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Sensitive Areas & GM-maize cultivation

Development and application of criteria and indicators for the definition of ecologically particularly sensitive areas regarding the cultivation of GM-maize for the justification of cultivation restrictions and prohibitions

Impressum

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Summary

The European legislation allows considering, on a case-by-case basis, ecologically particularly sensitive areas when imposing certain measures, e. g. restrictions, on GMO cultivation. Thus, it is necessary to define what can be considered an ecologically particularly sensitive area and what criteria and indicators can be applied for their identification in order to provide a basis for the justification of measures taken by a Member State.

This study focuses on insect resistant and herbicide tolerant GM-maize applications as they are currently the most relevant ones in GMO cultivation. This report provides an overview of the legal background and delineates the maize growing area of Austria, which was defined as the project area, as it can be assumed that potential GM-maize cultivation, which could have negative effects on ecologically particularly sensitive areas, could only take place within this area.

The development of a catalogue of criteria, as a basis for the identification of those particularly sensitive areas, is described in this report. It includes a description of possible categories of areas and potential environmental effects of GM maize that need to be taken into account. The catalogue of criteria is presented and the criteria as well as indicator groups and indicators are described.

In order to identify ecologically particularly sensitive areas data need to be available for the respective indicators. Thus, an extensive data search was conducted to identify potential data sources. The data analysis is presented with a discussion of e. g. the advantages and disadvantages, as well as the usability and applicability of the data. Selected data were used in a case study (GM-maize MON89034xMON88017) to show their applicability. In this case study a map representing the respective ecologically particularly sensitive areas was developed. In addition, the respective justifications were prepared so that these areas can be nominated during the GMO authorisation procedure.

It has been possible to show that, on the basis of the available data and depending on the trait(s) of the respective GMOs, ecologically particularly sensitive areas can be defined in large parts of the maize growing areas in Austria.

Zusammenfassung

Die EU-Gesetzgebung in Bezug auf GVOs erlaubt die fallspezifische Berücksichtigung ökologisch besonders sensibler Gebiete in Bezug auf bestimmte Maßnahmen wie z. B. Einschränkungen eines GVO-Anbaus. Dazu ist eine Definition des Begriffs „ökologisch besonders sensibles Gebiet“ notwendig. Daneben muss festgelegt werden, welche Kriterien und Indikatoren für ihre Identifizierung herangezogen werden können. Auf dieser Basis kann dann die jeweilige Auswahl der „ökologisch besonders sensiblen Gebiete“ durch die Mitgliedsstaaten erfolgen, und die entsprechende Begründung von Anbaueinschränkungen ausgearbeitet werden.

Die vorliegende Studie fokussiert auf den Anbau von insektenresistenten und herbizidtoleranten GV-Mais, da diese im Moment die größte Bedeutung in der EU haben. Der Bericht gibt einen Überblick über den rechtlichen Hintergrund und beschreibt das Maisanbaugebiet in Österreich. Dieses Gebiet wurde als Projektgebiet definiert, da angenommen werden kann, dass nur hier ein potentieller GV-Mais Anbau stattfinden kann, der negative Effekte auf ökologisch besonders sensible Gebiete haben könnte.

Die Entwicklung eines Kriterienkataloges als Basis für die Identifizierung dieser besonders sensiblen Gebiete sowie für eine entsprechende Begründung wird beschrieben. Dies inkludiert die Diskussion möglicher Gebietskategorien und Umwelteffekte von GV-Mais, welche berücksichtigt werden müssen. Der Kriterienkatalog wird präsentiert sowie Kriterien, Indikatorgruppen und Indikatoren im Detail beschrieben.

Um ökologisch besonders sensible Gebiete identifizieren zu können, sind Daten für die entsprechenden Indikatoren notwendig. Deshalb wurde eine umfassende Datenrecherche durchgeführt, um potentielle Datenquellen zu identifizieren. Die Datenanalyse wird dargestellt, wobei unter anderem Vor- und Nachteile der Daten, sowie deren Nutzbarkeit diskutiert werden. Die Anwendbarkeit des Kriterienkataloges und der ausgewählten Daten wurden in einem Fallbeispiel (GV-Mais MON89034xMON88017) getestet. In diesem Fallbeispiel wurde nicht nur eine Karte ökologisch besonders sensibler Gebiete entwickelt, sondern auch entsprechende Begründungen erarbeitet, um diese Gebiete im Zulassungsverfahren nominieren zu können.

Es konnte gezeigt werden, dass auf Basis der verfügbaren Daten und abhängig von den Eigenschaften des jeweiligen GVOs ökologisch besonders sensible Gebiete in einem großen Teil des Maisanbaugebiets Österreichs definiert werden können.

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Introduction

In the context of GMO cultivation, the consideration of environmental aspects remains an important topic, not only regarding the environmental risk assessment in principle but also in view of regional aspects and nature conservation issues. Although European legislation demands an environmental risk assessment of a GMO before authorisation, uncertainties remain and negative effects cannot be excluded. This is especially relevant regarding potential long-term or large-scale effects since these are harder to predict and to quantify. The reasons for this are the fragmentary knowledge of potential environmental effects, the limited number of available studies (often not comparable because of different methods used (DOLEZEL et al. 2009)), and therefore a higher level of uncertainty regarding the possibility of occurrence of these effects. These uncertainties and the complexity of ecosystems make it difficult to estimate and quantify potential (long-term) effects. Thus the estimation of hazards and risks is a very demanding task.

These issues are also important in nature protection especially where ecologically particularly sensitive areas which need special protection are concerned and where no risk should be taken given their importance, endangerment and sensitivity.

The relevance of the remaining uncertainties and the need to protect ecologically particularly sensitive areas is also reflected in the respective legislation. Article 6 (5) e) and Article 18 (5) e) of Regulation (EC) No. 1829/2003 stipulate that "conditions for the protection of particular ecosystems/environments and/or geographical areas" may be included in the opinion of EFSA:

"*In the event of an opinion in favour of authorising the food, the opinion shall also include the following particulars: [...] (e) where applicable, any conditions or restrictions which should be imposed on the placing on the market and/or specific conditions or restrictions for use and handling, including post-market monitoring requirements based on the outcome of the risk assessment and, in the case of GMOs or food containing or consisting of GMOs, conditions for the protection of particular ecosystems/environments and/or geographical areas*".(REGULATION (EC) NO. 1829/2003, Article 6 (5) e))

Another Reference is made in Directive 2001/18/EC in Article 19 (3) c), where it is stated that the written consent shall explicitly specify:

"... the conditions for the placing on the market of the product, including any specific condition of use, handling and packaging of the GMO(s) as or in products, and conditions for the protection of particular ecosystems/environments and/or geographical areas;" (DIRECTIVE 2001/18/EC, Article 19 (3) c))

Those conditions can comprise restrictions and even prohibitions of cultivation as stated by the conclusions of the European Council in 2008 (COUNCIL OF THE EUROPEAN UNION 2008). The same Council Conclusions further specify particular ecosystems or geographical areas:

"[The Council]

15. UNDERLINES the need to take full account of the specific regional and local characteristics of the Member States, particularly ecosystems/environments and specific geographical areas of particular value in terms of biodiversity or particular agricultural practices in line with the existing legislation;

16. UNDERLINES the possibility, under existing authorisation procedures of GMOs for cultivation, of taking case specific management or restriction measures, including prohibition measures, in order to ensure biodiversity protection in fragile ecosystems such as Natura 2000 sites designated under directives 79/409/EEC and 92/43/EEC on the basis of an environmental risk assessment based on scientific information;

CALLS for particular attention to be given to these ecosystems on these grounds;

INVITES Member States and applicants to provide appropriate information as early as possible in the evaluation procedure;

POINTS OUT that in accordance with Community law, which includes the precautionary principle, regions with specific agronomical and environmental characteristics, including small isolated islands, may require particular case-specific management or restriction measures, including prohibition measures for GMO cultivation" (COUNCIL OF THE EUROPEAN UNION 2008).

Regulation (EC) No. 1829/2003 and the Council Conclusions (REGULATION (EC) NO. 1829/2003, COUNCIL OF THE EUROPEAN UNION 2008) provide some general guidance for particular ecosystems and geographical areas, but the details on the selection of those areas remain unclear. In addition, some procedural aspects are still open, also because so far no Member State of the European Union has tried to restrict GMO cultivation based on Article 6 (5) e) and/or Article 18 (5) e) of Regulation (EC) No. 1829/2003. However, according to Regulation (EC) No. 1829/2003, areas and conditions applicable must be included in the opinion of EFSA. Another important point is, as clearly stated by the European Commission during the discussions preceding the Council Conclusions that conditions such as restriction measures must be science-based and justified.

In order to select and nominate ecologically particularly sensitive areas in the authorisation procedure, a system needs to be established that can be used as a tool for the identification of such areas and provides a basis for the justification of restriction measures. Austria puts special emphasis on avoiding negative effects of

GMO cultivation on its diversity-rich natural and semi-natural landscapes as well as on species biodiversity, in particular on species occurring in agricultural areas. The aim of this project was thus to elaborate a catalogue of criteria with respective indicators based on potential environmental effects of GMOs, suitable to select ecologically particularly sensitive areas in Austria regarding GM-maize cultivation for which special protection measures are necessary. In this context, only possible environmental effects of herbicide tolerant and insect resistant GM-maize applications were taken into account for the development of criteria and respective indicators. Socio-economic aspects were not considered.

Methodology used and structure of the report

A stepwise approach was used in order to elaborate the necessary justification for measures to restrict the cultivation in ecologically particularly sensitive areas:

- Definition of the project area: Using certain inclusion and exclusion factors the project area was defined. Only criteria and data relevant for this area were used in the study.
- Development of criteria: Based on possible negative effects of the cultivation of GM-maize on species, habitats and other environmental protection goals, a list of possible criteria and indicators was created. This list was discussed and refined in an expert workshop.
- Based on this refined list an extensive data search was performed, in order to get an overview which data are available for the selected criteria and where they are stored.
- The data were then analysed for their quality, availability and usability and a decision was made, also based on the discussions in a second expert workshop, which data could be used for a definition of ecologically particularly sensitive areas.
- The applicability of the catalogue and the suitability of available data were tested in a case study (cultivation of GM-maize MON89034xMON88017). As a result a map showing areas (with respective justifications for a restriction or ban on MON89034xMON88017 cultivation) that can be nominated as ecologically particularly sensitive areas was developed.

The report follows the same structure to demonstrate the stepwise approach and the logical order in which the different steps need to be carried out. Thus a sound justification for the nomination of certain areas in the GM authorisation process as ecologically particular sensitive can be provided.

Project area

This report is focused on ecologically particularly sensitive areas in Austria with regard to GM-maize cultivation. As a basis for the development of a catalogue of criteria as well as for the application considered in the case study, a project area was defined, based on the Austrian maize cultivation area. The method applied, individual working steps and the resulting project area are presented in the following.

Method

The project area was defined by using certain inclusion as well as exclusion factors. Areas that are relevant for maize cultivation should be incorporated, whereas areas that cannot be used for agriculture like forests or settlements should be excluded. In addition, areas with a high percentage of organic farming as well as areas designated for seed production should also be excluded, because GM-maize cultivation might be restricted in these areas through coexistence measures. In addition, protected areas of various categories in the different Federal States (Bundesländer) should be excluded if agricultural use is not allowed there. For the calculations as well as the graphical representations MS Access 2007 and ArcGIS 10.2 were used.

Inclusion factor

Due to different factors like market values and crop rotation, the maize cultivation area is liable to change. Hence, the total potential maize cultivation area has been determined by extrapolating cultivation data from the last decade. Possible new applications like e. g. drought or cold tolerant GM-maize could shift or enlarge this area in the future. However, the intended catalogue of criteria and the respective case study are focused on insect resistant and herbicide tolerant GM-maize applications, which will be the most relevant ones in the near future.

For the definition of the maize cultivation area, data from the Integrated Administration and Control System for Agricultural Subsidies (IACS=INVEKOS) were used. INVEKOS data originally refer to single parcels. However, reference to grid cells of 1 km^2 has been possible from 2009 onwards. The values in the grid cells represent the sum of maize cultivation area per grid cell per year.

For the calculation of the maize cultivation area, data from 2003 to 2010 could be used. Former years were not accounted for due to the high irregularity and low coverage before 2003. However, data quality improved after 2003, and data could therefore be used for the calculations. For example, INVEKOS data cover about 97 % of the agricultural area utilised in Austria in the year 2010. Data used for the calculations include all kinds of maize cultivation, e. g. corn, silage maize, sweet maize or maize grown for bio-energy production, as identified by their respective land use code (105 grain maize, 109 silage maize, 135 green maize, 106 Corn-Cob-Mix (CCM), 131 Corn-Cob-Mix (CCM)/field vegetable (field-grown), 107 sweet corn, 134 sweet corn/field vegetable (field-grown), 421 SL: grain maize, 442 SL: biogas – maize, 445 SL: combustion maize, 464 SL: CCM, 465 SL: silage maize (SL= “set aside” cultivation before 2008)).

For 2009 and 2010 data per grid cell were used directly. As it has been possible to link the parcels (and therefore the maize cultivation area) directly to the grid cells in the INVEKOS database only from 2009 onwards, it has been necessary to use a workaround to localise the parcels for the years 2003 until 2008, as described in the following. Those parcels which could still be identified in 2009 by their cadastral number were localised and were included in the mapping process. Those with a number unknown in 2009 were summed up in a pool of “non-localised” parcels which could not be included in the mapping process. The number of these non-localised parcels increases as one goes back in time back from 2009, with a maximum of 11 % of the utilised agricultural area in 2003.

Based on the aggregated parcel data per grid cell per year, a mean acreage was calculated as an indicator of maize presence and to give an overview of the distribution of maize cultivation (Figure 1).

The use of raster data and the inclusion of all grid cells even with marginal maize cultivation allows for the delineation of the potential maize cultivation area. The inclusion of grid cells with marginal cultivation of maize together with the grid size of 1 km² also takes into account potential impacts of GM-maize outside the field (MENZEL et al. 2005). In this way the protection distance of 800 m proposed by (UMWELTBUNDESAMT 2011) is also accounted for.

Figure 1 presents the mean maize cultivation area in hectares per km². The minimum area per km² is below 1 ha, the maximum area 50 ha per km². The agricultural area utilised for maize cultivation is not distributed homogeneously all over Austria. Although widespread, maize cultivation is mainly found in the basin of Klagenfurt, the southern part of Styria, the eastern part of Burgenland, in Upper Austria and along the northern edge of the Alps. The main maize cultivation areas are surrounded by areas with less maize cultivation. These areas are broader in the lowlands and smaller near the Alps. Maize is also cultivated in the alpine valleys, but only on a very small scale.

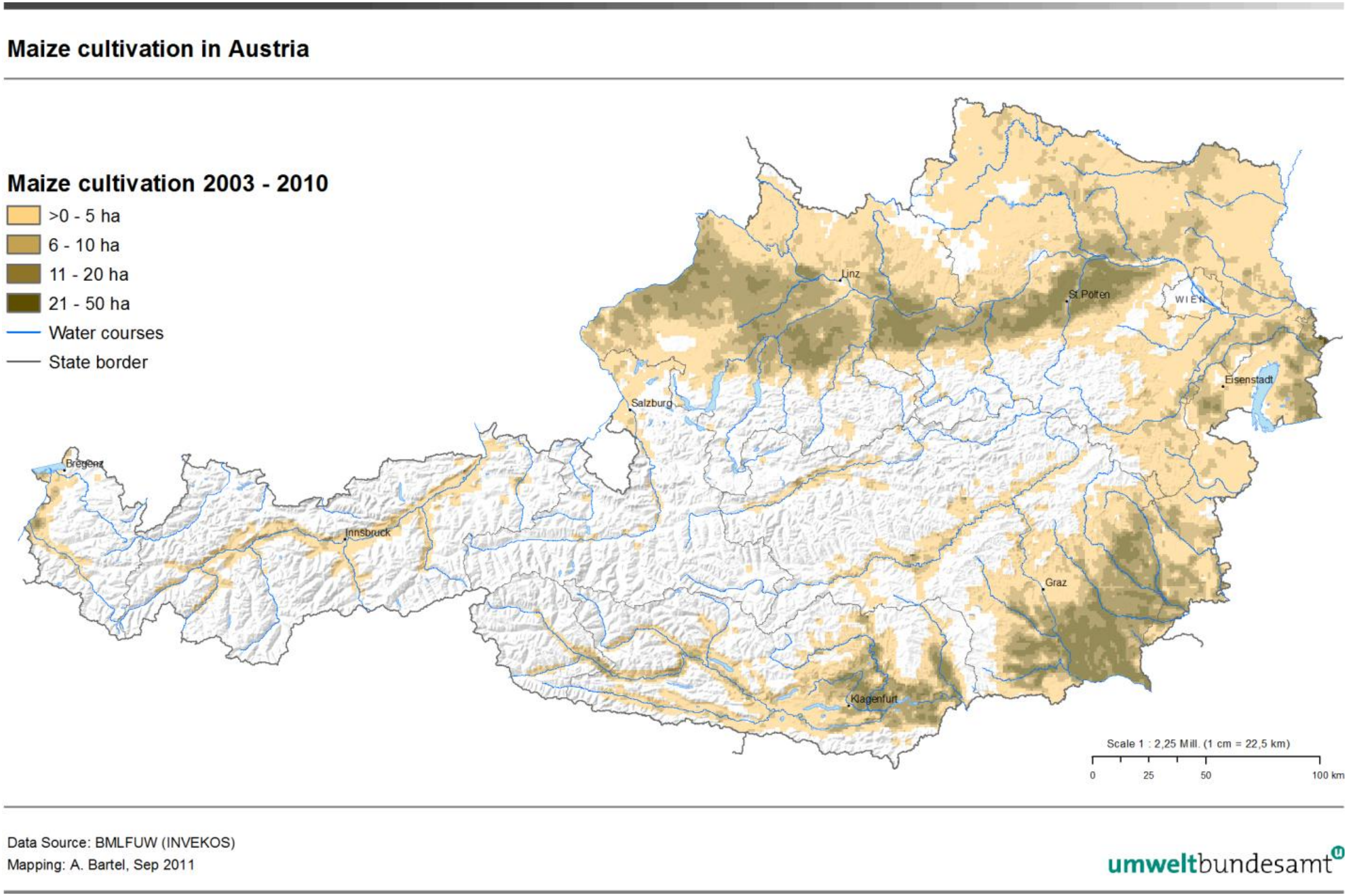


Figure 1: Maize cultivation in Austria

Exclusion factors

As described above, a number of potential exclusion factors were defined in order to exclude areas that are either not relevant for potential GM-maize cultivation in Austria or where GM-maize cultivation could be restricted, based on socio-economic arguments like coexistence measures. Such exclusion factors were:

- areas not suitable for agricultural production like forests, areas with a high percentage of sealed surface or mountainous regions;
- areas with a high percentage of organic maize cultivation;
- areas dedicated to maize-seed production;
- protected areas if agricultural use is prohibited.

Water bodies were not excluded in order to take potential impacts on aquatic organisms into account, e. g. effects on Trichoptera (ROSI-MARSHALL et al. 2007).

How these factors were applied is described in the following.

Areas not suitable for agriculture

Since the inclusion factor "maize cultivation area" is the basis for the delineation of the project area, large areas not suitable for agricultural production were excluded from the start. However, grid cells with marginal maize cultivation were included in the maize cultivation area. Therefore, cells with high shares of non-agricultural or non-arable land were also marked as maize (and potential GM-maize) cultivation area. Even in cities, excluding the city centres, maize is grown on a small scale in several cases. Based on calculations carried out beforehand, most parts of the Alps, the Hausruck area in Upper Austria and the military training area of Allentsteig in Lower Austria were excluded as they are large, closed areas without any maize cultivation (Figure 1).

