Reference 3

Press Release

30 September 2011

Ministry of Agriculture, Forestry and Fisheries

Distribution of radioactive materials in forests and its analysis results (interim report)

The Ministry of Agriculture, Forestry and Fisheries (MAFF) has been investigating the contamination levels in forests due to radioactive materials discharged by the accident at the TEPCO Fukushima Daiichi Nuclear Power Plant, and it has been conducting demonstration tests on forest decontamination.
This interim report compiles the investigation results obtained to date and, based on the results, summarizes the latest important points in forest decontamination work near residential areas.

1. Objective of the investigation

Due to the accident at the TEPCO Fukushima Daiichi Nuclear Power Plant, significant amounts of radioactive materials were deposited on forest areas that dominate the terrain surrounding the plant, and that has resulted in wide areas of contamination.

The impacts of the accident at the Chernobyl Nuclear power Plant on forests have been investigated in various studies and are now widely known. However, given the completely different climate, terrain, soil, and forest vegetation in forests of the two countries, Japan and the Ukraine, actions to be taken for the contaminated forests need to be studied, based on the correct understanding of the contamination due to the present accident.

Therefore, MAFF is releasing the information obtained to date and the important points in forest decontamination work near residential areas, based on the investigation results of the distributions of radioactive materials in forests and forest decontamination demonstration tests conducted mainly by the Forestry and Forest Products Research Institute (hereinafter referred to as FFPRI).

2. Overview of the distribution of radioactive materials in forests (Annex 1)

FFPRI has been investigating the radioactive contamination levels in national forests at three locations in Fukushima Prefecture (Kawauchi Village, Otama Village, and Tadami Town). Specifically, it set investigation plots where trees such as Japanese cedar trees were cut, and concentrations of radiocesium were measured for parts of the trees (leaves, branches, bark, sapwood*[1], and heartwood*[2]). The concentrations of radiocesium on fallen leaves in the forests (the organic litter layer comprised of fallen leaves and branches) and in soil were also investigated.

Among these studies, the results on national forest land for Japanese cedar in Otama Village were clear. The highest concentration of radiocesium was obtained on fallen leaves that covered the soil and the second highest was obtained in leaf portions. Calculations of the distribution of radiocesium in this forest based on the results indicated that the radiocesium was distributed in leaves and fallen leaves dominantly; 38% and 33%, respectively.

This trend is consistent with the data, "Results of the Investigation and Research on the Radioactive Material Distribution (Investigation on Migration of Radioactive Materials in Forests) Conducted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)" *[3] and released by the MEXT on 14 September 2011.

The current results also indicated that almost no radiocesium was contained in sapwood and heartwood of the trees, which are used as wood materials.

*[1]: Light-coloured surrounding part of the tree trunk
*[2]: Dark-coloured central part of the tree trunk
*[3]: The MEXT investigation report is available at:
http://radioactivity.mext.go.jp/ja/distribution_map_around_FukushimaNPP/0002/5600_091412.pdf

3. Important points in forest decontamination work near residential areas based on the distribution of radioactive materials (Annex 2)

Forests in the living environment in particular can be sources of radioactive materials in themselves. In areas where the additional annual exposure dose from the nuclear accident ranges from 1 mSv to 20 mSv, it is vital to decontaminate forests near residential areas in order to reduce daily exposure dose of the residents.

Therefore, the following important points can be drawn from the latest results on the distribution of radiocesium to effectively and efficiently decontaminate forests near residential areas.

(1) Removal of organic litter including fallen leaves

In evergreen needleleaf forests such as Japanese cedar plantations, large amounts of radiocesium have been accumulated on both leaves and the organic litter under the present circumstance that almost half a year has passed since the biggest releases of radioactive materials occurred. As it generally takes about 3 - 4 years for the leaves of evergreen needleleaf trees to fall off, removing fallen leaves continuously over such a period may be the best way to decontaminate the forest area as opposed to doing so just once. By contrast, large amounts of radioactive materials tend to accumulate on the organic litter in deciduous broadleaf forests because the biggest releases of radioactive material occurred in March, which was before the new leaves had emerged. This suggests that one-time decontamination may be effective.

According to the simulation on effectiveness of removing the fallen leaves based on the distribution of radioactive materials in forests obtained in this study and verified through the demonstration test, it will be effective and efficient to remove fallen leaves in areas within approximately 20 meters from the forest boundary, although this should be verified in forests under various conditions in the future.

