

Standing Committees for

- Life, Earth and Environmental Sciences (LESC)
- Humanities (SCH)
- Social Sciences (SCSS)

ESF Exploratory Workshop on
Developing criteria for an ecological and ethical valuation of
environmental impacts of genetically modified crops

Engelberg, Switzerland, 4 – 6 June 2008

Scientific report

Convened by
Franz Bigler¹⁾ and Olivier Sanvido¹⁾
Klaus Peter Rippe²⁾ and Andreas Bachmann²⁾

1)  Swiss Confederation
Agroscope Reckenholz-Tänikon
Research Station ART

2)  ethik im diskurs

Co-sponsored by
Swiss National Science Foundation



Benefits and Risks of the Deliberate Release of Genetically Modified Plants
National Research Programme NRP 59

Table of contents

1	Executive summary	1
2	Introduction.....	3
3	Scientific content of the Exploratory Workshop	4
3.1	Introduction to the workshop	4
3.2	Plenary session 1: Introductory talks on existing conceptions of environmental damage	4
3.3	Group work 1: Identification of existing criteria for the evaluation of environmental damage	5
3.4	Plenary session 2: Introductory talks on the impacts of agricultural management on biodiversity	10
3.5	Group work 2: Evaluation of pre-selected criteria for environmental damage	11
3.6	Plenary session 3: Feedback, outlook, follow-up activities	16
3.6.1	Aims of the Exploratory Workshop	16
3.6.2	Baseline	17
3.6.3	Different needs of involved stakeholders	17
3.6.4	Evaluation criteria	18
3.6.5	Uncertainty	18
3.6.6	Role of ethics	18
4	Assessment of the results.....	18
4.1	Contributions to future directions of the field	18
4.1.1	Clearly define the objectives.....	19
4.1.2	Use a clearly defined common terminology	19
4.1.3	Define the target audience of the guidance document.....	19
4.1.4	Find a consensus on an applicable approach to be used in decision-making	19
4.1.5	Find a consensus on the protection goals and on the baseline to be applied	20
4.2	Outcome	21
4.2.1	Continuation of the collaboration with the involved experts.....	21
4.2.2	Publications.....	21
4.2.3	Link to other research activities	21
5	Final list of participants	22
6	Statistical information on participants.....	24
7	Final programme	25

1 Executive summary

Background

The legal frameworks regulating the approval and use of genetically modified (GM) crops require both notifier (i.e., usually the company marketing the GM crop) and regulatory authorities to decide which environmental changes are relevant and represent environmental damage. The current debate on potential risks of GM crops on biodiversity illustrates that consensus on criteria that would allow an objective valuation of environmental damage is presently lacking. Tools to improve decision-making are needed, otherwise decisions on environmental risks of GM crops could be arbitrary. The ESF Exploratory Workshop on “Developing criteria for an ecological and ethical valuation of environmental impacts of genetically modified crops” taking place in Engelberg, Switzerland, from 4-6 June 2008 aimed at developing a new approach for the valuation of environmental damage. The workshop provided an opportunity to discuss both ecological and ethical questions among the participating experts that came from a wide range of fields including ethics, agro-ecology, agronomy, regulation and the agricultural biotechnology industry.

The 2 ½ days workshop included both plenary sessions providing introductory talks and group works with synthesis discussions. The first day covered existing conceptions of environmental damage from an ecological, ethical and legal point of view. The second day dealt with existing impacts of agricultural management on biodiversity and included an evaluation of proposed criteria for the valuation of damage to biodiversity. Finally, the last half day of the workshop was devoted to an extended feedback round and discussions on follow-up activities.

Existing criteria for the evaluation of environmental damage

The aim of the first group work was to elaborate an introduction to existing criteria for environmental damage from the perspective of the respective fields. Participants were thus grouped according to their expertise into the three groups *Regulation*, *Ethics* and *Ecology*. The working group *Regulation* concluded that the protection goals as specified by existing legislation were the exclusive starting point for a definition of the term damage. Any negative effect on these protection goals would consequently constitute damage. They furthermore noted that protection goals may differ among member states of the European Union (EU) and have thus to be defined accordingly by policy-makers or by the society. The working group *Ecology* proposed to use a case-by-case matrix as a tool when approaching the term damage. Protection goals were separated into two principal aspects: *Conservation* and *Ecological functions*. It was proposed to assess damage to each of the two aspects according to a number of criteria such as intensity, time and spatial scale, reversibility and economic impact of the effect. Finding an operational way of measuring these criteria was recognized as the most critical point related to such an assessment. The discussion within the working group *Ethics* revealed that there was little consen-

sus among the involved group members on a status quo regarding an ethical approach to environmental damage. Some of the group members proposed to use an ethical matrix that was composed of the two axis *Stakeholders* and *Ethical Principles*. This approach was, however, not supported by all group members.

Evaluation of pre-selected criteria for environmental damage

The second group work was based on the results of the first group work that had been elaborated on the previous day of the workshop. Its aim was to evaluate and weigh the list of discussed criteria for environmental damage with regard to their applicability in decision-making processes. Participants were randomly grouped into three interdisciplinary working groups and each working group concentrated on a specific environmental compartment (floral, arthropod or soil biodiversity). Given that both the group on floral biodiversity and on arthropod biodiversity had structured their group work based on matrices (as one possible way to approach the definition of criteria as proposed on day 1 of the Exploratory Workshop), the synthesis of the results started with a condensed matrix combining the ecological and the ethical criteria on one axis and the two biodiversity goals *Conservation* and *Ecological functions* on the other axis. The subsequent discussions, however, demonstrated that finding an operational way of measuring and evaluating the various proposed criteria for the three environmental compartments turned out to be to be challenging. The discussions clearly showed that the matrix approach has operational limits since it can only be used on a case-by-case basis and only if the pre-conditions to be considered are defined. Defining the pre-conditions, however, is not a straightforward process since this includes defining the protection goals and the baseline to be considered.

Feedback and follow-up activities

The discussion during the group works and in the plenum illustrated that both *protection goals* and *baseline* were two consistently emerging issues. Regarding *protection goals* it was noted that these should be independent from the technology used and the question was asked how they were set, by which process and by whom. *Baselines* were recognized to be the crucial point of any decision-making process to determine what makes a change a damage. This automatically led to the question what *baseline* should be applied, that is, what agricultural management practice would be the most suitable benchmark when assessing potential effects of GM crops. It was also recognized that *protection goals* and *baselines* are two interlinked issues, which are difficult to separate since both are based on existing policies and legislation. Elaborating a guidance document that would not necessarily be restricted to one particular country could become challenging since legal frameworks and policies can considerably vary among EU member states. A guidance document that is as broadly applicable as possible should nevertheless remain the main objective of the work following this Exploratory Workshop.

2 Introduction

Within the legal frameworks regulating the approval and use of GM crops, both notifier (i.e., usually the company marketing the GM crop) and regulatory authorities have to decide which environmental changes are relevant and represent environmental damage that requires corrective action. The current debate on potential risks of GM crops on biodiversity illustrates that consensus on criteria that would allow an objective valuation of environmental damage is presently lacking. This is mostly due to the fact that the criteria that have so far been proposed to assist regulatory authorities in the evaluation of environmental impacts of GM crops are difficult to apply in actual situations of decision-making. Regulatory authorities need a tool to improve decision-making, otherwise decisions on environmental risks of GM crops could be arbitrary. The conception of environmental damage covers both ecological and ethical questions. Damage can thus not be defined on a purely scientific basis, but only together with an ethical evaluation.

The convenors are currently working on an interdisciplinary project called “Valuating environmental impacts of GM crops - ecological and ethical criteria for regulatory decision-making (VERDI)” linking environmental biosafety and ethics. It aims at defining practicable and science-based decision criteria to value effects of GM crops on biodiversity. Concentrating on environmental impacts of GM crops on biodiversity, the aim is to develop a new approach for the valuation of environmental damage. One proposed approach could be to compare the effects of GM crops to known environmental impacts of current modern agricultural management practices. The final aim of the project is to provide regulatory authorities with a guidance document to improve environmental decision-making. The document will include applicable and science-based decision criteria to value impacts on biodiversity both from an ecological and an ethical point of view.

The Exploratory Workshop on “Developing criteria for an ecological and ethical valuation of environmental impacts of genetically modified crops” that took place in Engelberg, Switzerland, from 4-6 June 2008 was a first step to address both the ecological and the ethical questions involved in making this approach operational. It provided an opportunity to discuss various questions among the participating experts that came from a wide range of fields including ethics, agro-ecology, agronomy, regulation and the agricultural biotechnology industry.

The workshop was organized over 2 ½ days and contained both plenary sessions providing introductory talks and group works with synthesis discussions. The first day covered existing conceptions of environmental damage from an ecological, ethical and legal point of view. The second day dealt with existing impacts of agricultural management on biodiversity and included an evaluation of proposed criteria for the valuation of damage to biodiversity. Finally, the last half day of the workshop was devoted to an extended feedback round and discussions on follow-up activities.

