POSITION // JANUARY 2016

5-point programme for sustainable plant protection

German Environment Agency

Umwelt Bundesamt

Publisher:
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Design:
Atelier Hauer + Dörfler GmbH, Berlin

Publications as a pdf:
https://www.umweltbundesamt.de/
publikationen/5-point-programme-for-sustainable-
plant-protection

Photo credits:
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As at January 2016

ISSN: 2363-829X

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I. Extended summary

In recent decades, with EU and national subsidies for farming in Germany, the conventional cultivation of crops has established itself as the basis of an increasingly intensified agriculture and food production. For many crops, a key requirement for this form of production is the intensive application of chemical plant protection products, on which the system is now practically dependent. This is reflected in the assumption that the amounts of chemical plant production products currently used and the frequency of their application represents a "necessary minimum" (in German language: "notwendiges Maß").

However, products that protect crops and benefit farmers may have undesirable impacts on nature and the environment. Even for present-day insecticides, herbicides and fungicides, the general principle remains: No effects (i.e. plant protection) without side-effects (i.e. impacts on nature and the environment). In view of the considerable potential environmental threats they pose and because they are applied in large quantities over ample areas of land, plant protection products may only be used if they have successfully undergone strict testing and approval procedures. In Germany, the Federal Environment Agency (UBA) is responsible for assessing the environmental risks.

But even though the UBA has rated the anticipated environmental impacts of each individually approved plant protection product as acceptable, there remain residual risks of chemical plant protection that cannot be assessed conclusively, e.g. regarding long-term impacts. In addition, environmental risk assessment currently examines each plant protection product in isolation, although most crops are treated numerous times with various plant protection products in application sequences each season. The decisive factor for the overall risk or the actual environmental impacts is therefore the sum of the applications, or the amounts applied, i.e. the overall intensity of the chemical plant protection. According to UBA calculations, German farmers currently use an average annual of 8.8 kg of plant protection products containing 2.8 kg of active substances per hectare of arable land.

This intensity of chemical plant protection has considerable negative impacts on nature and the environment. To this extent, the warnings expressed by Rachel Carson more than fifty years ago in her classic book "Silent Spring" are still valid for the modern plant protection products, even though these are now much better tested. Current examples of the relevance of the environmental impacts of chemical plant protection are:

- The impacts of the widespread application of neonicotinoid insecticides on honey bees and wild pollinators (e.g. bumble bees);
- The increasing loss of flora diversity in the agricultural landscape as a result of the blanket application of herbicides (e.g. glyphosate), in turn depriving wildlife of food resources;
- The regular detection of pesticide residues in groundwater (e.g. bentazone, isoproturon, chloridazon).

In 2009, in order to reduce the risks and impacts of pesticide use on people's health and the environment in the European Union, a directive (2009/128/EC) was adopted which establishes a framework for action to achieve the sustainable use of pesticides. The directive stipulates that the Member States set up national action plans, *"to reduce risks and impacts of pesticide use on human health and the environment and (...) the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides (...)."* In 2013, the German Federal Government implemented some of the important nature conservation and environmental protection requirements of the directive in its "National Action Plan on Sustainable Use of Plant Protection Products" (NAP). The German action plan was developed in a multi-stakeholder process, in the course of which environmental and nature conservation associations repeatedly criticised that the action plan was oriented too much towards the interests of the agricultural industry. The UBA was also involved in drawing up the action plan, and worked for the inclusion of targets and measures for environmental protection and nature conservation that are specific, binding, and ambitious. However, this was only partially achieved, so that in the opinion of the UBA there is a clear need for improvements when the action plan is revised in the upcoming years (2016/2017).

The opinion of the UBA is that the current intensity of the chemical plant protection in Germany is environmentally unsustainable and threatens the achievement of key targets of environmental protection and nature conservation policies. Plant protection that deserves the attribute "sustainable" must be much more ambitious, specific and transparent that is the case with the current German NAP. In order to promote truly sustainable plant protection, the UBA recommends an integrated approach across all relevant policy fields (plant protection, environmental protection, nature conservation, and agriculture) in accordance with the following five basic principles:

1. Minimising use

From the point of view of nature conservation and environmental protection, the use of chemical plant protection products should be minimised. The argument that the current intensive use constitutes a "necessary minimum" is an inacceptable attempt to legitimise the dependence of conventional agriculture on chemical plant protection. Policy-makers should rather aim to establish a general framework for a much more moderate "necessary minimum" or for a general minimisation of the use of chemical plant protection products. The UBA recommends the following measures and instruments:

- Effectively anchoring a general minimisation requirement in plant protection legislation.
- Supporting Integrated Plant Protection (often referred to as Integrated Pest Management,) that is committed to the use of non-chemical plant protection methods as a priority.
- Effectively supporting the expansion of organic farming.
- Ensuring widespread, independent plant protection consultancy.
- Avoiding the application of chemical pesticides in private gardens and public green spaces.
- Defining a clear reduction target for the annual amounts of plant protection products applied in Germany.

2. Identifying, quantifying and communicating risks

Chemical plant protection generally poses a risk to nature and the environment. For this reason, an environmental risk assessment is legally required before a plant protection product is approved. However, at present some gaps remain in the environmental risk assessment. For example, insufficient consideration is given to impacts on amphibians and reptiles or wild pollinators. The further development of the testing procedures for plant protection products to take into account scientific and technological advances is thus an on-going process. While this is necessary, it also means that the assessments are becoming increasingly more comprehensive and time-consuming. A further factor contributing to the steadily increasing scope and scientific complexity of the approval procedure is the fact that the producers of plant protection products submit so-called "refined" risk assessments (i.e. more realistic risk assessments for specific test areas) in order to obtain approval for their product without or only with less restrictive obligations for risk mitigation. This development raises concerns, both from a technical perspective (protectivity of the assessment), as well as from a legal point of view (democratic legitimation and independence of expert decisions, transparency of decision making, time and effort of approval procedures). The UBA is active in the updating of the environmental risk assessment regarding the implementation of the following measures and instruments:

- Removal of blind spots and uncertainties in the prescribed assessment procedures for plant protection products.
- Describing and managing environmental risks rather than "discounting" these with complex and inadequately validated methods.
- A ban on hazardous active substances in accordance with the legislative exclusion criteria at European level.
- A further improvement to the transparency and clarity of the decision-making processes in the approval procedure for plant protection products.
- A better description of the environmental risks and impacts resulting from the intensity of chemical plant protection in its entirety in Germany.

3. Optimising risk management

Plant protection products are introduced directly into the environment. Therefore, the aim at least must be to prevent plant protection products and their residues as far as possible from spreading to adjacent non-target areas, natural resources (e.g. groundwater) and habitats. This requires making the best possible use of the technically available and economically

viable options for risk management. The UBA recommends the following measures and instruments for the optimisation of risk management:

- A ban on the use of plant protection products in nature conservation areas.
- Limits on the use of plant protection products in drinking water protection areas, avoiding use as far as possible.
- Support for the rapid introduction of the best available technology for the application of plant protection products and the implementation of a minimum level of risk management (e.g. drift-reducing technology).
- Ensuring compliance with legal risk mitigation measures for plant protection products with a strict monitoring programme.
- Nationwide establishment of permanent, vegetated field margins and buffer zones to reduce the spread of plant protection products to adjacent areas or surface water bodies.

4. Compensating for unavoidable effects

The inevitable indirect effects of chemical plant protection are one of the factors contributing to the decline in biodiversity in the German agricultural landscape. The widespread intentional elimination of weeds and insects by plant protection products leads to such a depletion of the food supplies for wild mammals and birds (e.g. the partridge), that these cannot reproduce successfully and their populations decline. These indirect effects on biodiversity are not sufficiently considered in the environmental risk assessment of plant protection products, despite the fact that the protection of biodiversity is a specific requirement in Europe's plant protection legislation. The indirect impacts on biological diversity should, in the view of the UBA, be compensated for by the provision of ecological compensation areas. These should make up for the unavoidable direct effects of the plant protection product in the treated area to the extent that the indirect food web effects are also reduced to an acceptable level. The current agricultural policy requirements and instruments for the protection of biodiversity (5 % ecological focus area in accordance with the greening requirements of the EU Common Agricultural Policy (CAP) and agri-environmental measures from the CAP "second pillar") are not sufficient in the judgement of the UBA. In order to ensure the protection of biological diversity in landscapes heavily influenced by agriculture, the UBA therefore sees the need to expand the risk management of plant protection products. A precondition for the application of plant protection products with a high risk of indirect impacts on biodiversity should be the existence at the level of farms of ecological compensation areas where no plant protection products are applied (e.g. fallow land, flower strips, and untreated areas of spaced sowing). With the introduction of corresponding management obligations, it will remain possible to obtain legally-valid approval for plant protection products with high risks of indirect effects on biological diversity. At the same time, the measures would serve to implement the German National Strategy for Biological Diversity.

5. Internalising external costs

The short-term benefits for the producers from the use of chemical plant protection products are obvious (high, stable yields and marketable quality), and there are also benefits for consumers (assured supplies, low retail prices). However, it is doubtful whether the current intensive chemical plant protection is indeed sustainable with regards to the social dimension. The question is whether the societal benefits outweigh the societal costs. Are the benefits and the costs distributed fairly between the actors (PPP producers, farmers, trade, consumers) and those who are affected (the general public, tax payers, future generations)? The "socialised" costs borne by society as a whole are incurred by the monitoring bodies, by avoidance and repair measures (e.g. treating groundwater to prepare drinking water), and as a result of the impacts on human health and the environment. These are external costs because they are not fully reflected in the market prices of the plant protection products, harvested crops, and foodstuffs. In the opinion of the UBA there is a need for clarification and a political discussion about both the extent of the external costs of chemical plant protection and the distribution of the costs within society. At first, socio-economic analyses should be carried out in order to provide a basis for a rational and fact-based discussion. A second step should consider the possibilities and limits of political instruments to compensate for the effects of market distortions or for the internalisation of external costs (e.g. reform of EU and national farm payments or the introduction of a levy on plant protection products).