It is possible that some areas not used for agricultural production - especially settlements – have only recently come into existence through conversion of agricultural areas. In those cases it is possible that - because of maize cultivation in the past - such areas are included, even if cultivation is not possible any more. However, the grid size of 1 km² provides a buffer in the event of such errors on a single parcel level.

As a large part of Austria's surface area is covered by forest, forest areas (forest map from GSE Forest Monitoring, Joanneum Research 2008) were subtracted from the maize cultivation area. The results are presented in Figure 2. It is shown that also in the main maize cultivation areas arable land is mixed with small-sized forests.

Areas with a high percentage of organic maize cultivation

Based on the INVEKOS dataset, the organic maize cultivation area was calculated in order to define areas with a high percentage of organic maize cultivation. Since the highest level of organic maize cultivation in Austria was reached in 2009, this year was used as basis for the calculations. The same calculations as those for the calculation of the maize cultivation area (described above) have been used for organic maize farming. The resulting percentage of organic maize area in relation to the total maize area per 1 km² grid cell is presented in Figure 3.

As demonstrated in Figure 3, organic maize was grown in 2009 throughout the maize cultivation area, but the mean share of organic maize cultivation area in relation to the total maize area was below 5 %. The rate of organic maize cultivation per grid cell in 2009 was from 0 % to 100 %, with the highest shares generally in cells with a very low total acreage of maize cultivation. In some cases only one - sometimes even very small - maize field was located in a grid cell. If this field is cultivated with organic maize, it leads to an optical over-representation of organic maize in Figure 3.

As the cells where organic maize is grown are not concentrated in special regions within the potential maize cultivation area, there is no defined zone which could be excluded as a whole on grounds of coexistence-related arguments. Thus, it is not feasible to use organic farming as an exclusion factor for the definition of the project area.

Areas defined for maize-seed production

The designation of large closed areas for seed production is an instrument laid down in the Austrian seed production law (ORDINANCE Federal Legal Gazette II No. 128/2005). The goal of this ordinance is to facilitate the registration process and the implementation of the required preconditions for certified GM-free seed production by avoiding or minimizing cross contamination by establishing large areas designated only for seed production.

Currently, conventional (non-GM) and organic seed production takes place in fields scattered in the agricultural area. Although isolation distances in general need to be kept from neighbouring fields where the same species (irrespective if it is conventional or organic) is grown, e. g. 200 m for maize, these fields are no “closed seed production areas” (AGES 2004).

So far no such area has been established in Austria and therefore there are no areas which can be excluded for this reason from the maize cultivation area.

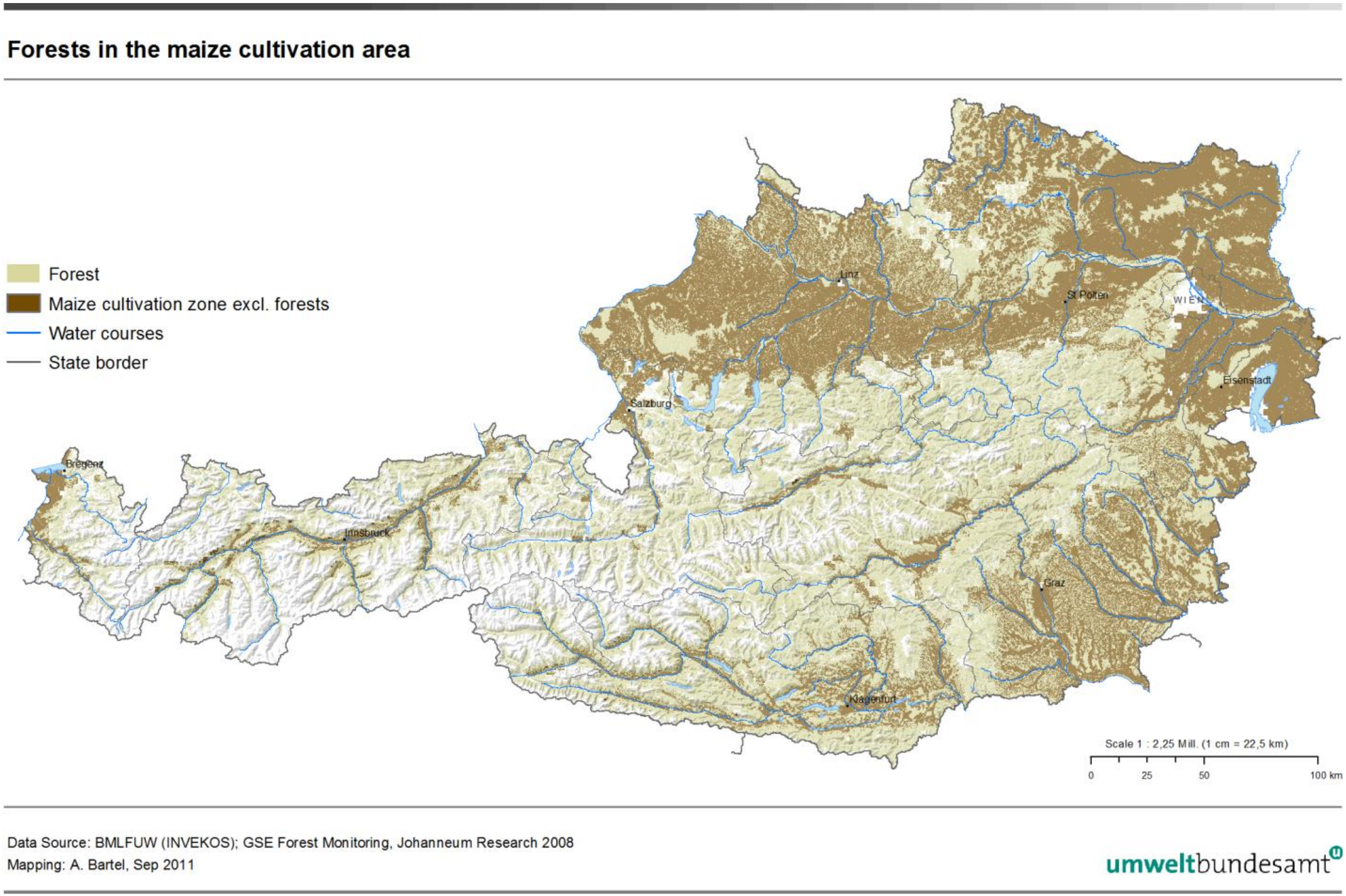


Figure 2: Forests in the maize cultivation area

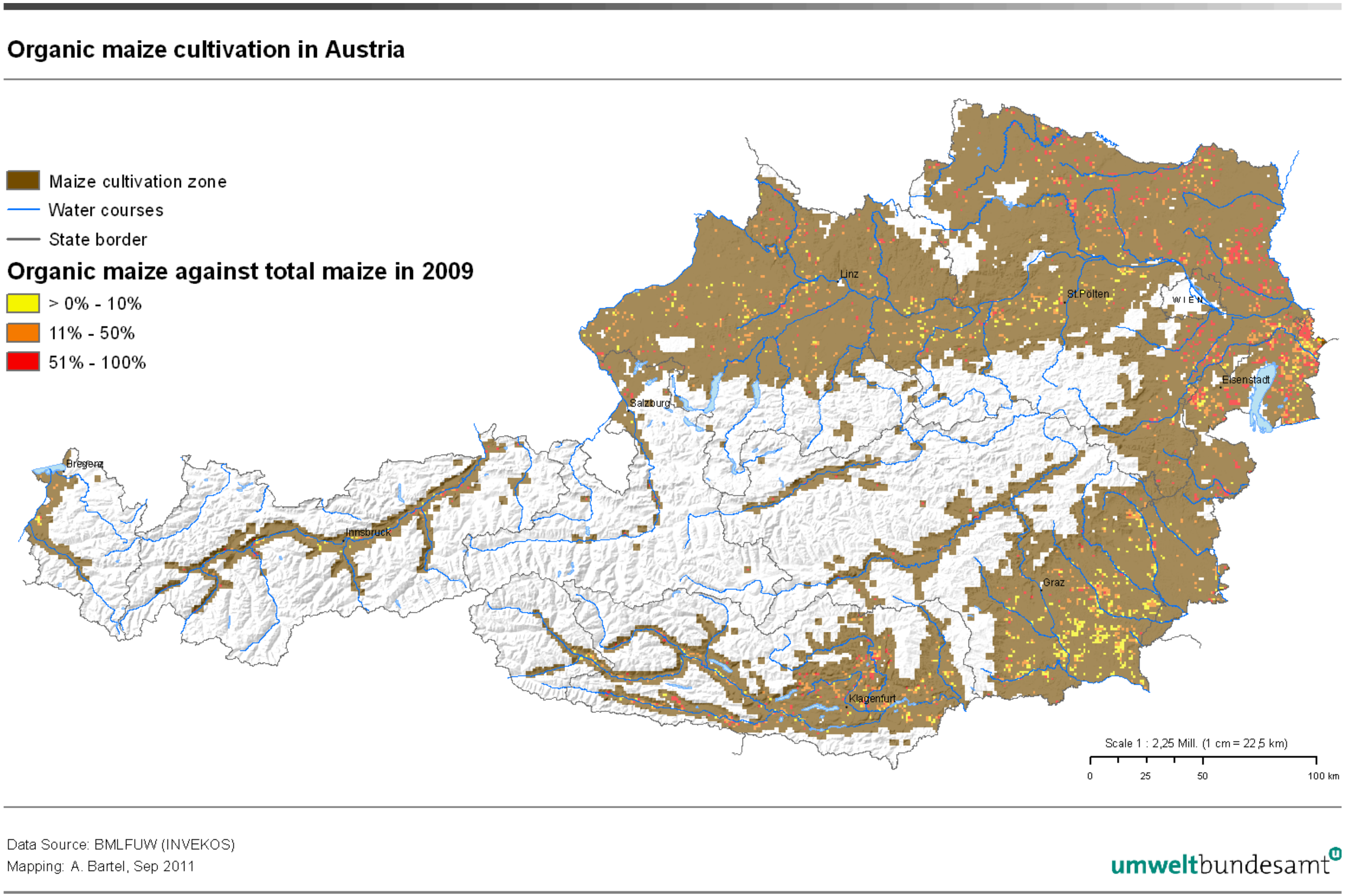


Figure 3: Organic maize cultivation in Austria

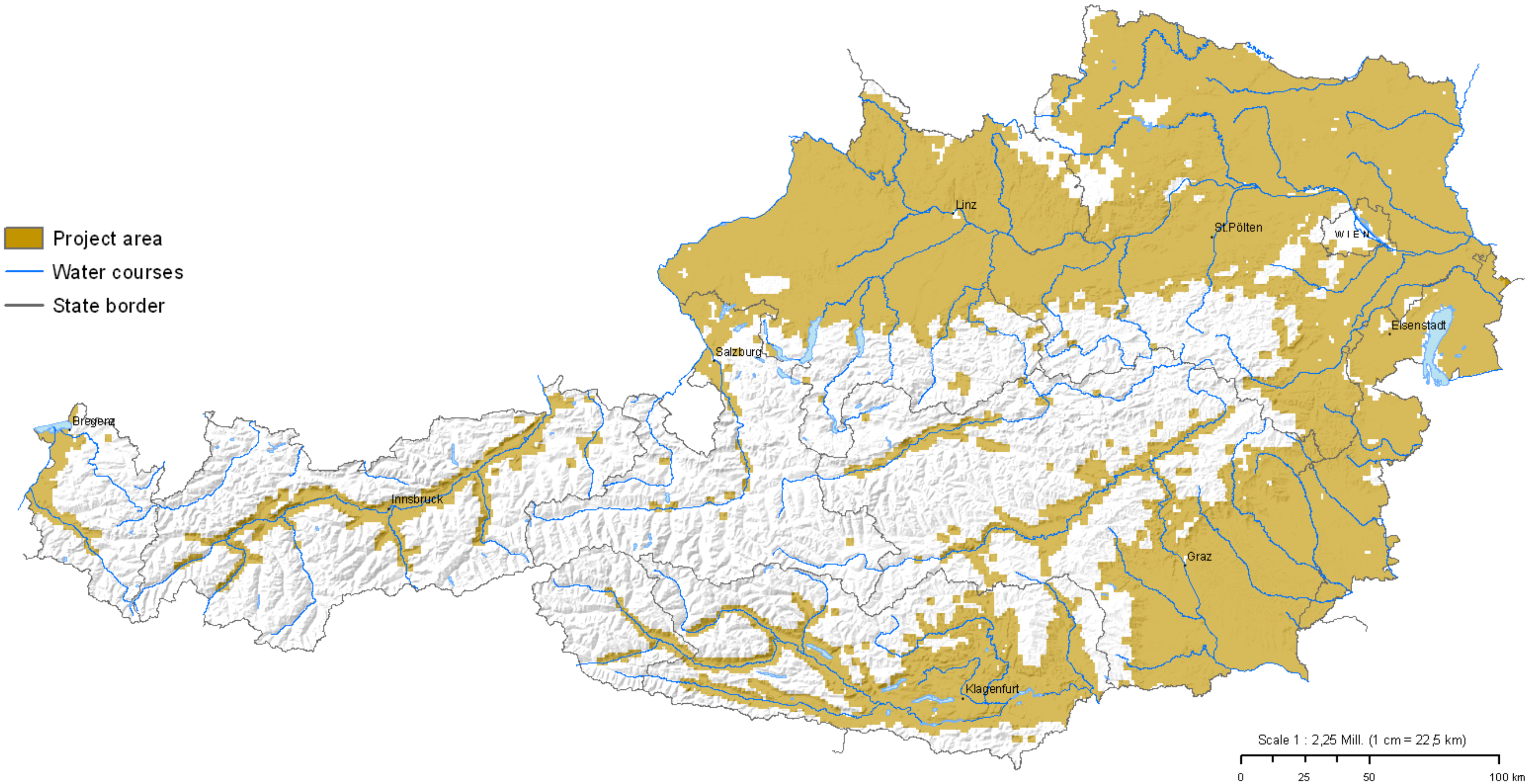
Protected areas

In Austria certain areas are protected for nature conservation purposes based on the nature conservation laws of the Austrian Federal States. There are various categories of protected areas e. g. nature conservation areas, landscape protection areas or Natura 2000 sites. However, none of the Federal States prohibits agricultural use in those areas in general and therefore GM-maize cultivation is in principle possible (UMWELTBUNDESAMT 2011). Therefore, protected areas situated in maize cultivation areas must also be evaluated as to whether they are ecologically particularly sensitive to a certain GM-maize application.

Result

On the basis of INVEKOS data from the last decade and a grid size of 1 km², the potential maize cultivation area was identified (see Figure 1). Exclusion factors like enclosed forest areas and alpine regions had already been accounted for as a first step because no maize cultivation is possible in those areas. However, the small-scale structure of agriculture, forestry and settlements and the defined grid size do not lead to closed areas which could be excluded as such. This is also true for the exclusion factor “organic farming”. First, organic maize is only grown on a small scale (<5 % of the total maize production area in Austria) and second, the fields are not concentrated within the maize cultivation area. As no closed seed production areas have been defined in Austria so far and seed production is currently scattered in the agricultural area, such areas could not be used to reduce the project area. However, the approach used as described above and the resulting project area consider also areas that might be affected by nearby maize cultivation. The inclusion of all grid cells even with marginal maize cultivation and the definition of the project area on the basis of grid cells with a size of 1 km² create a buffer in respect to the level of single maize parcels. The project area as presented in Figure 4 is therefore identical with the Austrian maize cultivation area and contains single maize parcels as well as various kinds of biotope types situated in the maize cultivation area that might be affected by nearby GM-maize cultivation.

Project area



Data Source: BMLFUW (INVEKOS)
Mapping: A. Bartel, Sep 2011

umweltbundesamt

Figure 4: Project area

Development of a catalogue of criteria

The developed catalogue of criteria presented in the following is limited to criteria and respective indicators for insect resistant and herbicide tolerant GM-maize. It is intended as a tool for the identification and selection of ecologically particularly sensitive areas in Austria on a case-by-case basis. In addition, it is intended to be used as the scientific basis for the justification of restriction measures *vis-a-vis* the respective EU institutions.

Methods

In order to establish the catalogue of criteria, a two-step approach was chosen. First, possible areas which are important from a nature conservation perspective and which might be negatively affected by GM-maize cultivation were identified on the basis of the potential environmental effects of GM-maize. These include e. g. areas with occurrences of protected species, protected habitats or biodiversity hot spots. Based on the results of this area identification, criteria and respective indicators were developed as a second step.

Workshops

In the course of the development of the catalogue of criteria two workshops were held in order to discuss criteria, indicators and data issues with experts from various disciplines and representatives of the contracting authorities. Among the participants were experts from nature conservation, environmental risk assessment, monitoring, vegetation ecology, zoology and agriculture from Austria, Germany and Switzerland. The workshops took place at the Umweltbundesamt (Environment Agency Austria) on 19th September 2011 and on 14th February 2012. Based on the discussions and recommendations of the participants, the catalogue of criteria was revised and indicators refined. The participants also played a role in the selection of data for the case study.

The aim of the first workshop was to discuss the first version of the catalogue of criteria, reflecting on its completeness and suitability. Possible and necessary criteria and indicators were discussed independently of the respective data quality and availability. The discussions were focused on the structure of the catalogue, the completeness of criteria and the most appropriate basis for the selection of indicators. In addition, important contributions regarding problematic data issues like data availability and usability of data in principle, down- or up-scaling of data as well as the use of data derived from modelling approaches were made by the participants.

The aim of the second workshop was to discuss a revised version of the catalogue that was drafted following the recommendations of the first workshop concerning the respective data (data availability, data quality) derived from an intense data enquiry. The discussion was focused on the practicability of the catalogue, possibilities to refine indicator species, the importance of Austria-wide comparable data as well as the definition of and thresholds for hot spots. In comparison to the first workshop, more in-depth discussions took place regarding the spatial resolution of data, the preconditions for and difficulties in the use of modelling data as well as the necessary time and financial efforts to improve the actual data quality. Further aspects of the discussion were possible indicator rankings and the selection of data for the case study.

Ecological considerations

As authorised GM-maize is cultivated without confinement it interacts with the respective environment. Environmental effects can differ depending on the modified plant, the introduced transgene and the new trait. These potential effects can be direct or indirect. Effects can also differ depending on the observed timeframe (immediate or long-term effects) or scale (e. g. on the level of an individual, a population or an ecosystem). Consequences with respect to nature conservation or biodiversity (endangerment of protected species, shifts in the species composition of a certain area and impact on biodiversity) cannot be excluded. Some potential effects of insect resistant or herbicide tolerant GM-maize relevant for ecologically particularly sensitive areas can be based on MENZEL et al. (2005):

On the level of the individual

- Adverse effects on non-target organisms caused by the respective Bt-toxin

On the level of the population

- Decimation or advancement of species groups (e. g. by expressed toxins of the GM-maize or changes in the agricultural management)

On the level of the ecosystem

- Effects on the food web (e. g. predator-prey-relationships)
- Changes in the species spectrum

On the level of the landscape

- Changes in the landscape assemblage (e. g. landscape structure, habitat types)
- Changes in the landscape picture (e. g. by intensification)

Besides the intended effect on the target organisms also non-target organisms could be negatively affected. The negative effects (as discussed in detail in UMWELTBUNDESAMT 2011) could be direct (lethal or sublethal) but also indirect (e. g. on the food web by effects on the next trophic level). Depending on the protein produced by the respective GM-maize, different groups of non-target organisms may be affected. The different Bt proteins of insect resistant maize, for example, act on different groups of organisms. They are e. g. intended to affect Lepidopteran or Coleopteran species. Changed management practices like e. g. alterations in herbicide management may have an influence on biotopes near the maize fields. Intensification of agricultural management caused by large-scale cultivation of GM-maize could lead to changes in the landscape structure (e. g. reduction or decreased size of landscape elements) affecting the number and diversity not only of habitats but also of species.