3 Scientific content of the Exploratory Workshop

3.1 Introduction to the workshop

In his welcome address, *Franz Bigler* introduced participants to the background, the main goals and the schedule of the Exploratory Workshop. The main expected outcomes of the Exploratory Workshop were to

- 1) Find a consensus on a first set of applicable criteria to evaluate environmental damage,
- 2) Make a synthesis of challenges for decision-making when applying the elaborated list of criteria,
- 3) Identify the most important ecological and ethical knowledge gaps to be subsequently used as a basis for future work,
- 4) Obtain feedback from participants on the approach chosen, on follow-up activities and on possible collaborations.

Subsequently the ESF representative *Zeljko Kucan* gave an overview on the objectives of the European Science Foundation and its different funding possibilities. The introduction to the workshop was completed by a short round of introductions of all participants.

3.2 Plenary session 1:

Introductory talks on existing conceptions of environmental damage

In order to prepare participants for the first group work, the first plenary session chaired by *Jeremy Sweet* aimed at introducing existing conceptions of environmental damage from an ecological, an ethical and a legal point of view.

Olivier Sanvido started his presentation on the ecological perspective of environmental damage by presenting existing definitions of the term “environmental damage” to biodiversity. He identified three common features of all proposed definitions: damage is occurring to a natural resource or resource service (such as conservation and sustainable use of biodiversity), it is characterized by an adverse change and it should be measurable by some means. These three common features lead to three fundamental questions: (1) *what to protect*, (2) *what is adverse* and (3) *what to measure*? He closed his talk by formulating three main conclusions. Regarding the question *what to protect*, he noted that the concept of biodiversity is well defined in theory, but in practice there are a number of knowledge gaps. How can scientist and policy-maker determine what needs protection? Regarding the question *what is adverse* he specified that a purely scientific definition of what has to be considered adverse is impossible. Decision-making processes are always influenced by ethical values, political, social and economical factors. The question then arises, how strong we weigh the different fields. Finally, for the question *what to*

measure he concluded that we can only value what we perceive and thus the question remains how we decide what we have to focus on.

Andreas Bachmann, who substituted *Klaus Peter Rippe*, unfortunately not being able to attend the workshop, presented an ethicist look at environmental damage. He started with explaining the fundamental basis of damage having a genuinely normative aspect since it refers to goods and values that deserve protection. By definition damage is thus a change which should be evaluated negatively. He introduced three different kind of values: instrumental value (*the environment should be protected because it provides benefits to human*), relational value (*it should be protected because someone considers it worthy of protection*), and inherent value (*it should be protected for its own sake*). The three kinds of values refer to three different kinds of damage: damage to humans in case of instrumental value, damage to the beholder in case of relational value and damage to the environment itself for intrinsic value. He moreover pointed out that there are two necessary conditions for damage. First, the *existence-criterion* defines that something that does not exist (e.g., a nation) cannot be harmed. Second, *sentientism* claims that an intervention can only be harmful if it is experienced as such. He thus concluded that ecosystems by themselves cannot be harmed since they only exist in a nominal sense and they are not sentient beings. Hence, only living individuals inside or outside ecological systems may be harmed (by changes of these systems) as they meet the criteria mentioned. Ultimately, from an ethical point of view it has thus to be determined whether human or sentient beings are harmed.

Finally *Julian Kinderlerer* discussed the legal approaches to environmental damage. He stated that legal approaches crucially depend upon definitions. He took the Cartagena Protocol on Biosafety as an example for an international treaty that seeks to protect biological diversity from the potential risks posed by genetically modified organisms. He noted that damage to the “*conservation and sustainable use of biological diversity*” is described with terms such as “*adverse environmental impacts*” or “*serious or irreversible*”. He argued that, although there are attempts to define these terms in the legislation, most terms currently used in legal texts lack appropriate operational definitions. Most often the definitions remain ambiguous making clear decision difficult.

3.3 Group work 1:

Identification of existing criteria for the evaluation of environmental damage

The aim of this first group work was to elaborate an introduction to existing criteria for environmental damage from the perspective of the respective fields and backgrounds of the participants. For the first group work, participants were thus grouped according to their expertise into the three workings groups *Regulation*, *Ethics* and *Ecology/Agronomy* (see Table 1).

Table 1: Grouping of participants for group work 1 according to their respective expertise¹⁾

Regulation	Ethics	Ecology / Agronomy
Devos	Bachmann	Bigler
Gathmann	Kaiser	Bohanec
Gielkens	Perry	Duelli
Kiss	Raybould	Cortet
Kinderlerer	Roupakias	Ekbom
Link	Von Troil	Krogh
Linnestad	Welin	Kudsk
Pleysier		Kalediene
Sweet		Sanvido
Wust-Saucy		

1) The ESF representative Z. Kucan and the moderator K. Sinemus did not participate in the group work

Participants had 1.5 h to discuss the given task in their group and to document the outcomes of their discussion on a pin board. After the lunch break, participants met again in the plenum for a feedback circuit. The plenum was split into three random groups for the feedback circuit and one rapporteur per working group presented his results to each of the three mixed groups. Participants that had not taken part in the respective group discussions gave their feedbacks on each of the three group work results (see Figure 1a-c for detailed results of each working group).

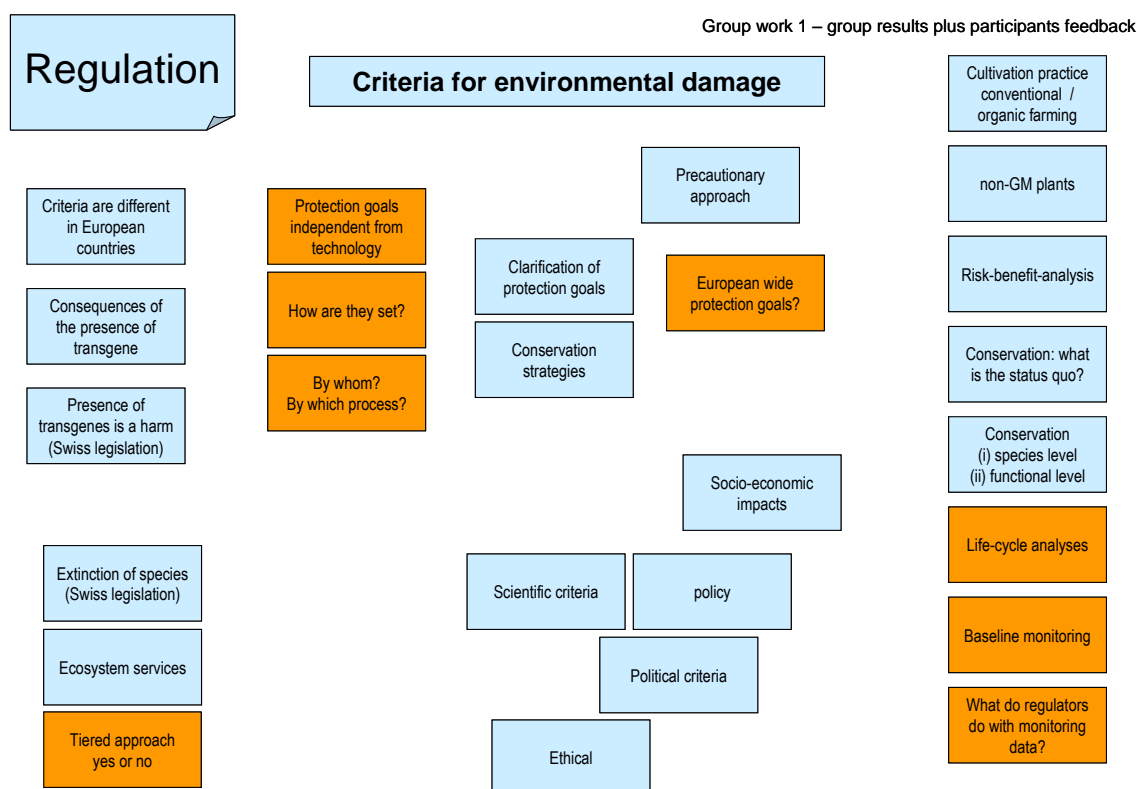


Figure 1a: Results of group work 1 "Regulation" (feedback by participants is indicated in orange)

