Description of the forest food chain and dose model FDMF in RODOS PV6.0

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Description of the forest food chain and dose model FDMF in RODOS PV6.0

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Management Summary

This document contains the model description of the forest food chain and dose model, FDMF of RODOS PV6.0.

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1 Introduction

1.1 Background and aims of the revised model FDMF

Post-Chernobyl radioecological studies have confirmed the long residence times of certain radionuclides, notably ^{134}Cs and ^{137}Cs in semi-natural terrestrial ecosystems (Moberg et al. 1999; Belli 2000). The assessment of human radiation exposure through radionuclide contamination of forests is emphasized in Europe due to contamination of forest products.

The main aim of the forest food chain and dose model FDMF is the assessment of human radiation doses from contaminated forests since the contaminating deposition until 50 years later. Additional aim is the prediction of contamination of timber.

The model has been revised to improve its applicability to forested areas in Europe and to allow interaction with a new countermeasure model LCMforest. The time-dependence of the activity concentration in the different forest compartments is now obtained by numerically solving a system of first order differential equations. The compartment structure was slightly revised to better account for the contamination of timber. The explicit soil compartments corresponding to different transfer characteristics of radionuclides were chosen to clarify the effect of chemical transformation of radionuclides in forest soil on the uptake by plants.

Currently, FDMF provides the user with a prediction of the distribution of deposited radionuclides in a forest ecosystem until 50 years after contaminating deposition. FDMF also estimates activity concentrations in wild foodstuffs and debarked wood, and external and internal doses received by different population groups from the utilisation of contaminated forests. In addition, the need for intervention and effect of countermeasures can be predicted interactively with the forest countermeasure model LCMforest.

1.2 Documentation of the model FDMF and changes after the version PV4.0

This report contains the model description of the FDMF and gives advice for its adaptation to geographic regions not covered by the current model data. Functional specifications including technical details for integration of the model in the RODOS system and for further development of the software are given in RODOS(RA3)-TN(01)07. User guide is also available as a RODOS document.

The first version of the Forest Food Chain and Dose Model FDMF was integrated into the RODOS system since version PV4.0 (Ehrhardt and Weis, 2000). It was developed in collaboration between IRSN (previously IPSN), France, and STUK, Finland. A description of the previous model version is given in RODOS(WG3)-TN(99)-53 and in STUK-A178.

Algorithms and model parameters (Annex 2) for calculation of deposition and interception, as well as dietary intake and ingestion doses, and kerma rate and external doses are identical with the previous version PV4.0. New data was provided for the time spent in forests. Changes were made in a few algorithms of the dynamic module, and in calculation of contamination of wild foodstuffs.

The current computer software was coded again (Michael Ammann). The structure of the FDMF database was changed and is composed of simple text files. Most data is unchanged and referenced in detail in the documentation of the FDMF PV4.0. Changed data is referenced in this report (Section 3). The tables in Annex 1 (Identification codes) and Annex 2 (parameters) are in the same type of format as in the software.

2 Overview of the model FDMF

2.1 Dose pathways

After accidental contamination internal radiation dose to local inhabitants through wild foods like berries, mushrooms and game meat can significantly exceed the earlier doses during several years. External dose rates in forests may call for restrictions of access in early phase of a severe fallout situation. Contamination of wood and other non-food forest products can cause harm to rural life through limitations to their use. Predictions for these pathways are the main targets of FDMF.

The model FDMF is in the RODOS system parallel to the terrestrial, aquatic and tritium model. It receives data from atmospheric dispersion models (ADM) of RODOS for calculation of the deposited or intercepted activities in different parts of forests. The FDMF delivers collective doses to Dose Combination Module of RODOS (Fig. 1).

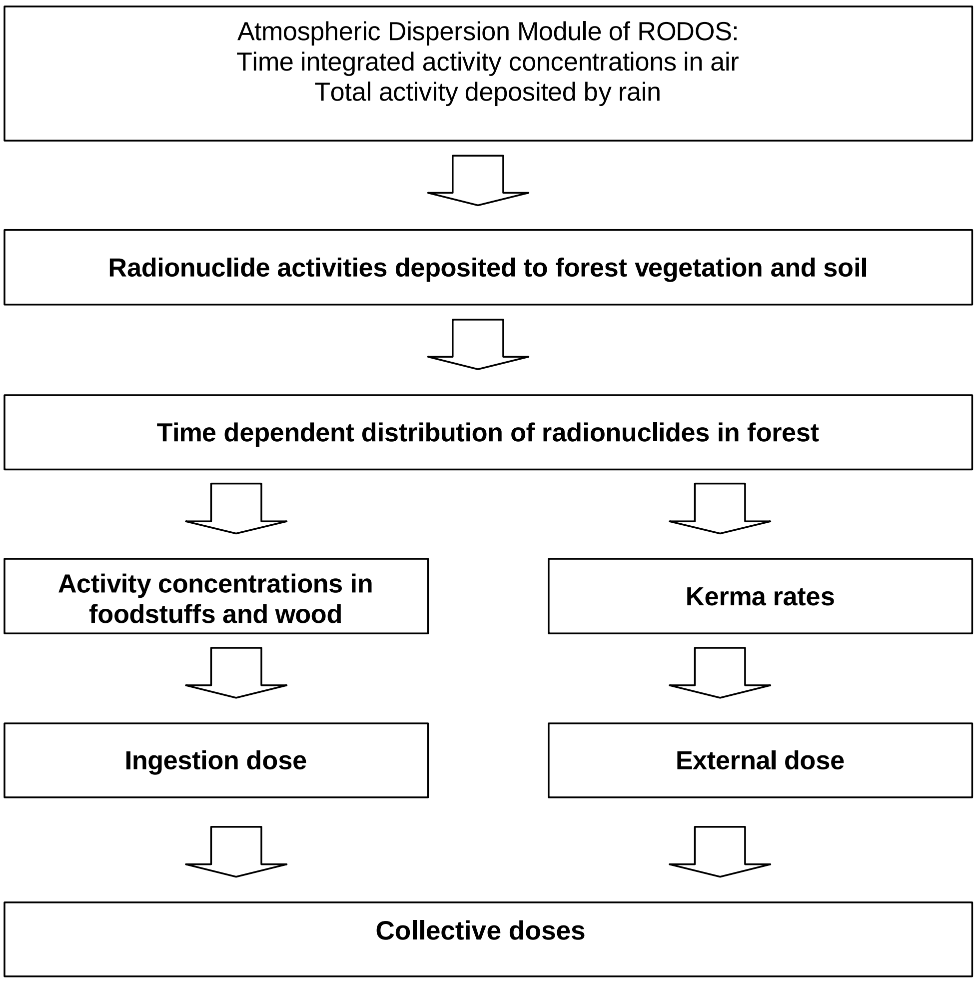

Figure 1. **Modules and data flow in the FDMF.**

The regional and time-dependent model outputs are useful features of all RODOS food chain models. In the FDMF regional deposition of radionuclides, activity contents in foodstuffs and wood, and radiation doses are given on maps. They demonstrate the scale of contamination and the need for intervention.

FDMF produces output in form of thematic maps, time-plots and tables for:

- Activity concentrations in mushrooms, berries, game meat and debarked stem wood
- External dose-rate in forests for an adult member of the population
- Effective dose that different population groups receive via forest related pathways
- Collective dose of the population groups.

2.2 Compartment structure

A compartment model is used in the dynamic module to estimate the time behaviour of radionuclides in forests. Soil is currently divided into topsoil and two virtual compartments, for bio-available radionuclides, and radionuclides fixed in soil or not bio-available for any other reason. The vegetation compartments understory, and overstory divided by average crown limit into trunk layer and crown layer. Trunk layer is divided into bark and wood compartments (Fig. 2).

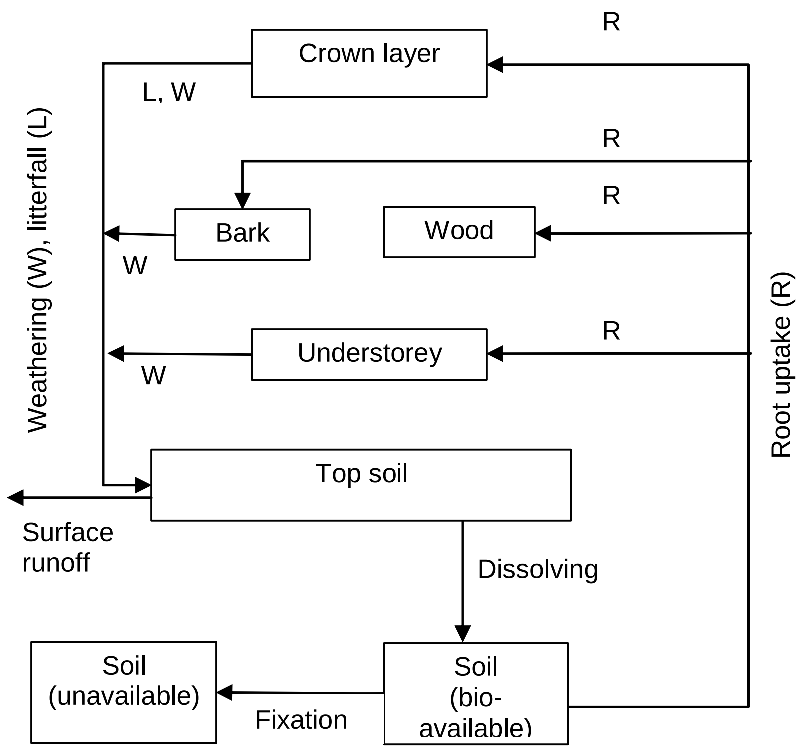

Figure 2. Dynamic module of the FDMF

2.3 Deposition and interception

FDMF receives integrated air concentrations from the ADM of RODOS, and calculates the distribution of radionuclides initially deposited during dry weather. Using the total wet deposition from ADM the forest model derives distribution of intercepted radionuclide activities deposited wet.

2.4 Dynamic transfer of radionuclides

The time-dependent redistribution of radionuclides in forest after contaminating deposition is based on the processes surface runoff, weathering, foliar absorption (from an implicit external canopy compartment), translocation, litter fall and root uptake, as shown in Fig. 2. The processes are the same as in the earlier version of the model. The division of crown and understory into external and internal fraction of directly deposited contamination is accounted for implicitly, as in previous version of the model.

In the early phase wild food contamination is modelled using two parallel transfer processes since the time of deposition. Direct deposition to mushrooms is derived through interception by understory. Foliar deposition to understory contributes to activity concentrations in berries through translocation before the harvest, and to activity concentrations in game meat through external and internal contamination in understory. Another fraction of activities in wild foods is derived through root uptake since the time of deposition. This fraction will gradually increase with the bio-available fraction of radionuclide activity in soil, and it corresponds to the entire content of activities in wild foodstuffs after some months.

