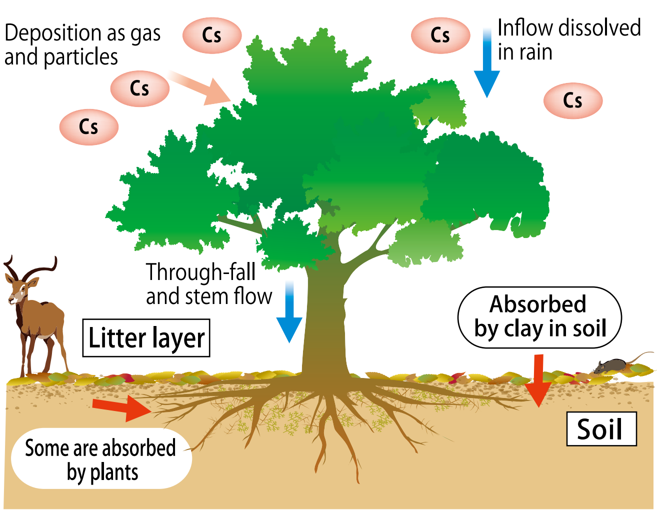
II Dynamics of Radioactive Substances in Forests

Forestry Agency set monitoring sites in three municipalities (Kawauchi Village, Otama Village, and Tadami Town) in Fukushima Prefecture in 2011 to clarify the distribution of radioactive cesium within forests. It investigates the concentrations and accumulated quantities of radioactive cesium in soil, in litter layers, and in the leaves, trunks, and other parts of trees.

Dynamics of Radioactive Substances in Forest Ecosystems

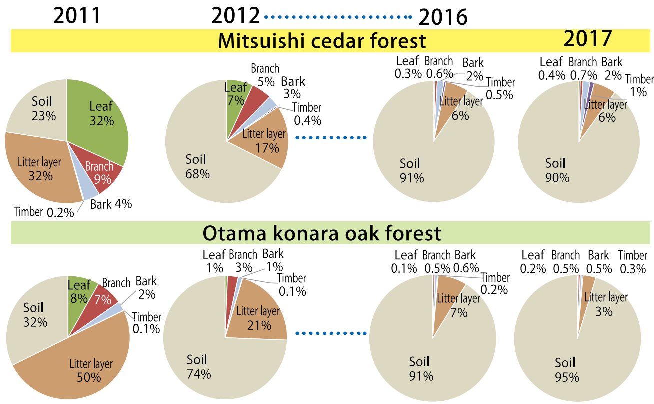
Fallout radioactive cesium into forests was carried as gas and particles in the air, dissolved into rain water, and attached to trees, mainly in the forest canopy (the upper parts of trees, with thick leaf growth). After that, the leaves fall and deposits are washed off by rain, moving into the litter layer on the ground surface. Next, the litter layer is decomposed and moves into the soil (Figure 1). This process was also revealed by investigations after the Chernobyl reactor accident.

Just as in the surveys areas where the Forestry Agency has been continuously taking measurements since 2011 (Mitsuishi cedar forest in Shimo-Kawauchi, Kawauchi Village, Futaba District, Fukushima Prefecture and Otama konara oak forest in Tamai, Otama Village, Adachi District, Fukushima Prefecture), the proportion of radioactive cesium in leaves, branches, and litter layer fell sharply and the proportion in soil rose between 2011 and 2012, the first year after the accident. After that, the proportion of radioactive cesium in soil rose further. In 2017, around 90% of radioactive cesium in forests was in soil, and a majority of that was present in the top layer of soil, at depths of 0-5cm deep (Figure 2).



[Figure 1] Dynamics of Radioactive Cesium in Forest Ecosystems

Reference : 2017 symposium document by the Forestry and Forest Products Research Institute

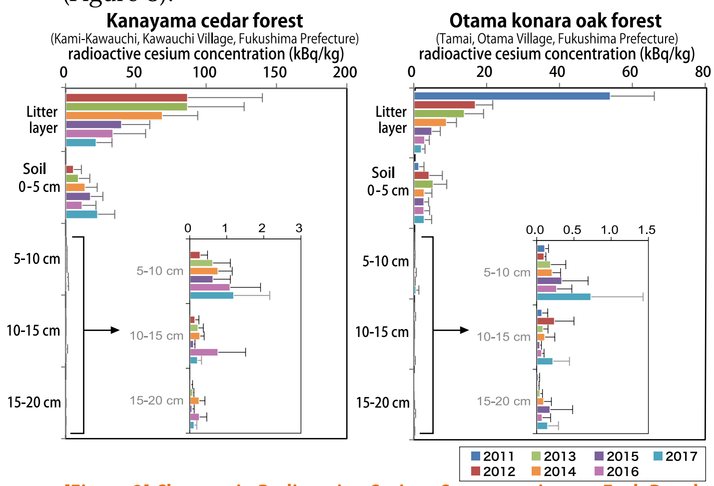


(Note) Survey results between 2013 and 2015 have been omitted.