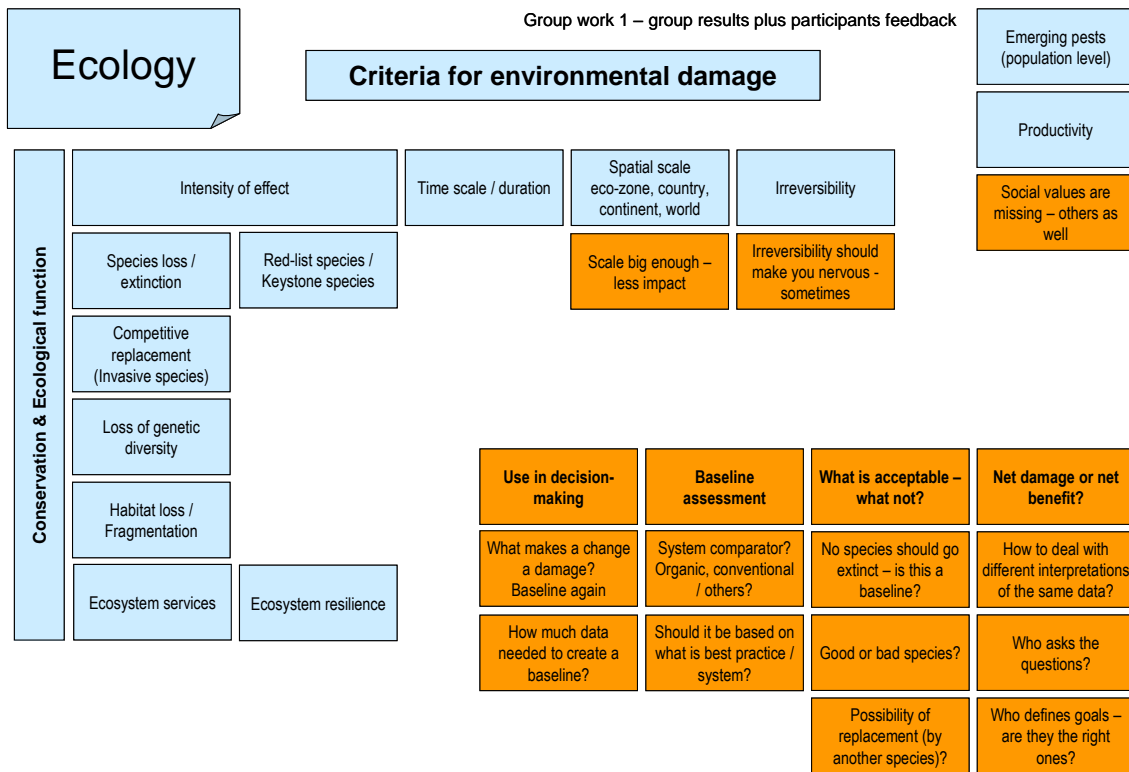


Figure 1b: Results of group work 1 “Ecology” (feedback by participants is indicated in orange)

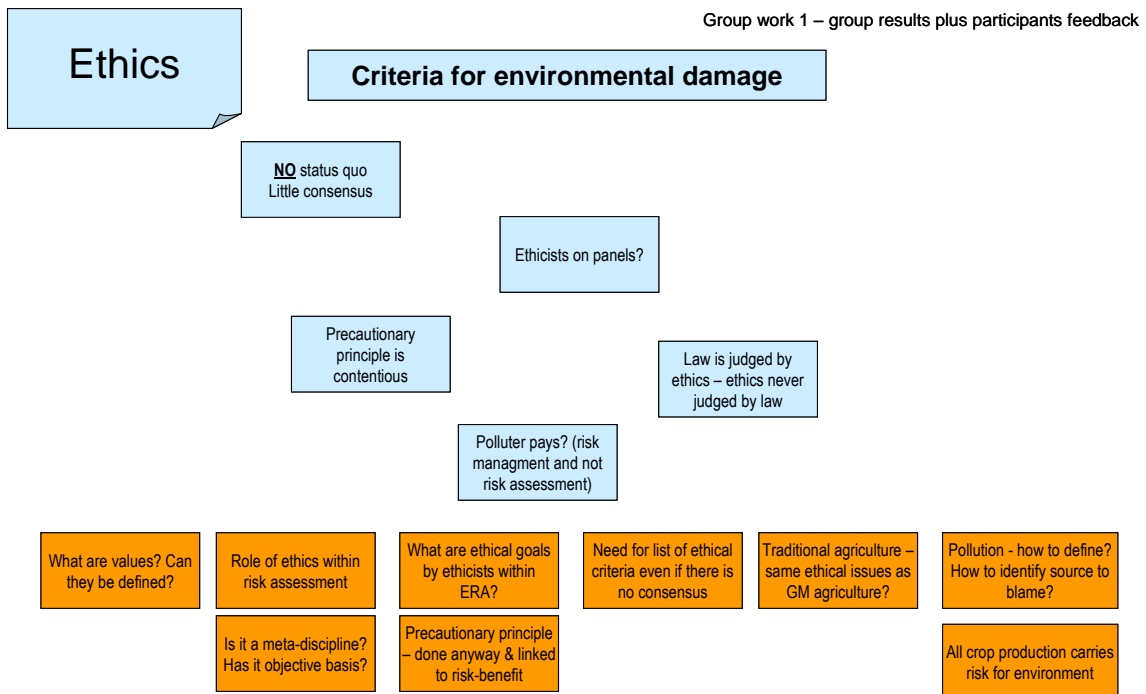


Figure 1c: Results of group work 1 “Ethics” (feedback by participants is indicated in orange)

The final plenary session of the day was moderated by *Kristina Sinemus* and aimed at condensing the elaborated results of group work 1. The results of each working group on how criteria for the evaluation of environmental damage could be defined from their point of expertise plus the obtained feedback from the other participants were presented to the plenum by a rapporteur of each of the 3 working groups.

The working group *Regulation* concluded that protection goals as specified by existing legislation were the exclusive starting point for a definition of the term damage (Figure 2a). Any negative effect on these protection goals would consequently constitute damage. They noted that protection goals are different for each EU member state and have thus to be defined accordingly by policy-makers or by the society.

The working group *Ecology* proposed to use a case-by-case matrix as a tool when approaching the term damage from an ecological perspective (Figure 2b). Protection goals were separated into two principal aspects: (1) *Conservation* and (2) *Ecological functions*. Damage to conservation was, for example, specified as species extinction or loss of habitats, loss of genetic diversity, or loss of red-list species. Damage to ecological functions was defined as damage to ecosystem services or to key-stone species. It was proposed to assess damage to each of the two aspects according to a number of criteria such as intensity, time scale/duration, spatial scale, reversibility and economic impact of the effect. Finding a possibility or an operational way of measuring these criteria was recognized as the most critical point related to such an assessment.

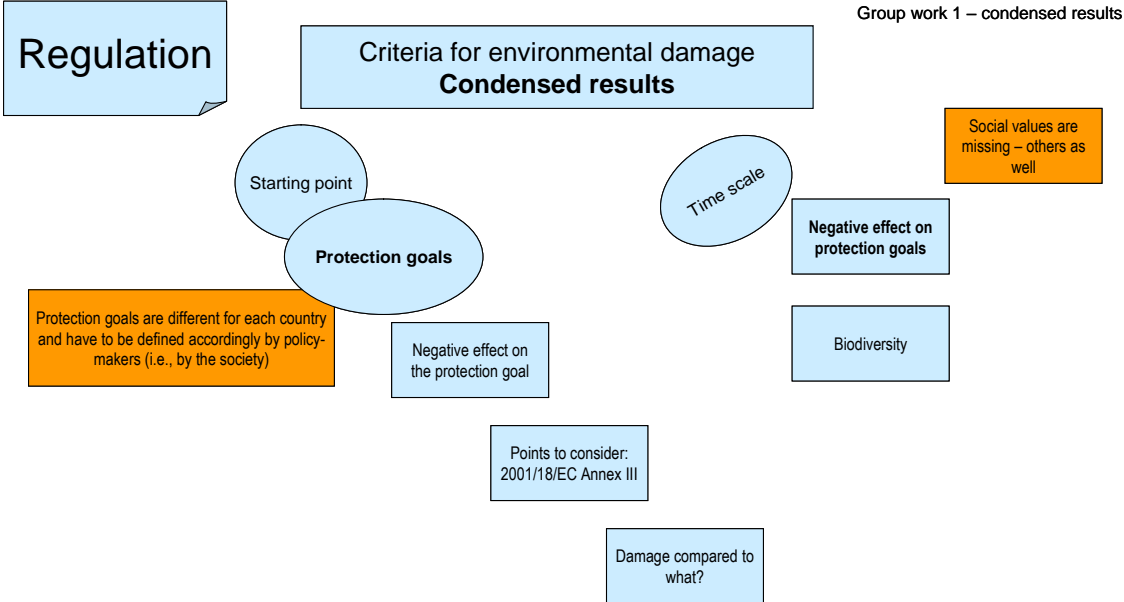


Figure 2a: Condensed results of group work 1 “Regulation”