Regarding nature conservation and biodiversity, the endangerment of protected species or shifts in species composition, both affecting biodiversity, should receive special attention as well as effects on the landscape level which may result in a reduction of biotope diversity. Unintended possible direct and indirect effects are especially relevant for ecologically particularly sensitive areas.

As demonstrated in UMWELTBUNDESAMT (2007) and UMWELTBUNDESAMT (2011), protected areas and agricultural areas are often interconnected. This means that protected areas are often located within the agricultural area or directly adjacent to them. Moreover, agriculture can take place also in protected areas (e. g. Natura 2000 areas). It can be assumed that these facts are the same for sensitive areas in general. Depending on the various factors like the size or the protection status of an area and the cultivated GMO, those areas are more or less sensitive to GMO cultivation. Thus protected species may be more affected by Bt maize than by herbicide tolerant maize. On the other hand, changes in agricultural management and the influence of altered herbicide applications due to herbicide tolerant maize may lead to effects on the biotope or landscape level.

Since environmental effects can occur on various spatial levels, and are not limited to the GM-field itself, not only ecologically particularly sensitive areas next to the GM-field but also in the vicinity may be affected. The distance over which such effects can occur varies depending on factors like pollen distribution, environmental conditions, GM-maize trait and associated risks etc. Taking this into account, the whole maize cultivation area was considered for the selection of data and the case study when developing the catalogue of criteria (see also chapter “project area”). In addition, the conclusions drawn on a certain spatial level depend on the data basis as will be shown in the following chapters. Therefore, not only agricultural habitats were considered but also other habitats situated in the project area with some exceptions as described below.

Result

As discussed above, the legal basis provides no definition of particular ecosystems, environments or geographical areas (REGULATION (EC) No. 1829/2003). It is also not clear what can be summarised under the term 'geographical areas of particular value' in terms of biodiversity, fragile ecosystems or regions with specific environmental characteristics.

All the different areas referred to in the Council Conclusions (COUNCIL OF THE EUROPEAN UNION 2008) can be summarised as "ecologically particularly sensitive areas". Special emphasis is put on areas which are important from a nature conservation perspective. Therefore, four main categories were identified as a basis for the development of a catalogue of criteria:

- Areas with endangered species or biotope types (e. g. species or biotope types endangered according to the Red List)
- Areas with protected species or biotope types (according to federal, national or European law)
- Protected areas (e. g. nature reserves, national parks, Natura 2000 areas)
- Biodiversity hot-spots

It needs to be noted that not all areas important for biodiversity are natural landscapes (PASCHER et al. 2010a). In fact, agricultural landscapes can be very important for biodiversity especially if they are small structured and contain a variety of different habitats (PASCHER et al. 2011). In addition, the species and habitat diversity in agricultural environments is closely linked to certain agricultural management practices. This aspect is of particular importance since possible effects of GM-maize cultivation on species and ecosystems will occur most probably in maize cultivation areas rather than in wilderness areas e. g. in alpine environments.

As described above, the catalogue of criteria developed in the course of this study is limited to criteria and respective indicators for insect resistant and herbicide tolerant GM-maize. It should serve as a tool for the identification and selection of ecologically particularly sensitive areas in Austria on a case by-case basis and shall in addition provide the scientific basis for the justification of restriction measures vis-à-vis the respective EU institutions. As such justification is essential, criteria and indicators must be related to possible negative effects of GM-maize cultivation.

The case-specific approach is of utmost importance because it forms the basis for the authorisation procedure in the European Union. Not all ecologically particularly sensitive areas are influenced by every GMO or influenced in the same way. Therefore, it is not possible to prepare a general list of areas to be used in every GMO authorisation procedure. Although it is most likely that there are criteria and indicators that can be applied for a set of GMOs e. g. if they are plant- or trait-specific, the selected areas may vary since their sensitivity depends on the species trait combinations and the related possible impacts on the environment. Hence, not all suggested indicators may be applicable for all GM-maize lines. A respective subset of indicators needs to be selected depending on the potential effect of the GM-maize line on a case-by-case basis in order to allow for a scientifically sound justification. In principle, all indicators in the catalogue of criteria are equivalent.

As also agreed by experts participating in the workshops, the catalogue of criteria with its indicators needs to be practical in order to make it possible to define ecologically particularly sensitive areas with reasonable time and effort, since those areas must be nominated in due time to allow EFSA to include them in its scientific opinion, according to Regulation (EC) No. 1829/2003. Therefore, the delineation and justification must be based on existing data since it is not practicable to collect relevant data on a case-by-case basis in the given time.

As recommended by the experts, all criteria and indicators remained in the catalogue of criteria irrespective of the current availability of data. If appropriate data for some indicators were not found during the data search, this would be important for the identification of data gaps.

The catalogue developed and presented in Table 1 includes levels, criteria, indicator groups, and single indicators. Levels provide the outline for the identified criteria taking into account that different criteria and indicators are needed in order to represent direct and indirect as well as medium and long-term effects. Criteria are concrete issues representing aspects where GM-maize cultivation is in conflict with environmental protection goals. Indicators describe the respective criterion and should be quantitative and measurable. Hence, they are the basis for the data search. However, indicators are only listed at the level “landscapes”, since the list of indicator species and biotope/habitat types is too extensive and will need to be refined further in some cases by the respective experts in the future. In order to enable a comprehensive data search, indicators were summed up in indicator groups. Available data sources like databases of museums contain information on various single species. Therefore, the search on indicator groups (e. g. which databases contain information on endangered Lepidoptera) is more efficient than the search on individual species.

The various aspects taken into account in the catalogue of criteria are discussed in the following sections. An overview is given of the number of indicators on the level of species and biotope/habitat types as well as their selection and possibilities for further refinement.

Table 1: Catalogue of criteria (indicator species and indicator biotope types are not listed in detail since 419 endangered species, 21 endemic species, 28 protected species, 124 endangered biotope types and 32 habitats of Community interest were defined) n.a. = not applicable

Level	Criterion	Indicator group	Indicator
Species	Endangered species and their habitats	Occurrence of endangered Lepidoptera Occurrence of endangered Trichoptera Occurrence of endangered Coleoptera	Occurrence of single species of the respective indicator group
	Endemic species and their habitats	Occurrence of endemic Lepidoptera Occurrence of endemic Trichoptera Occurrence of endemic Coleoptera	Occurrence of single species of the respective indicator group
	Protected species and their habitats	Occurrence of protected Lepidoptera Occurrence of protected Trichoptera Occurrence of protected Coleoptera	Occurrence of single species of the respective indicator group
Habitats & protected areas	Endangered biotope types	n.a.	Occurrence of single endangered biotope types as defined in the Austrian Red List
	Habitats of Community interest	n.a.	Occurrence of single biotope types as defined in the Habitat Directive and relevant for Austria
	Protected areas if agricultural use is not prohibited	n.a.	Protection goal could be negatively influenced by GM-maize cultivation
Landscapes	Important areas for biodiversity	Biodiversity hot spot	Existence of bird biodiversity hot-spot Existence of Lepidoptera biodiversity hot-spot Existence of Coleoptera biodiversity hot-spot Existence of Trichoptera biodiversity hot-spot Existence of vascular plant hot-spot Existence of biotope biodiversity hot-spot Existence of agricultural areas with high biodiversity
	Structurally diverse landscapes	n.a.	Existence of agricultural areas with high structural richness

Level "species"

In agreement with the experts participating in the workshops, this level comprises criteria in relation to possible direct and short- to medium-term effects of GM-maize cultivation. Three criteria were identified: "endangered species and their habitats", "endemic species and their habitats" and "protected species and their habitats". Indicators are defined on the species level as "occurrence of species xy". As recommended by the experts, rare species were not included since the category "rare" in the context of the Red Lists of Endangered Species is the subject of controversial discussions and has also been deleted from the Red List categories developed by IUCN.

Species groups included in this level are Lepidoptera (butterflies and moths), Trichoptera (caddisflies) and Coleoptera (beetles). Lepidoptera and Coleoptera are considered in this context since all insect resistant GM-maize lines authorised or in the authorisation pipeline in the EU express Bt-toxins against one or both of these species groups. Trichoptera are included because this order is closely related to Lepidoptera and negative effects have already been reported in the scientific literature (ROSI-MARSHALL et al. 2007). Amphibian and fish species are not considered since potential effects would derive from the application of the corresponding broad spectrum herbicide. Those effects cannot be considered to justify restrictions of GM-maize cultivation since the herbicides have been authorised under the respective legal provision. However, other species orders may be included in the future if negative effects from GM-maize cultivation are reported in the scientific literature (e. g. Heteroptera, Auchenorrhyncha or nectar feeding species).

It was also recommended by the experts that not only the species order but also the functional group should be considered for the selection of applicable indicators since the feeding behaviour of species might be an important aspect regarding potential negative effects. Therefore, it was decided to select only those species as indicators that could realistically come into contact with GM maize. Based on this precondition a first selection of indicator species was performed for this study. However, that selection still resulted in a far too long and comprehensive list especially regarding species of the criterion “endangered species and their habitats”, that could not be displayed in Table 1. Moreover, a fine selection of single species as indicators would require detailed zoological expert knowledge on the ecology, e. g. the feeding behaviour or habitat preference, of all possible indicator species, and therefore was not possible in the framework of this study. In addition, indirect effects of GMO cultivation are also discussed in the literature as mentioned above (e. g. predator-prey relationships). These should also be taken into account wherever possible. Therefore, as also confirmed by the experts, for further refinement a respective standardised methodology for indicator selection needs to be developed including various aspects like feeding habits or habitats. However, it must be noted that, in principle, the notifier of a GMO for which an application for cultivation in the European Union has been submitted has to perform an exposure assessment. Therefore, if such an assessment is not available, negative effects on the species as discussed below cannot be excluded and in line with the precautionary principle should be considered in the definition of ecologically particularly sensitive areas.

Regarding possible data sources for the indicator species it was stressed by the experts that the occurrence of fodder plants should not be used as an indicator for the potential occurrence of indicator species. This would be an oversimplification, not taking into account other important ecological parameters like landscape structure, climate or the occurrence of predators.

Endangered species and their habitats

Regarding the criterion “endangered species and their habitats” indicators for Trichoptera and Lepidopera were defined, based on the “Red List of Endangered Animals in Austria” (BERG et al. 2005, EDER et al. 2007, HOLZINGER et al. 2009). Since the Red List of Coleoptera in Austria has not been published yet (September 2012), no indicators could be specified for the indicator group “occurrence of endangered Coleoptera”. Regarding the indicator group “occurrence of endangered Lepidoptera“ species of diurnal butterflies as well as moths were taken into account.

In addition to the Red List for Austria there are also Red Lists for the Federal States in Austria. Unfortunately the lists of the Federal States are inconsistent in terms of coverage and availability. However, the “Red List of Endangered Animals in Austria” contains the latest (updated) data and has been compiled according to consistent criteria and is therefore comparable Austria-wide. This was the main reason why experts agreed that only species classified as “critically endangered”, “endangered” and “vulnerable” in the "Red List of Endangered Animals in Austria” were selected for this study. If possible, the functional group and the species habitat were considered in the selection of indicator species (e. g. species occurring in alpine regions only were not included). However, respective information about e. g. habitats and altitudinal distribution was provided in the Red List of Endangered Animals in Austria only for moths.

Since in most cases it was not possible to achieve an at least rough refinement of the species list according to habitats and functional groups, the resulting list of indicator species is very extensive. An overview of the respective species numbers is provided in the following:

- Occurrence of endangered Lepidoptera: 229 indicator species
  - Critically endangered: 69 indicator species
  - Endangered: 87 indicator species
  - Vulnerable: 73 indicator species
- Occurrence of endangered Trichoptera: 150 indicator species
  - Critically endangered: 7 indicator species
  - Endangered: 47 indicator species
  - Vulnerable: 96 indicator species

Endemic species and their habitats

As recommend by experts, Austrian endemic species were included in the catalogue of criteria. Those species only occur in Austria, often within a narrow distribution area. Therefore, those species are potentially at risk, depending on factors like the distribution area, population size and habitat specificity. As recommended, endemic as well as subendemic species were considered, as the definition of subendemic is very narrow (i. e. that more than 75 % of their total range is within Austria, see RABITSCH & ESSL (2009)).

Relevant indicator species were defined based on RABITSCH & ESSL (2009) taking into account their occurrence in the project area and, where available, information on the species' altitudinal distribution, habitats and endangerment. The occurrence data on the resulting species were overlaid with the project area for a further refinement, resulting in 21 indicator species as presented below:

- Occurrence of endemic Lepidoptera: 10 indicator species
- Occurrence of endemic Trichoptera: 9 indicator species
- Occurrence of endemic Coleoptera: 2 indicator species

Protected species and their habitats

Regarding the criterion "protected species and their habitats" indicators were defined, based on species of Community interest according to the Habitats Directive (COUNCIL OF THE EUROPEAN UNION 1992). This list is not country-specific as it is valid for the whole European Union. As the data search was not based on the definition of indicators on the species level, but on more general level, e. g. the availability of data on protected butterflies, it was not necessary to analyse those extensive species list in detail at this stage. However, at a later stage, and in order to select those species of Community interest occurring in the project area, as described in detail in chapter "Data for the implementation of the catalogue of criteria", data on Austria (Article 17 report) were intersected with the project area. This intersection resulted in 17 indicator species for the indicator group "occurrence of protected Lepiodoptera" and 11 indicator species for the indicator group "occurrence of protected Coleoptera". No Trichoptera are protected according to the Habitats Directive.

Species protected under the respective ordinances of the Austrian Federal States could not be taken into account for the following reasons: First, nature protection is the responsibility of the Federal States and the definition of protected species and methods for their selection therefore varies, resulting in very inhomogeneous species lists that are not comparable. The regulations of e. g. Carinthia and Lower Austria contain mostly information on the species level. Other regulations contain only a few species but also species groups like all species of a certain genus or family. The Federal State Vorarlberg e. g. protects all Lepidoptera and Coleoptera species except pest species. But an indicator on the level of a genus or family could not be used for the purpose of this study. In addition, the catalogue of criteria should be applicable Austria-wide which is not possible given the inhomogeneity of the legal framework. The resulting number of indicators based on the protected species of all Federal States would be extremely high resulting in 617 indicator species for the indicator group “occurrence of protected Lepidoptera”, 13 species for the indicator group “occurrence of protected Trichoptera” and 775 species for the indicator group “occurrence of protected Coleoptera”. It needs to be considered that most species are only protected in one Federal State and only a few species (mostly species listed in the Habitats Directive) in several States.

The participating experts recommended during the workshop discussions that indicators should be comparable Austria-wide and, therefore, the use of species according to Annex II and IV of the Habitats Directive.

Level “habitats & protected areas”

As agreed upon with experts at the workshops this level comprises criteria in relation to more indirect and long-term effects, e. g. effects related to the complementary herbicide on habitats or protected areas in the vicinity of GM-maize fields. At this point the effect of the herbicide was taken into account since not the herbicide *per se* is evaluated but changes in management practices that go along with the production of GM-maize, like time or frequency of the application, amount of herbicide applied and management measures going along with the development of weed resistances. In Austria, broad spectrum herbicides like glyphosate are usually applied prior to sowing followed by one or two applications of a selective herbicide depending on the respective weed pressure. However, the use of herbicide tolerant GM-maize would allow the application of the broad spectrum herbicide throughout the growing season. Therefore, the potential consequences of a change in the management of glyphosate or glufosinate as post-emergence herbicides, linked to the cultivation of herbicide tolerant GM-maize, need to be taken into account.

The criteria defined are “endangered biotope types”, “habitats of Community interest” and “protected areas, if agricultural use is not prohibited”. For the first two categories indicators are defined on the level of the biotope or habitat type. The indicator for the third criterion serves as a tool to select those protected areas that could be at risk from GM-maize cultivation, depending on the protection goal for the respective area.

During the workshops it was discussed whether or not it would be possible to include characteristic or “valuable” species of certain habitats as indicators in order to determine negative effects on the habitat. However, the question was raised as to the extent to which a threat for a certain habitat could be substantiated by the risk to certain species. Moreover, the term “valuable” is very subjective and would lead to extensive discussions. As a consequence, no respective criterion was defined. The experts recommended also that rare habitats or biotope types should not be included as a criterion for the same reasons as discussed above for rare species.

Endangered biotope types

In agreement with the experts, endangered biotope types were selected and respective indicators defined, based on the Austrian Red List of Biotope Types (ESSL et al. 2004, ESSL et al. 2008, TRAXLER et al. 2005a), with a focus on those biotope types situated within the maize cultivation areas (= the project area) and by giving special attention to segetal biotopes, dry grasslands and wetlands. The selection of indicators at this level takes regional aspects into account since the Red List uses a very fine classification. Experts also agreed that only biotope types classified as “critically endangered”, “endangered” and “vulnerable” should be selected as indicators. It was noted that when considering indirect effects on habitats (e. g. by the used herbicide) only those biotope types are considered justifiable on the basis of scientific arguments. In the only rough selection process which was possible within the limits of this project, biotope types where impacts of (nearby) GM-maize cultivation would be very unlikely were not included as indicators. These biotope types were e. g. biotope types without vegetation, alpine and nival biotopes, geomorphologically defined biotopes or forests.

Biotope types in the Austrian agricultural area as defined in the BINATS project (PASCHER et al. 2010a, b) were not directly taken into account as described in the following. Although the classification used in the BINATS project was based on the Austrian Red List of Biotope Types, the Red List was used in a simplified form adapted to the requirements of field work. Therefore it was decided to use the original Red List of Biotope Types in Austria as the basis for the definition of indicators as recommended by experts. However, the biotope list of the BINATS project together with biotope types listed in the HNV project (BARTEL et al. 2011) were used to cross-check for the completeness of the chosen indicators.

Since the indicators were defined at the level of the biotope type they are very specific e. g. “occurrence of dry grasslands on loess soils” and the list of indicators resulted in 124 biotope types of the following classification:

- Critically endangered: 9 biotope types
- Endangered: 66 biotope types
- Vulnerable: 49 biotope types

Habitats of Community interest

As suggested by the experts participating in the workshops habitats of Community interest as defined in Annex I of the Habitats Directive were selected as a suitable criterion to cover the issue of protected habitats, as it was agreed that a justification based on Community law is of utmost importance for restriction measures.

An analysis of the laws of the Federal States for the protection of certain habitats showed that the definitions used were not comparable and would therefore only be valid for the respective Federal State. How and if to define criteria on the basis of these laws was discussed extensively at the workshops. The recommendation of the experts was, in order to avoid unclear, incomplete or even contradictory results to refer as much as possible to the Habitats Directive or to Federal Law which provide definitions and criteria that are valid for the whole area of Austria. Therefore the different habitats protected according to the laws of the Federal States were not taken into account when defining criteria for the purpose of this study.

Annex I of the Habitats Directive contains 209 habitat types and is not country-specific. Therefore, the respective habitat types were not listed in Table 1. As described above (under “species of Community interest”), data are available pursuant to the Article 17 report as will be discussed also in chapter “General aspects”. Data for Austria were intersected with the project area resulting in 65 habitat types of Community interest occurring in the project area. Since for some an impact of GM-maize cultivation would be unlikely (e. g. forests or nival habitats as mentioned above) they were deleted, resulting in 32 habitat types as indicators for the criterion “habitats of Community interest”, with definitions such as “occurrence of lowland hay meadows”. For the data selection and justification of particularly sensitive areas the indicator group as a whole needs to be taken into account.