[Figure 2] Proportion of Accumulated Radioactive Cesium in Each Part in Each Survey Area

Reference : Forestry Agency "Results of a Survey of Radioactive Cesium Distribution in Forests" (2017)

The radioactive cesium concentration at each depth level within soil appears to be shifting gradually over time, from above ground to the litter layer, and then into soil between 0 to 5cm in depth. In some monitoring sites, movement to deeper layers can be seen, so it will be necessary to watch the state of movement closely in future (Figure 3).



[Figure 3] Changes in Radioactive Cesium Concentrations at Each Depth in Soil (examples of Kanayama cedar forest and Otama konara oak forest)

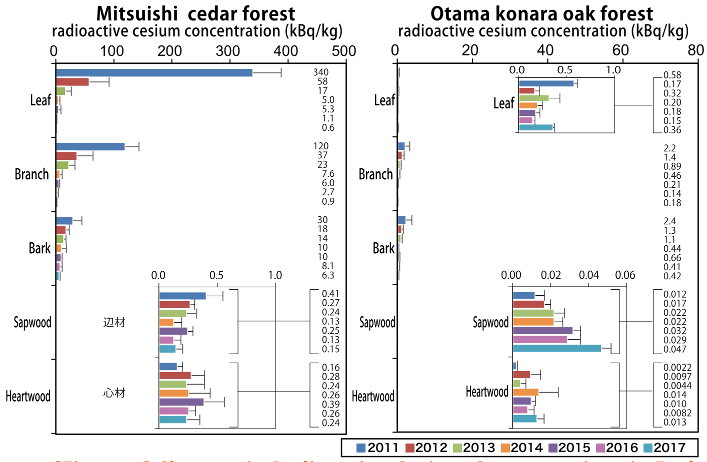
Reference : Forestry Agency "Results of a Survey of Radioactive Cesium Distribution in Forests" (2017)

Distribution of Radioactive Substance Concentrations in Each Part of Trees

Concentrations of radioactive cesium in the leaves, branches, bark, and other parts of trees declined sharply between 2011 and 2012, but after 2012, the decline in concentrations has been more gradual. Also, in every investigation area, the heartwood and sapwood within timber has had lower concentrations than the leaves, branches, bark, and other parts (Figure 1).

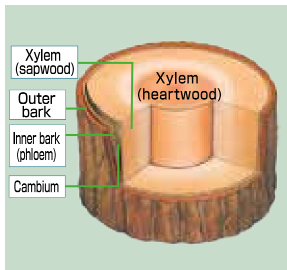
The decline of concentrations in the leaves of evergreen trees such as cedar and Japanese cypress is thought to be influenced by replacement with new leaves as old leaves fall, in addition to washing by rain.

As concentrations of radioactive cesium within wood have not changed greatly since 2011, it appears that most of the radioactive cesium absorbed immediately after the accident accumulated in internal parts of trees. Also, as the leaves of konara oaks, which are grown new every year, include radioactive cesium, and concentration changes are observed in the sapwood and heartwood of cedars and konara oaks, it appears that part of the radioactive cesium concentration is migrating within trees. In cedars, in particular, research to date has revealed a rising trend in radioactive cesium concentrations in heartwood. Furthermore, as radioactive cesium is found even in saplings that were grown after the accident, it is also necessary to investigate the effect of absorption from the root (Figure 3).



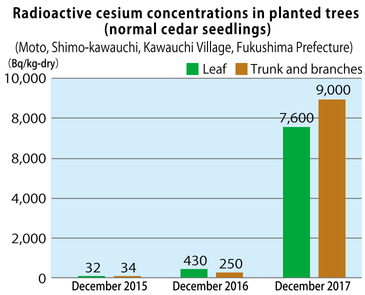
[Figure 1] Changes in Radioactive Cesium Concentrations in Each Part of Trees in Mitsuishi Cedar Forest and Otama Konara Oak Forest

Reference : Forestry Agency "Results of a Survey of Radioactive Cesium Distribution in Forests" (2017)



