Bystanders, Residents, Operators and WorkerS Exposure models for plant protection products

Final Report Summary - BROWSE (Bystanders, Residents, Operators and WorkerS Exposure models for plant protection products)

Executive Summary:
The BROWSE project, supported by the EU 7th Framework Programme, has:

- Reviewed, improved and extended the models currently used in the risk assessment of plant protection products (PPPs) to evaluate the exposure of operators, workers, residents and bystanders.
- Used the new and improved exposure models to contribute to the implementation of Regulation 1107/2009 on authorisation of PPPs, replacing Directive 91/414/EC.
Used the new and improved exposure models to contribute to the implementation of the Thematic Strategy on the Sustainable Use of Pesticides.

Involved all relevant stakeholder and end-user communities and taken full account of relevant gender issues in developing the exposure models and policy tools.

The principal outputs of the project are:

- New and improved models for assessing exposure of operators, workers, residents & bystanders to pesticides, providing significant advances compared to existing models. The models are implemented in freely available, easy-to-use software, which end-users can download at www.browse-project.eu and run on their own computers, accompanied by user instructions and detailed technical documentation. The models and software are designed to be suitable for adoption by the authorities responsible for pesticides regulation.

- A new e-training platform (http://www.opentea.eu/) that allows users to search and view a wide range of existing training materials on sustainable use of pesticides and practices to reduce exposure and risk. The platform includes a facility enabling users to select materials of interest and combine them to create new programmes of training, customised to their particular needs and audiences.

- A new approach to pesticide risk indicators, using indirect behavioural indicators that do not attempt to measure risk directly but instead are measures of progress in actions to reduce risk, such as training for farmers and operators, improved application techniques, procedures for handling pesticides and disposing of waste, etc. This is intended for use by the competent EU Member State authorities as the basis for a common approach for developing new indicators to measure and verify the impact of their risk reduction initiatives.

- A new research methodology for assessing the link between risk perceptions, attitudes and protective behaviours related to pesticide exposure for operators, workers, residents and bystanders, designed to generate data that will help optimise the targeting of risk communication and risk mitigation initiatives. The methodology was tested in surveys in 3 EU Member States (Italy, Greece and UK).

Project Context and Objectives:

Regulation 1107/2009 (replacing Directive 91/414/EC) requires assessment of the exposure of operators, workers, bystanders and residents to plant protection products before they can be authorised for sale in the EU. When the BROWSE project started, there was no harmonised EU approach for these assessments (EFSA 2009). Models developed in the UK (UKPOEM) or Germany are normally used to assess the potential exposures of operators, but these models give somewhat different estimates for the same scenario. Worker exposures may be estimated using the EURPOEM II model, or models developed in Germany or California. No well-standardised methods are available to assess the exposures of bystanders and residents, and different Member States follow different approaches (EFSA 2009). Responsibility for development of Guidance Documents for pesticide risk assessment has been transferred from the European Commission to the European Food Safety Authority (EFSA). A consultation with EU Member States identified guidance on exposure assessment for operators, workers, residents and bystanders as a priority. Accordingly the EFSA PPR Panel published a draft opinion on this subject, including a draft text for a guidance document (EFSA 2009). This eventually led to publication of a final guidance document and exposure calculation tool in October 2014, just as the BROWSE project was ending. However, EFSA (2009) recommended that the final Guidance Document should be reviewed periodically, as and when relevant new data become available: this provides scope for the introduction of improved approaches emerging from research projects such as BROWSE.
Operator exposure assessment

Current approaches for assessing operator exposure, and new approaches currently under development, were recently comprehensively reviewed by Hamey et al. (2008) and EFSA (2009). These reviews identified a number of limitations in the current state of the art. For some scenarios, the datasets used for estimating specific exposures are small. Some data come from unrepresentative conditions, e.g. highly trained operators using new equipment. All the models assume a linear relation between exposure and amount of pesticide applied or handled, but the data show significant non-linearity (Hamey et al. 2008) that will tend to over-estimate exposures when larger quantities are used (EFSA 2009). Also, there was a lack of information on operator practices (use of controls and protective equipment) across Member States.

Worker exposure

Existing models of worker exposure to pesticides consider only dermal exposure. EFSA (2009) proposed to improve estimation of dermal exposure and extend the assessment to include inhalation exposure. EFSA proposed that the contributions for each relevant source and route should be summed, and that reductions due to use of protective equipment (where applicable) may be estimated using the same protection factors as for operators. Both Hamey et al. (2008) and EFSA (2009) recognise that the approaches for assessing worker exposures are based on limited data for a limited range of scenarios.

Resident and bystander exposure

Current regulatory approaches to exposure assessment for residents and bystanders were reviewed by Hamey et al. (2008). They concluded that the UK and German approaches were similar and could provide the basis for a harmonised approach pending the development of new models (BREAM, see below). EFSA (2009) stated that the contributions from all relevant pathways should be summed to estimate total worker exposure. Again, there were significant limitations in the current state of the art. Hamey et al. (2008) noted that concerns existed that neither the UK nor German drift data reflected modern application practice in many member states. The BREAM project had clearly shown that higher levels of drift will lead to higher levels of bystander exposure (Glass et al, 2010a) and demonstrated that there was a relationship between bystander exposure and airborne spray that can be exploited in improved exposure models. Finally, the current assumptions relating to bystander behaviour (proximity and duration of exposure) were not protective in all possible situations.

Both Hamey et al (2008) and EFSA (2009) cited the UK BREAM project (Butler Ellis and Miller, 2009) as a potential basis for future improvements in exposure assessment for residents and bystanders. BREAM was led by BROWSE partner TAG, with input from Fera, and was therefore fully available for use as a starting point in BROWSE. BREAM developed a model of exposure to spray drift from boom sprayers and vapour from field crops for residents and bystanders in UK scenarios, but this needed to be extended to cover a wider range of scenarios appropriate to other member states.

Scenarios for exposure assessment

The conditions in which operators, workers, residents and bystanders are exposed to pesticides vary widely in many ways that may influence the degree of exposure. It is not feasible to consider all possible variations, so the usual strategy for regulatory approaches is to define a limited number of different scenarios for which exposure is assessed. In general, these scenarios are chosen to represent situations where exposure is expected to be relatively high, to make the assessment also protective for other scenarios that are not assessed. Neither Hamey et al. (2008) nor EFSA (2009) discussed the extent to which scenarios might differ between different Member States or regulatory zones within the EU, or with gender. In principle, some variation might be expected, as many factors influencing exposure vary across the EU (e.g. meteorological conditions such as wind speeds, humidity, temperature; types of equipment
used for mixing, loading and application of pesticides; use of engineering or operational controls and personal protective equipment; type and coverage of normal clothing; and the behaviour of residents and bystanders and their proximity to treated crops).

Volatilisation of pesticides from treated areas

Modelling volatilisation of pesticides from treated areas, from both indoor and outdoor applications, is necessary to assess their subsequent transport downwind to potential resident and bystander locations. Volatilisation is also relevant to exposure of workers and operators. Volatilisation was therefore treated as a cross-cutting theme in BROWSE, to ensure consistency in its handling for different scenarios and to avoid duplication of effort. Modelling volatilisation is technically challenging. In the APECOP project (Vanclooster et al. 2003) the PEARL model was developed further to include an improved description of the volatilization from soil as well as the dependence of volatilization on the moisture condition of the soil surface. Another model assessing volatilization from soils and crops is AgroChemicals developed by BROWSE partner UCSC (Trevisan et al., 2007). Further improvements were made in the PEARL model by including descriptions of processes occurring on the plant surface competing with volatilization (Vanden Berg and Leistra, 2004). Consensus-PEARL considers not only volatilization but also other competing processes occurring on the plant surface. Consensus-PEARL was tested in the BREAM project for its suitability as a model for volatilization from crops (Butler Ellis et al, 2010). The results showed that while worst-case emission of a high vapour-pressure active ingredient was predicted relatively well, the measured emissions of a pesticide with low vapour pressure was not predicted well. Further analysis was required of the uncertainty in the input values used for the model to describe volatilization, the relevant competing processes on the plant surface and the uncertainty in the measured volatilisation rates. Work by Spanoghe et al 2009 also supported the hypothesis that a model based on vapour-pressure alone was unlikely to be adequate for a tier 1 assessment.