The favourable conservation status was not used for the selection of indicators, which was suggested by some experts since areas containing a certain habitat type of Community interest are ecologically particularly sensitive regardless of their conservation status.

It should be noted that the classification of habitat types in the Habitats Directive is different from the system used in the Austrian Red List of Biotope Types. The two systems are therefore not completely compatible, since not all biotope types of the Red List can be assigned to the respective habitat type of the Habitats Directive. Although many biotope types of the Red List can be assigned to the appropriate habitat type of the Habitats Directive the definitions of the biotope types of the Austrian Red List are much more precise.

Protected areas if agricultural use is not prohibited

Protected areas are established by the respective ordinances of the Federal States. There are various categories in Austria, varying in definition and protection goals between the different Federal States, with agricultural use not prohibited *per se*. Since a potential negative impact of GM-maize cultivation depends on the respective protection goal, one indicator was defined accordingly (see Table 1). On a case-by-case basis, the ordinances establishing the respective protected areas situated in the project area have to be evaluated regarding their protection goals as well as the potential of negative effects from a certain GM-maize application on these goals.

It should be noted that protected areas could also be negatively influenced by agricultural practices in the vicinity. However, since there are no general legally binding isolation distances between the GM-maize field and the protected area, this aspect could not be taken into account at this stage.

Level “landscapes”

Regarding this level, two criteria were defined: “important areas for biodiversity” and “structurally diverse landscapes” due to the possible occurrence of long-term and indirect effects of GM-maize cultivation (e. g. changed agricultural management as described above in chapter “Level “habitats & protected areas””). Thus this level comprises biodiversity aspects on the landscape level since the establishment of a line of argumentation built on the preservation of biodiversity was considered to be very important. Even though specific biodiversity protection goals have not yet been established for Austria, experts have agreed on the importance of this argument.

Important areas for biodiversity

For this criterion seven indicators were defined comprising hot-spots for birds, Lepidoptera, Coleoptera, Trichoptera, vascular plants and biotopes as well as agricultural areas with high biodiversity. Birds were included at this level since the farm-scale evaluations carried out in the UK in 2002 considered the potential impact of GMO cultivation on birds via reduced weeds, segetal plants and the resulting reduced seed pool necessary as feed (FIRBANK 2003, HEARD et al. 2003).

Experts suggested also the use of species groups defined as substitute indicators for biodiversity in general. For instance, a study in Switzerland had shown a clear relation between the diversity of Heteroptera and overall biodiversity (DUELLI & OBRIST 1998). This is also the case for grass- and leafhoppers (SAUBERER et al. 2012). However, considering the line of argumentation for the selection of species groups that could be negatively affected, i. e. where there is scientific evidence of negative effects, it was decided to not include those species groups (as also described in chapter “Level “species”” above), as so far there are no scientific publications showing adverse effects on Heteroptera, grass- and leafhoppers.

Structurally diverse landscapes

Structurally diverse landscapes were considered as an additional criterion since biodiversity and landscape structures are closely related and landscape structure is a very important feature regarding plant and animal species diversity. The relevance of indicators which link species diversity to land use structures and agricultural management was also stressed by experts in the workshop discussions. Diversity of crop species, plot size or land use type are other important issues which need to be considered.

Data for the implementation of the catalogue of criteria

General aspects

As stressed by experts participating in the two workshops, an analysis of available data for their suitability to identify ecologically particularly sensitive areas with regard to GM-maize cultivation is of utmost importance. However, the availability of data may vary between species groups, depending on factors like available experts, species richness and the species' attractiveness for laymen. Apart from the fact that data on certain issues may not be available, data which have been assessed for a specific purpose may not be suitable for another (e. g. monitoring data collected with different methods and on different scales). In general classification of data (e. g. biotope types), spatial resolution and other factors depend on the respective scientific research question and available resources. Conclusively, data from different sources may not be compatible or the combination into a combined data pool, if possible, is very resource-consuming, as stressed by experts participating in the workshops. The Red List of Endangered Species was, for instance, developed exclusively on the basis of scientific interest and thus does not take into account issues of environmental risk assessment. Moreover, data were collected at different scales (e. g. different grid size) and it is therefore most likely that data will have to be up-scaled or down-scaled, depending on the scale at which ecologically particularly sensitive areas will finally be determined. It was stressed that modelling data need to be carefully evaluated to establish whether they are suitable to justify restriction measures. The quality of data derived from such models is highly dependent on the parameters included, the data used and the scale for which conclusions can be drawn.

As also described in the BINATS project, data can provide information on a regional scale (e. g. 3x5`) or on a local scale (e. g. < than 1 km²), e. g. regarding species biodiversity. Data on a regional scale are often agglomerated according to the information provided on a certain issue (e. g. hot spots of segetal vegetation), on the basis of samples contained in various databases and complemented by literature research or additional samplings. Data on the local scale often provide basic information on species or habitats in a defined area, e. g. a nature conservation area or a sampling area that was installed as part of a monitoring network. Those small-scale field studies can be combined and used for large-scale studies (e. g. regional studies) if the data are stored electronically in appropriate databases and if they are publicly available. Experts pointed out that data sets covering Austria country-wide with a comparable method would be preferable, as it was done in the BINATS project or when collecting data for the Red List of Biotope Types in Austria.

At the workshops the issue was raised that grid cells are artificial units and predictions regarding ecologically particularly sensitive areas should be made on the level of biotope types. However, this cannot be achieved with reasonable time and effort. The assignment of data to raster cells is very common, since it is more useful to provide information on a regional scale in Austria. As stated by experts in the workshop discussions the reference to a grid size of 3x5' is standard in botanical field research, and 1x1 km² with zoological data when analysing data pools in order to answer a specific research question. Sampling plots for the collection of the respective data e. g. in the framework of a monitoring system are defined on a much smaller scale. This has been confirmed by the result of the data search. It has been shown that most of the comprehensive studies use the 3x5` grid size.

Regarding information on the regional scale, the problem of pseudo absences needs to be kept in mind especially with respect to animal species. If e. g. a certain grid cell does not show the occurrence of a certain species this does not necessarily mean that the species does not occur in that area but it could also mean that no sampling has been conducted there. It also should be noted that mapping of animal species is very much dependent on the method and the sampling time (e. g. the activity of butterflies is weather-dependent).

In many cases data are not available free of charge. Either a fee has to be paid for using the data as such, or the working time has to be paid (e. g. for complex database queries). Even if no fee has to be paid, data use must be permitted by the data owner. Apart from the fact that it is often a very difficult task to establish - and a highly controversial issue - who is the owner of the data, permission for using the data is usually granted only for one single study (e. g. data from the Article 17 report). Therefore, for a long-term or permanent use of data – for the purpose of identifying and nominating ecologically particularly sensitive areas - special agreements should be negotiated.

In this study, data need to be used in whatever form they are available since intra- and extrapolations, as well as the compilation of different data sets, are very time and resource consuming. Especially where biodiversity hot spots are concerned, only those data can be taken into account were hot spots are explicitly defined.

The data basis for the development of ecologically particularly sensitive areas should be updated regularly.

Data search

The aim of the data search was to determine the different sources of available data in Austria for the indicators chosen as presented above.

The following procedure was applied. First, data requirements were defined and the owners of relevant data identified. Subsequently, they were contacted and informed about the content and aim of the project. In some cases personal meetings took place. The data format and age, data availability and costs, the effort for data preparation in an appropriate electronic form as well as the methodology of data acquisition and the geographic coverage and spatial scale of the respective data surveys were clarified.

Wherever possible data should:

- consistently be available in the future and not only once for the report at hand.
- be available quickly without time-consuming efforts, since Member States only have limited time to comment on new GM applications in the authorisation procedure.
- be available area-wide as far as possible. This means that they should at best cover the whole project area. Their significance should be ranked as follows: complete coverage of the project area, coverage of special regions like Natura-2000 sites and finally local small-scale analyses.
- should be permanently updated.
- be useful and appropriate for the purpose of the current report.

In addition it would be useful if data from the different data pools use the same classification, e g. of biotope types, in order to be convertible to a uniform level. Since this is a very resource-consuming task as also pointed out by experts in the workshops (see also chapter “general aspects” above, the focus should be the identification of already existing comprehensive data pools, like Austria-wide databases.

The following institutions/experts were identified as potential owners of appropriate data:

- Museums;
- Governments of the nine Austrian Federal States;
- Federal Ministries which commission scientific projects;
- Universities implementing projects, moreover scientific publications like diploma theses, doctoral theses, etc.;
- Companies performing projects e. g. environmental impact assessment, mapping of biotopes, surveys according to the Habitats Directive (Council of the European Union 1992);
- Experts for certain indicator groups like Lepidoptera (butterflies and moths), Trichoptera (caddisflies) and Coleoptera (beetles).

In that respect the following Austrian museums were asked for distribution data for the chosen species groups Lepidoptera (butterflies and moths), Coleoptera (beetles) and Trichoptera (caddisflies):

- "Haus der Natur" nature museum in Salzburg (http://www.hausdernatur.at)
- Museum of Natural History Vienna (http://www.nhm-wien.ac.at)
- Tyrolean State Museums (http://www.tiroler-landesmuseum.at)
- Inatura in Vorarlberg (http://www.inatura.at)
- Database ZOBODAT / Zoological-Botanical Database in Upper Austria (http://www.zobodat.at)
- Universalmuseum Joanneum in Styria (http://www.museum-joanneum.at)
- Global Biodiversity Information Facility GBIF (http://www.gbif.at).

The search for relevant projects dealing with the chosen indicator groups was conducted on the Internet using relevant search criteria combinations, e. g. relevant species groups (vascular plants, caddisflies, butterflies, beetles and birds), single protected species of the indicator groups, habitats and biotopes, Austrian Federal States and special regions (e. g. Natura 2000 sites, national parks) as well as the names of relevant Austrian scientists.

Databases used were Google, Google Scholar, online libraries like the library of the University of Natural Resources and Life Sciences (database information system DBIS, http://www.boku.ac.at/datenbanken.html) and the online-library of the University of Vienna (http://bibliothek.univie.ac.at/) as well as the Zoological-Botanical Database (ZOBODAT) located in Upper Austria (http://www.zobodat.at). Moreover, the addresses of the institutions and scientists were collected via the Internet.

During the data search, all nine Federal States were asked separately to provide information and ESRI shape files on biotope mapping as well as on habitat types listed in Annex I of the Habitats Directive.

Results & data analysis

In this chapter the result of the data search is presented and available data analysed regarding their usability to define ecologically particularly sensitive areas. For every criterion / indicator group the most suitable data are identified and presented in respective maps. This working step is the precondition for the concrete application e. g. in the case study as presented in chapter "case study MON89034xMON88017".

It needs to be noted that the different data sets available for different indicators are not based on the same spatial resolution. However, the selection of datasets is explained under the relevant chapter structured along the lines of the defined "levels" (see Table1). Within each of the indicators or indicator groups, respectively, data were only used if they were available at the same spatial resolution. In between the different indicators or indicator groups, respectively, different resolution may occur, according to the scientific methodology most appropriate for data acquisition in the field. Therefore each of the different indicators or indicator groups has been analysed separately and the results are presented in individual maps.

Level "species"

Endangered species

Data for the "species" level (comprising Lepidoptera, Trichoptera and Coleoptera) especially regarding endangered species are available either from databases or from small-scale studies. In this respect it should be noted that data from single studies have, to a certain extent, also been incorporated into comprehensive databases like the ZOBODAT.

Available databases are the biodiversity database of the "Haus der Natur" nature museum in Salzburg, the database of the Tyrolean State Museum, the Inatura database in Vorarlberg, the database from the Universalmuseum Joanneum in Styria, the Zoological-Botanical Database in Upper Austria (ZOBODAT) and the database of the Global Biodiversity Information Facility (GBIF). In addition the museum of Natural History in Vienna collects data on various species, but these data are not available in an electronic form.

In most databases, the locality of a species is reported as coordinates. Since various facts can influence the measurement of coordinates (e. g. cloudiness, technical equipment) these can be biased. In addition, data coverage varies, since (in most cases) there are areas where a lot of samples are taken (e. g. biodiversity-rich areas of interest for the respective experts or areas in the vicinity of their homes). The general area of occurrence of a species can thus be biased and for a realistic picture either field studies have to be conducted or modelling approaches used. The latter, however, is a complex task since a lot of ecological variables need to be taken into account (see also chapter “general aspects” above).

The geographic coverage of the various databases varies. The biodiversity database of the “Haus der Natur” nature museum in Salzburg focusses on the Federal State of Salzburg, the Tyrolean State Museums focus on species distribution data from the alpine region. The Inatura database in Vorarlberg covers data from the Federal State of Vorarlberg and surrounding regions and the Universalmuseum Joanneum in Styria focuses on data from Styria. From the Zoological-Botanical Database in Upper Austria (ZOBODAT) and the database of the Global Biodiversity Information Facility (GBIF) Austria-wide data are available. The latter is an international initiative and provides data on worldwide species diversity free of charge on the Internet. The Austrian contributions to GBIF are coordinated by the Umweltbundesamt (Environment Agency Austria).

Not all databases cover data on all three species groups selected for the catalogue of criteria (Lepidoptera, Trichoptera, Coleoptera). Also the conditions for data use vary. In some cases fees must be paid for data supply. However, for usage within scientific projects special conditions can be negotiated.

Data are also available from various (sometimes small-scale) studies. The Governments of the Federal States commission studies to assess e. g. the regional distribution of single species of Annex II and IV of the Habitats Directive. The Federal States differ strongly in respect to the organisation and structure of their data pools. In some cases the distribution data on mapped species are included in the databases of museums (e. g. biodiversity database of the “Haus der Natur”, Inatura or the Tyrolean State Museums). In other cases, the data can be requested from environmental bureaus, scientists or directly from the Governments of the Federal States. In all cases - excluding the museums - the respective Governments of the Federal States have to grant permission to use their data. Relevant data can sometimes also be ordered via the Internet (e. g. GEOShopStyria). Locations of the occurrence of animal species are sometimes also available as electronic data (e. g. Tyrol, one-time usage, data have to be deleted after usage).

Studies are also commissioned by the Austrian Government like e. g. the BINATS (Biodiversity–Nature–Safety) project that ascertained positioned up-to-date butterfly species records (2007 and 2008) in 100 test areas (collected in ten randomly dispersed plots in a test area of 625x625 m) in the Austrian maize and oilseed rape cultivation area (PASCHER et al. 2010a, PASCHER et al. 2010b, PASCHER et al. 2011).

As discussed during the workshops, it is very important to use data that are comparable Austria-wide. At the moment this is mainly the case for species according to the Habitats Directive. In addition, it was recommended that data from comprehensive databases should be used since it is a very demanding task to incorporate different data sources into one single database. Regarding the study at hand, this would go beyond the available resources and the time and effort needed for such a task are not proportional to the added value gained. Since the GBIF database incorporates data from different databases and new and additional data are included on a weekly basis, it is recommend to use data from there. Underlying data sources of the GBIF database are e. g. the “Haus der Natur” nature museum, Inatura, Tyrolean State Museums and the ZOBODAT. In order to demonstrate the data format, age and coverage a query was carried out for the indicator group “occurrence of endangered Lepidoptera” (see Figure 5). It should be noted that the GBIF database is still under construction and not all species groups are included. This may be the reason why only data on 192 Lepidopteran species (out of 229 defined as indicators for the indicator group “occurrence of endangered Lepidoptera”) are available for Austria. The result of the query is shown in Figure 5. As can be seen, the data points are not distributed evenly across the project area. In addition, most entries date back to the time between 1845 and 1979. Only a minority of data points in the GBIF database have been collected in the last 30 years. The aspect of data age is a well-known problem (and all databases contain data of varying age) since up-to-date data as well as high quality data are a matter of resources, and not only financial resources but also experts for the various species groups are required. Therefore, if information on a small scale is to be provided, old data may lead to a stronger bias than if the focus is on a larger area. The reason for this is that local changes can be very dramatic (e. g. if a road is built on dry grassland). However, on a larger scale, other plots of dry grasslands may still be available to provide habitat for species originally found within the destroyed area. In addition, most studies on larger areas use a grid size of 3x5’ as a reference, e. g. ESSL et al. (2002), ESSL et al. (2004), ESSL et al. (2008), RABITSCH & ESSL (2009), TRAXLER et al. (2005a, b).

All these aspects are common challenges in ecological research, irrespective of the data source.

However, the number of indicator species selected according to their status of endangerment is very high. The complete list was discussed with experts. There was a general agreement that a fine selection of single species based on their potential exposure to GMOs is necessary (see chapter “development of a catalogue of criteria” above). As this fine selection requires detailed zoological and ecological expert knowledge, e. g. on feeding behaviour, or habitat preferences and selection of habitats by the species, and the relevant information is currently (September 2012) not available, the experts agreed that the criterion “endangered species” and respective data should not be used in the case study as this would be easy to criticise. However, at a later stage and if the relevant information is collected via expert-studies, this criterion might be useful to substantiate the argumentation by Austria.

For future use of species distribution data it should be noted that Trichoptera have never been recorded systematically and area-wide in Austria (as stated in HOLZINGER et al. (2009)). However, a lot of data are stored in the ZOBODAT database. Regarding data on Trichopera distribution, it is recommended that only data from adults and no larvae data are used as stated by GRAF et al. (2012, unpublished) and HOLZINGER et al. (2009). Data on larvae are mostly available only on genus or family level and are therefore not suited.

Endemic species

For endemic species data from RABITSCH & ESSL (2009) are recommended since the basis for this publication was an intensive data search. Species distribution maps are available on the level of 3x5' grid cells and include data from 1900 onwards (as demonstrated in the distribution maps published in RABITSCH & ESSL (2009)).

The distribution of endemic species occurring in the project area is shown in Figure 6. Here a point demonstrates the locality of a species. As can be seen, endemic species do not occur everywhere in the project area. However, there are some places in the project area where a large number of endemic species occur, e. g. in the vicinity of the river Gail valley in Carinthia or the river Mur valley in Styria.

As pointed out above a fine selection of single species as indicators based on their potential exposure to GMOs was suggested by experts. Taken this into account, the criterion "endemic species" and respective data should, for the time being, not be used in the case study.

Protected species

The protected species considered in this study were limited to those species which are listed in the Habitats Directive as described above. Since data on those species need to be provided and updated every six years, data from the latest available article 17 report are recommended as a basis. At the moment these data are contained in ELLMAUER (2008). The data on Lepidoptera and Coleoptera are presented in Figure 7 and Figure 8, respectively. As can be seen, the data refer to a grid size of 3x5'. Especially for Lepidoptera the map shows that species of Community interest occur over wide stretches of the project area.

As noted above in chapter "development of a catalogue of criteria" the notifier of a GMO for which an application for cultivation in the European Union has been submitted has to perform an exposure assessment. Therefore, if such an assessment is not available, negative effects on the species as discussed above cannot be excluded. In contrast to the other criteria of the level "species", indicators for the criterion "protected species" where based on species protected based on European law. Since in the case study no such exposure assessment is available, taking into account the precautionary principle, these species and respective data should be used in the case study.

