 7, 205–231.
	In order to reduce the water phase concentration of pesticides by 50%, the required length of vegetated	Moore, M.T., D.L. Denton, C.M. Cooper, J. Wrysinski, J.L. Miller, K.

	ditches was estimated to be ca. 22 m for permethrin and 55 m for diazinon; V-shaped and vegetated ditches were considered to be the most effective ditch type for mitigation.	Reece, D. Crane and P. Robins. 2008. Mitigation assessment of vegetated drainage ditches for collecting irrigation runoff in California. Journal of Environmental Quality. 37:486-493.
	About 300 m long drainage ditches were able reduce the water phase concentration of chlorpyrifos by 20% and permethrin by 67% from inflow to outflow.	Moore, M.T., D.L. Denton, C.M. Cooper, J. Wrysinski, J.L. Miller, I. Werner, G. Horner, D. Crane, D.B. Holcomb, G.M. Huddleton 2011. Use of vegetated agricultural drainage ditches to decrease pesticide transport from tomato and alfalfa field in California, USA. Environ. Toxicol. Chem. 30, 1044-1049.
	The authors demonstrated that the presence of plants and organic material in the retention system optimized the retention of pesticides, which is especially effective for more hydrophobic active substances.	Vallee, R., Dousset, S., Billet, D., Benoit, M. 2014. Sorption of selected pesticides on soils, sediment and straw from a constructed agricultural drainage ditch or pond. Environ. Sci. Pollut. Res. 21, 4895-4905
Fascines *(conc. flow)*	*Artificial wooden structure (small fences made of stakes and interwoven branches) is put into the known pathways/erosion channels of concentrated runoff, thereby interrupting the runoff low and leading to sedimentation of eroded soil particles and spreading of the concentrated flow at its lower edge.*	
	Field evidence from TOPPS-prowadis colleagues in Italy and France (Prof. Aldo Ferrero; Benoit Real).	

Table A2.3: Proposed toolbox of basic runoff mitigation measures and their effectiveness to reduce total peak pesticide losses, taking into consideration pesticide sorption properties

Runoff Mitigation measure	**Scientific Data Basis***	**Pesticide K_{OC} (L Kg^{-1})**	**Average Mitigation Effectiveness[1]**	**Proposed Modelling Tools or Parameter Modifications**
Edge-of-field measures				
5 m vegetated filter strip	+++	<1000	40%[2,3]	VFSMOD
		>1000	50%[3]	

10 m vegetated filter strip	+++	<1000	60%[3]	VFSMOD
		>1000	75%[3]	
20 m vegetated filter strip	+++	<1000	70%[3]	VFSMOD
		>1000	90%[3]	
Edge-of-field bunds	+	all	40%[4]	water retention calculation
In-field measures				
No-till / reduced tillage	++	<1000	50%[5,6, 7,8]	curve number adjustment: -3
		>1000	75%[8]	
In-field bunds (row crops)	+	all	50%[4]	curve number adjustment: -3[14]
5 m vegetated buffer strips	++	all	50%[9]	VFSMOD
Inter-row vegetated strips (in permanent crops)	++	all	50%[2,4]	Proportionate consideration of curve numbers[15]
Off-field measures				
Detention ponds / artificial	+++	<1000	60%[3,10,11]	water / sediment retention
wetlands		>1000	90%[3,10,11]	calculation
Vegetated ditches	++	all	50%[12,13]	water retention calculation

* Symbols mean: +: few scientific publications existing; ++: many scientific publications existing; +++: abundant scientific publications existing.

1 value describing the needed reduction of PEC to achieve the regulatory acceptable concentration in surface water or sediment (e.g. a needed reduction from 10 µg/L to 1 µg/L equals a mitigation need of 90%); this value is used to derive mitigation points for each measure from respective mitigation point scale (see Table 6.2).

2 CCPF-Ministero della Salute, 2009. Misure di mitigazione del rischio per la riduzione della contaminazione dei corpi idrici superficiali da deriva e ruscellamento. >Documento di orientamento.

27 pp, CCPF/MitRis/Finale- 20 July 2009, Italy.

3 Reichenberger S., Bach M., Skitschak A., Frede H.G. 2007. Mitigation strategies to reduce pesticide inputs into ground-and surface water and their effectiveness; a review. Science of the Total Environment 384: 1-35.

4 Proposal of Swiss regulatory authority for runoff mitigation efficiency: 50%; in ref. 2 a mitigation efficiency of only 20% was proposed.

5 UBA 2004. Bodenschutz und landwirtschaftliche Bodennutzung - Umweltwirkungen am Beispiel der konservierenden Bodenbearbeitung. Gemeinsame Fachveranstaltung der Gesellschaft für konservierende Bodenbearbeitung (GKB e.V.) des Umweltbundesamtes (UBA) und der Bundesforschungsanstalt für Landwirtschaft (FAL), Braunschweig, Germany, 2003.

6 Miao, Z., Vicari, A., Capri, E., Ventura, F., Padovani, L., and Trevisan, M. 2004. Modeling the effects of tillage management practices on herbicide runoff in northern Italy. J Environ. Qual. 33, 1720-1732.

7 Deasy, C. Quinton, J.N., Silgram, M., Bailey, A.P., Jackson, B. and Stevens, C.J. 2010. Contributing understanding of mitigation option for phosphorus and sediment to a review of the efficacy of contemporary agricultural stewardship measures. Agricultural Systems 103, 105-109.

8 Maetens W., Poesen, J., Vanmaercke, M. 2012. How effective are soil conservation techniques in reducing plot runoff and soil loss in Europe and the Mediterranean?. Earth Sci. Rev. 115, 21-36.

9 Reichenberger S., Bach M., Skitschak A., Frede H.G. 2007. Mitigation strategies to reduce pesticide inputs into ground-and surface water and their effectiveness; a review. Science of the Total Environment 384: 1-35. See Fig. 1, and reflecting the fact that buffer strips closer to runoff source have higher efficiency than edge-of-field or riparian buffer strips.

10 Stehle, S., Elsaesser, D., Gregoire, C., Imfeld, G., Niehaus, E., Passeport, E., Payraudeau, S., Schäfer, R.B., Tournebize, J., Schulz, R. 2011. Pesticide risk mitigation by vegetated treatment systems: A meta-analysis. J. Environ. Qual. 40, 1068–1080.

11 Maillard, E., Payraudeau, S., Ortiz, Fl. Imfeld, G. 2012. Removal of dissolved pesticide mixtures by a stormwater wetland receiving runoff from a vineyard catchment: an inter-annual comparison. Intern. J. Environ. Anal. 92, 979-994.

12 Moore, M.T., D.L. Denton, C.M. Cooper, J. Wrysinski, J.L. Miller, K. Reece, D. Crane and P. Robins. 2008. Mitigation assessment of vegetated drainage ditches for collecting irrigation runoff in California. Journal of Environmental Quality. 37:486-493; as well

13 Gregoire, C. , Elsaesser D., Huguenot, D., Lange, J., Lebeau, T., Merli, A., Mose, R., Passeport, E., Payraudeau, S., Schütz, T., Schulz, R., Tapia-Padilla, G. Tournebize, J., Trevisan, M., Wanko, A. 2009. Mitigation of agricultural nonpoint-source pesticide pollution in artificial wetland ecosystems. Environ. Chem. Lett. 7, 205–231.

14 Bund are equivalent to terraces:Using the TR-55 curve number (CN) guideline, up to 4 lower CN are recommended;Use a fraction, if the bund only catches part of the runoff (bypassed)

15 Proportionate calculation means:curve number CN= (% permanent crop area * CN(permanent crop)) + (% vegetated strip * CN(vegetated strip))

Table A2.4: Results of survey on surface runoff mitigation measures and related information among responsible authorities/bodies of EU member states and associated countries.

Question:	What type of water body is protected in regulatory assessments?	
All types	**Specific definition**	**No definition**

BE, BG, DK, GR, NO	**FI**: only permanent bodies, excl. small streams and artificial bodies with no fish (catchment <10 km²) **ES**: only DW abstraction bodies, Natura 2000 areas **IT**: all, excl. irrigation channels, paddy rice fields, rain water collection ditches **LI**: all, excl. small ponds **PL**: all, excl. artificial stagnant bodies, not connected **DE:** all, excl. temporary (intermittent) water bodies	**UK** (WFD definition)

Question:	How do you measure the distance from field to surface water body?	
From the water edge	**From the upper edge of the stream bank**	**No information**
CZ, FI, GR, NO	**BE, BG, DE, DK, LI, PL,** **UK** (for spray-drift)	**ES** **IT** (contradictory information)

Question:	Is regulatory runoff risk mitigation accepted? If yes, which measures?	
Yes: Measures (VFS: vegetated filter strip)	**VBS method**	**No**
BE: VFS (10m, 20m) **BG:** no-till strips **CZ:** VFS (5m, 10m, 15m, 20m) **DE:** VFS (5m, 10m, 20m); retention systems for runoff **ES:** VFS (10m, 20m) **FI:** all practical ones (no retention ponds) **GR:** VFS on slopes >2% (maximum of 20 m) **IT:** VFS (3m, 5m, 10m), edge-of-field bunds, reduced tillage, soil incorporation, band spraying **LI:** VFS (10m) **PL:** VFS	FOCUS L&M - FOCUS L&M FOCUS L&M FOCUS L&M ?; VFSMOD in disc. FOCUS L&M – combined drift and run-off mitigation not to exceed 95% FOCUS L&M FOCUS L&M+SWAN FOCUS L&M	**DK, NO, UK**

Question:	Are vegetated filter strips (VFS) obligatory due to other legislation?
Yes	**No**

Regulations: **BE** (1m field, 3m orchards), **DK** (2m old → 10m new) CAP cross-compliance: **IT, UK** CAP 2nd-pillar incentives (voluntary): **FI**	**BG, CZ, DE, ES, GR, LI, NO, PL**

Table A2.5: Overview on expert rating of runoff risk mitigation measures regarding practicability aspects

Risk mitigation measure	**Category[1]**	**Technical Feasibility[2]**	**Effective-ness[3]**	**Agro-nomical practica-bility[4]**	**Use in Risk Assessment[5]**	**Legal & Regulatory Feasibility[6]**	**Zonal Aspects[7]**	**Easy Enforc ability**
IN-FIELD								
No till / reduced tillage	3	M	H	M	Y	H	Y	Y
Contour tilling / disking	3	M	M	M	N	H	N	Y
Rough seedbed preparation	3	M	M	H	N	H	N	N
Vegetative filter strips	2	H	H	M	Y	H	N	Y
Inter-row vegetative filter strips (permanent crops)	2	H	H	H	Y	H	N	Y
Bunds (row crops)	3	M	M - H	M	N	H	N	N
Crop rotation	3	H	M	H	N	M	N	N
Strip Cropping	2	M	M	H	N	H	N	Y
Intercropping	4	M	M	L	N	H	N	N

Double sowing across slope	4	H	L - M	L	N	H	N	Y
Enlarge headland	3	H	L	H	N	H	N	Y
Grassed talweg/water way	2	M	H	M	N	H	N	Y
Double sowing in talweg/waterway	4	H	M	L	N	H	N	Y
Tramline management	2	H	H	H	N	H	N	Y
Reduced application rate	1	H	M	M	Y	H	N	N

Risk mitigation measures	Category[1]	Technical Feasibility[2]	Effective-ness[3]	Agro-nomical practica-bility[4]	Use in Risk Assessment[5]	Legal & Regulatory Feasibility[6]	Zonal Aspects[7]	Easy Enforce-ability[8]	Con
EDGE-FIELD / OFF-FIELD									
Vegetative buffer strip	1	H	M - H	M - H	Y	H	N	Y	Con for per nee defi
Hedge	2	M	H	H	N	H	N	Y	
Bunds	3	M	M	H	N	H	N	Y	
Vegetated ditch	2	M	H	M	N	M - H	N	Y	Dep area serv
Retention pond / artificial wetland	2	M	H	L - M	Y	M	N	Y	Dep area serv
Fascines	3	M	M	L	N	H	N	Y	Con

1 Values mean: 1: well established in EU and widely used and consolidated; 2: Established somewhere in EU and consolidated; 3: Well documented mitigation measure but needs more efforts for consolidation; 4: idea status, needs more field research; 5: rejected as not suitable.

2 Letters mean: H: high – no technical obstacles identified; M: Medium – technical obstacles exist but can be overcome L: low – no concrete route to overcome obstacles.

3 Letters mean: H: high – risk reduction potential estimated at >50%; M: Medium – risk reduction potential estimated at 30 to 50%&; L: low – risk reduction potential estimated at <30%.

4 Letters mean: H: high; M: Medium; L:low.

5 Letters mean : Y: yes; N:no ; U: unknown/untested.

6 Letters mean: H: high – no legal obstacles identified ; M: Medium – legal obstacles exist but can be overcome ; L: low – no concrete route to overcome legal obstacles.

7 Letters mean : Y:yes ; N: no.

8 Letters mean : Y: yes, can be easily controlled in the field (permanent structure); N: No (field documentation system needed, e.g. via GPS-tagged pictures).

Appendix 3 Feedback of Member States on Risk Mitigation measures for Groundwater

The aim of this questionnaire was to extend the knowledge about existing and future risk mitigation measures concerning groundwater. The questionnaire was primarily aiming at getting feedback from regulatory authorities.

Question 1 and Questions 3 to 6 are about tools that are already in use. Question 2 is a generic one about the definition of the protection goal "groundwater". Questions 7 and 8 are about measures that could possibly be considered for groundwater risk mitigation in future.

Question 1: Which of the following risk mitigation measures for groundwater are applicable in your country in context of PPP authorization (implementation in the label)? Remark: It is assumed that each registration is given for a certain crop or crops and for a specified maximum rate; therefore the restriction to crop and/or rate is not considered as a risk mitigation in this context
RMM 1: Restrict the application to certain growth stage of the crop
yes: **DK**, **LV**, **NO**, **IE**, **UK**, **BE**, **PL**, **CZ**, **GR**
no: **LT** (GAP is modified in respect to safe use), **FI** (Could be used, but not needed so far), **DE** (this is part of the GAPs), **AT**, **CH**, **FR**, **ES**, **IT**, **BG**
RMM 2: Restrict the application to a certain timing in the year (if so, how specific; e.g. no autumn application, only application from … to…?)
yes: **DK** (eg. No application in the spring/autumn), **LV** (the autumn or spring applications can be restricted based on the model calculations), **NO** (no autumn application), **BE** (e.g. only spring application), **DE** (e.g. "For use only between 15 May and 31 July."), **PL** (depending on the results of modeling exposure assessment the temporal restrictions, e.g no autumn application, specific dates of application can be imposed on the given product), **AT** (currently under evaluation), **CH** (e.g. not allowed to be used in autumn; reduced application rate in autumn use), **ES** & **GR** (heavy rainfall periods), **IT** (no autumn application), **BG** **FI**, **IE**, **UK** & **CZ** (no autumn application, only application from…to…)
no: **FR**, **LT** (the GAP is modified in respect to safe use)
RMM 3: Restrict to a max number of applications per year
yes: **DK**, **FI**, **LV**, **NO**, **IE**, **UK**, **BE**, **DE** (e.g. "Other products containing the active substance XXX are not to

be used additionally within the same calendar year on the same area.”), **PL**, **CZ**, **AT** (currently under evaluation), **CH**, **ES**, **IT**, **GR**, **BG**
no: **FR**, **LT** (the GAP is modified in respect to safe use).
RMM 4: Restrict to a max number of applications within a 2 year / 3 year period
Products containing the active substance XXX must not be used in the following calendar year on the same area.”), **PL**, **CZ**, **AT** (currently under evaluation), **CH**, **ES**, **IT**, **GR**, **BG**
no: **FR** (the respect of homologated dose is mandatory).
RMM 5: Restrict (or exclude) the application to a certain soil type respectively to certain soil parameters (org. C, clay content, pH, others?) (SPe2 from 547/2011); if yes, please specify
yes: **FI** (The use of the product should be avoided in fine sand soils or soils coarser than fine sand. (pH is taken into account in the risk assessment, if needed, because the Finnish soils are more acidic than in other countries in EU. pH is not mentioned in the risk mitigation measures in the label)), **LV** (Possibility to apply these phrases on label-„SPe 2 To protect groundwater, / do not use in sand soils, dusty clay soils, where soil organic matter is <1%/ do not use in soils with clay content ≥30%”), **LT** (In some cases yes (pH, org. C content, clay content)), **BE** (e.g. “SPe2: To protect groundwater, do not apply this product containing XXX on vulnerable soils such as soils with an organic carbon content less than 1%”), **DE** (e.g. “Not to be used on soils with an average clay content > = 17%.” or “Not to be used on the following soils: pure sand, slightly silty sand and slightly clayey sand.” or “Not to be used on soils with an organic carbon content under 1 %.”), **PL** (for the compounds displaying the dependence of the adsorption on soil pH such restrictions, e.g. no use on alkaline soils, can be imposed), **CZ** (soil type, acidic, alkaline soils, clay content), **AT** (currently under evaluation), **CH** (inhibition of the use of the active substance in specific areas with vulnerable soil (such as Karst area in Switzerland); temperature of soil higher than x), **ES** (sandy soils), **IT** (low Koc (<1%), sandy soils (sand >80%), alkaline soils, acidic soils), **GR** (low OC content, sandy soils, alkaline soils, acidic soils)
no: **FR** (extension services may have specific mission to alleviate pollution by ad hoc agricultural practices), **DK**, **NO**, **IE**, **UK**, **BG**
RMM 6: Exclude applications to drinking water abstraction areas / to zones with drinking water wells
yes: **FI** (The use is not allowed nearer than 30–100 meters to the wells and springs used for drinking water), **BE**, **PL** (this restriction is independent to the GW exposure assessment; falls under WFD provisions), **CZ** (it is possible to exclude application in the zone established to protect ground sources of drinking water), **AT** (currently under evaluation), **CH** (general rule: use in a specific area around the drinking water supply site (ground water protection zone of 10 m) is prohibited; related to substances with a potential groundwater concern the specific area around the drinking water supply site is larger (ground water protection zone for groundwater with a residence time of less than 10 days.), **FR** (strictly forbidden in the well head delimitation zone (some dozen of meters around the well, pending local conditions)), **BG** (at least 50 m buffer zone to areas for drinking water abstraction (SW and GW) for unprotected water sources in groundwater bodies and 5-15 m buffer zone to areas for drinking water abstraction for sources in protected water bodies and water sources located in the regulatory

