Ⅲ Impact of Radioactive Substance on Forest Management

The Forestry Agency and Fukushima Prefecture have set up test sites in the prefecture to work on various projects. These efforts include investigating the impact of activities such as thinning on air dose rates, validating techniques intended to suppress the movement of radioactive cesium, and reduction of exposure doses to workers working within forests.

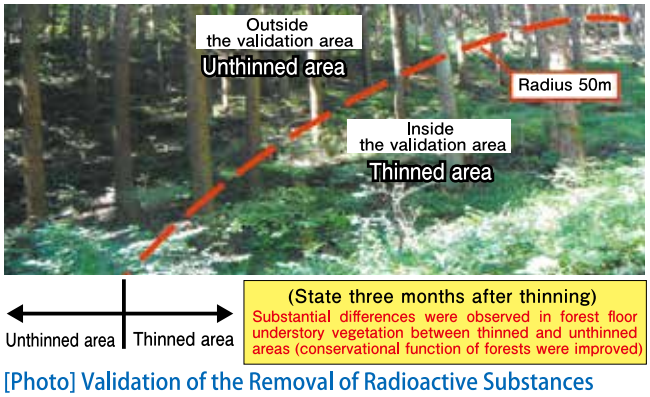
Effects of Thinning, and Its Impact on Air Dose Rates

In Fukushima Prefecture, a test site in a Japanese red pine forest was set up in Kawauchi Village from 2012 to 2017,and used to survey the impact of thinning on air dose rates. In April 2012, air dose rates were measured before and after thinning and harvesting operation. The air dose rate, which was 4.52 μSv/h before operation, decreased by 12% to 3.87 μSv/h after the operation. By three months after the thinning, undergrowth vegetation had flourished on the forest floor, so the vegetation was obviously different from that before thinning (photo).

Thinning brightens the inside of the forest and promotes the growth of understory vegetation, reducing the direct impact of rain drops on the ground surface, which is expected to suppress the movement of radioactive cesium by suppressing movement of topsoil.

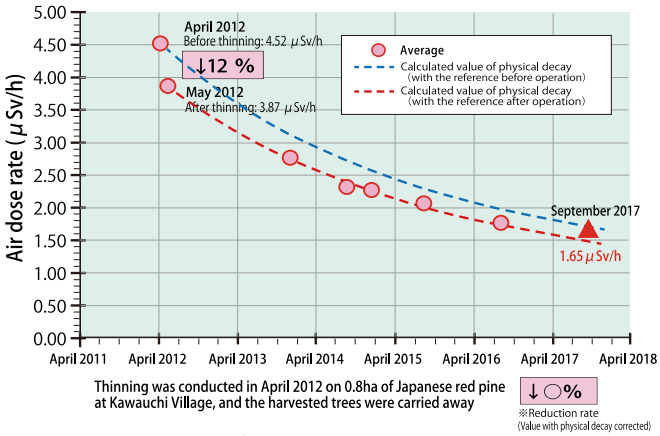
In September 2017, five years and five months later after the thinning, it was confirmed that the air dose rate was continuing to decrease at almost the same rate as the value estimated from physical decay of radioactive cesium (Figure 1). At this moment of seven years and seven months after the reactor accident, most of the radioactive cesium in forests has accumulated in the soil surface layer, and the proportion included in trees is small. Therefore, it seems that the air dose rate does not change greatly between before and after thinning at the current stage.

Furthermore, forest management work such as harvesting and thinning improves the light environment in the forest, and raises the soil surface temperature. This would appear to have an effect in promoting movement of radioactive substances to the soil, by assisting decomposition in the litter layer. The illustration below (Figure 2) shows the movement of radioactive substances within forests.