Transfer coefficients

Transfer of residues from treated and contaminated surfaces contributes to exposure of operators, workers, residents and bystanders. The resulting exposure depends on the extent to which residues are available for transfer, and the nature of the contact. Hamey et al. (2008) commented on the limited quantity and transparency of data available for estimating transfer factors, as well as the wide range of values reported. EFSA (2009) highlighted transfer factors as an area deserving further research. As transfer factors are required for workers, residents, bystanders and some operator scenarios, they were treated as a cross-cutting theme in BROWSE, to ensure consistency in their derivation and use for different scenarios and to avoid duplication of effort.

Software tools for regulatory risk assessment

Uptake of exposure and risk assessment methods for regulatory use can be greatly facilitated by providing them in the form of user-friendly software tools. Currently, software tools of this type are established in the EU only for operator exposure assessment. The existing software tools were based on the UK POEM and German models for operator exposure, combining applicator and mixing/loading exposures for both dermal and inhalation routes. The underlying datasets were limited to common use scenarios for the UK and Germany, so were not representative of many uses in southern Europe or small-scale farming. The two models function in a similar manner, although they express dermal exposure in different ways. When BROWSE started, no software tools were yet established in the EU for assessing exposure of workers, residents or bystanders, although presumably some notifiers and companies have internally standardised spreadsheets. Basic models covering all four groups of receptors have since been provided by EFSA (2014).
Sustainable Use Directive

Directive 2009/128/EC establishes a framework for Community action to achieve the sustainable use of pesticides. A primary objective of the Directive is to reduce the risks and impacts of pesticide use for human health and the environment. Provisions that are especially relevant to BROWSE include: National Action Plans (Article 4), Training (Art.5) Information and awareness (Art. 7), Reduction of pesticide use or risks in specific areas (Art.12) Handling, storage and disposal of pesticides and their packaging (Art. 13), Integrated pesticide management (IPM) (Art. 14) and Risk indicators (Art. 15).

Training and public awareness

At the first meeting of the expert group on the Thematic Strategy on the Sustainable Use of Pesticides on 4 June 2009 (ec.europa.eu/environment/ppps/meeting040609.htm) training was identified as a key aspect for successful implementation of the strategy. In addition to the existing national sources, there are also other initiatives for training and awareness-raising. The industry association ECPA (European Crop Protection Association) established its own ‘Sustainable Use Initiative’ in 2002. The TOPPS project (Training Operators to Prevent Point Source pollution, www.topps-life.org) is funded by the EU-Life programme and ECPA. It has established an inventory of over 1300 experts and stakeholder organisations and developed a programme of training and awareness-raising activities. Effective training strategies for workers and operators must take account of behavioural and perceptual factors associated with potentially risky behaviours, and worker preferences for training and communication regarding pesticide use (e.g. Perry and Bloom, 1998). They should also take account of demographic differences in operator and worker tasks and preferences, including regional and gender differences.

Risk indicators

Directive 2009/128/EC requires the establishment and use of harmonised risk indicators to assess progress in reducing impacts of pesticides on human health and the environment. There is a variety of indicators available for environmental risks of pesticides, contrasting in their objectives, complexity, spatial and temporal scale and ease of use. Fewer indicators consider risks to operators, workers and bystanders. The EC supported the research project HAIR (HArmonised environmental Indicators for pesticide Risk) which aimed at delivering a set of harmonised environmental and human health risk indicators. The EC then commissioned a further study to evaluate the HAIR indicators (the Arcadis study). Arcadis made a series of important recommendations for further development of harmonised EU indicators. Further activities to address the ARCADIS recommendations continued in parallel with BROWSE. Therefore, to ensure efficient use of resources, BROWSE consulted with all the relevant parties (including Commission, EFSA, EUROSTAT and HAIR partners) to determine what contributions from BROWSE would be most useful and in what form they should be delivered in order to integrate with other work on harmonised EU indicators.

Stakeholder and end-user involvement

Developing effective risk analysis and policy associated with PPPs, as well as optimising risk management decisions, is contingent on systematically incorporating the expertise and views of all relevant stakeholders into the relevant decision-making process (Wentholt et al, 2009). It was therefore essential for BROWSE to involve relevant stakeholder and end-user groups in appropriate ways. Some, including DG SANCO and DG Environment, EFSA, selected Member State authorities, ECPA, PAN-Europe, EFFAT and the US EPA were invited to nominate members for the project’s Advisory Panel. General stakeholder workshops were held at the beginning and end of the project, and more targeted stakeholder consultations addressed specific topics (gender issues, development of exposure scenarios, design and testing of end-user software, development of risk indicators, and development and testing of training and
communication materials).

Gender issues
There is evidence that exposure to pesticides, as well as their toxicity, may vary according to the gender of the individual concerned, whether a bystander, resident, operator or worker. Furthermore, gender differences are related to other socio-economic, demographic and regional factors. The European Agency for Safety and Health at Work (OHSA) published a report (OHSA, 2003) detailing the gender issues for health and safety at work and highlighted a number of points relevant to the agricultural sector, many of which relate to the use of PPPs. It was therefore important for BROWSE to take account of potential gender differences in exposure when developing scenarios and exposure models, including surveys to collect new data on relevant tasks and activities in different EU member states.

BROWSE project objectives
The BROWSE project aimed to contribute to addressing the needs and issues identified above. Specifically,

- Review, improve and extend the models currently used in the risk assessment of plant protection products (PPPs) to evaluate the exposure of operators, workers, residents and bystanders.
- Use the new and improved exposure models to contribute to the implementation of Regulation 1107/2009 on authorisation of PPPs, replacing Directive 91/414/EC.
- Use the new and improved exposure models to contribute to the implementation of the Thematic Strategy on the Sustainable Use of Pesticides.
- Involve all relevant stakeholders and end-users and take full account of relevant gender issues in developing the exposure models and policy tools.

References
Project Results:

Work Package 1: operator exposure

Summary of technical work completed

Tasks 1.1: Review of existing models and population of an exposure database:

During the first 3 months of the project a review was carried out of all existing and emerging operator exposure models, including not only pesticide models like UK POEM and the German BBA model, but also biocide models (e.g. BEAT) and other relevant industrial exposure models like ART, RiskOfDerm etc. In addition to this, all available operator exposure data was reviewed and collated, including databases behind existing (and emerging) models, exposure data from public and grey literature and exposure data from consortium partners. This work was done in collaboration with WP2 (worker exposure). Unfortunately the ECPA exposure data (which was the subject of negotiation) was not been provided by ECPA to the BROWSE consortium and could therefore not be included in the review.

Criteria for the acceptance of data were also set up and a database was constructed in Excel for the structural collation of accepted operator exposure data. Operator and worker exposure data was entered into this Excel database, and it was updated throughout the project as new data and information became available. This work was also done in collaboration with WP2 (worker exposure) and WP3 (resident and bystander exposure).

Task 1.2: Definition of assessment objectives and scenarios:

The objectives of the BROWSE exposure models were defined, taking into account the requirements from EC Regulation 1107/2009 and the Sustainable Use Directive, and stakeholder input from the first stakeholder workshop (see WP4 for details). Furthermore, workpackages 1-4 cooperated to ensure a consistent approach to identification and prioritisation of scenarios for exposure. Exposure scenarios were identified and prioritised based on the scenarios covered by the current exposure models, the anticipated frequency of each scenario (common case assumption), the extent of the exposure that is foreseen (worst
case assumption), input from the Stakeholder workshop and availability of exposure data.

