FOOTPRINT

SIXTH FRAMEWORK PROGRAMME

Functional Tools for Pesticide Risk Assessment and Management

FOOTPRINT Newsletter 2007

In this issue:

Editorial by Professor Bob Breach

Modern approaches to water quality and environmental management are increasingly focussing on the need to better understand and mitigate risks. This reflects the fact that risks vary considerably, both spatially and over time, and thus a "one size fits all" approach to environmental management is not cost effective.

However for such flexible risk based approaches to work effectively it is becoming more and more important to have both regulatory systems and tools which encourage and facilitate their adoption.

The benefit of risk based management systems is well illustrated by ways being developed to manage the environmental impact of pesticides. There has been strict control of pesticide approval for many years in Europe, but historically this has not reflected the great variation in the routes by which pesticides can reach the aquatic environment and the many factors that can influence this.

The FOOTPRINT project is developing a range of tools that can better support an understanding of pesticide leaching risks at national, catchment and farm scale. In conjunction with the draft EU Framework Directive for the sustainable use of pesticides it is hoped that this will provide a much better way for future environmentally sustainable crop protection.

But such tools can only bring real benefit if in parallel it is recognised that land management must become more dynamic to take account of the variable impact of weather on leaching risks

Bob Breach is an independent water quality and environmental consultant. Bob has worked in the water sector for over 30 years most of which was with Severn Trent Water, one the largest UK water companies. During his career, Bob has been active at national and international level with a recognised expertise in water quality and water resource protection. Bob is a Level-1 member of the FOOTPRINT Advisory Committee.

Professor Bob Breach MBE. BSc. PhD. MCIWEM.

Looking back at 2006

2006 will be remembered for years by the FOOTPRINT partners. It is often considered that EU projects tend to have a round of observation when project partners get to know each other and work together effectively. This has not been the case in FOOTPRINT. Much progress in understanding each other and everyone's contribution had already been achieved in the 'FOOTPRINT week' organised on 20-24 February 2006. This was completed by regular remote or 'in flesh' technical meetings to discuss key points in the project. All this has contributed to all 11 first project deliverables from the first year being submitted to the EC on time.

All FOOTPRINT members have displayed a great enthusiasm for the project and this has transpired outside the consortium in several instances. May I take this opportunity to thank all of them for their impressive dedication and contribution to the project.

A significant effort has been put in 2006 into communicating about the project and the reception to the FOOTPRINT science and tools has been very positive in all conferences which were attended. The 260 individuals currently registered with the FOOTPRINT Announcement List are a testimony to the vast international interest in FOOTPRINT.

2007 will be a very important year for the project as it will see the birth of the FOOT tools in the form of their Beta versions. Developing computerised tools in such a short time was always to be a challenge, but the FOOTPRINT tool developers are ready to face it and will work intensively during the year to achieve these goals.

2007 will also be mid-term of the project and already the time to think about the post-FOOTPRINT. Numerous suggestions have already been made to improve the FOOT tools and we are therefore confident that so much interest and proposition capacity will lead to various sponsors contributing to the long-term viability of the FOOTPRINT tools.

Igor Dubus FOOTPRINT Co-ordinator

Credits & Acknowledgements:

Editor: G. Azimonti (giovanna.azimonti@icps.it)

Director of publication: I.G. Dubus (i.dubus@brgm.fr)

Date of Publication: First Semester 2007

The funding of FOOTPRINT by the European Commission through its 6th Framework Programme is gratefully acknowledged

The EU project FOOTPRINT

FOOTPRINT (Functional TOOls for Pesticide RIsk assessmeNt and managemenT) is a new three-year research project, funded by the European Union, whose aim is to support EU policies with regard to pesticide risk evaluation and reduction in Europe.
The project aims at developing a suite of three pesticide risk prediction and management tools, to be used by three different end-user communities:

- farmers and extension advisors (farm scale)
- water managers (catchment scale)
- policy makers/registration authorities (national/EU scale).

The tools will allow users to:

- identify the dominant contamination pathways and sources of pesticide contamination in the landscape;
- estimate pesticide concentrations in local groundwater resources and surface water abstraction sources; and,
- make scientifically-based assessments of how the implementation of mitigation strategies would reduce pesticide contamination of adjacent water resources. (FOOTPRINT Tools).