It should be noted that, from the standpoint of maintaining forests and preventing new dispersions of radioactive materials, it is important to protect the surface soil exposed by the removal activities from being carried away due to actions such as rainfall. Therefore, a stepwise approach should be used to remove fallen leaves by expanding decontamination areas gradually while checking the condition, instead of removing them in a wide area all at once.

(2) Removal of branches and leaves

It was found that large amounts of radiocesium have adhered to branches and leaves of standing trees, specifically those of evergreen needleleaf forests such as Japanese cedar and cypress. This result suggests that it may be effective to remove those trees near forest boundaries if removal of fallen leaves does not provide a sufficient decontamination effect.

It can be presumed that a relatively large amount of radioactive materials adheres to leaves of standing trees on forest boundaries adjacent to residential houses where the quantity of leaves is generally large. Thus, it may be necessary to remove branches at as high a point as possible depending on the situation at the site. It should be noted however, that it is recommended that branches be removed at less than one half of the height of tree canopies so that it will not considerably hamper growth of the standing trees.

(3) Maintenance of forests after decontamination

If surface soil in forests on steep slopes is exposed due to removal of organic litter including fallen leaves, it may be carried away in rain runoff. When fallen leaves in such locations are removed or when runoff by rain is actually observed after the removal, actions should be taken to prevent soil loss by means of putting sandbags along the forest boundary.

In addition, as opposed to fertilized agricultural land, forests depend on the organic litter including fallen leaves for their nutrient supply. Thus, removing organic litter may degrade soil fertility. However, although this may temporarily hamper growth of trees, there will be no major impacts on forest function if the removal target area is small, considering that soil fertility can be recovered by obtaining a nutrient supply from fallen leaves and rainfall at a later time.

4. Future plans

FFPRI is currently analyzing the samples taken at forests in Fukushima Prefecture during the investigation, and conducting demonstration tests.

MAFF, in cooperation with FFPRI, will continue to investigate in detail the behaviour of radioactive materials in forests and conduct decontamination demonstration experiments in cooperation with other institutions as well to further study how to treat the forests, based on these results.

< Attachments>

- (Annex 1) Overview of the distribution of radioactive materials in forests
- (Annex 2) Important points in decontaminating forests near residential areas based on the distribution of radioactive materials

Contact:
Research, Extension, and Environment Policy Division, Private Forest Department, Forestry Agency
This material is available on the MAFF website at:
http://www.maff.go.jp/j/press/

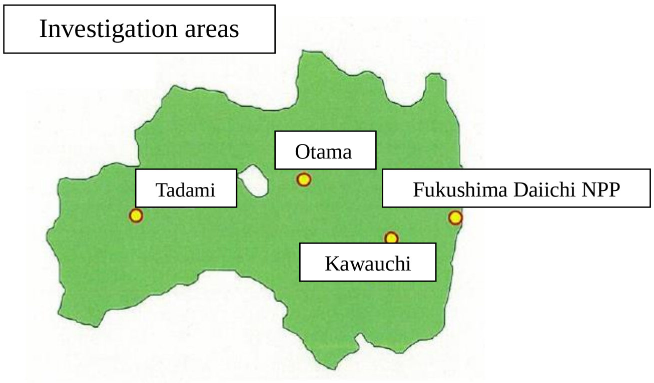
(Annex 1)

Overview of the distribution of radioactive materials in forests

1. Responsible organization Forestry and Forest Products Research Institute

2. Overview of the investigation areas

In order to understand the distribution level of radioactive materials in forests, three investigation areas (Kawauchi Village, Otama Village, Tadami Town) were selected based on their different distances from the Fukushima Daiichi Nuclear Power Plant.



(Reference) Ambient dose rates at the investigation points during the investigation

Kawauchi Village	3.11 μSv/ h
Otama Village	0.33 μSv/ h
Tadami Town	0.12 μSv/ h

The results in this study were for the following investigation area.