Task 1.3: Development of conceptual model:
For operator exposure a very generic conceptual model was developed, which could be applied to all possible operator exposure scenarios based on a source-receptor model and including the inhalation, dermal and oral routes of exposure. For the dermal route distinction was made between dermal exposure via bulk (splashes), via transfer and via deposition. The main modifying factors determining the exposure were identified and taken up in the conceptual model.

An Excel database was developed which contained information on relevant determinants of exposure and exposure mechanisms influencing exposure (based on literature search and review). This database was used for the development of the mechanistic models (Task 1.4) for the different scenarios.

Task 1.4: Development of mechanistic model(s):
The mechanistic models of the first set of scenarios (boom spraying and mixing/loading liquids) were delayed because of limited access to good quality data. However, these mechanistic models were completed, followed by the remaining models: mixing/loading solids, orchard spraying and hand-held spraying. Where appropriate, the results from the stakeholder surveys (Deliverable 4.3 WP4) were used as input to define distributions of model inputs in the models. The modelling procedure for each scenario included the collation of available evidence from the literature, statistical (regression and correlation) analyses of the available exposure data, identifying exposure determinants and allocating effect sizes and distributions of model inputs, adopting experimental data as input for the models (where available and/or appropriate) and finally developing mechanistic algorithms. Depending on the available evidence of exposure determinants of a given scenario, available experimental data and existing models, the most useful type of model was selected. The WP1 exposure models predict potential (external) operator exposure. Together with BPI a method was developed to convert external exposure to internal exposure using appropriate defaults.

Task 1.5: Model calibration, refinement and cross-validation:
Models were calibrated by FERA (in collaboration with TNO) using exposure data from the BROWSE database. In order to calibrate the mechanistic models, the available datasets were coded according to the model parameters. A major issue was that the data was often lacking contextual information for coding and calibration. In such cases, it was decided to impute missing values using statistical methods. Because of small datasets, imputation and high exposure variability within the datasets, it was decided not to fit or transform the models with the available data. Instead, the calibration was rather a testing procedure to compare model output distributions with the available (coded) data, and to check and refine any inconsistencies in the model algorithms, parameter distributions and background calculations used to estimate model inputs and outputs. Sensitivity analysis was carried out on the boom spraying and mixing and loading models, for both solids and liquids, which were considered to be the highest priority models. As part of the validation of the models, BPI carried out a detailed comparison of BROWSE model outputs with the output of existing pesticide exposure models (Report on “Example scenarios for testing BROWSE models and comparison with the existing models”). Example exposure scenarios were used for estimating the operator exposure levels with both BROWSE models and the existing models/tools currently used for pesticides assessment.
For the preparation of this report several software versions were tested. The respective comparisons have been performed for all finalised WP1 models.

Task 1.6: Delivery of completed operator exposure models:
All the WP1 models were finalized and implemented in the final version of the exposure assessment software (see WP5 for details). A scientific paper of the operator exposure models was published in 2012 (uploaded).

Reserve Fund project
As part of the reserve fund TNO carried out a literature review on PPE (personal protective equipment) and performed a statistical analysis on exposure databases available in order to come up with a set of defaults on PPE Efficacy that could be taken up in the BROWSE models (as exposure reduction measure). The report on this work is submitted as an annex to the final report.

In addition to this TNO participated in the field work carried out by BPI (Greek Greenhouses), attending some of the field work days and providing expertise on the protocol and the conduct of this field work. This work is also reported in the annex to the final report.

Overview of the developed BROWSE operator models
The BROWSE models for operator exposure consider three main routes of personal exposure, i.e. inhalation (via respiratory tract), dermal (via skin) and ingestion (via mouth). The dermal exposure is the most complex route of exposure and occurs through three potential pathways, i.e. deposition from the air, contacts of the hands and body with surfaces, direct transfer through splashes or dripping (from liquids) and impaction (from solids). A conceptual model of how these different routes contribute to overall exposure of operators is shown in Figure 1.

For each scenario and exposure route, the most important determinants that influence the transport of a PPP from the source to the receptor were identified and, where appropriate, included in the models. The size of their effect and their distributions were evaluated and determined by means of data analyses, literature reviews and expert opinion. Subsequently, mechanistic algorithms were developed using the available evidence to underpin the models. The model inputs, which are distributions, represent a range (with lower and upper values) of the best available data on ‘representative’ conditions in practice.

For each exposure route, models were developed to predict the ‘potential’ exposure of an operator to PPP without taking into account work or protective clothing or respiratory protective equipment. These models were tested with available empirical exposure data. In addition, the potential operator exposure estimates obtained using the BROWSE models were compared to existing model outputs (e.g. EUROPOEM). By considering factors such as skin or respiratory protection, breathing rate, etc., the model also gives an actual exposure estimate.

Workpackage 1 Highlights
• The delivery of a report with an overview of currently used and emerging operator (and worker) exposure models and data.
• The delivery of a finalised operator and worker database with operator and worker exposure data for inhalation, and potential and actual dermal exposure.
• The delivery of models for boom spraying, orchard spraying, hand-held applications and mixing/loading liquids and solids. Compared to existing models, the BROWSE operator models include more model
parameters and distinguish between more exposure routes or exposure types (e.g. both hand and whole body, ingestion).

- The publishing of a scientific paper on the development of the operator exposure models.

**Work Package 2: worker exposure**

**Summary of technical work completed**

**Tasks 2.1: Review of existing models and population of an exposure database:**
This task was carried out in collaboration with work package 1, as described under Task 1.1 above.

**Task 2.2: Definition of assessment objectives and scenarios:**
The objectives of the BROWSE exposure models were defined, taking into account the requirements from EC Regulation 1107/2009 and the Sustainable Use Directive, and stakeholder input from the first stakeholder workshop (see WP4 for details). Work packages collaborated to ensure consistent approaches to identification and prioritisation of scenarios for operator exposure. Exposure scenarios were identified and prioritised based on the scenarios covered by the current exposure models, the anticipated frequency of each scenario (common case assumption), the extent of the exposure that is foreseen (worst case assumption), input from the Stakeholder workshop and availability of exposure data.

The agreed prioritised scenarios were:

i. Outdoor
   - Orchards (fruit trees) - harvesting and pruning/thinning
   - Grapes - harvesting and pruning/thinning

ii. Indoor
   - Ornamentals - harvesting
   - Fruiting vegetables (i.e. tomatoes-high crop) - harvesting

iii. Seed treatment - sowing treated seeds

iv. Vapour exposure
   - Vapour emissions from open fields – all crops
   - Vapour emissions from protected crops

**Task 2.3: Development of conceptual model:**
The final conceptual model is schematically shown in the figure 2.

An Excel database was developed which contained information on the parameters of the exposure models (based on literature search and review). This exposure determinants database was used for the implementation of the model (Task 2.4) for the different scenarios.

**Task 2.4: Development of mechanistic model:**
WP 2 developed a modelling approach to assess dermal, inhalation and oral exposure. The way that the exposure is estimated is summarised below and explained in detail in the WP2 technical report (D2.4).

**Dermal exposure**

Dermal exposure is estimated based on the Transfer Coefficient (TC), the Dislodgeable Foliar Residue (DFR) and the duration of the activity (T). The basic algorithm is as follows:
DE = TC x DFR x T

This modelling approach has improved and extended those taken by previous models. First, the effect of work clothing and Personal Protective Equipment (PPE) has been taken into account by adding coverage factors and clothing/PPE migration factors. Second, the model can provide an estimate of the DFR based on the results of the PEARL-OPS model. The PEARL-model models the volatilisation from the crop. This model has been linked to the dispersion model OPS, which calculates the concentration of the PPP in the air as a result of volatilisation from the crop. Third, an extensive transfer coefficient database has been created that draws on open and grey literature. An analysis of the data for the different exposure scenarios has been performed in order to propose transfer coefficients for the priority scenarios. In addition, the TCs currently being considered by EFSA (personal communication) are based on published data from EUROPOEM or US EPA and have also been made available within the newly developed BROWSE software. Finally, new survey data generated within the BROWSE and CAPEX projects have been considered when proposing defaults for use in the model (Glass et al., 2012).