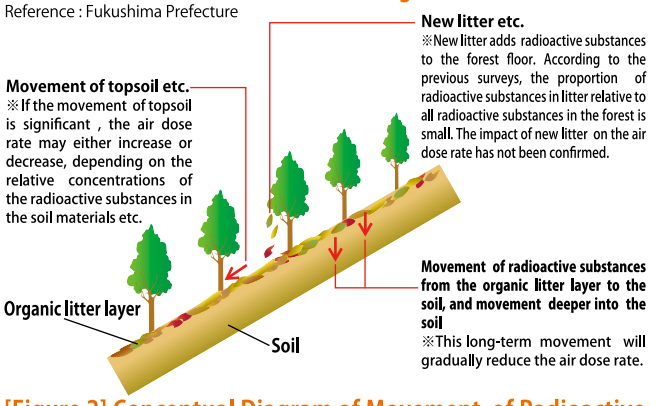
[Photo] Validation of the Removal of Radioactive Substances from Forests (Effects of Thinning)

(Note) The validation area was set as a circle of 50m radius of approximately 0.8ha.
Reference : Fukushima Prefecture "Long-term Monitoring of Radioactive Material in the Forest and Associated Countermeasures" (FY2014 and FY2015)



[Figure 1] Validation of Countermeasures against Radioactive Substances in Forests (effects of thinning, etc.)

Reference : Fukushima Prefecture



[Figure 2] Conceptual Diagram of Movement of Radioactive Substances Observed in the Forests

Reference : Forestry Agency (FY2017) "Results of the Validation and Development Project for Countermeasures against Radioactive Substances in Forests"

Monitoring Survey of Impacts of Thinning etc. on Movement of Soil Materials and Radioactive Substances

The Forestry Agency set up test sites in Hirono Town from 2012 to 2017, and investigated the amounts of movement of soil material etc. and radioactive cesium due to thinning and the removal treatment of litter layer. Investigation of surface running water and movement of soil etc. within forests observed that almost no radioactive cesium was found in the surface runoff water , and the radioactive cesium in the forest moved mainly together with the sediment.

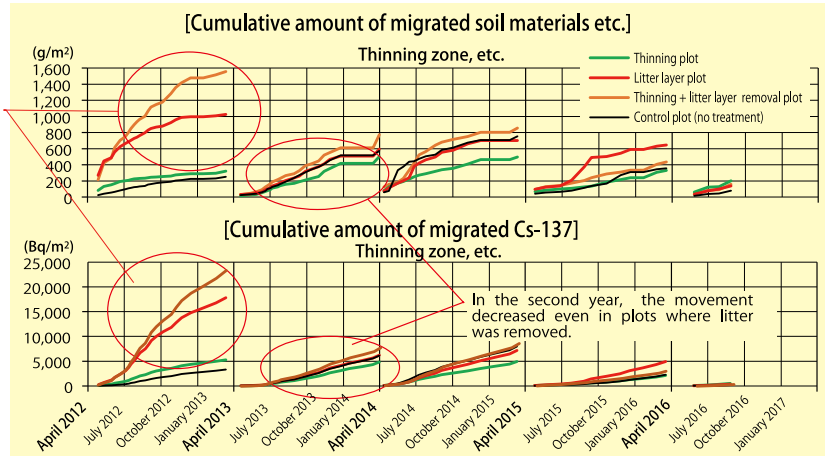
Measurement results for the following four treatments within the test area are compiled into the graph.

(1)Thinning plot
(2)Litter layer and debris removal plot
(3)Thinning + litter layer removal plot
(4)Control plot (no treatment)

The movement of sediment and radio cesium significantly increased where litter was removed.

There was no major difference of amount of soil movement between "(1) Thinning treatment" and "(4) Control plot (no treatment)". In the "(2) Litter layer and debris removal plot" and the "(3) Thinning + litter layer removal plot" , the amount of migrated soil material and radioactive cesium greatly increased in the first year. However, it reduced to the same level as the "(4) Control plot (no treatment)" in the second year.

These results indicate that when the forest is thinned, there is little soil material movement if the forest floor is not greatly disturbed, and there appears to be little impact on the movement of radioactive cesium.