[Figure2] Structure of a Tree Trunk

Reference : "Data Collection to Know Forest No.1", Zenrinkyou



[Figure3] Changes in Radioactive Cesium Concentrations in Planted Trees

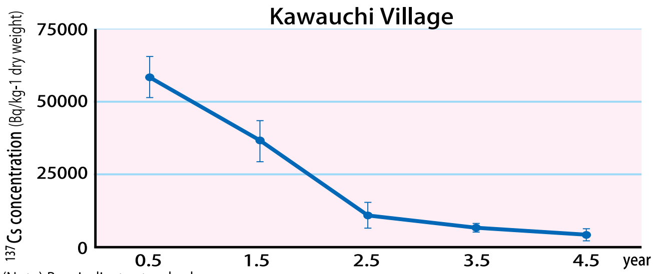
Reference : Forestry Agency "Validation Project for Forestry Revitalization in Districts Preparing for Evacuation Order Lifting" (Futaba District), 2017

Impact of Radioactive Substances on Small Mammals Living in Forests

Since 2011, the Forestry Agency has been running a survey to grasp the real state of radioactive contamination in earthworms and field mice living in forests.

Radioactive cesium concentrations in earthworms collected in Kawauchi Village decreased substantially between 0.5 and 2.5 years after the accident, and then continued with a more gradual decline (Figure 1). To see the ease of radioactive cesium movement into the bodies of earthworms, the ratio between radioactive cesium concentrations in the litter layer that they eat and in the bodies of the earthworms was investigated. Compared to the concentration in the litter layer, the concentration within earthworm bodies tended to be lower. That is thought to be the case because as the absorption of radioactive cesium from the litter layer to clay etc. advances, it becomes harder for it to migrate into earthworms.

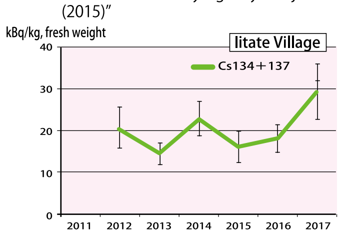
Also, looking at annual changes in radioactive cesium concentrations in the bodies of field mice, there was an increase in levels in field mice in Iitate in 2017, a decrease in Kawauchi Village, and no significant change in Kita-Ibaraki. Patterns of concentration change differed regionally (Figure 2).

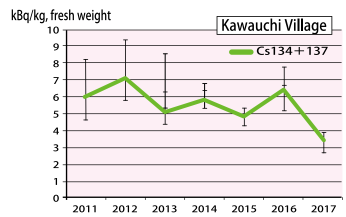


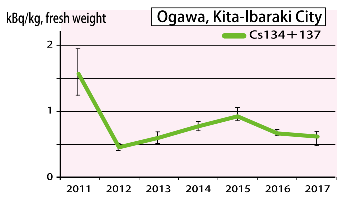
(Note) Bars indicate standard error.

[Figure 1] Changes in Radioactive Cesium Concentrations in Earthworms (gastrointestinal tract content removed, per unit dry weight)

Reference : Forestry Agency "Project Report of Survey on Radioactive Substances in Forests (2015)"







(Note) Bars indicate standard error.

[Figure 2]Annual Changes in Radio-Active Cesium Concentrations in Field Mice in Each Survey Area

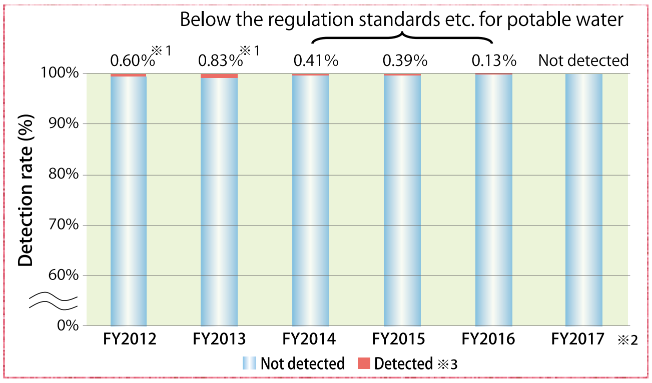
Reference : Forestry Agency "Project Report of Survey on Radioactive Substances in Forests (2017)"

Impact of Radioactive Substances on Mountain Stream Water and Potable Stream Water

In 2012, during the thawing season, the Forestry and Forest Products Research Institute conducted a monitoring survey by measuring the radioactive cesium concentrations at the daily fixed time, at six locations in Fukushima Prefecture, in mountain streams originating in forests. Results indicated that almost no radioactive cesium was detected in mountain stream water flowing out of forests (the lower limit of detection was 1 Bq/L), but it was detected in some samples on days with rainfall. At the times of detection, the water was muddied with particles of fine soil. After filtration, no cesium was detected in the filtered water. From that, it can be inferred that the main source of radioactive cesium in mountain stream water is particles of fine soil etc.