2.5 Overstory compartments

Forest was previously divided into similar compartments for quantification of environmental transfer of radionuclides and for definition of sources of external radiation. Soil and understory compartments were combined for calculation of kerma. Dynamic processes were considered for soil, understory, and trunks and crowns of trees (Fig. 2). In the revised model, distinction between trunk layer and timber was considered through parameters for overstory biomass and radionuclide uptake from the soil.

Trees were divided into crowns and trunks for their different radionuclide uptake rates, to achieve a realistic vertical distribution of activity for calculation of kerma rate. Crown comprises all parts of a standing tree above the crown limit: trunk, branches, twigs and leaves or needles.

‘Tree’ and ‘overstory’ refer to combined trunk and crown compartments. The stem wood referring to timber in FDMF includes also trunk in crown layer that is acceptable for sawn timber or mass industry.

In the biomass of trunk layer also understory trees lower than crown limit of dominant trees are included. Uptake rates for bark and stem wood were assumed to compensate for different biomass fractions included in trunk layer (bark and wood activities provide trunk layer activity for kerma) and in the trunk for timber.

2.5 Kerma rate caused by radionuclides in different forest compartments

Forest biomass was assumed to consist of three homogeneous layers which are understory, trunk and crown layer. The two layers of trees plus air comprise a "forest equivalent medium" (FEM) which interacts with photon radiation. These layers are assumed homogeneous, and horizontally infinite or semi-infinite. The activities of forest compartments are given per surface area of the ground.

For calculation of kerma rates in air, the soil and understory compartments were combined, and activities in ground layer refer to the sum of activities in understorey and soil. In connection of external radiation, the sum of activities in all three soil compartments (bio-available and non-available including fixed) is used (Fig. 3).

The assessment of element composition of the forest equivalent medium, other details of overstory biomass, and the method of calculation of kerma are described in detail in the report STUK-A178 and in RODOS(WG3)-TN(99)-53.

Fig. 3. Layers of a forest used in the kerma rate calculation; ρ_1 and ρ_2 are the biomass densities of trunk and crown layer, respectively; h_1 and h_2 is the layer thickness; β is the parameter of the function that gives time-dependence of the vertical activity distribution in soil.

2.6 Population groups

Rather low consumption rates of wild foods and non-frequent use of forests for outdoor activities explain why radionuclide contamination of forests typically does not cause considerable doses to people in many European countries. However, some population groups can consume wild foods above average or spend longer times in forests. These groups are hunters, berry and mushroom pickers and forest workers, and their doses from forests originate in radionuclides in game meat, berries and mushrooms, and external radiation in forests.

Some individuals may belong to more than one special group by their consumption habits. The profile of hunters, studied by Ermala and Leinonen (1995), has shown that many hunters are also pickers of berries and mushrooms.

The average fraction of population belonging to each group is applied in the calculation of collective dose for a particular group in each location, without trying to remove overlap of groups which were formed to assess doses to people who might be exceptionally at risk. The same approach was used in definition of values for consumption rates derived from a nationwide survey on wild foods picked, hunted or purchased by Finnish households (Markkula and Rantavaara, 1997).

Vegetarians and fishermen are in the FDMF regarded equal to the public when doses from ingestion of wild foods and external radiation in forests are calculated. Dose-conversion factors for adults and children differ, thus making children a special subgroup.

3 Calculations in the FDMF

3.1 Dry deposition

The dry deposition module receives as input the time-integrated activity concentration in air (Bq s m^{-3}), and the date of deposition. For dry deposition the seasonal leaf area indices for tree stand and ground vegetation are taken into account. Deposition velocities are specific to different forest compartments.

Initial activities for radionuclides (*n*) selected for a model run are calculated per unit area of forest land in different vegetation compartments and on ground. The activity content A_c in a compartment *c* at time t_0 is $A_c\ (t_0,\ x,\ n)$, referring to crown, trunk, ground vegetation and soil. At this time the activities A_c correspond to the initial condition for the dynamic module after the deposition event. The activities A_c are given in Bq per m^2.

Dry deposition to the crown and ground vegetation compartments *(c)* is calculated as follows:

$$A_c^{dry} = v_c^{\max} \frac{lai_c^0}{lai_c^{\max}} C^{air} \qquad (1)$$

Dry deposition to the trunk and soil is calculated without considering the potential seasonal change in the deposition velocity v_c:

$$A_{dry} = v_c C_{air} \qquad (2)$$

A_c^{dry} denotes the activity concentration (Bq m^{-2}) derived from dry deposition in compartment *c;*

$v^{\max}$ is the deposition velocity (m s^{-1}) to compartment *c* for fully developed foliage of crown and ground vegetation;

v_c is deposition velocity to trunk and soil (no seasonal change);

lai_c^0 and $lai_c^{\max}$ are the leaf-area indices of compartment *c* (here: crown and ground vegetation) at the time of deposition and for fully developed foliage, respectively;

C^{air} is the time-integrated activity concentration in air (Bq s m^{-3}) at the end of the deposition event.

3.2 Wet deposition

The wet deposition module receives the total wet deposition per unit area of land (Bq m^{-2}) and the rainfall (mm from the air dispersion module of RODOS). The FDMF calculates the fractions of activities intercepted by different compartments of forest and derives the distribution of initial activity after a wet deposition event. For wet deposition the average canopy coverage (*cov*) of the stand is needed.

The probabilities that the radionuclides are intercepted in the crown, bark, ground vegetation and top soil compartments (f_c^{icept}) are calculated using Equation 3:

$$f_c^{icept} = cov_c \; lai_c^0 (s/R)\left(1 - e^{-\ln(2)R/(ps)}\right) \text{ if } f_c^{icept} \leq 1, \text{ 1 else;} \qquad (3)$$

The parameter cov_c represents the canopy cover fraction of the crown layer; it equals 1 for all other layers; lai_c^0 is the leaf-area index of layer c at the time of deposition; R is the rainfall (mm); s is the retention coefficient (mm); p_c is a layer-specific correction factor.

The activity content (A_c^{wet}) in crown (C), bark (B), ground vegetation (understory, U) and top soil (S) layers is calculated as follows:

$$A_C^{wet} = f_C^{icept} A^{total} \qquad (4)$$

$$A_B^{wet} = f_B^{icept}(1 - f_C^{icept}) A^{total} \qquad (5)$$

$$A_U^{wet} = f_U^{icept}(1 - f_B^{icept})(1 - f_C^{icept}) A^{total} \qquad (6)$$

$$A_S^{wet} = (1 - f_U^{icept})(1 - f_B^{icept})(1 - f_C^{icept}) A^{total} \qquad (7)$$

Where

f_c^{icept} are the intercepted fractions in the crown, trunk, ground vegetation and top soil layers

A^{total} is the total wet deposition (Bq m^{-2}) to forest.

3.3 Redistribution in the forest ecosystem

The dynamic transfer of deposited radionuclides in forests is calculated through weathering, foliar absorption, litter fall, surface runoff, migration, dissolving and fixation of radionuclides in soil, and root uptake by plants. Translocation from direct contamination on ground vegetation to edible parts of plants, notably berries, is modeled using a time-dependent translocation factor.

Compared to previous version (4.0) of FDMF, the trunk compartment was divided into a separate bark and wood compartment. Three soil compartments are included in the model. The topsoil is receiving deposited activity and activity removed from vegetation compartments through weathering. Soil *R* is a compartment containing dissolved, bio-available fraction of radionuclide activity, and soil *F* contains both chemically fixed forms of radionuclides, not available to root uptake, and the activity migrated downwards below the root zone (Fig. 2).

Soil processes for dissolving and migration of deposited material to root zone are described by an availability rate, which is the same as transfer rate from topsoil S to soil R. Migration of radioactive material outside the root zone and removal of radionuclides from biological nutrient cycle by chemical fixation, are described by a combined fixation rate in the model. It refers to transfer from soil

R to compartment soil F. The net flow of radionuclides to different soil compartments is considered in parameter choices.

The results of the dynamic module are time-dependent activities of radionuclides in different forest compartments, A_c *(t, x, n).* They are used for estimation of activity concentrations in wild foodstuffs and wood, and for estimation of kerma in forest air.

The activity concentrations in all forest compartments, crown (A_C), bark (A_B), wood (A_W), ground vegetation (A_U), top soil (A_S), root zone (A_R) and fixed or migrated activity content in soil (A_F) are solutions of the first order differential equations (8) – (14).

The transfer rates are constants λ (d^{-1}) as follows:

- λ^{rad} denotes radioactive decay;
- λ_{CS}, λ_{BS} and λ_{US} denote net removal through weathering (considering absorption), and litter fall from crown, weathering from bark and ground vegetation, to topsoil;
- λ_{RC}, λ_{RW}, λ_{RB} and λ_{RU} denote root uptake from soil R by crown, wood, bark and ground vegetation;
- λ^{a} denotes absorption from external to internal foliar contamination in crown (and understory), applied for $t < 15$d.
- λ_{SR} denotes transfer from topsoil S to soil R, *i.e.* becoming available to root uptake;
- λ_{RF} refers to fixation or removal from root zone, i.e. transfer from soil R to soil F.

Ground frost and snow cover are considered by seasonal values for foliar absorption and in the transfer of radionuclides between soil compartments, where relevant. Data are provided in the database for PV4.0 (STUK-A178). [The computer programme (February 2004) does not consider winter conditions.]