II. The current situation

a) System dependency on chemical plant protection

Chemical plant protection in conventional crop production

"Farming, forestry and agricultural business are among (...) the key sectors of the German economy..." (DBV, 2015). This statement is valid despite the fact that agriculture contributes only 0.9 percent to the German gross domestic product (European Commission, 2014) since it is the crops cultivated by farms that provide basis for our existence. Cereals, fruit and vegetables are among our most important foodstuffs, fodder plants feed our livestock, and for some years we have grown increasing quantities of "energy crops" to produce biogas and electricity. This is not possible without the ample use of natural resources (land, soil, water). About half the area of Germany (16.7 million hectares) is used for agriculture, and much of the German landscape has been shaped by crop production on some 285,000 farms (German Federal Statistics Office, 2014). Most farms (94%) operate conventional crop production, which is characterised in particular by the use of mineral fertiliser and chemical plant protection products (PPPs). Mineral fertiliser provides maximum nutrient supply to the crops and the PPPs are used to tackle harmful bacteria and fungi, harmful animal organisms, and undesirable weeds. It is the combination of mineral fertiliser, chemical plant protection and modern high yield crop varieties that make the current intensive crop production possible, with its tight crop rotation and monocultures. This in turn provides the high yields of conventionally produced plant products at consistently high marketable quality (Gutsche, 2012).

Figure 1

Mean treatment with PPPs of important crops in Germany in 2013

Crop	Treatment frequency	Treatment index
Potatoes	8.7	11.2
Winter wheat	4.2	5.2
Sugar beet	4.8	3.8
Hops	6.2	8.0
Eating apples	21.3	31.9
Grapes	10.4	17.2

Source: our presentation, data from the PAPA Web site of JKI: http://papa.jki.bund.de/index.php?menuid=1, see also Rossberg, 2013

Since the "Green Revolution" in the mid-20th century, the conventional cultivation system has been continually optimised so that it meanwhile provides the basis for our largely intensive agriculture and food production. The intensive use of chemical PPPs in conventional crop production is reflected in the annual surveys of the Julius Kühn Institute (JKI). Expressed as the so-called treatment index (i.e. number of PPPs used relative to the maximum permissible applied amounts and the cultivated area) in 2013 wheat was treated on average 4-times with PPPs, potatoes 11-times, grape vine 17-times, and apple trees and apple trees 32-times (Fig. 1).

The "necessary minimum" is not hewn in stone

The current dominance of conventional farming systems is not only the result of free market forces. This development has also in part been due to the German und European agricultural policies of past decades, which mainly aimed at increasing efficiency and yields (Meier, 2012). A key factor was that European and national subsidies were provided for agriculture, paid for through taxation. Although they have been declining for some years, agricultural subsidies still account for some 42% of the total EU budget (European Commission, 2014). In Germany, the agricultural sector received a total of EUR 6.8 billion in 2012, and on average the transfer payments made up some 48 percent of the income of German farmers (European Commission, 2014). The European and national support for conventional cultivation systems not only offered advantages for the farmers, but also for the consumers. The reliable supply of high quality fruit and vegetables and food products all round the year at more and more favourable prices is something that consumers have come to expect. The increased consumer expectations ("unblemished and cheap") are also in part to blame for the current degree of dependence of conventional crop production on chemical plant protection.

The dependency is justified with reference to the "necessary minimum" (in German language: "notwendiges Maß"), which "denotes the amount of plant protection products that is necessary to secure the cultivation of crops, particularly from the aspect of economic viability" (German NAP, 2013). This term, with its ideological undertones, suggests that the constraints of the market economy clearly leave the individual farmer with no choice other than the "nec-

essary" use of PPPs. But given the political influence on the market – in particular with farm payments – this line of argument is not entirely convincing. A different agricultural policy could well lead to a lower "necessary minimum". However, implementing this would require political conviction (see also d), and at the same time it is important not to lose sight of the reality of the global markets for agricultural produce.

(Note: The focus in the following is solely on PPPs. Relevant analyses and recommendations for mineral fertiliser (in particular nitrogen) are provided in other publications of the Federal Environment Agency, e.g. UBA, 2015.)

b) Assessment and management of environmental risks

Plant protection products: No effects without side-effects

Chemical PPPs are used because of their biological efficacy in key areas: bactericides and fungicides are used to combat plant diseases caused by bacteria and fungi, insecticides kill insects such as aphids or caterpillars that damage plants, and herbicides are used to control "weeds". In order to achieve these effects, the PPPs – which can consist of mixtures of up to 20 different chemicals – typically contain one or more chemically synthesized active substance. However, usually their effects are not very specific, i.e. not restricted to the target organisms in question. The description of the potential side effects is therefore an important element of the testing and approval procedure for PPPs. The direct effects of a PPP are described mainly on the basis of laboratory experiments in which indicator organisms such as algae, water fleas, fish, earthworms, bees, birds, and rats are exposed to the active substances or the PPP. These studies are used to determine the acute and/or chronic toxicity of PPPs for the so-called "non-target organisms". Generally speaking, all PPPs must be expected to have more or less severe side-effects – if the non-target organisms are exposed to relevant quantities. In other words: No effect (plant protection) without side-effects (on organisms in the environment). The side-effects profile of the PPP usually corresponds to the intended pesticidal effect: herbicides are particularly toxic for algae and non-target plants that are close to the "weeds" phylogenetically and biochemically; similarly, insecticides are often just as toxic for beneficial insect species (honey bees, wild bees, butterflies, etc.) and other arthropods (spiders, woodlice, etc.) as they are for pest insects. With regard to bactericides and fungicides, the profile of the side-effects is usually less clear. Considering the level of natural biocenosis and ecosystems, it is known that direct PPP-effects on certain organisms can lead in turn to indirect PPP-effects on other organisms that are not directly affected by the toxicity (see also c).

Concerning risks and side-effects ask the Federal Environment Agency

In view of their potential side-effects and because they are introduced directly into the environment in considerable quantities (see c) and over large areas, the application of a PPP is only allowed in the European Union after it has successfully passed through a harmonised testing and approval procedure applicable in all member states since 2012. The legal framework for this in Germany is established by the Plant Protection Act (PflSchG, 2012) in combination with the European Regulation (EC No. 1107/2009) concerning the placing of plant protection products on the market. For each proposed application of a PPP to combat a defined harmful organism in a defined crop, the acceptability of the resulting environmental impacts is to be examined. Note that the objective is not absolute protection or a zero-risk, but only that there should be no unacceptable effects on the environment. However, weighing up the pros and cons between protection of the crops and the protection of the environment is not explicitly part of the risk assessment, but is carried out on the basis of decision criteria defined in the PPP Regulation (EC No. 1107/2009) and in corresponding technical guidance documents.

In Germany, the Federal Environment Agency (UBA) is responsible for the environmental risks assessment of PPPs – including the impact on the groundwater. The UBA commits considerable human resources to fulfilling this task with independent expertise and in accordance with the state of knowledge in science and technology. In order to ensure that the environmental impacts are acceptable, the German Federal Office of Consumer Protection and Food Safety (BVL), which is the overall responsible national authority for the approval procedure, draws on the risk assessment provided by the UBA to formulate legally binding conditions of use and risk mitigation measures that are displayed on the PPP packaging and with

which farmers have to comply. In the case of spraying this might involve technical regulations for the application (e.g. using drift-reducing technology) or requirements for maintaining a certain distance from surface water bodies. The PPPs currently authorised in Germany including the conditions of use and required risk mitigation measures can be viewed on the online BVL database (https://apps2.bvl.bund.de/psm/jsp/index.jsp). Monitoring compliance with the risk mitigation measures in Germany is the responsibility of the individual Federal States (in German language: Bundesländer).

c) Residual risks, overall risks and environmental impacts

Difficult predictions and residual risks

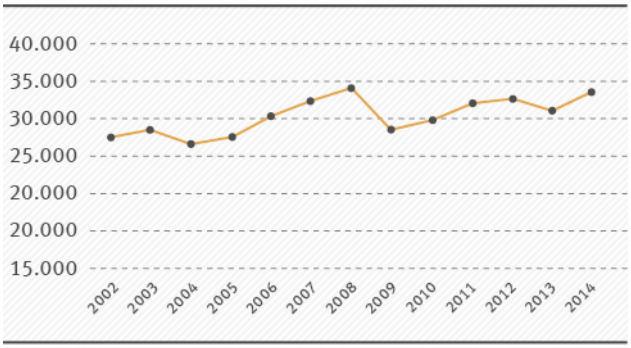
Even though the environmental impacts of each individual PPP authorised in Germany was judged by UBA to be acceptable on the basis of current knowledge, there still remain residual risks that cannot be conclusively assessed. This is the case firstly for long-term risks, which in view of the complexity of the organisms and ecosystems can only be estimated to a limited extent with the available test and assessment methods, involving considerable uncertainties. Even if there is further scientific progress that can be taken into account in the official assessment procedure, there will always be gaps in our knowledge. As a result of the complexity, there are things that cannot be known and cannot be predicted as a matter of principle, leading to residual risks of chemical plant protection that are often overlooked (Scheringer et al., 1998).

The total dose is what counts

Another problem of the current authorisation procedure is that by examining the individual PPP application in isolation consideration of "the big picture" is omitted. As already seen with the treatment index, most crops are treated a number of times in the course of the growing season with the same and/or various PPPs. The sum of the applications and the total amount applied on a crop is therefore decisive for the overall risk or the environmental impacts in the agricultural landscape, and not the individual PPP. A rough calculation demonstrates the general intensity of the use of PPPs in Germany: in 2014, 106,155 tonnes PPP containing 34,515 tonnes of active substances (without inert gases) were sold in Germany (BVL, 2015) – this amount has remained largely constant over the past 10 years or has even increased slightly (cf. Fig. 2). Ignoring the differences in treatment intensity between crops, and assuming some 12.1 million hectares of arable land under cultivation, this gives an average application of 8.8 kg PPPS and 2.8 kg active substances per hectare.