boundaries of the settlements (under National water law, Ordinance № 3))
no: **DK** (1. We do not authorize a product if there is a risk to ground water (PECgw (95th percentile) > 0.1 µg/L; the limit must not be exceeded in more than 1 of 20 years). 2. Almost all drinking in Denmark comes from ground water. Therefore is there a lot of other legislation that ban the use of pesticides near the drinking water wells. At the moment a 25 m buffer zone around all public wells has to be applied.), **LV**, **LT**, **NO**, **IE**, **UK**, **DE** (in former times but not any more in context of PPP authorization because of the general protection of groundwater in Germany and not only for drinking water areas.), **ES**, **IT**, **GR**
RMM 7: Exclude application to areas with certain geohydrological properties; if yes, please specify
yes: **BE** (e.g. do not apply on karstic soils), **IT** (vulnerable areas: the identification is demanded to regional authorities)
no: **DK**, **FI**, **LV**, **LT**, **NO**, **IE**, **UK**, **DE**, **PL**, **CZ**, **AT**, **CH**, **FR** (in some “special action zones” excepted, In this case the prefect may impose all kind of measures tending to solve the question of pollution. It is one of the rarest cases in France where there is a result obligation. The prefect may pronounce land confiscation if no result), **ES**, **GR**, **BG**
RMM 8: Band application (e.g. in orchards)
yes: **FI**, **IE**, **UK**, **ES**, **IT**, **BG**
no: **DK**, **LV** (There is one PPP authorized with such conditions. However it is not as mitigation but as something considered in the GW calculations during the assessment to simulate more realistic exposure. This should be applicable to multiyear vegetation (orchards) with unchanged band widths. The dose rate per ha in the model input would be corrected for the band widths), **LT**, **NO**, **BE**, **DE** (band application is not a reduction criteria because the total applied area is no parameter on exposure assessment), **PL**, **CZ**, **AT**, **CH**, **FR**, **GR**
RMM 9: Restrictions for “classes” of compounds or compounds with common metabolites (SPe1 from 547/2011)
yes: **DK**, **NO**, **AT** (currently under evaluation)
no: **FI**, **LV**, **LT**, **IE**, **UK**, **BE** (considered but not applied with SPe 1), **DE**, **PL**, **CZ**, **CH**, **FR**, **ES**, **IT**, **GR**, **BG**
RMM 10: Others? (which?)
DK (Applications for use on paved areas will always be assessed on an ad hoc basis - at the moment only glyphosate and diflufenican are allowed on paved areas.) **DE** (e,g, RMM with respect to the pathway drainage/runoff—> surface water —> bank filtration —> groundwater, e.g. “Not to be used on drained surfaces.” or “Between treated areas with an incline of more than 2% and surface water - except only occasionally but including periodically water-bearing

surface water - there must be a border under complete plant cover. The border's protective function must not be impaired by the use of implements. It must be at least 10 m wide. This border is not necessary if: - sufficient catching systems are available for the water and soil transported by run-off, which do not flow into surface water or are not connected with the urban drainage system or - the product is used for mulch or direct drilling methods.")

BG (restriction for applications on or along roads, railway lines, very permeable surfaces or other infrastructure close to surface water or groundwater, or on impermeable surfaces with a high risk of leakage into surface waters or sewage (under PPP-law)).

Question 2: What is the protection goal regarding 'groundwater' in your country? (e.g. "groundwater" to be used for drinking water production; "groundwater" in general in the meaning of water in the saturated zone of a soil from a precautionary aspect; deep groundwater)

DK: All ground water in general is protected as almost all of the drinking water in Denmark comes from ground water.

FI, **NO**, **PL**: Groundwater in general.

LV, **AT**: "groundwater" to be used for drinking water production.

LT: Protection goal in Lithuania is groundwater resources as a whole - from shallow to deep, because groundwater is the main source for drinking water supply.

The more strict regulations are applied in the areas of sanitary protection zones, established around well-fields (catchment areas), less strict in the rest of territory (including shallow groundwater).

IE: -

UK: 'The UK National Action Plan for the sustainable use of pesticides has compliance with Water Framework Directive standards as the goal (whatever the WFD standards are. We will look to achieve this through a combination of application of the pesticides risk assessment process and promotion of good/best practice by users.

BE: drinking water + general meaning (water in soil).

DE: Groundwater in general in the meaning of protection of groundwater as natural resource, as habitat for biota and also for drinking water production. Generally the aim of governmental strategies in Germany is to avoid any entry of anthropogenic substances in groundwater as far as possible, based on the precautionary principle.

CZ: Groundwater in general in the meaning of water naturally occurring below the land surface since all sources of groundwater is seen as a potential source of drinking water.

CH: Groundwater that is used as drinking water or is intended to be used as drinking water.

0.1 μg/L for active ingredients and relevant metabolites; 10 μg/L for non-relevant metabolites.

ES: As defined in the WFD.

IT: "groundwater" in general in the meaning of water in the saturated zone.

GR: Groundwater is protected from a general aspect. That being said, drinking water in Greece is almost exclusively coming from groundwater treatment, while surface water reservoirs play the role of strategic reserves. The groundwater horizon in Greece is in turn very deep.

BG: Buffer zone is regulatory requirement. Use of PPP within I (50 m) and II (1500 m) saturated zone is forbidden and restricted in III (25 000 m) saturated zone. Spraying with aircraft is forbidden Ordinance No. 3 of 16.10.2000 on the conditions and order for research, design, establishment, validation and operation of sanitary protection zones around water sources and facilities for drinking and domestic water supply and around the sources of mineral water used for healing, preventive, drinking and hygiene needs (promulgated SG 88 of 27.10.2000)- This ordinance determines the conditions and order for conducting a research, design, establishment, validation and operation of sanitary protection zones (SPZ) around the water sources and the facilities for: drinking and domestic water supply from surface water; drinking and domestic water supply from groundwater; and mineral water used for healing, preventive, and hygiene-related needs. To minimize leaching into groundwater in some cases a vegetation protection strips are proposed, if such potential risk exists.

Question 3: How are SPe1 and SPe2 phrases implemented in the labeling of PPP?

3a: Regarding timing restriction

DK: The use can be limited to either autumn or spring use.

FI: To protect groundwater do not apply this or any other product containing this active substance after…(time specified according to the assessment of a substance).

LV: The autumn or spring applications can be restricted based on the model calculations. This is clearly stated on the label.

LT: Modifying GAP.

NO: We do not use the SPe1 phrase, but groundwater hazard is taken into consideration when setting the GAP. Timing restrictions are specified on the label.

IE: Not seen either SPe1 or 2 implemented yet.

UK: These are included in the statutory conditions of product authorization.

BE: no. However, if a use is identified as critical for groundwater due to the time of application, this use is limited in the GAP (eg. only spring application in wheat).

DE: e.g. “Not to be used before 15 April in each calendar year.” or “Products containing the active substance XXX are not to be used in the following calendar year on the same area.”

PL: yes

CZ: SPe1 To protect groundwater do not apply this or any other product containing active substance more than (time period specified).

AT: No application between dd/mm and dd/mm.

CH: e.g. not allowed to be used in autumn. Reduced application rate in autumn uses.

ES: No information found in the time frame to send the questionnaire.

IT: “Do not use in Autumn”.

GR: General phrase: ”Do not use PPP during high rain periods”.

3b: Regarding frequency

DK: Not used in Denmark at the moment.

FI: To protect groundwater do not apply this or any other product containing this active substance more than x times in the year (time specified according to the assessment of a substance).

LV: According to the evaluation or EU regulation the application can be restricted to the use of every second or every third year or to the certain amount of substance in certain time period. This is clearly stated on the label.

LT: Including phrase in the label.

NO: We do not use the SPe1 phrase, but groundwater hazard is taken into consideration when setting the GAP. Frequency/number of treatments is specified on the label.

IE: Not seen either Spe1 or 2 implemented yet.

UK: These are included in the statutory conditions of product authorization.

BE: yes

DE: e.g. “The maximum application rate of 1000 g active substance per hectare and year for the same area - even in combination with other plant protection products containing this active substance - may not be exceeded.” or “Other products containing the active substance XXX are not to be used additionally within the same calendar year on the same area.”

PL: yes

CZ: SPe1 To protect groundwater do not apply this or any other product containing active substance more than (frequency to be specified).

AT: Not more than n applications per year.

CH: Restrictions of uses/year; number of applications/year; application/ x years.

ES: No information found in the time frame to send the questionnaire.

IT: “Do not use more than x times per year”; “The maximum application rate of XX g active substance per hectare and year for the same area - even in combination with other PPP containing this active substance - may not be exceeded.”

GR: The approved GAP has already taken into account the protection of groundwater, so the frequency of use has an intrinsic margin of safety.

3c: Regarding soil characteristics (texture, pH, OC content)

DK: Not used in Denmark at the moment.

FI: The use of the product should be avoided in fine sand soils or soils coarser than fine sand.

LV: We have registrations were the „SPe 2 phrases: To protect groundwater, / do not use in sand soils, dusty clay soils, where soil organic matter is <1%/ do not use in soils with clay content ≥30% ” are used. This is clearly stated on the label.

LT: Including phrase in the label.

NO: We do not use the SPe2 phrase. Groundwater hazard is taken into consideration when deciding if authorization is acceptable.

IE: Not seen either SPe1 or 2 implemented yet

UK: The UK pesticide regulatory assessment currently does not allow regulatory restrictions on use based on soil characteristics.

BE: yes

DE: e.g. “Not to be used on soils with an average clay content > = 17%.” or “Not to be used on the following soils: pure sand, slightly silty sand and slightly clayey sand.” or “Not to be used on soils with an organic carbon content under 1 %.”

PL: yes

CZ: SPe2 To protect groundwater do not apply to (soil type specified) soils.

AT: - no application on soils with clay contents < x %

- no application on the following soil types

- no application on soils classified as "soil with low humus content.

CH: Inhibition of the use of the active substance in specific areas with vulnerable soil (such as Karst area in Switzerland); temperature of soil higher than x.

ES: No information found in the time frame to send the questionnaire.

IT: "Do not use on alkaline/acidic soil"; "Do not use on soil with less than 1% OC"; "Do not use on sandy soils".

GR: General phrases: "Do not use PPP on soils with alkaline/acidic pH", "Do not use PPP on soils with low OC" and "Do not use PPP on soils with high infiltration properties (e.g., sandy soils).

3d: Regarding the use of PPP containing active substances with the same metabolites

DK: Example of label phrase for some of our products: „To protect the groundwater this product or other products containing tribenuron-methyl, iodosulfuron, metsulfuron-methyl, triasulfuron or thifensulfuron-methyl may only be used once every year".

LV: Currently this is not evaluated in LV.

LT: Was not ever used in practice.

NO: We do not use the SPe1 phrase. Maximum number of treatments is specified on the label, sometimes the total amount active substance is specified.

IE: Not seen either SPe1 or 2 implemented yet

UK: This would be considered on a case by case basis for individual substances.

BE: has been considered, but not by adapting SPe1 or SPe2

DE: Safety Phrases only address active substances or PPP because applicants have no information on metabolites.

PL: no

CZ: We do not use SPe1 and/or SPe2 phrases for this situation.

AT: no

CH: no

ES: No information found in the time frame to send the questionnaire.

IT: no

GR: No specific provisions are in place.

Question 4: Are SPe1 and SPe2 phrases implemented as a general rule (in the whole territory) or in connection to the location of vulnerable/protected groundwater bodies in the context of WFD?

DK: They are implemented as a general rule.

FI: In connection to the location of vulnerable/protected groundwater bodies.

LV: The restrictions concerning protection groundwater are implemented as a general rule.

LT: General rule.

NO: They are not implemented. All authorizations are national, we have no local restrictions.

UK: Implemented as a general rule.

BE: They are implemented as a general rule on the label of the product as a result of the risk assessment before the granting of the authorization.

DE: They are implemented in general as a general rule (with very low exceptions in special cases) with respect to our protection goal (see Question 1).

PL: They are implemented for the whole territory of the country.

CZ: They are implemented as a general rule in the whole territory.

AT: General rule.

CH: The rules mentioned above are general rules (whole territory). Furthermore, there are rules concerning the protection zone around drinking water supply sites; general rule: use in a specific area around the drinking water supply site (ground water protection zone of 10 m) is prohibited. S2 Phrase: related to active substance with a potential groundwater concern; the specific area around the drinking water supply site is larger (ground water protection zone for groundwater with a residence time of less than 10 days).

ES: The Ministry of Agriculture, Food and Environment is the Authority responsible for the evaluations and authorizations of PPP at national level. The implementation of labels is competence of the regional/local governments. They are responsible for implementing the label restrictions within the each regional territory limits and considering the agro-environmental characteristics of each region. See attached paper as example.

IT: They are implemented in general as a general rule.

GR: They are implemented as a general rule.

Question 5: Do you have implementation programs for these measures?

DK: No

FI: No

LV: No, this has to be taken into account when using the PPP.

LT: No

NO: No

UK: Training programs and advice for pesticide users emphasize that compliance with the statutory conditions of product authorization is a fundamental requirement. Inspections and other compliance activity are undertaken by Government Agencies to ensure these conditions are adhered to.

BE: At local level.

PL: No

CZ: No

AT: No

CH: Active ingredients are published on the homepage of the federal office for agriculture. For the monitoring the federal office for the environment is responsible, the implementation is the following: information is provided by the federal office for agriculture on a regular basis to the cantons, control by the various cantons and drinking water supply sites.

ES: This is competence of regional governments. No information found in the time frame to send the questionnaire.

IT: No

GR: No particular implementation programs exist.

Question 6: Do you have specific monitoring programs in groundwater to assess the success of these mitigation measures?

DK: We do not have specific monitoring programs to check the specific mitigation measures, but:

1) All drinking water is regularly checked for pesticides (a minimum defined list) by the authorities, as wells will be closed if the limit is exceeded by one or more substances.

2) Beside this, we have the Danish Pesticide Leaching Assessment Program, which provide an early warning of the risk of groundwater contamination when approved pesticides are used in accordance with current regulations (http://pesticidvarsling.dk/om_os_uk/uk-forside.html). In cases where a pesticide or its degradation products leach to the groundwater, the monitoring results generated by the program will provide a basis for reassessment of the substance by the Danish EPA.

FI: We have monitoring programs but not specific to measure the success of the mitigation measure.

LV: No

LT: No

NO: We have some monitoring of groundwater, but not aimed at specific mitigation measures.

UK: The UK Environment Agency is the relevant regulatory body which carries out groundwater monitoring to assess compliance with water legislation requirements.

BE: Yes. There are two kinds of monitoring programs which are used for regulatory purposes: the large scale retrospective monitoring programs carried out by the regional competent authorities to comply with the WFD and the small scale dedicated monitoring studies conducted by the authorization holder of PPP in response to a specific regulatory request.

DE: a) Post-authorization monitoring of single substances on the request of the competent authority

b) Monitoring programs by the German federal states (general monitoring to describe the trend of contaminations in groundwater without special focus on single Safety Phrases of PPP authorization)

PL: No

CZ: Yes, we have groundwater monitoring program in the Czech Republic, it is possible to monitor specific active substance or metabolite.

AT: General GW groundwater monitoring program; however, not specifically targeted at measuring the success of such measures.

CH: The federal office for the environment is responsible for a general survey of PPP and metabolites in groundwater. However, the federal office for agriculture recommends to survey specific compounds having a potential groundwater concern (based on the data of the FOCUS calculations). Programs are divided in a general survey and a specific program looking for substances of concern such as e.g. chloridazon metabolites.

ES: They are competence of regional governments.

IT: a) Post-authorization monitoring of single substances/metabolites on the request of the competent authority.

b) Monitoring programs by the Italian regions (general monitoring to describe the trend of contaminations in groundwater without special focus on single Safety Phrases of PPP).

GR: The Ministry of Rural Development and Food requests the owners of authorizations of “suspect” PPPs to run monitoring programs on vulnerable areas where the particular PPPs are used. The Ministry of Environment, Energy and Climate Change has established specific monitoring programs in groundwater through the Specific Secretariat for Water (http://www.ypeka.gr/Default.aspx?tabid=249&language=en-US).

Question 7: Cover crops during the non-cropped season or inter-row crops (e.g. in vines, orchards) might reduce leaching of PPP to groundwater. Assuming this beneficial effect could be demonstrated (e.g. by FOCUS modeling), would you consider the use of cover or inter-row crops as a possible risk mitigation option for the authorization of PPP?

7a: If 'yes', how could such a mitigation measure be implemented (e.g. within catchment management plans, potential label restriction)?

DK: —; We have not yet decided whether this could be an option or not.

FI: Yes; Good question! Label restriction is the method used so far, but also other methods could be used if proved efficient.