The predictive reliability and usability of the tools will be assessed, as part of the project, through a substantial programme of piloting and evaluation tests at the field, farm, catchment and national scales.
As a major improvement over current risk assessment procedures for pesticides, the project will provide a characterisation of all EU agricultural land, using a large number of generic, effectively homogeneous agro-environmental scenarios covering the diversity in European agricultural and environmental conditions (FOOTPRINT scenarios).

The FOOTPRINT consortium is made of 15 partners, which altogether represent the multidisciplinary and complementary critical mass required to fulfil the project objectives.
The 15 partners from 9 European countries have a proven track record in undertaking research to understand the fate of pesticides in the environment and putting together software tools to evaluate the risk of pesticides impacting on water resources. (FOOTPRINT Partners)

The project is expected to become a powerful tool in decision–making for different end-users, as it will develop new approaches to identify 'hot spots' for pesticide contamination in the landscape and to convert local leaching and small water body concentrations into concentrations likely to be observed in local groundwater resources and surface water abstraction sources.

More information about the project can be found at http://www.eu-footprint.org

3 FOOT tools for 3 end-user communities

FOOT-FS

FOOT-FS is the FOOTPRINT farm-scale tool and is mainly intended for use by farmers and extension advisers. It aims to assist in the development of environmentally sound pesticide strategies for the farm by identifying the activities and pathways that most contribute to the contamination of water resources. It will also provide site-specific recommendations to limit transfers of pesticides in the local agricultural landscape.
FOOT-FS will be available in two formats. Firstly a stand-alone software system will be developed in Microsoft Visual Basic. A web portal to the system will also be developed. In addition both versions will be available in a range of European languages including English, French, Italian, German and Danish.
A classification of the agricultural land will be performed according to the pathways leading to contamination of water resources by pesticides. The prediction of pesticide concentrations in leaching and runoff/erosion will rely on the deterministic models (MACRO and PRZM) while simpler, more pragmatic, approaches will be used for assessing pesticide inputs via spray drift and point sources (storage places, farmyards).

FOOT-CRS

FOOT-CRS is the catchment and regional-scale tool and will be available as an ArcGIS extension. FOOT-CRS is mainly targeted at water managers, local authorities and stewardship managers.

The main objectives of the FOOT-CRS tool are to:

- identify those areas that most contribute to pollution of waters by pesticides
- define and/or optimise action plans at the scale of the catchment.

The tool will contain two main parts with different outputs:

- The "landscape analysis" part will provide a map showing the spatial distribution of the dominant pesticide contamination pathways (i.e. leaching, drainflow, runoff/ erosion, drift) in the catchment of concern. The classification of the agricultural land according to the pathways leading to contamination of water resources by pesticides will be based on remote sensing data (satellite imagery or aerial photos) and an adaptation of the HOST/CORPEN methodology used in the farm-scale tool FOOT-FS.
- The "diagnostic" part will address the location of hot spots in the catchment, the potential risk in the catchment for groundwater resources together with the identification of possible mitigation measures.
- The estimation of pesticide concentrations due to leaching, drainage and surface runoff/ erosion will rely on the deterministic models MACRO and PRZM while simpler, more pragmatic approaches will be used for assessing pesticide inputs via spray drift and point sources.

FOOT-NES

FOOT-NES is the national and EU-scale tool and will be available as an ArcGIS extension. FOOT-NES is mainly targeted at decision and policy makers, but has also relevance to the registration context. The tool will have the potential to support the pesticide registration authorities and the crop protection industry for higher-tier modelling purposes.
The main objectives of the FOOT-NES tool are to:

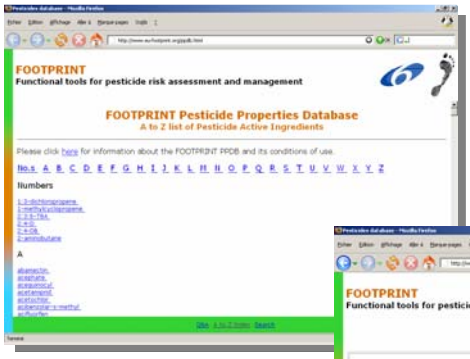
- identify the areas most at risk from pesticide contamination
- assess the probability of pesticide concentrations exceeding legal or ecotoxicologically-based thresholds.