Figure 2

Sales in Germany of PPP active substances (without inert gases) in tonnes



Source: BVL, 2014; BVL 2015

When "theoretical" risks become real environmental impacts

The remaining assessment uncertainties and the overall treatment intensity not only constitute "theoretical" risks, but have had and continue to have considerable negative impacts on nature and the environment. In retrospect, the development of chemical plant protection can be seen as an example of "pathological learning" (Troge, 2009). It is now half a century since the classic "Silent Spring" by Rachel Carson (1963) raised public awareness about the environmental damage caused by the first PPP generation. The old active substances (DDT, organophosphates, etc.) have largely been replaced by more modern and much better tested active substances. But three examples show the continuing relevance of PPP-environmental impacts:

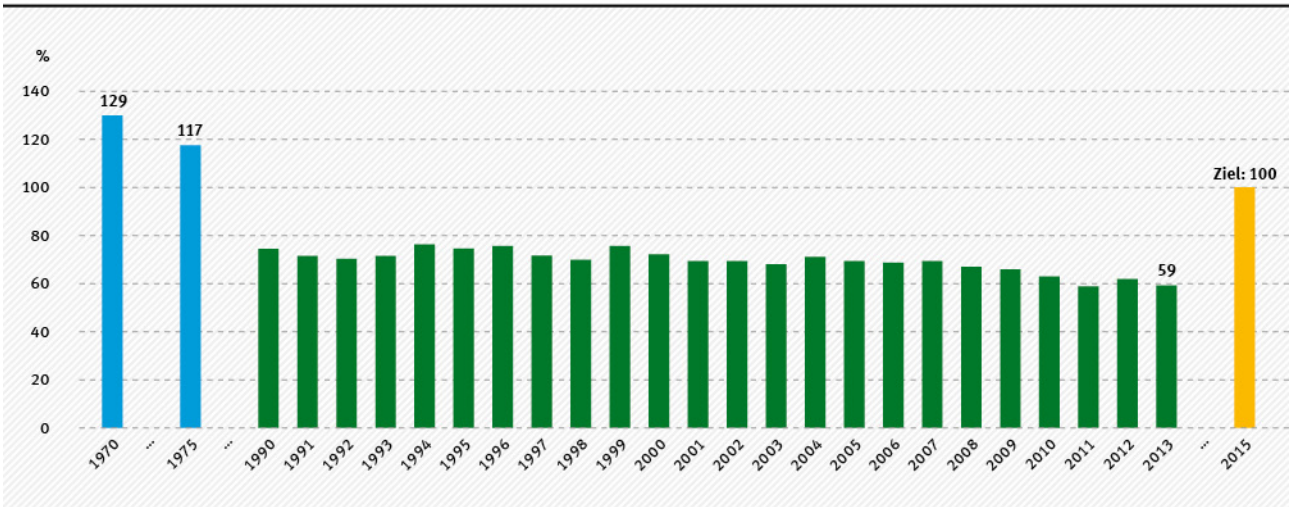
- **Neonicotinoids:** This group of highly-effective insecticides have been widely used in the past 20 years for seed treatment (seed coatings). These "systemic" active substances are taken up by the seedling, offering protection against sucking insects and some chewing insects. In 2008, the spread of abrasion dust from coated seeds spread by pneumatic seed drilling equipment led to a massive poisoning of bee colonies in south-western Germany (BVL, 2015). The importance of the

airborne distribution of abrasion dust had been underestimated in the EU approval for the active substances and in the PPP testing. The European Food Safety Authority (EFSA) reassessed the risk of the main neonicotinoids for honey bees and wild pollinators (e.g. bumble bees) in the light of the new scientific findings and found serious gaps in the data – in particular concerning long-term toxicity. For many applications, EFSA concluded that an unacceptable risk was indicated or could not be excluded. As a consequence, the EU Commission banned these critical applications in 2013 and called on the producers to provide the data that was missing (European Commission, 2013). It remains to be seen what decisions will be reached by the EFSA, the EU Commission and the national authorities on the basis of the data that is provided – also taking into account the massive criticism of this group of substances by scientists (van der Sluijs, 2014) and by environmental and nature conservation associations (e.g. BUND, 2015).

- **Glyphosate:** This is the most important herbicide in Germany and worldwide, and in contrast to neonicotinoids it is thought to be relatively harmless for non-target-organisms in the environment at present (although this is currently being re-evaluated in the EU). The environmental problems arise in this case from the blanket application of this broadband herbicide on a massive scale. The amount sold and used in Germany has risen sharply over the past 15 years, and some 5000 tonnes are now used by German farmers every year (Deutscher Bundestag, 2011). This is due in particular to increase in no-till cultivation. There are many environmental arguments in favour of less ploughing (e.g. reducing erosion on slopes, protecting against run-off from heavy soils, avoiding soil compaction, improved soil water household), but in most cases economic considerations provide the main motivation for this trend. Farmers can save time and money if they control weeds using the relatively cost-effective glyphosate products. However, the massive use of glyphosate and other herbicides leads to a progressive loss of abundance and diversity in the farmland flora, with indirect effects on sensitive fauna. In the case of ground-nesting bird species such as the partridge, these food web-effects are scientifically proven (Jahn et al., 2014). The elimination of field weeds by herbicides and of arable

Figure 3

Changes in the populations of indicator bird species in Germany's agricultural landscape



Notes: The change of indicator bird species is given relative (%) to the target value ("Ziel: 100 %") as officially defined for the year 2015. There is a significant negative trend observable for this indicator. The values given for the years 1970 and 1975 have been recalculated from historical data. The indicator species do comprise: Whinchat, woodlark, little owl, meadow lark, lapwing, black-tailed godwit, yellowhammer, red-backed shrike, corn bunting, red milan.

Source: BfN, 2016

farmland insects by insecticides depletes food supplies, so that the birds are not able to successfully reproduce in intensively-farmed agricultural landscapes. As a result, populations are declining (Fig. 3). Chemical plant protection is to this extent one of the causes contributing to the disturbing ongoing decline in biodiversity in the German agricultural landscape (Sudfeldt et al., 2013).

- **Tolyfluanid:** The authorisation of PPPs containing this fungicidal active substance was withdrawn in 2007. The reason for this was the "delayed" discovery that a metabolite (N,N-dimethylsulfamide) which can find its way into groundwater, though previously classified as toxicologically harmless, can be transformed during the preparation of drinking water by ozonisation into a genotoxic and carcinogenic substance (N-nitrosodimethylamin). As a precautionary measure for the protection of drinking water, the use of the active substance was therefore prohibited (European Commission, 2007). However, residues of other active substances such as atrazine, which has long been banned in Germany, are still found in groundwater and other currently authorised active substances (e.g. bentazone, isoproturon, chloridazon) and their metabolites are frequently found in groundwater at concentrations above the limit levels (UBA, 2013). There have recently been intensive debates in Germany about the pollution of groundwater and about the problems faced by water utilities endeavouring to maintain the high quality of German drinking water. The position of the water utilities is *"that the active substances in plant protection products and their metabolites should be kept away from the water cycle at the first opportunity in a precautionary manner"* (Steinbach, 2014).

d) Chemical plant protection and sustainability – a politically controversial topic

"Sustainable use directive" and the national action plan

In "A Thematic Strategy on the Sustainable Use of Pesticides" in 2006, the EU Commission had already noted that in addition to the authorisation procedure the use phase was decisive for the risks and impacts of PPPs (European Commission, 2006). As a consequence, EU Directive 2009/128/EC established a framework for Community action to achieve the sustainable use of pesticides, introducing "sustainability" as a political goal. The Directive obliges the Member States to draw up national action plans, *"aimed at setting quantitative objectives, targets, measures, timetables and indicators to reduce risks and impacts of pesticide use on human health and the environment and at encouraging the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides[...]"* (European Union, 2009). However, neither the Thematic Strategy nor the Directive proposed a precise quantitative reduction target for the application of PPPs. Despite this, the European Commission expected a significant reduction in PPP use as a result of the measures of the Thematic Strategy (European Commission, 2006).

Some of the Directive requirements were transposed in Germany as "hard" regulations in the Plant Protection Act (e.g. regarding certificates of competence for sellers and professional users, or the aerial application of pesticides). In these cases, violations and infringements against key provisions of the law can lead to prosecution and the imposition of fines. However, most of the important requirements relating to nature conservation and environmental protection in the Directive were not transposed in the Plant Protection Act, but were included in the German National Action Plan on Sustainable Use of Plant Protection Products (NAP) concluded by the German Federal Government on 10 April 2013. The National Action Plan represents a comparatively soft regulatory instrument and most of the targets and measures it contains are not legally binding. The NAP is closer in character to a declaration of intent and the success of the implementation depends on the degree of motivation of the actors involved (in particular the Federal Government, Federal States (Bundesländer), and agricultural associations) as well as on the funding available for the implementation.

Sustainability in plant protection – disputes about the need for action

The German NAP was developed over a number of years in a multi-stakeholder process organised under the responsibility of the Federal Ministry for Food, Agriculture, and Consumer Protection (BMELV; meanwhile: Federal Ministry for Food and Agriculture, BMEL). The environmental protection and nature conservation associations, the professional beekeepers, and the water management sector were all critical

of the draft version of the NAP. In a clear signal, the associations terminated their further participation; in a press release dated 24.11.2011 they stated: "*The Agriculture Ministry orients itself in the Action Plan towards the interests of the agricultural industry and seems deaf to suggestions to seriously reduce pesticide pollution. They will not receive support from the Associations for this.*" (PAN, 2011).

Under the Plant Protection Act, the UBA is involved in drawing up and implementing the German NAP according to its responsibilities for the environmental risk assessment of PPP. In this context, the UBA provided expert advice for the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU; meanwhile: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, BMUB). The common goal of BMU and UBA was to realise an action plan that included targets and measures for environmental protection and nature conservation that were specific, binding, and ambitious. This was only partially successful, so that in the opinion of the UBA there is a clear need for improvements with regard to environmental protection and nature conservation when the action plan is revised in the upcoming years (2016/2017). This view is not shared by the conventional agricultural sector, where the general opinion is that plant protection in Germany is already sustainable. According to an analysis of the EU Commission, this attitude is widespread among the EU Member States: "The majority of NAPs appear to adopt the default position that the current PPP use pattern in their M(ember) S(tate) is sustainable." (European Commission, 2014). This is irritating because the Member States had in principle acknowledged the need for political action on the sustainable use of pesticides yet have so far seemed unwilling to follow words with deeds.