Inhalation exposure

Inhalation exposure is estimated by taking into account the concentration of the PPP in the air (AirCt), the breathing rate (BR) and the duration of the activity (T). These three parameters can be found in the algorithm used to calculate inhalation exposure:

IE = AirCt x BR x T

The novelty of this approach is that the concentration of the PPP in the air is modelled with the PEARL-OPS model. The PEARL module estimates the volatilisation from the crop. This volatilisation is influenced by the substance properties, application parameters, crop properties and meteorological data. The calculated amount of volatilisation is considered to be the source of PPP in the dispersion model OPS. Both acute and longer term exposure to single or multiple applications can be dealt with in the PEARL-OPS model.

Oral exposure

Oral exposure is considered to occur as a result of hand-to-mouth contact. An approach to modelling this was developed by TNO in work package 1 and adapted for use in work package 2. During such contact it is assumed that a certain amount of PPP is transferred from the hands to the mouth, resulting in the oral ingestion of PPP. Hence, oral exposure (OE) is estimated by taking into account the dermal exposure of the hands (DE_hands), the hand-to-mouth contact and the duration of the activity (T). The hand-to-mouth contact is characterized by the fraction of the hands in contact with the mouth (Am/Ah), the skin-to-mouth transfer efficiency (SE) and the number of contacts (N). The algorithm is as follows:

OE = DE_hands x (Am/Ah x SE x N) x T

Task 2.5: Model calibration, refinement and cross-validation:

An approach for calibrating and validating the model was developed in collaboration with BPI, which was then applied to the final version of the BROWSE software. In short, the BROWSE model outputs are compared with estimates generated by other models (e.g. EUROPOEM II model for re-entry exposure). This approach also provides an indication of the sensitivity of the models to different scenarios.

Task 2.6: Delivery of completed worker exposure models:

The required model algorithms, inputs and outputs have been described for all priority scenarios for which
appropriate data (e.g. TC data) were available and passed to WP5 for implementation in the software. These scenarios were: pruning or thinning orchard fruits, harvesting orchard fruits, harvesting fruiting vegetables, harvesting ornamentals, harvesting grapes and harvesting soft fruit.

Reserve fund work
The volatilisation experiments, performed as part of the reserve fund work, were aimed at improving the current knowledge of the volatilisation process from plant surfaces in greenhouses by studying the effect of the air ventilation rate, air temperature, measurement height, location within the greenhouse, substance properties and competing processes on the measured concentrations in the greenhouse air. In the meantime, a complete and comprehensive dataset was developed that was used to test and improve the recent PEARL model for estimating greenhouse concentrations of plant protection products. The results of this study are submitted as an annex to this report and have been accepted for publication:

Volatilisation of pesticides after application in vegetable greenhouses (accepted). K Doan Ngoc, F van den Berg, M Houbraken and P Spanoghe. Science of the Total Environment in press

Overview of the developed BROWSE worker models
The BROWSE model for worker exposure considers three exposure routes: exposure to contaminated surfaces (dermal exposure), exposure to contaminated air (inhalation exposure) and hand-to-mouth contact (ingestion exposure). The model comprises of 4 different modules: the PEARL(-OPS) module for modelling pesticide fate in the crop canopy and in air, and 3 modules for calculating dermal, inhalation and oral exposure. The PEARL-(OPS) module can provide inputs for estimating dermal and inhalation exposure by means of estimates of the dislodgeable foliar residue and the concentration of the substance in the air, respectively. Figure 3 gives an overview of these modules and how these are linked together to estimate worker exposure.

Work Package 2 Highlights
• The delivery of a report with an overview of currently used and emerging operator and worker exposure models and data.
• The delivery of a finalised operator and worker database with operator and worker exposure data for inhalation, and potential and actual dermal exposure.
• The delivery of models for worker exposure assessments for which the following elements are considered to be significant improvements when compared to the current approach:
  o BROWSE...
  - provides an estimate of the DFR in function of time after application
  - includes oral, dermal and inhalation exposure
  - estimates acute and longer term exposure resulting from single or multiple applications
  - takes account of regional and gender differences
  - provides default values but also allows user inputs (flexibility)
  - has contributed to the understanding of indoor volatilisation by performing volatilisation experiments in vegetable greenhouses as part of the reserve fund work.
  - has a user-friendly software
• The publishing of a scientific paper on the development of the worker exposure models.
Work Package 3: resident and bystander exposure

Summary of technical work completed

The first project milestone was to review existing models and data relating to bystander and resident exposure. This was accomplished by the due date, and was important in informing the subsequent prioritisation of scenarios for model development. The development of a database of the limited amount of exposure data for bystanders and residents that is available was also completed by the due date.

The agreed prioritised scenarios were:

Exposure to spray
- Boom sprayers
  - Field crops,
  - Broadcast air assisted
  - Orchards, fruit, hops, vines

Exposures to vapour
- Outdoor applications

Conceptual models were developed for each of these scenarios. Extensive discussions between partners took place to determine the description of each of these scenarios, in particular factors such as the timescale of exposure, the location of the bystander relative to the treated field(s), the layout of treated fields, the pattern of application.

Boom sprayer model – exposure to spray drift
The following work has been undertaken to complete a model for the assessment of exposure of residents and bystanders to spray from a boom sprayer:

1. Updating of the mechanistic spray drift model which was the basis for the BROWSE model
   1.1. Eliminating software bugs
   1.2. The addition of further spray categories
   1.3. Tailoring model outputs to those required by BROWSE
   1.4. Undertaking model training runs for the development of the emulator and for undertaking a sensitivity analysis
   1.5. Using the results of the sensitivity analyses to refine and improve the spray drift model
   1.6. Complete the first batch of final training runs

2. Reviewing and updating the existing models of bystander and resident behaviour to integrate with the mechanistic spray drift model
   2.1. Reviewing literature on transfer coefficients and turf transferable residues
   2.2. Reviewing literature on human factors, including activity patterns, breathing rates, bodyweight
   2.3. Revising data for collection efficiency of the human body to airborne spray plume, including (through a small reserve fund project) evaluation of the potential effect of movement on the collection efficiency
   2.4. Providing significant input into the development of surveys to obtain data that will supplement published literature and inform the use of the final BROWSE bystander and resident exposure models
   2.5. Integrating available information into a new bystander and resident behaviour component for
3. Developing details of the scenario, and the ranges of input variables and making available the necessary information to allow Fera to begin software development in WP5.
4. Collaboration with Fera on the implementation and testing of the model in the software interface
   4.1. Testing the BROWSE model at stages through its development and identifying software bugs;
   4.2. Producing and supplying to Fera training data for building emulators;
   4.3. Undertaking model runs for exploring model sensitivities and identifying improvements;
   4.4. Developing default inputs for realistic worst case scenarios;
   4.5. Contributing to designing the user-interface.

Broadcast air-assisted sprayers – exposure to spray drift
The spray drift exposure model for broadcast air-assisted orchard and fruit sprayers was completed and delivered to Fera.

1. The database of airborne spray and ground deposit data from the Netherlands was combined with UK data, and analysed to extract relevant data for the exposure models;
2. Algorithms for extrapolating to different distances and different levels of drift reduction were derived;
3. Scenarios for the exposure models were developed;
4. Algorithms and equations for relating spray drift to bystander and resident exposure were defined;
5. A specification for the interface for resident, bystander, operator and worker orchard models was developed;
6. An extensive process of testing the software, identifying and eliminating bugs and implementing improvements has been carried out;
7. A paper outlining the methodology underlying the resident and bystander exposure model was prepared and presented at an international conference.

