

*Sampling/monitoring programmes in the forests affected by the Chernobyl accident, and dynamic models for evaluation of caesium behaviour and countermeasures for contaminated forests*

Sergey Fesenko

チェルノブイリ事故により汚染された森林におけるサンプリング及びモニタリングプログラム  
放射性セシウムの挙動評価及び汚染された森林対策の動態モデル

Department of Nuclear Sciences and Applications

International Atomic Energy Agency

s.fesenko@iaea.org



IAEA

International Atomic Energy Agency

[Unclear] I suppose you're able to hear me well. Okay. Yes, I would like to start my talk with [Unclear] how my colleague and friend Vasyl started, so I'd like to thank you very much for inviting us to take part in this seminar. You take lot of [Unclear] show us your sites, your research, and [Unclear]. Thank you very much, once again. My talk will touch actually several problems. First problem is application of the different management system for assessment of [Unclear] in forests, user based information on cesium [Unclear] etcetera and my second part is review of the models which can be applied for [Unclear]. Would you like to translate or I will proceed?

Yamamoto [ph] [Unclear], Sergey Fesenko, International Atomic Energy Agency for the Energy Environment Laboratories. This is [Unclear] a division and which the department which provides support on the environmental management on contaminated sites. In Belarus, in Kazakhstan, in many, many countries, even Australia, and even [Unclear] etcetera. Well, this is actually a short-term job to provide support in the environmental management.

Forest is an essential part of our job, so we provided many big documents on forests. Many projects were started on forests and this is our one of the key activities.

## Significance of contaminated forest and freshwater ecosystems

森林及び淡水生態系の放射能汚染の重要性

- Natural ecosystems are extensive natural resources, which provide economic, nutritional, recreational and social benefits.  
自然生態系は大きな自然資源であり、経済的、栄養学的、レクリエーション、社会的な利益をもたらす。
- Contaminated forests are an important source of internal and external exposure of the population.  
放射能汚染を受けた森林は、人々の内部及び外部被ばくの原因となる
- In the long term after the radiation accident, the contribution of contaminated forests to exposure of population is increased  
原子力事故の後の長期間に渡って、放射能汚染された森林は外部被ばくを増加させる
- There are «critical groups» of the population with high exposure levels due to consumption of forest products  
ある特定の集団は、森林に関わることで高い外部被ばくを受ける
- Natural ecosystems are very sensitive to many of remedial options and ecological consequences of remediation should be always considered.

自然生態系は、どんな対策を選択するかに敏感に反応し、その結果生態系がどうなるか常時考慮されなければならない



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[Unclear] to start with some very pivotal statements why forest are important for the people, for the public, because forests are natural ecosystem which are extensive natural resources which provides a lot of different I would say benefits to the population. Forest is very important for people [Unclear] agricultural, nutritional, recreational, and social benefits.

Contaminated forests [Unclear] serves as an important source of the internal and external exposure for those population. We know some times, in the case of Japan for the whole population, but for some protection groups but it is important source of the population or the exposure of the population.

In the long term after radiation incident, you will see that the importance of radiation in forest, rates will go up, means we would [Unclear] to respond to this challenge. There are so-called critical groups of the population [Unclear] critical groups of the population with high exposure levels due to the consumption of forest products. Natural ecosystems are very sensitive to application of various technical evaluations [ph]. So there are just remedial set of options which are actually available for forest. Do you want me to take it from here?

## Scale of the Problem: Contamination of forest following the Chernobyl accident, th. ha

チェルノブイリ事故後の森林の放射能汚染  
森林の放射能汚染について、セシウム沈着量ごとに森林面積を示している

	沈着量 <i>Deposition density</i> kBq m <sup>-2</sup>			
	37-185	185-555	555-1480	>1480
<i>Belarus</i>	1100	330	142	5
<i>Russia</i>	930	110	36	2.6
<i>Ukraine</i>	1087	106	31	95
<i>Total</i>	3117	546	209	103

森林面積 ha



Just to illustrate these statements, I'd like to show you the areas which are affected by forest after the Chernobyl accident. You see, as I said, [Unclear] after the contamination after the Fukushima incident, and there are high areas, large areas where contamination levels are still high. And you can see the data which we used for the official assessment.

*Contributions of different pathways to the exposures of population in contaminated areas of Russia, %*

	Normal population	Critical group
External dose within the forest	3	18
External dose within the settlement	41	11
Internal dose from milk and meat consumption	33	58
Internal dose from berries consumption	2	1
Internal dose from mushrooms consumption	19	11
Internal dose from the other products consumption	2	1
<b>Contribution of forest pathways to the total dose</b>	<b>24</b>	<b>88</b>



IAEA Training course, 4  
Vienna 2004

And I was coming to the question asked by [Unclear], a good friend from here in Japan. You can see how much important the contaminated forest, for example, for local population. In the project called Project [Unclear] commission we studied more than 200 settlements located in Russia, west Belarus, and west Ukraine and here we've provided Russian data part. You can see that there are many settlements and critical group of the population for whom the exposure from the forest is very, very important. This is just – impression that forest should be properly processed and proper forest management is of high importance.

## *Forest soil survey (Snapshot)*

森林土壌調査

- Objective: to identify forest soil contamination for making decisions on forest management and protection of population.
- Based on forest compartment (quarters) used for forest service provision by the governmental forest Agencies.
- Two step procedure: external dose rate measurement + forest soil sampling.

目的：

森林土壌の汚染を明らかにし、森林管理と住民の安全保護の政策決定に活用する

政府森林関連機関による森林サービスの提供のための森林区画（部署）

二段階の手順：外部被ばく測定と森林土壌サンプリング

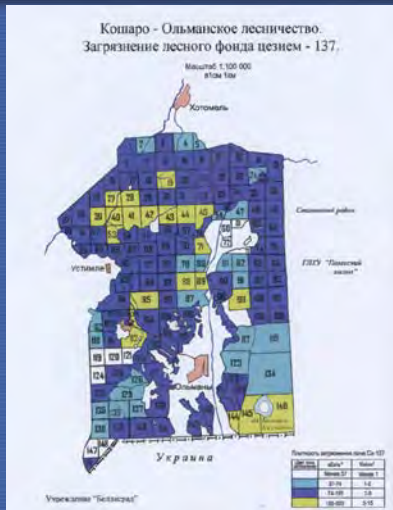


Actually to get information for forest management we need to provide some kind of segmental studies. There are actually different segmental studies. Just I would say the growth [ph] is forest [Unclear]. To get information for forest management we have to organize [Unclear] studies.

There are different types of monitoring. Here we started with forest soil survey, so-called snapshot survey.

The objectives are to identify forest soil contamination for making decisions to classify soil in terms of their contamination and to – we should provide this information for making decision. Actually this measure includes two steps; first step is screening, using external dose rate measurements.

## Example of Forest enterprise with forest compartments



- Survey is based on forest compartment (quarters) used for forest service provision by the governmental forest Agencies.
- Data are reported at the level of individual forest compartment.



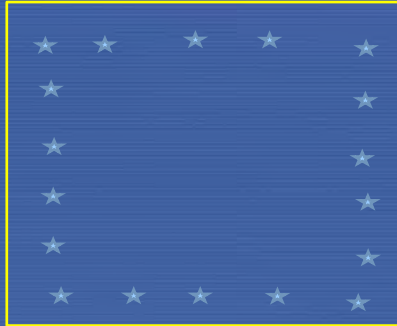
This is quite simple two-step procedure and it is based on the forest quarters. What is then forest quarters? You can see from this picture because [Unclear] and used to [Unclear] forest compartments so called division of the forest of some parts of some quarters is homogenous basis in terms of the forest trees, forest soil, etcetera. And you can see how it looks with the contaminated forest area. So this is a map gives contamination of the territory, of the forest enterprise which is subdivided into different forest areas.

This is actually a basic subdivision for the method of the contamination of the [Unclear] soil. So we provide average information for [Unclear] forest compartment as you see here. We see here this data given here is a map with a range but for each such forest unit there is exact data available on the different levels of contamination of the – distribution of contamination points etcetera.

The size of this forest unit can vary from 50 hectare to 1 square kilometer or 1000 hectares, dependent on the homogenous of forest [Unclear].

## Forest soil survey: initial screening based on external dose rate measurements

森林土壌調査：外部被曝量測定に基づく初期スクリーニング



- 1m高での外部被曝量測定
- 各地点で3回測定
- 測定値の最大値と最小値の比が3.3以上の場合、10-15地点で追加測定
- 比が3.3以下の場所については、いくつかに分類

- External dose rate ( $E$ ) measurements at the height of 1 m;
- 3 measurements per each point;
- If  $E_{max}/E_{min} > 3.3$  measurements are being performed additionally in 10-15 sampling points.
- The unit is divided into several parts where  $E_{max}/E_{min} < 3.3$



This is actually the result of how we're doing this survey. At the first stage, we provide the measurement of the external dose rates which is in the air, in the around 20 – between 20 and 30 points, around the border of the forest unit and the distance from the border [Unclear] points would be not less than 20 meters.