Equations for compartment activities are the following:

$$\frac{dA_C}{dt} = -(\lambda_{CS} - \lambda^a + \lambda^{rad})A_C + \lambda_{RC}A_R$$
$$\frac{dA_B}{dt} = -(\lambda_{BS} + \lambda^{rad})A_B + \lambda_{RB}A_R$$
$$\frac{dA_W}{dt} = -\lambda^{rad}A_W + \lambda_{RW}A_R$$
$$\frac{dA_U}{dt} = -(\lambda_{US} - \lambda^a + \lambda^{rad})A_U + \lambda_{RU}A_R \qquad (8 - 14)$$
$$\frac{dA_S}{dt} = \lambda_{CS}A_C + \lambda_{BS}A_B + \lambda_{US}A_U - (\lambda_{SR} + \lambda^{rad})A_S$$
$$\frac{dA_R}{dt} = \lambda_{SR}A_S - (\lambda_{RC} + \lambda_{RB} + \lambda_{RW} + \lambda_{RU} + \lambda_{RF} + \lambda^{rad})A_R$$
$$\frac{dA_F}{dt} = \lambda_{RF}A_R - \lambda^{rad}A_F$$

The initial conditions are as follows:

$$A_C(0) = A_C^{dry} + A_C^{wet}$$
$$A_B(0) = A_B^{dry} + A_B^{wet}$$
$$A_W(0) = 0$$
$$A_U(0) = A_U^{dry} + A_U^{wet} \qquad (15 - 21)$$
$$A_S(0) = A_S^{dry} + A_S^{wet}$$
$$A_R(0) = 0$$
$$A_F(0) = 0$$

3.4 Kerma rate

The activities $A_c\ (t, x, n)$ are starting values for kerma rate in forest air. Defined at level 1 meter above the ground surface, kerma rate $K_c\ (t, x, n)$ is given in nGy per hour. Kerma rates from ground and from crown and trunk layers are given by K_G, K_C and K_T, respectively. Their algorithms were derived for FDMF PV4.0 by Golikov et al. (1999). Irradiation from the ground layer, i.e. from all soil compartments and ground vegetation, is calculated as follows:

$$f_G = 3.6\,10^4 \left\{ \frac{a_1\,\mathrm{e}^{-a_2\rho_1}}{1 + a_3\dfrac{\mathrm{e}^{-a_4\rho_1}}{\beta}} + \frac{a_5}{1 + \dfrac{a_6}{\beta}} \right\} \qquad (22 - 23)$$
$$K_G = f_G(A_S + A_R + A_F)$$

Irradiation from crown and trunk layers (24 - 30):

$$x_0 = 0.12 + 0.11\rho_1$$
$$x_1 = (0.12 + 0.11\rho_1)(h_1 - 1)$$
$$x_2 = (0.12 + 0.11\rho_2)h_2$$
$$f_T = 3.6\,10^{-4} /(x_0 h_1)\left\{b_1(x_0 + x_1) + b_2(x_0^2 + x_1^2) - b_3\left(x_0 \ln(x_0) + x_1 \ln(x_1)\right)\right\}$$
$$f_C = 3.6\,10^{-4} / x_2\left\{b_1 x_2 + b_2(x_2^2 + 2x_1 x_2) - b_3\left((x_1 + x_2)\ln(x_1 + x_2) - x_1 \ln(x_1)\right)\right\}$$
$$K_T = f_T(A_W + A_B)$$
$$K_C = f_C A_C$$
$$(24-30)$$

K_G, K_T, K_C are the kerma rates in air (nGy h^{-1}) one meter above ground from irradiation from the ground, trunk and crown layers, respectively; A_C, A_B, A_W, A_U, A_S, A_R, A_F are the activity concentrations per unit area (Bq/m^2) in the crown, bark, wood, understory, and the soil compartments: top soil, soil available and soil unavailable; β is the depth distribution parameter (cm^2 g^{-1}); a_1 to a_6 are six constants; b_1, b_2 and b_3 are three constants; h_1 and h_2 is the respective thickness (m) of trunk and crown layer; ρ_1 and ρ_2 are the biomass densities (kg m^{-3}) of trunk and crown layers, respectively.

3.5 Dose-rate from external irradiation

Dose rates from radionuclides *(n)* are derived from kerma rates as follows:

$$\dot{D}^{ext} = \sum_n (kf_C K_C + kf_T K_T + kf_G K_G) \quad (31)$$

K_G, K_T, K_C are the kerma rates in air (nGy h^{-1}) one meter above ground from irradiation from the ground, trunk and crown layers, respectively; kf_C, kf_T, kf_G are the kerma-to-dose factors (Sv Gy^{-1}) for crown, trunk and ground exposure; $\dot{D}^{ext}$ is the potential effective dose-rate (nSv h^{-1}). D_g^{ext}, the potential effective dose (Sv), is calculated as follows (32):

$$D_g^{ext} = \int oc_g\, mc_g \dot{D}^{ext} dt' \quad (32)$$

Where

$\dot{D}^{ext}$ is the potential effective dose-rate (nSv h^{-1}); oc_g is the average time spent in forest (d a^{-1}) for a population group *g; mc_g* is a mass correction factor for members of group *g*. Mass correction is needed to take into account for the different exposure geometry for subjects of different size. In FDMF the correction for children was related to body mass (Golikov et al. 1999).

3.6 Activities in wood and wild food products

Activity concentration in barked wood, A_W *(t, x, n)* is converted from an output (in Bq m^{-2}) of the dynamic module, and is given in Bq kg^{-1} dry weight. In FDMF the activity in barked stem wood is assumed to originate entirely in the soil compartment R containing the radionuclides available to root uptake.

Activity concentrations $A_p(t, x, n)$ in wild foods are derived from two sources. One is the initial deposition to understory vegetation, and another is bio-available fraction of activity in soil. $A_p(t, x, n)$ refers to uncooked food products that are mushrooms (A_M), berries (A_B), and game meat (A_G), given in Bq kg^{-1} fresh weight.

The fraction of activity transferred from soil to wild food products, $A_p(t, x, n)$, is calculated using aggregated transfer factors *(tc)* from soil R to foodstuffs. For mushrooms the initial deposition on fruit bodies during harvest season is estimated from activity intercepted on understory, multiplied with land cover ratio of mushrooms and divided by leaf area index of understory at the time of deposition (33). For berries translocation factors *(tl)* are used to derive the contribution of activity deposited initially on understory vegetation to the activity concentration of edible part of the plant (34).

For mushrooms the activity concentration is

$$C_M(t) = (1/y)(c/lai_U{}^0)\ A_U(0)\,\mathrm{e}^{-(\lambda^{rad}+\lambda^{weath})t} + tc_M\ A_R(t) \quad (33)$$

Where

C_M is the activity concentration in mushrooms. In the first term of the sum of equation (33) y is the biomass of fruit bodies (kg m^{-2}) of growing mushrooms; c is the land cover ratio of mushrooms; lai^0_U is the leaf area index of ground vegetation(understory), and $A_U(0)$ is the activity (Bq m^{-2}) in the ground vegetation compartment, all at time of deposition. In the term for root uptake, tc_M is the aggregated transfer coefficient (m^2 kg^{-1} f.w.) from soil to mushrooms; A_R is the activity available to root uptake, *i.e.* activity content in soil compartment R (Bq m^{-2}).

For berries, activity concentrations are

$$C_B(t) = 1/y\ tl\ A_U(0)e^{-\lambda rad*t} + tc_B\ A_R(t) \quad (34)$$

Where

C_B is the activity concentration in fresh berries;

y is the biomass (kg m^{-2}) of the ground vegetation; tl is the time and element (mobile/immobile) dependent translocation factor for berries; tc_B is the aggregated transfer coefficient (m^2 kg^{-1} f.w.) from soil to berries; $A_U(0)$ is the activity content (Bq m^{-2}) of the ground vegetation at time of deposition; A_R is the activity content (Bq m^{-2}) in the soil R.

For different types of game meat the activity concentrations are calculated (35):

$$C_G(t) = 1/y\ fr\ tf\ \lambda^{bio}\int_0^t A_U(t')e^{-(\lambda^{rad}+\lambda^{bio})(t-t')}dt' + tc_G\ A_R(t) \quad (35)$$

$$A_U(t') = A_U(0)e^{-(\lambda^{rad}+\lambda^{weath})t'}$$

Where

C_G is the activity concentration in game meat (Bq kg^{-1} fw.); y is the biomass (kg m^{-2} f.w.) of the ground vegetation; fr is the feeding rate (kg d^{-1}) of a game animal; tf is the feed-to-meat transfer factor (d kg^{-1}); tc_G is the transfer coefficient (m^2 kg^{-1} f.w.) from soil (R) to game meat; A_R is the activity (Bq m^{-2}) in the root layer; λ^{bio} is the biological transfer rate (d^{-1}) in game animal, λ^{weath} denotes weathering from understory, and λ^{rad} is the decay rate (d^{-1}) of the radionuclide.

3.7 Picking or hunting, and storage of wild food products

Within the collection or hunting season, wild products of the day of delivery (default) are assumed to be consumed. Typically there is a time delay after delivery of products before they are consumed; the parameter t^{delay} is applied in calculation of activity concentration in raw product on the day of consumption:

$$C_p^{raw}(t) = C_p(t - t^{delay})\, e^{-\lambda^{rad} t^{delay}} \qquad (36)$$

Outside the collection or hunting season wild products are consumed that have the average contamination that prevailed during the past season. Radioactive decay is accounted for in the calculation:

$$C_p^{raw}(t) = C_p^{avg} e^{-\lambda^{rad}(t - t^{end})} \qquad (37)$$

Where

C_p is the potential activity concentration (Bq kg^{-1} f.w.) in the wild product p; t^{delay} is the typical delay between collection or hunting and consumption within season; C_p^{avg} is the average contamination (Bq kg^{-1} f.w.) during the past season; t^{end} denotes the end of the season; C_p^{raw} is the activity concentration (Bq kg^{-1} f.w.) in the raw product p before food preparation.

3.8 Wild food preparation

Processing losses of radionuclides are considered by using correction factors specific to food types:

$$C_p^{proc} = pf_p\, C_p^{raw} \qquad (38)$$

Where

C_p^{proc} is activity concentration (Bq kg^{-1} f.w.) in the processed product p; pf_p is the food processing factor for product p; C_p^{raw} activity concentration (Bq kg^{-1} f.w.) in product p at time of consumption before food preparation.

3.9 Ingestion dose

Dietary intake and effective dose are calculated as follows:

$$F_g = \sum_p cr_{gp} C_p^{proc} \tag{39}$$

Where

F_g denotes activity intake rate (Bq d^{-1}) of a member in group g; cr_{gp} consumption rate (kg d^{-1}) of product p for a member in group g; C_p^{proc} denotes activity concentration in product p (Bq kg^{-1} f.w.) at time of consumption.

Committed effective dose received through ingestion is calculated:

$$D_g^{ing} = \sum_n e_g^{50} \int F_g dt \tag{40}$$

Where

D_g^{ing} denotes dose (Sv) of a member in group g; e_g^{50} committed effective dose conversion factor (Sv Bq^{-1}) for group g; and F_g is activity intake rate (Bq d^{-1}) of a member in the group g.

