Spatial variability and seasonal change of radioactive caesium concentration in grassland vegetation

Mikinori Tsuiki, Saaya Eguchi, Yusuke Nagata and Takeki Maeda

Iwate University, 3-18-8 Ueda Morioka Iwate 020-8550 Japan, www.iwate-u.ac.jp
Contact email: tsuiki@iwate-u.ac.jp

Keywords: Grassland, Fukushima Daiichi Nuclear Power Plant level 7 event, radioactive caesium concentration, seasonal change, spatial variability.

Introduction

The damage from the Fukushima Daiichi Nuclear Power Plant caused by the Great East Japan Earthquake and tsunami on March 11, 2011 resulted in serious radioactive pollution over Eastern Japan. The distribution of radioactive fallout was largely determined by wind and rainfall patterns in March 2011. Distribution patterns were not necessarily in accordance with the distance from the nuclear power plant. In Iwate Prefecture (160 to 340 km north of the nuclear power plant), the amount of fallout of radioactive material in the southern region was greater than in the northern, but the distribution pattern was complex (Fig. 1, Tsuiki and Maeda 2012a; 2012b). In the southern region, the radioactive caesium (Cs) concentrations of herbage plants exceeded the provisional safety standard for dairy and fattening cattle feed, and the livestock industry has been seriously affected in numerous ways e.g. needing to dispose of polluted forage, grazing prohibitions, declines in beef prices, suspension of vending, and blanket testing of beef cattle. In this study, the spatial variability of radioactive Cs concentration in soil and vegetation was evaluated on grasslands in 2012.

Methods

Experimental area

The study was conducted using a pasture in the southern region of Iwate Prefecture (Fig. 1). The annual mean air temperature was 10.7°C and the annual precipitation was 1326 mm. The pasture (15.44 ha) was established 1989 and the site had an elevation ranging from 310 m on the northeastern side to 430 m on the southwestern side (Fig. 2). The soil type is mostly Andosol, which is a nutrient-poor and high organic acidic soil. Twenty Japanese Black cows (*Bos Taurus* L.) were stocked from June to November 2011. In 2012, grazing was restricted. Orchardgrass (*Dactylis glomerata* L.) and Kentucky bluegrass (*Poa pratensis* L.) were the dominant sown pasture species; *Artemisia indica* var. maximowiczii and *Rumex obtusifolius* L. were the dominant weed species within the pasture.

Measurement methods

A 20×20 m^2 site (site A) and a 2.5 × 2.5 m^2 site (site B) within the pasture were selected as sampling sites to measure radioactive Cs concentration of the soil and vegetation. Measurements were conducted in spring (site A: 30 May, site B: 4 June) and in autumn (site A and B: 15 October), 2012. Air radiation dose rates (μSv/h) were measured at 25 (5 × 5) points (4 m intervals for site A, 0.5 m intervals for sites B) by an environmental radiation monitor (PA–1000 Radi, Horiba Ltd., Kyoto, Japan) at a height of 1 cm. The distributions of soil surface radioactive Cs (kBq/m^2) was calculated using previously published regression equations (Tsuiki and Maeda 2012a; 2012b). Radioactive Cs concentrations in vegetation (Bq/kg FW or Bq/m^2) were measured by gamma spectroscopy using a NaI (TI) detector (EMF211, EMF Japan Ltd., Kawachinagano, Japan).

Results

At both sites, radioactive Cs concentrations in soil in spring (site A: 195 ± 27 kBq/m^2, site B: 255 ± 112 kBq/m^2) were higher than in autumn (site A: 156 ± 30 kBq/m^2, site B: 198 ± 68 kBq/m^2). As these decreases beyond the decay correction, vertical or horizontal movement of radioactive Cs may occur. At both sites, radioactive Cs concentrations in vegetation during spring (site A: 1546 ± 685 Bq/kg FW, site B: 1976 ± 649 Bq/kg FW) were higher than in autumn (site A: 272 ± 97 Bq/kg FW, site B: 449 ± 284 Bq/kg FW). This result indicates seasonal variation of radioactive Cs

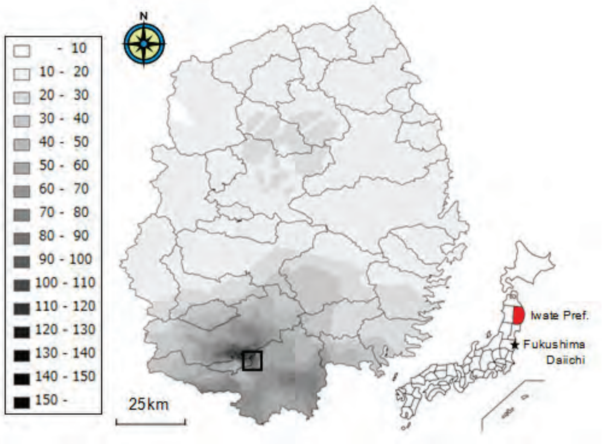

Figure 1. Soil radioactive material contents of Iwate Prefecture (Tsuiki and Maeda 2012a; 2012b, kBq/m^2). The square within the map is experimental area.