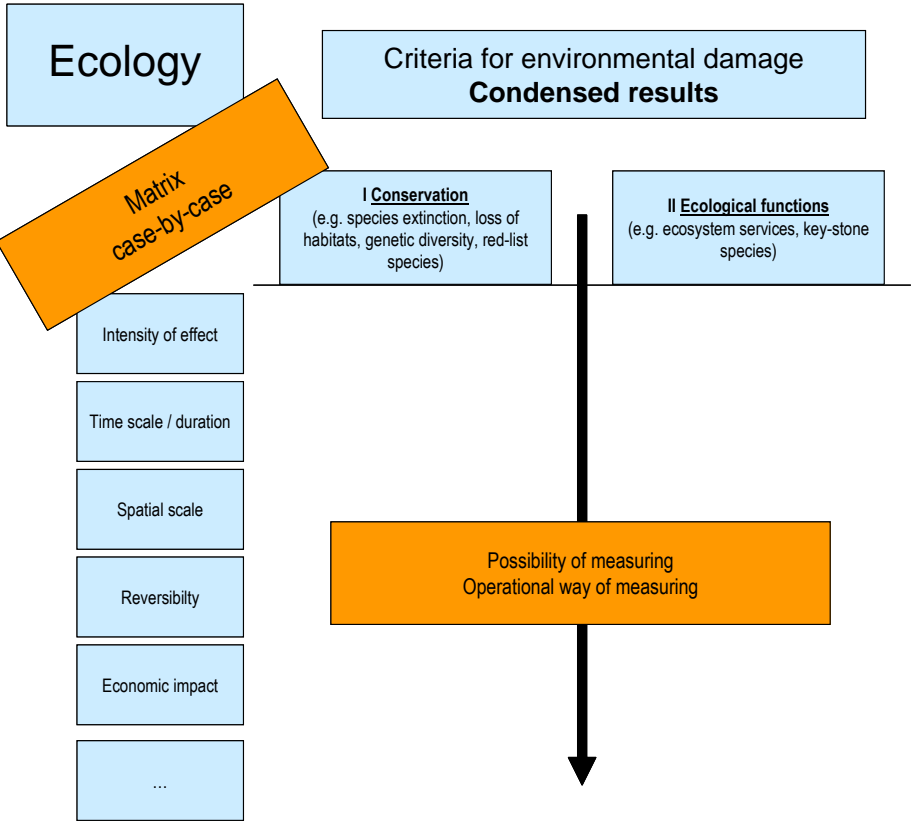


Figure 2b: Condensed results of group work 1 “Ecology”

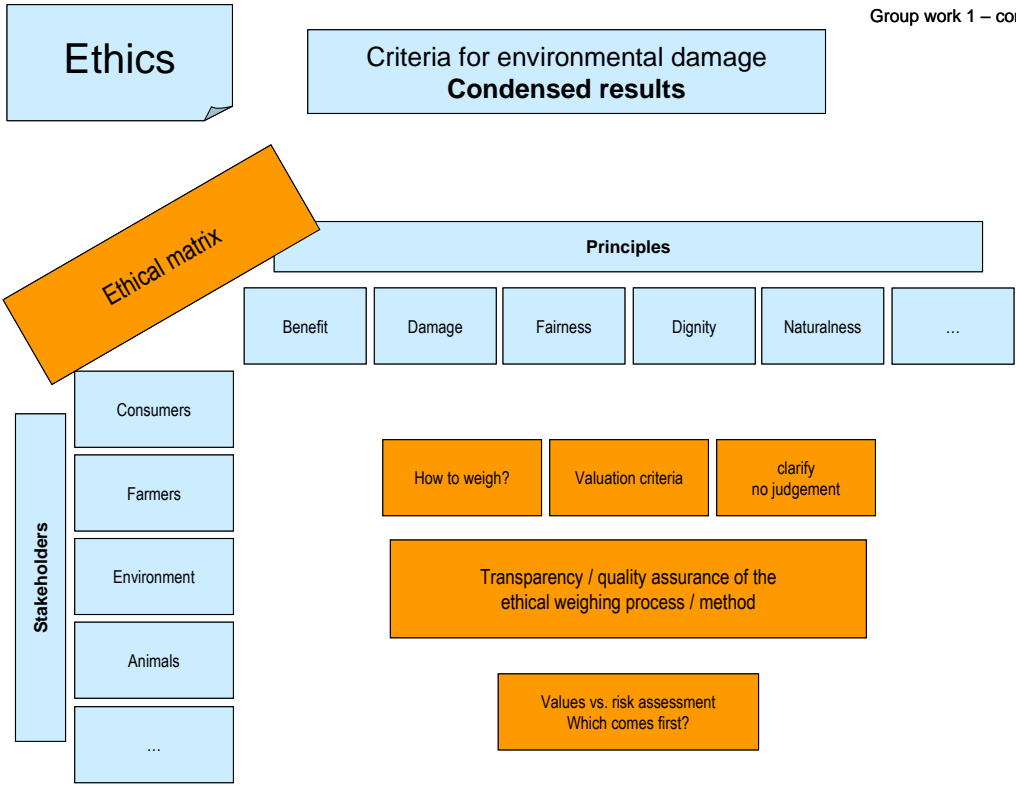


Figure 2c: Condensed results of group work 1 “Ethics”

The discussion within the working group *Ethics* revealed that there was little consensus among the involved group members on a status quo regarding an ethical approach to environmental damage. Some of the group members proposed to use an ethical matrix that was composed of the two axis *Stakeholders* and *Ethical Principles* (Figure 2c). Stakeholders could, for example, include consumers, farmers, the environment, animals and be supplemented by additional stakeholders if necessary. The ethical principles to be considered could include among others benefits, damage, fairness, dignity and naturalness. Transparency and quality assurance of the ethical weighing process and method were recognised to be the most crucial points in such a process. Not all group members, however, supported such an approach.

3.4 Plenary session 2:

Introductory talks on the impacts of agricultural management on biodiversity

The second day of the Exploratory Workshop started with a plenary session chaired by *Jozsef Kiss* offering three introductory talks on the impacts of agricultural management on biodiversity.

In the first talk on botanical diversity in farmlands and fields, *Jeremy Sweet* explained that farmland biodiversity is composed of different levels such as the landscape, the farm and the field scale. He illustrated that post-war farming trends have led to an intensification of agriculture in Europe including larger field units, increased fertilizer and agrochemical usage, and higher seed purity. All of these changes have led to a smaller range of weed species in arable fields and in grassland. This inevitably also resulted in food chain effects, given that fewer weeds translate into less food for insects, birds and small mammals. He further showed that modern integrated pest management strategies (including the use of GM herbicide tolerant varieties) aims at achieving a balance between necessary weed control and sustaining of farmland biodiversity.

In the second talk *Franz Bigler*, used three examples to illustrate the impacts of agricultural management on arthropod biodiversity. In the first example relating to the cultivation of maize, he showed that different soil management and soil cover, as well as different herbicide and nitrogen use that can be applied in maize cropping systems, led to altered arthropod patterns. Using a maize meadow or leaving a cover of dead plant material usually led to significantly higher arthropod abundances when compared to conventional maize cropping systems with bare ground. In the second example, he showed that pesticides had a greater negative impact on non-target arthropods than transgenic *Bt*-maize, expressing the insecticidal protein Cry1Ab from *Bacillus thuringiensis*, given the lack of specificity of the toxins contained in synthetic pesticides. In the last example, he demonstrated that current agricultural practices such as mowing can have tremendous impacts on the survival of insects. The use of a rotary cutter with a follow-up processor, for example, can kill up to 60% of the honey bees present in the bloom layer of a meadow. This obviously seems acceptable since mowing does not seem to be a contested ag-

gricultural management technique. He concluded that effects on biodiversity of the same magnitude, but caused by different practices, are often valued differently by the society.

The last talk by *Paul Henning Krogh* dealt with soil biodiversity. He introduced participants to the various forms of soil invertebrate diversity and the various life forms occurring therein. He summarized the results of a large EU project (ECOGEN) assessing the effects of GM cropping systems on soil biodiversity. The results of ECOGEN showed no effects of *Bt*-plants on earthworms and collembola. In case effects had been observed, they were most likely not due to the *Bt*-toxin, but to plant nutrient constituents. He noted that the most important parameters affecting soil micro-arthropods were soil type, age of the current soil conditions and tillage practices. He concluded that a risk assessment for soil environments must include the following elements of agricultural practice: crops and cropping sequences, pesticides and pesticide scenarios, tillage systems and fertilisation.

3.5 Group work 2:

Evaluation of pre-selected criteria for environmental damage

The starting points of the second group work were the condensed results of group work 1 that had been elaborated at the end of day 1 of the Exploratory Workshop (see Figures 2a-c). The aim of group work 2 was to evaluate and weigh the list of discussed and pre-selected criteria for environmental damage with regard to their applicability in decision-making processes, their methodological limits, potential dilemmas and knowledge gaps. Participants were randomly grouped into three interdisciplinary working groups (Table 2). Each working group concentrated on a specific environmental compartment (floral, arthropod or soil biodiversity) and used two case studies (*Bt*-maize and herbicide-tolerant oilseed rape) for their discussion. Each group had 2:45 h to discuss the given task and to document their results on a pin-board (see Figure 3a-c for details).