3.10 Collective dose

The quantities of wild food products taken from forests were assumed to be equal to amounts consumed, which are known from dietary surveys. Yields of wild food products in terms of existing food resources in forests cannot mostly be used as a basis for collective doses, as the degree of their utilisation varies significantly both locally and by radioecological regions (Kangas 2001). The number of persons in population groups must be consistent with the implicit definition of the consumption and exposure pattern in the group. Collective dose is calculated (41):

$$D_g^{coll} = Nw_g (D_g^{ext} + D_g^{\mathrm{int}}) \tag{41}$$

Where

D_g^{coll} is the collective dose (person-Sv) for population group g; Nw_g is the number of members in each group g; which is approximated by the fraction w_g of the whole population N. D_g^{ext} and D_g^{int} are the external and internal (effective, committed) doses (Sv) to members of group g.

4 Database of the FDMF

4.1 Parameters after the version FDMF4.0

New model parameters are root uptake rates for wood and bark. Trunk layer that is used in kerma rate calculation is composed of bark and wood biomass in trunk layer. In the dynamic module the lambda values for weathering from understory were adjusted for more realistic contamination prognosis of wild foods in the first weeks and months after deposition. The rate of radionuclides becoming available to root uptake was increased for the same reason. New experimental data were used for estimation of the time-dependent depth distribution parameter used in calculation of kerma rate from radionuclides in the soil.

Time spent in forests was thoroughly examined and the previous estimates revised using new survey data for time used for outdoor activities in Finland (Sievänen 2001). The times spent in forests were found longer than values in the previous database. The new data for time spent in forests has been provided for PV6.0 in Annex 2. Full list of references to all previously given parameter values is included in model description of FDMF 4.0 (RODOS(WG3)-TN(99)-53) and in the report STUK-A178 (2001).

In the previous version of FDMF the model parameters were included in and retrieved from the parameter database of the terrestrial food chain and dose module FDMT. The current database is independent of the previous structure.

4.2 Presentation of the model parameters

The values of model parameters can be regional, or dependent on element, season, and time since deposition, or forest type. Some parameters can be generally applicable to all regions and forest types. Currently the model database includes values for both Central Europe and Finland. Radionuclides of caesium are by far the most important. Values for caesium were given as default values of parameters for other nuclides, if specific parameters were not available.

Like in the other food chain and dose models, many of the parameters depend on the radio-ecological region. FDMF receives the region IDs from the RODOS geographical database. This database also provides the population number at each location, which is used to assess the collective dose.

The model parameters are grouped into forest, berry, mushroom, or game related parameter sets. For each radiological region there can be more than one such parameter set in the database. For example, parameter values for different tree species and development classes may be kept in the database. The user is asked at program start to specify the parameter sets of choice.

Technically the parameter database of the FDMF is a set of text files that can be modified with a text editor. Each parameter is stored in a separate table with index columns for possible nuclide, region, forest type or other dependencies. The model programme calls for values by variable names indicated in the names of the files in the software.

The FDMF uses, as other RODOS Food Chain models, the common database of RODOS which becomes available to the new users in connection of installation of RODOS. For instance European population data and all physical parameters related with about 70 radionuclides (half-lives, dose conversion factors) are in the RODOS database.

The first factor dividing data into various categories is radioecological region. Season dependent values are given for twelve months. Element dependent foliar absorption rates and translocation factors are given for groups of elements. Radionuclides of caesium are by far the most important radionuclides for forest related pathways and are therefore most thoroughly investigated. Sometimes the values of caesium are also taken for the parameters of other, not sufficiently well known, elements.

Tables of selected parameter values are given in Annex 2. Currently the parameter database includes values for Central Europe (region ID 001) and Finland (region ID 230). The model data in Annexes 1 and 2 are given in format that reminds the database. The tables are organised in sections with headings similar to the subroutines of the model.

5 Adaptation of the model to regions not currently covered

In connection of installation of the RODOS system new users have a chance to access the model database and edit the values in individual files. Thereby the model should be adapted to conditions in the geographic region concerned. Technically the revision of database is simple, and revising the files is supported by the Annex 1 of this report, and by Functional specification of the FDMF (RODOS(RA3)TN(01)-7, latest version).

The adaptation to areas not covered by the current database is made through defining the name of a new region for RODOS, and inserting regional parameter values to thematic text files the FDMF database is composed of. The forest model FDMF PV6.0 has also been revised to provide reference data for assessment of regional countermeasure effectiveness with a new RODOS model LCMforest. Stem biomass was inserted in the database for, among others, the estimation of profitability of timed felling operations.

Currently the radioecological regions defined in the model are Central Europe (1) and Finland (230). There is in principle no size limit for a region. In the database regional data has sometimes been replaced by default values, due to lack of regional data.

Through data that represents forests and their use in the region realistic model results can be obtained. Defining relevant forest types and parameters for dose pathways related to them requires examination of local conditions. Dose pathways typical of the region direct both the choice of forest types and values of model parameters. Groups of people receiving significant radiation exposure should be considered. Important parameters are those for ingestion dose estimation, particularly the intake rates of wild foods. Availability of dietary information as regards wild foods may be scarce in many regions. To avoid biased estimates for ingestion doses, the accepted sources of data should clearly indicate the distinction between wild and cultivated products. For estimation of external dose of adults, the time spent in forests in different seasons is needed.

Both the forest ecosystem and the dynamics of deposited radioisotopes in forests are complex. Availability of representative field data would improve model results related with dynamic calculations. Local surveys on the use of forest products, particularly wild foods, improve the dose pathway assessment. Adaptation of the model to new conditions should not demand major efforts, but knowing the modelling approach of FDMF and the meaning of various parameters facilitates focussing the search for model data. The radionuclide distribution in a forest depends on the site and the structure of the stand. For a region and forest type the radioecological parameters should not be arbitrarily combined from data sources representing separate sites, times or stand structures.

External radiation from forest overstory is at maximum immediately after interception of contaminating radionuclides by the canopy layer in forests after the initial deposition. Therefore, relevant forest types related with various ways of utilising and managing forests are chosen for the database. Both advanced and young forests should be covered by the model data. In saplings the tree canopies are rather close to the exposed human subject, and their activity content can be substantially increased by interception of radioactive material from air during the passage of a radioactive plume.

The sudden changes in radionuclide distribution in forests during the first weeks after contamination have not been too well studied. This is reflected by the current database where calculation of deposition and early changes in certain forest compartments are often described with default parameters irrespective of region or forest type.

Climatic zones and their effect on growth period, forest biomass densities, leaf area indices, and canopy cover fractions are shown by data given separately for Central and Northern Europe. In the north the annual increment of forests is lower than in more favourable conditions elsewhere in Europe. Therefore, in choosing parameter values typical to a region the age of a stand can refer to much higher biomass density than in the north.

Future testing and validation of the FDMF will demonstrate the sensitivity of the model output to the change of the forest vegetation zone (or climate) in Europe. Relevancy of the data at all stages of model calculations is important for elimination of apparently logical model outputs that hide compensating errors in the data.

6 Discussion

The forest food chain and dose model FDMF of RODOS PV6.0 was revised for better applicability in various radioecological regions in Europe. An improved dynamic model and a simplified database structure support the assessment of the consequences of contamination of forests. FDMF also provides reference input data for an assessment of regional countermeasure effectiveness, which can be done with the newly developed forest countermeasure module LCMforest.

The FDMF was developed for prognoses of human exposure to internal and external radiation through contaminated forests. Another objective was to provide an indication of the need for protection of people. External exposure is mostly received from radionuclides in the ground layer of forests. Overstory can be a significant radiation source during the first days or weeks after deposition, *i.e.* before the distinct decline of activity content of tree crowns through weathering, and decay of short-lived radionuclides. The long term collective doses received through radioactive contamination of forests are often dominated by internal exposure through wild foods. The availability of data for modelling this pathway is relatively good, thus improving reliability of assessment results. However, the diversity of the ways people use forests and wild food products calls for systematic regional surveys and compilation of statistics on consumption and food processing data. Furthermore, an update of information on multiple uses of forests in Europe would improve possibilities for realistic modelling of the dose pathways related to forests.

Concerning radioecological data for FDMF, it is emphasized that climate and geographic area have effect on species structure, biomass content, rotation period and use of forests. Uptake of radionuclides by forest vegetation is site specific. For a representative model database experimental data for dynamic transfer of radionuclides in forests, valid for the particular region are valuable.

Contamination of wood is calculated using data for boreal forests, and parameters can hardly be generally applicable to various development stages and stand structures in different vegetation zones. Conditions on site are crucial when conclusions for production of acceptable timber are drawn from prognosis based on model results. Therefore the indication on contamination level the model gives is relevant for demonstration purposes, but for decisions on investments for restoration of contaminated forests measurements performed with quality assured methods are also required.

Adaptation of the model database assumes general knowledge of forests and their use in the region. The new users of FDMF responsible for adaptation will certainly consult experts on forestry and forest research in early phase of searching local data. Availability of descriptive data on forests, typically collected in connection of an inventory of forest resources, varies by countries. A default forest defined for a region could be an option to simplify adaptation.

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Annex 1: Identification codes in FDMF

1 Compartment ids for deposition and dynamic modules

Compartment_id	Name
1	Crown
2	Bark
3	Stemwood
4	Understorey
5	Top soil
6	Soil available
7	Soil unavailable

2 Available forest IDs

Different forest related parameter sets can be provided in each radio-ecological region, and the relevant parameter tables have a forest_id column. The user can choose the appropriate parameter set (ie parameter set) during program initialization.

Note: Forest type specific parameters of region 230 are categorized according to dominant tree species and age (development stage).

Reg_id	Forest_id	Short_name	Long_name
1	1	"Mixed"	"Mixed_forest"
1	2	"Deciduous"	"Deciduous_forest"
1	3	"Coniferous"	"Coniferous_forest"
230	1	"Pine_advanced"	"Pine_advanced_thinning_stand"
230	2	"Spruce_advanced"	"Spruce_advanced_thinning_stand"
230	3	"Pine_seedling"	"Pine_seedling_stand"

3 Available Region IDs

Reg_id region ids as defined in RoGIS
Short nam string
Long name string

Reg_id	
Short_name	Long_name
1	"Central Europe"
230	"Finland"

4 Available population group IDs

Pop_id	
Short_name	Long_name
1	"Adult"
2	"Child_5y"
3	"Hunter"
4	"Collector" (picker)
5	"Forest worker"
6	"Vegetarian"

5 Available wild product IDs

Prod_id	Name
1	mushroom
2	berry
3	game

6 Available berry IDs and transfer parameters for isotopes of caesium

Different berry related parameter sets can be provided for each radio-ecological region, and the tables for transfer parameters have a berry_id column. The user can choose the appropriate berry_id (ie parameter set) during program initialization. − *Note:* Berry specific parameters of regions 1 and 230 are arranged into 4 groups according to the magnitude of their (soil to fruit) transfer coefficients for caesium.