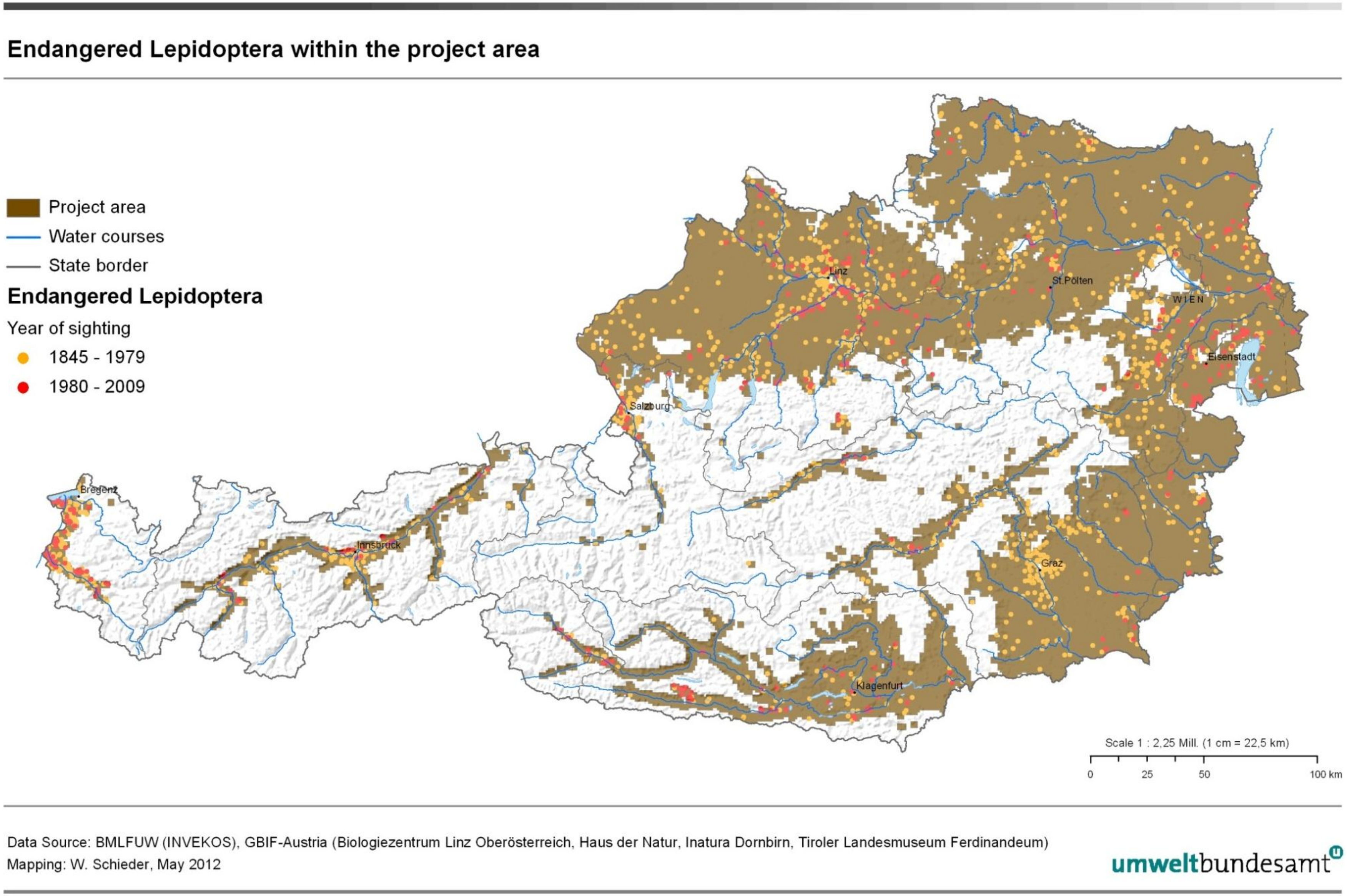


Figure 5: Endangered Lepidoptera within the project area

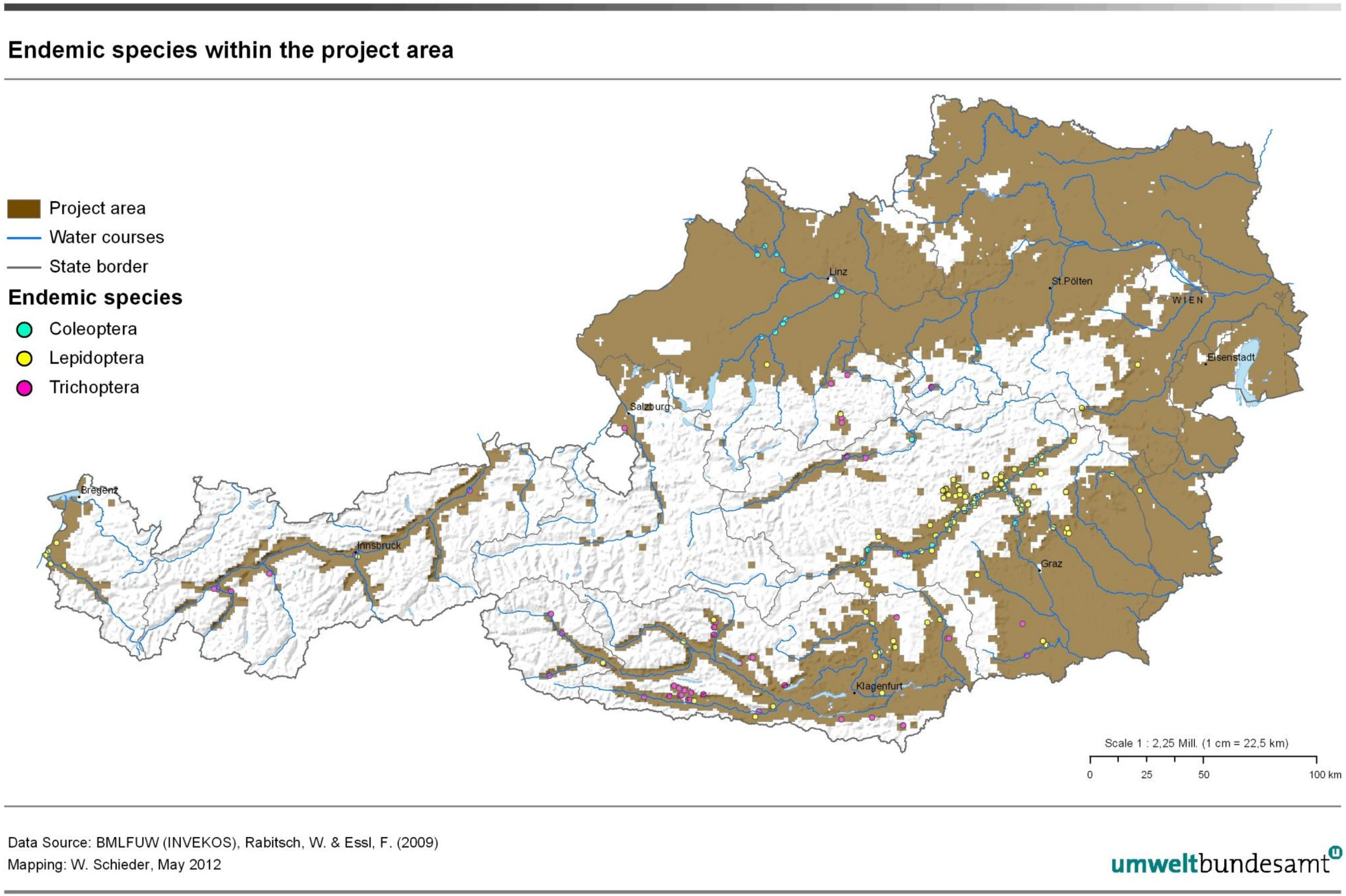


Figure 6: Endemic species within the project area

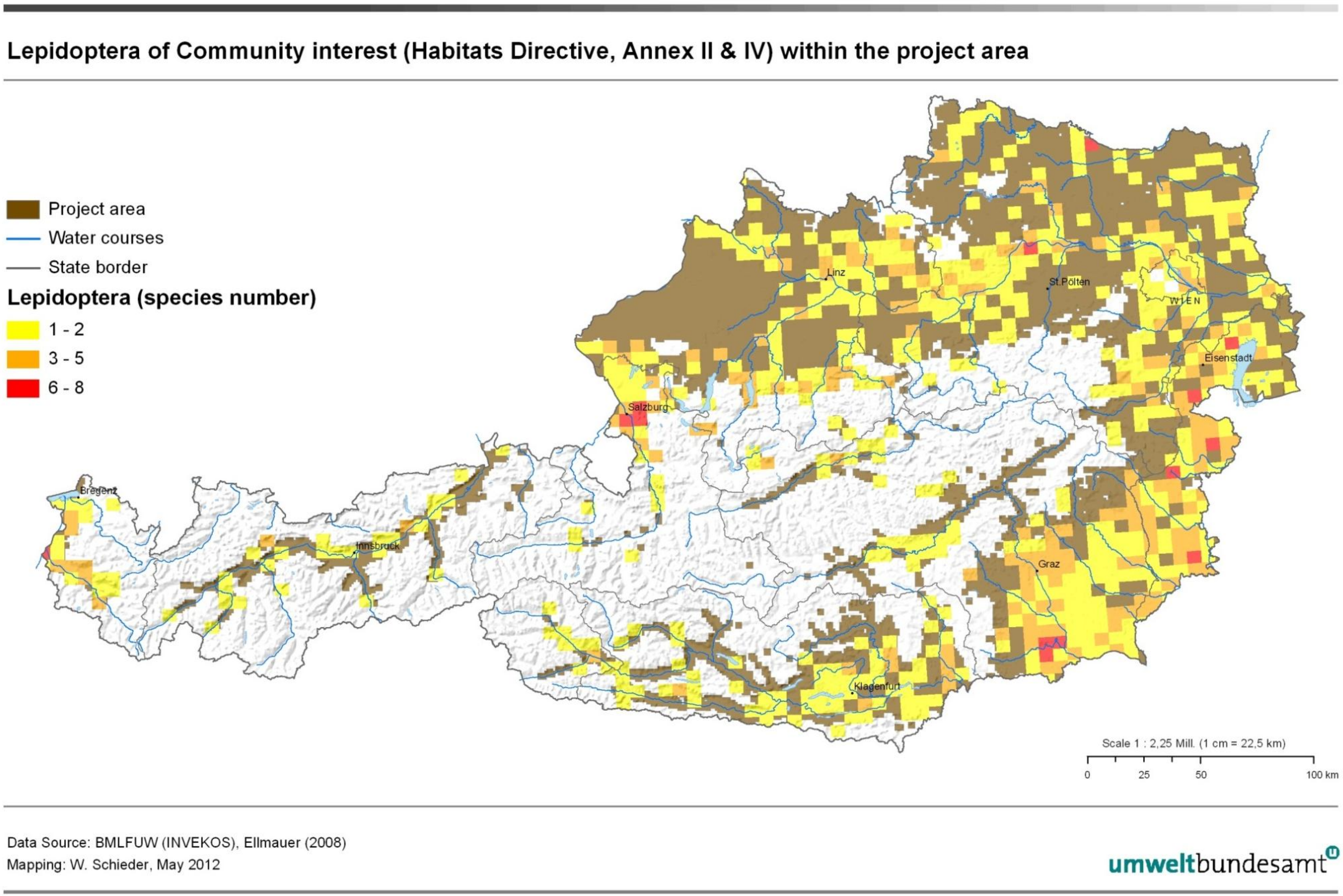


Figure 7: Lepidoptera of Community interest within the project area

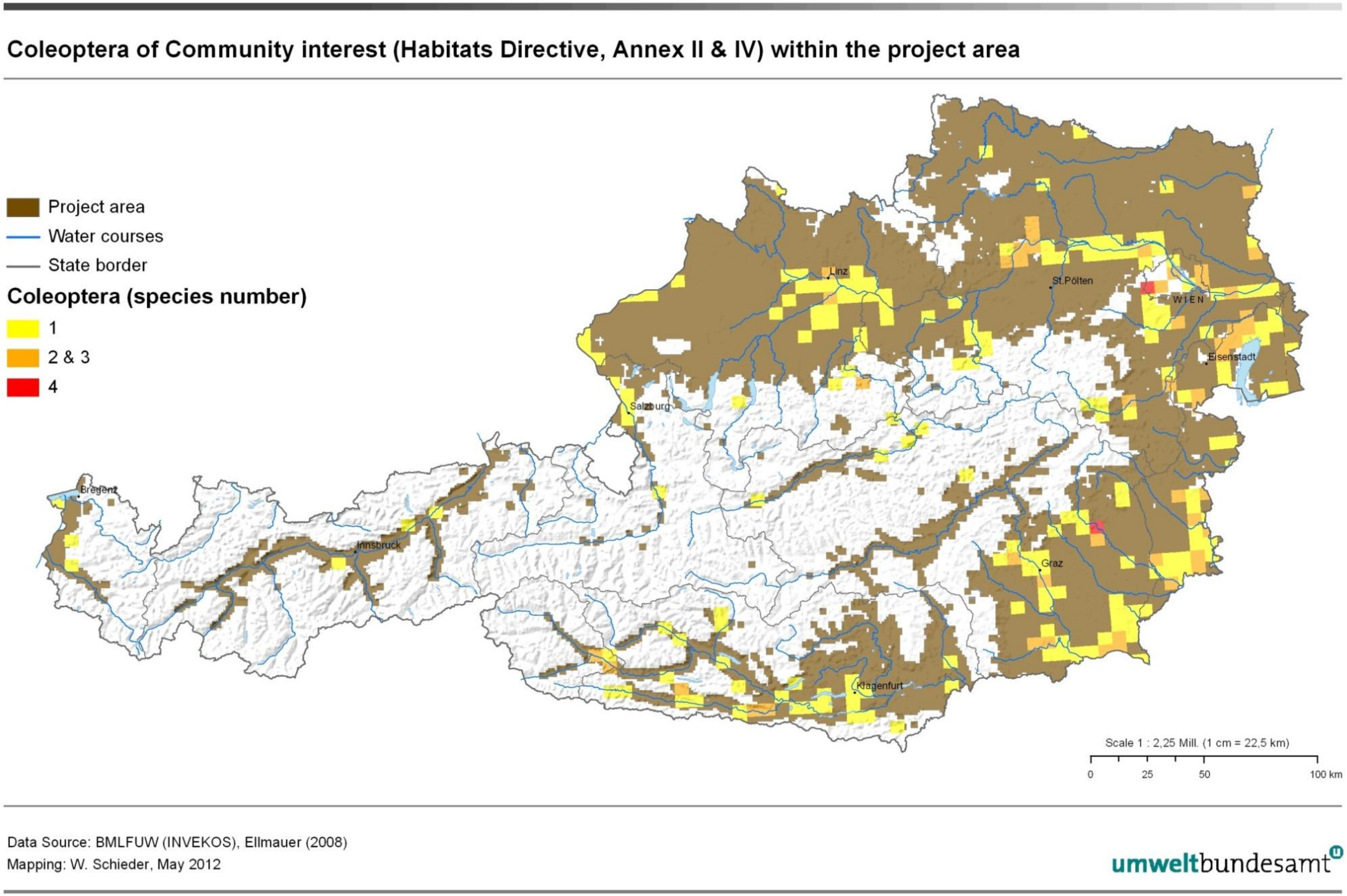


Figure 8: Coleoptera of Community interest within the project area

Level "habitats & protected areas"

Endangered biotope types

Data for the criterion "endangered biotope types" are either available from a comprehensive database or from a variety of single studies, like e. g. the biotope mapping of the Austrian Federal States.

The distribution database for biotope types in Austria, managed at the Umweltbundesamt (Environment Agency Austria) uses a classification of biotope types based on the Red List of Biotope Types in Austria (ESSL et al. 2002, ESSL et al. 2004, ESSL et al. 2008, TRAXLER et al. 2005a). Data are therefore comparable across all Federal States. In addition, the status of endangerment is available according to the IUCN classification.

The Red List of Biotope Types in Austria uses a uniform approach and methodology for the classification of endangerment. It comprises all biotope types occurring in Austria and makes a significant contribution to the standardisation of the nomenclature of biotope types. The Red List of Biotope Types also provides distribution maps either on the level of 3x5` grid cells or on the level of landscape units. Biotope types are classified according to different degrees of endangerment on the regional level as well as Austria-wide. Since the goal of the study at hand is Austria-wide information on ecologically particularly sensitive areas only the latter classification is recommended.

Since nature conservation falls within the competence of the Austrian Federal States, biotope (or habitat) mappings are carried out independently. Therefore, data (if available) vary with respect to their age, geographic coverage, spatial resolution, methods of the surveys, attributes (e. g. status of endangerment) and classification of the biotope types. Although almost all Federal States commissioned biotope mapping, the data are heterogeneous and not comparable.

In addition data are available from various projects. Biotope types e. g. surveyed in the course of the BINATS study are available for 100 test areas (PASCHER et al. 2010a, b, PASCHER et al. 2011). In that study biotope types were mapped area-wide in 100 test areas of 625x625 m, in the years 2007 and 2008, within the Austrian maize and oilseed rape cultivation area. They provide current data with a small geographic resolution. The classification system used for the biotope types is a (in some parts) simplified version of the Red List of Biotope Types in Austria. In general single projects surveying biotopes use different classification systems adapted to the respective scientific research question and the available resources. The usage of different classifications is a problem when attempting to unify data from various sources. However, a unification of data would be a basic prerequisite to enable the use of these data pools and draw Austria-wide conclusions. Since the indicators for the criterion "endangered biotope types" are based on the Red List of Biotope Types in Austria, the respective habitat data should use the same classification or must be assignable accordingly. A data set covering as much as possible of the project area is to be preferred in order to minimise time and effort, e. g. for the harmonisation of different data sets, elimination of duplicates etc. This was also recommended by the experts participating in the two workshops.

Therefore, although for a few biotope types the data are also available in the BINATS database, the data set in the distribution database of biotope types in Austria is recommended as the most suitable data source for further use in this study. In the BINATS project a simplified Red List of Biotope Types in Austria adapted to the requirements of field work has been used and only some biotope types defined in the project use the same classification as described above.

It should be noted that data use is only permitted for the purpose of this study. For future uses in the context of the selection of ecologically sensitive areas (e. g. GMOs different from herbicide tolerant and insect resistant GM maize) an agreement regarding the use of the data has to be made with the data owner. In addition, it is recommended that the list of ecologically sensitive areas based on this criterion is updated regularly, since the distribution database is also updated on a regular basis.

Figure 9 shows the data on selected indicators available in the database with a resolution of 3x5`. For 48 (out of 124) indicators data are available on this scale. However, this includes the most important biotope types like various types of grassland, dry grasslands and fields. Data available on the scale of landscape units were not taken into account since resolution is coarse and would not be justifiable. In Figure 9 the number of endangered biotope types per 3x5` raster cell is pictured. This shows that endangered biotope types are not distributed homogenously and that more than ten endangered biotope types occur only in few areas. The three selected classes of endangerment ("critically endangered", "endangered", "vulnerable") should be considered as equal when defining ecologically particularly sensitive areas. However, it is shown that endangered biotope types occur in most parts of the project area. If data were to be available on the other indicators on the level of the 3x5' grid cell in the future, this picture would change to some extent since it is most likely that the data on additional indicators would lead to more grid cells containing endangered biotope types, or to more biotope types present in a cell.

Based on the data from the distribution database of biotope types in Austria, the criterion "endangered biotope types" should be taken into account in the case study.

Habitats of Community interest

The collection of data on habitats of Community interest is the responsibility of the Austrian Federal States as stipulated in the Habitats Directive (COUNCIL OF THE EUROPEAN UNION 1992). These data need to be submitted to the European Commission by the Member States. Since the report according to Article 17 of the Habitats Directive is prepared by the Environment Agency Austria, the respective data (in a compiled form) are available there. However, the owners of the data are the respective Federal States and permission for data use has to be granted. The available data refer to a spatial resolution of 3x5‘ (as also used in the distribution database of biotope types in Austria) and are updated every six years as requested by Community law.