Table 2: Random grouping of participants for group work 2 into three different environmental compartments¹⁾

Flora	Arthropods	Soil
Devos	Bigler	Bachmann
Kaiser	Duelli	Bohanec
Kudsk	Ekbom	Cortet
Linnestad	Gathmann	Gielkens
Perry	Kiss	Kalediene
Pleysier	Link	Kinderlerer
Raybould	Von Troil	Krogh
Roupakias	Welin	Wust-Saucy
Sanvido		
Sweet		

1) The ESF representative Z. Kucan and the moderator K. Sinemus did not participate in the group work

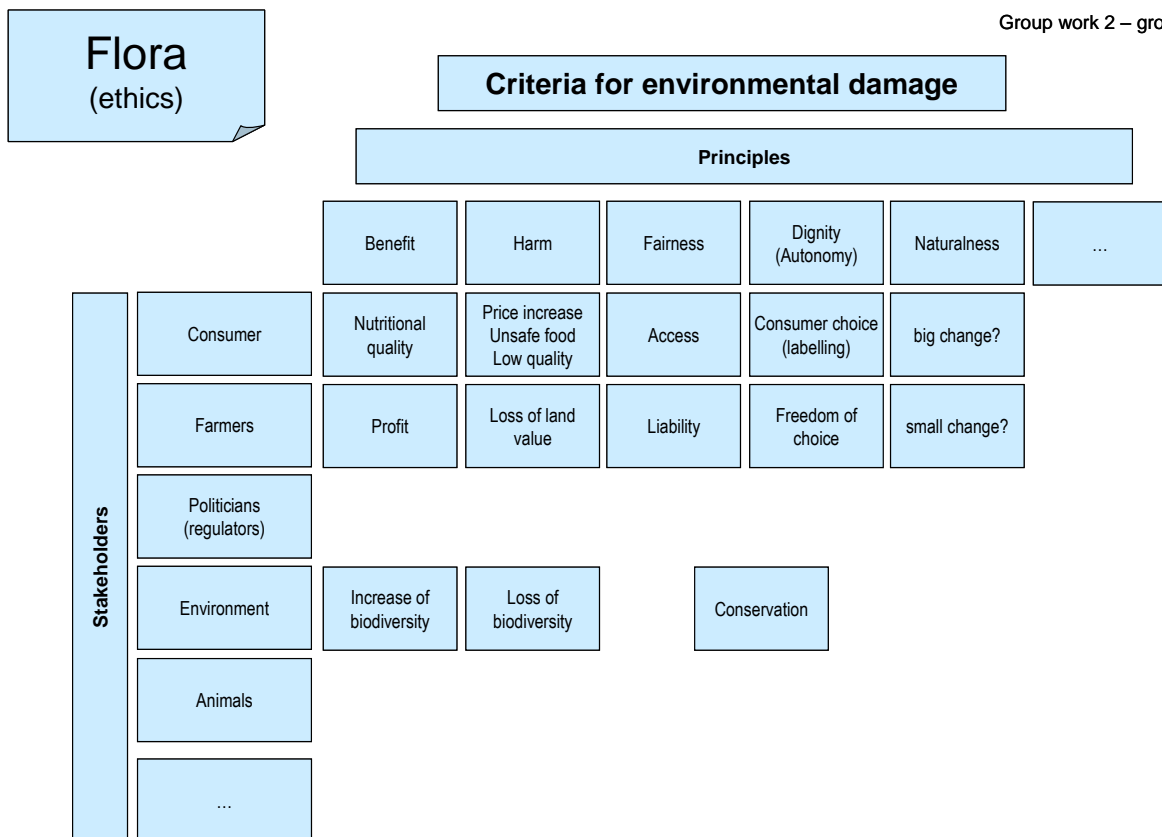
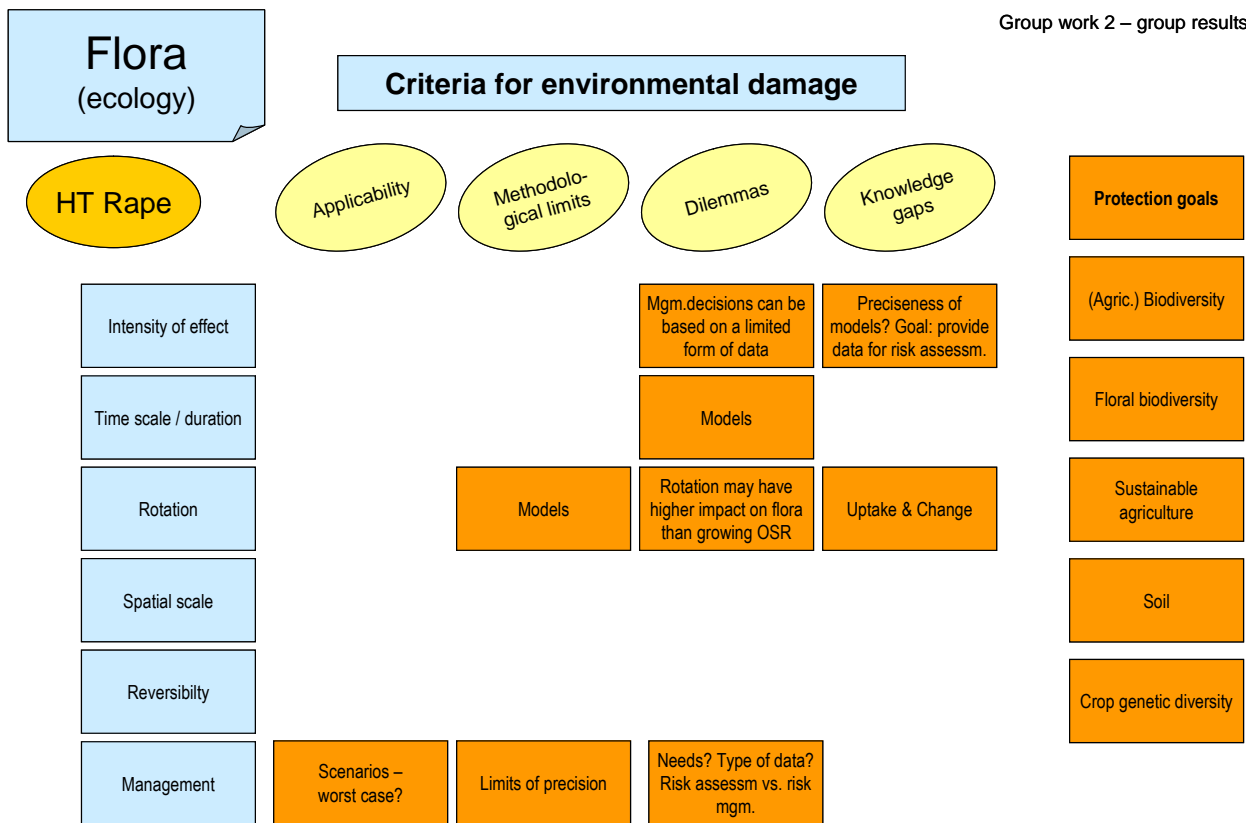


Figure 3a: Results of group work 2 “Floral biodiversity” divided into the two components ecology and ethics

Arthropods
(ecology)

Criteria for environmental damage

Bt-maize

Applicability	a	+ = yes - = no	Conservation (butterflies)				Ecological functions (biological control)			
			a	m	d	k	a	m	d	k
Methodological limits	m	Intensity of effect	+	-	-	-	+	-	-	-
		Time scale / duration	+	-	-	-	+	-	-	-
Dilemmas	d	Spatial scale	+	-	+	-	+	-	+	-
		Reversibility	+	-	+	-	+	-	+	-
Knowledge gaps	k	Economic impact	-				+	-	-	-
		...								

Arthropods
(ethics)

Criteria for environmental damage

Bt-maize

HT Rape

+ = yes - = no	Benefit	Harm	Fairness	Freedom of choice	Naturalness	...Dignity
Farmers	+	+		+		(+)
Consumer	? (+)			+	+	(+)
Biodiversity	+			-		
Animals (Farm...)	+			-		
Industry	+			+		
Conservationists	+ (dilemma)			?	+	(+)

Figure 3a: Results of group work 2 “Arthropod biodiversity” divided into the two components ecology and ethics