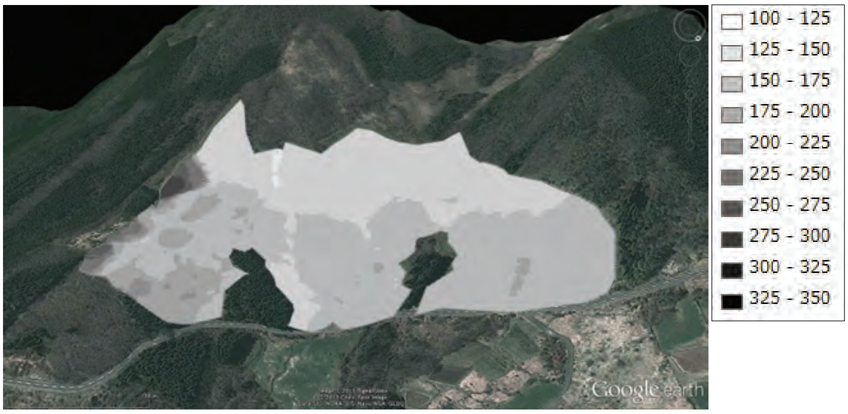

Figure 2. Spatial distribution of radioactive Cs activity in the pasture (kBq/m^2, Tsuiki and Maeda 2012a; 2012b). The square within the map is site A and B. The terrain is exaggerated three times in elevation.

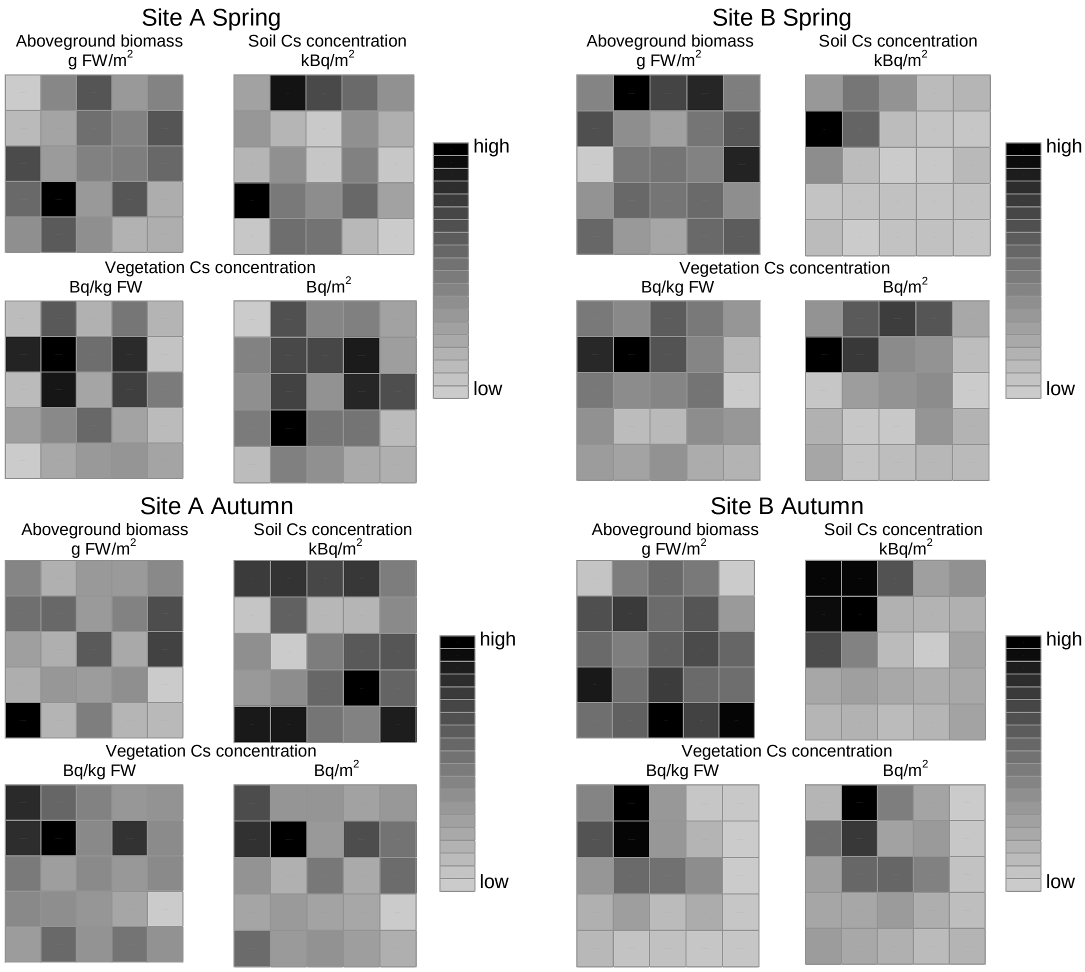

Figure 3. Spatial distributions of aboveground biomass, soil Cs and vegetation Cs concentration.

concentrations. On site B, a significant positive correlation was observed between Cs concentration of soil and vegetation (Fig. 3). As Cs concentration was affected by soil exchangeable potassium, clay and organic matter concentrate-ion, only site B with narrow area and similar soil characteristics showed significant correlation.

Conclusion

Fallout radioactive Cs by the Fukushima Daiichi Nuclear Power Plant was heterogeneously distributed in various scales. Soil and vegetation Cs concentrations were higher in spring than in autumn. Transfer of radioactive Cs from soil to plant was affected by soil characteristics.

References

Tsuiki M and Maeda T (2012a) Spatial distribution of radioactive caesium fallout on grasslands from the Fukushima Daiichi Nuclear Power Plant in 2011. *Grassland Science*, **58**: 153-160.

Tsuiki M and Maeda T (2012b) Spatial variability of radioactive caesium fallout on grasslands estimated in various scales. *Grassland Science*, **58**: 227-237.