LV: Yes; In Latvia the inter rows in orchards and other bush berry cultures are mostly cropped (grassed). However the consideration of cover crops during the non-cropped season is not a realistic risk mitigation option for the authorization of individual PPP in Latvia.

LT: No

NO: Yes

IE: Yes; Label restriction.

UK: —; Such mitigation measures would have to be explored as a general option for mitigation, not as a substance specific measure; currently such options are unavailable.

BE: Yes; Before using these risk mitigation, this kind of mitigation measures have to be proven to be efficient methods. Their potential reduction has to be quantified. If these mitigation measures have to be implemented, a horizontal label restriction is preferred in order to facilitate their implementation but also to facilitate their control.

DE: No

PL: No

CZ: No

AT: Yes; still unclear.

CH: yes (run-off); a) first step: label restrictions; restriction of the use on soil or crops covered with grass (crop interception to be 70-99%). b) Second step:; general recommendation to enhance the cover in permanent cultures such as orchards and vineyards (not always possible due to a lack of rainfall).

ES: —; In order to use the cover crops as risk mitigation option in the zonal evaluation context under regulation 1107/2009., there is a need to quantify and validate harmonized leaching reduction factors for the agro-environmental conditions represented by each one of the FOCUS GW scenarios. When these factors are available then it is easy to include cover crops in the label during the authorization of PPP. However, it should be taken into account that a modification of Regulation (EU) No. 547/2011 would be necessary since this risk mitigation measure is not included in it.

IT: Yes; Potential label description.

GR: Yes; Measures such as management plans and label restrictions would be plausible; however it would difficult to enforce such label restrictions.

BG: No; Remark: not investigated.

Question 8: Do you consider modern/new high technology spray drift reduction technology (SDRT) (e.g. sensor driven spray systems in the context of precision farming) as a risk mitigation option within

the context of PPP authorization?
8a: If not, would it be possible to consider such high-tech SDRT using label restriction in the future?
8b: Are there any programs to promote high-tech SDRT in your Member State?
8c: If yes, please provide further information (e.g. information campaign for farmers, financial incentives, training)
DK: No; 8a) Yes; 8b) No **FI**: Yes; 8b) No **LV**: No; 8a) No; 8b) No **LT**: No. There is no reliable information how many farms are able to use spray drift reduction technology and thus we do not consider drift reducing nozzles in the risk assessment and do not accept such a mitigation measure; 8a) Yes. However more information on accessibility of SDRT to farmers is required and also legal framework should be created; 8b) No **NO**: No; 8a) Yes; 8b) No **IE**: No; 8a) Yes; 8b) No **UK**: No; 8a) Possibly in future; 8b) Yes; 8c) The UK has a Local Environment Risk Assessment for Pesticides (LERAP) scheme which promotes SDRT by in effect providing a financial incentive for farmers to invest in the technology. See http://www.pesticides.gov.uk/guidance/industries/pesticides/topics/using-pesticides/spray-drift/leraps/local-environment-risk-assessment-for-pesticides-leraps.htm **BE**: No; 8a) Yes; 8b) Yes; 8c) Partial refund of investments in high tech SDRT. **DE**: No; 8a) Perhaps. It seems highly difficult to quantify the reduction potential for e.g. sensor driven spray systems as a Germany-wide measure; 8b) UBA is not the competent authority for this question (please ask Martin Streloke from the BVL). **PL**: No; 8a) No; 8b) No **CZ**: No; 8a) Yes; 8b) No **AT**: Yes; 8b) No **CH**: Yes (proposal state); 8a) Yes; 8b) Yes; 8c) Financial incentives: precision farming is supported to reduce emissions of PPP. **ES**: No; 8a) No, At the moment, the costs of the precision farming are very high (mapping, SIG processing data technology/machinery for located applications and farmer`s specific formation). These costs cannot be supported by small and medium size farms. In the figure below there is an analysis of size agricultural plots for field crops in Spain. Based in these data, considering high-tech SDRT as label restriction, although interesting, it would not be much extended under national conditions at this moment. To its implementation two conditions should be met: farmer training and a reduction of costs of this technology. Furthermore, to include refinement in the risk assessment based on precision farming. There is a need of implementation and validation a harmonized approach in the current FOCUS models and scenarios and zonal evaluations under regulation 1107/2009. ; 8b) No information found. However, several universities and research institutes have developed several help tools for the adjustment of doses in vines (dosaviña), fruit trees (dosafrut), and citrus (dosacitrus) taking into canopy characterization of these crops with ultrasonic and LIDAR sensors. These tools have been developed in the framework of PULVEXACT and OPTIDOSA projects funded by the Spanish Ministry of Science and Education. **IT**: No; 8a) Yes; 8b) No

GR: No; 8a) Yes; 8b) No

BG: No; 8a) Yes; 8b) No, Remark: No information campaign for farmers, financial incentives, training are implemented in the moment, but such is envisaged in the future.

Appendix 4: List of available methods for vulnerability mapping

Process-Based Methods				
Name of the Model/Method	**Description**	**Have been applied where?**	**Comment**	**Reference**
EuroPEARL	Spatially distributed Model of PEARL	Europe		Tiktak et al. 2004, Journal of Hydrology 289:222-238
EuroPEARL2012	Spatially distributed Model of PEARL	Europe		Waterborne & Syngenta: Poster B21 , York conference 2013
GeoPEARL	Spatially distributed Model of PEARL	Netherland, Austria		
SuSAP - PELMO (version 3.0)	Spatially distributed Model of PELMO	Regione Lombardia Regione Veneto		Life Environment Project (LIFE98/ENV/IT/00010)
MACRO		Case study in England and Wales		Holman et al., 2004

Statistical Methods				
Name of the Model/Method	**Description**	**Have been applied where?**	**Comment**	**Reference**
MetaPEARL	Metamodel of EuroPEARL. Multiple linear regression model that mimics the behavior of EuroPEARL.	Europe	Easy applicable to GIS data	Tiktak et al. 2006, Journal of Environmental Quality 35:1213-1226
Fuzzy logic approach				Dixon, 2005
Bayesian methods	based on the weight of evidence approach (using location of known contamination as training set)			Masetti et al., 2007

Index methods			
Name of Model/Method	**Description**	**Have been applied where?**	**Reference**
DRASTIC	The DRASTIC parameters (Depth to Water, Net Recharge, Aquifer Media, Soils, Topography, Impact of Vadose Zone, Hydraulic Conductivity) are weighted and then summed to come up with a vulnerability rating or DRASTIC index.	USA, Turkey, Japan, Romania	Aller et al. 1987, EPA
EPIK Epikarst, Protective cover, Infiltration, karstic network)	Like DRASTIC it can be classified as PCSM method (see note on index methods). Mainly focused on karst system. Based on additive parameters which are weighted by different coefficients	Spain (Andreo et al., 2006); South German (Neumann, 2008)	Neukum et al., 2008
SINTACS	It is an adaptation of DRASTIC to Italian conditions (infiltration factor instead of net recharge factor)	Italy	Civita and De Maio, 2004
Irish approach	The approach can be classified as MS (see my note on index methods) and produces maps at the scale of 1:50000 with 4 classes of vulnerability	Applied in Ireland	
SNIFFER	MS method based on soil and subsoil properties, lithology and depth to groundwater	???	Ball et al., 2004
GLA (Geologisches Landsamt)	RS method (see my note on index methods) based on the protective capability of the 3 layers (topsoil, subsoil and rock) overlying groundwater	Case study in Spain	Lamelas et al., 2007
COP	RS method which considers several parameters (Concentration of flow, Layers, Precipitation, Karst network)	Case study in Spain	Vias et al., 2006
SINTACS + IPNOA	Based on DRASTIC methodology (see above) to produce a vulnerability map and integrated with a Control Factor based on Soil Organic Matter to produce a hazard (pericolosità) map	Regione Toscana Regione Emilia Romagna	1) Civita M., De Maio M. 2000, 2) Padovani L., Trevisan M. 2002.
SINTACS + PEARL	Two level mapping: 1) Contamination risk map which combines an Intrinsic vulnerability map based on SINTACS (DRASTIC) and a Intensive agriculture zones map; 2) Active substance specific/potential vulnerability map based on PEARL	Regione Calabria	
TOT (Time Of Tavel) + Soil	Combining two maps 1) Time of Travel of a water transported contaminant; 2) Soil capacity to protect	Regione Piemonte	1) Hollis, J.M. 1991.

capacity to protect aquifers	aquifers (soil attenuation capacity)		2) Bove et al. 2003

Appendix 5: GIS data available at European level for vulnerability mapping

The situation regarding pan-European GIS data for use in creating vulnerability maps is clear with a wide range of comprehensive electronic datasets available for soils, climate, cropping, land use, water quality etc. available from the EU Joint Research centre, ISPRA, Italy (MARS climate data, European Soils Bureau) and the European Environment Agency, Copenhagen, Denmark (Corine land use, WISE and WATERBASE water quality data). This data can be used to prepare vulnerability maps at pan-European and probably at national scale with a reasonable degree of confidence.

There are a number of Geoportals available which are always a good starting point to search, view and access different types of GIS datasets. Lists of these web portals including some useful datasets are put together in the following table. However, we make no claim that the list is complete.

Type of information	Name	Source	Datatype	publication date	Weblink
Geo-Webportals					
Geo-Portal	INSPIRE Geoportal				http://inspire-geoportal.ec.europa.eu
Soil data on European level					http://eusoils.jrc.ec.europa.eu/data.
Different geo-spatial data					http://www.fao.org/geonetwork/srv
Statistical data	EUROSTAT				http://epp.eurostat.ec.europa.eu/po
Statistical data	GISCO		Vector	2010	http://epp.eurostat.ec.europa.eu/po
Geology	OneGeology				http://www.onegeology-europe.org/

GIS datasets					
Soil, Climate, Landuse	EFSA spatial data	JRC	Raster, 1km	2013 (ver. 1.1)	http://eusoils.jrc.ec.europa.eu/librar
Soil	European Soil Database ESDB	JRC	Vector or Raster	2006 (ver. 2.0)	http://eusoils.jrc.ec.europa.eu/ESDB
Soil	LUCAS topsoil survey	JRC	Vector (point)	2013	http://eusoils.jrc.ec.europa.eu/proje
Soil	Soil pH in Eurpe	JRC	Raster, 5km	2009	http://eusoils.jrc.ec.europa.eu/librar

Soil	SPADE-2	JRC	Vector (point)	2006	http://eusoils.jrc.ec.europa.eu/proje
Soil	OCTOP	JRC	Raster, 1km	2003	http://eusoils.jrc.ec.europa.eu/ESDB
Soil	Harmonized World Soil Databese HWSD	FAO, IIASA, ISRIC, ISSCAS, JRC	Raster, 30 arc-second	2012	http://webarchive.iiasa.ac.at/Resear
Land cover	CORINE Land Cover	European Environmental Agency		2006	http://www.eea.europa.eu/data-anc
Climate + Meteo	MARS	JRC			http://mars.jrc.ec.europa.eu/mars
Hydrogeology	Depth to groundwater table	GLOWASIS		2013	https://glowasis.deltares.nl/thredds/

Appendix 6: Member State situation for GIS data

The situation at Member State level is much more varied and electronic datasets can be hard to find. Some countries such as France, Germany and Italy have taken an enlightened view and made key datasets freely available in order to ensure that all scientists working in the field of water quality are using the same data. To this end the national hydrography network for France is freely available (http://professionnels.ign.fr/bdcarthage) as are aggregated soil properties datasets at canton level (BDAT, http://bdat.gissol.fr/geosol/index.php) and cropping statistics (http://agreste.agriculture.gouv.fr/). Supporting administrative layers are also available (http://www.ign.fr/institut/lign-lopen-data). In Germany a national soils map is available (three maps considering different land uses, BÜK 1000 N) but this has highly aggregated soils properties data resulting in a limited number of soil profiles representing the whole country. Soils profile data are also available online. Limited long term climate data are freely available (www.dwd.de) and agricultural statistics at community level can be purchased (National Statistics Office) but are reasonably priced. Agencies in the Italian province of Lombardia have also made mapping data available for free (http://www.cartografia.regione.lombardia.it/). Hydrographic, topographic, hydrogeological and land use datasets are available amongst others from this site.

This data can be used to prepare more precise regional or sub-regional maps. Further datasets are available in all countries but these are subject to license agreements and must be purchased. License fees vary depending on the status of the requestor (commercial, research, education) meaning it may be easier for administrators to acquire the necessary data than water companies or private industry.

A more typical situation at Member State level however is that the data is not freely available and must be obtained under license agreements from the appropriate agency. Therefore, for example, soil properties data in the UK must be licensed from the UK National Soils Research Institute (www.cranfield.ac.uk), geology data from the British Geological Survey (www.bgs.ac.uk, limited free data available), ordnance survey maps are obtained from the UK Ordnance Survey (data can be very expensive), Agricultural Statistics from FERA (www.fera.DEFRA.gov.uk), agricultural census data is obtained directly from the national statistics agencies and is free (access to detailed information can be hampered by disclosure issues), land use (datasets available from ADAS and EDINA at limited cost) and weather data from the UK Met Office (www.metoffice.gov.uk, access to data can be costly if a lot is required). Access to data may be even more complex when different agencies are responsible for the data in the different Member States (England, Wales, Scotland, Northern Ireland) and may also be stored in different formats. License fees can vary typically from <£0.1/km^2 of data to >£50/km^2 but access to some datasets may cost more. Datasets (especially state funded) are increasingly available at reasonable cost with discount pricing available for projects seeking to comply with government legislation.

Appendix 7 Questionnaire in off-crop/off-field issues

During the discussions of the 1st MAgPIE workshop, the need to fill gaps and for further refinement of the knowledge on risk mitigation measures in Member States was identified. The working group prepared two additional sets of questions to support the inventory and make the understanding of these measures as sharp as possible. These questionnaires were primarily aiming at getting regulatory authorities feedback. But as common understanding of these issues is critical every contribution was regarded as most welcome. Member States were asked to indicate their preferred options using the figure below and share the definitions they would use if different of the definitions proposed. An update version of this figure elaborated based on the feedback of Member States is proposed in chapter 8.

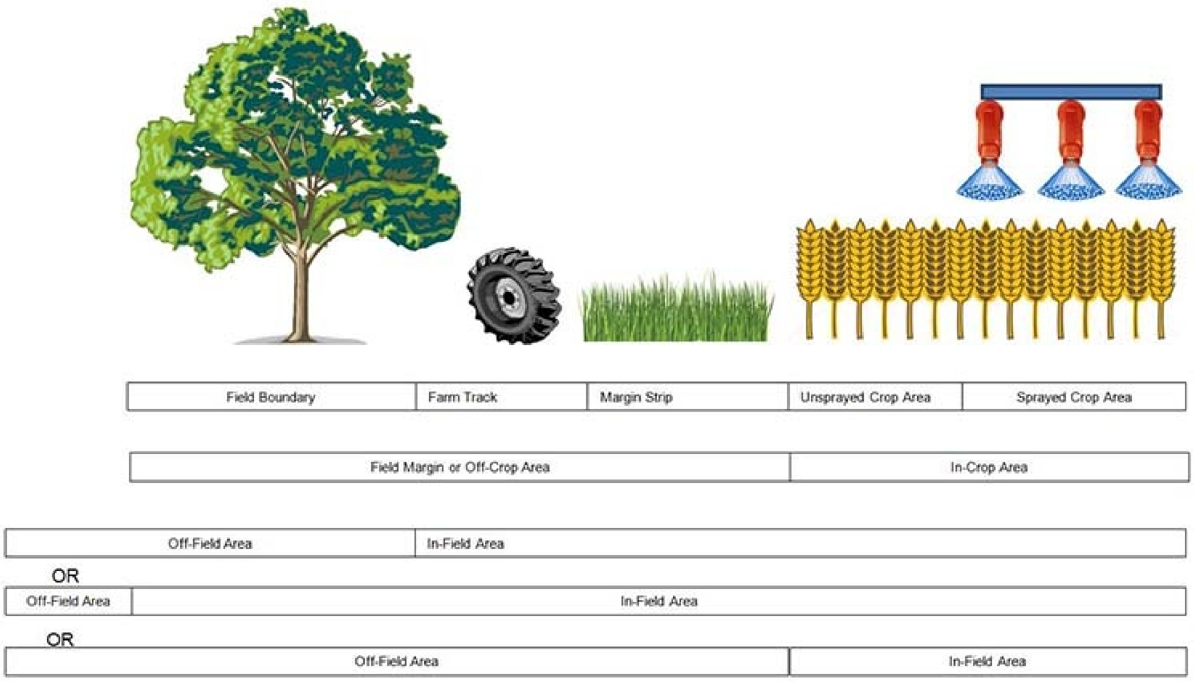

Figure A7.1 Terminology relating to non-target areas

Table A7.1 Compilation of MS answers on questionnaire "Terminology and Definitions"

General question concerning terminology: We are aiming to obtain a common understanding of the terminology relating to non-target areas. Does your Member State agree with the first line of the definitions shown in the below picture?
Synthesis: Agreement on what the crop is. There are concerns regarding what is "in-field" and "off-crop" and what is "off-field" and should therefore be protected from spray drift. We need to define all these areas including figures. IE has a clearer definition of the field boundary and off-field/off-crop

area.
Answers by MS
BE, PL highlight 2nd Off-/In-field definition in the picture
BG, GR do not comment
IT, NO agree
DE disagrees that any of these types of off-crop structures can be defined as being per se a part of the in-field area. In reality, this varies a lot. Hedgerows can be planted on arable land (i.e. private land owned by the farmer) or on common ground. The same applies to tracks or meadow strips. (Semi-) natural structures outside the cropped land should generally be considered off-field non-target areas and protected from spray drift. To my understanding, the category "in-field-off-crop" should be limited to temporal flowering strips and non-cropped buffer zones on arable land.
DK (EPA) agrees with the definitions in the first line, but farm tracks and margin strips are not commonly used in Denmark. Due to this, we define the in-crop and off-crop areas as in the second line.
IE agrees in principle with lines 1, 2 & 3 below. We would slightly adjust the diagram in line 1 to show the field boundary as the centre line of the tree. The Farm Track may or may not be present. In line 2, the field margin extends just to the centre line of the tree. The off-crop area is defined differently to the field margin, as it extends beyond the field boundary. In line 3 we define the in-field area as extending up to the centre line of the field boundary. The off-field area begins at the centre line of the field boundary.
LT comments 'In-Field Area = The in-crop area'

Field Boundary
Proposal: Trees, hedges, fences, walls, ditches (including planted wind breaks)
Synthesis: The definition below is approved: Trees, hedges, fences, walls, ditches (including planted wind breaks), margin strips or farm tracks, however field boundaries are to e considered as off-field (see above)
Answers by MS
BE, BG, GR, LT, NO do not comment
AT, DK, IT agree
DK agrees with the definitions in the first line, but farm tracks and margin strips are not commonly used in Denmark. Due to this, we define the in-crop and off-crop areas as in the second line.
DE 'All of these elements are not necessarily connected with cropped land and should therefore not be defined as field boundaries. Landscape elements as ditches, trees, hedgerows and meadow strips should generally be considered (semi-)natural non-target areas to be protected from spray drift.