Exposure to vapour
The vapour exposure model which is part of the boom sprayer, orchard sprayer and worker exposure models was completed and delivered to Fera.

1. Scenarios for resident, bystander and worker were defined;
2. The basis of the exposure model – the PEARL and OPS models coupled together – was provided to Fera;
3. The post-processing algorithms for PEARL-OPS outputs were defined and provided to Fera;
4. The method of integrating into the BROWSE boom sprayer model was defined;
5. An extensive process of testing the software, identifying and eliminating bugs and implementing improvements has been carried out;
6. A comparison of the PEARL-OPS component of the BROWSE software package with experimental data has been undertaken.

Stakeholder and technical workshops
Material was prepared for the stakeholder and technical workshops in October 2013
Overview of the developed BROWSE resident and bystander models

The current BROWSE model for residents and bystanders includes exposure to spray drift from boom and orchard (air blast) sprayers during a spray application, as well as exposure to vapour and deposited spray drift following an application, assuming residents and bystanders are immediately downwind of the application.

The models have three main components:

- the source (i.e. the quantity and characteristics of the active substance emitted into the air)
- dispersion downwind
- interaction with the bystander or resident to determine exposure.

A mechanistic Spray Drift model is used to determine airborne concentrations at different heights and distances downwind from boom spray applications, as well as ground deposits. Due to the time required to run the full model, BROWSE uses an emulator which retains the most important variables influencing spray drift namely: sprayer boom height; spray quality; distance downwind; wind speed; crop height; and forward speed. Spray drift reduction measures and humidity can also be taken into account.

No mechanistic model currently exists that can be used in a regulatory context to predict spray drift and ground deposition for orchard airblast sprayers. Instead, field measurements of spray drift from the Netherlands and the UK are used to determine a potential distribution of airborne and ground deposits of spray drift for a given sprayer type (cross flow or axial fan) and growth stage (dormant, transition, full leaf). The distributions represent variability due to factors such as wind speed, crop size and structure. Empirical models are used to take account of distance and drift reduction.

The emission of vapour from a treated crop is described by the PEARL model, which has been used since
2001 in the EU registration process for leaching to groundwater and tested in volatilisation studies against experimental data. PEARL has been coupled to OPS, which simulates atmospheric dispersion. The combination of PEARL and OPS is used to predict time-dependent air concentration at locations around and within the source field, using five years of real meteorological data from locations identified as worst case (90th percentile of average temperature across the growing season) within each EU regulatory zone. The distribution of meteorological conditions across the five growing seasons results in a distribution of concentrations in air.

The interaction between spray or vapour drift and the resident or bystander is modelled in a similar way to existing regulatory models, with an additional component that relates airborne spray to dermal and inhalation exposure, and using distributions of inputs (such as transfer coefficients, bodyweights, and breathing rates).

Acute exposure over a period of up to 24 hours is considered for residents or bystanders who are adjacent (within 20 m) and downwind of the treated area. Longer term exposure is considered for residents or bystanders who are surrounded by fields on all sides within 20 m, and remain in that location for 365 days a year. For people exposed during spray application, routes of exposure considered are spray coming into contact with their skin (direct dermal exposure) and spray being inhaled (inhalation exposure). For people exposed after spraying, routes considered are breathing in vapour which is emitted from the crop after application (inhalation exposure) and drifting spray settling on the ground followed by skin contact with the contaminated ground (indirect dermal exposure). In both situations, hand-to-mouth contact (ingestion exposure) can also be determined.

Total exposure for a resident or bystander includes all of these exposure routes, added together probabilistically, for both acute and longer-term exposure calculations.

Work Package 3 Highlights
A new mechanistic model was produced for assessing exposures to vapour. The models PEARL and OPS as well as the scenarios for the vapour exposure assessments for residents and bystanders have been implemented in the BROWSE software. The underlying models contain options for refinement that can be made accessible to the user by improving the interface of the BROWSE models in the future. The new vapour exposure model has allowed an investigation into the primary factors driving resident and bystander exposure, and has demonstrated some hitherto unforeseen effects.

A new model was produced for assessing exposures to spray drift from fruit and orchard sprayers. This is based on a database of spray drift data for airborne spray and ground deposits, combined with an empirical approach to determine resident and bystander exposures.

An improved model for exposures to spray drift from boom sprayers has been developed that will be applicable to a very wide range of application conditions across EU member states, allowing a very flexible approach to risk assessment and risk management.

Scenarios for assessment of residents’ and bystanders’ exposure to agricultural pesticides have been developed and suggested default model inputs have been justified and documented.
A technical document defining all aspects of the model has been prepared.

Work Package 4: stakeholder and gender issues
Summary of technical work completed

Deliverables 4.1 (Stakeholder database finalised) and 4.2 (Report on initial stakeholder workshop)
A stakeholder workshop was held in Brussels in April 2011. A total of 27 stakeholders participated across different EU member states, types of institutional affiliation (industry, regulators, NGOs, trade unions and academics) and expertise (risk assessment, risk communication, policy). The workshop focused on the views of the stakeholders regarding the scope, focus, objectives and priorities of the Browse project, on their expectations regarding the project outcomes and on the implications of these outcomes for policy, operator and worker training and risk communication with residents, and bystanders. A report summarizing the main conclusions was delivered.

Aims under milestone 4 were also achieved. Newcastle developed the survey questionnaires for each stakeholder group (B,R,W,O) in collaboration with modellers from WP1, WP2 and WP3 plus additional contributions from Fera, BPI and UCSC and review by the chair of the BROWSE Advisory Panel. The priority crops per country were also identified and refinements were made accordingly:
- Greece: Greenhouse vegetables and olives
- Italy: Wine grapes
- UK: Arable crops

Each questionnaire consists of a modelling part measuring exposure to pesticides and a socio-economics part eliciting people’s attitudes and risk perceptions. A protocol for data collection was also developed to ensure consistency of the sampling procedures across countries. The protocol was communicated to Greek and Italian partners and Newcastle visited the partner institutions in the two countries to train the interviewers and discuss the sampling guidelines.

Deliverable 4.3 First results from stakeholder surveys available for modelling
This deliverable was completed and the data made available for modelling. A scientific paper on the results from these surveys was completed (see D4.4 below).

Deliverable 4.4 Scientific paper on the results of the stakeholder surveys
This paper has been finalised and is in press for the journal “Science of the Total Environment”. (K. Remoundou, M. Brennan, G. Sacchettini, L. Panzone, M.C. Butler-Ellis, E. Capri, A. Charistou, E. Chaideftou, M.G. Gerritsen-Ebben, K. Machera, P. Spanoghe, R. Glass, Marchis, A. Hart and L.J. Frewer). Perceptions of pesticides exposure risks by Operators, Workers, Residents and Bystanders in Greece, Italy and the UK. The late delivery of this paper was due to the need to link perception data collected in the surveys with exposure data from the modelling work packages.