Reg_id	Berry_id	Short_name	Long_name
1	1	TC = 0.003 m^2 kg^{-1}	Blueberry, Bilberry (Vaccinium myrtillus)
1	2	TC = 0.002 m^2 kg^{-1}	Lingonberry (Vaccinium vitis-idaea)
1	3	TC = 0.004 m^2 kg^{-1}	Raspberry (Rubus idaeus)
1	4	TC = 0.008 m^2 kg^{-1}	Cloudberry (Rubus chamaemorus)
230	1	TC = 0.004 m^2 kg^{-1}	Blueberry, Bilberry (Vaccinium myrtillus)
230	2	TC = 0.004 m^2 kg^{-1}	Lingonberry (Vaccinium vitis-idaea)
230	3	TC = 0.001 m^2 kg^{-1}	Raspberry (Rubus idaeus)
230	4	TC = 0.008 m^2 kg^{-1}	Cloudberry (Rubus chamaemorus)

7 Available Game IDs and transfer coefficients for isotopes of caesium

Different game related parameter sets can be provided for each radio-ecological region, and the relevant parameter tables have a game_id column. The user can choose the appropriate game_id (ie parameter set) during program initialisation.

Note: Game specific parameters of regions 1 and 230 are arranged into 8 groups according to the magnitude of their transfer coefficients for caesium.

Reg_id	Game_id Short_name	Game id Long_name *(scientific name)*	TC $m^2\ kg^{-1}$
1	1	Brown_hare (*Lepus_europaeus)*	0.005
1	2	Mountain_hare (*Lepus_timidus*)	0.03
1	3	Roe_deer (*Capreolus capreolus)* (Aug-Dec)	0.1
1	4	Red_deer *(Cervus elaphus)*	0.04
1	5	Moose (*Alces alces*)	0.01
1	6	Wild boar *(Sus scrofa),* (Sep-Mar)	0.05
1	7	Terrestrial_birds	0.015
1	8	Waterfowl	0.01
230	1	Brown_hare (*Lepus_europaeus*)	0.005
230	2	Mountain_hare (*Lepus_timidus*)	0.03
230	3	Roe_deer (*Capreolus capreolus*) (Aug-Dec)	0.1
230	4	Red_deer (*Cervus elaphus*)	0.04
230	5	Moose (*Alces alces*)	0.01
230	6	Wild boar (*Sus scrofa*), (Sep-Mar)	0.05
230	7	Terrestrial_birds	0.015
230	8	Waterfowl	0.01

8 Available mushroom IDs and transfer coefficients (soil to fruit body) for isotopes of caesium

Different mushrooms related parameter sets can be provided for each radio-ecological region, and the relevant parameter tables have a mush_id column. The user can choose the appropriate mush_id (ie parameter set) during program initialisation.
Note: Mushroom specific parameters of regions 1 and 230 are arranged into 4 groups according to the magnitude of their transfer coefficients for caesium.

Reg_id	Mush_id	Short_name	Long_name
1	1	"TC = 0.01 m2/kg"	*"Agaricus arvensis, Agaricus sylvaticus, Armillaria mellea, Boletus appendiculatus, Boletus elegans, Cantharellus cornucopiensis, Leccinum aurantiacum, (Macro) Lepiota procera, Lepista nuda, Lepista saeva, Lycoperdon perlatum, Psalliota campestris, Sarcodon imbr."*
1	2	"TC = 0.05 m2/kg"	*"Boletus aestivalis, Boletus edulis, Cantharellus cibarius, Cantharellus palens, Clitocybe nebularis, Collybia burhyracia, Collybia confluens, Collybia dryophylla, Collybia maculata, Collybia peronata, Hydnum repandum, Kuehneromyces mutabilis, Lactarius deterrimus, Lactarius helvus, Lactarius odoratus, Lactarius picinus, Leccinum sp., Leccinum versipelle, Lepiota naucina, Oudemansiella sp., Oudemansiella radicata, Pholiota aegerita, Russula decolorans."*
1	3	"TC = 0.01 m2/kg"	*"Boletus cavipes, Cantharellus lutescens, Cantharellus tubaeformis, Clitocybe infundibuliformis, Lactarius lignyotus, Lactarius quietus, Lactarius torminosus, Lactarius turpis, Leccinum scabrum, Russula nigricans, Suillus grevillei, Tricholoma aurata, Trichomolopsis rutilans."*
1	4	"TC = 0.50 m2/kg"	*"Clitocybe cavipes, Dermocybe sp., Hebeloma sp., Hygrophorus sp., Hygrophorus olivaceoalbus, Laccaria amethystina, Laccaria laccata, Laccaria proxima, Lactarius sp., Lactarius camphoratus, Lactarius necator, Lactarius porninsis, Lactarius rufus, Lactarius theiogalus, Lactarius trivialis, Rozites caperata, Russula sp., Russula badia, Russula erythropoda, Russula ochroleuca, Russula turci, Suillus bovinus, Suillus granulatus, Suillus luteus, Suillus variegatus, Xerocomus badius, Xerocomus chrysenteron, Xerocomus subtomentosus."*
230	1	"TC = 0.01 m2/kg"	*"Boletus edulis, Armillaria borealis, Scutiger ovinus, Ramaria flava, Gyromitra esculenta, Leccinum versipelle, Leccinum vulpinum, Cantharellus cibarius, Suillus luteus, Lactarius deterrimus, Lactarius delicious, Lactarius turpis"*
230	2	"TC = 0.05 m2/kg"	*"Cantharellus tubaeformis, Cratellus cornucopioides, Lactarius torminosus, Russula paludosa, Russula decolorans, Leccinum scabrum"*
230	3	"TC = 0.10 m2/kg"	*"Lactarius rufus, Suillus variegatus, Lactarius trivialis, Hydnum repandum, Hydnum rufescens, Russula paludosa"*
230	4	"TC = 0.50 m2/kg"	*"Rozites caperatus, Hygrophorus camarophyllus"*

Annex 2: Model calculation parameters of FDMF

1 Deposition and interception

Canopy cover fraction

Reg_id (1) Central Europe, (230) Finland
Forest_id according to table 'forest_id.dat'
Compartment_id according to table 'comp_id.dat'
Fraction canopy cover fraction (unitless)

Reg_id	Forest_id	Compartment_id	Fraction
1	1	1	0.7E-00
1	2	1	0.7E-00
1	3	1	0.7E-00
230	1	1	0.25E-00
230	2	1	0.3E-00
230	3	1	0.25E-00

Correction factor for retention

Reg_id (1) Central Europe, (230) Finland
Forest_id according to table 'forest_id.dat'
Compartment_id (1) crown, (2) bark, (4) understorey
CF correction factor for retention

Reg_id	Forest_id	Compartment_id	CF
1	1	1	6.0
1	1	2	6.0
1	1	4	3.0
1	2	1	6.0
1	2	2	6.0
1	2	4	3.0
1	3	1	6.0
1	3	2	6.0
1	3	4	3.0
230	1	1	2.0
230	1	2	6.0
230	1	4	3.0
230	2	1	7.5
230	2	2	6.0
230	2	4	3.0
230	3	1	2.0
230	3	2	6.0
230	3	4	3.0

Deposition velocities (V_c) for all regions

Compartment	Deposition velocities (10^{-3} m s^{-1})		
	Aerosol bound nuclides	Elemental iodine	Organic bound iodine
v_{crowns}	4.5	45	0.45
v_{trunks}	0.5	5	0.05
$v_{understorey}$	2	20	0.2
v_{soil}	0.5	3	0.05

Leaf-area index, monthly values (1/4)

Reg_id (1) Central Europe, (230) Finland
Forest_id according to table 'forest_id.dat'
Comp_id compartment ID: 1 crown, 4 understorey
Month 1 Jan, 2 Feb, etc.
LAI leaf-area index

Reg_id	Forest_id	Comp_id	Month	LAI
1	1	1	1	5
1	1	1	2	5
1	1	1	3	5
1	1	1	4	6
1	1	1	5	7
1	1	1	6	8
1	1	1	7	8
1	1	1	8	8
1	1	1	9	8
1	1	1	10	6.5
1	1	1	11	5
1	1	1	12	5
1	2	1	1	1
1	2	1	2	1
1	2	1	3	1
1	2	1	4	3
1	2	1	5	5
1	2	1	6	7
1	2	1	7	7
1	2	1	8	7
1	2	1	9	7
1	2	1	10	4
1	2	1	11	1
1	2	1	12	1
1	3	1	1	10
1	3	1	2	10
1	3	1	3	10
1	3	1	4	10
1	3	1	5	10
1	3	1	6	10
1	3	1	7	10
1	3	1	8	10
1	3	1	9	10
1	3	1	10	10
1	3	1	11	10
1	3	1	12	10
1	1	4	1	0.5

Leaf-area index, monthly values (2/4)				
Reg_id	Forest_id	Comp_id	Month	LAI
1	1	4	2	0.5
1	1	4	3	0.5
1	1	4	4	1.3
1	1	4	5	2.1
1	1	4	6	3
1	1	4	7	3
1	1	4	8	3
1	1	4	9	3
1	1	4	10	1.7
1	1	4	11	0.5
1	1	4	12	0.5
1	2	4	1	0.5
1	2	4	2	0.5
1	2	4	3	0.5
1	2	4	4	1.3
1	2	4	5	2.1
1	2	4	6	3
1	2	4	7	3
1	2	4	8	3
1	2	4	9	3
1	2	4	10	1.7
1	2	4	11	0.5
1	2	4	12	0.5
1	3	4	1	0.5
1	3	4	2	0.5
1	3	4	3	0.5
1	3	4	4	1.3
1	3	4	5	2.1
1	3	4	6	3
1	3	4	7	3
1	3	4	8	3
1	3	4	9	3
1	3	4	10	1.7
1	3	4	11	0.5
1	3	4	12	0.5
230	1	1	1	3.5
230	1	1	2	3.5
230	1	1	3	3.5
230	1	1	4	3.5
230	1	1	5	3.5
230	1	1	6	3.5
230	1	1	7	3.5
230	1	1	8	3.5
230	1	1	9	3.5