IE ‘Field Boundary = Centre line of trees, hedges, fences, walls, ditches (including planted wind breaks)
PL Trees, hedges, fences, walls, ditches (including planted wind breaks), margin strips or farm tracks

In-Field Area
Proposal: The in-crop area plus the field boundary, any farm track and any margin strip (planted or bare soil)
Synthesis: MS rather agree on a definition of the field that corresponds to the crop. Hedges, boundaries, may be either managed or not therefore their status may not be defined a priori. A solution could be to provide advice regarding the precautions to take to the farmer as he knows which boundaries are managed and which are not.
Answers by MS
AT, GR, PL comments In-field area = in-crop area
BE comments ‘Parcel/in-field: cultured surface (with crop); hedges/boundaries with or without vegetation: are excluded so off-field’
BG comments In-field area = in-crop area plus any margin strip (planted or bare soil) if existent
DE disagrees. Off-crop structures cannot be defined as being per se a part of the in-field area. Reality varies a lot. Hedgerows can be planted on arable land (i.e. private land owned by the farmer) or on common ground. The same applies to tracks or meadow strips. (Semi-) natural structures outside the cropped land should generally be considered off-field non-target areas and protected from spray drift. The category “in-field-off-crop” should be limited to temporal flowering strips and non-cropped buffer zones on arable land.
DK, LT, NO do not comment
ES, IT agree
IE comments in-Field Area = The in-crop area plus any farm track and any margin strip (planted or bare soil), as far as the centre line of the field boundary.

Farm track
Proposal: The area used for transport of farm machinery
Synthesis: agreement on the definition, with similar reservation regarding the status as previously.
Answers by MS
AT, IE, IT, PL agree
BE, BG, DK, GR, LT, NO do not comment
DE comments ‘Tracks can be on private or on common land. Most tracks will be on common land; many will be multi-functional and cannot be defined as part of the in-field area’.

Margin Strip
Proposal: Any area of bare soil or grass or wildflower area left untreated with pesticide
Synthesis: agreement on the definition but with similar concerns regarding the status as above, and additional concerns regarding the temporary character of managed ones.
Answers by MS
AT, IE, IT, PL agree
BG comments **'b**ut when consolidates a small land in a big one the margin strips may disappear and also farmer can plowed and sown this area, so we consider this margin strips as a part of in-field area'
BE, DK, GR, LT, NO do not comment
DE comments 'This depends on the type of ground on which these structures are found. In Germany, grass / meadow-strips accompanying tracks are mostly on common ground and cannot be considered as a part of the in-field area. As a general rule, grass or wildflower areas bordering cropped areas should be considered as off-field.'

Unsprayed Crop Area
Proposal: Any area of crop plants left unsprayed with a pesticide
Synthesis: agreement with the definition
Answers by MS
AT, DE, IE, IT, PL agree
BE, BG, DK, GR, LT, NO do not comment

Sprayed Crop Area
Proposal: The area of crop or soil sprayed with a pesticide
Synthesis: agreement with the definition
Answers by MS
AT, DE, IE, IT, PL agree
BG, BE, DK, GR, LT, NO do not comment

Off-Crop Area
Proposal: The area starting at the edge of the cropped area, that is not sprayed with a pesticide

Synthesis: agreement, with the proposal to consider off crop as off field.
Answers by MS
AT, IE, IT, PL agree
BE, DK, GR, LT, NO do not comment
BG comments 'off-crop Area = The area starting at the edge of the in-field area'
DE agreements and comments 'except that the passage "…, that is not over sprayed with a pesticide" should be deleted as a non-cropped area that is intentionally or unintentionally sprayed over is still an off-crop area. Alternatively, the passage could read "Off-field areas are non-target areas and must not be over sprayed.'

Field Margin OR Off-Crop Area
Proposal: The area in the field that is not planted with crop plants
Synthesis: agreement, with the proposal to consider off crop as off field.
Answers by MS
AT, IE, IT agree
BE, DK, GR, LT, NO do not comment
BG comments 'off-crop area = the area in the field that include margin strips plus'
DE Field margin structures can be in-field or off-field. As a general rule, they should be considered off-field. Again, the category "in-field-off-crop" should be limited to temporal flowering strips and non-cropped buffer zones on arable land.
PL comments 'off-crop area = off-field area'

In-Crop Area
Proposal: The area sown with the crop plants, including the space between the crop rows
Synthesis: agreement on the definition
Answers by MS
AT, DE, IE, IT agree
DK, BE,BG, GR, LT, NO do not comment

Off-Crop Area

Proposal: The area surrounding the in-field area, excluding neighbouring in-field areas
Synthesis: agreement on the definition
Answers by MS
IE, IT agree
DK, BG, BO,,GR, LT, do not comment
AT agrees and comments 'excluded: Field boundaries and margin strips of less than 3 m width (taken from comments on illustration)
BE comments 'Parcel/in-field: cultured surface (with crop); hedges/boundaries with or without vegetation: are excluded so off-field'
DE comments 'this definition is problematic when hedgerows etc. are defined as part of the in-field area. In that case, trees, hedgerows etc. planted by a neighboring farmer would possibly not be considered as an area deserving protection from spray drift.
PL comments 'The area surrounding the in-field area, excluding neighboring in-crop areas'

Question 1: Are all the off-crop / off-field areas (pending on your definition) considered as to be protected or does your Member State distinguish off-crop / off-field areas according to the expected level of protection (i.e. are roads, farm tracks, etc considered as different to vegetated strips)? Are managed boundaries, or boundaries created for risk management purposes (i.e. wind break) or horticulturally used areas considered equivalent to non managed natural boundaries? If yes please define the categories of off-crop / off-field area and if defined in your country, please provide your definition of the related protection goals for each off-crop area category	
Synthesis: agreement as yes (all off crop areas are to be protected in the same way). Some countries report exceptions for agriculturally or horticultural used areas (neighboring fields), paved roads/paths, constructions, industrial areas etc	
BG, ES, GR, NO	say no.
AT	Definition of protected off-crop: see above, no further definitions are available
BE	In risk assessment on national level, only the distance from the sprayed crop area is considered, without further specification of the nature of the surrounding area. Risk must be acceptable outside the 1 or 3 meter standard buffer zone (see point 2.), or the product/substance specific larger buffer zone, but not (necessarily) inside that buffer zone. In Belgium buffer zones are only installed for the protection of surface water. The buffer zone can be part of the parcel, or outside. Hedges: not considered to be part of the parcel.
CZ	Roads and permanent tracks, constructions, industrial areas etc. are not considered as protected areas.
DE	Generally, all types of adjacent areas (areas bordering to the cropped area) are considered to deserve protection from spray drift with the exception of agriculturally

	or horticulturally used areas, roads, paths and public places.
DK	The only off-crop areas that has to be protected is §3-habitats as in the Danish Protection of Nature Act (e.g. salt marshes, meadows, heath, dry grassland and bogs). These areas are known by the farmers. On the label will be put: “To protect non-target arthropods/plants respects an unsprayed buffer zone of (distance) to non-agricultural §3-habitats”.
IE	no defined policy in this area
IT	YES, we do not distinguish among different off-crop areas when setting RMM. Managed and non-managed boundaries are considered equivalent in the risk assessment.
LT	On national level in field area=in crop area and off crop area considered as to be protected.
PL	We only consider the impact of ppp on in-field and off-field area which means we don’t differentiate off-fields areas in any way.
UK	All off-crop/off-field areas are afforded an equivalent degree of protection (the law requires that pesticide users must ensure that chemicals are applied to the target area).
NL	Agree with the first line of the definitions. At this moment we prefer using the terms ‘in-crop’ and ‘off-crop’ because we think it’s the most explicit way of expressing what is meant. Mitigation measures like wind breaks preventing drift to surface water are excluded as protection goal. For flowering buffer strips to stimulate ecosystem services, this point isn’t clear yet.

Question 2: What is your Member State definition of a Buffer Zone? Does this currently only relate to aquatic situations or is the term Buffer Zone also used in relation to non-target areas? What size(s) of Buffer Zone do you specify (please precise the boundaries)? What kind of agricultural management is allowed in the buffer zone?	
Synthesis: Buffer zones have been defined primarily alongside water bodies but are now progressively defined for NTAs and NTPs. It usually starts at the edge of the field and is of a defined width (1 to 50 meters). One country reports that the buffer zone is in-field cropped (“crop are allowed”) but defines them at the edge of the crops. An unsprayed buffer zone can be specific for different pesticides, and can be part of the crop. E.g. Use of insecticide requiring 5m buffer zone, but herbicides and fungicides used on the buffer zone as none may be required.	
AT	Buffer zones: Distance (not sprayed, but can be in-field or off-field area) to protected areas. Only related to aquatic water bodies as drift reducing nozzles are used for non-target plants and non-target arthropods Buffer zones to aquatic water bodies: 1 or 3 m regular distance, 5, 10, 20, 30, 40, 50 m
BE	Only for the protection of aquatic organisms. A buffer zone for the protection of non target aquatic organisms is a non treated strip between the treated area and surface water as well as surfaces where a large risk for run off towards surface water exists.

	The water body includes the shore of the water surface, where the slope becomes the ground level (top of slope). Surface water can be permanent or temporary. Size: minimum 1 meter for horizontal crops (crops sprayed vertically downward), and 3 meter for other crops (except for protected crops, post harvest). If larger buffer zones appear to be required in order to fulfill the requirements for registration as set by the regulation (1107/2009), then these are mentioned on the authorization certificate and thus mandatory. Use of drift reducing means or measures can reduce the required buffer zones (conversion tables are available). Maximum buffer zones: 20 meter for horizontal crops, 30 meter for vertical crops, possibly taking drift reducing means or measures into account (in practice: max. 20 meter buffer zone with 90% drift reduction or max. 30 meter buffer zone with 90% drift reduction). Updated tables exist for risk reducing potential (%) of nozzles and hedges. The only specification for the buffer zone is that no plant protection products can be applied in that zone.
BG	Buffer zone is the area starting at the edge of the in-field area and the area of protection. Buffer zone used in relation to aquatic situation and also for non-target areas. Size of Buffer zone is at least 5 m up to 30 m (vine and orchards). This definition is use only by the evaluators and it’s not specified in any law.
CZ	There is no common definition. Non-target areas are defined by the law (Art. 49 (§(1)), 52a, 52b of Act 327/2009 Coll. and Art. 13 of the Regulation 327/2012). . There are a scale of different areas, where any PPP may be used, with different management practices.
DE	An exception is that adjacent areas (e.g. field boundaries, hedges, groups of woody plants) which were demonstrably planted on agriculturally or horticulturally used areas are not a subject to risk mitigation measures. This exception was established in order to encourage farmers to plant (or at least keep) hedgerows on their ground. However, the exception has been critizised as it is not always known (and thus not controllable) how the land under the hedgerows was used before the planting. Therefore, a revision of this rule is currently discussed.
DK	The buffer zone is an unsprayed buffer zone in-field, where crops are allowed. The sizes of the buffer zones is: 1, 5 and 10 m for field crops and vegetables/ornamentals/small fruit < 50 cm 3, 5 and 10 m for fruit crops, grapevine, hops and vegetables/ornamentals/small fruit > 50 cm The distances is measured from the edge of the field (crops).
ES	No definition for buffer zone is set out in our regulation. We use buffer zones for aquatic protection and also for off-crop areas. We specify from 5 until 50 meters buffer zones. No specific management is established
GR	The term buffer zone is related to aquatic, non-target arthropods and non-target plants. For aquatic organisms: Buffer zones from surface waters: As buffer zone is defined the distance between the limit of the cultivated field/ orchard and the surface waters. The maximum buffer zone proposed is 40 m for orchards, vines and leafy crops and 20 m field crops. Non-target arthropods: As buffer zone is defined the safety distance between the limit of the cultivated field (fences included) and the inner side of the cultivated field/ orchard. Buffer zone distance needed to ensure acceptable risk to non-agricultural land is 10 m for orchards and vines and 5 m for field crops and leafy crops Non-target plants: As buffer zone is defined the safety distance between the limit of the cultivated field (fences included) and the inner side of the cultivated field/ orchard. Buffer zone distance needed to ensure acceptable risk to non-agricultural land is 10 m for all crops.
LT	1. Buffer zone used by Plant Service to protect non target arthropods and non-target plants are

	from 5 to 30 m and it is in field; it is usually cropped; it is enforced by authorities of a defined width and it is unsprayed crop area. 2. Buffer zone is defined for surface water. Costal buffer is a surface water body coastal greenery (trees, shrubs, perennial grasses) stretch, in which economic and other activity is limited. In costal buffer zone it is prohibited to use fertilizers, pesticides or other chemicals, to plough or use the land for rural work. 3. The buffer protection zones ;The buffer protection zones are to be established on the State strict nature reserves, the State parks, biosphere reserves, the heritage objects, in order to preserve the visual environment of these areas, in order to reduce the negative activity impact against them, and such zones may be established for the State nature resorts. The buffer protection zones are established when approving the special planning documents (limit plans) of the preserved areas. The following is prohibited in buffer zones of the nature reserves: 1) to install new quarries of mineral resources; 2) to change hydrological regime; 3) to use fertilizers and pesticides on non-farming lands; 4) to lumber mainly using smooth slashing in 300 meters wide zone around the nature reserve.
NO	Only uses buffer zones as a no-spray zone near open surface water. Specifies 5, 10, 20 or 30 meters (from the water edge) on the product label, if necessary. The only restriction is no spraying.
PL	We establish buffer zones according to the outcomes of risk assessment for every ppp. Buffer zones can be both to protect water bodies or NT arthropods or NT plants. Buffer zones are defined as the distance/area between the edge of a field and the water body (top of the bank) or the distance/area between unsprayed crop area and non-agricultural land. No specific agricultural management requirements.
UK	A buffer zone is area of land, usually adjacent to a watercourse or other designated feature, which must not be directly oversprayed during the application of a pesticide. Buffer zones most commonly relate to aquatic situations, but in a small number of cases are also used to protect terrestrial organisms. Until relatively recently buffer zones were fixed at 5m for horizontal boom sprayer applications and 20m for broadcast air-assisted sprayers – set on a product basis. The UK regulator has, however, introduced new arrangements for horizontal boom sprayers with buffer zones of up to 20m being set on an individual crop basis. The pesticide regulatory regime does not specify management arrangements for buffer zones. Buffer zones established under Agri-Environment Schemes specify a number of management conditions, including restrictions on pesticide applications (for example: only allowing spot treatments to certain areas of land; no applications within 2m of hedgerows, or centres of ditches; prohibiting use in beetle banks).

Question 2.1: If buffer zones are used in relation to non-target areas, what about landscape features (hedgerows, flower strips, wind breaks) that the farmers plant themselves “in-field”?. Does an Unsprayed or No-Spray Zone or a Buffer Zone also apply in these cases (please precise the boundaries)?
Synthesis: MS report a low implementation of landscape features therefore no buffer zone apply. Some countries report no buffer zone restriction apply to landscape features belonging to the farm or that the width of the landscape features matters (restictions >=3m).

AT	In case the landscape feature has a width less than 3m, a no-spray zones does not have to be respected
BE (Flan)	Hedges are considered to be off-field, but contribute to reduction of spray drift (percentages of reduction are given in a document on website Belgian Pesticide service: http://www.fytoweb.be/NL/doc/water%20sept%202006.htm, click on 'list van drift reducerend materiaal')
BG	In the label, up to a maximum size allowed is 30 m but recommendation is given to reduce this size using the available and relevant risk mitigation measures.
CZ	Depends on the type of landscape features. In most cases it depends on the farmer what type of management he chooses.
DE	In Germany, no-spray zones are used to mitigate spray drift to aquatic and terrestrial non-target areas. The cut-off point is the margin of the crop. In the no-spray zones, there is no restriction to any other agricultural measurement. For terrestrial non-target areas, only a 5 m buffer zone is specified. For water bodies, buffer widths of 5m, 10m and 20 m are specified. The edge of water body is defined as the upper edge of the inclination of the river bank.
DK	No, only to the areas specified under question 1.
ES	The distance for a buffer zone to non-target areas is established in 1, 5 or 10 meters, regardless of what exist in these non-target areas.
GR	Does not comment
IE	In field landscape features such as these may be included within the Buffer Zone.
IT	No. The function of hedgerows located within the buffer zone in preserving biodiversity and as refuge for arthropods is mentioned in the national "aquatic" mitigation measures guidance. No specific guidance available for non-target areas.
LT	Other features not legally enforced
NL	Flower strips and wind breaks are in this case not a protection goal.
NO	Does not comment
PL	Hedgerows, flower strips or wind breaks are not common in PL. In the assessment their existence is not taken into account.
UK	Yes in the case of watercourses.