Deliverable 4.5 Report on final evaluative stakeholder workshop
This has been completed and submitted

Deliverable 4.6 Scientific paper on test of training and communication materials.
This deliverable has been split into two reports, 1 now published as a scientific paper. The first focused on the feasibility of using pictograms as a communication tool for workers, operators, residents and bystanders. (Emery, S. B., Hart, A., Butler-Ellis, C., Gerritsen-Ebben, M. G., Machera, K.,
Work Package 4 Highlights
Risk perceptions, knowledge and attitudes associated with passive and occupational exposure to pesticide potentially influence the extent to which different stakeholders adopt self-protective behaviour. A methodology for assessing the link between attitudes, adoption of self-protective behaviours and exposure was developed and tested. A survey was implemented in the Greece, Italy and the UK, and targeted stakeholders associated with pesticide exposure linked to orchards, greenhouse crops and arable crops respectively. The survey examined different stakeholders’ perceived levels of risk from exposure to pesticides, and their global attitudes regarding pesticides use. Examination of the factors affecting individual’s inclination to engage in self-protective behaviour was made. These were linked to exposure estimates for workers and operators, although data were not available for residents and bystanders. The results indicated that the adoption of protective measures is low for residents and bystanders when compared to operators and workers, who tend to follow recommended safety practices. A regression analysis conducted using the data obtained for residents and bystanders suggested that the likelihood of engaging in self-protective behaviour is not significantly affected by their perception that their own health has been affected by pesticides. However, individuals caring less about the future tended not to adopt protective behaviours. Gender and country differences were also found in the case of residents. Perceptions about health risks were found to significantly affect the level of operators’ exposure with individuals who believed that their health had been negatively affected by exposure to pesticides having higher exposure to pesticides. Recommendations for improved communication include the need for specific focus on vulnerable groups. Little is known about how to effectively communicate to residents and bystanders in particular.

The literature was reviewed to assess the understanding and interpretation of pictograms used in pesticide exposure risk communication, and to assess the results in the context of the new EU regulatory context for the sustainable use of pesticides. The results indicate that the understanding of pictograms used on pesticide labels by workers and operators is generally low. Standardised approaches, contrary to their claims, are not easily understandable, culturally neutral, or universally understood. Although there is scope for the greater use of pictograms in training, it is important to stress that they should never replace full and frequent verbal training in a language understood by the trainee. They can, however, be used to complement training, facilitate recall and encourage compliance. Whilst the policy affecting the handling, labelling, and use of pesticides is applied across the EU, there has been no analysis of the different types of pictograms that have been used in the European context, nor the different ways that they are employed (e.g. on labels, on signs, during training), nor understanding of their meaning by European workers and operators. Furthermore, the implications for risk with residents and bystanders are less clear than for workers and operators.

Work Package 5: effective tools to support the implementation of the PPP authorisation regulation 1107/2009

Summary of technical work completed
Task T5.1 Consultation with stakeholders on priorities for BROWSE contributions to implementation of Regulation 1107/2009

A contact point was established on the project website for stakeholder and end-user enquiries about BROWSE activities relating to development of exposure models for use under Regulation 1107/2009.

The first consultation with stakeholders occurred as part of the initial stakeholder workshop (see WP4 for details). Presentations were given including a brief review of the state of the art relating to guidance and tools for regulatory assessment of operator, worker, resident and bystander exposure, and a summary of the proposed plans for WP5. The feedback from the workshop was used by Fera in planning the consultation with selected stakeholders on the detailed plans for WP5.

Fera organised a Stakeholder Workshop on software for exposure assessment which focused on developing the detailed plans for the primary deliverables of WP5, i.e. user-friendly software and contributions to future revision of EU guidance. The workshop was attended by a wide range of stakeholders, including regulators and industry. The report of the initial stakeholder workshop (produced by WP4) was distributed to participants before the meeting, together with draft proposals for how WPs 1, 2, 3 and 6 planned to address stakeholder requirements expressed at the workshop, and a draft design specification and prototype version of the BROWSE software user-interface.

At this one-day Workshop, the stakeholders provided proposals for changes or improvements, and feedback on the various options for design presented at the meeting. Participants expressed a preference for the software to be delivered as a standalone application with a Windows-style interface, for users to download from the BROWSE website. Many detailed suggestions were made regarding the detailed design of the interface, including options for data input and the formatting of outputs. A report containing detailed results of the consultations and draft conclusions on their implications for the subsequent tasks of WP5 and other WPs, was prepared for discussion by partners at project meeting 3 and was submitted to the Commission (D5.1).

T5.2 Design and implementation of user-interface for BROWSE exposure model software

A design for the software user-interface was developed in the Java programming language using the feedback from the software workshop and inputs from the modelling work packages (WPs 1 – 3). The design was distributed to project partners for discussion at project meeting 4. Following the project meeting, the design was further revised and was submitted to the Commission (D5.2).

T5.3 Design and implementation of BROWSE exposure model code

The BROWSE exposure models detailed in Table 1 were implemented in Java. These were implemented as alternative options within a single integrated software module (subject to consultation with stakeholders). The software is delivered in executable form suitable for downloading, installation and running as standalone executable programmes on end-users’ personal computers.

Alpha-testing: the model code and software were rigorously tested for bugs by Fera using a variety of techniques including unit testing.

Beta-testing: once a stable version of the tool had been developed, the tool was distributed (via secure link on project website) to project partners to test and evaluate. The outputs from the Java model code were
validated by comparison with results produced from the original development models in WP 1-3 by both Fera and the individual work packages. Feedback from partners was used to locate and correct bugs and implement improvements in function and user-friendliness. In addition to this, extensive testing and comparison to existing models was carried out by BPI and is reported in deliverables 1.4 2.4 3.4 and 5.4. A workshop for end-users was organised by Fera in collaboration with all BROWSE partners in month 34, to carry out further evaluation and testing of the software. The workshop was held in Brussels, which is a location convenient for the primary end-users from EFSA, national authorities and industry. The workshop was timed to immediately precede the stakeholder workshop (see deliverable 4.5) to ensure the maximum number of participants. The Participants were asked to bring their own laptops to test the installation, functioning and usability of the software and the suitability of the accompanying guidance and training materials (produced in T 5.4). Feedback from the workshop was used to further refine and improve the software, guidance and training materials.

The final version of the end-user software for use in support of Directive 1107/2009 was delivered to end-users at the end of the project (month 46). It is available on the project website along with necessary documentation to use software and understand the underlying models (deliverables 1.4 2.4 3.4 and 5.4)

T 5.4 Development of documentation and training materials for the BROWSE exposure model software and draft guidance on the potential application of BROWSE outputs under Directive 1107/2009

• Documentation and training material for use of the BROWSE software has been developed by Fera with contributions from other partners. Appropriate technical details (e.g. regarding selection of data inputs, interpretation of outputs), background information (e.g. overview and references on modelling approaches), and worked examples have been provided by WPs 1-3 (TNO, Ugent, TAG) and is provided in the technical documents from each work package. A training manual was developed by Fera, containing step-by-step instructions and examples for new users of the software. The materials have been implemented as an appropriate combination of ‘tool tips’ (in the software) and documents (pdf downloads on the project website). Initial drafts of the materials were reviewed by partners prior to the final software workshop and then by end-users, stakeholders and the Advisory Panel at that workshop. The materials were revised and improved taking into account the feedback received and the final versions were delivered to end-users alongside the software on the project website.

• It is recognised that, before the BROWSE model software could fully contribute to the implementation of Directive 1107/2009, they would need to be reviewed and accepted by the relevant authorities and incorporated into future revisions of the EU guidance document on risk assessment for operators, workers, residents and bystanders. To assist this process, Deliverable 5.5 provides an overview of the BROWSE models and discusses what steps would need to be taken to evaluate and implement them within EU regulatory assessment, including potential implications for future revisions of EU guidance.

Work Package 5 Highlights

New and improved exposure models developed in Work Packages 1-3 have been implemented into software in order to contribute to the implementation of the PPP authorisation Regulation 1107/2009, replacing Directive 91/414/EC.

The BROWSE models were implemented in user-friendly software, which is intended to be suitable for use in regulatory risk assessment. The software is publicly available, together with supporting user guidance and technical documentation underpinning scientific justification for the use of the newly developed
approaches, data and tools. These materials are available on the project website (https://secure.fera.defra.gov.uk/browse/software/). A screenshot of part of the software is shown in Figure 4.

