Objectives

The aim of the SAVE project was to develop a modelling approach to predict geographical variation in radionuclide behaviour and to identify areas in Western Europe particularly vulnerable (or resilient) to radiocaesium deposition. The intention was to develop a semi-mechanistic soil-plant model linked to soil/land use maps to predict radiocaesium transfer. Outputs would be combined with other relevant variables such as food production and diet within geographical information systems.

Spatial Analysis of Vulnerable ecosystems in Europe (SAVE)
Spatial and dynamic prediction of radiocaesium fluxes into European Foods

Problems to be solved

Caesium-137 is a radionuclide of major concern due to its long physical half-life (30y) and potential long-term high mobility in some ecosystems. Studies following the Chernobyl accident have greatly improved our understanding of the environmental behaviour of this radionuclide and have demonstrated large variation in transfer and dose as a consequence of spatially varying parameters.

A central aspect of the work was the identification of vulnerable areas which, by virtue of the processes governing the transfer of radiocaesium through food chains, deliver high individual, or collective doses to man. Social factors (e.g. dietary preferences) and agricultural production techniques also contribute to vulnerability.

Achievements

Spatial and temporal analyses of factors contributing to vulnerability were implemented by combining dynamic models of radionuclide behaviour with spatial databases of the model input parameters within Geographical Information Systems (GIS).

A soil-plant uptake model was parameterised using derived relationships between radiocaesium uptake and soil properties. This was combined with aspects of the existing ECOSYS-87 and Pathway models and extended to use generally available spatial inputs to predict radiocaesium transfer not only to a range of agricultural products but also to semi-natural food products. This approach allows improved estimates of both individual and collected doses by spatially attributing fluxes more accurately, especially over the mid to long term. The dynamic models and spatial input data have been integrated into a user friendly software package (SAVE-IT).

Soil-plant uptake

The model for soil-plant transfer forms an important part of the SAVE generic model. Published values for observed transfer of radiocaesium from soil to grass were critically evaluated, and confirmed the commonly reported trend in increasing radiocaesium uptake of clay < loam < sand < organic. However, considerable variability within, and overlap between, these four soil groups exist. An alternative, mechanistically based modelling approach for quantifying soil-to-plant transfer was developed to enable predictions of radiocaesium soil to plant transfer across a wide range of soil types. Experimental studies performed in the project using Western European soils showed that radiocaesium availability to plants is related to: radiocaesium fixation by the soil (K_d) and the concentration of potassium in soil solution (Figure 1). Based on these data, a semi-mechanistic model was developed using readily available parameters (radiocaesium deposition, % clay, exchangeable K, % organic matter and pH) to predict plant uptake. This model was successfully verified against critically reviewed field data (arable crops).

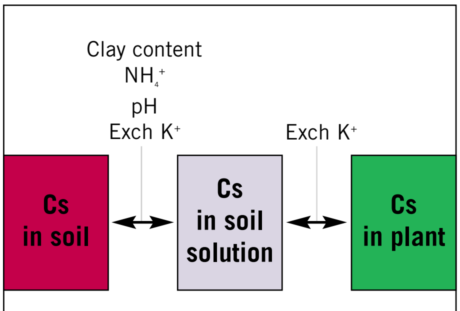

Figure 1. Soil characteristics determining plant uptake of Cs from soil.

Spatial variability in transfer, production and harvesting of agricultural and semi-natural products

Agricultural production data collated for Western Europe at a detailed spatial scale showed that there is considerable variation both between and within countries in the amounts and types of production. For instance, nearly half the cow milk production occurs in France and Germany and 90% of sheep and goat milk is produced in Greece, Spain, France and Italy. Information on the harvest of wild foods and hunting of wild animals was also collated.

Radiocaesium transfer to semi-natural and wild foods was shown to be much higher and to persist for longer than many agricultural products, although considerable variability both within and between species exists.

Dietary habits

From a compilation of the spatial variation in dietary habits at both national and regional scales, Mediterranean and Nordic diets could be differentiated from those of the other European counties. Within a country diets in different regions tended to be similar; however, diets in some regions of Germany, France and Belgium were alike. The consumption of milk is highest in Northern countries, particularly Finland and Ireland. Little information is available from national statistics on the consumption of wild food, but data collated during the project suggest that consumption of wild and semi-natural foods are greatest in Nordic countries (Figure 2).