Leaf-area index, monthly values (3/4)				
Reg_id	Forest_id	Comp_id	Month	LAI
230	1	1	10	3.5
230	1	1	11	3.5
230	1	1	12	3.5
230	2	1	1	8
230	2	1	2	8
230	2	1	3	8
230	2	1	4	8
230	2	1	5	8
230	2	1	6	8
230	2	1	7	8
230	2	1	8	8
230	2	1	9	8
230	2	1	10	8
230	2	1	11	8
230	2	1	12	8
230	3	1	1	3.5
230	3	1	2	3.5
230	3	1	3	3.5
230	3	1	4	3.5
230	3	1	5	3.5
230	3	1	6	3.5
230	3	1	7	3.5
230	3	1	8	3.5
230	3	1	9	3.5
230	3	1	10	3.5
230	3	1	11	3.5
230	3	1	12	3.5
230	1	4	1	0.5
230	1	4	2	0.5
230	1	4	3	0.5
230	1	4	4	0.5
230	1	4	5	1.7
230	1	4	6	3
230	1	4	7	3
230	1	4	8	3
230	1	4	9	3
230	1	4	10	1.7
230	1	4	11	0.5
230	1	4	12	0.5
230	2	4	1	0.5
230	2	4	2	0.5
230	2	4	3	0.5
230	2	4	4	0.5
230	2	4	5	1.7

Leaf-area index, monthly values (4/4)				
Reg_id	Forest_id	Comp_id	Month	LAI
230	2	4	6	3
230	2	4	7	3
230	2	4	8	3
230	2	4	9	3
230	2	4	10	1.7
230	2	4	11	0.5
230	2	4	12	0.5
230	3	4	1	0.5
230	3	4	2	0.5
230	3	4	3	0.5
230	3	4	4	0.5
230	3	4	5	1.7
230	3	4	6	3
230	3	4	7	3
230	3	4	8	3
230	3	4	9	3
230	3	4	10	1.7
230	3	4	11	0.5
230	3	4	12	0.5

2 Dynamic calculations

Note: Transfer parameters for isotopes of caesium from soil to edible mushrooms, berries and game are given in connection of ID parameters in Annex 1, in tables 6, 7 and 8.

Soil-mushroom transfer coefficients

For each region there are four groups of mushroom species according to equal soil - mushroom transfer coefficient TC for Cs (m^2 kg^{-1} f.w.). Values of TC for iodine, strontium and plutonium are independent of region and mushroom ID. For all other elements (not included in the table below) values of TC are from Cs, mush_id 2 (= 0.05)

Reg_id − according to table 'reg_id.dat'
Mush_id − according to table 'mush_id.dat'
Element − symbol of element

Reg_id	Mush_id	Element	TC
1 (or 230)	1	Cs	0.01
1 (or 230)	1, 2, 3, 4	I	0.04
----	----	----	----
1 (or 230)	1	Pu	0.0002
----	----	----	----
1 (or 230)	1	Sr	0.0001
----	----	----	----
1 (or 230)	2	Cs	0.05
----	----	----	----
1 (or 230)	3	Cs	0.1
----	----	----	----
1 (or 230)	4	Cs	0.5
----	----	----	----

Understorey-berry translocation factor

Note: except for iodine, strontium and plutonium, values are currently from caesium

Reg_id (1)Central Europe, (230) Finland

Element symbol of element

TL understorey-berry translocation factor (without unit)

Reg_id	Element	TL
1	Ag	0.1
----	---	----
1	Cs	0.1
1	I	0.1
1	Pu	0.02
----	----	----
1	Sr	0.02
----	----	----
230	Cs	0.1
230	I	0.1
----	----	----
230	Pu	0.02
----	----	----
230	Sr	0.02

Stem biomass (debarked) by age of trees

Values for Region 1 are copied from region 230.
In Region 230, values for even decades are based on surveillance data.

Reg_id according to table 'reg_id.dat'
Forest_id according to table 'forest_id.dat'
Age refers to age (in decades from 1 to 14) of harvested wood
Biomass refers to debarked stem biomass (kg m^{-2}) (50% dry matter)

Reg_id	Forest_id	Age	Biomass
1	1	1	3.0
1	1	2	3.0
1	1	3	6.0
1	1	4	6.0
1	1	5	8.0
1	1	6	8.0
1	1	7	10.0
1	1	8	10.0
1	1	9	11.0
1	1	10	11.0
1	1	11	11.0
1	1	12	11.0
1	1	13	12.0
1	1	14	12.0
1	2	1	3.0
1	2	2	3.0
1	2	3	6.0
1	2	4	6.0
1	2	5	8.0
1	2	6	8.0
1	2	7	10.0
1	2	8	10.0
1	2	9	11.0
1	2	10	11.0
1	2	11	11.0
1	2	12	11.0
1	2	13	12.0
1	2	14	12.0
1	3	1	3.0
1	3	2	3.0
1	3	3	6.0
1	3	4	6.0
1	3	5	8.0
1	3	6	8.0
1	3	7	10.0
1	3	8	10.0
1	3	9	11.0
1	3	10	11.0
1	3	11	11.0
1	3	12	11.0
1	3	13	12.0
1	3	14	12.0
230	1	1	2.61
230	1	2	2.61
230	1	3	5.99
230	1	4	5.99
230	1	5	7.97
230	1	6	7.97
230	1	7	9.34
230	1	8	9.34
230	1	9	10.46
230	1	10	10.46
230	1	11	10.96
230	1	12	10.96
230	1	13	11.09
230	1	14	11.09
230	2	1	0.50
230	2	2	0.50
230	2	3	5.58
230	2	4	5.58
230	2	5	9.25
230	2	6	9.25
230	2	7	11.52
230	2	8	11.52
230	2	9	12.38
230	2	10	12.38
230	2	11	12.38
230	2	12	12.38
230	2	13	12.38
230	2	14	12.38
230	3	1	2.61
230	3	2	2.61
230	3	3	5.99
230	3	4	5.99
230	3	5	7.97
230	3	6	7.97
230	3	7	9.34
230	3	8	9.34
230	3	9	10.46
230	3	10	10.46
230	3	11	10.96
230	3	12	10.96
230	3	13	11.09
230	3	14	11.09

Mushroom land cover

Reg_id (1) Central Europe, (230) Finland
Cov refers to land cover of mushrooms (m^2 m^{-2})

Reg_id	Cov
1	0.001
230	0.001

Mushroom yield

Reg_id (1) Central Europe, (230) Finland
Yield -- mushroom yield (kg/m2 f.w.) at time of harvest

Reg_id	Yield
1	0.05
230	0.05

Understorey biomass

Reg_id (1) Central Europe, (230) Finland
Biomass -- understorey biomass (kg m^{-2} f.w.)

Reg_id	Biomass
1	1.5
230	1.5

Weathering-rate for mushrooms

Reg_id (1) Central Europe, (230) Finland
Element -- symbolic name of chemical element
Lam -- weathering rate for mushrooms (1/day)

Reg_id	Element	Lam
1 (or 230)	Ag (and all other elements)	0.05
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Canopy absorption rates (d^{-1}) for crowns and understory by forest type

Central Europe

Radionuclide	Pine-dominant, deciduous and mixed forests				Spruce dominant forests and conifer seedling stands			
	Month				Month			
	11-4	5	6-9	10	11-4	5	6-9	10
Ag, Am, Ce, Cm, Nb, Nd, Np, Pr, Pu, Rh, Sr, Tc, Zr	0	0	0	0	0	0	0	0
Ba, La, Y	0	0	0.0007	0	0	0	0.0009	0
Sb	0	0.0009	0.002	0.0009	0	0.001	0.002	0.001
Ru	0	0.002	0.003	0.002	0	0.002	0.004	0.002
I, Mn, Mo, Te	0.0006	0.003	0.005	0.003	0.0008	0.004	0.006	0.004
Co	0.002	0.007	0.01	0.007	0.002	0.009	0.016	0.009
Cs, Na, Rb	0.0016	0.0073	0.013	0.0073	0.0021	0.009	0.017	0.009

Northern Europe

Radionuclide	Pine-dominant, deciduous and mixed forests				Spruce dominant forests and conifer seedling stands			
	Month				Month			
	11-4	5	6-9	10	11-4	5	6-9	10
Ag, Am, Ce, Cm, Nb, Nd, Np, Pr, Pu, Rh, Sr, Tc, Zr	0	0	0	0	0	0	0	0
Ba, La, Y	0	0	0.0007	0	0	0	0.0009	0
Sb	0	0.0009	0.002	0.0009	0	0.001	0.002	0.001
Ru	0	0.002	0.003	0.002	0	0.002	0.004	0.002
I, Mn, Mo, Te	0	0.003	0.005	0.003	0.0001	0.004	0.006	0.004
Co	0.0002	0.007	0.01	0.007	0.0002	0.009	0.016	0.009
Cs, Na, Rb	0.0002	0.0073	0.013	0.0073	0	0.009	0.017	0.009

Runoff rates

Reg_id -- according to table 'reg_id.dat'
Forest_id -- according to table 'forest_id.dat'
Month -- 1 Jan, 2 Feb, etc.
Lam -- runoff rates (1/day)

Reg_id	Forest_id	Month	Lam
1	1	1	0.000
1	1	2	0.000
1	1	3	0.000
1	1	4	0.006
1	1	5	0.006
1	1	6	0.006
1	1	7	0.006
1	1	8	0.006
1	1	9	0.006
1	1	10	0.006
1	1	11	0.000
1	1	12	0.000
1	2	1	0.000
1	2	2	0.000
1	2	3	0.000
1	2	4	0.006
1	2	5	0.006
1	2	6	0.006
1	2	7	0.006
1	2	8	0.006
1	2	9	0.006
1	2	10	0.006
1	2	11	0.000
1	2	12	0.000
1	3	1	0.000
1	3	2	0.000
1	3	3	0.000
1	3	4	0.006
1	3	5	0.006
1	3	6	0.006
1	3	7	0.006
1	3	8	0.006
1	3	9	0.006
1	3	10	0.006
1	3	11	0.000
1	3	12	0.000

230	1	1	0.000
230	1	2	0.000
230	1	3	0.000
230	1	4	0.006
230	1	5	0.006
230	1	6	0.006
230	1	7	0.006
230	1	8	0.006
230	1	9	0.006
230	1	10	0.006
230	1	11	0.000
230	1	12	0.000
230	2	1	0.000
230	2	2	0.000
230	2	3	0.000
230	2	4	0.006
230	2	5	0.006
230	2	6	0.006
230	2	7	0.006
230	2	8	0.006
230	2	9	0.006
230	2	10	0.006
230	2	11	0.000
230	2	12	0.000
230	3	1	0.000
230	3	2	0.000
230	3	3	0.000
230	3	4	0.006
230	3	5	0.006
230	3	6	0.006
230	3	7	0.006
230	3	8	0.006
230	3	9	0.006
230	3	10	0.006
230	3	11	0.000
230	3	12	0.000

Weathering rates for vegetation compartments

Reg_id (1) Central Europe, (230) Finland
Forest_id according to table 'forest_id.dat'
Compartment_id (1) crown, (2) bark, and (4) understorey
Period (1) months 1-2, (2) months 3-12, and (3) later.
Lam weathering rate (1/day)