Question 3: What is your Member State definition of specific vulnerable areas in terms of environmental protection (e.g. nature protection sites, species; dwelling zones)?
Synthesis: MS consider Natura 2000 and in IE Natural Heritage Areas (NHA), Special Areas of Conservation (SAC), Special Protection Areas (SPA), areas and a variety of other areas, at the national level (drinking water supply, hospitals etc).

AT	Natura 2000 areas (nature protection areas established under the 1992 Habitats Directive or 1979 Birds Directive or both) Nature protection measures in connection with Cross Compliance
BE (Flan)	The Habitats Directive (more formally known as Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) is a European Union directive adopted in 1992 as an EU response to the Berne Convention. It is one of the EU's two directives in relation to wildlife and nature conservation, the other being the Birds Directive.[1][2] It aims to protect some 220 habitats and approximately 1,000 species listed in the directive's Annexes. Annex I covers habitats, Annex II species requiring designation of Special Areas of Conservation, Annex IV species in need of strict protection, and Annex V species whose taking from the wild can be restricted by European law. These are species and habitats which are considered to be of European interest, following criteria given in the directive.[3][4] The directive led to the setting up of a network of Special Areas of Conservation, which together with the existing Special Protection Areas form a network of protected sites across the European Union called Natura 2000.[1][2] Article 17 of the directive requires EU Member States to report on the state of their protected areas every six years. The first complete set of country data was reported in 2007. In Flanders the directives are implemented in the law of 21/11/1997 concerning the protection of nature.
BG	According to the Law on Biodiversity Bulgaria Establishing a national ecological network, including Protected areas as part of the European ecological network "Natura 2000", which may include protected areas - are intended to preserve or restore the favourable conservation status of the included natural habitats and species in their natural range (BIODIVERSITY ACT & The Protected Areas Act). Protected areas which do not fall within the protected areas (Natura 2000) - Protected areas for the conservation of biodiversity in ecosystems and the natural processes occurring in them, as well as typical or remarkable objects and landscapes. Categories of protected areas are: 1. Wildlife sanctuary; 2. National Park; 3. Natural phenomenon; 4. Maintained Wildlife sanctuary; 5. Nature Park; . Protected area. stems and the natural processes occurring in them, as well as typical or remarkable objects and landscapes. CORINE sites, Ramsar sites, Important Plant Areas and Important Bird Areas. All these areas aimed at conservation and sustainable development
CZ	Definition given by specific legislation on the environmental protection (regulations for national parks, protect areas and national parks)
DE	Nature protection sites and areas for drinking water abstraction are doubtless vulnerable to damage caused by PPP application. In Germany, however, no specific restriction are defined for such areas in the context of the authorisation of a PPP. Rather, use-restriction are issued on a local level for the single areas.
DK	§3-habitats (areas defined under question 1) Nature 2000 areas

ES	Specific vulnerable areas are: water extraction areas (to human consumption), habitats' protection areas, aquatic species' protection areas and other species' protection areas.
GR	The definition of vulnerable areas according to the draft National Action Plant (NAP): Hospitals, charitable institutions, playgrounds, campsites and other recreational facilities, schools and educational institutions, sports facilities, public parks, Hotels, camps, archaeological and tourist sites, Cottages outside the city, houses in the city Amenities except parks Natura 2000 areas
IE	In Ireland, there are a number of specific designations of vulnerable areas, such as Natural Heritage Areas (NHA), Special Areas of Conservation (SAC), Special Protection Areas (SPA), Protected Areas and Natura 2000 areas These are designated under EU legislation such as the Water Framework Directive, Birds Directive & Habitats Directive. In addition, under the SUD National Action Plan, certain designated areas are subject to restrictions on the use of PPPs.
IT	Specific definition being developed in updating the National ACTION Plan provided by the EC directive 128/2009.
LT	"Protected areas" shall mean the land and/or water areas which have clearly defined boundaries, an acknowledged scientific, ecological, cultural and other value and for which a special protection and use regime (procedure) has been introduced by legal acts. Lithuanian system of protected areas includes: Strict reserves and reserves National and regional parks Biosphere reserve and polygons European ecological network "Natura 2000" Any economic activities are prohibited in strict reserves, limited agrarian activity zones are in other areas.
NL	No information on this issue
NO	No definition.
PL	Nature protection sites (national parks, nature reserves), plantations of herbs and spices, habitats of plants covered by species protection, apiaries, drinking water abstraction areas.
UK	There is no formal definition of vulnerable areas. A working definition would be: from an environmental perspective, all water bodies and nature conservation areas; and from a human health perspective those areas inhabited by 'vulnerable groups' as defined in Article 3 of Regulation (EC) no. 1107/2009.

Question 4: Does your Member State specify the use of a No-Spray Zone, a Buffer Zone or Special restrictions for these vulnerable areas? If so what size of zone is required in these cases (please precise the boundaries)?
Synthesis: MS have various approaches. Beside specific precautions regarding the use of the land in protected areas (also groundwater), some specific protections may be defined as for example specific buffer zones around houses, hotels etc. Other countries do not distinguish these area from others which are to be protected anyway.

<table>
<tr><td>AT, NO</td><td>No</td></tr>
<tr><td>BE (Flan)</td><td>In the decree specific zones are determined and in the reserve it is prohibited to use pesticides, the use of non selective pesticides that are harmful for the protected species are forbidden.
It’s foreseen in the Flemish action plan Sustainable use to establish a buffer zone when necessary.</td></tr>
<tr><td>BG</td><td>Coincide with product risk mitigation measures</td></tr>
<tr><td>CZ</td><td>There are no permanent buffer zones in these areas at present. It is established on case-by-case basis.</td></tr>
<tr><td>DE</td><td>Non. See above.</td></tr>
<tr><td>DK</td><td>§3-habitats: As defined under question 1 (only in relation to RMM during the risk assessment)</td></tr>
<tr><td>ES</td><td>In those vulnerable areas the specifications set in regulation are: use of low risk PPP and biological control measures. In the vulnerable areas where water extraction points or pozos for drinking water exist, a 50 meters (minimum) buffer zone to surface water bodies and wells is mandatory.</td></tr>
<tr><td>GR</td><td>According to the draft National Action Plant (NAP):
<table>
<tr><th rowspan="2">Vulnerable areas</th><th colspan="3">Low drift nozzles</th><th rowspan="2">Conventional nozzles</th></tr>
<tr><th>PPP classified as T or T+</th><th>PPP classified as Xn or Xi</th><th>PPP without classification</th></tr>
<tr><td>Hospitals, charitable institutions, playgrounds, campsites and other recreational facilities, schools and educational institutions, sports facilities, public parks</td><td>500 m</td><td>200 m</td><td>50 m</td><td>1000 m</td></tr>
<tr><td>Hotels, camps, archaeological and tourist sites</td><td>200 m</td><td>100 m</td><td>Without limitation</td><td>500 m</td></tr>
<tr><td>Cottages outside the city,</td><td>50 m</td><td>3 m</td><td>Without limitation</td><td>100 m</td></tr>
<tr><td>Houses in the city</td><td>100 m</td><td>50 m</td><td>Without limitation</td><td>500 m</td></tr>
<tr><td>Amenities except parks</td><td>50 m</td><td>3 m</td><td>Without limitation</td><td>500 m</td></tr>
</table>
In the Natura 2000 areas a specific plan of pest control will be proposed taking into account:

The crops of these specific areas and the need of pest control
The biological control measures of pests, diseases and weeds,
The low-risk pesticides that may be used,
The justification of the necessity of using other pesticides, except for low risk ones
The ecosystem and the risk of the use of plant protection products
Data and studies on adverse effects of pesticide use in these specific areas,

</td></tr>
</table>

	• Control measures for use in conjunction with the management bodies of protected areas and • The specialized indicators for monitoring the use of pesticides in these areas The specific plan of pest control will be submitted for approval to the National Competent Authority and will be reviewed every five (5) years or sooner if necessary.
IE	There are general restrictions on the types of PPPs that can be used in the designated areas listed at point 3 (above), and these may include no-spray zones. The size of the no-spray zone is determined by the relevant authorities. In some cases, authorization of a relevant authority must be received to use PPPs in these designated areas. For water abstraction points, no-spray zones range from 5m to 200m, depending on the volume of water abstracted and/or the number of people to whom water is supplied. For ground-water vulnerable areas (including karst areas, sink-holes and collapse features), there is a no-spray zone of 15m.
IT	Restrictions are being developed in updating the National ACTION Plan by the EC directive 128/2009. Some site specific provisions are given on case by case basis (e.g. no spray zone for dwelling areas).
LT	There are special restrictions for example, prohibited following activities: meadows or pastures turn into arable land or re-sowing them cultural grass; installation of drainage and irrigation systems; the use of fertilizers, plant protection products or liming agricultural land;
NL	In the NL there are Groundwater protection areas where the use of certain products is prohibited. At regional level it's indicated where these specific areas are located.
PL	20 m for above mentioned areas (or a wider zone if required on the basis of risk assessment outcome) - till the beginning of 2014. After that date any restrictions (mitigation measures) will be based on the outcome of risk assessment for a particular ppp. However for drinking water abstraction areas it will be still required to observe a non-spray zone established according to Polish Water Law.
UK	Buffer zones are established to protect watercourses when this is necessary to control exposure and reduce risk to acceptable levels. Where pesticide applications take place in or close to certain nature conservation areas additional restrictions may be requested by conservation authorities – they may include prohibition of use in particular areas or the use of buffer zones.. If a buffer zone would be required to control exposure of human beings and reduce risk to acceptable levels products are not authorised.

Question 5: Does your Member State specify the use of a No-Spray Zone, a Buffer Zone or other explicitly to protect biodiversity? Are these set up in addition to RMM to organisms in the scope of product risk assessment (aquatic organisms or NTA) or are they independent? Please precise the boundaries. If so, what sizes of Zone is required.
Synthesis: No, in one country case-by case.
AT, BE (Flan), BG, DK, GR, NO, UK say no

CZ	There are no permanent no-spray zones
DE	Currently, no specific risk mitigation measure for the biodiversity of farmland plants, insects and birds and mammals (affected indirectly) is established. However, this considered to be urgently needed in order to protect biodiversity, especially the populations of farmland bird species.
ES	No. (see new law ENP)
IE	The authorities designated to control the specially designated areas listed at point 3 above may specify no-spray zones when authorising PPP use. (No-spray zones are independent of product risk assessment.)
IT	Not at present. Restrictions are being developed in updating the National Action Plan by the EC directive 128/2009.
LT	Does not specify the use of a no spray zone to protect biodiversity.
NL	The crop free zone to protect aquatics is independent but if the level of protection is not sufficient in case of a certain PPP, the label of the PPP indicates what additional measures have to be taken.
PL	We use non-spray zones depending on the outcome of the risk assessment. No specific zones are set in case the risk assessment demonstrates low risk without risk mitigations measures.

Question 6: Does your Member State specify the use of a No-Spray Zone or a Buffer Zone under any other legislation e.g. Biocides that could overlap with RMM for pesticides? If so, what sizes of Zone is required (please precise the boundaries).	
Synthesis: In general no specific buffer zones are defined for biocides. Exceptions are noted where biocides are considered as part of pesticides (1 country) or for the protection of drinking water abstraction area (1 country).	
AT, GR, LT, NO say no	
BE (Flan)	Pesticides= plant protection products and biocides, the rules are the same.
BG	At least 50 m buffer zone to areas for drinking water abstraction (SW and GW) for unprotected water sources in groundwater bodies and 5-15 m buffer zone to areas for drinking water abstraction for sources in protected water bodies and water sources located in the regulatory boundaries of the settlements (under National water law, Ordinance № 3)
CZ	There are no permanent no-spray zones
DE	No overlap / conflicts known.
DK	Buffer zones are not used in the biocides legislation. We are not aware of any other legislation with buffer zones.
ES	No answer received

IE	No-spray zone under Birds Directive, Habitats Directive, Water Framework Directive, as listed above.
IT	A buffer zone is established under CAP policy. For inorganic fertilizers 5m from surface water.
NL	Yes, as part of the environmental legislation, with a base line of crop free zones for protecting aquatic organisms (as mentioned before). And in addition to this, an extra crop free zone indicated on the label of a PPP if non-target organisms are not protected sufficiently.
PL	Does not comment
UK	Buffer zones area is a condition of cross compliance under agri-environment schemes. Farmers have the option of establishing 12m buffer zones adjacent to watercourses

Question 7: How does your Member State communicate risk mitigation tools to the farmers (e.g. training, information distribution, i.e. winter schools)? Is this done on or off the farm?	
Synthesis: Most countries report training either through courses or on-line training. Four report the implementation of certification processes, already implemented or underway.	
AT	It is part of the training course for farmers to obtain a certificate of competence
BE (Flan)	Web application: http://lv.vlaanderen.be/nlapps/docs/default.asp?id=130 Guideline Good Agricultural Practices- Nature Training is given by conferences, lessons and demonstrations.
BG	Off farm training, workshops, seminars, information campaigns, fairs
CZ	Mostly done off the farm. Regular seminars, leaflet distribution, internet pages and proficiency courses.
DE	Federal Level: Label phrases, specific online information material on "plant protection & environment" (http://www.folienserie.agroscience.de/); State level: seminars, workshops, information campaigns
DK	Label phrases.
ES	In the PPP label
GR	RMT are communicated to the farmers by the regional units-control authorities and the label. According to the draft National Action Plan farmers will be trained.
IE	Specific risk mitigation measures are detailed on PPP labels. Training of new entrants to agriculture is carried out by agricultural colleges. The state agricultural research and advisory body (Teagasc), independent agricultural consultants, and merchants and suppliers of PPPs provide information and training to farmers. Most of these activities are carried out off-farm, but some are carried out on-farm. A voluntary scheme called IASIS provides training and relevant information to agricultural advisors & retail distributors of PPPs. As part of the SUD NAP, from November 2015, only trained and registered professional users will be allowed use PPPs authorized for professional use. The training provided in this

	context will include training on risk mitigation measures.
IT	Training for professional use. Public and private information distribution both in and off the farm. Product label. National guidance “Risk mitigation measures for the reduction of surface water contamination from spray drift and runoff” (2009) in the official Health Ministry’s web site.
LT	Lithuanian agricultural advisory service carry out farmers’ education both according to formal (prepared training programs, e.g. safety at work courses related with agriculture, participants of which are awarded the state recognized qualification) and informal curriculums (seminars, field days, courses, demonstrational trials, etc.). MoA (ministry of agriculture) subsidy is allotted for the latter. Other events organized for farmers’ continuous vocational training are commercial ones (e.g. safety at work, plant health courses) or financed by the European Union and the state funds according to the training programs registered by MoA.
NL	A well established system exists in which all farmers need a certificate. Aim is to reduce the use and dependency of PPPs and to reduce risks (environmental, human). Renewal certificates each 5 years requiring 5 comprehensive courses, with subjects like risks for non target organisms, IPM etc. Can be done both, on and off the farm
NO	Through the obligatory training needed to be certified to buy and use plant protection products. No-spray zones etc. are specified on the product labels.
PL	Mandatory trainings for professional users including RMM issues.
UK	Risk mitigation is communicated to farmers by a variety of means including: compulsory and voluntary training programs; advice; and articles in trade journals.

Question 8: Are you aware of farm or crop assurance schemes (of retailers, grower associations) or other environmental schemes (e.g. CAP) in your Member State which are actually applied in practice and address the establishment of buffer zones, ecological compensation areas, etc. on the farm?	
Synthesis: Several countries report the implementation of buffer zones through the certification system or to protect area from the transfer of fertilizers. In Ireland, two voluntary schemes are reported as a complementary.	
AT, BE(Flan), BG, DK, ES, NO say no	
CZ	Yes. There are several environmental schemes subsidized by the EU or nationally which relate to establishment of buffer zones and ecological compensation systems.
DE	In Germany, the Federal States are responsible for the management of the rural development in the frame of the CAP. In that context, the Federal states run specific programs, including funding of flowering margins, no-spray zones and other measures to protect the environment
GR	Several private certification schemes such as GLOBALGAP, AGRO 2.1-2.2 (national schemes) etc. which are applying Good Agricultural Practice include establishment of buffer zones.
IE	Crop Assurance Schemes - The Bord Bia Quality Assurance Schemes, Irish Grain Assurance Scheme & Global GAP all prescribe that PPPs be used in accordance with the legal stipulations

	on the PPP labels, including buffer zones where stated. Environmental Schemes – The Rural Environmental Protection Scheme (REPS) prescribes 1.5m no-spray aquatic buffer zones as a standard condition of the scheme, and larger 2.5m aquatic buffer zones as an option within the scheme. Another voluntary environmental scheme (AEOS) – provides for a 3m margin strip along all boundaries of an arable field, and a 3m, 5.5m, 10.5m, or 30.5m riparian margin, on which pesticides may not be applied. Both of these schemes are voluntary, and very few farmers who use medium to large quantities of PPPs are members of these schemes.
IT	Yes (CAP, integrated pest management).
LT	According Lithuanian Law on protected areas." Where a protected area is established, the status of an existing protected area is changed, activity restrictions are established or modified by a state institution, compensation shall be paid from funds of the State budget, and where a protected area is established, the status of an existing protected area is changed, activity restrictions are established or modified by a municipal council, compensation shall be paid from the budget of a municipality."
NL	No answer received
PL	There are regions in Poland where vegetated buffer zones have been established (2-5m) to protect against fertilizers run-off. Those actions act independently to the ppp label restrictions as the label may require to observe a different width of buffer zones.
UK	Crop assurance schemes highlight the importance of taking environmental protection into account when applying pesticides.