Since Austria has to report on the status of Habitats of Community interest according to Article 17 of the Habitats Directive, it is recommended to refer to this official data source and use the data from the latest Article 17 report. Information contained in management plans of the Austrian Federal States are not suitable since they only provide summary reports and do not contain raw data.

In addition (and as also discussed above), not all habitat types of Community interest occurring in the project area have been used in this study. As for the selection of indicators regarding the criterion “endangered biotope types” those habitat types where an impact of GM-maize cultivation in the vicinity would be very unlikely were deleted as a second step, e. g forest, alpine or rocky habitats. This has resulted in 32 habitat types that can be used as indicators. An overview of the final selection of habitats is presented in Figure 10. Again, the number of habitat types per 3x5‘ grid cell is presented here.

The conservation status was not taken into account, since habitats according to the Habitats Directive are protected even if they have favourable conservation status.

Like the Red List of Biotope Types, data on habitats of Community interest are comparable Austria-wide since they are based on a unified standard. Therefore, as also noted by experts, they are to be preferred and should be considered in the case study.

Protected areas

Since nature protection falls within the responsibility of the Austrian Federal States, up-to-date data have to be obtained from the respective Federal States, together with a permit for data use. However, for the commitment on reporting designated areas to the European Environment Agency such data have recently been compiled by the Umweltbundesamt (Environment Agency Austria). This data set does not contain information on Ramsar Sites, but those can be downloaded from the homepage of the European Environment Agency. Both data sets do not use the generalised raster format but provide data on the actual area. The available data are pictured in Figure 11.

The different Austrian Federal States allocate various categories of protected areas with respective protection goals. Although there are some similarities, not all categories exist in all Federal States and also the respective protection goals can differ to some extent. Since protected areas can only be justified as ecologically sensitive areas with respect to GM-maize cultivation if a negative influence on the protection goal is possible, the used data were refined. However, those categories of protected areas which are listed in the gene technology precautionary laws of the Federal States were included. These are e. g. national parks, biosphere reserves, nature protection areas or European nature reserves. Not included were nature parks, since they are already part of a nature protection area, a landscape protection area or a Nature 2000 area. Landscape protection areas were not considered either, since the protection goals here are more abstract, e. g. the conservation of natural beauty and the value of these areas for tourism and recreation purposes. The selected protected areas which can be found within the project area are shown in Figure 11. As can be seen, only a few large-scale nature protection areas are situated within the project area. There are some larger Natura 2000 areas, however, which have been set up only for certain species or habitats of community interest.

It should be noted that protected areas can only be selected as ecologically particularly sensitive areas if the respective protection goals may be negatively influenced by GM-maize cultivation. This is especially relevant for European nature reserves (Natura 2000 areas) which have been designated to protect only certain animals, plants or habitats according to the Habitats Directive. Since for the selection of ecologically particularly sensitive areas every single ordinance (e. g. ordinance for the establishment of Natura 2000 area xy) must be checked and a justification provided accordingly, it is recommended to focus the selection of ecologically particularly sensitive areas on the other criteria and not use the criterion “protected areas” and respective areas for the time being.

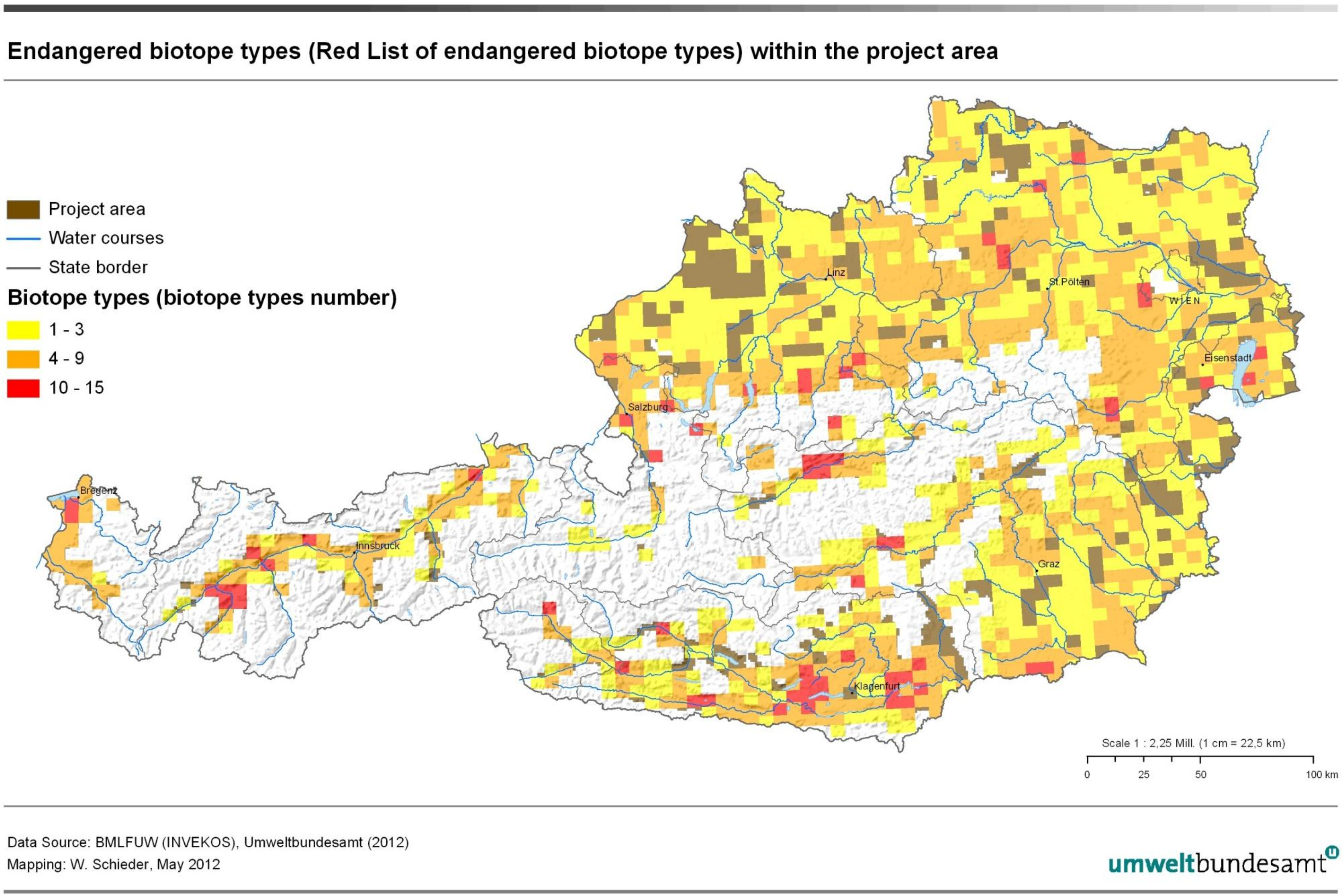
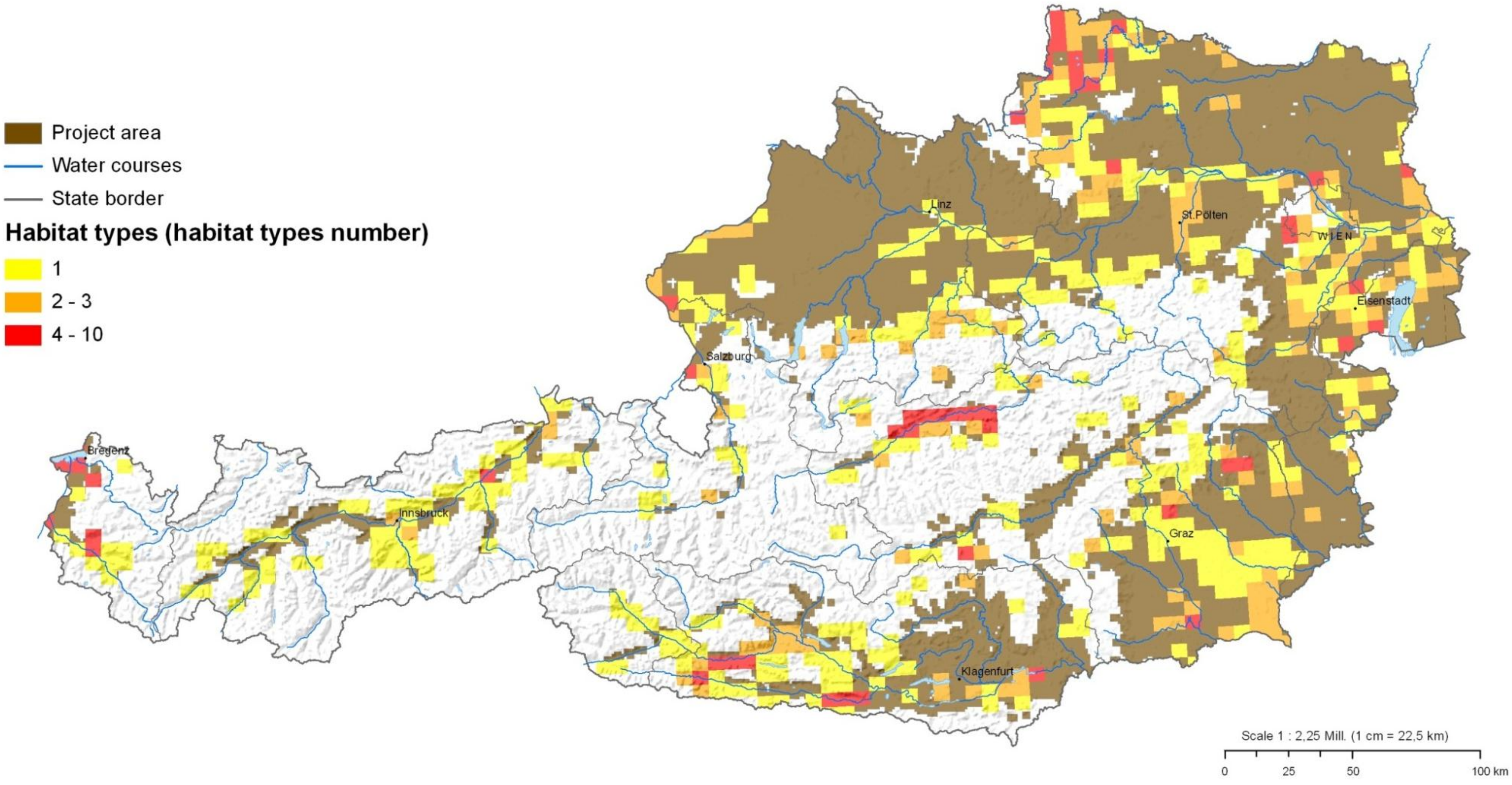


Figure 9: Endangered biotope types within the project area

Habitat types of Community interest (Habitats Directive, Annex I) within the project area



Data Source: BMLFUW (INVEKOS), Ellmauer (2008)
Mapping: W. Schieder, May 2012

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Figure 10: Habitat types of Community interest within the project area

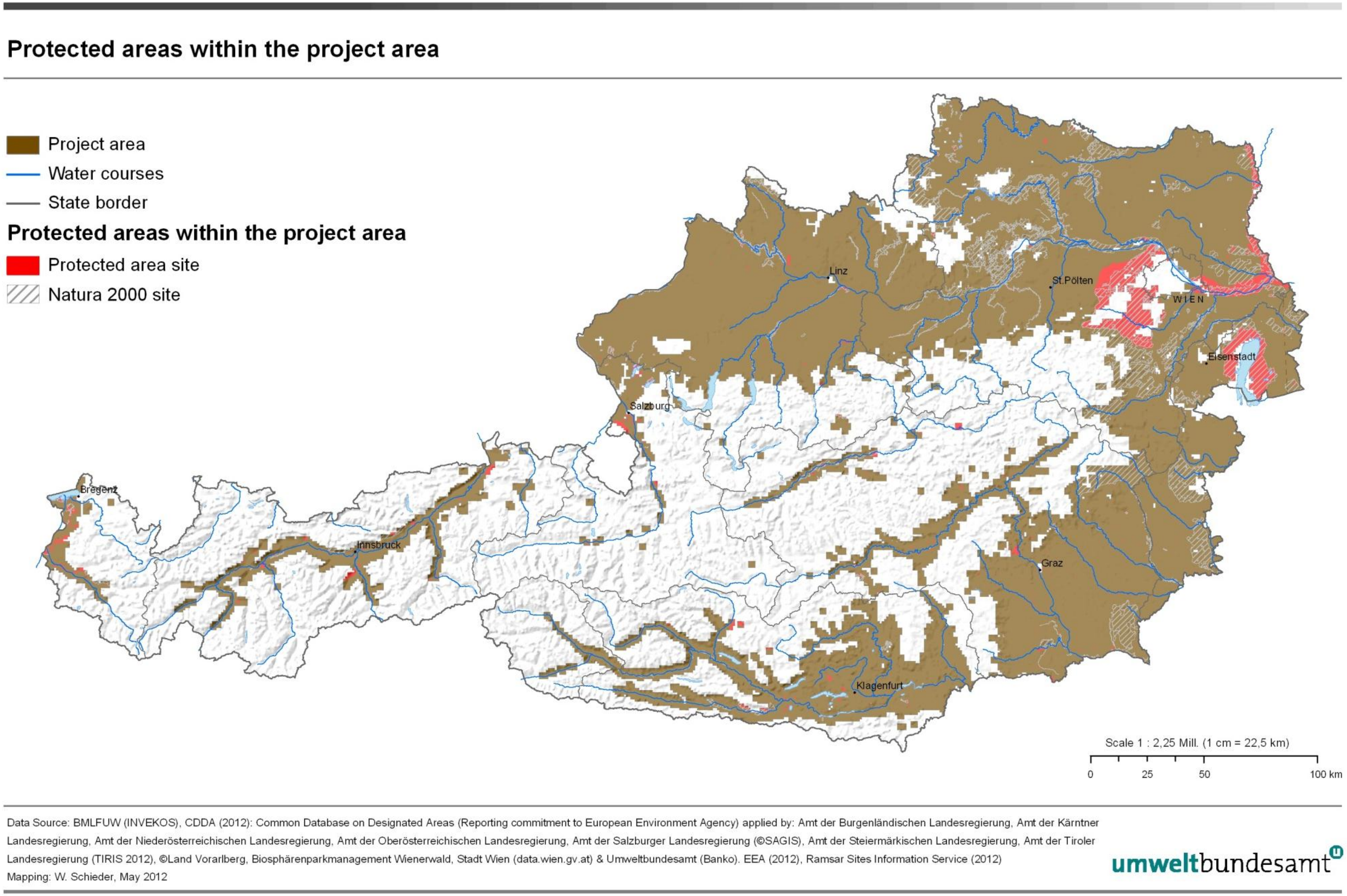


Figure 11: Protected areas within the project area

Level "landscapes"

Hot-spot indicators

No data on hot-spots are available for the indicators "Existence of bird biodiversity hot-spot", "Existence of Coleoptera biodiversity hot-spot " and "Existence of biotope diversity hot-spot". Also no data for the indicator "Existence of vascular plant hot-spot" are available. However, for a subset (segetal vegetation) hot-spots are available. The development of hot spots based on available data from various projects was not part of this study.

Hot-spot studies are very scarce. Although there are some studies providing diversity indices with respective classifications, often no thresholds were identified. Also, experts participating in the workshops noted that how to identify a hot spot is a matter of discussion, although the basic idea - that certain hot spots are incompatible with GM-maize cultivation - has been agreed on. The main difficulties are appropriate data which can be used as a basis, the definition of indices, classifications as well as the definition of thresholds.

It should be noted that hot-spot calculations for a given issue can vary, depending on the above aspects. The methodology for the development of hot spots (e. g. indices used as a basis) and the definition of thresholds can lead to different results. On the other hand, the available data and the scale on which hot spots are defined can have an influence. Also, the interpretation of the result is crucial. Identification, for example, is possible on the basis of a biodiversity index giving an impression of species numbers. Another approach is to weight the occurring species to establish whether they are specialists or generalists or whether they are endangered or not. Various indices or combination of indices are a possible basis for the definition of hot spots. The resulting data can then be classified e. g. according to quantiles, indicating for example areas with the highest values. However, the definition of thresholds (which classes can be considered as hot spots) is more subjective and a matter of expert opinion. All in all, it is not possible - within the framework of this study - to define these thresholds if only an index and a respective classification are available.

As also discussed in the workshops, hot spots depend very much on the available data. Data on certain species or species groups are not mapped area-wide and a lot of data sets vary in age, the methodology used or expertise (species mapped by academics or laymen). In addition, a common problem is the inhomogeneous distribution of data. For some areas lots of data are available and for others very few. This results in a distorted picture which has to be adjusted e. g. with modelling approaches if area-wide predictions are to be provided on a very small scale. However, as discussed above, those modelling approaches can vary in quality. On the other hand, if information is to be provided on a larger scale the bias can be reduced. Also, the expert opinion provided by GRAF et al. (2012, unpublished) has shown that it is not feasible to define hot spots on a small scale. Since Trichoptera are influenced by rivers and other wetlands, hot spots for Trichoptera were e. g. calculated on the level of catchment areas.

It is a fact that biodiversity data can vary, depending on the scale examined. It is e. g. possible that on a larger scale only a low level of biodiversity is observed (e. g. in an intensively managed agricultural area). On the other hand, small-scale areas - e. g. a small nature protection area situated within the same agricultural area - can show very high levels of biodiversity. However, local biodiversity hot spots do not necessarily have an effect on the regional level. This may also explain why hot spots calculated in TRAXLER et al. (2005b) are not congruent with the evaluation in PASCHER et al. (2010). Therefore, it needs to be decided on which scale hot spots are to be defined. Since biodiversity differs at different spatial scales, the results can vary between local and regional levels of biodiversity and are therefore often not comparable. Since ecologically particularly sensitive areas should be identified Austria-wide, regional data are more suitable.

As mentioned above, some studies explicitly define hot spots like TRAXLER et al. (2005b). Other studies include indexes that were classified, but where no thresholds for hot spots have been defined. The data available in PASCHER et al. (2010) e. g. are based on field data in the course of an Austria-wide baseline survey for GMO monitoring. Data refer to a small, local scale. They are up-to-date data from 2007 and 2008. For the calculation of Lepidoptera biodiversity, species numbers were taken into account. Data were classified on the basis of the species number. However, thresholds for hot spots would need to be defined for the purpose of the study at hand. This is also true for the diversity of vascular plants.

For other indicators hot-spot calculations could be commissioned in the future on the basis of available data. Depending on the favoured complexity and available financial resources, those studies could either be developed similar to those calculated by TRAXLER et al. (2005b) or by an expert opinion.

Since for the purpose of this study area-wide predictions are more important, it is recommended to use the data published by TRAXLER et al. (2005b) for Lepidoptera hot spots, although only diurnal butterflies are covered. For Trichoptera hot spots an expert opinion was sought and provided by GRAF et al. (2012, unpublished). Since no hot-spot calculations for vascular plants are available, the use of the calculations of TRAXLER et al. (2005b) (which are limited to segetal flora) is recommended. Although they comprise only a sub-set of plant diversity, this sub-set is most likely to be the most relevant one with regard to GM-maize cultivation.

TRAXLER et al. (2005b) calculated hot spots on the regional level, explicitly with a view to GMO risk assessment. The basis was provided by available data from various databases. In addition, some gaps were filled by field mapping. The identification of segetal vegetation hot spots was based on a combination of indices, taking not only aspects such as relative frequency and general species richness into account but also habitat dependency and endangerment. Area-wide data on the segetal flora for the Austrian agricultural region were compiled from the 'Floristic Mapping of Austria' (NIKLFELD 1999, NIKLFELD 2010). Regarding the calculation of hot spots for diurnal butterflies, not only species frequency and general species diversity but also endangerment was taken into account. This approach is very much in line with the overall set-up of the catalogue of criteria were also endangered and protected species are considered. The resulting indices were classified in TRAXLER et al. (2005b) and the categories with the highest values were defined as hot spots. Hot spots occurring in the project area are shown in Figure 12 and Figure 14, respectively. The data refer to grid cells of 3x5', covering the project area to a certain extent. For the calculation of ecologically particularly sensitive areas, all index classes that were defined as hot spots should be treated equally. As shown in Figure 14, hot spots for segetal vegetation cover a substantial part of the project area in the eastern parts of Austria.