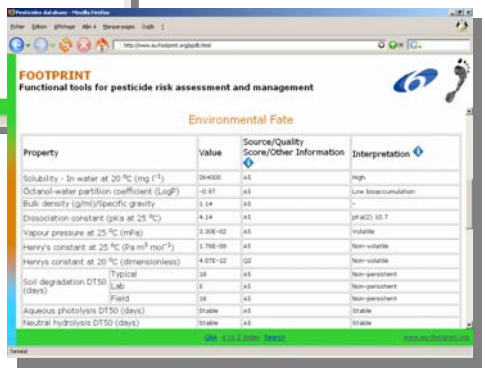
As well as in FOOT-CRS, the estimation of pesticide concentrations due to leaching, drainage and surface runoff/erosion will rely on the deterministic models MACRO and PRZM while simpler, more pragmatic approaches will be used for assessing pesticide inputs via spray drift and point sources. Predicted concentrations in surface water will allow risk assessments to be performed for aquatic taxa as FOOT-NES will include a database of ecotoxicological threshold values for fish, invertebrates, higher aquatic plants and algae (FOOTPRINT PPDB).
The user will have the option to use the FOOTPRINT metamodels of MACRO and PRZM

The FOOTPRINT PPDB

FOOTPRINT PPDB is a comprehensive database of physicochemical and toxicological data relating to pesticide active substances. As the pesticide fate and risk models within the FOOT-tools will use the data in the database it is important that the data are of the highest quality possible. The best sources of information currently available are the monographs produced as part of the EU 91/414 review process.

These documents are the first choice for data but as they are not available for all pesticides, alternative sources of data are used including national government resources, manufacturers, online databases and peer reviewed scientific publications. Data sets are cross-checked against each other as a means of ensuring data integrity. Where different sources of data have widely different values, these are validated by comparison with the original publications wherever possible. The database will be actively updated as additional information is identified and new and/or better data becomes available. Each data item is 'tagged' with a code indicating the confidence the developers have in its quality. Confidence values are in the range 5 (high) to 0 (low). A low value will not necessarily indicate that the data is incorrect but only that it can not or has not been validated.





The database holds:

- General data describing the chemical such as its appearance, chemical structure and formula and in which EU States it is registered for use.
- Environmental fate data. For example the pesticide octanol-water partition coefficient (Log P), sorption distribution coefficient (K_{oc}) and soil dissipation half-life (DT_{50}).
- Ecotoxicological data. For example acute and chronic endpoint data for fish, aquatic invertebrates and aquatic plants.

This database will be embedded into the FOOT-FS and FOOT-CRS software packages in MS Access 2000 format. The database is also available online at:

http://www.eu-footprint.org/ppdb.html

Introducing SUGAR - the SUrface water / GroundwAter contRibution index

Large-scale vulnerability assessments are typically based on the combination of GIS data such as climate, land use, soils, underlying geology (the 'overlay methodology). The main limitations of the approach are that:

i. the method requires detailed data to be available for all regions of interest;
ii. the combination of information layers is typically done subjectively, hence subject to much uncertainty;
iii. any validation of the results is difficult to undertake.

As part of FOOTPRINT, we are extending a methodology developed by BRGM in France in the mid-1990s ('IDPR') to develop an index ('SUGAR', for SUrface water / GroundwATer contribution index) which describes the relative contribution of rainfall to surface water and groundwater recharge. The main advantage of the method is that it has very low data requirements in that it only requires a Digital Elevation Model and a drainage network dataset.

The methodology is based on the comparison of an artificial drainage network obtained using the DEM and the real drainage network. The methodology despite having low data requirements has proved to be consistent with expert knowledge and results of more complex assessment methods.

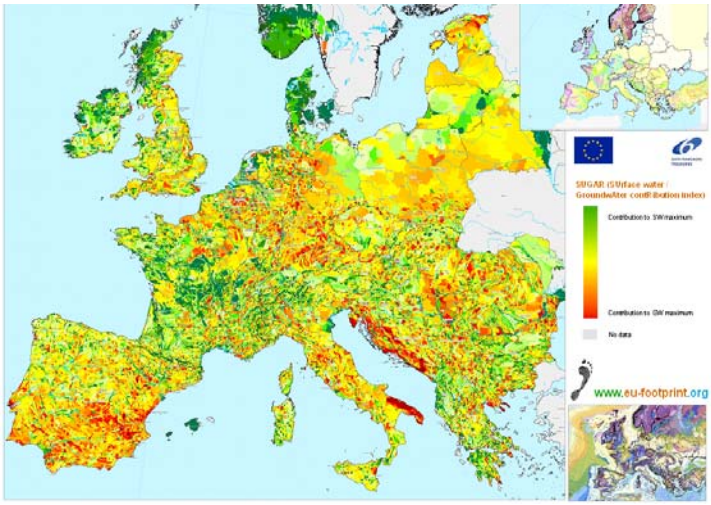
The map below shows interim results obtained when combining the SRTM 90m × 90m DEM with the 1:1,000,000 DCW drainage network dataset. The map can help:

i. to undertake vulnerability assessments for water bodies,
ii. to design/optimise monitoring programmes and
iii. To identify a priori the most effective areas to limit pesticide contamination of water resources.