Investigation area: Otama Village, Adachi County, Fukushima Prefecture (National forest within the jurisdiction of the Fukushima Regional Forest Office)

Investigation Date: Monday, 8 August to Friday, 12 August 2011

Tree type: 41-year-old Japanese cedar trees (Photo 1)

Photo 1 Japanese cedar forest at the investigation area in Otama

3. Description of the test method

Investigation plots were set in the forest of the investigation area to study the growth of trees in the forest and measure ambient dose rates (Photo 2). In the investigation plots, three Japanese cedar trees with different growth levels were selected and fallen leaves (organic litter layer consisting of fallen leaves and fallen branches) and soil were sampled around the trees (Photo 3). The selected trees were cut, and separated into leaves, branches, bark, and trunks, and the trunks were further separated into heartwood and sapwood and samples were prepared (Photos 4 and 5). After the samples were dried and crushed into small pieces, the quantity of radioactive materials was quantitatively measured by using gamma ray spectrometry.

Photo 2. Measuring ambient dose rate

Photo 3. Sampling soil

Photo 4. Curing to prevent contamination during tree cutting

Photo 5. Slicing of wood samples

4. Test results

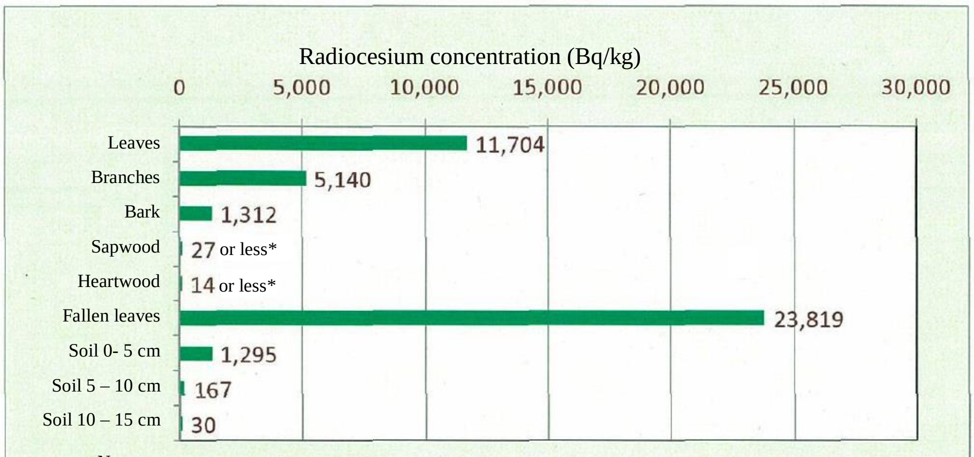
Ambient dose rates at a height of 1 meter ranged between 0.31 and 0.33 μSv/h in the investigation area.

The concentration of radiocesium in trees was approximately 11,700 Bq per kilogram (dry weight) for Japanese cedar leaves, the highest concentration (Figure 1). While branches and bark had the second highest concentrations, 5 out of 12 samples of heartwood and sapwood had concentrations below the detection limit. Even when these concentration values were assumed tentatively to be the value of the detection limit, the average of the entire wood material (heartwood and sapwood) was below 20 Bq/kg (17 Bq/kg in the air-dried state in which wood material is generally used), which is a considerably low concentration. Fallen leaves on the forest floor showed an extremely high concentration of 23,800 Bq/kg. The concentration of soil in the surface layer (0 – 5 cm in depth) was approximately 1,300 Bq/kg, which is far lower than that of fallen leaves. The drastic decrease of radiocesium concentration with increasing depth of soil suggested that radiocesium is distributed in the very shallow layers of soil.

The amount of radiocesium in the entire forest was calculated by multiplying the concentration of radiocesium of each tree part by each weight per unit area. The calculation showed that 38% of the entire radiocesium was on tree leaves and 11% was on branches, suggesting 51%, i.e. about half of the entire forest amount, was distributed on trees. It also showed that 33% of the entire radiocesium was on fallen leaves on forest floor and 17% in the soil surface layer (Figure 2).