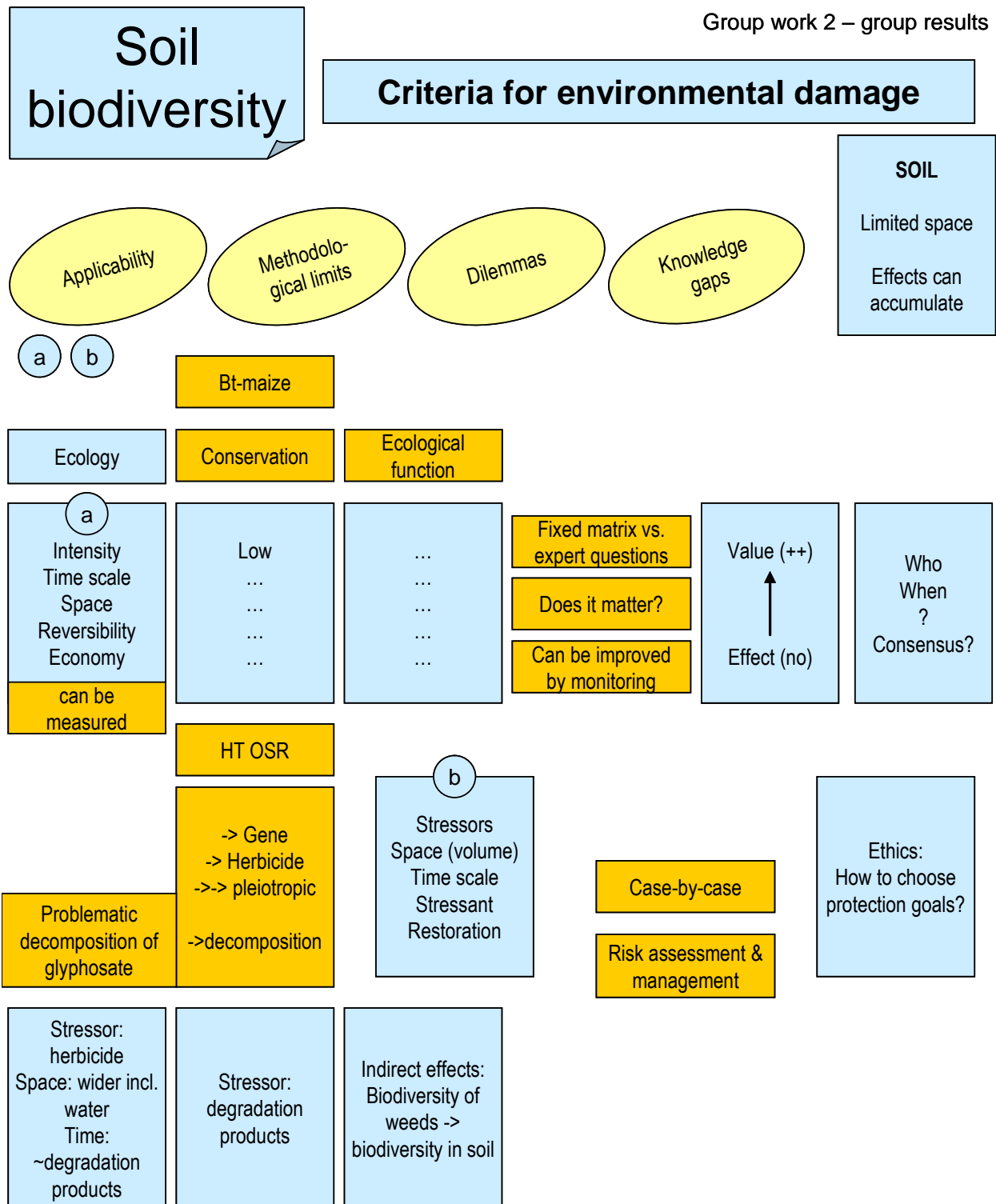


Figure 3c: Results of group work 2 “Soil biodiversity”

The plenary session at the end of day 2 aimed at collecting the different results obtained in the three working groups during group work 2 and at identifying the common features among the three discussed environmental compartments flora, arthropod and soil biodiversity. The session also aimed at possibly elaborating a synthesis of the results that could be used for future work. The results of each of the three working groups were presented to the plenum by a rapporteur.

Given that both the group on floral biodiversity and the one on arthropod biodiversity had structured their group work based on matrices (as one possible way to approach the definition of criteria as proposed on day 1 of the Exploratory Workshop), the chair of the plenary session *Kristina Sinemus* started to synthesise the results by proposing a condensed matrix combining the ecological and the ethical criteria on one axis and the two biodiversity goals “conservation” and “ecological functions” on the other axis (Table 3).

	Conservation				Ecological functions			
	Satisfactory methodology available	Open questions	Applicability	Sufficient knowledge available	Satisfactory methodology available	Open questions	Applicability	Sufficient knowledge available
ECOLOGY								
Intensity of effects								
Reversibility								
Time Scale								
Spatial scale								
Economic impact								
ETHICS								
Benefit								
Damage / Harm								
Fairness								
Dignity								
Consumer choice								

Table 3: Proposed matrix to condense the results of group work 2

With the help of the workshop participants, *Kristina Sinemus* subsequently aimed at filling in the boxes for the different evaluation criteria relevant to each environmental compartment. Shortly after having started filling in the first boxes, the plenum recognized that the goal to obtain a satisfactory result of the exercise within the time remaining for the plenary session was too ambitious. Participants realized that discussing how to fill in a specific box was not a

straightforward process that could easily be done within a short time frame. First, it was realised that the use of symbols (such as “+” or “-”) or denotations (such as “yes” or “no”) to fill in the matrix showed to be ambiguous since the symbols could have different meanings or be interpreted differently depending on the points considered. Second, it was recognized that the matrix could only be filled in on a case-by-case basis and only if the pre-conditions to be considered were set. The pre-condition to be considered in the present case are defined by the protection goals set by legislation. Since legislation may differ among different European member states, different countries could have different pre-conditions. In addition, it was noted that protection goals are only operational if they are characterized by assessment endpoints that represent measurable entities of a specific protection goal and if the outcomes that are not acceptable are defined. The question then arose who in practice is defining specific assessment endpoints and scenarios that are not acceptable (be it scientists, regulators or policy-makers?). The plenum realised that the initial aim of the session to synthesise the results of group work 2 could not be achieved within the time given due to the identified challenges. The plenum then decided to abandon this task.

3.6 Plenary session 3:

Feedback, outlook, follow-up activities

At the beginning of day 3 of the Exploratory Workshop, the convenors realized that their initial aim to elaborate a consensus on a set of criteria to evaluate ecological damage by the end of day 2 of the Exploratory Workshop could not be achieved since this process showed to be not as straightforward as expected. The discussion among participants during the last plenary session of day 2 led the convenors to modify the programme of day 3 of the Exploratory Workshop. Instead of the initially planned group work 3 aiming at identifying challenges for decision-making on environmental damage, it was decided to involve participants in an extended feedback round on the aims, the organisation and the development of the Exploratory Workshop. In the following, the feedback obtained by participants is grouped according to similar topics:

3.6.1 Aims of the Exploratory Workshop

A number of participants noted that in the course of the Exploratory Workshop, the objectives of the workshop had become blurred. For many participants the main goals of the workshop were unclear, in particular whether the goal was to find criteria for pre-market risk assessment of GM crops prior to commercial approval, or for the evaluation of environmental impacts that would be observed during post-market monitoring of GM crops. There was also confusion on whether the goal was to find criteria for the evaluation of the impacts of GM crops on biodiversity or criteria for environmental damage. Finally, there was a misunderstanding concerning the aim of the planned guidance document - was it intended to be a tool for the present situation based on the existing legislation or for an ideal future situation? One participant suggested that

it could be easier to first analyse the problems related to the current regulatory framework instead of providing right away a catalogue of ideal solutions to resolve all open questions. It was also suggested that a risk determination framework (i.e., speaking of “*points to consider*” instead of “*criteria*”) may be more helpful than trying to define objective criteria.

3.6.2 Baseline

It was noted that there had been not been an in-depth discussion during the group works on what constitutes an unacceptable environmental impact (or how this could be assessed). Moreover, the initially suggested approach to evaluate impacts of GM cropping systems in comparison to accepted conventional practices had not been discussed in detail. There had also not been a discussion on the fact that environmental impacts are valued differently depending on the type of agriculture causing them. Similarly, a discussion trying to explore why environmental impacts caused by certain agricultural management practices are accepted and others not had not taken place.

One participant observed that the discussions during the workshop had achieved a lot for currently available GM crops, but there had been no discussion, and hence no bases, for risk assessments of future products (e.g., for GM crops with drought tolerance). He further noted that there was no consensus on what society wants to achieve with regard to agriculture. Referring to the baseline discussion, one participant then raised the question “*what is the comparator*”? He asked the question whether there was a need to shift the baseline towards a desired environmental condition and whether it was necessary to compare GM crops with this (obviously stricter) desired baseline instead of comparing GM crops to the baseline of currently accepted agricultural management. It was mentioned that the level of acceptance may vary from country to country depending on the political environment and the respective agricultural and environmental policies. Countries will have different baselines depending on their needs regarding the type of agriculture wanted (e.g., food production, promotion of biodiversity), which in turn defines the desired baseline. Another participant noted that baselines are quickly shifting over the years and that there was literally no knowledge on what constitutes a realistic effect size (i.e., what constitutes an ecologically relevant effect) for different groups of biodiversity. Finally, one participant mentioned that the approach chosen by Sweden to define a baseline was to state that the biodiversity goal consisted in having no loss of species in comparison to the status of 1990.

3.6.3 Different needs of involved stakeholders

The regulators present in the audience emphasized that regulators have to stay within the boundaries of the existing legal frameworks. They noted that from a regulatory point of view, a comparative approach is not appropriate since conventional agriculture is not regulated in the same way, and more importantly not as thoroughly, as GM crops. It was argued that the goal of

the Exploratory Workshop should be to solve the current dilemma of broadened protection goals for GM crops in comparison to conventional agriculture instead of trying to find an ideal solution that is not necessarily based on current legislation. The aim of the Exploratory Workshop to provide a guidance document for regulators proposing a comparative approach was questioned since there might be a risk that regulators could not stick to the proposal. Another participant, however, noted that sticking to the existing EU legislation would be too limiting.

3.6.4 Evaluation criteria

One participant raised the question whether criteria for sustainable agriculture could represent applicable evaluation criteria. Sustainable agriculture covers ecological, economical and social aspects. Apart from ecological protection goals, there should thus also be both economical and social protection goals. This would inevitably lead to a trade-off between the different aspects and the need to find a balance between, for example, crop yield and biodiversity.