[Figure] Trend of Annual Accumulated Migrated Soil and Radioactive Cesium after Forest Management Work

Reference : Forestry Agency (FY2016 and FY 2017) "Results of the Validation and Development Project for Countermeasures against Radioactive Substances in Forests"

Countermeasures against Radiation Exposure While Working within Forests (internal exposure and external exposure)

The Forestry Agency measured the amount of dust generated by each work type and the radioactive cesium concentration of the dust, to investigate workers' internal radiation exposure. The highest internal exposure dose per hour was 0.000046 μSv/h, for working in chip laying. The average air dose rate in the survey area at that time was 0.62 μSv/h.

That means that the internal exposure dose was extremely low, tens of thousands of times smaller than the external exposure dose, so it is important to reduce external exposure in forest work.

The longer the working hours of the work type, the higher the external exposure dose. Also, even within the same type of work, those who spend more time in the cab of a timber processor or a grapple etc. tended to have lower external exposure doses than those working outside. Comparing external exposure doses per unit time, those for land preparation and logging with heavy equipment are around 10% lower than those for manual labor (Figure).

That means that to reduce the exposure involved in working in forests, it would be effective to keep working hours as short as possible, and to use heavy equipment.

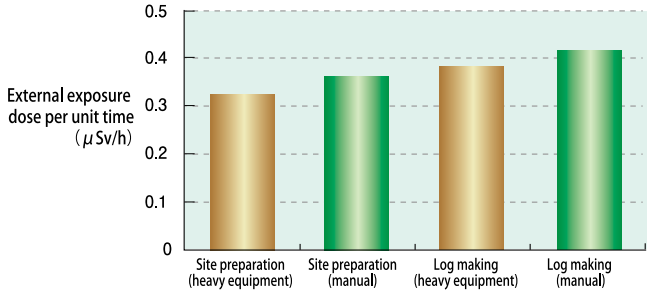
Work type	Average dust concentration mg/m³	Total working time h	Inhaled amount of dust ※1 mg/h	Inhaled amount of dust ※1 mg	Radioactive cesium concentration of dust ※2 134Cs Bq/kg	Radioactive cesium concentration of dust ※2 134Cs Bq/kg	Internal exposure dose μSv/h
Improvement cutting	0.29	379.5	0.35	131.3	86	260	0.4×10^{-5}
Forestry operation road construction ※3	0.17	147.0	0.20	29.6	1500	3800	3.6×10^{-5}
Regeneration cutting	0.10	120.5	0.16	19.7	220	680	0.5×10^{-5}
Site preparation	0.10	70.5	0.13	8.8	1500	3800	2.2×10^{-5}
Mechanized regeneration cutting ※2	0.08	18.5	0.09	1.7	1500	3800	1.7×10^{-5}
Planting	0.10	336.5	0.12	40.7	1500	3800	2.2×10^{-5}
Chip laying	1.24	77.0	1.48	114.2	220	680	4.6×10^{-5}

※1：Estimation of worker's inhalation of radioactive substances for each work type was calculated based on measurement using a digital dust meter and inhalation quantity of 1.2m3/h (from ICRP Pub 1.23).
※2：For improvement cutting, the average value of understory vegetation radioactive cesium concentration was used. For forestry operation road construction, site preparation, mechanized regeneration cutting, and planting, the average values of radioactive cesium concentration for litter and soil were used. For regeneration cutting and chip laying, the average value for radioactive cesium concentration of logs was used.
※3：Forestry operation road construction and mechanized regeneration cutting are jobs done by operators sitting inside heavy equipment, so the amounts of dust inhalation and internal exposure dose can be expected to be greatly reduced, but the same method as for outdoor work was used.

[Table] Internal Exposure Dose Estimated Calculation Results

Reference :Forestry Agency (2014) "Report on Validation Projects in Districts Preparing for Evacuation Order Lifting (Tamura City)"

[Photo] Thinning Using Cabin-equipped Forestry Equipment



[Figure] External Exposure Dose Per Unit Time for Each Work Type

Reference : Forestry Agency (2014) "Report on Validation Projects in Districts Preparing for Evacuation Order Lifting (Tamura City)"