Actually at every point, we have to take three measurements. We have to make three measurements.

And [Unclear] value used for the calculation [ph] of average sampling point like every point shown here [Unclear] value used for calculation [ph].

After that we need to have a look at the all variables and to compare maximum values for this – [Unclear] sampling points and we get minimum value.

If this ratio is higher than 3.3 we have to subdivide this forest compartment into several compartments.

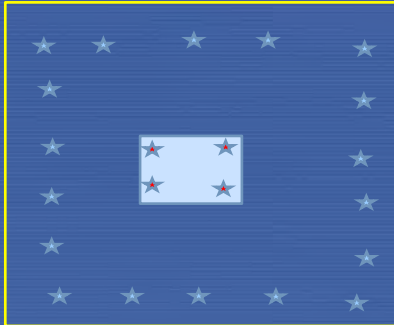
And we have to maintain uniform measurements.

If this ratio is lower than 3.3 we can continue with soil survey.

## Forest soil survey: initial screening based on air dose rate measurements

森林土壌調査：外部被曝量測定に基づく初期スクリーニング

試験サイトのサイズ



- ★ Point of soil sampling  
土壌サンプリング地点
- ★ Point of dose rate measurement  
線量率測定地点



- Test site 30-50 m × 30-50 m
- Difference between external dose at the site and average for forest unit should be less than 10% 林分全体の平均値と各地点の測定値の差が10%以下でなければならない
- Type of forest should be same around the site 森林タイプが同じであること
- Depth 20 cm 深度20cmまで
- Four samples taken in the corners of the site form average (balk) sample 試験サイトの4角でバルク土を採取
- Plane relief, to avoid effect of run-off 平坦地（水流出の影響を避けるため）
- Reported data represent a contamination density, kBq m<sup>-2</sup>!!! 沈着量も報告すること

In this case you have to select sampling points, or sampling test site which normally has a size 50 to 30 meters, sorry [Unclear] 50 meters square. The external dose rate in the perimeter of the square should be lower than 10% from the average identified for the entire forest compartment. After that we have taken four samples in the corners of this site. After that we take four samples; one, two, three, four in the corners of this site. At the depth of the 20 centimeters. And the four balk samples or [Unclear] samples based on these four samples taken. Some requirements to that, it should be a plane site. There should be not [Unclear]. Then we report all this data in terms of the kilobecquerel per square meter so in terms of the contamination density. This is actually different – another system which was implemented in Japan, because Japan provided information in becquerel per kilogram.



## *Routine Forest monitoring (long-term system of permanent observation)*

定期的な森林モニタリング (持続的調査の長期的システム)

- Objective:
  - To provide input to assessment of the patterns of  $^{137}\text{Cs}$  redistribution in forest ecosystems 森林生態系内でのセシウム137の移動様式の評価
  - To identify a critical exposure pathways and forest products 被曝の主要経路及び林産物の評価
  - To prevent use of forest products/commodities with contamination above action/reference level 林産物の使用規制/対策が必要な汚染レベルの産物について/基準値について
  - To support application of forest management actions 森林管理事業の助成申請
- Is a part of the routine forest service in areas affected by radionuclides 放射性物質の影響地域における慣例の森林サービスの一部として



Routine forest monitoring, now, it comes from the – way from the system of the permanent observation.

Yeah, forest monitoring. Actually, the purpose is to assess patterns of the redistribution in the forest ecosystem.

For that we have to measure, of course, every year major areas and some are [Unclear] actually concentrations of cesium in different forest compartments such as, forest soil, forest trees, leaves, understory species, bushes, etcetera, so all these examples will be sampled.

The purpose is to identify critical exposure pathways and to identify most critical exposure forest products. The purpose is also to identify a critical exposure pathways and forest products, critical forest products.

We use the data to prevent use of forest products or forest commodities which have contamination above action/reference levels. Yes, I know that there are no action levels for forest products yet to be published until now, but Russia, Ukraine and Belarus have such levels. To organize such proper management, we needed such action or permissible levels.

Finally, this information was – the goal was to provide appropriate advice for the forest management.

In the Chernobyl affected countries this job is job which provides official government or its authorities.

## *Routine Forest monitoring (long-term system of permanent observation)*

定期的な森林モニタリング (持続的調査の長期的システム)

- Routine monitoring includes major forest products, by-products and commodities produced from contaminated forest products, including:  
定期調査は主要な林産物を含む、放射能汚染された森林から生産された産物と商品
  - round wood, firewood, construction wood, wood mills, mushroom, berries, cones, seeds, Christmas trees, medical herbs, etc.
- Sampling 丸太、薪、建材、木材工場、きのこ、ベリー、球果、薬草、など
  - within forest products harvest/collecting, 林産物の収穫、採集
  - during preparation and processing, 準備・加工
  - during storage, 保管時
  - before sending products to the consumers. 消費者へ商品が届くまで
- Check of homogeneity of samples is extremely important. サンプルの均一性が非常に重要！



Here I would like to demonstrate which are subject for this forest monitoring so they monitor round wood, firewood, almost all products which are available from the forest.

They take samples at different stages of the sampling and comprises of the forest products and forest commodities.

Then continue this monitoring until these commodities or products are sent to the final consumer.

Official procedure was developed to check homogeneity of these samples because you see we have to be aware that we didn't miss some samples is [Unclear] various contamination is [Unclear].

## *Model oriented forest monitoring (long-term system of permanent observation)*

モデルによる森林モニタリング

- Objective:
- (i) to identify long-term patterns of  $^{137}\text{Cs}$  redistribution in forest ecosystems,
- (ii) to provide input to the dynamic models describing radionuclide behavior in the forest,
- (iii) to provide input to the long-term forest management.
- 目的:
  - (i) 森林生態系におけるセシウム137の長期分布特性の評価
  - (ii) 森林内の放射性物質の動態を予測するモデルへのインプット
  - (iii) 長期的な森林管理へのインプット



And model oriented forest monitoring, this is already a short type of the monitoring which is intended to identify long-term patterns of cesium behavior in the forest ecosystems. This method is intended to provide input to the dynamic models, to develop such models and to provide input to the long-term forest management.

*Model oriented forest monitoring: Programme*

モデルによる森林モニタリング プログラム

- **Cs-137 Soil** 土壤中のセシウム137
  - Speciation of <sup>137</sup>Cs in different soil horizons 各土層のセシウム137
  - Vertical distribution 深度分布
  - Kds in different soil horizons 各深度の分配係数
- **Cs-137 in soil-plant system** 土壌-植物系でのセシウム137
  - Cs accumulation in leaves, needles (different age), wood 葉 (異なる葉齢)、樹幹へのセシウムの吸着
  - Age effects 林齢の影響
  - Cs concentrations in understory species 下層植生のセシウム濃度
  - Cs concentrations in mushroom and berries きのことびべリーのセシウム濃度
- **Cs-137 in game** 鳥獣のセシウム濃度
- **Compilation of ecological data:** 森林生態データの比較
  - type of forest, biomass and age of trees 樹種、バイオマス、林齢、
  - forest soil properties 森林土壌特性
  - game feeding data (by seasons) 鳥獣の狩猟データ (季節ごと)



Okay. These are examples I provide information about our monitoring program which we perform in the Bryansk region, so this monitoring program was recording in details studies of soil.

Including study of the speciation of different soil horizons.

Vertical distributions.

Kds for different soil horizons.

So distribution coefficient.

Distribution coefficient.

Distribution coefficient

Kd means distribution coefficient.

Okay. We study these processes of the typical forest soil [Unclear] representative conditions for the contaminated forest areas. We also study accumulation in seasonal leaves, different [Unclear] season cause the concentration of radionuclides in leaves goes up [Unclear] is much higher than in September, for example. So establish – design processes during the season. We also study contamination of needles of different age, wood in certain sections are subject to forest [Unclear].

It is clear that young people can accumulate cesium much faster than older people, sorry not people, trees. Young trees can accumulate cesium much

higher than with old trees. Various studies also with age effect of the radionuclide transfer to the trees for different version, [ph] statistics.

Important point is also to study the concentration of cesium in the understory species because understory species which provide a lot of forest food. It is important also to study the understory species because these understory species such as berries, mushrooms can provide a lot of forest food.

Game is also of highest importance because there are meat hunters who hunt game and they can consume lot of contaminated muscles of game, contaminated meat which can provide [Unclear].

We should be able to explain on growing levels of contamination of meat from game, muscles of game, which is why we study feed duration [ph] of game, we study accumulation of cesium in the species which are consumed by game so such processes are also of importance and such process are also a subject of our studies.

And to – which explain a [Unclear] we need to have a lot of ecological information. For example, distribution of roots, fiber roots in the forest soil, for example, some product [ph] such as contamination values in a specific of trees, of understory is maximum to youth and certainly we need such homogenous [ph] information to make contribution but we also study ecological provisions of this in stages.

We also studied external growth rates which are dependent on the properties of soil, dependent on the forest biomass, etcetera, such factors, give also insight to the monitoring program.