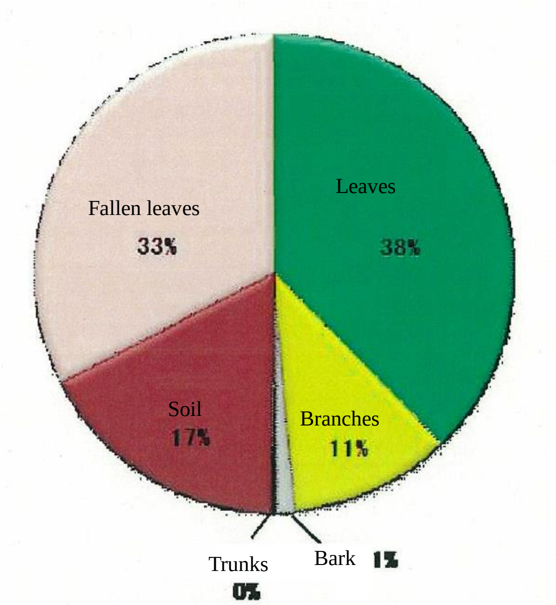
*This trend is consistent with the data, "Results of the Investigation and Research on the Radioactive Material Distribution (Investigation on Migration of Radioactive Materials in Forests) Conducted by the Ministry of Education, Culture, Sports, Science and Technology " released by the MEXT on 14 September 2011. (See Page 5.)

Figure 1 Radiocesium (Cs-134+Cs-137) concentrations for tree parts, fallen leaves, and in soil (Bq/kg)



Note:
1) Concentration per dry weight
2) "Or less" because the concentrations of some samples from sapwood and heartwood were below the detection limit. The average of the entire wood material was below 20 Bq/kg.

Figure 2 Percentage distribution of radiocesium in a Japanese cedar forest



Note: The distribution of the amount of radiocesium in the entire Japanese cedar forest was calculated by multiplying the concentration of radiocesium of each part illustrated in Figure 1 by each weight per unit area.

(Reference) Extraction from the report, "Results of the Investigation and Research on the Radioactive Material Distribution (Investigation on Migration of Radioactive Materials in Forests) Conducted by the Ministry of Education, Culture, Sports, Science and Technology" released by the MEXT on 14 September 2011.

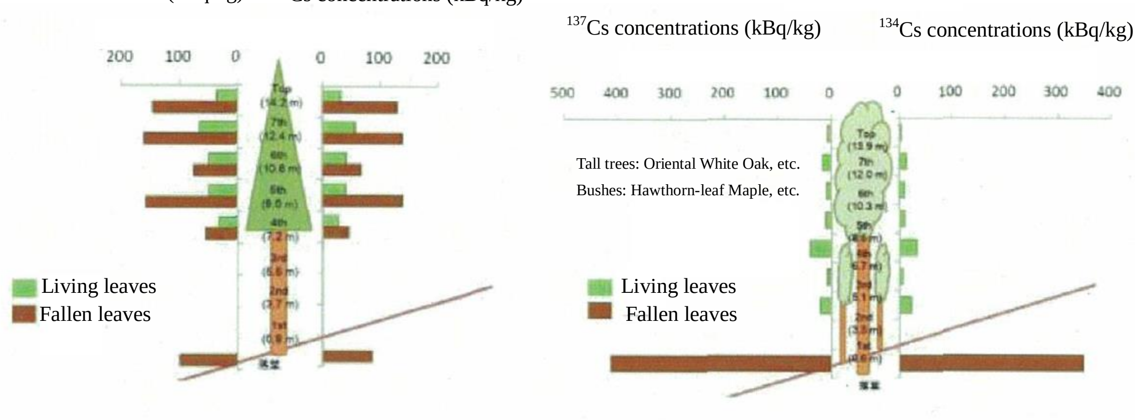
Distribution of radiocesium in trees

Mature Japanese cedar stand (40 - 50 years old)

Broadleaf forest

^{137}Cs concentrations (kBq/kg) ^{134}Cs concentrations (kBq/kg)

^{137}Cs concentrations (kBq/kg) ^{134}Cs concentrations (kBq/kg)



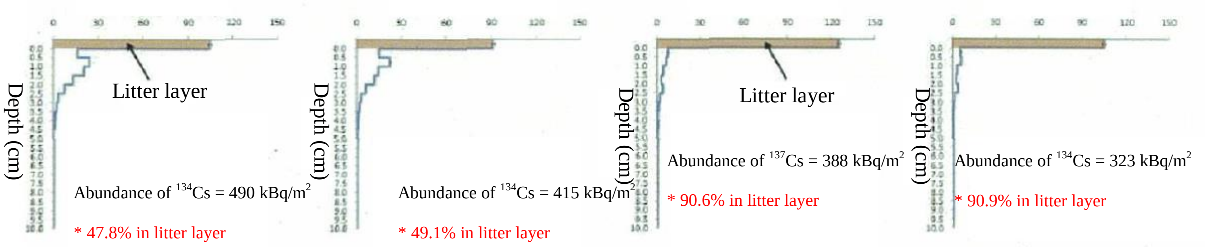
* In mature Japanese cedar forests, more radiocesium was adhered to the leaves of the canopies, while more was found on fallen leaves in broadleaf forests with less adhesion to the leaf canopies.

