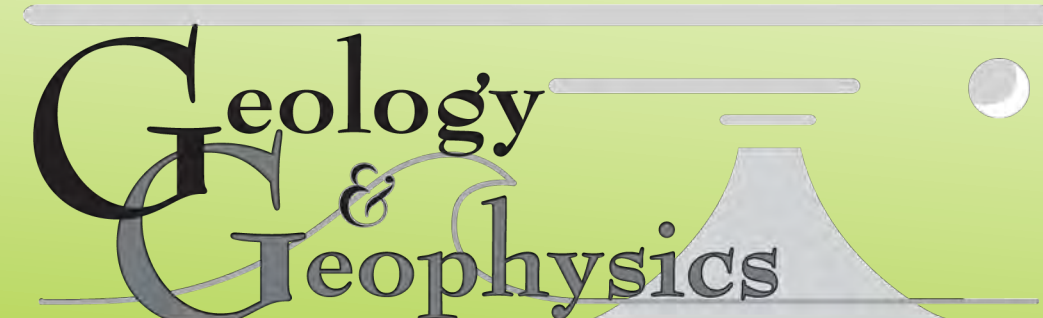


# Quantifying Atmospheric Fallout of Fukushima-Derived Radioactive

## Isotopes in the Hawaiian Islands

Trista McKenzie (tristam@hawaii.edu), Dr. Henrietta Dulai (hdulaiov@hawaii.edu)  
Geology and Geophysics, University of Hawai'i at Mānoa



### Introduction

On March 11, 2011, the Fukushima Dai-ichi Power Plant suffered catastrophic damage and released the radioactive isotopes iodine-131, cesium-134, and cesium-137, amongst others into the atmosphere<sup>1</sup>. On March 20, 2011, these isotopes were detected in aerosols over the state of Hawai'i and were deposited onto the islands by means of wet deposition<sup>3</sup>. Indeed, iodine and cesium were detected in milk samples on the Big Island. Moreover, it was suggested by a health study that Fukushima-derived iodine-131 in the atmosphere caused a notable increase in congenital hypothyroidism amongst newborn babies born in the western United States and the state of Hawai'i during the three-month period after the meltdown<sup>3</sup>. This is inconsistent with the EPA's data that showed that radioactivity concentrations in the air were well below a level that would concern human health. This conflicting information may mislead the concerned public in the absence of actual estimated data on the amount of radionuclides deposited after the accident. My objective is to investigate the levels of deposited radionuclides to reassure the public that there is not a concern to human health.

### Hypothesis

1. The atmospheric fallout from the Fukushima nuclear disaster in the Hawaiian Islands was present but far below the levels of health concern.
2. Wet deposition was the major driver of radionuclide deposition<sup>4</sup> and there is a positive correlation between rain and deposited amounts of cesium.
3. Fukushima-derived cesium activities will be less than nuclear weapons testing fallout as previously quantified by Cox<sup>5</sup>.

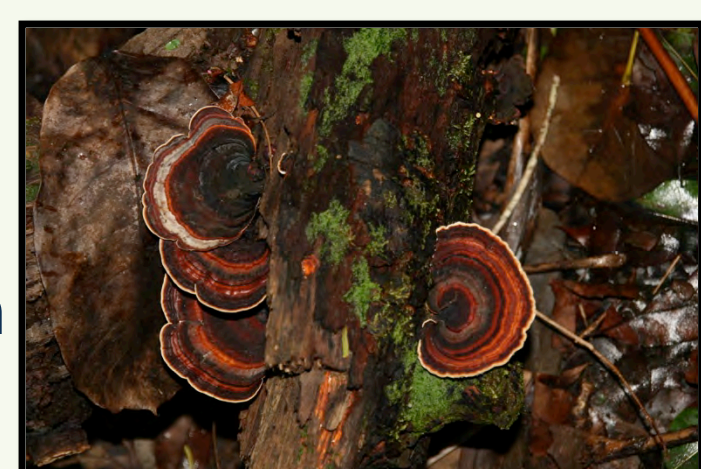
### Methods

#### Sample Collection:

1. Mushroom samples were collected along precipitation gradients on O'ahu, Kaua'i, Maui, and the Big Island in order to find locations of measurable Fukushima-derived fallout
2. Soil samples were collected on O'ahu after mushroom analysis to quantify deposition amount.
3. Radiocesium activities in Hawaiian soils were previously determined in the 1980's by Malcolm Cox. Nuclear weapons fallout and Fukushima fallout can be differentiated because of the difference in half-lives between Cs-134 ( $t_{1/2} = 2$  years) and Cs-137 ( $t_{1/2} = 30$  years).