*Model oriented forest monitoring: 5 forest sites  
representative for contaminated forests*

モデルによる森林モニタリング 汚染森林を代表する5つの森林サイト

Experimental sites	Type of forest	Group of soil	<sup>137</sup> Cs deposition density, kBq m <sup>-2</sup>	
			Geometric mean	Range
Site 1	Coniferous 針葉樹	Automorphic 自成土	1347	804–2260
Site 2	Mixed	Semi-hydromorphic	1702	890–2850
Site 3	Mixed	Hydromorphic 水成土壌	1384	998–1729
Site 4	Mixed	Automorphic	1063	523–1623
Site 5	Deciduous 落葉樹	Automorphic	746	414–1531



You can see actually five of our sites where we actually [Technical Difficulty] yet research for the time approximately 7 years, 8 years. These sites are located in the Bryansk region and we see different density and type of soil and type of forest.

Contamination level, as you see, are quite high.

The level of the sites, contamination is close proximity to the Fukushima station and the level of that – around 2000 kilobecquerel per square meter and that was very high to the wildlife.

## *Model oriented forest monitoring*



Site 1



Site 2



Site 4



Here I would like to show you the [Unclear] outside. On the left side, this is automorphic, coniferous site. You have pine trees of the automorphic soil. You see forest here and you can compare how this in Japan. This is a site at the automorphic site, site 4. Here is site 3 where you also have deciduous forest at the automorphic site. Actually, we used these sites not only for the study of the behavior of radionuclides [ph] in the forest ecosystem. We also studied the effect of different – in the middle portions there. As I told you, forest is very, I would say, sensitive issue in which [Unclear] actions. That's why we started some actions which should not, which can [Unclear] forest very much. I'm afraid up here you can see some liming. So this area was limed because you see this [Unclear] and we provided some lime to increase activity, concentration of potassium [ph] from soil to plants. You know that forest soil normally have high potassium compared to soil with little potassium.

Our intention was also to develop a model, which would allow us to optimize application of lime for such purpose, depending on the forest soil properties and we developed such model.

It was presented at the conference [Unclear] in 2004 and in some international conferences.

It's been 15 years [Unclear] agency.

*Model oriented forest monitoring – Dynamic model – Decision Making Framework-Recommendations on Long-term Forest Management*

動態モデル

長期的な森林管理に推奨される政策決定の枠組み



Actually, through the system of our internal program was to study experimental [Unclear] fine grade potassium in the forest ecosystems to model this process system, prepare models. After that to provide application of these models for the exposure pathway analysis and after that to provide some decision making framework for the application of the various countermeasures, for the application of the different types of the forest management.

Here I just would like to demonstrate some representative papers which that or everything what I'm saying is available from the international strategy [ph].

If you like, I'll leave my business card at the second table. You can take it then you can send me your request. I can always send you papers, [Unclear] sending information we have on the behavior of the forest and the ecosystems.



試業により抽出されたセシウム137の割合

Soil horizon	Depth of the layer (cm)	Percentage of the total activity (%)	Percentage of <sup>137</sup> Cs extracted by reagents (%)				
			H <sub>2</sub> O	AcNH <sub>4</sub>	1 N HCl	3 N HCl	Rest
Site 1							
AoL	0-2	2.4	7.5	8.0	6.8	7.9	69.9
AoF	2-3	6.4	0.26	3.9	4.0	10.2	81.6
AoH	3-3.5	18.7	0.08	3.2	4.3	11.6	80.9
AoA1	3.5-5	46.2	0.02	1.1	3.0	9.0	86.8
A1	5-16	18.8	0.17	11.1	7.8	14.9	66.0
A1A2	16-24	6.3	0.28	18.5	8.5	14.1	58.6
B	24-40	1.3	4.4	29.4	15.1	16.9	34.3
Site 2							
AoL	0-2	1.2	8.2	17.0	11.8	18.3	44.7
AoF	2-5	11.3	1.1	8.6	5.7	12.9	71.7
AoH	5-7	43.4	0.28	6.7	5.0	12.3	75.7
A1	7-12	32.9	0.04	3.1	1.4	2.1	93.3
A1A2	12-20	9.8	0.22	3.2	1.4	1.8	93.3
B1	20-40	1.5	2.3	16.1	5.1	12.2	64.4



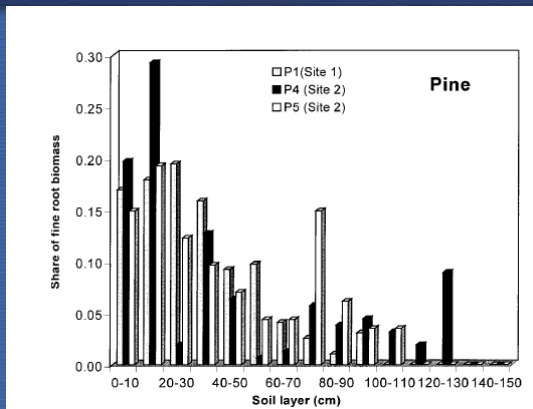
[Unclear] number of the [Unclear] or just give me yours and I will send the information [Unclear].

And coming to some experimental results which we achieved on these sites. Here, I just would like to show you differences in the, I would say, geochemical performance. It is accepted that the alginates [ph] from we just extracted – which can be extracted from the soil by application of the this different portion of acids, can be used [Unclear] use this approach for assessment of soil in terms of the availability of cesium in those soils.

## Distribution of fine roots at the different sites

各調査地点の細根の分布の違い

細根バイオマス量の割合



土壤深度

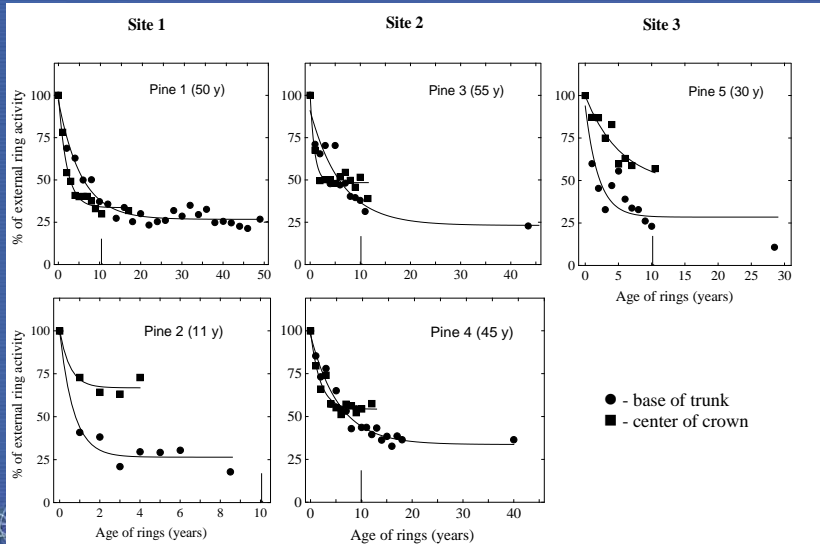


This is just an example of what we have at this site. This is an example of the distribution of the pine roots because not all roots part are possible for the recognition potential [ph], but I have to study different roots and this is a question which is close to the plant physiology and what [Unclear] with a plant ecologist on site, to study these ecological processes.

I would say, normally, the team which [Unclear] scientist of different categorizations should be used for understand and fully understand [Unclear] processes in the forest.

## Radial distribution of $^{137}\text{Cs}$ at different vertical positions along the trunk of *Pinus sylvestris*.

ヨーロッパアカマツの樹幹でのセシウム $^{137}\text{Cs}$ 分布



And here you can see [Unclear] radial distribution of cesium of external [ph] rings.

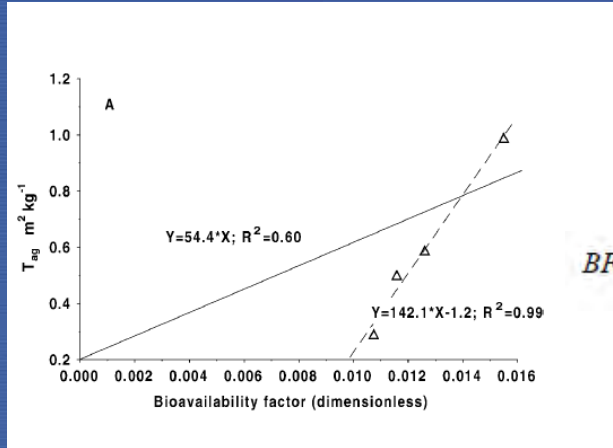
You can see how different patterns dependent on the forest soil and dependent on the age of trees.

We took samples at the height of the breast height. Normally it is 1.3 meters. Our colleague from Japan agency of radiation protection of forest all does it [Unclear] centimeters but we took at [Unclear] centimeters [Unclear] 120.

[Unclear] the little trees and the [Unclear] height of trees. This is actually one approach used for the forest trees.