Accumulation level of radiocesium by depth in soil

Mature Japanese cedar stands (40 - 50 years old)

Broadleaf forest

Cs-137 concentration (kBq/kg) Cs-134 concentration (kBq/kg) Cs-137 concentration (kBq/kg) Cs-134 concentration (kBq/kg)



* Large amounts of radiocesium were accumulated in the litter layer (fallen leaves layer) on the topsoil.

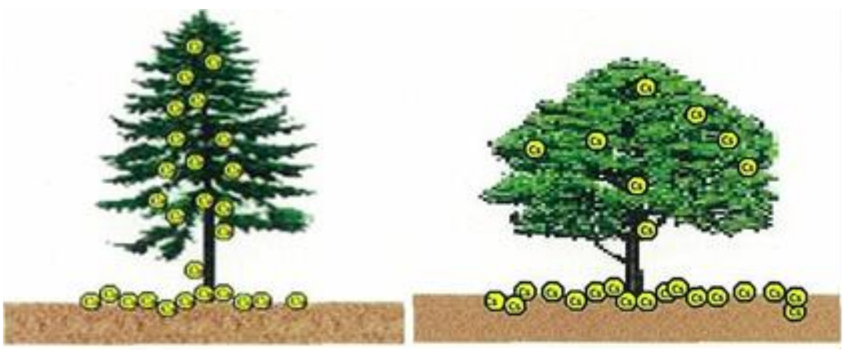
Important points in decontaminating forests near residential areas based on the distribution of radioactive materials

Particularly in forests near residential areas in the living environment, the following methods can be considered appropriate as ways for decontaminating forests in order to reduce daily exposure dose of the residents.

Parts to be decontaminated	Method	Remarks
Removal of fallen leaves, etc.	• Remove fallen leaves in areas within approximately 20 meters from the forest boundary.	• In order to prevent runoff of surface soil, a stepwise approach should be used by expanding target areas gradually, instead of removing fallen leaves in a wide area all at once. • Effective if the removal continues for 3 - 4 years to decontaminate evergreen tree forests. • One-time decontamination work is expected to be effective when conducted on deciduous tree forests.
Removal of branches and leaves, etc.	• For the trees with large quantities of branches and leaves adjacent to residential houses, remove them at as high a point as possible.	• Remove branches to almost one half of the height of the tree canopies so that growth of the standing trees will not be considerably hampered. • Conducted when removal of fallen leaves alone does not provide sufficient effect.

(Reference 1) Adhesion conditions of radioactive materials on evergreen and deciduous trees

Evergreen trees (Japanese cedar/cypress, etc.) Deciduous trees (Japanese oak, etc.)



* It is likely that while large amounts of radiocesium have adhered to leaves of the canopies of evergreen trees, most of the radiocesium that fell on deciduous trees was accumulated in the fallen leaves layer because the nuclear accident occurred before the new leaves had emerged.

(Reference 2) Overview of decontamination demonstration test in a forest (removal of underbrush and fallen leaves)

1. Responsible organization

Forestry and Forest Products Research Institute (in cooperation with Fukushima Forestry Research Center)

2. Test Dates

Wednesday, 14 - Friday, 16 September 2011

3. Test location

Tadano Experimental Forest, Fukushima Forestry Research Center

(Ouse Town, Koriyama City, Fukushima Prefecture, 47-year-old Japanese cedar and cypress planted forest)