Appendix 8 Compilation of Member States answers on the questionnaire ‘managed and natural recovery areas as off-crop/off-field risk mitigation tools’

The aim of this questionnaire was to complete the knowledge on existing and intended risk mitigation tools for off-field areas in the Member States.

Off-field areas can serve as space for recovery of agro ecosystem wildlife and be a source of recolonisation of the in-field area. According to the feedback received on the questionnaires for MAgPIE 1 & 2 we feel, that there have are already been experiences with managed and natural recovery areas as off-field risk mitigation tools. We need to learn more on this topic from stakeholders to map out and evaluate the current situation.

Off-field recovery areas can be managed or unmanaged non sprayed vegetated strips, wildlife corridors, habitat patches, conservation buffers, greenways outside but in a certain proximity (spatial relation) to the agricultural fields.

Question 1: Are agricultural landscapes in your country considered sufficiently equipped with off-field areas to compensate for in-field effects and to safeguard biodiversity? If yes please briefly describe how is this accessed?
Synthesis: Four of five countries consider the countries’ agricultural landscapes as not sufficiently equipped especially not in landscapes with intensive cropping systems.
Answers by MS
BG, CZ consider the countries’ agricultural landscapes as not sufficiently equipped
DE and **NL** refer to the countries’ agricultural landscapes with an intensive cropping system to be considered as not sufficiently equipped
IE consider the countries’ agricultural landscapes as sufficiently equipped. IE comments ‘IE is characterized by a number of factors that help compensate for in-field effects and safeguard biodiversity. Overall land-use pattern - a high proportion of Irish agriculture is low-input grassland farming, with very low levels of PPP use. Large areas of monoculture are not a feature of Irish agriculture. The reasons for this are as follows: - Small average farm size. - Small average field size - A high degree of fragmentation of farm holdings. - Widespread short-term renting of land.

Large areas of contiguous land are very unlikely to be treated with the same PPPs. Land treated with any given PPP is very likely to be adjacent to land not treated with that, or any, PPP. This greatly increases the potential for recovery of populations of non-target species. The Irish landscape is characterised by an abundance of hedges, and in particular large volume hedges, which serve as habitats for many species.

Question 2: Are measures that consider compensatory mechanisms of off-field recovery areas currently applied in your country? If yes, which type of landscape elements are considered off-field areas serving compensatory mechanisms? Which size of off field recovery areas compare to in field areas? Which spatial distance is accepted between off field and field areas? How is the measure communicated to the farmer? How is the farmer's perception? Can you list literature describing the measures?
Synthesis: In one country a system is established to consider compensatory mechanisms of off-field recovery areas.
BG, CZ , IE, NL say no
In 2002 **DE** introduced a system called 'Index of regional proportions of ecotones'. The tool helps to access, if agricultural landscapes are sufficiently equipped with off-field areas to compensate for effects of pesticides and to safeguard biodiversity. The approach is described in RMMTS#10 (landscape-dependant buffer zones).

Question 3: Do you intend to implement such measures in future? If yes, please briefly describe leverages (regulatory framework, scale of implementation i.e national, farmland) and within which timeline? If no, for which reason? Is it due to in-field measures, lack of feasibility or for any other reason? Please briefly describe:
Synthesis: The intentions vary from MS to MS.
BG comments to prefer an initiative on this issue on EU level and would support this.
NL comments that the new strategy in the Netherlands on sustainable crop protection (2013-2023) intends to stimulate farmers on voluntary base to the growing of flower strips. If possible, with financial compensation from the CAP.
CZ comments that this issue is still under discussion. It is considered to be implemented within CAP greening program and IPM in the next five years.
DE comments to currently review the methodology of its approach and thinks of extending it to explicitly safeguard biodiversity.
IE comments not to intent an implementation for the reasons mentioned in the answer to question#1.

Question 4: Do you consider that off-field recovery areas may be integrated into the risk assessment process? If yes, which one and how? If no, for which reason?

Synthesis: There is a general agreement, that off-field recovery areas could/should be integrated into the risk assessment process, but implementation is considered to be difficult.
BG comments not having identifies this issue yet.
NL comments that 'NL accepts in-crop effects if recovery takes place within 1 year. For off-crop we only accept short term effects (recovery within a short time)'.
CZ comments no and amends that 'there is still no harmonization so it is very difficult to specify the way of taking into account this measure into the risk-assessment'
DE comments yes.
IE comments yes and believes 'that in some cases there may be value in this. We are not sure how to approach the issue. The issues to consider are hugely complex, with many species with diverse life-cycles, generation times, specific habitats and other characteristics.'

Appendix 9 Additional recommendations with regards to seed mixes to be used for sown wildflower mixes, pollen and nectar mixes in order to promote and maintain bee populations

There are several seed mixtures on the market, which have been designed for supporting pollinators in agricultural landscapes. All seed mix may however not have the same beneficial effect in every crop or agricultural landscape. Seed mixtures designed for northern climates may be not adapted to climatic conditions in warmer regions or vice versa, the plant species used in the mixture may not attract specific pollinators for the crops etc. Therefore, some preliminary aspects have to be considered before using these mixtures. In the following, advice given in several studies is summarized (Lemoing and Pasquet 2011, Marshall at al. 2001, Nicholls and Altieri 2012, Pontin et al. 2005).

There are some key attributes of plant species important for pollinators:

Species per se: generalist pollinators may forage on a wide range of different plant species, while oligolectic pollinators (*i.e.* specialized on single plant species or families) need specific plants as pollen sources. In addition, certain anatomic structures of flowers attract different pollinator species (*i.e.* blue zygomorphic flowers attract bumblebees (e.g. sage); red actinomorphic flowers with deep corolla (e.g. red campion) are mainly visited by butterflies). Flower attractiveness for different pollinators should be taken into consideration also if it is intended to support pollination of specific crops by the seed mixtures.

Structures offered by plant canopy: a variety of different structures formed by the plants may not only offer foraging opportunities but also nesting habitats and/or overwintering sites for pollinators. e. g., flowering hedges (blackthorn, hawthorn etc.) may provide foraging resources and nesting and/or overwintering habitats. For stable populations of pollinators, both habitat types must be present in smaller scales; habitat connectivity may be offered by flowering strips along field margins.

Phenology: different pollinator species have specific activity periods; to enhance a stable pollinator community species composition in seed mixes should guarantee flowering species for the whole growing season. Otherwise, for attracting pollinators for specific crops, plant species in the seed mixture should have the same flowering period than the crop.

Plant species per se	Structures offered by plant canopy	Phenology
Minimum of three flowering species at any given time	Foraging sites	Species flowering at different time of the year (spring, summer, fall)
Combination of different species	Foraging sites, nesting habitat	Annuals and perennials
Plants in clumps	Better attraction for foraging, ground structures may provide nesting/hibernation habitat	—
Weed and floral diversity along field margins	Habitat connectivity	—
Native plants for attracting native pollinators and larval hosts for some pollinator species	—	Specialized pollinators (oligolectic species that visit only certain plant species/groups) have adapted phenology to native plants
—	Create diversity of landscape features (hedges, piles of stones, patches of bare soil)	—

Appendix 10. Summary of the Stewardship Activities identified in our inventory

Stewardship Activity Summary (1)

Name	National Action Plans
Member State(s)	All
Instigator(s)	European Parliament and Council Directive; Sustainable Use Directive 2009/128/EC
Start date	26 November 2012
Protection goal	Training, Water and Biodiversity
Brief summary	Under the Sustainable Use Directive2009/128/EC; Member States shall adopt National Act to set up their quantitative objectives, targets, measures and timetables to reduce risks ar of pesticide use on human health and the environment and to encourage the developmer introduction of integrated pest management and of alternative approaches or techniques to reduce dependency on the use of pesticides. The date for submission of these plans to Commission was 26 November 2012. Member States have published their plans and they cover such aspects as Information anc Awareness-raising (Article 7), Aerial spraying (Article 9), Specific measures to protect the a environment and drinking water (Article 11), Reduction of pesticide use in specific areas (A and Indicators (Article 15). An example NAP for the UK is linked below.
Website link	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221034 nap-pesticides-20130226.pdf

Stewardship Activity Summary (2)

Name	Biodiversity and Environmental (BETA) Training for Advisors
Member State(s)	UK
Instigator(s)	BASIS and the Voluntary Initiative (VI).
Start date	2003
Protection	Agri-Environment

goal	
Brief summary	BASIS was established by the pesticide industry in 1978 to develop standards for the safe storage and transport of agricultural and horticultural pesticides and to provide a recognised means of assessing the competence of staff working in the sector. The BETA training syllabus aims to progress the knowledge and skills of on-farm advisers in those important aspects related to Crop Protection use. The BETA modular training programme aims to promote the protection and enhancement of biodiversity, in the context of best practice of crop protection use on farm and the sustainability of profitable farming. The combination of Integrated Crop Management with Crop Protection Management plans and biodiversity training puts together a wider package which leads to more holistic Integrated Farm Management support. Module 1 - Biodiversity and Environmental Training 1 day Module 2 - Environmental Protection ½ day Module 3 - IFM Training: 1 day Module 4 - Climate Change ½ day By 31 March 2011, 847 advisor agronomists had completed the BETA training module. Many farmers have also completed the training and taken the examination.
Website link	http://www.basis-reg.co.uk/media/documents/SYLL_BETA_SYLLABUS.pdf

Stewardship Activity Summary (3)

Name	Campaign for the Farmed Environment
Member State(s)	UK
Instigator(s)	See below
Start date	Ongoing
Protection goal	Agri-Environment
Brief summary	The Campaign for the Farmed Environment aims to pull together the huge amount of work that farmers and land managers already do to encourage wildlife, to benefit soil and water resources and support farmland birds. It promotes existing stewardship schemes and encourages voluntary management that will benefit the environment, whilst ensuring efficient and profitable food production. The CFE is a true partnership approach, supported by many organisations committed to both agriculture and the environment (Agriculture & Horticulture Development Board, Agricultural Industries Confederation, Association of Independent Crop Consultants, Central Association of Agricultural Valuers, Country Land & Business Association, Department for Environment Food & Rural Affairs, Environment Agency, Game & Wildlife

	Conservation Trust, LEAF, Natural England, NFU, The Wildlife Trusts and RSPB).
Website link	http://www.cfeonline.org.uk/home/

Stewardship Activity Summary (4)

Name	Voluntary Initiative (VI)
Member State(s)	UK
Instigator(s)	Agricultural Engineers Association (AEA), Country Land and Business Association, National Association of Agricultural Contractors, NFU Scotland, Agricultural Industries Confederation (AIC), Crop Protection Association (CPA), NFU and Ulster Farmers Union.
Start date	2001
Protection goal	Agri-Environment
Brief summary	In 2001 the Government accepted proposals put forward by the farming and crop protection industry to minimise the environmental impacts from pesticides for a 5 year period. By 2006 the programme had met or exceeded the vast majority of its targets. In the light of this, the VI Steering Group proposed to Ministers that The Voluntary Initiative should continue as a rolling two year programme. These proposals were welcomed by the Government and the VI has continued since as a voluntary programme of work promoting responsible pesticide use. An independent Steering Group directs the implementation process and reports progress to DEFRA Ministers. As part of the Sustainable Use Directive, the UK government is required to develop and promote approaches to integrated pest management practices. The NFU has developed a new Integrated Pest Management Plan (IPMP) for the VI which will effectively replace the Crop Protection Management Plan. Under this initiative, Environmental Information Sheets (EIS) are produced by pesticide manufacturers for each of their products. The availability of these sheets allows growers to conduct an environmental assessment as to which product would be most appropriate to their particular environmental conditions. Example attached. Envidor Version 2 - Mar 2011 - Guideline \ Various advisory leaflets are also produced and training provided under this initiative e.g. http://www.voluntaryinitiative.org.uk/importedmedia/library/1284_s4.pdf

Website link	http://www.voluntaryinitiative.org.uk/en/home

Stewardship Activity Summary (5)

Name	Linking Environment and Farming (LEAF)
Member State(s)	UK
Instigator(s)	See below
Start date	1991
Protection goal	Agri-Environment
Brief summary	LEAF is the leading organisation promoting sustainable food and farming. They help farmers produce good food, with care and to high environmental standards, identified in-store by the LEAF Marque logo. They build public understanding of food and farming in a number of ways. These include Open Farm Sunday,Let Nature Feed Your Senses and year round farm visits to our national network of Demonstration Farms.
Website link	http://www.leafuk.org/leaf/home.eb

Stewardship Activity Summary (6)

Name	IPM Guidance Notes & Checklist
Member State(s)	Ireland
Instigator(s)	Department of Agriculture, Food & Marine
Start date	2014
Protection goal	Agri-Environment
Brief summary	Practical guide to implementing IPM on Irish Farms. The checklist included in the guide facilitates compliance with national IPM requirements Directive.
Website link	http://www.pcs.agriculture.gov.ie/Docs/Guidance%20Notes%20on%20Integrated%20Pes

Stewardship Activity Summary (7)

Name	Common Agricultural Policy (CAP) Greening
Member State(s)	UK
Instigator(s)	Department of the Environment and Rural Affairs (UK)
Start date	2015
Protection goal	Agri-Environment
Brief summary	In 2015 the Single Payment Scheme will be replaced by the Basic Payment Scheme (BPS). BPS will include new ‘greening’ rules farmers must follow to get a greening payment that be worth about 30% of the total payment. Any farmer with more than 15 hectares of arab land will need ‘Ecological Focus Areas’ (EFA) – unless they qualify for an exemption. EFAs areas and/or features which the EU has decided are beneficial for the climate and the environment. EFA rules present an excellent opportunity to help pollinators. Farmers in England will be able to choose from hedges, nitrogen-fixing crops, catch/cover crops, buff strips and fallow land in order to comply with the new greening requirements. Farmers ne consider how EFA options can bring the greatest environmental benefit on their holding, particularly for bees and pollinators. Voluntary management actions on fallow land or buf strips in particular can provide benefits for pollinators. Sowing nectar and pollen-rich wildflower seed mixtures can encourage high flower densities which attract pollinators. Managing buffer strips through grazing and cutting can help prevent grass domination anc further encourage wildflowers and pollinators. All farmers with hedgerows, whether they being used to meet their EFA requirement or not, can consider voluntarily reducing the frequency with which they trim them in order to encourage flower production. A new scheme for environmental land management will replace Environmental Stewardsh (ES), the English Woodland Grant Scheme (EWGS) and capital grants from the Catchment Sensitive Farming (CSF) programme in 2015.
Website link	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/345073 reform-august-2014-update.pdf

Stewardship Activity Summary (8)

Name	Environmental Stewardship
Member State(s)	UK
Instigator(s)	Department of the Environment and Rural Affairs (UK)
Start date	1991
Protection goal	Agri-Environment

Brief summary	The current Rural Development Programme for England (RDPE) ends on 31 December 2013. Work is being carried out nationally on the design for a successor to this scheme. DEFRA are actively discussing with the European Commission what can be done in the interim period to safeguard the good environmental work previously delivered under the existing schemes. Environmental Stewardship is an agri-environment scheme that provides funding to farmers and other land managers in England to deliver effective environmental management on your land. There are four elements to Environmental Stewardship: • Entry Level Stewardship (ELS) provides a straightforward approach to supporting the good stewardship of the countryside. This is done through simple and effective land management that goes beyond the Single Payment Scheme requirement to maintain land in good agricultural and environmental condition. • Organic Entry Level Stewardship (OELS) is the organic strand of ELS. It is geared to organic and organic/conventional mixed farming systems and is open to all farmers not receiving Organic Farming Scheme aid. • Uplands Entry Level Stewardship (Uplands ELS) was launched in February 2010 to support hill farmers with payments for environmental management. This strand of Environmental Stewardship succeeds the Hill Farm Allowance. It is open to all farmers with land in Severely Disadvantaged Areas, regardless of the size of the holding. • Higher Level Stewardship (HLS) involves more complex types of management and agreements are tailored to local circumstances. HLS applications will be assessed against specific local targets and agreements will be offered where they meet these targets and represent good value for money.
Website link	http://www.naturalengland.org.uk/ourwork/farming/funding/es/default.aspx

Stewardship Activity Summary (9)

Name	Sites of Special Scientific Interest (SSSI)
Member State(s)	UK
Instigator(s)	Department of the Environment and Rural Affairs (UK)
Start date	Ongoing
Protection goal	Environment
Brief summary	It is a legal requirement to protect SSSI's. An SSSI is one of the country's very best wildlife and/or geological sites. SSSIs include some of the most spectacular and beautiful habitats: wetlands teeming with wading birds, winding chalk rivers, flower-rich meadows, windswept shingle beaches and remote upland peat bogs. There are over 4,100 Sites of Special Scientific Interest (SSSIs) in England, covering around 8% of the

	country's land area. More than 70% of these sites (by area) are internationally important for their wildlife.
Website link	http://www.naturalengland.org.uk/ourwork/conservation/designations/sssi/default.aspx

Stewardship Activity Summary (10)