Stakeholder workshops resulted in very good attendance by a wide range of stakeholders. Participants reacted positively to the software whilst providing detailed feedback and suggestions for changes that they would like to see. These suggestions were taken into account in refining the final implementation. BROWSE activities have been coordinated to maximise the suitability of the exposure models and software for regulatory use in the EU, within the context of the new plant protection products Regulation 1107/2009 (replacing Directive 91/414);

Work Package 6: effective tools to support the implementation of the sustainable use directive
Summary of technical work completed

Task T6.1 Consultation with stakeholders to refine and prioritise plans for BROWSE contributions to implementation of the Thematic Strategy on Sustainable Use of Pesticides
A consultation process was undertaken to identify stakeholder priorities in order to develop activities that could be efficiently integrated with the existing materials, initiatives and experiences. The consultation was held in two phases: A first consultation with stakeholders (Brussels 14-15 April 2011) and a second consultation with stakeholders (Brussels 14th-15th December 2011).

In both phases several questions have been asked (through an electronic multiple-choice questionnaire) and discussed (through several debates) in order to get opinions about how BROWSE should develop new training and communication material for awareness raising as well as new risk indicators.

The stakeholders invited for the stakeholder consultation process were selected from a database specifically established for BROWSE (D4.1) and included about 400 key stakeholders drawn from academia, the policy community, industry, and the NGO community.

During the process the latest information was gathered on current activities and initiatives, including activities of the Commission, Member States, ECPA and trade unions. In particular, regarding training and awareness raising, relevant information was obtained about related EU projects (EcoPest, HydroSense, sage10), other training initiatives made by ECPA (Safe & Sustainable Use Initiatives, Safe Disposal, TOPPS PROWADIS, Illegal use) and by ENDURE (such as the EU project PURE). Furthermore, it was also possible to discuss the situation about training and awareness raising in the frame of the SUD requirements in some of the EU countries (Greece, Spain, Germany, Poland). On the other hand, regarding risk indicators, work has been founded on previous risk indicator experience on pesticide use (focused on the HAIR project, the Arcadis report, the HAir Repair Project/HARP and the Dutch approach).

Results are described in detail in D6.1.

T 6.2. Development of risk indicators
The framework used in this task was mainly focussed on the use of the results of three different but
interconnected activities developed in the frame of the European project BROWSE: a stakeholder consultation process (T6.1) the development of new exposure predictive models (WP 1-3) and the implementation of systematic surveys “on the field” (T4.2). Taking into account their outcomes, it was decided to develop specific toolboxes of practical indirect risk indicators to reduce Operators, Workers, Bystanders and Residents exposure to be used by Member States (MSs) based on their specific context. Detailed description of the method used and outcome obtained can be found in the scientific paper produced (D6.2) and that is currently under review in Pest Management Science http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1526-4998/homepage/ForAuthors.html.

T 6.3 Contribution to development of databases for harmonised risk indicators
UCSC produced detailed specifications of the data required to use the BROWSE indicators, so that this can be taken into account by other organisations (possibly EFSA or EUROSTAT) responsible for developing databases to support harmonised EU indicators. In PM3 it was decided that the BROWSE reserve fund would not be used to contribute directly to the development of such database, but instead used for other studies aimed at providing additional data for exposure modelling.

T 6.4. Development and dissemination of communication materials for training and awareness-raising
Following the outcome of the stakeholder consultation (T6.1) and taking into account the resources available (see D6.2) in PM4 it was decided to focus the efforts in developing a new e-training resource included in a new open website platform called OpenTEA (Open Training and Education Association). The main objective of this activity was to build a transparent science based platform to be used by the different stakeholders involved in the use of pesticides (i.e. farmers, trainers, industries, academia, etc). The e-training course and the platform were developed in their structure and in their contents through the collaboration of all the partners of the consortium as well as the involvement of stakeholders along all the entire process. Indeed, the first complete version of the course/platform was presented in Brussels during the BROWSE final stakeholder workshop (see D4.5) where important comments have been taken into account to develop a refined version which was scientifically evaluated by UNEW involving a selected group of stakeholders and likely users in the frame of WP4 (see D4.4). Feedback from this evaluation were used for the implementation of final adjustments that have been finalised in September 2014. Detailed description of the method used and outcome obtained can be found in D6.5.

Work Package 6 Highlights
‘OpenTEA’ Online Training Platform
A new e-training platform has been developed within the ‘OpenTEA’ framework called “Sustainable use of Plant Protection Products”. The main objective in its development was to provide a transparent science-based training platform to the different stakeholders involved in the use of pesticides. A screen shot of the home page (http://www.opentea.eu/) is shown in figure 5.
This is an interactive resource that allows users to search and view a wide range of training materials and includes a facility enabling users to select materials of interest and combine them to create new programmes of training, customised to their particular needs and audiences. Not only does it enable Web-Users to access and use the contents, but it allows them to make comments,
vote and offer feedback on these. Furthermore, Web-Users are able to upload new materials (subject to review) and build training programmes to meet their individual needs. It is anticipated that as the ‘OpenTEA’ platform grows, so will the wealth of information and training materials available to users and it is envisaged that it will become an important network for users to refer to for pesticide-related information. Because of the limited resources available in the project, the training materials are currently only available in English, but it is structured in a way that in the future could be easily modified to include other language options.

The training platform has been structured to collect, integrate and discuss the most efficient and scientifically-sound training materials concerning sustainability in the use of plant protection products, taking into account the needs identified during a stakeholder consultation. The final version of the platform was then scientifically evaluated through a further stakeholder consultation. Feedback from this evaluation was used to make final adjustments.

A paper has been published on the approach taken to developing the OpenTEA concept: The stakeholder-consultation process in developing training and awareness-raising material within the framework of the EU Directive on Sustainable Use of Pesticides: The case of the EU-project BROWSE. G Sacchettini, M Calliera, A Marchis, L Lamastra, E Capri. Science of The Total Environment, 438: 278–285.


The objective of this study was to make a useful and robust contribution to the development of new and improved risk indicators, addressing the new legal requirements in the EU Directive on the sustainable use of pesticides (EU128/2009/EC). For this reason, it was decided to develop specific toolboxes of practical indirect risk indicators referring to each group of people (Operators, Workers, Resident and Bystander) exposed to pesticide following the definition used by EFSA.

In order to address this objective a stakeholder consultation process was used to identify appropriate approaches and priorities in order to develop risk indicators that could be efficiently integrated with the existing needs, initiatives and experiences. Stakeholders felt that existing indicators for pesticides did not reflect actual effects on health and that additional, pragmatic indicators are needed.

Exposure models were analysed to identify the main key factors and mechanisms influencing exposure as well as the most appropriate mitigation measures that could be applied for each category (Operators, Workers, Resident and Bystander). Finally, systematic interview surveys were conducted “in the field” to obtain quantitative data on potential socio-behavioural factors influencing exposure of residents, bystanders, operators and workers to PPPs (i.e. information about behaviours, estimate exposures and how/if these are influenced by perceptions).

The output of this work was a new approach, using indirect behavioural indicators that do not attempt to measure risk directly but instead are measures of progress in actions to reduce risk, such as training for farmers and operators, improved application techniques, procedures for handling pesticides and disposing of waste, etc. The paper includes example sets of indirect indicators for measuring progress in reducing risks to operators, workers and residents and bystanders. These are intended for use by the competent EU Member State authorities as the basis for a common approach for developing new indicators to measure and verify the impact of their risk reduction initiatives.
Potential Impact:

Stakeholders and End-users

Relevant stakeholder groups for the project were identified in an initial stakeholder analysis and engaged in the project through a series of workshops at key points in the workplan. Stakeholders for pesticide use in the EU include: the general public (as residents and bystanders, as consumers of food, and as non-professional users of pesticides); operators; workers; farmers; agricultural consultants and extension services; businesses involved in the production, marketing, sale and distribution of pesticides; national governments (including health, agriculture and food authorities); the European Food Safety Authority and the European Commission. European Union (EU) -level stakeholder organisations include: the pesticide industry association ECPA; the NGO Pesticides Action Network (including PAN-Europe); and relevant trade unions (including the European Federation of Trade Unions in the Food, Agriculture and Tourism sectors, EFFAT, and COPACOGECA, representing associations of farmers and agri-cooperatives). International stakeholder organisations include OECD, FAO, WHO, and regulatory authorities in other countries (e.g. US Environmental Protection Agency).