3.6.5 Uncertainty

It was noted that there are uncertainties to transfer measured impacts into damage. Regulators need to make decisions in circumstances where there is considerable variation in the quality and quantity of evidence/information. The decision-making process is often complicated by lack of information and other aspects of uncertainty. Questions arising include: what are we uncertain on and where are the most uncertainties? There would be a need for a clear method to show uncertainties, that is, when are we uncertain and how uncertain are we.

3.6.6 Role of ethics

An important question related to the role of ethics in the whole process, which was unclear to some of the ethicists present in the plenum.

4 Assessment of the results

4.1 Contributions to future directions of the field

The Exploratory Workshop was a first step to address both the ecological and the ethical questions involved in finding an operational approach to the definition of damage to biodiversity that could occur due to the use of GM crops. The three days of the workshop enabled an intensive discussion among the involved scientists from various fields including agro-ecology, agronomy, regulatory authorities, and the agricultural biotechnology industry. The discussions and the feedback from participants allowed identifying a number of important features that should be considered for future work and especially when planning to establish a guidance document to improve environmental decision-making.

4.1.1 Clearly define the objectives

A clear definition of the objectives of a guidance document is crucial. This includes answering the following three questions:

- At what stage of the process are the elaborated criteria to be used (i.e., during which phase of the life cycle of a specific GM crop can the criteria be used: *pre-market risk assessment* and/or evaluation of environmental impacts during *post-market monitoring*)?
- What is the scope of the planned document? Is it restricted to currently available GM crops or will it include potential future GM crops (e.g., crops with enhanced drought tolerance)?
- Will the guidance document elaborate criteria to valuate *impacts (of GM crops) on biodiversity* or *damage to biodiversity*?
- Will the planned guidance document be a tool to address challenges posed by the current EU (and Swiss) regulatory framework on GMOs, or will it more likely cover an ideal future situation that is not necessarily bound to the existing legal framework?

4.1.2 Use a clearly defined common terminology

There is a need to agree on a common set of terms that are unambiguously defined. This would include the following terms: *baseline, benefit, biodiversity, criteria, damage, environmental damage, ecological vs. environmental, protection goal, sustainable agriculture, threshold, unacceptable, uncertainty, valuation vs. evaluation, worst-case.*

4.1.3 Define the target audience of the guidance document

It became obvious during the Exploratory Workshop that scientists and regulators tend to have differing opinions on the goal of a guidance document. While scientists were primarily interested in finding the most optimal solution that would not necessarily be based on the current regulatory framework, regulators were rather strict on sticking to find a solution to overcome the challenges related to existing legislation. It has to be decided whether the initial idea to draft a guidance document primarily for regulatory authorities does not limit the project too much and whether the target audience should be broadened by additional stakeholders.

4.1.4 Find a consensus on an applicable approach to be used in decision-making

There is a need to elaborate an approach that most workshop participants can agree on. The discussion showed that not all participants entirely agreed on using a comparative approach where the impacts of GM cropping systems are compared to conventional agricultural management arguing that conventional agriculture is not regulated as thoroughly as the use of GM crops. The Exploratory Workshop also showed that according to regulators the protection goals as specified by existing legislation are the exclusive starting point for any definition of the term damage. While there was rather consensus among ecologists to use a matrix as a first ap-

proach for structuring these protection goals, the discussion among the involved ethicists showed that there was little consensus regarding an ethical approach to environmental damage. The subsequent plenary discussions and synthesis exercises, however, also showed that finding an operational way of measuring and evaluating the various proposed criteria for the different environmental compartments floral, arthropod and soil biodiversity showed to be challenging. The discussions clearly showed that the matrix approach has operational limits since it can only be used on a case-by-case basis and only if the pre-conditions to be considered are defined. Defining the pre-conditions, however, is not a straightforward process since this includes defining the protection goals and the baseline to be considered. Both protection goals and baselines can considerably vary among countries, given that they are depending on the respective agricultural and environmental policies. Such a process showed to be way beyond the possibilities of an Exploratory Workshop and will need future work.

A first step in finding an operational approach that could be used best in a regulatory environment requiring decisions within a relatively short timeframe could consist in determining existing approaches to environmental damage and then subsequently analyse the advantages and drawbacks of the different approaches possible. A number of approaches have already been discussed during the Exploratory Workshop including *protection goal*-, *baseline*-, *threshold*- and *matrix*-based approaches. The discussion of these approaches should be elaborated more in-depth following the workshop.

4.1.5 Find a consensus on the protection goals and on the baseline to be applied

The discussion during the group works and in the plenum showed that both *protection goals* and *baseline* were two consistently emerging issues. Regarding protection goals it was noted that these should be independent from the technology used and the question was asked how they were set, by which process and by whom. Baselines were recognized to be the crucial point of any decision-making process to determine what makes a change a damage. This automatically led to the question what baseline should be applied, that is, what agricultural management practice would be the most suitable benchmark when assessing potential effects of GM crops. There was more or less consensus that sustainable agriculture could be a potentially interesting baseline. Integrated Production, being an important agricultural management practice in Europe, was proposed as a possible benchmark, although it was also discussed whether other management practices (such as organic farming) could be more appropriate.

It was also recognized that protection goals and baselines are two interlinked issues, which are difficult to separate since both are based on existing policies and legislation. Elaborating a guidance document that would not necessarily be restricted to one particular country could become difficult since legal frameworks and policies can considerably vary among countries. Elaborating a guidance document that is as broadly applicable as possible should nevertheless remain the main objective of the work following this Exploratory Workshop.

4.2 Outcome

4.2.1 Continuation of the collaboration with the involved experts

Given that the convenors are currently working on a 2-year interdisciplinary project aiming at defining practicable and science-based decision criteria to evaluate effects of GM crops on biodiversity, the collaboration with the invited experts will be continued with own funds until the end of 2009. The feedback obtained by participants will be used to address the questions raised during the Exploratory Workshop. Participants will regularly be invited to provide feedback on the project results and on the draft guidance document. This will help to elaborate a guidance document, which could serve regulatory authorities as a tool for an informed decision-making process to evaluate effects of GM crops on biodiversity. It may also serve as model for similar scientific approaches in other fields where human activities may cause environmental impacts.

4.2.2 Publications

To make the Exploratory Workshop results available to all interested stakeholders involved in the decision-making of GM crops, it is planned to publish the main outcomes at a later stage of the project both in a scientific journal and as a guidance document. The final structure of the guidance document has not been determined yet, but it was discussed whether the experts involved could form smaller working groups that would provide different chapters of the planned publications. In addition, it is planned to present the project results at scientific conferences and to publish a number of articles in public newspapers and journals summarizing relevant results to assist the public and political discussion among interested stakeholders. The results will also be made available to internet sites such as www.biosicherheit.de and www.gmo-safety.eu, which are specialised in presenting information related to environmental safety of GM crops to a wider public.

4.2.3 Link to other research activities

Several participants emphasized that future work should consider existing knowledge and work by other scientists on related topics such as, for example, sustainable agriculture, biodiversity assessment and uncertainty. One promising research network is the *UK Rural Economy and Land Use research programme* and particularly the projects related to *Sustainable Farming in the New Europe* (www.relu.ac.uk/research/Challenge%203.htm). Some participants promised to provide the convenors with documents or contact details of scientists working in related fields to allow the potential build-up of additional networks.

5 Final list of participants

Andreas Bachmann (Co-convenor)

ethik im diskurs
Katzenbachstrasse 192
8052 Zürich
ambachmann@datacomm.ch

Franz Bigler (Convenor)

Agroscope Reckenholz Tänikon Research Station ART
Reckenholzstrasse 191
CH - 8046 Zürich – Switzerland
franz.bigler@art.admin.ch

Marko Bohanec

Institute Jozef Stefan
Department of Knowledge Technologies
Jamova 39
SI-1000 Ljubljana
marko.bohanec@ijs.si

Jérôme Cortet

Laboratoire Sols et Environnement
UMR INPL-INRA 1120
2 av. de Forêt de Haye BP 172
FR- 54505 Vandoeuvre-lès-Nancy
Jerome.Cortet@ensaia.inpl-nancy.fr

Yann Devos

European Food Safety Authority
Largo N. Palli 5/A
IT- 43100 Parma
Yann.devos@efsa.europa.eu

Peter Duelli

Swiss Federal Institute for Forest, Snow and Land-
scape Research
Zürcherstrasse 111
CH- 8903 Birmensdorf
peter.duelli@wsl.ch

Barbara Ekbohm

Swedish University of Agricultural Sciences
Department of Entomology
PO Box 7044
SE- 75007 Uppsala
Barbara.Ekbohm@entom.slu.se

Achim Gathmann

Federal Office of Consumer Protection and Food
Safety (BVL)
Referat 404, Mauerstrasse 39-42
DE- 10117 Berlin
achim.gathmann@bvl.bund.de

Marco M.C. Gielkens

National Institute for Public Health
and the Environment (RIVM)
P.O. Box 1
NL- 3720 BA Bilthoven
Marco.gielkens@rivm.nl