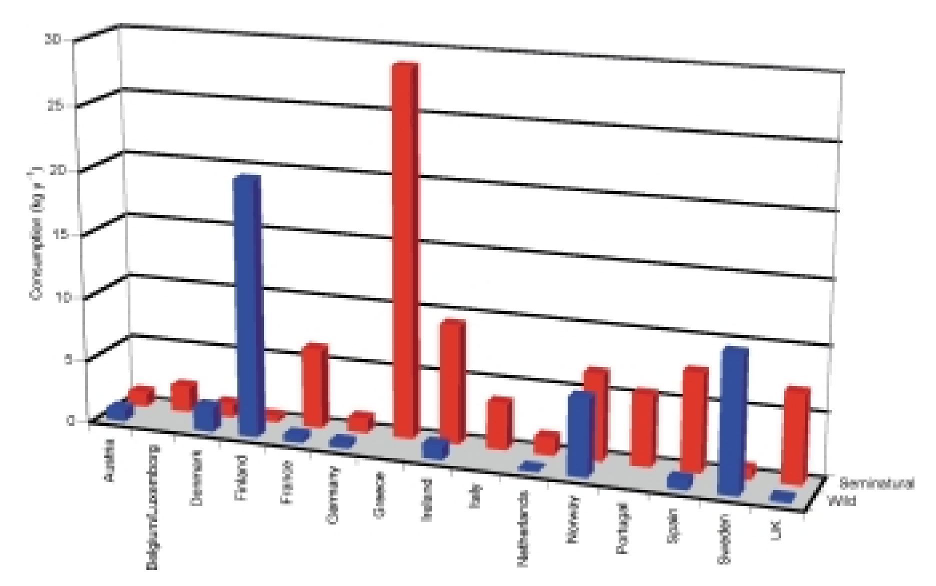

Figure 2. Consumption of semi-natural and wild foods.

Radiocaesium fluxes

Predictions of ^{137}Cs activity concentrations in food products were combined with production data to estimate the annual fluxes of radiocaesium arising from different regions. Fluxes are defined as the product of the radiocaesium activity concentration in a foodstuff and its annual production from an area (with units of Bq y^{-1}). In the mid-term (9-21 months after deposition), intensively produced agricultural food products dominate radiocaesium fluxes, and therefore intakes, across Western Europe. Over longer time periods, products from less intensive agricultural systems (e.g. sheep grazing upland pasture and wild food products) become increasingly significant contributors to radiocaesium fluxes, despite constituting relatively small proportions of total production.

Critical loads

The concept of the critical load, originally developed within the field of atmospheric pollution, was extended in SAVE for application within radioecology. The radiocaesium critical load for a given food product can be defined as the level of radiocaesium deposition necessary to lead to activity concentrations in that food product exceeding maximum permissible levels at a given time after deposition. Critical load maps for different food products can easily be combined with deposition maps for the rapid identification of areas that are either vulnerable or resilient to radiocaesium deposition. Areas identified as being vulnerable to radiocaesium deposition include those with the most highly organic soils, namely parts of Finland, northwest Scotland, Ireland and the Netherlands.

SAVE-IT

The SAVE-IT software system is a useful tool to predict spatial and temporal variation in vulnerability to radiocaesium deposition over large geographical areas. This is the first such system to integrate spatial variation in soil–plant transfer with agricultural production and diet to enable the estimation of radiocaesium activity concentrations, fluxes and intakes following deposition events. The model predictions have been verified against geo-referenced post-Chernobyl data. The model contains a set of default parameters which can be easily altered if site specific data are available. An example of SAVE-IT predictions for radiocaesium activity concentrations in lamb in England and Wales two years after the Chernobyl accident is shown in Figure 3.

SAVE-IT contributes to an understanding of variability and estimates of uncertainty allowing identification of areas and communities where resources and countermeasures should be directed over acute, mid and long terms. The software and supporting documentation is freely available via an Internet site (http://www.nottingham.ac.uk/environmental-modeling/).

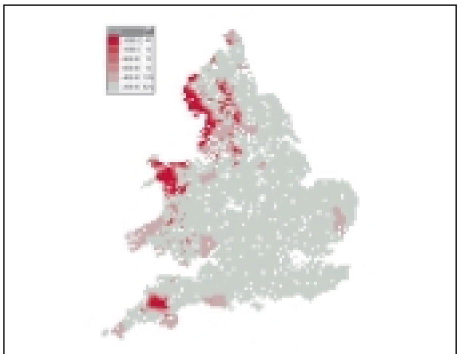

Figure 3. SAVE-IT predictions for radiocaesium activity concentrations in lamb in England and Wales two years after the Chernobyl accident

SAVE Information Column

Title:
Spatial **A**nalysis of **V**ulnerable ecosystems in **E**urope: Spatial and dynamic prediction of radiocaesium fluxes into European Foods. **(SAVE)**

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