Trichoptera hot spots were developed for catchment areas, based on the Trichoptera vulnerability index (GRAF et al. 2012, unpublished). For the index species number, endangerment and endemic species were taken into account. The analysis was based on data stored in the ZOBODAT database. Data on Trichoptera larvae were not included since they are very unreliable as also stated in HOLZINGER et al. (2009). The resulting hot spots are presented in Figure 13. As can be seen, the respective data do not refer to raster cells but to spatially more explicit polygons on the level of catchment areas. Hot spots could not be calculated on the level of 3x5' grid cells since data are very heterogeneously distributed throughout Austria. Therefore, hot-spots could only be defined for areas with an adequate sample density.

Based on the available data it is recommended to use the data on hot-spots of Lepidoptera, Trichoptera and segetal vegetation also in the case study.

Agricultural areas with high biodiversity and agricultural areas with high structural richness

For the two indicators "existence of agricultural areas with high biodiversity" and "existence of agricultural areas with high structural richness" the most suitable (because Austria-wide) available data are those derived from the calculations published in BARTEL et al. (2011). The concept of high nature value (HNV) farmland represents an instrument which identifies areas within the agricultural landscape that are considered worth preserving. In addition, also structurally diverse landscapes are identified. According to ANDERSEN et al (2003) HNVF, type 1 is farmland with a high proportion of semi-natural vegetation and HNVF, type 2 farmland with a mosaic of habitats and/or land uses. A detailed description is provided in the respective Guidance document of the European Commission (EUROPEAN COMMISSION 2009).

For the indicator “existence of agricultural areas with high biodiversity” the data on high nature value farmland, type 1 calculated for 2009 are shown. However, in contrast to BARTEL et al. (2011) only the 25 % grid cells with the highest values of type 1 farmland were selected, since in many cases only a few ha per km² are classified as high nature value farmland. Therefore, grid cells with only very limited areas of biodiversity-rich farmland were not taken into account, in order to limit outliers. The resulting data are presented in Figure 15. Data are assigned to a grid size of 1x1 km², demonstrating the number of hectares of high nature value farmland per grid cell.

For the indicator “existence of agricultural areas with high structural richness” high nature value farmland, type 2 calculated for 2009 was taken as a reference. Like in BARTEL et al. (2011) only the 10 % cells with the highest structural values are presented (see Figure 16).

The calculations for Austria are currently being adapted (as of September 2012). Therefore, the respective indicators should not be used in the case study. In the future, the adapted version could be used as a basis for the identification of ecologically particularly sensitive areas.

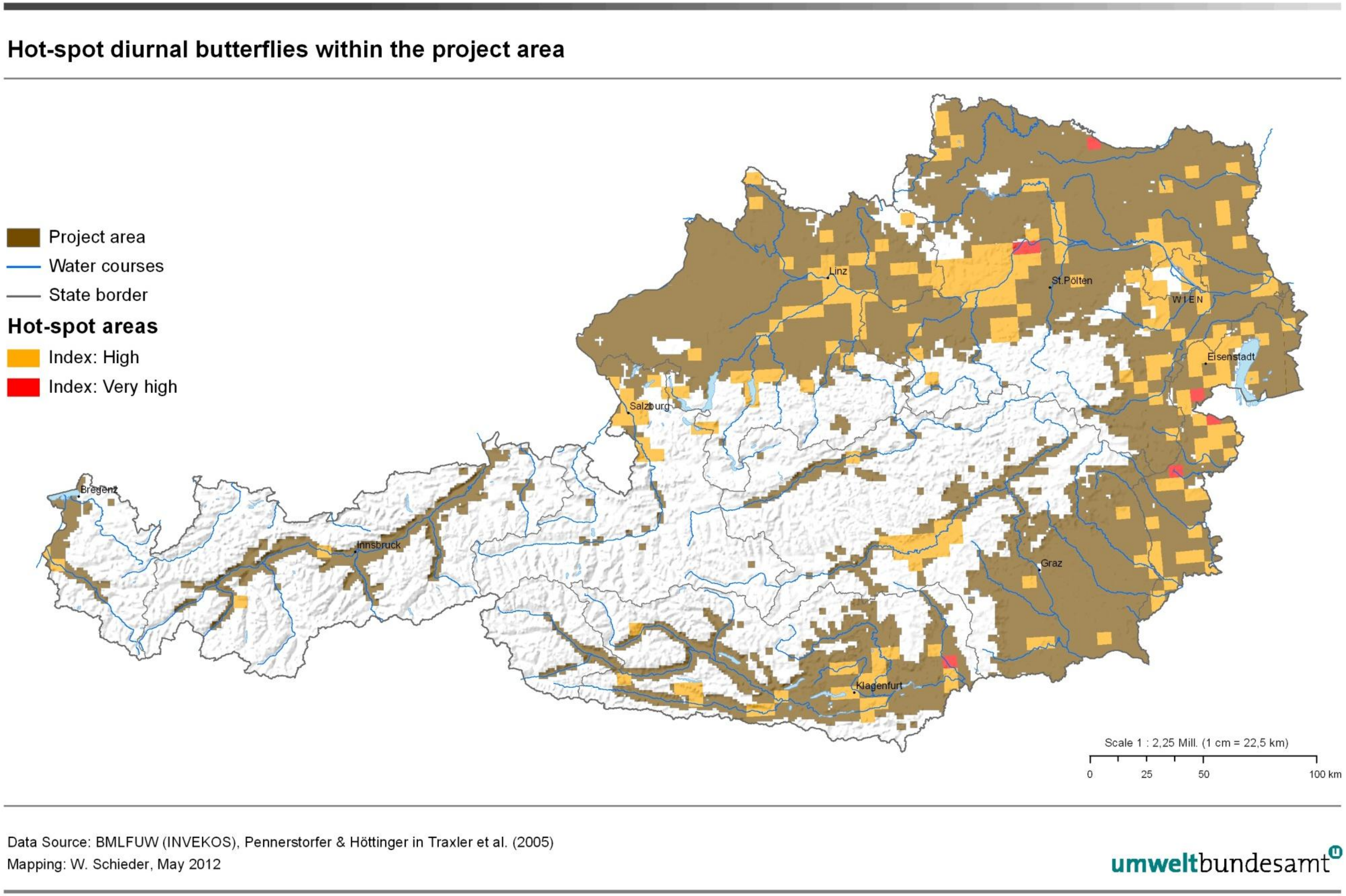
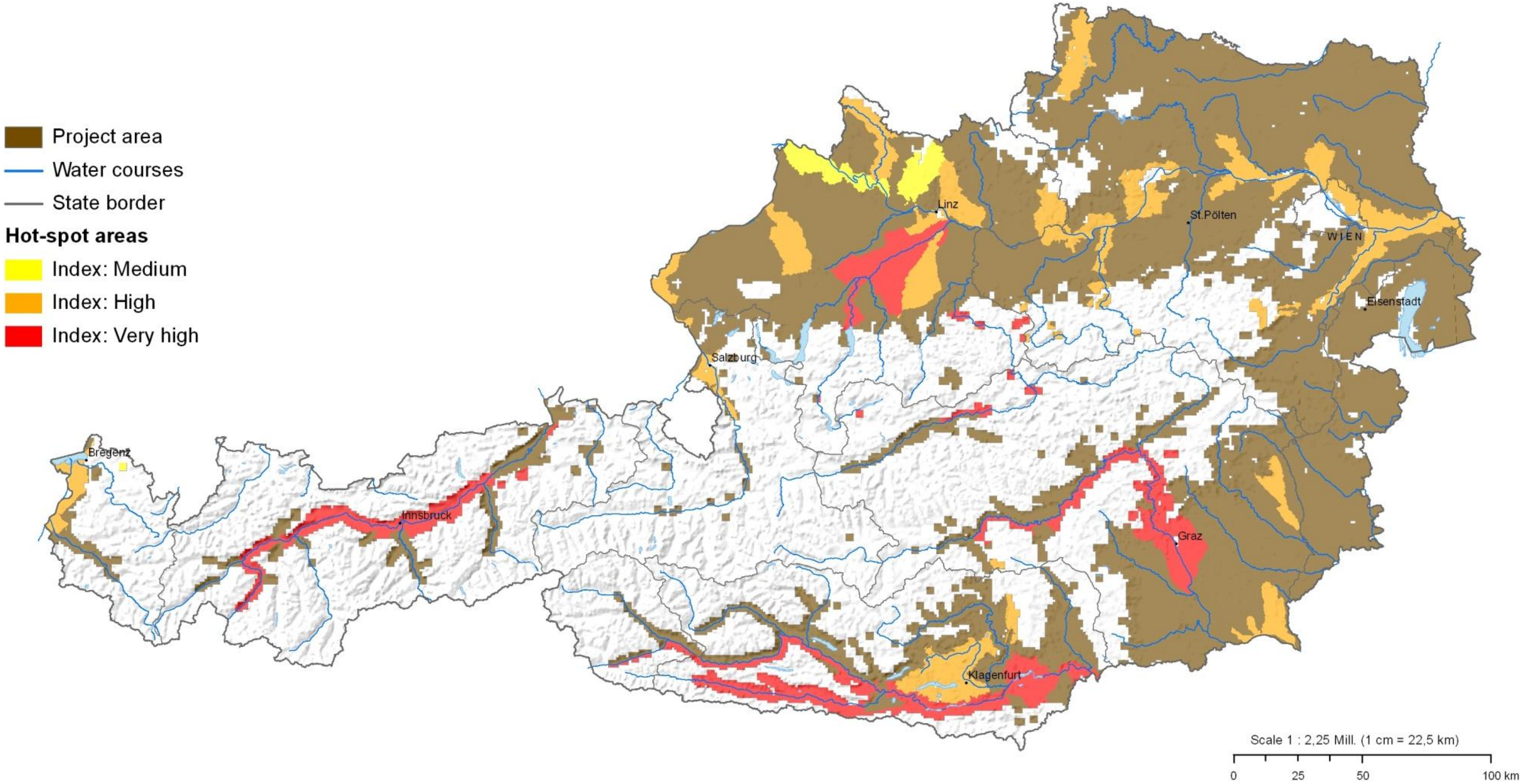


Figure 12: Hot-spot diurnal butterflies within the project area (hot-spot calculations based on a hot-spot index)

Hot-spot Trichoptera within the project area



Data Source: BMLFUW (INVEKOS), Graf et al. (unpublished)
Mapping: W. Schieder, May 2012

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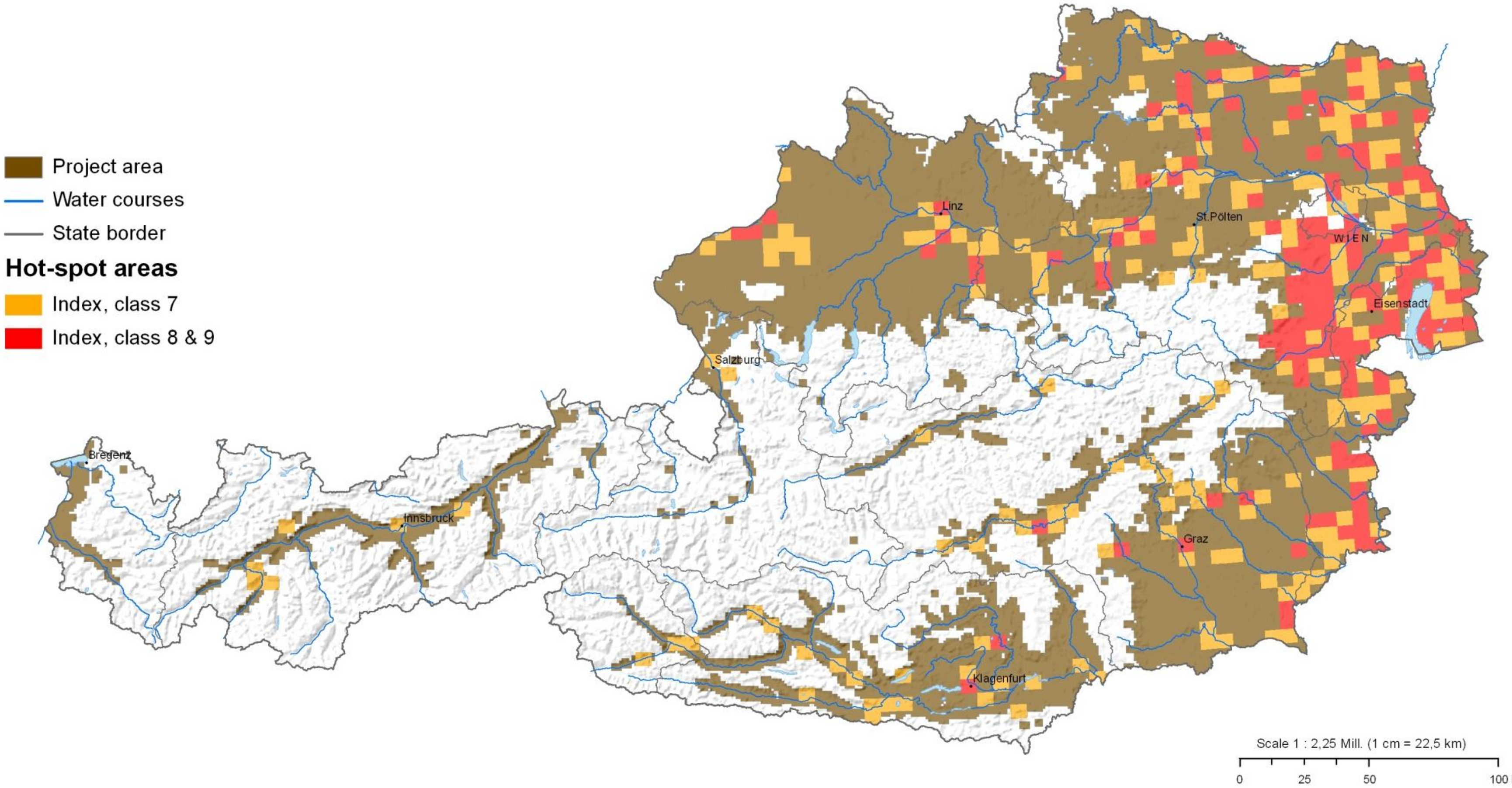
Figure 13: Hot-spot Trichoptera within the project area (hot-spot calculations based on a Trichoptera vulnerability index)

Hot-spot segetal vegetation within the project area



Data Source: BMLFUW (INVEKOS), Traxler et al. (2005)
Mapping: W. Schieder, May 2012

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Figure 14: Hot-spot segetal vegetation within the project area (hot-spot calculations based on a segetal biodiversity index)

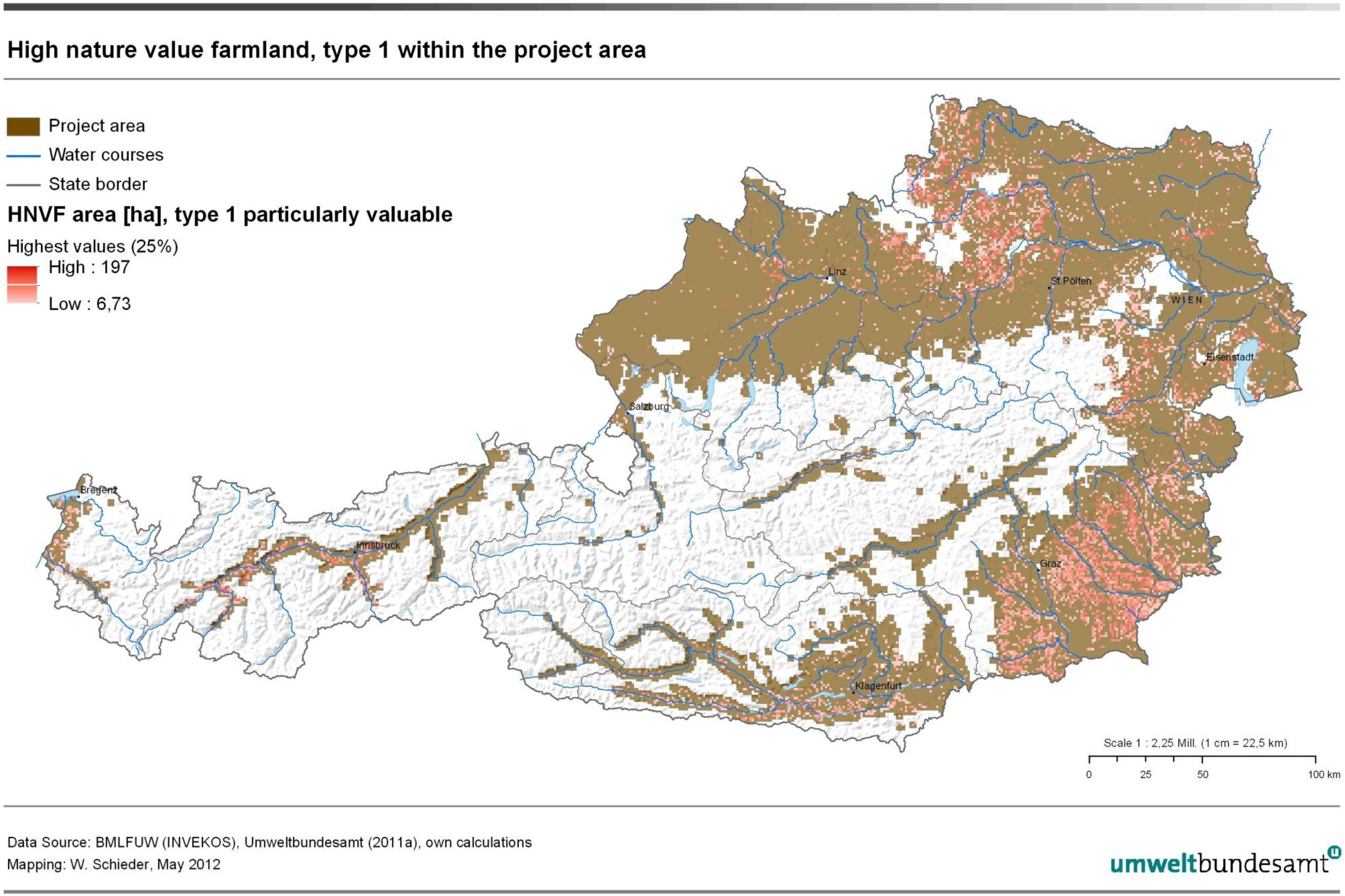
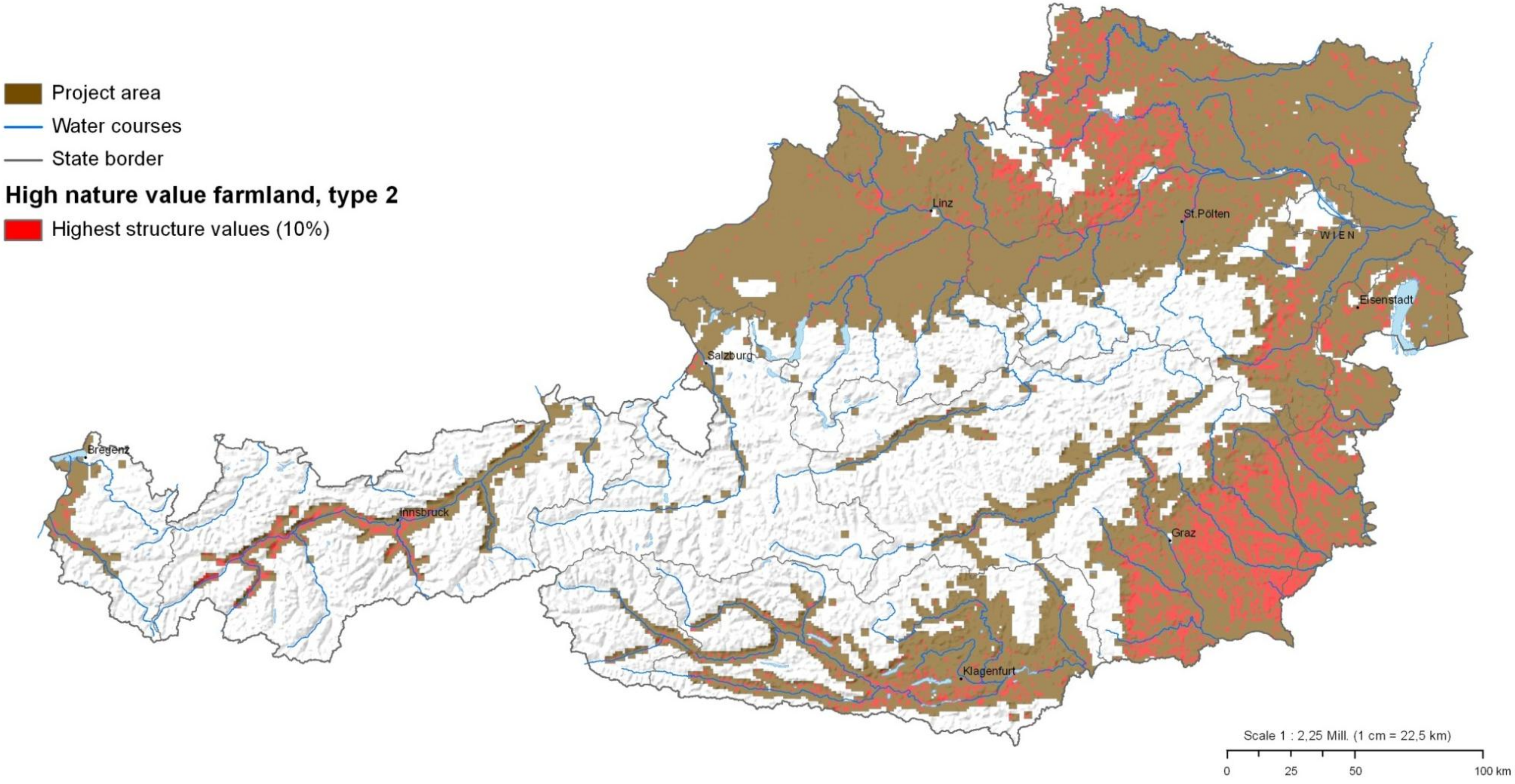


