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Measuring and Modeling Runoff, Soil Erosion and Sediment Yields to assess Management Options in the Post-Fallout Watersheds of Iitate Village, Fukushima, Japan

Chris S. Renschler [1,2], Kazutoshi Osawa[3], Takuhei Yamasaki[2], and Taku Nishimura[2]

[1]Dept. Geography, Univ. at Buffalo, USA, [2]Dept. Biol. & Environm. Engineering, University of Tokyo, Japan, [3]Dept. Environm. Engineering, Utsunomiya University, Japan

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1. Introduction: Following the radioactive fall out of the 2011 Fukushima Daiichi Nuclear Power Plant (FDNPP) accident, radiocesium (Cs-137) contaminated soils of forests, uplands, rice paddies and other land uses released contaminated sediments onto neighboring areas and into the creeks and rivers in Iitate Village, Japan. The study used conventional and Cs-137 fingerprinting techniques to determine runoff and suspended sediment discharges to assess the small and large-scale soil redistribution dynamics within contributing areas in two watersheds (fig 1.).

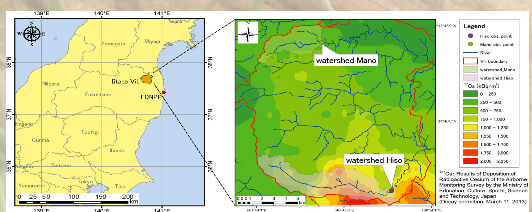


Fig 1.: Location of field monitoring sites in Iitate Village, Japan. Spatial distribution of 137Cs deposition data is from the Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) 2013.

2. Methods: We attempt to use 137Cs fingerprinting on hillslopes and gauging stations to identify spatial and temporal patterns of land use/ change on soil redistribution and sediments. The contributing areas near the outlets of the 30 km² Hiso watershed (the 10 km² Mano River is not discussed in this poster) were simulated at the hillslope and watershed scale using the process-based Water Erosion Prediction Project (WEPP) model (fig. 2) and the Geospatial Interface for WEPP (GeoWEPP) (Renschler, 2003) (see maps 1 to 3). Besides the simulation of historic soil redistribution events over the time period 2011-2016, particular emphasis was put on the identification and assessment of various land use and cover changes on soil redistribution (e.g. clear cut deforestation in map 1 to 3). Soil Loss Rates (2011-18) were calculated based total 137Cs profile measurements along two hillslope profiles utilizing the Diffusion and Migration Model by Walling, et al. (2011).

3. Profile Results: The measured and simulated soil loss rates along the long (126 m) (fig 2. and 3.) and short (88 m) (fig. 3 only) illustrate upslope erosion and mid slope deposition areas as well as the decontaminated area at the bottom slope. Please note that while the simulations have been performed with bare soil conditions (2011-18), the formerly deforested upslope and mid slope sections experienced a vegetation regrowth. That means that the six-year steady state no-regrowth simulations certainly tend to overestimate the soil redistribution soil loss and sedimentation, but indicate what most likely happened in year one and to a lesser degree in year 2 and 3 after the deforestation. One would assume that the soil redistribution took mainly took place in the first two to years after deforestation. Please note that the soil loss in the decontaminated areas reflect the artificial removal/ soil replacement.

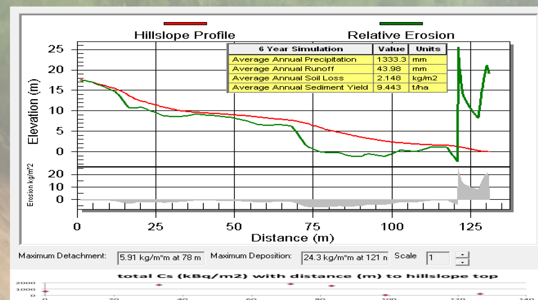


Fig 2.: WEPP soil redistribution simulation along longer hillslope transect with measured 137Cs soil samples. (see also bottom fig. 3)

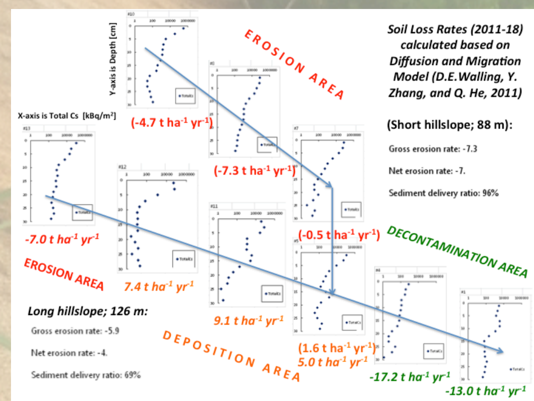
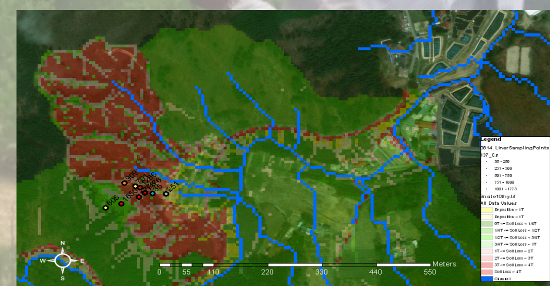


Fig 3.: WEPP soil redistribution simulation along hillslope transect with measured 137Cs soil samples.

4. Spatial Results: The measured 137-Cs in soil samples (fig. 3 – long hillslope) and WEPP simulation for the hillslope (fig. 2) indicate that soil redistribution is still very active where there have been drastic land use changes, e.g. deforestation in the fall 2010 (map 1). GeoWEPP on-site soil loss pattern and soil samples indicate soil erosion that occurred since 2011 (map 2). Corresponding GeoWEPP off-site sediment yields into the drainage pattern show the potentially drastic contribution of sediments from contaminated deforested hillslopes onto decontaminated upland rangeland and lowland rice paddy plots (map 3) having the potential to assist decision and policymaking for stakeholders.

5. Conclusions: These preliminary measurements and simulation results of the study indicate, that the proposed methods have the potential to facilitate scientists and farmers in this post-fallout landscapes (as well as natural resources and disaster managers in other areas) to investigate the consequences of active and passive land use and cover changes and their effects on the runoff and sediment dynamics at the plot, hillslope and watershed scales.

Map 1.: Land cover 2011, sampling locations for 137Cs, and delineated drainage near Hiso Outlet.



Map 2.: On-site GeoWEPP soil erosion and sedimentation pattern (T=10 t/ha/yr) near Hiso Outlet.

Map 3.: Off-site GeoWEPP sediment yield pattern (T=10 t/ha/yr) into drainage near Hiso Outlet.

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