# FORESTLAND concept on radionuclide transfer to plants

FORESTLANDモデル 植物への放射性セシウム移行の概念



For calculating the total fraction of Cs in the soil-litter system that can be transferred to understory species and tree species bioavailability factor  $BFJ(t)$  was suggested as:

$$BFJ(t) = \sum_i^N \delta_i(t) * q_i(t) * k_i^j$$

下層植生及び樹木に移行しうるセシウム（土壌-リターンシステム）の含有率の算出方法

生物利用能（利用率）BFJ(t)

生物利用能における土壌から樹木への移行係数の依存性



Dependence of aggregated transfer factor from soil to wood on bioavailability factor.

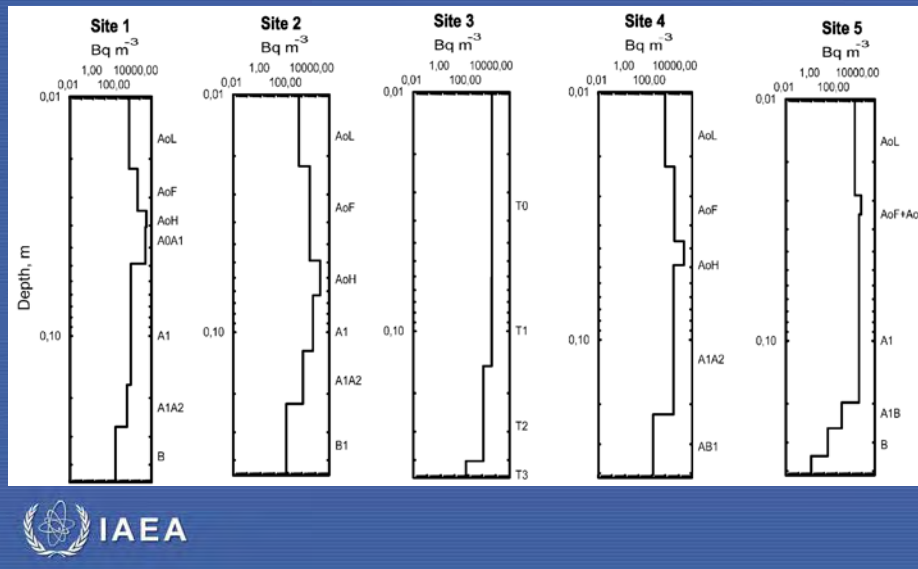
Based on this...

[Unclear] which are used for the development of the FORESTLAND model. For example, our assumption was that the transfer of radionuclides is dependent on the contribution of roots in the contamination with distribution of the radionuclides and it would be – it relates to the available amount of cesium in soil horizons.

For that we used – introduced a simple assessment so called bioavailability factors for trees whose understory differs which is presented here. You can see and we demonstrated that this approach also works for whose understory differs for different berries or mushrooms, etcetera – similar approach.

## Distribution of $^{137}\text{Cs}$ at the different forest sites

各森林サイトにおけるセシウム137の深度分布



Here you can see the vertical distribution with [Unclear] soil and you can see how different soils [ph] were found for cesium. Here you took samples each centimeter but here [Unclear] data is according to the different soil horizons upon request of the editor of our paper for the journal.

[Unclear] scale is taken into account the difference is identified [Unclear] to the normal scale [Unclear].

## *Final product of the monitoring is a guide for the forest management*



 IAEA

*This guide for the forest management intended for the population of the Stolypin District and provides recommendations on which forest products, where (based on forest maps), when and how can be sampled and utilized. The information presented in the very user-friendly form and can be easily understood by the public. Based on both monitoring data and model assessments/predictions. National permissible levels for all products are also presented. Similar recommendations are developed for all forest enterprises.*

How to use the data? Actually based on that and based on the suggestions made with different models, forest models, related models etcetera, we provided some kind of the guidelines for the optimal or say usable [ph] forest management in the contaminated areas. These documents, these guides were [Unclear], provided for every forest enterprise and for any forest district. This document which includes clear terms and conditions to the public which forest products can be taken, where, how, when and which actually products should be avoided for some areas. Actually we provided also much for every district so people knew actually which [Unclear] can do different activities. If somebody wants, I can show you this historical reference. We still have some [Unclear].

As you can see we supported very this activity so they were provided some expense and we provided some assistance [Unclear] very much and negative [Unclear] provision how to organize proper management of this area.

Actually, this document is very simple so it is very user-friendly. So the intention was to explain everything in very simple words to the public.



**ВЫ СОБИРАЕТЕСЬ  
В ЛЕС...**

Рекомендации для населения  
по пользованию лесами  
на территории Столинского района

 **IAEA**

*IAEA Environment Laboratories in Seibersdorf provides a long-term support to the development of the recommendation guides on optimized use of forest products.*

*Best examples derived from these projects could be of high importance for the Authorities and Institutes responsible for forest management in areas affected by the Fukushima accident.*

Actually, [Unclear] provided and provides [Unclear] support the relevance of such documents in different countries and actually I will say best examples and best experience from this in development of this document but we also delivered it to Japanese appropriate [Unclear] who were doing similar things.

## *Monitoring data used for development of the Permissible levels*

Permissible levels for  $^{137}\text{Cs}$  activity concentrations in forest products (SanPiN 2.3.2., 2002; PLS, 1997),  $\text{Bq kg}^{-1}$

Type of the product	After 2002	Before 2002
Round wood, not barked (logs)	11100	11100
Barked wood for sawed products	3100	3100
Wood products for household processing	2200	2200
Fire wood	1400	1400
Construction wood	370	370
Mushrooms (fresh weight)	500	1480
Berries (fresh weight)	160	1480
Mushrooms (dry weight)	2500	7400
Berries (dry weight)	800	7400

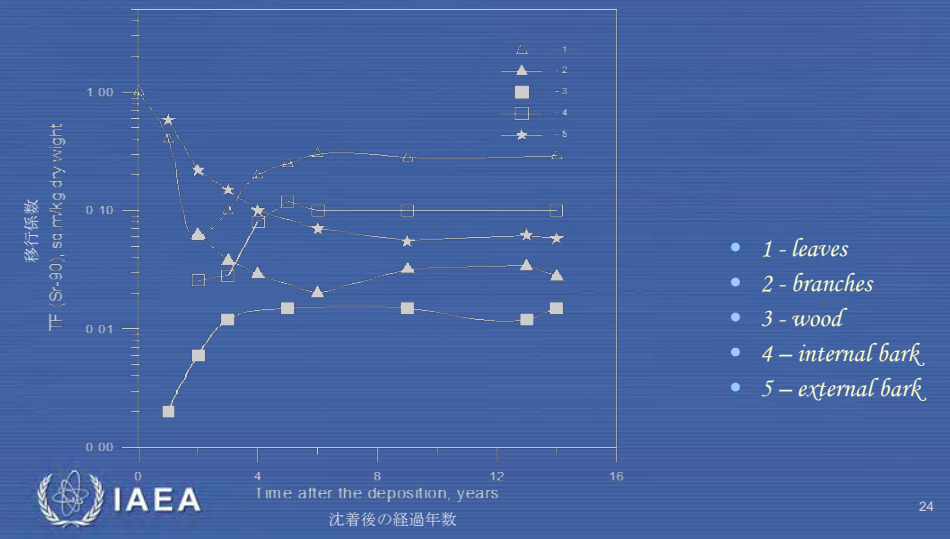


Here you can see another way have we use monitoring data. Monitoring data are very useful to develop historic conventions on permissible levels for different cesium activity concentrations in different forest products and commodities. And key examples such as documents which we have – which people have is in Russia. These documents are very useful because they would allow us to control how dangerous is the products of the contaminated plants. This document was very useful for people to organize proper forest management. Here you can see the example of that.



## Dynamics of $^{90}\text{Sr}$ activity concentrations in the birch forest after the Kyshtym accident (Tichomirov - Alexakhin, 1977)

Kyshtym (キシシュテム) 事故後のカバノキにおけるストロンチウム90濃度の動態



Coming to – this monitoring, I would like to mention that it is not the first case where a forest monitoring was recognized. Actually the first radiation accident where plutonium production [Unclear] was accident at the Kyshtym, a chemical plant. It was in 1958. It was [Unclear], and extensive research work was recognized already at that time. Look here, I've provided some information from those monitoring studies. So this activity concentrations in different compartments for Strontium because you see we still have no such information for Chernobyl. This information [Unclear] experience from Kyshtym accident would be also very useful for Fukushima and for other [Unclear].

## *Accumulation of radionuclides by plants and mushrooms*

植物とキノコによる放射性物質の吸収

- *Depth of roots (mycelium) location relative to contamination profile.* 土壌のセシウム汚染深度に対する根茎の深度分布
- *$^{137}\text{Cs}$  accumulation capacity of plants (mushrooms).* 植物のセシウム $^{137}$ の吸収能
- *Radionuclides distribution over the profile of soil and litter.* 土壌及びリター層での放射性セシウムの分布
- *Type of soil.* 土壌タイプ
- *Type of nutritious substrate (wood, litter, soil, etc.)* 栄養基材?
- *Type of forest.* 森林タイプ



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Actually I would mention also about contamination of mushrooms and berries. Here I would like to mention that there are a lot of factors which have to be studied. If we look at the mushrooms they are totally different in terms of the accumulation of cesium because actually they are consumed [Unclear]. But the actual contamination levels which depends on the location for the – depends on the root location, capacity of plants for some [Unclear], type of soil and type of the nutritious substrate, because they can be located on wood, [Unclear] litter, soil et cetera where contamination levels are totally different. And when we know such factors, such [Unclear] which can provide for most predictions what we can get in the future not only now.