Potential end-users for the BROWSE exposure models and software include: exposure assessors in EFSA; national regulatory authorities; pesticide companies; contract research organisations and consultancies; the European Commission (DG SANCO and DG Environment). Potential end-users for the OpenTEA training platform and risk indicator methodology include the European Commission (DG SANCO and DG Environment); authorities responsible for National Action Plans; organisations involved in training of pesticide operators, recipients of training (including farmers and farm workers); and the general public (as users of communication outputs of BROWSE).

Awareness

The primary audiences and end-users for the principal results of the project are the EU and national authorities involved in implementation of the Authorisation Directive and Sustainable Use Directive, the pesticide industry and NGOs with an interest in pesticide risks and regulation. The BROWSE project team have undertaken a programme of dissemination and outreach activities to raise awareness of the project among the key stakeholder and end user groups identified in the preceding section, and further activities are planned to continue this after the project (see Deliverable D7.5 dissemination strategy). These dissemination and outreach activities have included the following:

14/04/2011 The first BROWSE stakeholder workshop, Brussels
24/06/2011 International Symposium on Crop Protection, Ghent University
30/08/2011 XIV Symposium in Pesticide Chemistry, Piacenza
08/09/2011 AgChem Forum STREAM 2 Human Safety, Barcelona
17/11/2011 The first BROWSE Software stakeholder consultation, Brussels
06/12/2011 BROWSE project partners meet with Advisory Panel, Wageningen, The Netherlands
14/12/2011 The BROWSE Stakeholder Workshop: Training Materials for Sustainable Use Directive and Indicators, Brussels
10/01/2012 Meeting: International Advances in Pesticide Application, Wageningen
22/05/2012 International Symposium on Crop Protection, Ghent
12/06/2012 Conference on Safe and Sustainable Use of Pesticides, Romania
17/06/2012 EUROTOX Congress of the European Societies of Toxicology, Stockholm
02/07/2012 7th International Conference on the Science of Exposure Assessment, Edinburgh
06/09/2012 AgChem Forum, Barcelona
Pesticide operators, agricultural workers and members of the public including bystanders and residents are secondary audiences for BROWSE, as they are addressed indirectly through the dissemination, training and communication programmes of the EU and national authorities, the pesticide industry, and relevant trades unions and NGOs. Awareness of the project among these groups has been promoted via the BROWSE website (www.browse-project.eu) providing the public deliverables of the project as well as by providing background information on the project and news items on project activities and outputs. Further awareness is generated by links to the BROWSE project from the OpenTEA e-training platform.

Societal impact and implications
Contribution to expected impacts listed in the work programme
The Expected Impacts listed in the Work Programme for this topic (ENV.2010.1.2.3-1) were as follows: ‘The project will contribute to the implementation of revision of data requirements of the Directive 91/414/EEC and the Thematic Strategy on the Sustainable Use of Pesticides’. Directive 91/414/EEC has now been replaced by Regulation 1107/2009 on authorisation of PPPs, while the Thematic Strategy is being implemented through the Sustainable Use Directive 2009/128/EC. BROWSE was therefore specifically designed to make major contributions to the implementation of both the Authorisation Regulation (1107/2009) and the Sustainable Use Directive (2009/128/EC).

The specific areas in which the project results are expected to have impact are:
• Improved assessment of exposure and risk for operators, workers, residents and bystanders for use in the risk assessment of PPPs at EU and national level, enabling an appropriately high level of protection for human health, with particular attention to vulnerable groups of the population including pregnant women, infants and children (contribution to implementation of Regulation 1107/2009). This was addressed by developing new and improved exposure models for operators, workers, residents and bystanders, for an extended range of EU scenarios, taking account of the needs and priorities of stakeholders and end-users (as identified through stakeholder workshops organised by the project), and by delivering the models to all relevant end-users as freely-available, user-friendly software accompanied by user instructions and detailed technical documentation.
• Contribution to mutual recognition of exposure and risk assessments for operators, workers, residents
and bystanders, enabling reduction in the administrative burden for Member States and industry, providing for more harmonised availability and reduced obstacles to trade for plant protection products (contribution to implementation of Regulation 1107/2009). This was addressed by involving relevant stakeholders in EU and national authorities and industry, to ensure that the models, software and guidance produced by the project are designed to maximise harmonised uptake and use by national authorities and promote mutual recognition of risk assessments. In addition, the participation of US Environmental Protection Agency on the BROWSE Advisory Panel was intended to contribute to promoting harmonisation at international level.

- Improved training and awareness of pesticide operators and of workers in pesticide-treated areas, promoting improved application and working practices and hence reductions in risk to health of operators and workers, and also of bystanders and residents (contribution to implementation of Sustainable Use Directive 2009/128/EC). This was addressed by developing the e-training platform OpenTEA, facilitating access to and use of existing training materials to develop customised training for operators and workers in sustainable pesticide use and risk reduction practices.

- Improved indicators for the Commission and national authorities to monitor progress in the reduction of pesticide risks to operators, workers, residents and bystanders, enabling better-informed decisions on future implementation and adjustments to risk reduction policy and strategies (contribution to implementation of Sustainable Use Directive 2009/128/EC). This was achieved by developing a new approach using indirect, behavioural risk indicators designed for use by authorities at EU and national level.

Steps taken to bring about these impacts

The main steps taken during the BROWSE project to bring about the expected impacts were:

- Successful completion of the project outputs: new and improved exposure models, implemented as user-friendly software; a new e-training platform; a new approach to pesticide risk indicators; and new methodology for research on the link between risk perception, attitudes and protective behaviours.

- Steps to maximise the likelihood of uptake of the results by end users including EU and national authorities, industry and other stakeholders. This included:
  - Involvement of national, EU level and industry end-users and stakeholders in the project, including direct participation in the Advisory Panel and in the stakeholder workshops and consultations during the project;
  - Consortium members’ contacts with key organisations including the European Food Safety Authority, national authorities and pesticide companies;
  - Meetings with the key pesticide industry association, ECPA;
  - Numerous presentations at conferences and workshops attended by members of the key end-user groups.
  - Publication of results in scientific journals, providing wider scientific support for uptake in regulatory practice.

Account taken of other national and international activities

Many of the project consortium members had been involved with the most important developments in this area in previous national and international projects (EUROPOEM, ART, Article 36 project for EFSA, BREAM, etc.) and continue to be directly involved with the advancement of exposure assessment science taking place within national authorities and EFSA, including the development of draft EU guidance for assessment of risks to operators, workers, bystanders and residents (Hamey et al. 2008, EFSA 2009, EFSA 2014). All of this knowledge and progress has been taken into account in the implementation of the project.

In addition, strong links were established with the FP7 project ACROPOLIS (on models for assessment of
aggregate and cumulative pesticide risks), promoted by the direct involvement of the Coordinator of ACROPOLIS in the BROWSE Advisory Panel. In addition, 2 BROWSE partners were also partners in ACROPOLIS, and used their dual role to maximise integration between these two projects.

External factors that will influence achievement of impacts
The main external factor that will influence the achievement of the expected impacts is acceptance of the project outputs of by EU and national authorities, industry and other stakeholders. Steps have been taken during the project to maximise the prospects for acceptance by direct involvement of all these stakeholders in the project, including workshops, consultations and evaluations organised during the project and the representation of these stakeholder groups in the Advisory Panel.

List of Websites:
www.browseproject.eu
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