The current situation (summary)

In recent decades, with EU and national support for farming in Germany, the conventional cultivation of crops has established itself as the basis of an increasingly intensified agriculture and food production. For many crops, a key requirement for this form of production is the intensive application of chemical plant protection products, on which the system is now practically dependent. This is reflected in the assumption that the amounts of chemical plant production products currently used and the frequency of their application represent a "necessary minimum" (in German language: "notwendiges Maß").

However, products that protect crops and benefit farmers may have undesirable impacts on nature and the environment. Even for the insecticides, herbicides and fungicides now used, the general principle remains: No effects (i.e. plant protection) without side-effects (i.e. impacts on nature and the environment). In view of the considerable potential environmental threats they pose and because they are applied in large quantities over ample areas of land, plant protection products may only be used if they have successfully undergone strict testing and approval procedure. In Germany, the Federal Environment Agency (UBA) is responsible for assessing the environmental risks.

But even though the UBA has rated the anticipated environmental impacts of each individually approved plant protection product as acceptable, there remain residual risks of chemical plant protection that cannot be assessed conclusively, e.g. regarding long-term impacts. In addition, environmental risk assessment currently examines each plant protection product in isolation, although most crops are treated numerous times with various plant protection products in application sequences in each season. The decisive factor for the overall risk or the actual environmental impacts is therefore the sum of the applications, or the amounts applied in the course of the year. According to UBA calculations, German farmers currently use an average annual of 8.8 kg plant protection products containing 2.8 kg of active substances per hectare of arable land.

This intensity of chemical plant protection has considerable negative impacts on nature and the environment. To this extent, the warnings expressed by Rachel Carson more than fifty years ago in her classic book "Silent Spring" are still valid for the modern plant protection products, even though these are much better tested. Current examples of the relevance of the environmental impacts of chemical plant protection are:

- The impacts of the widespread application of neonicotinoid insecticides on honey bees and wild pollinators (e.g. bumble bees)
- The increasing loss of flora diversity in the agricultural landscape as a result of the blanket application of herbicides (e.g. glyphosate), in turn depriving wild animals of food resources
- The regular detection of pesticide residues in groundwater (e.g. bentazone, isoproturon, chloridazon).

In 2009, in order to reduce the risks and impacts of pesticide use on people's health and the environment in the European Union, a directive (2009/128/EC) was adopted which establishes a framework for action to achieve the sustainable use of pesticides. The directive stipulates that the Member States set up national action plans, *"to reduce risks and impacts of pesticide use on human health and the environment and (...) the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides (...)."* In 2013, the German Federal Government included some of the important nature conservation and environmental protection requirements of the directive in its "National Action Plan on Sustainable Use of Plant Protection Products". The German action plan was developed in a multi-stakeholder process; in the course of this environmental and nature conservation associations repeatedly criticised that that the action plan was oriented too much towards the interests of the agricultural industry. The UBA was also involved in drawing up the action plan, and worked for the inclusion of targets and measures for environmental protection and nature conservation that are specific, binding, and ambitious. However, this was only partially successful, so that in the opinion of the UBA there is a clear need for improvements when the action plan is revised in the upcoming years (2016/2017).

III. 5-point programme for sustainable plant protection

UBA is of the opinion that the current intensity of the chemical plant protection in Germany is ecologically unsustainable and threatens the achievement of key targets of environmental protection and nature conservation policies. Plant protection that deserves the attribute "sustainable" must be much more ambitious, specific and transparent that is the case with the current German NAP. Reforms are also necessary with regard to the authorisation of plant protection products. In order to promote truly "sustainable development" in plant protection, the UBA recommends an integrated approach for all relevant policy areas (plant protection, environment, nature conservation, and agriculture) based on the following five basic principles:

1. Minimising use

Anchoring minimisation in German plant protection legislation

From the perspective of nature conservation and environmental protection it is necessary to minimise the frequency of use of chemical PPPs and the amounts applied. However, the current situation is characterised by competition in the farming sector, rationalisation pressure, and favourable prices for PPPs, with the costs of undesirable PPP impacts born by the public. With no effective incentives for famers, introducing a legally anchored minimisation requirement would seem to be the correct approach. This would also start the urgently needed discussion among experts and policy-makers about what actually constitutes a "necessary minimum" (in German language: notwendiges Maß) for the use of PPPs from a societal perspective. The requirement can be anchored in the "Code of good practice for plant protection" (in German language: Grundsätze für die Durchführung der guten fachlichen Praxis im Pflanzenschutz) (BMELV, 2010), which has to be complied with under the Plant Protection Act, for the use of PPPs. However, if such a requirement is to be fully effective, three preconditions must be met:

- If they are to use PPPs sparingly for their crop production, farmers need better training and effective assistance from independent advisors about practical plant protection. In Germany, both tasks are now the responsibility of the plant protection services at the federal state level, but these are frequently understaffed (BLE, 2014). The consequence is that advice on plant protection is at present predominantly given by consultants acting on behalf of the PPP producers – and their primary goal is certainly not to advise on how to use PPPs sparingly. Therefore, widely available independent consultancy should be provided which has the clear goal of "minimising PPP use".
- An effective and independent monitoring system is required. It must be possible to determine whether an individual PPP-user is indeed working to minimise the amounts applied, and checks must be carried out frequently enough for these to be effective. The legal obligation of farmers to document their use of pesticides (in application records) provides a suitable basis for traceability. The responsibility for checking compliance with the minimisation requirement could again lie with the plant protection services at the federal state level. Their remit would be to define criteria for good farming practice for plant protection in accordance with the minimisation requirement, taking into account the regional conditions and "pest pressure", and to check compliance. This calls for random or targeted inspections of the application records.
- Obvious breaches of the minimisation requirement must meet with appreciable sanctions. One option would be the reduction or withdrawal of CAP direct payments.

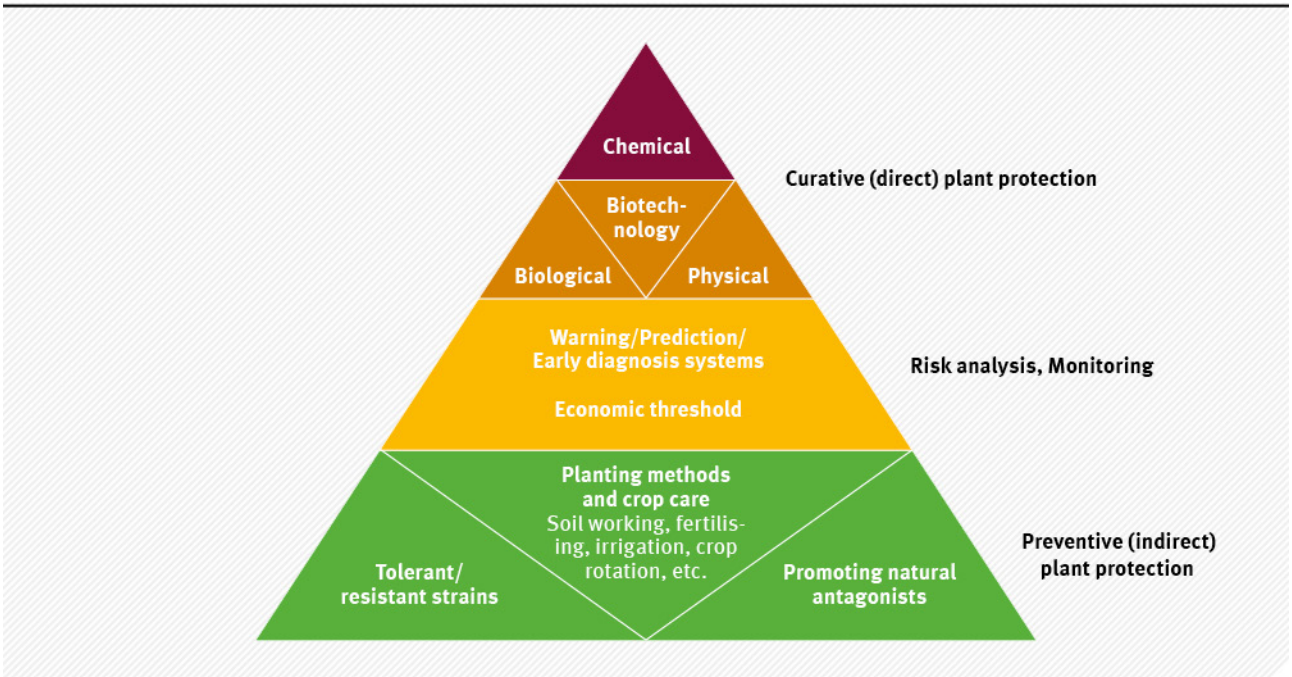
Integrated Plant Protection – back to the roots

For conventional cultivation, "minimising use" means adopting an integrated approach to plant protection for which the basic principle is: "Chemicals are the last resort!" (see Fig. 4). Integrated Plant Protection (often referred to as Integrated Pest Management, IPM) gives a priority to preventative measures (choice of varieties, crop rotation, cultivation methods) and biological measures, in combination with the strict adherence to the economic threshold principle, before a chemical PPP is used (European Union, 2009; Furlan, 2014).

However, this "pure doctrine" has obviously slipped into the background, as can be seen from the increasing prophylactic use of pesticides (e.g. in the form of

Figure 4

Basic principles of Integrated Plant Protection



Source: from a talk on "Nutzen und Risiken von Pestiziden" by Dr Eva Reinhard, BLW, Bern, 10.11.2014 at Oekotoxzentrum Dübendorf, Switzerland

seed coating) and in uses not primarily relating to plant protection (e.g. herbicides to accelerate ripening and to kill off foliage before harvesting). For "real" Integrated Plant Protection it is therefore essential to formulate specific minimisation requirements in the "Code of good practice for plant protection" (in German language: Grundsätze für die Durchführung der guten fachlichen Praxis im Pflanzenschutz) and combine these with a consultancy and inspection system (Lefebvre, 2014). It is vitally important that when a minimisation requirement applies for all farmers, financial constraints and competition should no longer serve to justify a use of pesticides which is not in accordance with Integrated Plant Protection (i.e. "The first to reduce spraying is the loser.")