Figure 15: High nature value farmland, type 1 within the project area (best parts)

High nature value farmland, type 2 within the project area



Data Source: BMLFUW (INVEKOS), Umweltbundesamt (2011a), own calculations
Mapping: W. Schieder, May 2012

umweltbundesamt

Figure 16: High nature value farmland, type 2 within the project area

Case study MON89034xMON88017

The application for the authorisation of placing on the market GM-maize MON89034xMON88017 was submitted by Monsanto in 2009. The scope of the application is "seeds and plant propagating material for cultivation in Europe (Part C of Directive 2001/18/EC) (MONSANTO 2009, TRANSGEN 2012). No scientific opinion has been published by EFSA so far, since EFSA requested additional information from the applicant.

GM-maize MON89034xMON88017 produces on the one hand the two insecticidal proteins Cry1A.105 and Cry2Ab2 that provide enhanced control of a wide spectrum of lepidopteran pests of maize (e. g. European corn borer, Mediterranean corn borer). On the the other hand, it expresses the Cry3Bb1 protein that provides protection against certain coleopteran insect pests belonging to the Crysomelidae familiy (i. e. corn rootworm complex). In addition, the 5enolpyruvyl shikimate-3-phosphate synthase (CP4 EPSPS) confers tolerance to glyphosate.

As required by the respective legislation, Monsanto presented an environmental risk assessment. However, the environmental risk assessment was not considered sufficient by Austria, in particular insofar as the assessment of potential effects on non-target organisms was concerned (Federal Ministry of Health, unpublished). The reason given by Austria is that most studies on effects on non-target organisms were not conducted with the relevant GM material derived from GM maize MON88017xMON89034. Specific eco-toxicological studies with the relevant GM material and adequate test organisms were not performed in trials that reflect conditions in the field (e. g. bi- or tri-trophic set-up). In respect to non-target organisms also Trichoptera should be taken into account as they are closely related to Lepidoptera and negative effects have been shown by ROSI-MARSHALL et al. (2007).

Identification of ecologically particularly sensitive areas for MON89034xMON88017

Methods

The identification of ecologically particularly sensitive areas in Austria was based on a two-step approach. First, on the basis of the information provided by the notifier, relevant criteria were selected as defined in the catalogue of criteria (Table 1). As a second step, appropriate data on the respective indicators, were available, were used as a basis for the selection of the respective areas (see also chapter "data for the implementation of the catalogue of criteria).

The criteria that should in principle be taken into account were the following:

- Endangered species and their habitats (indicator groups “occurrence of endangered Lepidoptera”, “occurrence of endangered Trichoptera”, “occurrence of endangered Coleoptera”)
- Endemic species and their habitats (indicator groups “occurrence of endemic Lepidoptera”, “occurrence of endemic Trichoptera”, “occurrence of endemic Coleoptera”)
- Protected species and their habitats (indicator groups “occurrence of protected Lepidoptera”, “occurrence of protected Trichoptera”, “occurrence of protected Coleoptera”)
- Endangered biotope types
- Habitats of Community interest
- Protected areas where agricultural use is not prohibited
- Important areas for biodiversity (indicators: ”Existence of bird biodiversity hot spot”, “Existence of Lepidoptera biodiversity hot spot”, “Existence of Coleoptera biodiversity hot spot”, “Existence of Trichoptera biodiversity hot spot”, “Existence of vascular plant hot spot”, “Existence of biotope biodiversity hot spot”, “Existence of agricultural areas with high biodiversity“)
- Structurally diverse landscapes

Based on the data analysis provided in the respective chapter above, no data were available for some indicators or the available data could not be taken into account for various reasons:

- Based on remaining uncertainties no species of endangered Lepidoptera, Trichoptera and Coleoptera can be deemed not to be at risk from the cultivation of GM-maize MON89034xMON88017. However, the lists of endangered species contain too many species to allow for efficient data queries. As also discussed above and agreed by experts a fine selection requires detailed zoological and ecological expert knowledge and the relevant information is currently (September 2012) not available and can therefore not be used in the case study. An additional challenge in this field is the inhomogeneous data set (e. g. data of various age, different spatial resolution). Therefore a standardised methodology for indicator selection needs to be developed as a prerequisite for a selection by respective experts.
- Endemic species were not taken into account at this stage, since the available data referred to data points and not to grid cells and as pointed out above a fine selection of single species as indicators can only be made after a thorough exposure assessment to GMOs, which is currently (September 2012) not available.
- Since the indicators chosen for the criterion “protected species and their habitat” were based on species of Community interest, no data on

"protected Trichoptera" are available (no Trichoptera species are listed in the Habitats Directive).

- Protected areas defined in ordinances or regulations of the Federal States were not included, since the respective protection goals are defined on a different basis and on different levels and in the case of Natura 2000 areas (being the most frequent category in the project area) vary from area to area. This decision was also based on the overall agreement of experts participating to the workshops.
- No data on hot spots of birds, Coleoptera and biotope diversity are available at the moment (as of September 2012)). Therefore, these aspects could not be accounted for.
- Since the data for the indicator "Existence of agricultural areas with high biodiversity" and the criterion "Structurally diverse landscapes" are based on HNV calculations, they were not taken into account for the time being as these data are currently being revised and recalculated (as of September 2012).

For the definition of ecologically particularly sensitive areas for GM-maize MON89034xMON88017 the most appropriate and latest available (see publication date) data for the remaining indicators were selected, based on the data analysis as presented in the respective chapter above. Data included were the following:

- Lepidoptera of Community based on the latest article 17 report (ELLMAUER 2008) interest as presented in Figure 7
- Coleoptera of Community based on the latest article 17 report (ELLMAUER 2008) interest as presented in Figure 8
- Endangered biotope types based on the distribution database of biotope types in Austria (UMWELTBUNDESAMT 2012) as presented in Figure 9
- Habitats of Community interest based on the latest article 17 report (ELLMAUER 2008) as presented in Figure 10
- Hot-spots of diurnal butterflies as reported in TRAXLER et al. (2005b) and presented in Figure 12
- Hot-spots of Trichoptera calculated by GRAF et al. (2012, unpublished) as presented in Figure 13
- Hot-spot segetal vegetation as reported in TRAXLER et al. (2005b) and presented in Figure 14

For the definition of ecologically particularly sensitive areas the respective data were intersected. In this respect every occurrence of an indicator in a grid cell (3x5') leads to the definition of the respective cell as an ecologically particularly sensitive area.

Results

The resulting ecologically particularly sensitive areas for GM-maize MON89034xMON88017 are presented in Figure 17. They refer to a grid cell of 3x5' since the majority of the underlying data are based on this scale. Since the project area was originally defined on the basis of a grid size of 1 km², the resulting ecologically particularly sensitive areas are somewhat larger than the project area. However, a buffer zone is included in the size of these areas.

The data sets listed above were used in their current form and no modelling approaches, extrapolations or interpolations were applied. The main advantage of the underlying data is that, except for the hot spots of Trichoptera, all data refer to a grid size of 3x5' and all provide Austria-wide information.

As described above, the occurrence of an indicator leads to the assignment of the respective grid cell as ecologically particularly sensitive areas for two reasons. First, indicators are defined on different levels. On the basis of scientific arguments, it is therefore not possible to rank the indicators according to their importance. For example, it is not possible to determine if the occurrence of protected species is more important than the occurrence of endemic species. Although it may be possible to argue that the occurrence of Lepidoptera hot spots is more important than the occurrence of one single protected species, the issue of how to substantiate this argument remains. Is the occurrence of a hot spot three times, ten times or 100 times more important than the occurrence of one protected species? Since it is not possible to answer this question, no respective conversion factor can be defined on a scientific basis. Second, since no scientifically justifiable conversion factor can be identified, no index for ecologically particularly sensitive areas can be calculated. Since a classification and an identification of thresholds would need to be based on non-scientific decisions, ecologically particularly sensitive areas have been selected in the way described above.

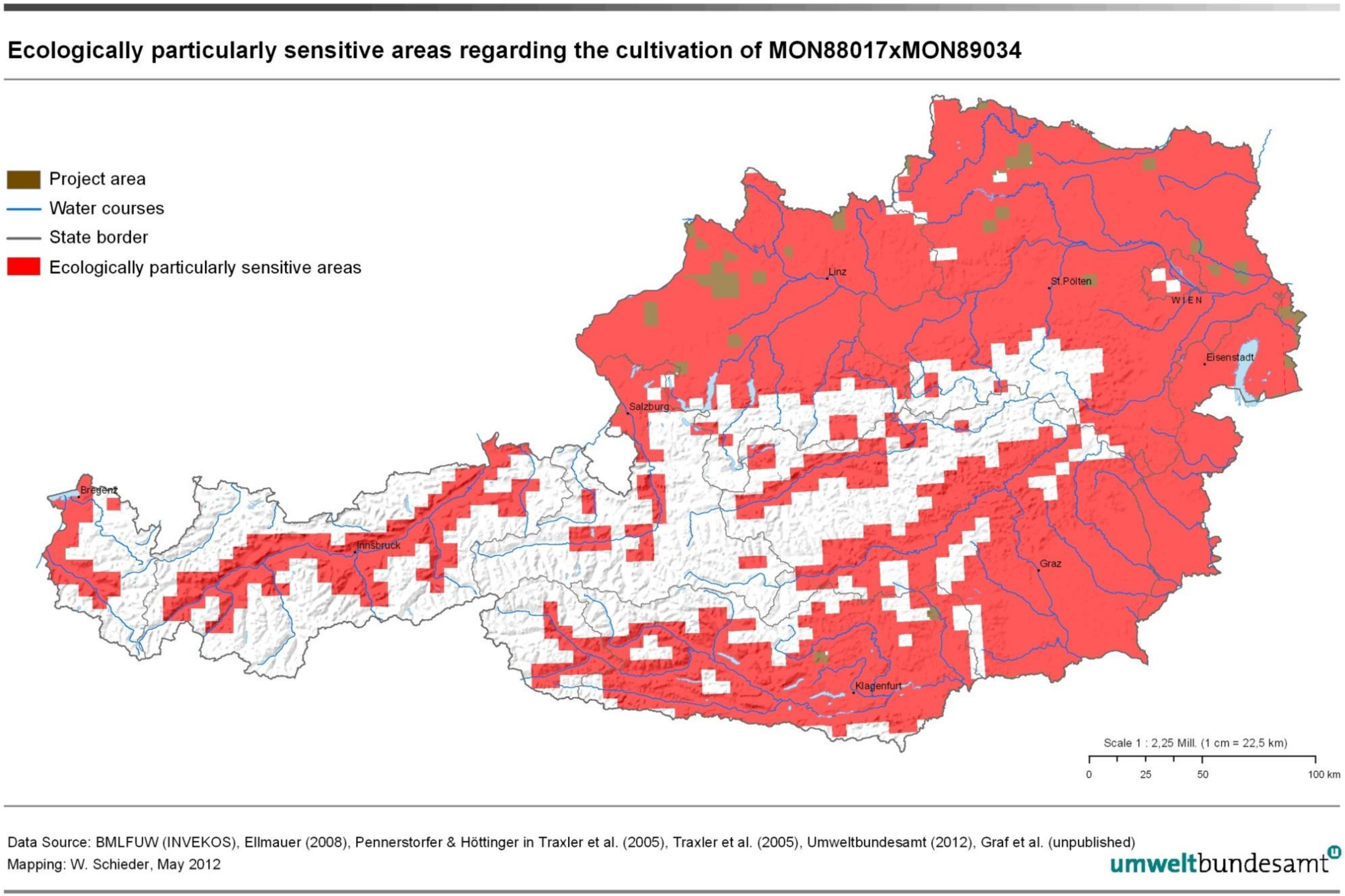


Figure 17: Ecologically particularly sensitive areas regarding the cultivation of MON89034xMON88017

Justification

Transgenic proteins of GM-maize MON89034xMON88017 will be carried into the surrounding landscape via pollen. Regarding the range of pollen deposition different information can be derived from the literature. Recent studies conducted by HOFMANN (2008) have shown that maize pollen dispersal can reach distances of more than 2.000 m. Also, modelling approaches as presented by ARRIT (2012) have shown long distance effects caused by environmental conditions like thermal convection. Therefore, not only areas in close vicinity to a GM-maize field were taken into account, but the whole maize cultivation area. This is necessary since the location and size of maize plots vary from year to year and the authorisation of a GMO is valid for a decade.

In Austria, no insecticides besides dressed seed are normally used in conventional maize production. Thus the cultivation of GM maize expressing Cry proteins would pose a higher risk for non-target organisms in Austria than the production of conventional maize. Also, TRAXLER et al. (2005) stated, and PASCHER et al. (2010a, 2011) confirmed, that relevant habitats for butterfly species are located in close vicinity to maize growing areas in Austria. Therefore, the exposure of butterflies to GM-maize MON89034xMON88017 is very likely. This is also relevant for Trichoptera (as they are closely related to Lepidoptera and organic material from GMOs enters aquatic ecosystems via runoff material from agricultural fields, plant debris and pollen deposition) and Coleoptera, being a target group of GM-maize MON89034xMON88017.

No exposure analysis (exposure pathways, exposure scenarious) or data addressing the eco-toxicity of GM maize MON89034xMON88017 on non-target organisms have been provided by the applicant (Federal Ministry of Health, unpublished). Since no tests have been carried out with the stacked product, high uncertainties especially regarding potential effects on endangered species or protected areas remain. An exposure analysis should cover both terrestric and aquatic environments, in areas where maize is cultivated as well as in adjacent areas (including semi-natural and natural areas). As no exposure analysis or test strategy addressing key functional groups and species of non-target organisms has been provided effects on the indicators/indicator groups cannot be excluded.

Therefore areas where Lepiodoptera and Coleoptera of Community interest occur, as well as areas regarded as hot spots for lepidopteran and trichopteran biodiversity, have been defined as ecologically particularly sensitve and should be excluded from the cultivation of GM-maize MON89034xMON88017.

Post-emergence treatments with glyphosate, on the other hand, lead to a change in agricultural management practices. They have a strong potential to alter biodiversity in the agro-ecosystem. Since the effects on the food web of the agro-ecosystem and adjacent habitats as well as long-term effects are not sufficiently addressed by the applicant effects on habitats and biotopes cannot be excluded. In this context, herbicide drift may be an important stressor for biotopes in the vicinity, since (depending on the changed application practices) they are exposed throughout the vegetation period.

Habitats of Community interest and endangered biotope types according to the Austrian Red List are at special risk. Areas where those habitats and biotope types occur have been defined as ecologically particularly sensitve and should be excluded from the cultivation of GM maize MON89034xMON88017.

Conclusions

The aim of this study was to define, for the first time, ecologically particularly sensitive areas according to Regulation (EC) No. 1829/2003 Article 6 (5) e). These areas were identified according to scientific data for the Austrian maize cultivation area. For their identification, a catalogue of criteria was developed, taking into account expert knowledge from various disciplines, to be used as a tool to make the selection clear and reproducible. This work is of utmost importance to avoid potential negative effects of GM-maize cultivation on the diversity-rich Austrian landscape.

Moreover, this study presents, also for the first time, an overview and an analysis of available and useable data in Austria with respect to the selection of ecologically particularly sensitive areas. It is demonstrated that Austria-wide data, based on a scale of 3x5‘ for a number of indicators, are available though not all of them are covered. However, there are ongoing efforts to structure and improve ecological data in Austria. It is shown that some challenges remain regarding the identification of the data owner, the right to use the respective data and corresponding limitations to data existence and availability, and also regarding the costs for the data or data processing.

Bearing this in mind, the following aspects need to be addressed in the future:

- The right to use the data, as they have been used in this study, is usually granted for one single use only, e. g. for one report or study. For the future identification of ecologically particularly sensitive areas, permission to use the data will have to be renewed every time. For reasons of feasibility, i. e. to be able to use the respective data for all currently ongoing GMO applications, it might be necessary to negotiate a respective agreement with the data owners, e. g. the Governments of the Federal States.
- Certain data used in this study need to be updated regularly, e. g. data on species and habitats of Community interest or data on endangered biotope types in order to keep the identified ecologically particularly sensitive areas up to date.
- Data on high nature value farmland are currently (as of September 2012) being updated. As soon as the new calculations are available, they should be analysed and ecologically particularly sensitive areas updated if applicable.
- The Red List of Endangered Coleoptera is currently (as of September 2012) being developed. As soon as it is published, the catalogue of criteria should be updated.
- Hot spots of Coleoptera biodiversity should be identified.

- The aspect of data limitation and modelling approaches need to be discussed further, especially regarding ongoing discussions on the European level.

The last two aspects are regarded as top priority issues when it comes to substantiating the justification of restrictions of GMO cultivation in identified ecologically particularly sensitive areas and to the preparation of discussions of this issue at the European level.

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