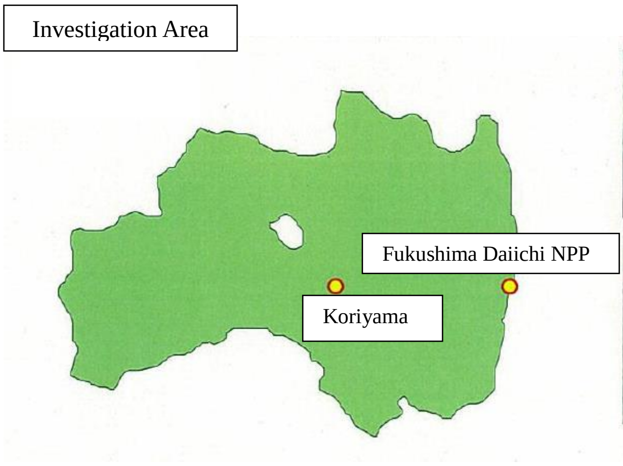


Photo 1. Test area view

4. Description of the test

Ambient dose rates were measured at the investigation point, while extending the removal area gradually (1m by 1m, 2m by 2m, 4m by 4m, 8m by 8m, and 12m by 12m; these lengths are diagonal distance from the investigation point) that was set on a hillside in the forest. And volumes of removed underbrush and fallen leaves were also measured.

Photo 2. Removal

Photo 3. Test area (Center is the test point)

Photo 4. Conditions before and after removing fallen leaves, etc.
(The right side of the photo shows the condition before removal. The left side shows the condition after fallen leaves, etc, were removed.)

5. Test results

After underbrush and fallen leaves were removed, the ambient dose rate at the investigation point at the height of 1 meter, which was 0.77 μSv/h before removal, was reduced to 0.63μSv/h (Table 1). Furthermore, the underbrush and fallen leaves removed from the 12 m by 12 m area weighed approximately 450 kg (Table 2). It should be noted, however, that this is the weight measured immediately after the removal (wet weight).

Photo 5. Measuring ambient dose rates after decontamination

Photo 6. Temporary storage of removed fallen leaves, etc.
(After the removed amount is weighed as per sandbag, the removed fallen leaves, etc. in the sandbags are stored, being covered by blue sheets to avoid dispersion.)

6. Analysis of the demonstration test by simulation

Simulation on how much the removal of fallen leaves, etc. would contribute to reducing ambient dose rates showed that decontamination is not so effective if the removal area exceeds 20 meters, although it depends on the forest type (Figure 1).

The results of the demonstration test were mostly consistent with the trend obtained by the simulation. Thus, it would be effective and efficient to remove fallen leaves in the areas within approximately 20 meters from the forest boundary.

Table 1 Ambient dose rates at the investigation points (Unit: μSv/h)

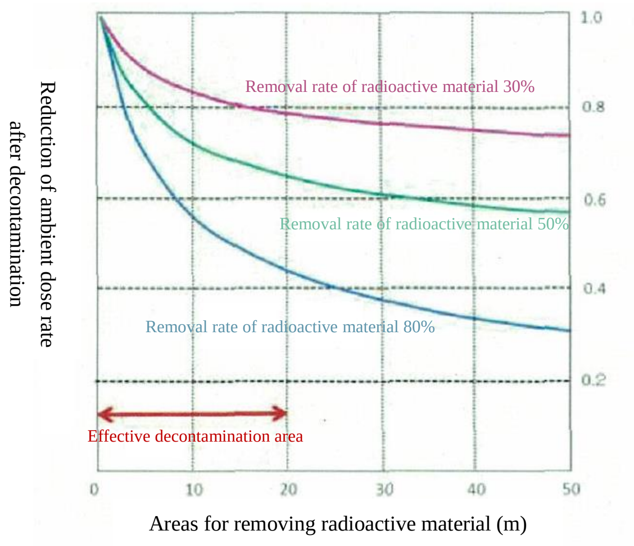
Measurement Height	Before decontamination	After decontamination				
		1m x 1m	2m x 2m	4m x 4m	8m x 8m	12m x 12m
1.0 m	0.77	0.73	0.69	0.69	0.63	0.63
0.5 m	0.86	0.73	0.69	0.66	0.62	0.58
0.1 m	0.90	0.72	0.68	0.66	0.59	0.62

Table 2 Cumulative weight of removed underbrush and fallen leaves (Unit: kg)

Target for removal	1 m x 1 m	2 m x 2 m	4 m x 4 m	8 m x 8 m	12 m x 12 m
Underbrush	0.4	0.5	3.5	7.2	12.2
Fallen leaves	2.2	9.0	39.3	178.6	433.4
Total	2.6	9.5	42.8	185.8	445.6

(The values in the table are obtained by adding the wet weight measured immediately after the removal.)

Figure 1 Simulated reduction of ambient dose rates after removal of fallen leaves, etc.



* The removal area was measured based on the distance parallel to the ground surface. Therefore, it is a diagonal distance when a slope is measured.