The implementation of the minimisation requirement in Integrated Plant Protection can be reinforced by setting up an agricultural equalisation fund – if applicable with initial state support. The idea is to cushion the effects of loss of earnings or yield risks for the individual farmers who adopt plant protection methods aimed at minimising the use of pesticides. Relevant experience is already available from Italy (Furlan, 2014). In addition, increased support must be provided for research and development work on Integrated Plant Protection – in particular non-chemical methods.

Supporting the expansion of organic farming

The minimisation requirement must of course apply equally for plant protection in organic farming. Organic farming has already adopted these principles inasmuch as the use of chemical-synthetic PPPs is not permitted under the EC Regulation on organic production and labelling of organic products (European Commission, 2008), or under the guidelines of the organic farming associations. Much smaller amounts of PPPs are used developed on the basis of natural substances (e.g. sulphur, copper, pyrethrum), although this does not necessarily mean that these are harmless with respect to the environment.

Organic farming therefore already meets the requirements of the EU "Sustainable use directive" 2009/128/EC for a cultivation system using smaller amounts of pesticides. Another advantage is that an effective certification and monitoring system is already in place (EU organic logo and Germany's Bio Seal, as well as various association seals).

Increasing numbers of environmentally aware and health-conscious consumers approve of the goals of organic farming and place their trust in organic products, as can be seen from the continually rising demand in recent years. Meanwhile, the demand for organically produced food in Germany exceeds the

supply, so that considerable amounts have to be imported (BÖLW, 2015). The fact that the development of German organic farming is lagging behind demand is attributable to the current economic and agri-political situation, which obviously makes conventional crop production more profitable.

In order to promote organic farming as an effective way to reduce the environmental risks and the dependence on chemical PPPs, it is therefore necessary to improve the framework conditions for those conventional farms that are willing to convert to organic farming. In particular, further training and assistance with conversion should be offered; improved financial support for organic farming is also needed.

The Sustainability Strategy of the German Federal Government from the year 2000 set a target of 20 % organic farmland by 2010, but currently the level is still only slightly above 6 % (German Federal Statistics Office, 2014). It is urgently necessary to review whether the increased incentives offered in recent times in some German Federal States (agri-environmental measures financed through the CAP "second pillar") for converting to or persisting with organic farming are adequate in order to reach the target in the medium-term. In 2014, the BMEL initiated the formulation of a "Strategy For The Future Of Organic Farming" (BMEL, 2014) in order to establish additional impulses for the expansion of organic farming in Germany. Together with representatives of the organic food sector and participants from the Federal States , science and various associations, BMEL proposes strategies and recommendations for key fields through to the end of 2016, by means of which the target of "20% organic farming" anchored in the Sustainability Strategy of the German Federal Government can be achieved (see also: http://www.ti.bund.de/de/thema/oekologischer-landbau/zukunftsstrategie-oekologischer-landbau/). The UBA welcomes this and calls for the energetic expansion of organic farming in Germany, not least as an important element for sustainable plant protection. This will also require strengthening research and development for plant protection in organic farming.

Doing without chemicals in private gardens and public green spaces

The call to minimise use of chemical PPPs also applies for public green spaces, private gardens and allotments. In contrast to farming, the economic benefits in this case are usually negligible and accordingly the priority is placed on aesthetic considerations ("weed-free lawns"). Giving preference to non-chemical alternatives in these cases is therefore both practicable and reasonable. Information is already available on minimising the use of chemical pesticides in gardens and allotments (e.g. BUND, 2015), and further advice is currently being developed on behalf of the UBA (http://www.umweltbundesamt.de/pflanzenschutz-im-garten-startseite).

In addition to the voluntary avoidance of chemical plant protection, the UBA is also promoting discussion of a complete ban on herbicides in gardens and allotments. The background for this is the repeated occurrence of inputs of herbicides into public sewers and wastewater treatment systems, obviously due in many cases to inappropriate application by private users, for example on paved areas (BVL, 2009; LANUV, 2013).

Regarding PPP use in public spaces, many German towns and local communities in the initiative "Pesticide Free Local Authorities" (in German language: Pestizidfreie Kommunen) have committed themselves to avoiding the use of chemical PPPs either completely or as far as possible (BUND, 2014). In France, a nationwide ban on chemical PPPs in public green spaces will come into effect from 2020 (European Commission, 2014). France has taken a big step towards implementing the measures provided for in the EU "Sustainable Use Directive" 2009/128/EC to minimise or ban the use of pesticides in places such as public parks and gardens, playing fields and sports facilities, schools and children's playgrounds and in the vicinity of healthcare facilities.

Defining clear policy targets for the reduction in the use of pesticides

In view of the prospective revision of Germany's NAP, the UBA recommends a political debate about a specific quantitative target for the reduction of the use of chemical PPPs. Thereby Germany would be following the examples of Denmark, which targeted a 40 % reduction in PPP use from 2011 to 2015, and France, which has set specific reduction targets for 53 active substances (European Commission, 2014). A suitable starting point for the discussion about a target for the reduction of the amounts of pesticides

used in conventional cultivation could be the experience gained in the "Demonstration farms for Integrated Plant Protection" (http://demo-ips.jki.bund.de/). Even under the current economic and agri-political conditions, they used up to 20 % less PPPs than in comparable normally operating farms in the region as a result of receiving improved advice from experts and adherence to the "threshold of damage" principle (Freier et al., 2014).

Point 1: Minimising use (summary)

From the point of view of nature conservation and environmental protection, the use of chemical plant protection products should be minimised. The argument that the current intensive use constitutes a "necessary minimum" is an inacceptable attempt to legitimise the dependence of conventional agriculture on chemical plant protection. Policy-makers should rather aim to establish a general framework for a much more moderate "necessary minimum" or for a general minimisation of the use of chemical plant protection products. The UBA recommends the following measures and instruments:

- Effectively anchoring a general minimisation requirement in plant protection legislation.
- Supporting Integrated Plant Protection (often referred to as Integrated Pest Management) that is committed to the use of non-chemical plant protection methods as a priority.
- Effectively supporting the expansion of organic farming.
- Ensuring widespread, independent plant protection consultancy.
- Avoiding the application of chemical pesticides in private gardens and public green spaces.
- Defining a clear reduction target for the annual amounts of plant protection products applied in Germany.

2. Identifying, quantifying and communicating risks

Eliminating "blind spots" in the environmental risk assessment of PPPs

For the authorisation process it is important to eliminate "blind spots" and weaknesses in the environmental risk assessment. For example, the assessment currently fails to pay sufficient attention to the impacts on amphibians, reptiles, wild pollinators, soil arthropods, aquatic and soil fungi, or the indirect effects on biological diversity (for the latter, see 4.). There is also considerable uncertainty about the extent to which the results of model calculations of the PPP residues expected in the soil, groundwater and surface water bodies are in fact representative. In order to improve the environmental risk assessment, it is thus necessary to continuously advance the principles on which this is based and to implement the scientific developments in appropriate testing requirements and assessment concepts. This is the responsibility of the UBA, in parallel to the processing of authorisation applications. It involves research projects, the results of which are also introduced into the further development of the testing and assessment procedures at the European level. This revision process is initiated primarily by the UBA for Germany and by EFSA , with the goal of meeting the requirement to implement the state-of-the-art. Scientific progress is thus one of the reasons for the marked increase in the complexity of environmental risk assessment for PPPs in recent decades.

Critically reviewing "refined" risk assessment for individual PPPs

A further driver of the growing complexity of the environmental risk assessment lies in the EU Regulation on Plant Protection Products. In the event of a negative assessment result at a lower assessment tier on the basis of standard data and conservative assumptions, the applicant can use a so-called "refined assessment" to show that no unacceptable environmental impacts of a PPP are to be expected under realistic application conditions. The investment in such a refinement of the risk assessment, e.g. in the form of mathematical models or more complex experimental studies (aquatic mesocosms, field studies) is usually

worthwhile for the applicant company. Either because it is the only way to obtain an authorisation, or because it makes it possible to avoid stricter requirements for risk management (e.g. concerning margins to adjoining surface water bodies). Increasing complexity in the refined risk assessment is observable in particular for environmentally critical PPPs that are being defended by all means possible.

This trend is questionable from a scientific point of view, because the more realistic risk assessment is still carried out in isolation for the individual PPP for which the application has been made. The fact that the exposure regime for the given crop will usually involve the multiple application of various PPPs over the growing season is ignored. Increasingly, doubts are being expressed about the "refined" acceptability of the environmental impacts and whether the management requirements for an individual PPP are sufficient when the exposure regime is considered (Hardy et al., 2012; EFSA, 2013). The relevance that common forms and intensities of PPP application in tank mixtures and spraying with a series of PPPs have for the evaluation and management of the environmental risks for individual PPPs has been and is being addressed in research projects commissioned by the UBA (e.g. Altenburger et al., 2013).

Generally, the UBA sees the need to discuss the extent to which the trend towards increasingly refined risk assessment for individual PPPs (i) is appropriate or is as a rule disadvantageous for the environment, (ii) causes unnecessary societal costs, and (iii) places excessive demands on the risk communication (see below). For an initial exchange on these questions, a working meeting was held in November 2015 at the instigation of the UBA, attended by experts from the relevant assessment authorities of a number of European countries.