Name	Hope Farm
Member State(s)	UK
Instigator(s)	Royal Society for the Protection of Birds (RSPB)
Start date	2000
Protection goal	Birds and Soil Erosion
Brief summary	In 2000, the RSPB purchased Hope Farm, a 181-hectare conventional arable farm with the aim to develop and trial farming techniques that produce food cost-effectively and benefit wildlife at the same time. The results have helped develop their messages and advice to farmers, government and the general public. Uncropped margins of arable fields provide important areas for wildlife within the farm and help protect waterways and hedgerows. Rough grass margins provide nesting sites for birds, such as grey partridges, and over-wintering habitats for insects. Wild flower margins can increase the number of pollinating Insects. Grass-dominated margins have less wildlife than those that contain a higher wild flower content. Without management, flower-rich margins can deteriorate, with the flowers rapidly becoming dominated by coarse grasses. At Hope Farm, they are attempting to address the problem of diffuse pollution in several ways. Firstly, the farm uses best practice farming techniques, applying pesticides and fertiliser accurately and in suitable weather conditions; sowing grass margin buffer strips along watercourses to reduce soil run-off and erosion; and sowing overwinter cover crops to reduce nitrate leaching from bare soil.
Website link	http://www.rspb.org.uk/ourwork/farming/advice/ http://www.rspb.org.uk/Images/hopefarmbooklet_tcm9-320935.pdf

Stewardship Activity Summary (11)

Name	Local Environment Risk Assessment for Pesticides (LERAP)
Member State(s)	UK
Instigator(s)	UK Chemicals Regulation Directorate

Start date	2001
Protection goal	Surface water
Brief summary	Certain plant protection products have an aquatic buffer zone requirement when applied by horizontal boom or broadcast air-assisted sprayers. If you want to reduce this aquatic buffer zone, there is a legal obligation to carry out and record a Local Environment Risk Assessment for Pesticides (LERAP). For horizontal boom sprayers it is only possible to reduce buffer zones of 5 metres; buffer zones of greater than 5 metres cannot be reduced. If you just want to apply the buffer zone specified on the label you don't have to carry out a LERAP. But you are still legally obliged to record this decision as normal in your spray records, as advised in section 6 of the updated Code of Practice for Using Plant Protection Products (keeping spray records) (originally in Part 4 of the Code of Practice for the Safe Use of Pesticides on Farms and Holdings (Green Code)). Some products specify use of drift reduction technology (DRT) recognised as having LERAP three star low-drift status and a buffer zone of 6, 12 or 18 m (as necessary for each crop) as a condition of authorisation for horizontal boom spraying. The specified distance must be recorded in Section A of the LERAP record form. Authorisations issued under these arrangements also specify a second buffer zone of 30 m, beyond which use of DRT is not required. This is necessary to protect watercourses from higher rates of drift arising from use of standard spraying equipment and procedures. These distances cannot be reduced under the LERAP scheme. Whilst include here for an example, technically the LERAP scheme is not an environmental protection measure. It is effectively a way of reducing buffer zones to enable a greater area to be cropped without increasing risk to water.
Website link	http://www.pesticides.gov.uk/guidance/industries/pesticides/topics/using-pesticides/spray-drift/leraps/local-environment-risk-assessment-for-pesticides-leraps.htm

Stewardship Activity Summary (12)

Name	Every Drop Counts and H_2OK?
Member State(s)	UK
Instigator(s)	Catchment Sensitive Farming (CSF), The Voluntary Initiative (VI) and Campaign for the Farmed Environment (CFE)
Start date	2001
Protection goal	Water
Brief	Overall, background levels of pesticides detected in water are declining and there are

summary	relatively few compliance problems with aquatic toxicology standards for pesticides. The work does not stop to completely protect drinking water abstraction points. In particular, peak pesticide levels in watercourses – often linked to rainfall events after applications to very wet soils – pose major problems for water companies despite extensive investment in-treatment facilities to remove pesticides. Water companies must comply with the 0.1ppb EU Drinking Water Standard at the tap. With new EU legislation, including the Water Framework Directive and the Sustainable Use of Pesticides Directive, being implemented more action is needed to protect water. Schemes have included the H2OK? Campaign; year after year of NRoSO training events run by agrochemical distributors; advisers working together with farmers in catchments with innovative communication methods; the Pelletwise Campaign, Catchment Sensitive Farming, Water Protection Action Sheets and local Catchment Officers focused on protecting the environment in specific catchments. Publications on this website summarise the latest knowledge on how pesticides reach water – whether a river, ditch, or underground aquifer. More importantly, they provide guidance on ways to prevent it happening. In most instances, it is not that difficult. Sensible approaches to filling sprayers and applying pesticides can make big differences. It makes sense for the environment; it also makes economic sense when using pesticides, to ensure that Every Drop Counts
Website link	http://www.voluntaryinitiative.org.uk/en/water/advice

Stewardship Activity Summary (13)

Name	Train Operators to Promote best Practices and Sustainability (TOPPS) and TOPPS-Prowadis (Protecting water from diffuse sources)
Member State(s)	Many EU member States
Instigator(s)	Industry
Start date	2005
Protection goal	Water
Brief summary	Best Management Practices (BMPs), training/demonstration material and diagnosis/evaluation tools have been developed for agriculture (some of this information is also applicable for uses in turf & amenity and greenhouses). Sections on point sources and diffuse sources of pollution and how to prevent it. Diagnosis and evaluation tools, Best Management Practices (BMPs), and training & demonstration material have been developed for drift, runoff from field and drainage. The website supports communication activities under TOPPS, that is, to help disseminate information on the prevention of point and diffuse source contamination of water bodies with plant protection products.

Website link	http://www.topps-life.org/ http://www.ecpa.eu/article/environmental-protection/protecting-water-spray-drift-run-and-erosion

Stewardship Activity Summary (14)

Name	Water Stewardship: Protect Water to preserve your crop protection tools and meet societ
Member State(s)	Diverse (UK, DE, HU, ES…)
Instigator(s)	BASF SE and country branches
Start date	2011
Protection goal	Water
Brief summary	12-page water protection guide: Focusing on pollution pathways, best practices to avoid p diffuse pollution pathways; quiz for farmers to check their knowledge about best practice:
Website link	http://www.agro.basf.com/agr/AP-Internet/en/function/conversions:/publish/upload/news_room/BASF_Practical_Advice_fc

Stewardship Activity Summary (15)

Name	Say No to Drift
Member State(s)	UK
Instigator(s)	Dow AgroSciences, Headland Agrochemicals and Makhteshim-Agan UK
Start date	2011
Protection goal	Surface water
Brief summary	The active ingredient chlorpyrifos is a highly valued insecticide, important in the control of a number of damaging pests across a spectrum of crops in the agricultural, horticultural and amenity sectors. The potential loss of the active has highlighted serious implications for the industry due to its great agronomic value. The campaign calls for chlorpyrifos users to support the continued availability of the active by adopting new application guidelines aimed at delivering a substantial reduction in spray drift. Spray drift reduction nozzles (SDRNSDRN) offer a cost effective practical solution to the problem of meeting the new assessments. When used in conjunction with a suitable buffer zone to water, SDRNSDRN would mean the maintenance of the products while providing the necessary level of water protection. Growers need to use a UK *** rated

	spray drift reduction nozzle and a 20 metre buffer zone to any ponds, streams and ditches when applying chlorpyrifos products with a conventional boom sprayer (a dry water body requires a 1 metre no-spray buffer zone).
Website link	http://www.saynotodrift.co.uk/

Stewardship Activity Summary (16)

Name	On Target Application Academy (OTAA)
Country(s)	USA
Instigator(s)	BASF North America Agricultural Products
Start date	2012
Protection goal	Spray drift reduction, avoidance of point sources (among others).
Brief summary	OTAA is about educating farmers on application best practices and new equipment technologies. To this aim BASF North America Agricultural Products has developed together with academia and other industry partners this training program, which focuses on best management practices for herbicide applications to reduce off-target movement (main issue: spray drift). Major topics in this training course are the proper nozzle selection to control spray droplet size, appropriate sprayer calibration and boom height, awareness on impact of environmental conditions on spray drift, new technologies to reduce spray drift, and proper sprayer cleaning procedures. The training is conducted at various locations around the US. More than 3000 growers have participated in the training to date (spring 2014). In future, also the use of online training modules is planned (until end of 2014).
Website link	http://www.agro.basf.us/stewardship/on-target-stewardship.html

Stewardship Activity Summary (17)

Name	Drift Reduction Technology
Member State(s)	UK and Italy
Instigator(s)	Industry (Dow AgroSciences initially)
Start date	October 2011
Protection goal	Water and biodiversity
Brief summary	Farmer awareness of spray drift reduction technology continues to spread, thanks to farmer education and awareness campaigns (e.g. TOPPS PROWADIS and other nationally

	oriented campaigns). When accompanied by effective product stewardship campaigns, grower's awareness of the need to more effectively manage drift issues for a given product is significantly improved. An example of this is the successful campaign for implementation of low-drift nozzles and no-spray buffer zones developed in UK ("Say-No-To-Drift") and in Italy ("Miralbersaglio") sicne 2011. The UK campaign was initiated in October 2011 and involved growers, farmer organizations and officials. The campaign resulted in an increase of the intention to use low-drift nozzles in the next coming season from only 7% in 2011 to 91% of users in 2013 (source: 200 Pesticide Usage Survey Group PUSG interviews). The main reasons for the initial reluctance to use of low-drift nozzles by farmers were a misconception regarding a loss of efficacy and the lack of familiarity with low-drift nozzles. This campaign showed that technology transfer from companies to farmers can be helpful to significantly improve take-up of low-drift nozzles and, thus, reduce drift more widely. A similar campaign was initiated in Italy in 2012 for apple and vine applications in two pilot areas: Emilia Romagna and Trentino Alto Adige. This campaign is still ongoing with technology transfer events having already taken place from the South to the North of Italy and involving regional extension services for phytosanitary management, growers, experts in ecotoxicology, environmental fate of pesticides and efficacy from the Pesticide Committee. The main objective of the Italian campaign is to demonstrate to farmers that the use of low-drift nozzles is easy and allows to ensure a real benefit to the environment. It is noted that in Italy the use of low-drift nozzles and no-spray zones will be linked to subsidies coming through CAP and to the Italian Action Plan as developed under the Sustainable Use Directive. In this context the campaigns on technology transfer represent highly effective and well-targeted tools for farmers to meet future obligations. The results of this campaign will provide useful comparative indicators of willingness of farmers in Southern Europe to access and employ low-drift nozzles.
Website link	http://www.topps-life.org/

Stewardship Activity Summary (18)

Name	Focus on Pesticides
Member State(s)	Sweden
Instigator(s)	LRF, Jordbruks Verket, Naturvards Verket, KEMI, Lantmannen and Svenskt Vaxtskydd
Start date	1997
Protection goal	Water and PPE
Brief summary	The Swedish safe use campaign 'Focus on Pesticides' has produced 14 short videos on different topics. It is advisory material for the target group operators. They are published on Youtube with English subtitles. The concept is the same in all films: An actor visits a person; farmer, advisor, researcher, and conducts a practical interview. This below website link connects to a video regarding the the Helper Guide on Wind-based Buffer Zones 'Hjälpreda'. Other short videos are viewed on the right-hand side on the Youtube site:

	In English: Swedish title Safety distances to water. *Skyddsavstånd:* Drainage wells *Dräneringsbrunnar:* Monitoring in surface water *Vemmenhögsån:* Handling of PPP in glasshouses *Hantering i växthus:* Maintanance of Biobed *Underhåll biobädd:* Upgrade sprayer *Uppgradera sprutan:* Calibrate boom-sprayer *Kalibrera sprutan:* About Personal protective equipment: PPE, Basic kit *Personlig skyddsutrustning, Grundskyddet* PPE Filling of sprayer *Personlig skyddsutrustning; Påfyllning av spruta*: PPE Boom sprayer *Personlig skyddsutrustning; Bomspruta::* PPE Mistblower *Personlig skyddsutrustning; Fläktspruta* PPE Knapsacksprayer *Personlig skyddsutrustning; Ryggspruta* PPE Glasshouses *Personlig skyddsutrustning; Fläktspruta*
Website link	http://www.youtube.com/watch?v=196AN3GzXo4

Stewardship Activity Summary (19)

Name	Bentazone: BASF EU Water Stewardship Programme
Member State(s)	UK, FR, BE, ES, IT, HU, RO, PO, PL, DK, CZ, NL, HE…
Instigator(s)	BASF SE and country branches
Start date	Spring 2011
Protection goal	Groundwater
Brief summary	Active initiative aimed at promoting responsible use of bentazone to prevent pollution inc exceedances and thus further use restrictions in the EU. BASF's Stewardship Programme i: pathways and investigations of exceedances, tackling both point sources, as well as diffus The following stewardship measures are promoted/implemented for bentazone: • Maximum use rate of 1000 g/ha/year • Do not use for autumn/winter applications. • Do not use on soils with low organic carbon content (<1% OC) • Do not use on soils with shallow groundwater (<1m below surface)

	• Do not use on karstic soils (on chalk or other limestone) that are shallow (<30-35cm soil type) • Only use on fields adjacent to watercourses, if a 5 m vegetated buffer strip is in plac • Improve compliance of farmers with good agricultural practices to avoid point sour pollution. For Belgium, where shallow groundwater conditions in Flanders are widespread, an intern of vulnerable areas was made available to farmers and advisors (http://www.agro.basf.be/agroportal/be/fr/m_crop_management_2/grondwater_diepte,
Website link	Example UK: http://www.agricentre.basf.co.uk/agroportal/uk/en/about_us_3/water_stev Example BE: http://www.agro.basf.be/agroportal/be/fr/m_crop_management_2/CROP_N

Stewardship Activity Summary (20)

Name	Biobeds
Member State(s)	Most
Instigator(s)	Sweden
Start date	1997
Protection goal	Water
Brief summary	Unsatisfactory management of pesticides and other chemicals can give rise to residues in surface and groundwater. Several field surveys and measurement campaigns on catchment scale have demonstrated that 40 to 90% of surface water contamination by pesticides is attributed to direct losses. The main direct losses are spillages resulting from the filling operation, leakages of the spray equipment, spray leftovers and technical rest volumes in the tank, pump and booms, rinsing water from cleaning the internal tank to avoid carry over effects (damage and residues) onto the following crop, water from external cleaning of spray equipment, etc. Physico-chemical waste water treatments are very effective, but in most cases too expensive for average farmers. Therefore some form of biological processing is usually the preferred method for the treatment of effluents containing pesticides. For agricultural purpose these treatment systems need to be cheap and reliable, easy to use with low labour and time input and low waste disposal cost. A possible approach is the use of biopurification systems to capture and treat contaminated water from the farmyard and/or spillages from the filling process. The biopurification system has generated interest in various countries all over the world. It's implementation has sometimes led to modifications of the original Swedish design, called the biobed. After the development of this system, variations to it have been made and are called Phytobac®,biofilter, biomassbed, etc. The concept of these three systems is similar. They all consist of a biological active matrix which retains the pesticides onto organic matter or soil particles, where enhanced or rapid microbial degradation of the pesticides occurs.

Website link	http://biobeds.org/velkommen

Stewardship Activity Summary (21)

Name	Get Pelletwise
Member State(s)	UK
Instigator(s)	Metaldehyde Stewardship Group
Start date	Autumn 2012
Protection goal	Water
Brief summary	'Get Pelletwise' is the campaign of the Metaldehyde Stewardship Group (MSG). Metaldehyde is the active ingredient contained within slug pellets that are used by the majority of UK farmers to control the pest. In recent years metaldehyde was widely detected - in raw water - well above the drinking water standard, with peaks following rainfall. It was an exceptional season, due to high slug pressure causing a related increase in the use of slug pellets. It illustrates the importance of stewardship measures. Whilst levels detected pose no danger to health or the environment, the UK's environment agencies and DEFRA are responsible for the implementation of the Water Framework Directive (WFD). Metaldehyde exceedances must be avoided to allow water companies to meet their obligations and ensure they are not challenged with diverting supplies, or temporarily switching off water supply. The MSG's aim is to promote and encourage best practice with metaldehyde slug pellets, to minimise environmental impacts, and, in particular, protect water. The Group is working with the farming industry to prevent the problem recurring. The Group is working with the farming, water and environment industries to prevent the problem recurring, and this includes the introduction of two new pilot schemes.
Website link	http://www.getpelletwise.co.uk/

Stewardship Activity Summary (22)

Name	BASF network of farm cooperations
Member State(s)	UK, FR, CZ, PL, IT and DE
Instigator(s)	BASF and local partners

Start date	2002 (UK), 2011 (FR), 2012 (CZ, PL, IT and DE)
Protection goal	Biodiversity, soil and water in highly productive farms
Brief summary	The BASF farm network is a group of farms, who collaborate with us to demonstrate how the Czech Republic, France, Germany, Italy, Poland and the UK. We work with key stakeholders – farmers, researchers, local environmental and farming o valuable expertise to the table. BASF and its local partners are responsible for advising far learnt are shared and incorporated into future programs. Monitored data includes the nu Apart from learning and collecting valuable information, the farms also provide a unique c farmers, a big part of the work undertaken is public outreach to important audiences, incl the advice. In the medium term, our goal is to see these farms provide feedback on how sustainable a and resources. In the longer term, we would like to see these techniques being embraced
Website link	http://www.agro.basf.com/agr/AP-Internet/en/function/conversions:/publish/upload/sus Example UK: http://www.agricentre.basf.co.uk/agroportal/uk/en/about_us_3/biodiversity_1/rawcliffe Example France: http://www.agro.basf.fr/agroportal/fr/fr/enjeux_et_engagements/programmes_de_rech Example Czech Republic: http://www.agro.basf.cz/agroportal/cz/cs/udrzitelnost/biodiverzita/biodiverzita_1.html

Stewardship Activity Summary (23)