#### Sample Analysis:

1. Samples were prepared for gamma spectroscopy. Mushroom samples were ashed at increasing temperature increments up to 450°C for 10 hours. Soil samples were oven-dried at 60°C for 72 hours. Samples were then transferred to a crucible for gamma spectroscopy.
2. Samples were analyzed by gamma spectroscopy using an Ortec high purity coaxial germanium (HPGe) detector.
3. Gamma spectra were analyzed using Hypermet-PC V5.01 software<sup>6</sup>. Detector efficiency was determined by analysis of Standard Reference Material (SRM) IEAE-385.
4. Samples were analyzed for Radionuclides of Interest (ROI) and decay corrected.
5. Rainfall amounts in March 2011 were found for each sample location using the Hawai'i Rainfall Atlas<sup>7</sup>.



### Results

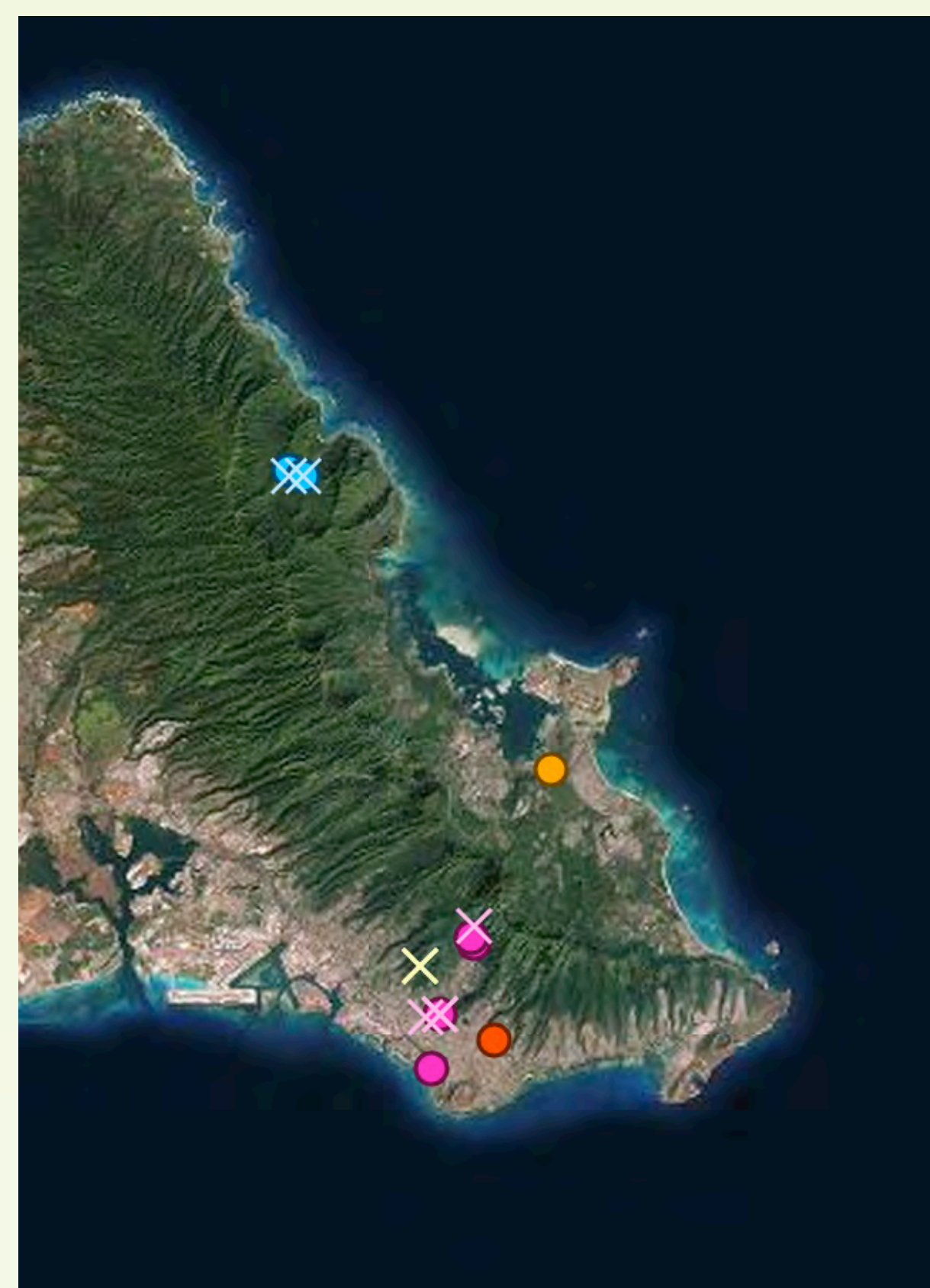


Figure 1: Locations of mushroom and soil sampling on O'ahu. • denote locations of soil sampling and X denote locations of mushroom sampling.