Matthias Kaiser

National Committee for Research Ethics
in Science and Technology (NENT)
Prinsensgate 18 - PO Box 522 Sentrum
NO- 0105 Oslo
matthias.kaiser@etikkom.no

Lilija Kalediene

Vilnius University
Department of Microbiology and Plant Physiology
Chiurliono str. 21/27
LT- 03127 Vilnius
lilija.kalediene@gf.vu.lt

Julian Kinderlerer

Delft University of Technology
Department of Biotechnology
Julianalaan 67
NL- 2628 BC Delft
jkinderlerer@gmail.com

Jozsef Kiss

Szent Istvan University
Plant Protection Institute
Pater Karoly utca 1
HU- 2100 Gödöllő
Jozsef.kiss@mkk.szie.hu

Paul Henning Krogh

University of Aarhus, NERI
Department of Terrestrial Ecology
Vejlssøvej 25
DK- 8600 Silkeborg
phk@dmu.dk

Zeljko Kucan (ESF rapporteur)

University of Zagreb
Department of Chemistry
Croatia
zkucan@chem.pmf.hr

Per Nielsen Kudsk

University of Aarhus
Department of Integrated Pest Management
Forsøgsvej 1
DK- 4200 Slagelse
Per.Kudsk@agrsci.dk

Julia Link

Swiss Expert Committee for Biosafety
c/o Federal Office for the Environment
CH- 3000 Berne
julia.link@bafu.admin.ch

Casper Linnestad

Norwegian Biotechnology Advisory Board
Rosenkrantz gt. 11 - P.O. Box 522 Sentrum
NO- 0105 Oslo
casper.linnestad@bion.no

Joe Perry

Oaklands Barn
Lug's Lane, Broome
UK- Norfolk NR35 2HT
joe.perry@bbsrc.ac.uk

Annick Pleysier

Monsanto Europe S.A.
Avenue de Tervuren 270-272
BE- 1150 Brussels
annick.pleysier@monsanto.com

Alan Raybould

Syngenta
Jealott's Hill International Research Centre
UK- Bracknell RG42 6EY
alan.raybould@syngenta.com

Demetrios G. Roupakias

Aristotle University of Thessaloniki
School of Agriculture
Dept. of Genetics and Plant Breeding
GR- 54124 Thessaloniki
roupak@agro.auth.gr

Olivier Sanvido (Co-convenor)

Agroscope Reckenholz Tänikon Research Station ART
Reckenholstrasse 191
CH - 8046 Zürich – Switzerland
olivier.sanvido@art.admin.ch

Kristina Sinemus (Moderator)

Genius GmbH
Robert-Bosch-Str. 7
DE-64293 Darmstadt - Germany
kristina.sinemus@genius.de

Jeremy Sweet

6 The Green, Willingham
UK- Cambridge CB4 5JA
jeremysweet303@aol.com

Helena von Troil

Archeon
Strandstigen 20 A 4
FIN-00330 Helsinki
helena.troil@archeon.fi

Stellan Welin

Linköping University
Department of Medical and Health Sciences
IHS Campus US
SE-58183 Linköping
stewe@ihs.liu.se

Anne-Gabrielle Wust Saucy

Federal Office for the Environment (FOEN)
CH- 3000 Bern
anne-gabrielle.wust-saucy@bafu.admin.ch

6 Statistical information on participants

28 participants (including 1 ESF representative) - one of the co-convenors, Klaus Peter Rippe, could unfortunately not participate in the workshop due to illness.

- 21 men

- 7 women

Country	Number of participants
Belgium	1
Croatia	1
Denmark	2
Finland	1
France	1
Germany	2
Greece	1
Hungary	1
Italy	1
Lithuania	1
Netherlands	2
Norway	2
Slovenia	1
Sweden	2
Switzerland	6 (including 3 convenors)
UK	3
Total	28

7 Final programme

Tuesday June 3, 2008	
19:00	Welcome dinner <i>Hotel Schweizerhof, Engelberg</i>
Wednesday June 4, 2008	
Plenary session	
Introduction to the workshop	
Chair: Franz Bigler, Agroscope ART, Zurich, Switzerland	
08:30 – 08:45	Welcome address Franz Bigler, Agroscope ART, Switzerland
08:45 – 09:00	Introduction by the ESF representative Zeljko Kucan, University of Zagreb, Croatia
09:00 – 09:15	Short round of introductions of all participants
Plenary session	
Introductory talks on existing conceptions of environmental damage	
Chair: Jeremy Sweet, Cambridge, UK	
09:15 – 09:35	Environmental damage from an ecological perspective Olivier Sanvido, Agroscope ART, Switzerland
09:35 – 09:55	Ethical conceptions of environmental damage Klaus-Peter Rippe, ethik im diskurs, Switzerland
09:55 – 10:15	Legal approaches to environmental damage Julian Kinderlerer, Delft University of Technology, Netherlands
10:15 – 10:45	Coffee break
Group work 1	
Identification of existing criteria for the evaluation of environmental damage	
Chair: Kristina Sinemus, Genius GmbH, Darmstadt, Germany	
10:45 – 11:00	“Warming up” Grouping of participants in 3 working groups by expertise (ethics, regulation, ecology)
11:00 – 12:30	3 working groups by expertise (ethics, regulation, ecology) to elaborate an introduction to existing criteria for environmental damage from the perspective of their respective fields
12:30 – 13:45	Lunch
13:45 – 14:00	Introduction of next steps plus group selection by the moderator
14:00 – 15:00	Group work 1 (continued) Feedback circuit Presentation of existing criteria for the evaluation of environmental damage in the respective fields by 3 representatives to obtain feedback by other participants
15:00 – 15:30	Coffee break

Wednesday June 4, 2008

Plenary session

Synthesis of the results of group work 1: Criteria for the evaluation of environmental damage

Chair: Kristina Sinemus, Genius GmbH, Darmstadt, Germany

15:30 – 16:00	Presentations by a representative of each of the three working groups (ethics, regulation, ecology) on their results and on the obtained feedback (10 min each)
16:00 – 16:30	Discussion and listing of criteria
16:30 – 17:00	Ranking of criteria for each discipline
17:00	End of day 1
17:30	Social programme & Dinner at Café Ritz, Gerschnialp

Thursday June 5, 2008

08:30 – 08:45	Introduction to the day Franz Bigler, Agroscope ART, Switzerland
---------------	---

Plenary session

Introductory talks on the impacts of agricultural management on biodiversity

Chair: Jozsef Kiss, Szent Istvan University, Gödöllő, Hungary

08:45 – 09:05	Impacts of agricultural management on (in-crop) floral biodiversity <ul style="list-style-type: none">- crop rotation, new crops, tillage, fertiliser use- herbicide management, herbicide resistance Jeremy Sweet, Cambridge, UK
09:05 – 09:25	Impacts of agricultural management on arthropod biodiversity <ul style="list-style-type: none">- crop rotation, new crops- pesticide use (direct effects)- tillage, herbicide use (indirect effects) Franz Bigler, Agroscope ART, Switzerland
09:25 – 09:45	Impacts of agricultural management on soil biodiversity <ul style="list-style-type: none">- crop rotation, crop choice, new crops- tillage, herbicide use Paul Henning Krogh, NERI, Denmark
09:45 – 10:15	Coffee break

Group work 2

Evaluation of pre-selected criteria for environmental damage (output of group work 1)

10:15 – 12:00	3 interdisciplinary working groups to evaluate and weigh the list of discussed criteria for environmental damage (applicability, methodological limits, dilemmas, knowledge gaps) Grouping by compartment: floral biodiversity, arthropod biodiversity, soil biodiversity 2 case studies: Bt-maize and herbicide-tolerant oilseed rape
12:00 – 13:30	Lunch
13:30 – 14:30	Group work 2 (continued) Evaluation of criteria for environmental damage
14:30 – 15:00	Coffee break

Thursday June 5, 2008

Plenary session

Synthesis of group work 2: Evaluation of criteria for environmental damage

Chair: Kristina Sinemus, Genius GmbH, Darmstadt, Germany

15:00 – 15:30	Presentations by a representative of each of the three working groups on the obtained results (10 min each)
15:30 – 16:15	Discussion and listing of criteria
16:15 - 17:00	Synthesis to find a consensus on a set of criteria that can be applied when evaluating environmental damage (to all biodiversity compartments)
17:00	End of day 2
17:30	Social programme & Dinner at Restaurant Alperösli

Friday June 6, 2008

Plenary session

Feedback round

08:30 – 08:45	Introduction to the day Kristina Sinemus, Genius GmbH, Darmstadt, Germany
08:45 – 09:30	Feedback exercise <ul style="list-style-type: none">- Positioning of participants on a scale from 0 to 100 to indicate project status obtained during the workshop- Selected feedback by participants
09:30 – 10:00	Coffee break

Plenary session

Closing of the workshop

Chair: Kristina Sinemus, Genius GmbH, Darmstadt, Germany and Franz Bigler, Agroscope ART, Switzerland

10:00 – 11:45	Discussion and identification of main future challenges of the project <ul style="list-style-type: none">- Feedback obtained in the first morning session- Outlook, follow-up activities, collaborative actions
11:45	Closing of the workshop
12:15	Lunch