The SUGAR methodology is suited to applications at the catchment scale and we are now looking at validating the SUGAR approach at this scale using high resolution drainage network datasets (1:100,000 or less).

If you possess such data and would be interested in gaining a map of SUGAR for your area, please feel free to contact Igor Dubus (i.dubus@brgm.fr) and Vincent Mardhel (v.mardhel@brgm.fr)

Interim map showing the distribution of the FOOTPRINT SUGAR index across Europe
Areas in **dark green** contribute to surface water most whereas zones in **dark red** are those which contribute most to groundwater recharge.



SIXTH FRAMEWORK PROGRAMME

Defining agro-environmental scenarios for the EU27

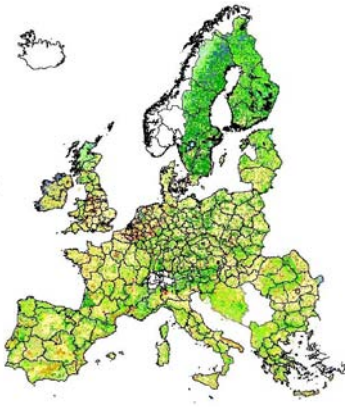
FOOTPRINT Agro-Environmental Scenarios

FOOTPRINT tools are based on the knowledge of processes, factors, and agricultural/ landscape characteristics influencing pesticides fate and behaviour in the environment.
A large number of generic scenarios, characterising the complete spectrum of the European agricultural environments, is a key element for the three tools. Each scenario represents a unique combination of those agronomic practices, soil and subsoil hydrological characteristics and climates that determine the fate of agriculturally-applied pesticides within Europe.
Up to now, FOOTPRINT team developed a great number of scenarios divided into:

- Soil scenarios,
- Climatic scenarios,
- Subsoil scenarios,
- Agronomic scenarios.

Soil scenarios are developed to:

- Differentiate the European soil population according to those characteristics that determine pesticide fate, especially those that are used to parameterise the MACRO and PRZM pesticide fate models;
- Derive a comprehensive set of unique soil property datasets for this purpose.



Four main sources of data were used:

- the Soil Geographic Database of Europe v. 1.0
- the SPADE-2 database,
- the Hydrology of Soil Types classification system,
- the CORPEN system, to identify pollutant transfer pathways in the field.

MACRO and PRZM models require a wide range of parameters of soil. Specific sets of algorithms or 'pedo-transfer functions' were developed and tested in order to derive parameters from basic, widely available soil property data, reducing the number of input parameters (soil type and soil layer properties) for the two Models.
A specific methodology was used to create a unique set of FOOTPRINT soil classes, which represent the entire spectrum of variation in the listed soil parameters within European agriculture. The methodology resulted in a total of 595 soil profiles required to characterise the complete spectrum of agricultural soils in Europe. It is emphasised that many of these soil types are of limited extent and very few encompass more than 2 or 3 FOOTPRINT climatic zones. In addition, most of them do not carry a full range of agricultural crops and a significant number occur only under managed grassland.

Climatic scenarios are developed to:

- Undertake a climatic zonation of Europe;
- Define climatic scenarios which will be subsequently used for modelling the environmental fate of pesticides within the context of FOOTPRINT.

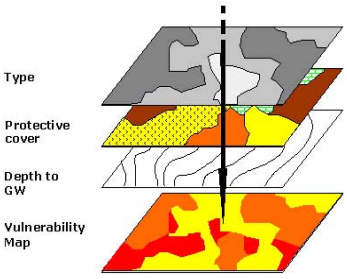
Extensive modelling was first undertaken to simulate the fate of various pesticides in different soils, under different climatic conditions. Statistics were then used to relate predicted pesticide losses to climatic characteristics to identify the key climatic factors influencing pesticide fate. Eight climatic variables were selected on the basis of these investigations and a climatic classification of Europe was created.