Reg_id	Forest_id	Compartment_id	Period_id	Lam
1	1	1	1	0.01160
1	1	1	2	0.00289
1	1	1	3	0.0000693
1	1	2	1	0.05000
1	1	2	2	0.00400
1	1	2	3	0.00007
1	1	4	1	0.01
1	1	4	2	0.0025
1	1	4	3	0.0002
1	2	1	1	0.01160
1	2	1	2	0.00289
1	2	1	3	0.0000693
1	2	2	1	0.05000
1	2	2	2	0.00400
1	2	2	3	0.00007
1	2	4	1	0.01
1	2	4	2	0.0025
1	2	4	3	0.0002
1	3	1	1	0.01160
1	3	1	2	0.00289
1	3	1	3	0.0000693
1	3	2	1	0.05000
1	3	2	2	0.00400
1	3	2	3	0.00007
1	3	4	1	0.01
1	3	4	2	0.0025
1	3	4	3	0.0002
230	1	1	1	0.01160
230	1	1	2	0.00289
230	1	1	3	0.0000693
230	1	2	1	0.05000
230	1	2	2	0.00400
230	1	2	3	0.00007
230	1	4	1	0.01
230	1	4	2	0.0025
230	1	4	3	0.0002
230	2	1	1	0.01160
230	2	1	2	0.00289
230	2	1	3	0.0000693
230	2	2	1	0.05000
230	2	2	2	0.00400
230	2	2	3	0.00007
230	2	4	1	0.01
230	2	4	2	0.0025
230	2	4	3	0.0002
230	3	1	1	0.01160
230	3	1	2	0.00289
230	3	1	3	0.0000693
230	3	2	1	0.05000
230	3	2	2	0.00400
230	3	2	3	0.00007
230	3	4	1	0.01
230	3	4	2	0.0025
230	3	4	3	0.0002

Litterfall rate

Reg_id (1) Central Europe, (230) Finland
Forest_id according to table 'forest_id.dat'
Month (1) Jan, (2) Feb, etc.
Lam Litterfall rate (d^{-1})

Reg_id	Forest_id	Month	Lam
1	1	1 - 9	0.0
1	1	10	0.0022
1	1	11-12	0.0
1	2	1 - 9	0.0
1	2	10	0.0067
1	2	11 - 12	0.0
1	3	1 - 9	0.0
1	3	10	0.0013
1	3	11 - 12	0.0
230	1	1 - 9	0.0
230	1	10	0.0017
230	1	11 - 12	0.0
230	2	1 - 9	0.0
230	2	10	0.0011
230	2	11 - 12	0.0
230	3	1 - 9	0.0
230	3	10	0.0017
230	3	11 - 12	0.0

Root uptake rates for crowns, trunks and understorey.

Default values for Cs and other elements in Northern and Central Europe.

Compartment	Uptake rate (d^{-1})
Crowns of trees	0.00001
Bark of trees	0.000005
Stem wood	0.000005
Understorey	0.00001

Availability rate for soil: 0.02 d^{-1}

For all regions, forest types, and elements the value for Cs is used.

Fixation rate for soil (d^{-1})

For all regions, forest types, and elements the value derived for caesium is used:

$9.5*10^{-5}$	During May - October
0.0	At other times

3 External exposure

Time dependent depth distribution in soil

Fitted parameters for depth distribution parameter β(t) = **a/(1+b*t/365)** ($cm^2\ g^{-1}$). The values **a** = 2.96 and **b** = 0.47 are from datafits for the depth distributions of ^{137}Cs. They are used for regions 1 and 230 for all forest types and all elements.

Reg_id (1) Central Europe, (230) Finland
Forest_id according to table 'forest_id.dat'
Element symbol of element

Reg_id	Forest_id	Element	a	b
1 or 230	1, 2 or 3	Ag etc.	2.96	0.47
----	----	----	----	---
1 or 230	1, 2 or 3	Cs	2.96	0.47
----	----	----	----	----

Kerma factor − conversion from kerma to effective dose

Note: currently independence of nuclide assumed

Comp_id -- layer id: (1) crown, (2) trunk, and (3) ground

KF -- kerma factor for adults $Sv\ Gy^{-1}$

Comp_id	KF
1	0.7
2	0.7
3	0.8

Biomass density for kerma-rate calculation

Reg_id -- according to table 'reg_id.dat'
Forest_id -- according to table 'forest_id.dat'
Compartment_id -- 1 crown, 2 trunk layer
Month -- 1 Jan, 2 Feb, etc
Biomass density -- in kg m^{-3}

Reg_id	Forest_id	Compartment_id	Month	Biomass_density
1	1	1	1 - 12	2.7
1	1	2	1 - 12	1.9
1	2	1	1 - 4	1.24
1	2	1	5 - 10	1.28
1	2	1	11 -12	1.24
1	2	2	1 - 12	1.03
1	3	1	1 - 12	2.7
1	3	2	1 - 12	1.9
230	1	1	1 - 12	0.81
230	1	2	1 - 12	1.16
230	2	1	1 - 12	1.36
230	2	2	1 - 12	0.92
230	3	1	1 - 12	0.33
230	3	2	1	0.23

Kerma-rate constants

Nuclide -- symbolic nuclide name
b_1, b_2 and b_3 are kerma-rate constans for crown and trunk exposure
a_1, a_2, … a_6 are kerma-rate constants for ground exposure

Nuclide	b1	b2	b3	a1	a2	a3	a4	a5	a6
Ag-110m	2.607+01	0.000+00	5.931+00	1.640+01	9.000-02	4.410-01	5.950-02	1.030+01	6.440-02
Am-241	3.400-01	3.762-03	1.111-01	2.530-01	8.680-02	1.420+00	1.270-02	1.210-01	2.580-01
Ba-140	1.903+00	1.895-03	4.551-01	1.190+00	9.100-02	5.550-01	4.500-02	7.800-01	7.900-02
Ce-141	7.362-01	1.038-03	1.737-01	4.700-01	8.610-02	8.130-01	3.100-02	3.720-01	1.280-01
Ce-143	2.948+00	3.634-03	7.194-01	2.020+00	8.080-02	5.880-01	4.440-02	1.060+00	8.030-02
Ce-144	2.260-01	6.750-04	5.855-02	1.710-01	7.700-02	9.230-01	3.050-02	8.710-02	1.350-01

Continues next page.

Nuclide	b1	b2	b3	a1	a2	a3	a4	a5	a6
Cm-242	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Cm-244	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Co-58	9.513+00	0.000+00	2.171+00	5.880+00	9.300-02	4.660-01	5.520-02	3.910+00	6.860-02
Co-60	2.259+01	0.000+00	5.100+00	1.420+01	9.500-02	4.330-01	6.110-02	9.000+00	5.900-02
Cs-134	1.530+01	0.000+00	3.493+00	9.460+00	9.300-02	4.700-01	5.500-02	6.310+00	6.990-02
Cs-136	2.056+01	1.030-03	4.683+00	1.320+01	8.900-02	4.350-01	5.600-02	7.970+00	6.480-02
Cs-137	5.591+00	0.000+00	1.278+00	3.390+00	9.400-02	4.920-01	5.100-02	2.380+00	7.320-02
Cs-138	2.051+01	1.238-04	4.601+00	1.330+01	8.900-02	4.000-01	6.150-02	7.630+00	5.560-02
I-129	6.500-01	9.139-03	2.504-01	6.240-01	7.800-02	2.280+00	2.270-02	8.190-02	6.950-01
I-131	3.859+00	5.250-04	8.869-01	2.290+00	9.100-02	5.400-01	4.800-02	1.720+00	8.450-02
I-132	2.166+01	0.000+00	4.936+00	1.366+01	9.000-02	4.440-01	5.800-02	8.590+00	6.650-02
I-133	5.987+00	0.000+00	1.368+00	3.730+00	8.900-02	4.630-01	5.800-02	2.420+00	7.230-02
I-134	2.443+01	0.000+00	5.553+00	1.550+01	8.960-02	4.310-01	5.940-02	9.550+00	6.380-02
I-135	1.381+01	0.000+00	3.111+00	8.820+00	9.200-02	4.160-01	6.160-02	5.320+00	5.760-02
Kr-85	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Kr-85m	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Kr-87	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Kr-88	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
La-140	2.057+01	0.000+00	4.628+00	1.330+01	8.800-02	4.000-01	6.100-02	7.650+00	5.690-02
Mn-54	8.083+00	0.000+00	1.843+00	4.970+00	9.400-02	4.640-01	5.310-02	3.340+00	6.720-02
Mo-99	1.449+00	4.576-05	3.299-01	9.170-01	8.770-02	4.650-01	5.370-02	5.860-01	7.110-02
Na-24	3.276+01	0.000+00	7.200+00	2.080+01	9.200-02	4.070-01	6.590-02	1.230+01	5.000-02
Nb-95	7.496+00	0.000+00	1.711+00	4.590+00	9.400-02	4.740-01	5.300-02	3.130+00	6.900-02
Nd-147	1.509+00	2.055-03	3.711-01	1.130+00	7.560-02	5.960-01	4.020-02	4.810-01	8.070-02
Np-239	1.563+00	2.338-03	3.668-01	9.940-01	7.780-02	5.820-01	4.300-02	6.940-01	1.090-01
Pr-143	8.745-08	0.000+00	1.997-08	5.340-08	9.200-02	4.770-01	3.770-02	3.630-08	7.000-02
Pu-238	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Pu-239	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Pu-240	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Pu-241	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Rb-86	8.818-01	0.000+00	2.000-01	5.490-01	9.410-02	4.430-01	5.720-02	3.560-01	6.190-02
Rb-88	5.258+00	0.000+00	1.172+00	3.370+00	9.120-02	4.040-01	6.100-02	2.000+00	5.340-02
Rh-105	7.800-01	0.000+00	1.777-01	4.410-01	9.410-02	5.800-01	4.550-02	3.760-01	9.270-02
Ru-103	4.736+00	0.000+00	1.084+00	2.820+00	9.400-02	5.220-01	5.100-02	2.090+00	7.890-02
Ru-105	7.663+00	0.000+00	1.750+00	4.750+00	8.950-02	4.670-01	5.550-02	3.130+00	9.270-02
Ru-106	1.958+00	0.000+00	4.475-01	1.210+00	9.000-02	4.720-01	5.500-02	8.100-01	7.300-02
Sb-127	6.802+00	7.310-06	1.554+00	4.210+00	9.050-02	4.730-01	5.540-02	2.800+00	7.260-02
Sb-129	1.340+01	0.000+00	3.040+00	8.590+00	8.850-02	4.240-01	6.130-02	5.130+00	6.220-02
Sr-89	8.086-04	0.000+00	1.841-04	4.990-04	9.400-02	4.580-01	5.440-02	3.320-04	6.540-02
Sr-90	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Sr-91	6.647+00	0.000+00	1.512+00	4.150+00	9.100-02	4.460-01	5.500-02	2.670+00	6.470-02
Sr-92	1.187+01	0.000+00	2.674+00	7.480+00	9.360-02	4.230-01	5.970-02	4.680+00	5.760-02
T-3x	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
TO-3x	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Tc-99m	1.098+00	0.000+00	2.361-01	6.100-01	9.530-02	6.920-01	3.890-02	6.600-01	1.300-01
Te-127	4.966-02	1.056-05	1.146-02	2.920-02	9.300-02	5.590-01	4.730-02	2.240-02	8.500-02
Te-127m	3.507-01	6.242-03	1.445-01	3.500-01	6.920-02	2.400+00	2.290-02	8.400-03	3.060-01
Te-129	6.883-01	2.664-03	1.846-01	4.580-01	8.300-02	6.300-01	4.260-02	2.230-01	7.530-02
Te-129m	5.551-01	4.799-03	1.763-01	4.040-01	7.860-02	1.010+00	1.790-02	1.290-01	7.160-02
Te-131	4.015+00	1.809-03	9.230-01	2.810+00	7.260-02	3.900-01	6.360-02	1.310+00	6.880-02
Te-131m	1.312+01	2.248-03	3.003+00	8.440+00	8.700-02	4.300-01	5.870-02	4.970+00	6.400-02
Te-132	2.717+00	1.034-02	7.261-01	1.760+00	8.300-02	8.660-01	2.700-02	1.070+00	1.060-02
Te-133	8.818+00	3.323-04	2.004+00	5.910+00	7.880-02	3.830-01	6.530-02	3.040+00	6.340-02
Te-133m	2.196+01	3.564-03	5.020+00	1.420+01	8.820-02	4.290-01	6.260-02	8.280+00	6.300-02
Te-134	8.922+00	4.636-03	2.081+00	5.790+00	8.320-02	4.690-01	5.750-02	3.380+00	7.360-02
Xe-133	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Xe-135	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Xe-138	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Y-90	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00	0.000+00
Y-91	3.305-02	0.000+00	7.471-03	2.070-02	9.460-02	4.310-01	5.690-02	1.320-02	5.970-02
Zr-95	7.253+00	0.000+00	1.656+00	4.430+00	9.400-02	4.760-01	5.000-02	3.050+00	6.970-02
Zr-97	1.671+00	0.000+00	3.787-01	1.090+00	8.480-02	4.040-01	6.160-02	6.160-01	6.150-02