Since December 2012, the Ministry of the Environment has monitored portable stream water etc , in municipalities which have requests in Fukushima Prefecture . According to survey data gathered over five years to date, no cesium was detected in 8,963 of all 9,020 samples (99.4%) in nine municipalities (Iitate Village, Okuma Town, Katsurao Village, Kawauchi Village, Kawamata Town, Tamura City, Namie Town, Naraha Town , and Hirono Town). After filtration, no cesium was detected in the filtered water from any location.

In FY2017, when stream water etc. was sampled at 142 locations and measured for radioactive cesium concentration, no cesium was detected in any sample (detection limit: 1 Bq/L) (Figure).



[Figure] Trend of Detection Rates of Radioactive Cesium in Monitoring of Potable Stream Water

※1 In FY2012 and FY2013, only three samples surpassed the regulatory standard for potable water.
※2 Measurement period: December 2012 - February 2018
※3 Lower limit of detection: 1 Bq/L

[Photo] Example of a Sampling Location (Iitate Village)

[Reference]]
- Standards for Foods and Additives, Based on the Food Sanitation Law (potable water) (Ministry of Health, Labour and Welfare Recommendation No.130, March 15, 2012) Radioactive cesium (total of Cs-134 and Cs-137): 10 Bq/L
- Target value for radioactive substances in mains water (Management target value for mains water facilities) (Ministry of Health, Labour and Welfare, Pharmaceutical Safety and Environmental Health Bureau, Water Supply Division manager's notification 0305-1, dated March 5, 2012) Radioactive cesium (total of Cs-134 and Cs-137): 10 Bq/L

Reference : Ministry of the Environment "Measurement Results of Monitoring of Stream Water etc. in Decontamination Special Areas" (Summary of results for the past five years and of samples collected in February 2018)"

Column Main Findings Obtained from the Chernobyl Nuclear Power Plant Accident

How have forests, forestry, and timber-related industries been impacted since the Chernobyl nuclear power plant accident, which happened in 1986 in what was then the Soviet Union? This column examines the main points, with reference to recent bibliography, such as published documents from the Science Council of Japan and the International Atomic Energy Authority.

(Movement of Radioactive Cesium in Forests)

Radioactive cesium which fell on forests after the reactor accident first adhered to the forest canopy and to bark. After that, part of it was absorbed through plant surfaces, and the other part of it settled into bark for the long term, but within a few years, most of the cesium had moved to the forest floor. With the decomposition of organic matter on the forest floor, cesium moved to the soil surface layer, and adsorbed strongly to clay minerals, tending to stay in that surface layer for the long term. Even 10 years and more after the Chernobyl accident, there has been almost no movement of the peak radioactive cesium concentration in soil to lower layers, and movement to deep layers appears to be progressing slowly.

On the other hand, part of fallout radioactive cesium into forests has been moving dynamically, together with the circulation of substances in the forest ecosystem. That is attributed to the fact that radioactive cesium is an alkaline element, like potassium, a major nutrient salt, and has similar properties. Also, within the circulation that makes efficient use of nutrient salts, radioactive cesium stays in a form that is relatively easy for organisms to incorporate. As a result, radioactive cesium remains in relatively high concentrations in living organisms in forest.

(Impact on Mushrooms etc.)

In Belarus, in Easterns Europe, there is long-standing contamination of mushrooms, raspberries, and wild animal meat. Average radioactivity levels in wild animal meat depend on the species, but are high in boar and deer.

(Radioactive Cesium in Timber)

In Belarus, there is said to be a correlation between radioactive cesium concentration in timber and the amount of cesium deposition in soil.

These findings obtained from the Chernobyl nuclear power plant accident is valuable for predicting the future for forests etc. impacted by the Fukushima accident in 2011. However, Japan and Chernobyl differ in climate, topography, geology, flora, and other aspects, and the utilizing manners of forest products are also different. Therefore, it is important to verify the differences based on resources such as results obtained.

Reference: Science Council of Japan "Radioactive Contamination from the Fukushima Reactor Accident and the Impacts on Forests, Forestry, and Timber-related Industries - Current Status and Problems", September 1, 2014;
IAEA (2006) "Report of the International Atomic Energy Authority Chernobyl Forum Expert Group "Environment" , Environmental Consequences of the Chernobyl Accident and their Remediation: Twenty Years of Experience", (translated by the Science Council of Japan)