*Average transfer factors for different species of mushrooms, ( $Bq. kg^{-1} / kBq. m^{-2}$ )*

キノコ類の放射性セシウム移行係数

Species of mushrooms キノコの種類	1986-1994, Russia	1989-1990, Belarus
<i>Boletus edulis</i> ヤマドリタケ	7.3	7.8
<i>Cantarellus cibarius</i> アンズタケ	6.2	8.6
<i>Xerocomus Badius</i> ニセイロガワリ	89.6	110.6
<i>Russula</i> ペニタケ属	10.0	28.3
<i>Suillus luteus</i> スメリイグチ	32.0	98.3
<i>Armillaria mellea</i> ナラタケ	16.0	7.4
<i>Leccinum scabrum</i> ヤマイグチ	15.0	46.4



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Here you can see some incidences which can be [Unclear] and explained based on this parameter, which we also studied at our sites for many, many site, [Unclear] many, many years.

## Forest models 森林モデル

Model name	Developers	Country
<i>RIFE1</i>	<i>G. Shaw</i>	<i>UK</i>
<i>FORESTLAND</i>	<i>S. Fesenko, S. Spiridonov, I. Goncharenko, R. Avila</i>	<i>Russia, Sweden</i>
<i>FOA</i>	<i>R. Bergman</i>	<i>Sweden</i>
<i>FORESTLIFE</i>	<i>A. Dvornik, T. Zhuchenko</i>	<i>Belarus</i>
<i>ECORAD-C</i>	<i>S. Mamikhin</i>	<i>Russia</i>
<i>FINNFOOD</i>	<i>A. Rantavaara</i>	<i>Finland</i>
<i>FORM (IAEA)</i>	<i>M.J. Frissel, M. Crick, E. Holm, C. Robinson, G. Shaw</i>	<i>Austria</i>

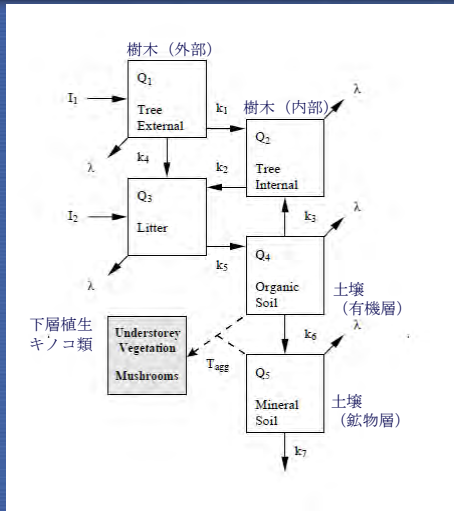


Then information of the forest research not only in Russia but also in Ukraine and also in Belarus especially, which resulted in the development of the many forest models. Actually, I'd just mention one, two, three, four, five, six, seven models. But [Unclear] international models in the world, agency provided a flow for each comparison studies everywhere.

Kyshtym accident. The Kyshtym accident which has happened in 1958 – September 1958, in south Europe. This was huge accident there in a chemical plant which area was worst contaminated and it was first large scale experiment where people got an experience. This experience was fully utilized after the Chernobyl accident because people who had such experience came from the Kyshtym accident or the Chernobyl accident maybe have to provide their expertise how to manage this accident. So Kyshtym was the first big accident.

## Structure of RIFE1 Model

RIFE1モデル構造



- RIFE1 is a 5 compartment model describing dynamic transfer of Cs in forest  
森林内のセシウム移行動態を表す  
5つのコンパートメント（区画）からなる
- Cs concentrations in mushrooms and berries are considered to be in equilibrium with those in soil.
- Model parameters are based on TRS 364, which was currently replaced by TRS 472

キノコやベリー  
のセシウム濃度は土壌濃度と平衡状態にあると仮定

モデルパラメータはTRS364に基づく。現在はTRS472に変更



Okay. Now, I would like to continue with some short overview – concise overview of the available models of [Unclear] in forests. Just to provide a flavor for these models and how they were developed.

Certainly, I cannot give you many, many [Unclear] compare the advantages of [Unclear].

RIFE1 model was developed by George Shaw from the UK. And in this model – the advantage of this model is that this is a very simple model.

This was based on the TRS 364 which was Agency documents published in 1994.

And currently I have to say this document was revised [Unclear] TRS 472 which is successor of the TRS 364.

The model considers five dynamic compartments and one feed [ph] compartment. The model considers five dynamic compartments and some [Unclear] compartments, dynamic compartments.

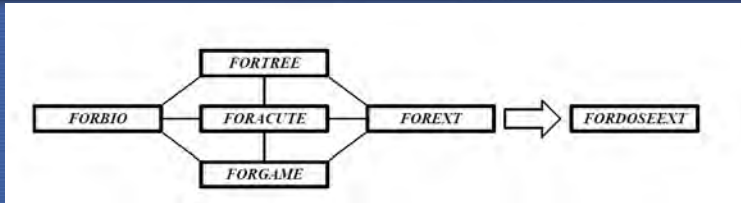
[Unclear] understory species and mushrooms is based on the concept of the Tag, aggregated transfer factors. So they assumed that contamination of the understory and mushrooms is in equilibrium with cesium concentrations in organic and mineral soils.

The disadvantage that this model is valid only for some, rather for periods which this model works which is validated [Unclear]. The advantage is the

model is valid for another period during this model was studied, validated. For example, I can explain you why because it is actually the case of almost all such models. Actually the fastest interaction of cesium in soil, greater penetration is directly at the time of the deposition because at that time all cesium is in available form. It's clear? The faster penetration cesium through forest soil movement of cesium through forest soil is directly after the deposition because at that time all cesium is in available form. After that you have first difference of [Unclear] cesium soil was [Unclear].

## FORESTLAND model

FORESTLANDモデル



- FORESTLAND was developed upon request from Ministry for Agriculture of RF and was a product of international cooperation (Russia, Sweden, France)
- The model was intended to support a long-term forest management and also assessments in case of potential accidents

FORESTLANDモデルはロシア農業省の要求を受けて、ロシア、スウェーデン、フランスの協働により開発されたモデルは、原子力事故が発生した場合の森林の長期管理とそのアセスメントの支援を目的とする

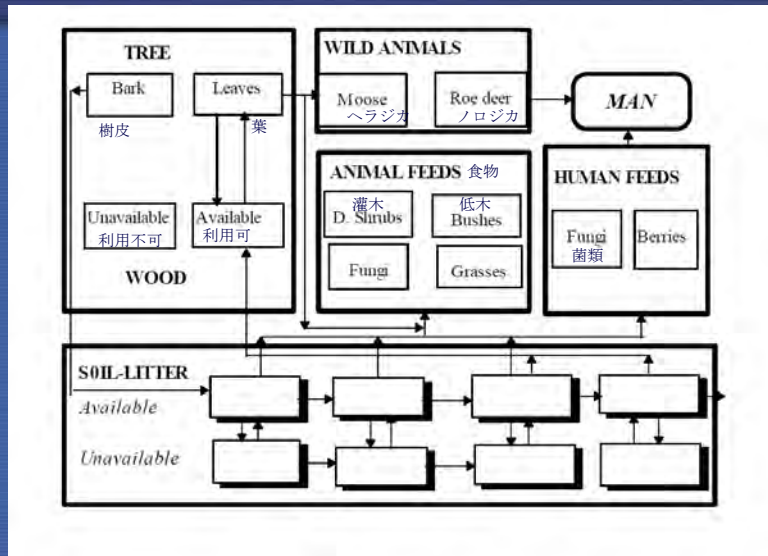


We use average data sometimes for the assessment of the parameters.

[Unclear] to make, in any case the screenings [ph] of forest soil. We need to make for the [Unclear] of forest soil we will have to make and slow down the transfer of radionuclides in the forest soil.