Improving transparency and risk communication

Further objections raised against this "refinement trend" in risk assessment concern the increasing loss of transparency and greater susceptibility to the influence of special interests. Considerable scientific expertise is required in order for PPP producers to be able to further refine the risk assessment and for the assessment authority bodies to understand the measures involved. It is meanwhile not unusual for scientists of standing to be commissioned by the applicants to present a report for a refined assessment which is then submitted to defend the authorisation of the PPP or to argue that fewer management measures are required. Even if the assessment authority is able to respond with equal expertise (which becomes more difficult the smaller the agency of an EU Member State is), this development is problematic. In general, as the expert judgements become more important, the decisions become less transparent for the public. The decision-making process becomes more susceptible to the influence of parties with special interests due to the relatively small numbers of actors involved. The independence of "super experts" and the democratic legitimation of their decisions, with their far-reaching implications, is a sensitive topic in modern knowledge societies (Müller & Vogel, 2014; Ratte, 2007). An indicator of the relevance and political delicacy of this development has been the public criticism expressed regularly in recent years about the composition of the panels of experts of EFSA (Robinson, 2011). Many experts with earlier or existing connections to the chemical industry are thought to have conflicts of interests. In order to maintain or increase societal trust in the authorisation procedure for PPPs, it is necessary to meet the understandable call for the independence, transparency and clarity of the decision-making processes. As a step in this direction, since 2009 the German Federal Office of Consumer Protection and Food Safety (BVL) has made public its authorisation decisions, including concise summaries of the evaluations (see http://www.bvl.bund.de in German). In the future, a significant step towards more transparency would be to make available in a publicly accessible database all the relevant data about the environmental behaviour and ecotoxicology of the active substance or PPP, including the results of confidential studies commissioned by the applicant. This is being considered both by the UBA and the EFSA.

Avoiding the complexity trap

As explained, the increasing complexity of the environmental risk assessment of PPPs is to some extent an unavoidable consequence of scientific advances. However, this does not apply for the complexity of the refined risk assessments for individual PPP enforced by applicant companies. In such cases, the principle of "risk management before risk refinement" offers a suitable way out of the threatening complexity trap. For a PPP that could already be authorised, all justifi-

able options for the management of the environmental risks should first be exploited before the authorities approve and accept highly complex refinements of the risk assessment which only have the aim of achieving more favourable conditions for application of the PPP (e.g. narrower margins to adjacent surface waters).

A further regulatory alternative is offered by the so-called cut-off criteria of the EU Regulation on Plant Protection Products, which provides for a ban on active substances with particularly hazardous properties, the so-called PBT-substances which are persistent (P), bio-accumulative (B) and toxic (T). A further exclusion criterion is targeting endocrine disruptors. The cut-off criteria represent a very progressive instrument in several pieces of Europe`s legislations for the regulation of chemicals, which is oriented more towards the precautionary principle than other international regulations. These criteria have been introduced by the political sphere and require a paradigm shift in the decision-making process. The decision on an approval or ban should in future only be based on the undesirable substance properties and not, as previously, on a quantitative risk assessment (i.e. the comparison of the expected environmental exposure concentrations with (eco)toxicological threshold concentrations/ doses for the harmful impacts on non-target organisms). Experts justify the hazard-based regulation by referring to the high level of uncertainty in the risk assessment for the targeted hazardous properties. With the cut-off criteria, an impulse is provided to develop and use active substances and PPPs that have lower environmental impacts. However, a practical implementation is currently not possible because the scientific and technical details of the cut-off criteria have not yet been developed and specified in subordinate regulations. The delays in the implementation have been due not least to the massive interventions of the European PPP industry, which categorically rejects hazard-based regulation and demands a return to risk assessment, even for such undesirable substance properties (ECPA, 2014). The UBA is of the opinion that the cut-off criteria are in principle well-suited to improve the protection of the environment against particularly hazardous PPPs. Because of this conviction and in accordance with its responsibilities, the UBA is also involved in the discussion about the specification and implementation of the cut-off criteria (Frische et al., 2013; Rauert et al., 2014). One challenge to be faced is that it is not always clear from an environmental point of view whether an alternative active substance really is better than the banned active substance it should replace. The same task of comparative assessment is also given at the level of PPP approval. In such cases, the EU regulation provides that a PPP containing so-called substitution candidates (e.g. active substances with two out of three PBT properties), should be replaced by a PPP with a lower environmental impact. The methodology of the comparative assessment of the environmental hazard or of the environmental risks of PPPs is not trivial and has so far not been sufficiently tested (Faust et al., 2014). However, the general public and users rightly demand that in future the assessment authorities should make increased use of their expertise to provide information about the more favourable alternatives from an environmental perspective. It remains to be seen, how effective the instrument of comparative assessment will prove in terms of making environmental impacts measurable.

Describing overall risks and impacts of PPPs

A further challenge is the description of the environmental risks and environmental impacts that result from the overall intensity of chemical plant protection in Germany. There is a need for scientifically relevant indicators that can be comprehended in the public sphere, making them useful for informing the public and for formulating policies. In the German NAP, some environmental indicators were used to review progress. Comparable to the risk assessment for individual PPPs, the SYNOPS indicator calculates a generic risk index for plant protection intensity in Germany for selected non-target organisms, e.g. for aquatic and soil organisms, and bees (Reineke et al., 2014). In addition to this “theoretical” SYNOPS risk, the German NAP also includes indicators for the actual environmental status (e.g. pollution of bodies of surface water by PPP residues, development trends of bird species populations in the agricultural landscape). Ideally, data from environmental measurements and environmental monitoring allow conclusions to be drawn about: (i) the plausibility of the risk assessment in the approval procedure, (ii) the efficacy of PPP-specific risk management for, and (iii) changes to the environmental status through the general use trend of PPPs. At present there is no representative PPP-specific monitoring in Germany for all potentially affected environmental compart-

ments, ecosystems and organisms. The German NAP only collates existing monitoring programmes, giving an incomplete overview of the current environmental impacts of chemical plant protection in Germany. The UBA sees a clear need for improvements and is active with an on-going research project within the framework of the German NAP to further the formulation of a strategy for monitoring the pesticide loads of small surface water bodies in the agricultural landscape (Brinke et al., in preparation – report soon available via www.umweltbundesamt.de/publikationen). The small surface water bodies make up a large proportion of the overall network of surface waters and are at greatest risk of pollution with PPPs due to their proximity to the application areas, but they are currently underrepresented in the monitoring in accordance with the EU Water Framework Directive. The UBA also plans to carry out a research project to test whether integrated monitoring could provide a better description of the environmental impacts of chemical plant protection. Integrated monitoring registers both the fate of PPPs or the PPP residues in the environment, as well as their impacts on organisms, ecosystems and ecological processes. This parallel registration is necessary in order to be able to identify the specific contribution of the chemical plant protection to changes in the environmental status, in particular if the processes are influenced by a number of different factors (e.g. the changes in population of bird or amphibian species in the agricultural landscape).

Point 2: Identifying, quantifying and communicating risks (summary)

Chemical plant protection generally poses a risk for nature and the environment. For this reason, an environmental risk assessment is legally required before a plant protection product is approved. However, at present some gaps remain in the environmental risk assessment. For example, insufficient consideration is given to impacts on amphibians and reptiles or wild pollinators. The further development of the testing procedures for plant protection products to take into account scientific and technological advances is thus an on-going process. While this is necessary, it also means that the assessments are becoming increasingly more comprehensive and time-consuming. A further factor contributing to the steadily increasing scope and scientific complexity of the approval procedure is the fact that the producers of plant protection products submit so-called “refined” risk assessments (i.e. more realistic risk assessments for specific test sectors) in order to obtain approval for their product without or only with less restrictive risk mitigation measures. This development raises concerns, both from a technical perspective (protectivity of the assessment), as well as from a legal point of view (democratic legitimation and independence of expert decisions, transparency of decision making, time and effort of approval procedures). The UBA is active in the updating of the environmental risk assessment regards the implementation of the following measures and instruments:

- Removal of blind spots and uncertainties in the prescribed assessment procedures for plant protection products.
- Describing and managing environmental risks rather than “discounting” these with complex and inadequately validated methods.
- A ban on hazardous active substances in accordance with the legislative exclusion criteria at European level.
- A further improvement to the transparency and clarity of the decision-making processes in the approval procedure for plant protection products.
- A better description of the environmental risks and impacts resulting from the intensity of chemical plant protection **in its entirety** in Germany.

3. Optimising risk management

Limiting PPP applications in protected areas

The simplest and most effective way to avoid the risks and impacts of chemical PPPs is not to use them. In the opinion of the UBA, this should apply not only for public green spaces, private gardens and allotments, but wherever possible also for nature conservation and drinking water protection areas. This recommendation is in accordance with the EU Sustainable Use Directive, which stipulates a minimisation of or a ban on the use of PPPs for nature conservation areas (protection areas for birds, FFH areas) and drinking water protection areas by the Member States (European Union, 2009). However, in Germany this is not transposed into a national regulation; rather the Plant Protection Act passes on the responsibility for introducing the appropriate measures to the Federal States (Article 22, Plant Protection Act PflSchG, 2012). As in an information paper of UBA and the German Federal Agency for Nature Conservation (BfN) on emergency approval for the use of PPPs in nature conservation areas (UBA, 2015), the UBA calls on the Federal States to put in place a general ban on the use of PPPs in nature conservation areas.

Minimising the distribution in the environment with modern application technology

If the use of chemical PPPs is unavoidable, then these should be applied making the best possible use of the available technology and economically justifiable options for risk management. The goal, as far as possible, is to stop PPP-residues from entering into or spreading to non-target areas, natural assets (e.g. groundwater and surface waters) and habitats adjacent to the application areas. Although this will never be completely possible, in view of an application of PPPs that is open to the environment, further improvements are possible with technical risk management. Technology should ensure that the PPPs are applied as accurately as possible, and without losses and spillage – whether they are in solid form (seed coating and granulates) or in liquid form (for spraying). In contrast, aerial applications (e.g. by helicopter) are difficult to control and are therefore generally banned in Germany under the Plant Protection Act, except for a few special cases, such as treating the crown zone of forests or steep vineyard slopes (PflSchG, 2012; Federal Environment Agency, 2015). When applying PPPs on arable land and for special crops (fruits, vines, hops) it is usually necessary to use mobile spraying gear with drift-reducing nozzle technology. Introducing the best available nozzle technologies is thus an effective way to reduce environmental pollution by PPP residues. The German NAP formulates the same target, but without specifying any measures to be adopted. It would, though, be possible to introduce an appropriate innovation and subsidy programme or to offer tax credits for adopting modern technology.