Name	Pesticides and Biodiversity
Member State(s)	EU-wide
Instigator(s)	European Landowners Organisation (ELO) and European Crop Protection Association (ECPA)
Start date	April 2013
Protection goal	Biodiversity
Brief summary	Agricultural productivity and biodiversity conservation - We all want a wide variety of high-quality and affordable foods available to us the year-round; we also want a prosperous countryside, and healthy and diverse ecosystems. A growing population and greater demands on agriculture presents society with one of the great challenges of the

	21st century – to produce more agricultural goods from the same hectare while protecting biodiversity. Fortunately, the solution is at hand; productive agriculture is a key component in the protection of water, health, food, soil, and biodiversity. This 36-page publication describes the important role that the responsible use of pesticides can play in protecting the benefits of biodiversity whilst reducing the impact of biodiversity based threats to agriculture.
Website link	http://issuu.com/cropprotection/docs/7584_biodiversity_v04_b_t/1?e=2167160/4766400

Stewardship Activity Summary (24)

Name	Soil Biodiversity and Agriculture
Member State(s)	EU-wide
Instigator(s)	European Landowners Organisation (ELO), European Crop Protection Association (ECPA), E-Sycon and RIFCON GmbH.
Start date	September 2010
Protection goal	Soil
Brief summary	*Fact*: soil biodiversity is one of the richest, most complex biological communities on earth - it is home to a larger share of biodiversity and genetic diversity than tropical forests. This 50-page publication aims to raise awareness of the critical importance of soil and soil biodiversity. In addition, it highlights some good practice land management techniques that can be adopted to support the generation and regeneration of healthy soil. Their diminutive nature and underground existence keeps them out of sight and out of mind; their other-worldly appearance, their crawling, squirming, gnawing, conspire to render them unattractive; but what they lack in size and beauty, they make up for in numbers and worth. The mites, lice and bacteria that inhabit the world beneath our feet are vital for maintaining balanced ecosystems and agricultural production - quite simply, we could not live without them.
Website link	http://www.ecpa.eu/files/gavin/soil_bio_and_ag_012_web.pdf Abridged version: http://www.ecpa.eu/files/gavin/soil_bio_and_ag_SHORT_issuu.pdf

Stewardship Activity Summary (25)

Name	Biodiversity Centres

Member State(s)	UK
Instigator(s)	Bayer CropScience
Start date	2005
Protection goal	Biodiversity
Brief summary	This 36-page booklet reports on the partnership between the Farming and Wildlife Action Group (FWAG) and Bayer CropScience and gives an overview of the conservation work and monitoring carried out at both Chishill and Shelford Biodiversity Centres in the UK. It includes maps of environmental features, habitat and species information and a summary of the monitoring information compiled to date. Both Centres cover approximately 20 hectares and support a wide range of species, habitats and crop trials. The differences in soil type, layout, history and landscape mean that whilst a common methodology can be used to promote conservation and biodiversity, each of the Centres are considered separately.
Website link	http://www.bayercropscience.co.uk/assets/Food-and-Environment/Biodiversity-Centres-Brochure2007.pdf

Stewardship Activity Summary (26)

Name	INSPIA
Member State(s)	All
Instigator(s)	The European Conservation Agriculture Federation (ECAF), the Institute for Sustainable Agriculture (IAD) and the European Crop Protection Association (ECPA)
Start date	22nd May 2014
Protection goal	Biodiversity
Brief summary	The INSPIA project brings together farmers, industry, and other stakeholders to share Best Management Practices for biodiversity across agricultural landscapes, including the soil. • Biodiversity affects key ecosystem services, such as the primary production of food for humans and the rest of nature, plus the recycling of nutrients and water. • One hectare of land contains a lot of biodiversity in the soil – equivalent to the weight of one cow of bacteria, two sheep of protozoa, and four rabbits of soil animals such as earthworms. The INSPIA* project is designed to give European farmers the opportunity to improve biodiversity and natural capital, whilst increasing the resource efficiency and competitiveness of their agricultural practices. The cultivation of land brings the grains,

	fruits and meat that sustain us, but without good appropriate management agricultural practices can be unsustainable. INSPIA farms will provide good example of the successful synergy that can be achieved between biodiversity and sustainable agriculture. INSPIA is an open project, launched by a coalition of stakeholders. The European Conservation Agriculture Federation (ECAF), the Institute for Sustainable Agriculture (IAD) and the European Crop Protection Association (ECPA) developed the project to raise awareness about the value of Best Management Practices (BMPs) to both biodiversity and agricultural productivity, and to provide guidance and demonstration about how to implement them practically in the field. Specifically INSPIA will: • Create a farm network and mobilise agricultural technicians to validate, demonstrate and communicate the BMPs • Provide an index on-farm sustainability based on a set of verifiable indicators linked to BMPs • Promote the adoption of BMPs throughout Europe • Promote partnerships in pursuit of common goals for sustainable agriculture and biodiversity • Raise awareness of EU policy stakeholders, technicians and farmers about sustainable agriculture
Website link	http://www.ecpa.eu/news-item/environmental-protection/05-22-2014/1331/sustainable-agriculture-promote-biodiversity

Stewardship Activity Summary (27)

Name	Biodiversity and diversity of habitats
Member State(s)	Germany
Instigator(s)	IVA
Start date	
Protection goal	Insects, wild animals and birds
Brief summary	Risks to biodiversity from PPPs can be reduced to a great extent by the standard risk mitigation measures. Diversity of habitats is of crucial importance for biodiversity. Only if enough food supply and suitable habitats exist can insects, wild animals and birds survive in the agricultural landscape where the fields are used intensively for production of animal and human food and energy plants. For this reason IVA (Association of German agrochemical industry) provides recommendations to the farmers for creating flowering strips, beetle banks, rough-soil habitats etc. The creation of wooded areas in the agricultural landscape that are not used for production is also valuable. The aim of the project is to establish a network of set aside areas and hedges. The first results of shown that these areas account for about

	10 % of the total agricultural landscape. All these areas can be used as basis for recovery and re-colonization. Communication is via brochures and field events etc.
Website link	http://www.iva.de/publikationen/nachhaltiger-pflanzenschutz http://www.iva.de/publikationen/die-bedeutung-der-bestaeuber-fuer-die-landwirtschaft http://www.iva.de/publikationen/landwirtschaft-biodiversitaet-und-pflanzenschutz

Stewardship Activity Summary (28)

Name	Risk Management of Pesticides
Member State(s)	OECD Countries
Instigator(s)	OECD
Start date	2014
Protection goal	Pollinators
Brief summary	This OECD website is intended to provide a central location where one can find information about the regulatory approaches adopted by OECD member countries to mitigate pesticide risks to insect pollinators. Following a survey of OECD member countries, it was concluded that mitigation of risks to insect pollinators is important to all its member countries, and that mitigation is a critical component of balancing the benefits of plant protection products with potential risks to insect pollinators. Risk mitigation options used by many stakeholders generally fall into three categories: Pesticide Labelling, Non-label Mitigation and Education & Training. This website provides links to OECD member country laws, policies and guidance relating to pesticides and risk management tools for insect pollinators, including precautionary labelling, use restrictions, technologies, training materials, Best Management Practices (BMP) and Integrated Pest Management (IPM) practices currently used by OECD countries to mitigate the risk of pesticides to insect pollinators.
Website link	http://www.oecd.org/chemicalsafety/risk-mitigation-pollinators/

Stewardship Activity Summary (29)

Name	Pollinators and Agriculture
Member State(s)	EU-wide
Instigator(s)	European Landowners Organisation (ELO), European Crop Protection Association (ECPA), and the European Initiative for Sustainable Development in Agriculture (EISA).
Start date	August 2013 (first published June 2011)
Protection goal	Pollinators
Brief summary	Around 70% of the world's most produced crop species rely to some extent on insect pollination, contributing an estimated €153 billion to the global economy and accounting for approximately 9% of agricultural production. In Europe a great variety of bees, butterflies, beetles and other insects are responsible for pollination; their collective contribution to the food in our diet is essential, however, this contribution is often misunderstood and frequently miscommunicated. As Europe experiences an overall decline in pollinator biodiversity, an understanding of the drivers of pollinator population change is timely and of significance to the future of pollination. It is in our best interest to ensure the conservation of pollinators. This 46-page publication examines the diversity and function of insect pollinators, describes the value of pollination to agriculture, examines trends in pollinator population decline and explores options for reversing his trend.
Website link	http://issuu.com/cropprotection/docs/pollinators_brochure_b__t2/48?e=0/4766149

Stewardship Activity Summary (30)

Name	Pollination Station
Member State(s)	EU-wide
Instigator(s)	European Crop Protection Association (ECPA)
Start date	November 2012
Protection goal	Pollinators
Brief summary	A website providing a one-stop-shop for links to various useful websites regarding pollinators and biodiversity.
Website link	http://www.pollination-station.eu/

Stewardship Activity Summary (31)

Name	Operation Pollinator
Member State(s)	France, Germany, Hungary, Italy, Spain, Portugal and the UK
Instigator(s)	Syngenta
Start date	2003
Protection goal	Pollinators
Brief summary	Operation Pollinator is an international biodiversity program to boost the number of pollinating insects on commercial farms. It works by creating specific habitats, tailored to local conditions and native insects. Farmers and golf course managers are provided with targeted seed mixtures, along with innovative pesticide use practices and agronomic advice designed to benefit pollinators. Initiated by Syngenta, Operation Pollinator is supported by a large number of partners, including: Universities, Farmer organisations, NGOs, Beekeepers' associations, Governmental bodies and Food producers. The Operation Pollinator program is based on scientific research. Its progress and success is assessed by independent scientific partners.
Website link	http://www.operationpollinator.com/

Stewardship Activity Summary (32)

Name	Bayer Beecare Program
Member State(s)	World-wide
Instigator(s)	Bayer CropScience
Start date	21 February 2012
Protection goal	Bees
Brief summary	The Bayer Bee Care program is part of the company's commitment to bee health. Its aims are to further promote and develop solutions to improve bee health, to actively promote the bee-responsible use of our products and to share knowledge and expertise with stakeholders from the beekeeping and agricultural communities and with scientific and governmental institutions, NGOs, policy makers and regulators. Some examples of joint projects:

	• Collaboration with researchers from Frankfurt University & other partners in Europe & the USA to find new ways to protect bees against the *Varroa* mite. • Various Varroa research projects focusing on resistance monitoring, mode of action of varroacides & testing of new candidates & solutions for Varroa control. • The Pollinator Biodiversity Project in Southwestern Germany is a co-operation with two ecological institutes (ILN & IFAB) to measure the effects of biodiversity-enhancing measures (e.g. flowering strips) on pollinator communities in a maize growing region. • Collaboration with the University of Lüneburg,Germany to survey all major crops on a global scale for their bee attractiveness, apicultural relevance, & dependence on bee pollination. • Participation in "FitBee", a collaborative project addressing interactions and correlations between single bees, bee colonies, bee diseases & environmental factors. The project is funded by the Federal Ministry for Food, Agriculture & Consumer Protection (BMELV) & the Federal Office for Agriculture & Food (BLE). Bayer is involved in two modules: • Impact of multifactorial influences on the single bee: investigation of immune response and injury thresholds (German) • Quantification of the crop protection products brought into the bee colony & reduction in the colony's influx of active substances by agricultural measures (German)
Website link	http://beecare.bayer.com/bayer-bee-care/bayer-bee-care-program

Stewardship Activity Summary (33)

Name	Bayer Beecare Website and Centres
Member State(s)	World-wide
Instigator(s)	Bayer CropScience
Start date	21 February 2012
Protection goal	Bees
Brief summary	The central Bayer Beecare website address, together with details of the Bayer Beecare Centres - two dedicated "Bayer Bee Care Centers" one in Monheim, Germany and a second in North Carolina, United States. The centers serve as a scientific and communication platform to consolidate existing and future bee health projects from Bayer companies in cooperation with external partners. They also foster information sharing and provide a platform for discussion and new ideas. The Centers have a dedicated full-time team of specialists, including two experienced

	beekeepers. It uses state-of-the-art technology to provide a modern meeting and workshop environment, bringing together beekeepers, farmers, research institutions, educational professionals and others concerned with the health and welfare of bees.
Website link	http://beecare.bayer.com/home http://beecare.bayer.com/bayer-bee-care/bayer-bee-care-centers

Stewardship Activity Summary (34)

Name	gEo-BEE
Member State(s)	Germany
Instigator(s)	GisEO; JKI; LIB; BtS and DELPHI IMM
Start date	1 February 2012
Protection goal	Bees
Brief summary	The structure, use and management of landscapes, including infrastructure projects, can have positive and negative effects on wild bee populations and successful and sustainable beekeeping. The possibilities for beekeepers and conservationists to be actively involved in local and regional development measures are generally limited to formal rights to participate during the planning stage of a project, or active participation takes place in an uncoordinated manner (e.g. creating species-rich bee pastures). The same is true for agriculture, which plays a key role here (landscape conservation, plant cultivation and protection). The diverse participation formats of the Internet offer the opportunity to speed up existing information and communication pathways, to increase the quality of these pathways or to create them in the first place. The participative discussion and information platform for protecting and promoting wild bees and honey bees establishes the technological basis for this. The platform uses internet-based mapping applications to combine existing databases and information sources of authorities with information on the current state of landscapes (e.g. deficits in agricultural areas due to plant cultivation systems, register of small habitat structures kept by the Julius Kühn-Institut). One element of the internet platform is the option of new databases, which can be successively created by participating beekeepers and farmers (e.g. information on current positions of bee colonies, migration behavior of beekeepers, current form of use of agricultural areas). These data streams are protected according to the required guidelines for data protection. In other interactive formats with geographic aspects (geotagging) new objects and descriptions of existing objects (e.g. wild bee habitats) can be entered. The tools and contents of the platform offer support for authorities and organizations that are proactively planning environmental measures as well as for activities of individuals. In addition to this, the platform promotes coordinated activities, e.g. of farmers and beekeepers regarding the pollination of agricultural areas.
Website link	http://www.fisaonline.de/index.php?lang=en&act=projects&view=details&p_id=5819

Stewardship Activity Summary (35)

Name	Honey bee care
Member State(s)	World-wide
Instigator(s)	Bayer CropScience
Start date	July 2011
Protection goal	Bees
Brief summary	A 16-page booklet fully describing the issues around honey bee care and providing solutio pathogens, Colony Collapse Disorder, nutrition, invasive alien species, weather, agricultur Information on pesticides, seed-applied insecticides and stewardship measures.
Website link	http://beecare.bayer.com/bilder/upload/dynamicContentFull/Publications/Honey_Bee_H

Stewardship Activity Summary (36)

Name	Toby and the Bees
Member State(s)	UK
Instigator(s)	Bayer CropScience (in partnership with Farming and Countryside Education (FACE), a chari educate children and young people about food and farming in a sustainable countryside).
Start date	September 2013
Protection goal	Bees
Brief summary	A childrens' book intended to help children understand the role that honey bees play in cc and fauna.
Website link	http://beecare.bayer.com/bilder/upload/dynamicContentFull/Publications/Toby_and_the

Stewardship Activity Summary (37)

Name	Netzwerk Blühende Landschaften
Member State(s)	Germany
Instigator(s)	Mellifera e. V.
Start date	

Protection goal	Pollinators, habitat connectivity, biodiversity
Brief summary	Website and print material with information about pollinators and concrete measures how to create and connect habitats.
Website link	http://www.bluehende-landschaft.de/nbl/index.html

Stewardship Activity Summary (38)

Name	Apolo Observatorio de agentes polinizadores
Member State(s)	Spain
Instigator(s)	Asociación Española de Entomología, Jardín Botánico Gijón, CIBIO, Ministry of Agriculture and Environment
Start date	2010
Protection goal	Pollinators
Brief summary	Website and print material with information about pollinators. Teaching and extension material.
Website link	http://apolo.entomologica.es/index.php

Stewardship Activity Summary (39)

Name	Seed Drilling Guides
Member State(s)	UK
Instigator(s)	Bayer CropScience
Start date	Ongoing
Protection goal	Wildlife
Brief summary	4-one page drilling guides describing best drilling practice for oil seed rape, maize and winter and spring sown cereals.
Website link	http://www.bayercropscience.co.uk/seasonal-updates-and-guidance/autumn/seed-treatment-stewardship/

Stewardship Activity Summary (40)

Name	Farming for bees
Member State(s)	UK
Instigator(s)	National Farmers Union (NFU)
Start date	6 September 2013
Protection goal	Bees
Brief summary	A 6-page leaflet that provides guidance for farmers on what they can do to aid bees and other pollinators. The leaflet was produced to link in with the NFU sponsorship of The 85th Midland and South-western Counties Convention of Beekeepers held on 6th September 2013.
Website link	http://www.nfuonline.com/assets/16203

Stewardship Activity Summary (41)

Name	Bee Safe Bee Careful
Member State(s)	UK
Instigator(s)	National Farmers Union (NFU), Crop Protection Association (CPA) and the British Beekeepers Association (BBA)
Start date	
Protection goal	Bees
Brief summary	An 8-page booklet that provides guidance on general stewardship principles, insecticidal seed treatments and caring for bees.
Website link	http://www.cropprotection.org.uk/media/1948/bee_safe_bee_careful.pdf

Stewardship Activity Summary (42)

Name	BeeConnected
Member State(s)	worldwide

Instigator(s)	CropLife Australia
Start date	
Protection goal	Bees
Brief summary	Application for beekeepers and farmers for notification and coordination of each other's activities. Beekeepers are informed about plant protection activities around their apiaries and farmers and spray contractor about beekeeping sites near their crops.
Website link	http://www.croplife.org.au/beeconnected