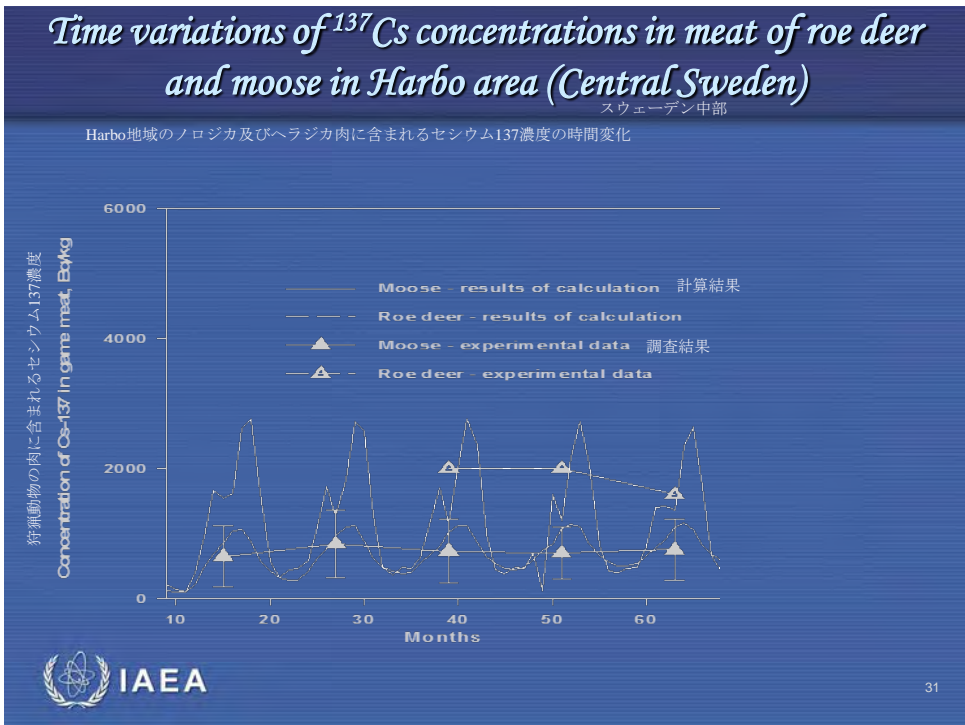
Okay. Let's come to the FORESTLAND model which was especially developed upon request from Russian ministry [Unclear] because it also has a forest department which is responsible for the radiation protection [Unclear] forest resources directly, monitoring [Unclear]. The development of the model was supported also by Sweden, France and also this is an international model. The model was intended to assess not only long-term forest management but also for reviewing the case of the potential future accidents because it included actually different models. Actually it is not a single model, essentially a family of model. It could – [Unclear] so a model which can begin to describe the behavior of [Unclear] in forest directly after the deposition but the variable used in the case of future accidents, forest tree [Unclear] limit that information and [Unclear] causes to humans and to non-human species.

## FORESGAME MODEL



Here as you can see [Unclear] FORESTGAME model and compartments and you see this model describes several dynamic [Unclear] shrub or fungi so it describe the [Unclear] potential in different seasons. And the model also describes absorption of cesium in different food [ph] levels. The model describes, also potential to moose and roe deer, the concentration of [Unclear]. In this case the model also model accumulation of cesium in the [Unclear] in animals behavior so the [Unclear] was considered the function of cesium, function of time here. It allow seasonal [Unclear]. And what drives this model was [Unclear] and which addressed the application of different management options.





One example, application of model for the Harbo area in Central Sweden. You can see that model works quite well but here [Unclear] some points. You see, this data was established data, but the seasonal dynamics is quite sharp here.

And this model, I'll give you an example how it could be applied for the assessment of different, I would say forest management options, how to provide forest management here. For example, [Unclear] for the big concentrations of cesium in muscles of animals, for example, here, we can get more clean muscles and so in this case transfer to the public will be much lower.

If you shift hunting periods when people are hunting [Unclear] for example, roe deer is [Unclear] in this case the [Unclear] will be much lower.

[Unclear] but it is not clear from this [Unclear] data.

The same thing is for the wild boar, the same thing is for wild pig, wild boar. And another point [Unclear] application of the salt licks ferrocene for animal range. In this case, you also can decrease contamination of the muscles of the forest game.

You see there are such measure as application of the ferrocene salt licks which [Unclear] salt licks animals like, salt lick because [Unclear] not like [Unclear] ferrocene salt, you can distribute that [Unclear] in the forest, and which

animals game, forest game can eat this ferrocene and in this case also can provide some effect in terms of the decrease of the contamination of game.

## FORESGAME MODEL: Main features

FORESGAMEモデル 主な特徴

- FORESLAND explicitly includes ecological models and many environmental parameters. This simplifies model adaptation for specific conditions and makes a choice of parameters more transparent
- FORESLAND is a family of models and provides assessments both for short and long term after the deposition.

FORESLANDモデルは生態モデルと複数の環境パラメータを含む。  
この簡便なモデルは、ある特定の条件に適用するように改良し、パラメータ選択がより簡単で分かりやすい

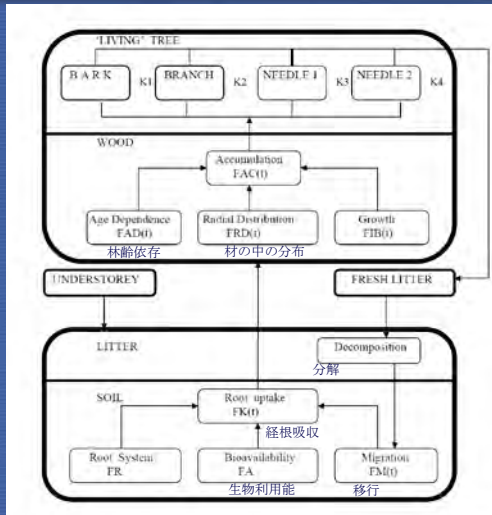
FORESLANDは、放射性物質の沈着後の短期～長期的な影響評価を行うモデルの1つである



You can see some features of the FORESLAND here about the method about [Unclear]. The most important that the parameters acquired are transparent here.

# FORESLIFE

FORESLIFEモデル



*Cs-137 vertical migration along the soil profile is described by two-component and convective-diffusion models.*

*It is assumed the rate of <sup>137</sup>Cs uptake in trees decreases with its age. The <sup>137</sup>Cs transfer factor into wood is considered to be time dependent.*

2成分と移流拡散モデルによる土層中のセシウム137の下方移行

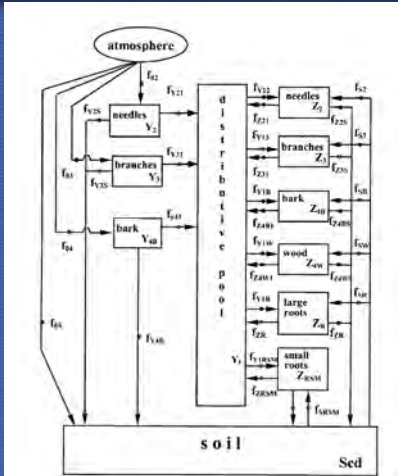
樹木によるセシウム137の吸収が時間とともに減少することを仮定。材へのセシウム137の移行係数は時間に依存すると考える。



FORESTLIFE model was developed in Belarus by Alexander Dvornik and Tatiana Zhuchenko. Actually, my colleague [Unclear] know him quite well. I suspect and as I also [Unclear] FORESTLIFE is a very good model. The only problem in interpretation of this model is that the parameters are not time dependent or for example, [Unclear] fraction of cesium is considered [Unclear] during migration and all other issues [Unclear] say this model is also quite good but I don't go ahead because my time is limited and does not [Unclear] because of that [Unclear] in many time.

# ECORAD-C

ECORAD-Cモデル



The transfer of Cs-137 is assumed to be similar to that of potassium. Radionuclide dynamics is considered in parallel with the dynamics of biomass of the tree compartments. Cs-137 in the vegetation is assumed to be pooled into two basic compartments: external and internal contamination, with separate analysis of each one. The model was verified using the data obtained during 1986–1994 in the 30 km zone of the accident on Chernobyl NPP.

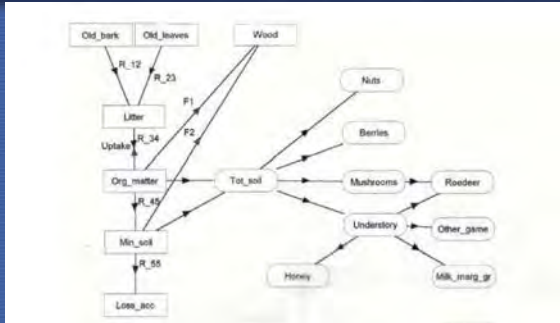
セシウム137の移行はカリウムと類似していると仮定。放射性物質の動態は、樹木成分のバイオマス量と対応する。植物内のセシウム137は2つの部位に貯留されると仮定。外部及び内部の汚染は別々に解析。モデル検証には、チェルノブイリから30km以内地域で1986～1994年に得られたデータを使用。



PASS

## IAEA-1995: FORM Model

IAEA-1995 FORMモデル

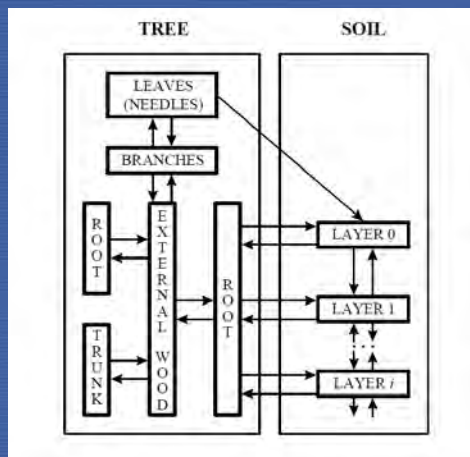


*FORM model been developed as a decision tool for the evaluation of countermeasures for contaminated forests. It consists of three parts: an ecological part, a dose assessment part and a financial part.*

FORMモデルは、汚染森林への対策評価の意思決定ツールとして開発された。3つのパートからなる（生態系評価、線量評価、経済評価）



FORM model; actually this model was developed by the IAEA group in 1995. It was especially done to support the evaluation of the countermeasures for contaminated forests. Because as we look at the agency [Unclear] is a subject already for many, many years agency has unique experience in the development of [Unclear]. This feature was adopted was not only for cesium but also for strontium that's good. And the model is quite, I won't say simple but it's a good of schematic [ph] model. It would be used for assessment of some [Unclear] feasibility of the forest. This is the main advantage of this model.