Layer thickness for kerma-rate calculation

Note: Trunk layer must be at least 1 meter.
Reg_id (1) Central Europe, (230)
Finland**Forest_id** according to 'forest_id.dat'
Compartment_id (1) crown, (2) trunk layer
Thickness in meters

Reg_id	Forest_id	Compartment_id	Thickness
1	1	1	15.20
1	1	2	13.70
1	2	1	11.30
1	2	2	8.10
1	3	1	15.20
1	3	2	13.70
230	1	1	8.30
230	1	2	7.90
230	2	1	14.5
230	2	2	4.2
230	3	1	3.70
230	3	2	1.10

Mass correction for children in external dose calculation

Pop_id -- according to table 'pop_id.dat'
MC -- mass correction for children
MC = exp(-0.11*(weight**0.3333-4.14))

Pop_id	MC
1	1.0
2	1.1757
3	1.0
4	1.0
5	1.0
6	1.0

Monthly time spent in forests (occupancy factors)

Reg_id (1) Central Europe, (230) Finland
Pop_id according to table 'pop_id.dat'
Month (1) Jan, (2) Feb, etc
Fac occupancy factor (time spent in forest, in hours/month)

Reg_id	Pop_id	Month	Fac PV 4.0	Fac PV 6.0
1	1	1 - 12	3.0	3.0
1	3	1 - 7	3.0	3.0
1	3	8 - 11	6.0	6.0
1	3	12	3.0	3.0
1	4	1 - 6	3.0	3.0
1	4	7 - 10	6.0	6.0
1	4	11 - 12	3.0	3.0
1	5	1 - 12	200	200
1	6	1 - 12	3.0	3.0
230	1 & 6	1 - 12	3.0	
230	1 & 6	1-3		9
230	1 & 6	4-5		0
230	1 & 6	6-8		14
230	1 & 6	9-12		10
230	2	1 - 12	3.0	3
230	3	1 - 7	3.0	
230	3	1-3		9
230	3	4-5		0
230	3	8 - 11	6.0	
230	3	6		14
230	3	7-8		23
230	3	9-12		17
230	3	12	3.0	
230	4	1 - 6	3.0	
230	4	7 - 10	6.0	
230	4	11 - 12	3.0	
230	4	1-3		9
230	4	4-5		0
230	4	6		14
230	4	7-8		18
230	4	9		13
230	4	10-12		10
230	5	1 - 12	200	150

4 Internal exposure

Annual consumption rates

Reg_id (1) Central Europe, (230) Finland
Prod_id (1) mushrooms, (2) berries, and (3) game meat
Pop_id according to table 'pop_id.dat'
Consumption_rate in kg per year

Reg_id	Prod_id	Pop_id	Consumption_rate
1	1	1	0.2
1	2	1	0.2
1	3	1	0.5
1	1	2	0.0
1	2	2	0.0
1	3	2	0.0
1	1	3	0.2
1	2	3	0.2
1	3	3	7.0
1	1	4	5.0
1	2	4	3.0
1	3	4	0.5
1	1	5	0.2
1	2	5	0.2
1	3	5	0.5
1	1	6	0.2
1	2	6	0.2
1	3	6	0.0
230	1	1	1.26
230	2	1	6.9
230	3	1	0.89
230	1	2	0.36
230	2	2	3.43
230	3	2	0.31
230	1	3	1.8
230	2	3	13.0
230	3	3	13.0
230	1	4	5.7
230	2	4	28.0
230	3	4	1.6
230	1	5	1.26
230	2	5	6.9
230	3	5	0.89
230	1	6	1.26
230	2	6	6.9
230	3	6	0.0

Feeding rate

Reg_id (1) Central Europe, (230) Finland
Game_id according to table 'game_id.dat'
FR feeding rate (kg day^{-1}) of understorey vegetagion by a game animal

Reg_id	Game_id	FR
1	1	0.25
1	2	0.25
1	3	4.0
1	4	7.0
1	5	15.0
1	6	5.0
1	7	0.1
1	8	0.1
230	1	0.25
230	2	0.25
230	3	4.0
230	4	7.0
230	5	15.0
230	6	5.0
230	7	0.1
230	8	0.1

Flag for picking / hunting season

Shows harvest seasons and hunting periods for wild foodstuffs by regions.

Reg_id -- according to table 'reg_id.dat'
Prod_id -- (1) mush, (2) berry, and (3) game meat
Month -- 1 Jan, 2 Feb, etc
Flag -- 1 for month within season, 0 outside season

Reg id	Prod id	Month	Flag
1	1	1	0
1	1	2	0
1	1	3	0
1	1	4	0
1	1	5	0
1	1	6	1
1	1	7	1
1	1	8	1
1	1	9	1
1	1	10	1
1	1	11	1
1	1	12	0
1	2	1	0
1	2	2	0
1	2	3	0
1	2	4	0
1	2	5	0
1	2	6	0
1	2	7	1
1	2	8	1
1	2	9	1
1	2	10	1
1	2	11	0
1	2	12	0
1	3	1	1
1	3	2	0
1	3	3	0
1	3	4	0
1	3	5	0
1	3	6	0
1	3	7	0
1	3	8	0
1	3	9	1
1	3	10	1
1	3	11	1
1	3	12	1
230	1	1	0
230	1	2	0
230	1	3	0
230	1	4	0
230	1	5	0
230	1	6	0
230	1	7	1
230	1	8	1
230	1	9	1
230	1	10	1
230	1	11	1
230	1	12	0
230	2	1	0
230	2	2	0
230	2	3	0
230	2	4	0
230	2	5	0
230	2	6	0
230	2	7	1
230	2	8	1
230	2	9	1
230	2	10	1
230	2	11	0
230	2	12	0
230	3	1	1
230	3	2	0
230	3	3	0
230	3	4	0
230	3	5	0
230	3	6	0
230	3	7	0
230	3	8	0
230	3	9	1
230	3	10	1
230	3	11	1
230	3	12	1

Remaining fraction of an element after food processing

Reg_id -- according to table 'reg_id.dat'
Element -- symbol of chemical element
Prod_id -- 1 mushrooms, 2 berries, and 3 game meat
PF -- processing factor, ie remaining fraction after processing

Note: Values for Sr, I, Cs and Pu are element specific, for all other elements the values are the same as for Cs.

Reg_id	Element	Prod_id	PF
1 (or 230)	Ag	1	0.5
1 (or 230)	Ag	2	0.8
1 (or 230)	Ag	3	0.9
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1 (or 230)	Cs	1	0.5
1 (or 230)	Cs	2	0.8
1 (or 230)	Cs	3	0.9
1 (or 230)	I	1	1.0
1 (or 230)	I	2	1.0
1 (or 230)	I	3	0.9
1 (or 230)	La	1	0.5
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1 (or 230)	Pu	1	1.0
1 (or 230)	Pu	2	1.0
1 (or 230)	Pu	3	1.0
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1 (or 230)	Sr	1	0.5
1 (or 230)	Sr	2	0.8
1 (or 230)	Sr	3	0.9
1 (or 230)	Tc	1	0.5
1 (or 230)	Zr	1	0.5
1 (or 230)	Zr	2	0.8
1 (or 230)	Zr	3	0.9
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5 Collective dose

Population distribution

Children assumed to be of age 0-4
Data for region 1 assumed equal to region 230
Fraction of vegetarians an assumption

Reg_id (1) Central Europe, (230) Finland
Pop_id according to table 'pop_id.dat', i.e. as follows: (1) adult, (2) child 5 years, (3) hunter, (4) picker, (5) forest worker, (6) vegetarian

Frac Fraction of total population

Reg_id	Pop_id	Frac
1	1	1
1	2	0.06
1	3	0.02
1	4	0.1
1	5	0.001
1	6	0.01
230	1	1
230	2	0.06
230	3	0.02
230	4	0.1
230	5	0.001
230	6	0.01

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