Effectively monitoring compliance with legal risk mitigation measures

Fines can be imposed on farmers failing to comply with the legally-binding PPP-specific risk mitigation measures for the protection of the environment. Key requirements relate to the maintenance of untreated margins of fields adjacent to bodies of water and terrestrial habitats (e.g. marginal biotopes, forest margins). As a rule, however, the yield and crop quality is lower for these untreated areas of farmland, so that financial losses result from observing the spacing requirements (Kehlenbeck et al., 2013). Just as road speed limits tend to be ignored if there are no regular speed checks, there is a risk here too that without regular checks and the prosecution of transgressions, these “inconvenient” regulations will lose their effectiveness and the number of transgressions will increase. However, the extent to which plant protection products are applied in accordance with the regulations in Germany is unclear. The results of the checks carried out by the Federal States are documented in annual reports on the plant protection monitoring programme (www.bvl.bund.de/psmkontrollprogramm), but these do not provide a basis for drawing conclusions. The 2013 report shows that relatively few checks were carried out. Compliance with the spacing requirements for the protection of surface water bodies was only checked for 423 application areas of 421 agricultural holdings in Germany, which represents less than one percent of all German farms. The main reason for this is obviously the understaffing of the Federal States plant protection services. At the same time, the results from 2013 also highlight a weak spot in the regulations. Transgressions were identified in ten percent of the inspections, but the report does not specify whether these were due to intent or the result of a lack of relevant knowledge. Intentional breaches of the legal requirements must be countered with increased controls and the punishment of all transgres-

sions. However, if a lack of specialist knowledge is the root cause, then this calls for a review of the further training courses offered for professional PPP-users seeking to obtain the legally required certificate of competence. A central module of the curriculum should explain the importance of nature conservation and environmental protection, and the obligation to comply with the relevant legal stipulations.

Reducing PPP risks by means of landscape management

In the opinion of the UBA, additional risk management options should be implemented that are as far as possible independent from the behaviour of the individual PPP-users. Agricultural landscape management is an effective measure, which would at the same time simplify the risk management and in part make it unnecessary to monitor compliance with risk mitigation measures (here: spraying distances). The basic idea is to separate the treated area from the environment adjoining it. By establishing permanent green margins and buffer strips or permanent three-dimensional vegetation structures (e.g. hedges, waterside margins with bushes and trees), the airborne transmission and run-off of PPPs to adjacent non-target areas or bodies of water is avoided or at least considerably reduced. A role model in Europe in this case is Switzerland, which requires three or six metre-wide green buffer zones along surface waters (BAFU and BLW, 2013). A similar regulation has also been in place in Denmark since 2012 (Danish EPA, 2015).

The NAP has set a long-term target for Germany to create buffer zones, permanently covered with vegetation and at least 5 m in width, for all surface waters in the agricultural landscape. However, no time-line is specified in the action plan, and the implementation is the responsibility of the individual Federal States (e.g. by including support for the creation of waterside margins in agri-environmental programmes). Some Federal States have already initiated appropriate measures (Dölz, 2014), but there is currently no systematic overview of the progress made in creating permanent green waterside margins for Germany as a whole. The German NAP has set an ambitious target for the creation of buffer zones by 2023 for all surface waters in protected areas for drinking water, nature reserves and in sensitive areas identified by hot-spot analyses. There is general consensus that use should be made of the greening requirement valid since 2015 under the EU Common Agricultural Policy (CAP) for such landscape-based risk management. In order to receive the full CAP area-based payments, farmers are required to dedicate five percent of arable land to 'ecological focus areas'. The NAP Forum (December 2014) concluded: *"The NAP Forum is of the opinion that the primary use of 'ecological focus areas' to create buffer strips, field margins and forest peripheries where the application of PPPs is banned under the Greening rules can provide an important contribution for the protection of surface waters and the preservation of biodiversity by increasing the proportion of habitats and sanctuaries in the agricultural landscape."* (BLE, 2014). The UBA expressly supports this recommendation and argues for the implementation of this effective approach to optimising the risk management of PPPs in Germany as widely and as quickly as possible.

Point 3: Optimising risk management (summary)

Plant protection products are introduced directly into the environment. Therefore, the aim at least must be to prevent plant protection products and their residues as far as possible from spreading to adjacent non-target areas, natural resources (e.g. groundwater) and habitats. This requires making the best possible use of the technically available and economically viable options for risk management. The UBA recommends the following measures and instruments for the optimisation of risk management:

- A ban on the use of plant protection products in nature conservation areas.
- Limits on the use of plant protection products in drinking water protection areas, avoiding use there as far as possible.
- Support for the rapid introduction of the best available technology for the application of plant protection products and the implementation of a minimum level of risk management (e.g. drift-reducing technology).
- Ensuring compliance with legal risk mitigation measures for plant protection products with a strict monitoring programme.
- Nationwide establishment of permanent, vegetated field margins and buffer zones to reduce the spread of plant protection products to adjacent areas or surface water bodies.

4. Compensating for unavoidable effects

Taking indirect effects of PPPs on biological diversity into account in environmental risk assessment

As already explained for the example of glyphosate, the indirect effects of the use of chemical PPPs are one of the relevant factors for the decline in biological diversity in the German agricultural landscape (Sudfeldt et al., 2013). Indirect effects arise because the intended rigorous elimination of the field weeds by herbicides and of farmland insects by insecticides also leads to a reduction in the food supplies for wild animals, so that they are unable to reproduce successfully and as a result their populations decline. In the past, such effects on food webs and habitats were ignored or their relevance was underestimated, despite the fact that the EU Plant Protection Products Regulation (EC No. 1107/2009) expressly calls for impacts on biodiversity to be taken into consideration for the approval of PPPs. However, there are not yet any harmonised methods at the EU level to assess the indirect impacts of PPPs on biodiversity.

Using ecological compensation areas for risk management

In order to meet the legal requirement for the protection of biodiversity from indirect effects of PPPs, it is urgently necessary to improve the risk management. The UBA recommends the introduction of special risk mitigation measures. A prerequisite for the use of PPPs with a high risk of indirect effects on biological diversity should be the provision at the farm level of ecological compensation areas where PPPs are not applied, e.g. set-aside areas, flowering margins, and untreated thinly-sown areas. This landscape-related requirement aims at a compensatory reduction of the risk. The ecological compensation areas should compensate for the unavoidable direct effects of the PPPs on the treated areas to such an extent that the indirect effects are also reduced to an acceptable level. The ecological compensation areas should offer fauna at least the space needed for finding food and for withdrawal.

Introducing PPP-specific risk mitigation measures for authorisation

This new application requirement should be included in the approval procedure using a risk-based approach. This means that the requirement should not be imposed as a blanket measure for all PPPs, but should be based on the risk assessment for the individual PPP. Such a requirement should only be imposed for PPPs with a high risk of indirect impacts on biodiversity. For each PPP, it would be necessary to examine whether the application in question would reduce food organisms or plants on the treated areas to such an extent that these would no longer be able to fulfil their habitat function for higher organisms (in particular birds and mammals). This assessment can be conducted quantitatively on the basis of the existing data. On the basis of a preliminary estimate, a large number of PPPs would be affected by the new requirement (nearly all herbicides and insecticides and about a third of fungicides). However, this is not particularly relevant for conventional holdings or those working with integrated measures, because the application requirements will be the same for all the affected PPPs, and thus once a farm has complied with these once, it will be able to use all PPPs. The UBA also favours the introduction of such new risk mitigation measures initially only for field crops, and primarily for those regions with a high proportion of land used for agricultural purposes that as a consequence of rural restructuring have a particularly poor “ecological infrastructure” that is relevant for the protection of biological diversity, such as hedges, waterside buffer-zones, forest margins, field verges and extensive grassland (“agricultural steppes”). The UBA and the German Federal Office of Consumer Protection and Food Safety (BVL) are in general agreement about the need for compensation measures for the protection of biodiversity against the indirect impacts of PPPs. Important questions of detail remain to be clarified concerning the lack of an EU-harmonised assessment method, legally valid evidence of the potential of a PPP to harm biodiversity, and ways of ensuring compliance. Another issue is the necessary minimum proportion of ecological compensation areas at the level of the individual holdings. The view of the UBA is that while taking economic viability into consideration, the ecological compensation areas without PPP application should account for not less than ten percent of the cultivated area of a holding. This proportion has already been shown to be reasonable, because there has been a minimum set-aside quota of ten percent in the EU until 2006 (Jahn et al., 2014).

Insisting on a contribution of PPP-risk management to protect biodiversity

The ideas of the UBA regarding compensation measures for the indirect effects of PPPs on biodiversity are vehemently rejected by the conventional farming associations and the PPP producers. In a position paper, they draw attention to the fact that the greening requirements of the EU Common Agricultural Policy (CAP) also serve to protect biodiversity, e.g. the requirement for 5 % ecological focus areas. They also argue that "the protection of biodiversity is already addressed in a variety of ways by the environmental and agricultural policies." (BAV et al., 2014). In the opinion of the UBA, however, neither dedicating 5 % of arable land as ecological focus areas in accordance with the CAP greening, nor the agri-environment measures from the CAP "second pillar" are sufficient to protect biological diversity in landscapes heavily influenced by agriculture, as required under German plant protection legislation (see also: Jahn et al., 2014). It is true that the ecological focus areas in accordance with the CAP can also be effective for the proposed PPP-specific application requirement for the protection of biodiversity. Therefore, the UBA supports the corresponding recommendation of the NAP Forum from December 2014 (see above).

Despite the criticisms, the UBA is convinced that its proposal can provide an important contribution to the implementation of the German National Strategy on Biological Diversity (BMU, 2007). This includes the following target: "By 2015, the populations of most species typical of agriculturally cultivated landscapes will have been secured and will have begun to increase again." Since it has still not been possible to achieve this turnaround, in part due to the growing pressure on farmland, for example due to the increased cultivation of energy crops and fodder crops for intensive livestock farming (Sudfeldt et al., 2013), effective action is now urgently needed. As a relevant influencing factor, the chemical plant protection sector must also make a contribution, not least in its own interests. Public confidence in the possibility of a plant protection that is compatible with nature and the environment should not be further endangered, and trust should be restored, even if this means acknowledging the necessity of self-limitation and a future with less-intensive use of PPPs.