- *Root uptake of radionuclide is considered to be a reversible process;*
- *Root system depth distribution are given as a function of time.*

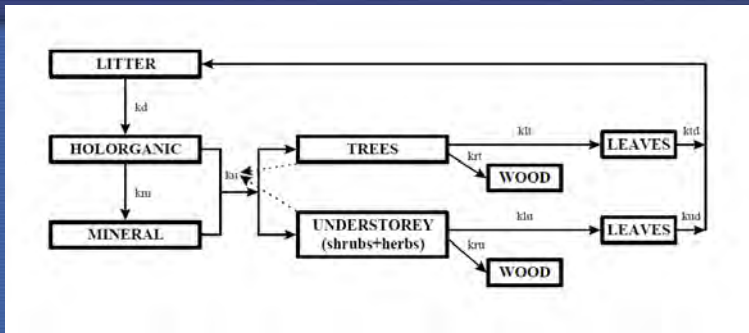
放射性物質の経根吸収は不可逆的なプロセス  
根茎システムの深度分布は時間の関数として与えられる

FORWASTE was developed by Alexei Konoplev and his group, so now he is moving from Obninsk to Fukushima and we'll be working in the [Unclear] group. We also – we're expecting not only in the area of [Unclear] but also attend the core group and deliver his point which was actually [Unclear] model as he wished to [Unclear] this model which was [Unclear].

Quite simple model but very good [Unclear] forest so this model would be applicable for the [Unclear] forest I'm afraid demonstrated quite good results for them.

# LOGNAT

LOGNATモデル



1. *No losses (sink) from the system are accounted for.* 系からの損失は無いと仮定
2. *Transfer parameters have been derived from experimental data and literature.* 移行パラメータは実験データ及び既往研究を利用
3. *The forest biomass evolution at long-term scale (i.e. 50 years) during simulations is calculated as growth rate function of the standing biomass.* 長期スケールでの森林全体のバイオマスは、地上部バイオマスの成長関数として計算
4. *Uptake rate is expressed as a fraction parameter per standing biomass*



経根吸収量は地上部のバイオマスあたりのパラメータ関数として表す

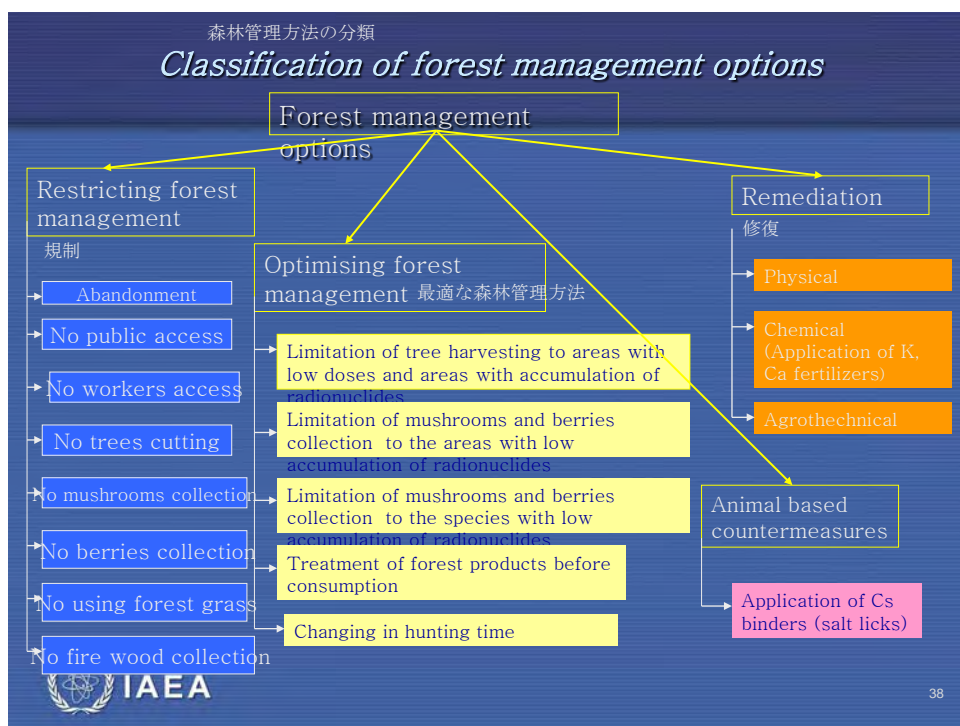
Also a simple model, which you can see from here was developed by Italy from [Unclear] University of Trieste, and based on the also [Unclear]. It considers the dynamic of the biomass intersection and we had the advantage of studying this model, growth rate is considered so. The uptake rate is expressed in fraction of standing biomass.

Actually, a similar model before was also developed in Italy by our colleagues from [Unclear].

Actually similar to other models, features that it considered [Unclear] dynamic on the forest biomass – forest tree biomass.

Feature of the model is also that the uptake rate was expressed as a fraction of the standing biomass, so it was static [ph] parameter.





Okay. Now [Unclear] 10 minutes and 30 minutes more okay, because I have just 2 slides here. My time is almost expired. Okay, let's come to the classification of the forest management options.

As I mentioned, there are not many options for forest.

But you see, actually several options which were tested after the Chernobyl accident. They've been classified into three groups.

Restricted options, or I would say, restricted management options, optimizing the forest management and remediation. We can classify into three groups that is given here.

[Unclear]. So first group includes, abandonment, when we just leave this [Unclear], we can actually close public access, we can close workers access, we can close tree cutting, so you can see all these options which we've listed [ph] here. And all these options can be assessed in terms of the [Unclear] experience. We can consider all that together the abandonment, but we consider also limited options here, no using of forest grass was very important for the forest cows and [Unclear] further and yet dependent on the contamination level.

Here you can see very important group of options, because it is forest optimization. We can optimize many, many things to make doses for the forest [Unclear] much lower based simply on the optimization. For that you

will need to have extended maintenance information. We need to have a look at different options and possibility. And I've tried to summarize these options here, but I can tell you that – I can say these options are quite most effective and most of them were tested in the different areas affected by the Chernobyl accident.

I mentioned already about changing in hunting time, [Unclear].

It cost not so much but [Unclear] incentives in terms of the increase of the contamination of forest products, which are available for harvest.

Valery Kashparov mentioned already about appreciation [ph] of the forest products because I can use different culinary mix to cook forest products. And in this case you also can achieve substantial decrease of the contamination of the final product.

Remediation, physical measures, it is exactly what our colleagues are doing now in Japan, this seen [ph] green [Unclear] etcetera all other options are in fact of the physical, remedial actions.

And we realize that new information is really available here and we would like to extend this option [Unclear] data which now are available for forest department.

Three elements. Next group is chemical options. Actually, as I mentioned already about lime, so lime and fertilizing forest we can increase cesium transfer to trees and to understory species by type so we can get some positive effect for maybe 3, 5, 7 years. Recent studies did in conjunct with [Unclear] and the paper was published in 2011, so we could consider also this option, as a matter, against internal exposure. We need to have clean wood, or something [Unclear].

Agrotechnical, it is just plowing, we could generally remove soil, but you also can plow the forest soil to beyond the contaminated layer. In this case it will increase the external exposure etcetera. This option was also tested in Japan.

Application of the various – application of the salt licks I've talked already, can be executed for animals salt with special properties, which would allow substantial decrease of the contamination of cesium in muscles.



Next slide which demonstrate the system which was implemented in the Bryansk region, Novozybkov region or Bryansk region, how again, we consider, how we select optimal [Unclear] options which in forest how we provide optimal forest management here. First step is now we have to assess whether remediation is really required? Second, we require models to assess doses to the population [Unclear] create resistance and looking at the radiation safety standards at the permissible level, we can come to the conclusion whether we really need to provide some actions or not. This is actually important step [Unclear] application of the remediation.

If we came to the conclusion that remediation is required, some protection is required, we can find the optimal management ways, how to do it. And in this case we can investigate forest exposure pathways, which factors are increasing the contamination of forest products, where DIL is derived investigation levels of accident etcetera. Based on that we can find options which can provide optimal effect.

Based on this information, we can assess different parameters for making decision and these parameters cannot be quantified or not all parameters can be quantified. You see quantifying as expressed something in monetary way, quantify something. In numbers, not only...