The 16 FOOTPRINT climatic zones

The main patterns were used in a clustering routine to group areas with similar characteristics, obtaining at the end a classification of 16 regions, the FOOTPRINT climatic zones, physically plausible in terms of input variables and of knowledge of the European climate. Representative climate series were selected for each of the 16 FOOTPRINT climatic zones using an objective method able to identify the stations representative of each climatic zone.
This approach represents a major scientific improvement over earlier methods as it relies on the subjective selection and combination of climate statistics. The FOOTPRINT climatic zones, which cover the EU25 and the candidate countries, will form the basis of subsequent modelling activities within the project.

Sub-soil scenarios

The intent to develop representative scenarios of subsurface systems is usually very complex, and several surface and subsurface properties, and their mutual effects, need to be monitored to determine the risk of groundwater contamination. The FOOTPRINT approach to groundwater aquifer vulnerability deviates to a basic and an extended approach.
The *basic approach* focuses on educational aspects and aims at providing the user with information on aspects making an aquifer more or less vulnerable. The descriptions are accompanied with data available at the EU-level.
In the *extended approach*, the main objective is the identification of areas that most likely contribute to the contamination of the aquifer by pesticides. To this purpose, the approach should allow a spatial differentiation between areas with respect to their vulnerability. An overlay/index method was selected as a suitable balance between the required detail and easiness of use. The overlay/index approach assess quantitatively



vulnerability by assigning an index or score to all relevant properties expressing the protective ability of the soil. A final vulnerability map is reached by multiplication or addition (or some combination hereof) of the indexes/scores. The method developed in FOOTPRINT is based on the origin-pathway-target concept, where the origin is the place of the contaminant release, the target is the water to protect, and the pathway includes all properties between the origin and the target. The FOOTPRINT method builds upon the MACRO meta-model which will be developed later within FOOTPRINT.
(../..)

The 16 FOOTPRINT climatic zones

(../..)

Agronomic scenarios are developed to characterise the complete spectrum of European agricultural environments with respect of pesticides usage.
A list of FOOTPRINT crops of interest was defined and templates for the critical crop growth stages required by the models to be used were derived. When possible, application dates of pesticides were included in the template. In order to identify homogeneous areas for selected agricultural practices, EU administrative areas at NUTS (Nomenclature of Territorial Units for Statistics) level 2 were grouped together according to the similar crop growth stages. Broad types of agriculture at a very fine spatial resolution (250 m × 250 m grid) were identified by CORINE 2000. The CORINE-based land classes are currently being intersected with the NUTS level 2 maps, and to each CORINE land cover-NUTS-2 combination attributes defining the crops present and their cover expressed as a percentage of the total agricultural area are being derived. In addition, a Principal Component Analysis was carried out to define a set of socio-agronomic zones within Europe that group together NUTS level 2 areas according to their similarity with respect to multiple socio-economic aspects. At this stage, it is envisaged that the information will most likely be used to inform the piloting and evaluation of the FOOTPRINT tools and to improve their communication and dissemination.

The FOOTPRINT partners

1 BRGM (Co-ordinator)
2 STRI, University of Hertfordshire
3 Swedish University of Agricultural Sciences
4 GEUS
5 Arvalis, Institut du Végétal
6 University Giessen
7 NSRI, Cranfield University
8 Agricultural University of Wroclaw
9 ICPS
10 GEOSYS
11 INRA
12 University of Newcastle Upon Tyne
13 Joint Research Centre
14 University of Ljubljana
15 NAGREF

Focus on specific FOOTPRINT partners

Cranfield University Silsoe The National Soil Resources Institute (Cranfield University) is the Government-appointed UK National Reference Centre for Soil: it holds the national soil archive of unpublished soil survey information and manages the LandIS system of spatial and other digital soil information under an agreement with DEFRA. NSRI's understanding of soil variability, soil functioning and the modelling of interactions between soil, climate, topography and land use is unrivalled within the UK.

John Hollis is an Independent Consultant specialising in pesticide environmental fate with over 20 years experience in this field. For the last 15 years John has been involved in the development of GIS-based decision support tools for all aspects of pesticide environmental risk assessment and, whilst employed by the National Soil Resources Institute of Cranfield University he was the principal scientist responsible for the development of the HOST system that groups soils according to their hydrological response. John has developed a number of tools currently used by the Pesticides Safety Directorate, the UK Environment Agency and the Agrochemical and Water Industries and was secretary of the EU FOCUS working groups on Surface Water models and the development of Surface Water Scenarios.