Learning from models for biodiversity conservation in conventional agriculture

The Swiss production label "IP-Suisse" (www.ipsuisse.ch) is a model for the successful implementation of voluntary measures for the protection and promotion of biological diversity in conventional crop production. Certified farms adopt various measures to promote biodiversity (e.g. lark nesting gaps, multi-year fallow, extensively used grassland, planting hedgerows, etc.). Compliance with the biodiversity requirements of the IP-Suisse guidelines are regularly assessed on the basis of a points system. A network of advisers support the farmers with the planning and implementation of measures to promote biodiversity. In addition to area-based compensatory measures, there is also a marked reduction in the use of PPPs for various crops. For example, growth regulators, fungicides and insecticides are not allowed for cereal crops. This is economically viable firstly because less-vulnerable varieties are used, and secondly because higher prices can be charged under the IP-Suisse-Label.

Point 4: Compensating for unavoidable effects (summary)

The indirect impacts of chemical plant protection are one of the factors contributing to the decline in biodiversity in the German agricultural landscape. The widespread intentional elimination of weeds and insects by plant protection products leads to such a depletion of the food supplies for fauna (e.g. the partridge), that these cannot reproduce successfully and their populations decline. These indirect effects on biodiversity are not sufficiently considered in the environmental risk assessment of plant protection products, despite the fact that the protection of biodiversity is a specific requirement in Europe's plant protection legislation. The indirect impacts on biological diversity should, in the view of the UBA, be compensated for by the provision of ecological compensation areas. These should make up for the unavoidable direct effects of the plant protection product in the treated area to the extent that the indirect food web effects are also reduced to an acceptable level. The current agricultural policy requirements and instruments for the protection of biodiversity (5 % ecological focus area in accordance with the greening requirements of the EU Common Agricultural Policy (CAP) and agri-environmental measures from the CAP "second pillar") are not sufficient in the judgement of the UBA. In order to ensure the protection of biological diversity in landscapes heavily influenced by agriculture, the UBA therefore sees the need to expand the risk management of plant protection products. A precondition for the application of plant protection products with a high risk of indirect impacts on biological diversity should be the existence at the farm level of ecological compensation areas where no plant protection products are applied (e.g. fallow land, flower strips, and untreated areas of spaced sowing). With the introduction of corresponding mitigation measures, it will remain possible to obtain legally-valid approval for plant protection products with high risks of indirect effects on biological diversity. At the same time, the measures would serve to implement the German National Strategy for Biological Diversity.

5. Internalising external costs

Paying more attention to the social dimension of sustainability

Private sector activities may in many cases generate macroeconomic benefits, but they can also result in costs for the general public. Ideally, sustainability should involve a just distribution of the benefits and costs of commercial activities so as to maximise the common good – both within today's society and also with future generations in mind. Whether current chemical plant protection meets this requirement is a topic of heated debate. The central questions are: Do the social benefits outweigh the social costs? Are the benefits and costs distributed fairly between the relevant stakeholders (PPP-producers, farmers, trade, consumers) and the affected parties (all citizens, tax payers, future generations)?

Raising awareness about the "external" social costs of chemical plant protection

As described in the introductory chapter, the use of chemical PPPs offers clear short-term benefits for the farmers (high, stable yields and marketable quality) and there are also advantages for the consumers (secure supplies, low shop prices). The producers, suppliers, and users of PPPs regularly point out that in addition to the directly measurable benefits for agricultural operators, chemical plant protection also provides considerable macroeconomic benefits. A study commissioned by the German Agricultural Industry Association (IVA) emphasises the *"special role of plant protection for specific socially relevant objectives"* and estimates the overall annual societal benefit of chemical plant protection at between one and four billion euros (von Witzke & Noleppa, 2011). However, a crucial weakness of this study is that it only takes into account the macroeconomic benefits, without considering the societal costs. In order to obtain a complete picture, the *"positive welfare effects"* of chemical plant protection identified by the authors should be set against the negative external impacts and costs. These are the costs which are borne by all of society ("socialised" costs) for the necessary monitoring and testing apparatus as well as for the impacts on human health and the environment. These costs are "external" because they are

not fully reflected in the market prices of the plant protection products, the harvested crops, and foodstuffs. This cost-externalisation is cited as one of the main reasons why the retail prices for conventionally produced food are much lower than prices for food from organic farms (BÖLW, 2015). Most consumers are not aware when they choose less-expensive conventionally produced wares that they will end up paying indirectly considerably more than the price at the cash till. This is due partly to farm subsidies funded through taxation and in part to the externalised costs of conventional cultivation systems. The social costs either have to be met at present or may have to be borne by future generations who have not had an opportunity to enjoy the current benefits.

Various types of external costs have to be taken into account

The main external effects or costs to be taken into account for a comprehensive analysis include in particular:

- Survey, monitoring and repair costs:
  - For PPP residues in groundwater and surface waters: costs incurred for monitoring, avoidance measures, and for water treatment are borne by the relevant authorities, and by water suppliers and their customers.
  - For PPP residues in agricultural produce or in food commodities made from these. The costs for monitoring levels of residues are incurred for the official monitoring programmes and for the extensive testing in the food retailing. The official testing is paid through taxes, whereas the food industry passes the costs on to the consumer.
  - Other official monitoring costs that are not passed on in full to the PPP-authorisation holder or PPP-users in the form of fees, but are funded through taxes (e.g. the portion of costs for official authorisation procedures that are not refinanced, consultancy and monitoring costs of the plant protection services of the Federal States , costs of PPP-specific research by state research institutions).

- Health costs as a result of acute or chronic exposure of PPP-users, local residents, or third parties and consumers to PPPs or their residues. These include costs for medical treatment, lost working time, and the immaterial costs of health impairments (suffering).

- Costs for the agricultural production:
  - Direct costs (bee-keeping, honey production) and indirect costs (pollination services) as a result of acute or chronic pollution of honey bees with PPP residues.
  - Costs for the impairment of ecosystem services, e.g. natural biological plant protection by beneficial insects, pollination by wild pollinators (e.g. bumble bees, solitary bees) or the production function of soil by soil organisms (e.g. earthworms).

- Costs of impacts on nature and the environment:
  - Impacts on aquatic organisms and the biodiversity of surface water bodies by PPP residues as a result of accidents, inappropriate use, or unavoidable diffuse inputs (dust or spray drift).
  - Impacts on biodiversity in soil as a result of unavoidable PPP inputs in the soil.
  - Impacts on the biodiversity of wild plants and invertebrates (insects, spiders, etc.) in the agricultural landscape as a result of diffuse inputs of PPPs (via dust or spray drift) in habitats adjoining the treated areas.
  - Direct effects of PPP applications (acute or chronic poisoning) and indirect impacts (food web) on vertebrates (birds, mammals, amphibians, reptiles, fish) and the biodiversity of vertebrates in the agricultural landscape.

Facing up to the methodological challenges

For various reasons, the quantification of the costs of impacts on nature and the environment represents a considerable challenge. Firstly, the methodology of monetarisation of environmental impacts is still in its early stages. This is not surprising, because it involves fundamental questions that cannot be answered objectively (e.g. “What is the value of a partridge?”). Secondly, a suitable database is often lacking for the assessment of environmental costs. This is the case in particular for the description or quantification of the specific contributions of chemical plant protection to environmental impacts, which are influenced by a range of factors and stressors (e.g. effects on water organisms of pollution with both PPP-residues and nutrients). Currently, the data and analyses needed for a rational and fact-based dis-

cussion are not available. The only comprehensive independent cost-benefit analysis for Germany was commissioned in 1991 by the Agriculture Ministry (Waibel & Fleischer, 1997). This study still has a model character, because no analyses of comparable scope have since been carried out in Germany. Meanwhile, however, conventions and proposals for criteria for carrying out socio-economic assessments of environmental impacts have been developed e.g. at the international level (OECD, 2001) and also by the UBA (UBA, 2013).

As a third factor, monetarisation also raises fundamental ethical questions. For example, would humanity be justified in allowing the extermination of individual animal and/or plant species if this provided an economic benefit?

Discussing the need for political action on the basis of sound data

In the opinion of the UBA there is a need for a systematic review of and a political discussion about both the external costs of chemical plant protection in Germany and the distribution of the costs within society. As a contribution to the scientific clarification, UBA commissioned a study drawing on the work of Waibel & Fleischer (1997). In a second step, it is necessary to discuss the scope for political actions concerning the "societal dimension" of chemical plant protection. This should also address the potential options for political action to compensate for the effects of market distortions and to internalise the external costs. Political influence could be exerted by means of reforms to the EU and national farm payments (e.g. increased payments for farms with low PPP use) or a levy on PPPs (which is common practice in some EU Member States, e.g. in Denmark). A study on the introduction of a levy or tax on PPPs in Germany carried out on behalf of the Federal States Schleswig-Holstein, Baden-Wurttemberg, and Rhineland-Palatinate recently reignited a discussion on this topic (Möckel et al., 2015). The UBA expressly welcomes the discussion about the prospects and the limits of this instrument – both with regard to the internalisation of external costs, and also with regard to providing incentives for minimising the use of chemical plant protection products (see Section III.1 "Minimising use").

Point 5: Internalising external costs (summary)

The short-term benefits for the producers from the use of chemical plant protection products are obvious (high, stable yields and marketing quality), and there are also benefits for consumers (assured supplies, low retail prices). However, it is doubtful whether the current intensive chemical plant protection is indeed sustainable with regards to the social dimension. The question is whether the societal benefits outweigh the societal costs. Are the benefits and the costs distributed fairly between the relevant stakeholders (PPP producers, farmers, trade, consumers) and those who are affected (the general public, tax payers, future generations)? The "socialised" costs borne by society as a whole are incurred by the monitoring bodies, by avoidance and repair measures (e.g. treating groundwater to prepare drinking water), and as a result of the impacts on human health and the environment. These costs are "external" because they are not fully reflected in the market prices of the plant protection products, harvested crops, and foodstuffs. In the opinion of the UBA there is a need for a systematic review and a political discussion about both the external costs of chemical plant protection and the distribution of the costs within society. At first, socio-economic analyses should be carried out in order to provide a basis for a rational and fact-based discussion.A second step should consider the prospects and limits of political instruments to compensate for the effects of market distortions or for the internalisation of external costs (e.g. reform of European and national farm payments or the introduction of a levy on plant protection products).

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