For example, reduction of individual and collective doses we can express in

some ways. Feasibility can also – [Unclear] but social feasibility we cannot express in some ways. We need a special approach on for doing it. Our decision should be based on the accumulation of different parameters some of them can be quantified, some of them cannot be quantified or qualified. This is actually an approach where we can use a special approach for that multi-attribute utility analyses and this, yes, approach is which inscribed in Agency documents that can provide advice how to involve stakeholders to support [Unclear] etcetera. The final point is I think you will want to translate it. Yes.

And we need to know how long we should provide [Unclear] remedial options. We need to understand the time scale to the problem. For that we need to also apply dynamic model such as FORESTLAND. And what you see is that in course of time the situation will be much more easier than now and in 5 years, 10 years, some [Unclear] for that you need to make some predictions based on the model slides [Unclear] models which I mentioned above. This is about the framework of forest. We identified all the optimal management framework.



And here I can show you some referral documents which have been quite useful for making some decision on the forest management. So this is a recent document where forest is mentioned and approach how to apply – how to identify problems [Unclear] is also addressed here. The documented [Unclear] it describes how to employ these options for urban, for the [Unclear], for the food environment, [Unclear] environment. So you can find this information in the Technical Report Series 475 which was recently was published with involvement of [Unclear] experts make on the remediation. Then also some recent [Unclear] 3 documents on the subject. There are books on the subject and there is also a Chernobyl forum.

## *Conclusions*

- *Effective monitoring in the contaminated forests is essential action for long-term management in the contaminated areas and forest models are suitable tool for identification of optimal management strategies for contaminated forests.*
- *Chernobyl experience, data and models may provide important input to mitigating consequences of the Fukushima Dai-ichi accident. However, this experiences should be properly understood and adapted for areas affected in Japan.*
- *The IAEA Environment Laboratories in Seibersdorf, being a holder for the world experience in the environmental management, can provide assistance in using wide set of environmental models, support in data assimilation and adaptation of suitable monitoring*



And now [Unclear] to establish conclusions. So I tried to prove that effective monitoring is of paramount importance for making decision on proper forest management.

And I also tried here to prove that forest models are very suitable tools for them.

It would be very nice if I was to succeed such [Unclear] and it would be very nice if I would get to accept my point in the future.

And [Unclear] Chernobyl experience, even though environmental conditions are quite different from the Fukushima's environmental conditions, would be very much important for the areas affected by the Fukushima Daiichi accident. At the same time, this experience would be properly evaluated, properly understood and adopted for areas affected in Japan. There's no direct way how to implement it but this way exists.

Agency Environment Laboratories is doing its job for already around 50 years would be [Unclear] in discussions and being a holder of the world experience [Unclear] to provide assistance to any organization looking for the environmental remediation – environmental impart assistance in various affected place accidents like Fukushima.

We can help you with [Unclear] implementation of the models with information, with some scope of different models and we could overcome them with little protection or suitable maintenance programs.



*...Thank you for your attention!*

Thank you for your attention and for your patience. I spoke a bit too long but I've tried to cover advantages [ph]. Thank you once again.

## 質 疑

### **Male Participant**

Thank you very much Sergey. How about a small talk? Yeah.

[Japanese]

### **Male Participant**

Thank you very much for you presentation. It was very, very, very interesting.

### **Sergey Fesenko**

It's my pleasure.

### **Male Participant**

But I have a question about the model because some of them has many compartments and how to measure some, for example, bioavailability of cesium in soil, do you have any details about that?

### **Sergey Fesenko**

Yes, I can. Actually, we have mainly with [Unclear] models which [Unclear], for example, with extraction, different material. If you have a look at our paper published in the central documents, in environment you may get [Unclear] so you can find that there was a poster already published there so we took this information directly. Because that documents we just used [Unclear] for that and we also introduced more simple model, process, time dependence, each parameters is different from [Unclear] level of cesium. For that we don't need to wish that model or the ecosystem. We can model just part of the ecosystem like [Unclear] volume study. So we use such approach for that. Sometimes you use direct ecological parameters. I told you that, each [Unclear], gathers information simply from the [Unclear] so you see I think the proper way for the modeling of such systems it is a combination of the ecological, and radical approach. We have to combine them, of course, you see radical is part [Unclear].

### **Male Participant**



Okay. Thank you very much.

[Japanese]

**Sergey Fesenko**

My knowledge of Japanese is still not sufficient to answer your question directly.

[Japanese]

**Male Participant**

In Chernobyl affected areas is there any force to encourage the use of those materials like mushroom or game animals or something like that?

**Male Participant**

In the surrounding area of the Chernobyl, is there any pressure from the, what you call, the people to use the timber or some forest materials including, some mushrooms, berries and games or the government or some other sector wants to force to the people to use that forest products like is it anyway in the surrounding areas, the condition of that?

**Sergey Fesenko**

I would say is that now, not because these areas are, [Unclear] they just, you see, the question is if they can consume this forest products without any restrictions? The restrictions is when there is a health episode outside of this area. And in this case some people outside have rejected these forest products, but in Bryansk region this area is, the product consumed wouldn't result in any restriction and there is no pressure. For cucumbers there are actually irrigation safety standards, restrictions which was shown in models presentation. If contamination levels are below these standards, these products will be considered as safe and European Commission, European Union is buying this wood without any restrictions, so there are many customers around [Unclear] and without any pressure.

You see [Unclear] is a natural phenomenon, you have to understand that. For example, cucumbers consists lot of potassium 15 [ph]. If you compare

the selection of the potassium 15 to cesium you'll find that many [Unclear] of natural level of potassium is much higher. There is no reasons to be afraid that this commodity, this root can provide some detrimental effect if contamination of cesium in such commodities or food products are below x levels. This is actually the approach. Now people have good experience, with understanding. Actually it is [Unclear] but if they see the contamination levels below admissible level, we always felt actually it is safe. If it is higher in this case you can face some pressure and some problems.

**Male Participant**

Thank you very much.

**Sergey Fesenko**

One thing and should not actually affect these products even it is higher than contamination levels. Because there are many ways how to proceed, how to process these products and [Unclear] product is acceptable safe. [Unclear], I'm expecting your question about [Unclear].

**Male Participant**

One simple question. You introduced remediation by using the liming or fertilizing. These methods are actually applied to the wide area of the forest, if yes, was it successful economically?

**Sergey Fesenko**

Actually not, because you see this method is quite expensive. You know, it is very difficult to deliver lime and fertilizers in the forest. It is quite costly. Because it is actually hand dropped [Unclear] it is why costly procedure. We can do it, certainly. Somebody can consider maybe some options to do it may be near the [Unclear]. But actually there were no straight reasons for that. But some small areas, in some cases could be feasible, as I was saying, but not on a large scale application, [Unclear].

**Male Participant**

Thank you.

**Male Participant**

Thank you very much. I would like to ask about sampling method. In your presentation you mentioned that, we have – when we set up the monitoring quarter, we have to avoid a relief or runoff or such any kind of...

**Sergey Fesenko**

Yeah, we should.

**Male Participant**

Yes. I suppose, you already know the trees from Fukushima is very different from Chernobyl so I'd like to hear about your impression of same in Fukushima situation?

**Sergey Fesenko**

You see, certainly as I told you the experience from the Chernobyl affected areas shouldn't be transferred directly. It will result any proper interpretation, any analysis. That's why I tried to explain some differences between actually forest and areas affected by the [Unclear] and after that [Unclear]. You need to have a look and you need to develop your approach for the way [ph], your approach for the selection of such sites.

The requirements from my point of view, this approach should be standard designed. It should be for all groups which were standard and wasn't affected [Unclear]. Otherwise we will not get comparable results. Second we need to decide how to, account for run-off in such case. We need to include a number of selection and we need to take it into account, we have to describe in the special document how to do this. It should be implemented somehow.

For now there are no any approaches [Unclear], think about and so we need to develop a document. Agency is organizing a special meeting on sampling. Of course, Agency wants to prepare the international guidelines on sampling strategies, etcetera. Professor [Unclear] who attended this meeting as a participant and help IAEA to [Unclear] Japan. I hope you will raise this point in the group and we'll try to provide some international view on this subject. But you see the reason Japan is actually – first of all it's your business to

propose the approach for that. If you need our advice we're always ready to come and [Unclear].

**Male Participant**

Okay. Thank you.

**Sergey Fesenko**

Thank you.

**Male Participant**

One more technical question. In your presentation you also showed one example of extraction of cesium from soils or litter. But in that table, the residual cesium of litter is very high, even if you extract with three normal hydrochloride, what do you think about very strong acid cannot extract the cesium?

**Sergey Fesenko**

You see, it is not always possible to extract all cesium. This is as a matter of fact [Unclear] but you see it is based on the actually standard [Unclear] approach used to categorize, the standard [Unclear] approach. This approach people were using [Unclear]. I see that not all cesium was destroyed here was, [Unclear] but that's what you have. Even for the real [ph] 0.2 used for the A8 [ph] level because litter is not only limited sources of fraction [ph] of that which is not easy to dissolve at the time of the extraction, certainly.

**Male Participant**

Okay, thank you.

[Japanese]

**Male Participant**

Thank you very much for. So, 20 minutes later a new meeting will shortly happen here.

**END**

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