FOOTPRINT involvement:
WP2 High resolution scenario-based spatial zonation with definition of representative soil scenarios and definition of representative agronomic scenarios.

UH The Science & Technology Research Institute (STRI) consists of a number of research units concerned with separate, but related, research areas within the disciplines of earth sciences and engineering. The Agriculture and Environment Research Unit (AERU) carries out applied research related to measuring the impacts of agriculture on the environment, with considerable experience in agricultural policy and regulation, agri-environmental impact assessment and indicator development, agricultural sustainability and farm software development.

Kathy Lewis is a leader in agri-environmental science and head of the Agriculture and Environment Research Unit at UH. She has considerable experience in agricultural risk assessments, particularly with respect to the use of pesticides and the use of remediation and abatement technologies to control perceived risks. She is a member of the pest management committee of the Society of the Chemical Industry (SCI) for which she has organised several conferences and workshops and is the agricultural advisor for the Hertfordshire Rural Forum, a local government initiative for rural development. Kathy has over 20 years experience of software development.

FOOTPRINT involvement:
WP5 Development of functional tools with Software specifications for FOOT tools, PPDB, Development of FOOT-FS.

Latest project news

Conferences in 2007

The FOOTPRINT work will be presented at the following conferences in 2007.

- Water Status Monitoring of Acquatic Ecosystems under the WFD Conference, 12-14 March 2007, Le Nouveau Siècle, Lille, France
- American Chemical Society 233rd National Meeting (session on Estimation of Environmental Exposure to Agrochemicals Using Spatial Data Analysis and Geographic Information Systems) 25-29 March 2007 in Chicago, USA (invited talk).
- SETAC Europe Annual Meeting on 'multiple stressors for the environment and human health -present and future challenges and perspectives' in Porto, Portugal.
- 9th Fresenius AGRO Conference 'Behaviour of Pesticides in Air, Soil and Water' on 27-28 June in Köln, Germany (invited talk)
- XIII Symposium on Pesticide Chemistry on 3-6 September 2007 in Piacenza, Italy (FOOTPRINT special session)

In 2006, the project was presented in 19 conferences.

The FOOTPRINT Annual Meeting 2007

The FOOTPRINT Annual Meeting 2007 will take place in Italy on **22 and 23 November 2007**. Further details will be circulated on the FOOTPRINT Announcement List in due course. Do pencil these dates in your diaries!

FOOTPRINT@Work

One of the most challenging aspects of FOOTPRINT is to undertake millions of runs of the pesticide fate models MACRO and PRZM. This would represent ca. 2 centuries of running if a single state-of-the-art computer was used. The running of so many model iterations within the 3 years of the project is achieved through the development of a specific IT architecture which makes use of corporate PCs during their idle time (e.g. at night, during weekends, during holiday periods). The system, called FOOTPRINT@work (a reference to the SETI@home well-known distributed data analysis initiative), automatically boots idle PCs, loads Linux onto the machines, retrieve modelling runs to be undertaken, undertakes the pesticide fate modelling, sends the results to a central server and then shuts the machines down, all this being transparent to the machine owner. The FOOTPRINT@work relies on ComputeMode, a distributed modelling application developed by the company Icatis. The system is currently being intensively tested through a collaboration with the consulting company Enviresearch Ltd.

Small footprints

Many congratulations on the birth of Lorenzo Galimberti on 21 January 2007. His father, Francesco, is a research scientist at ICPS and is actively involved in the dissemination of the FOOTPRINT results.

The FOOTPRINT announcement list

Please register with the FOOTPRINT announcement list if you want to be kept aware of the latest project developments.
Visit www.eu-footprint.org/keepuptodate.html
The list currently features 260 members.

Scientific Papers

The work undertaken in the first year of FOOTPRINT has led to the submission of 3 papers and a further 5 papers are currently being prepared.

Jarvis N.J. (2007). *A review of non-equilibrium water flow and solute transport in soil macropores: principles, controlling factors and consequences for water quality*. Accepted for publication in **European Journal of Soil Science**.

Nolan B.T., Dubus I.G., Surdyk N., Fowler H.J., Burton A., Hollis J.M., Reichenberger S. & Jarvis N.J. *Identification of key climatic factors regulating the transport of pesticides in leaching and to tile drains*. Submitted to **Environmental Science & Technology**.

Reichenberger S. *et al. State-of-the-art review on mitigation strategies to reduce pesticide inputs into ground- and surface water, and their effectiveness*. Submitted to **the Science of the Total Environment**.