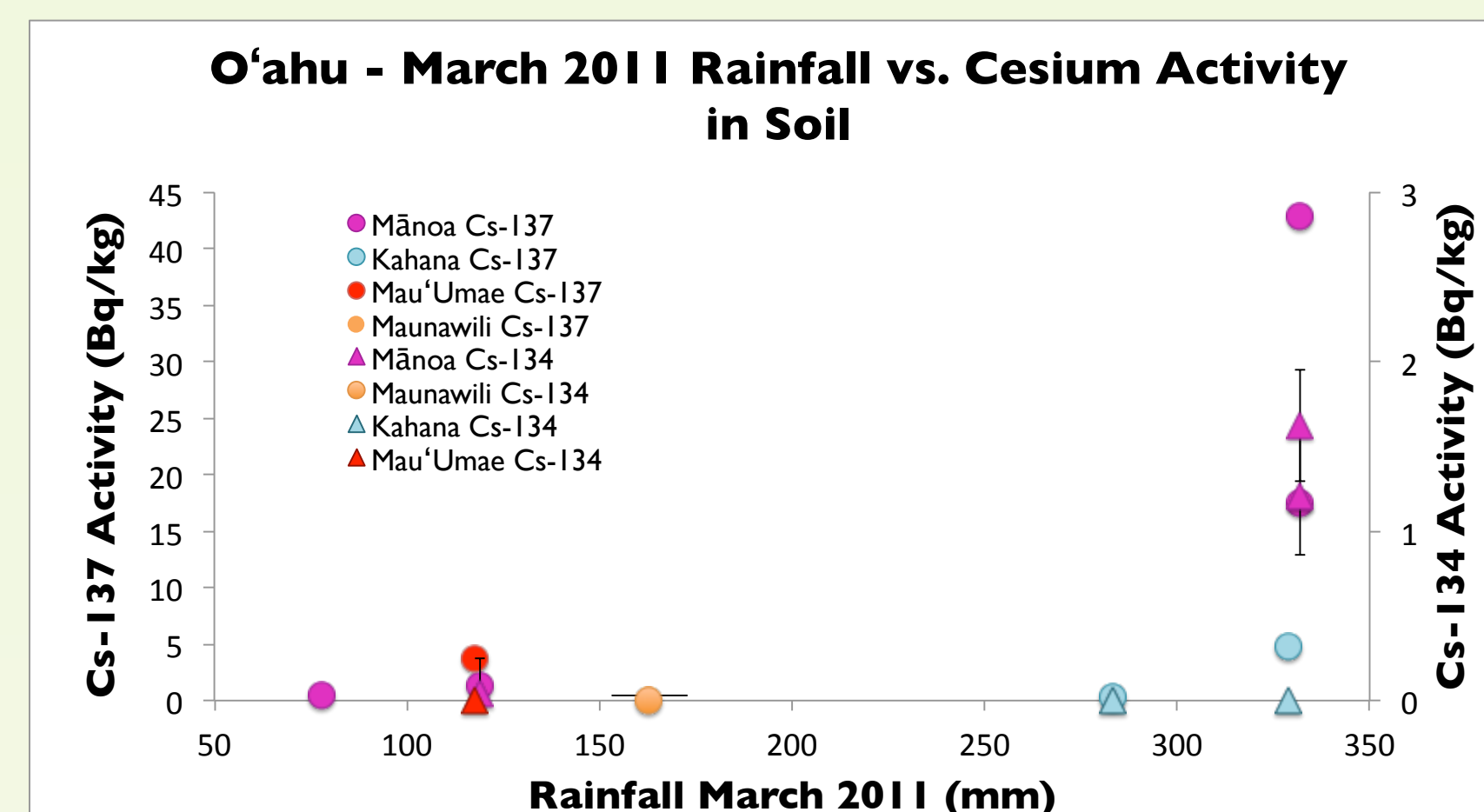


Figure 2: Cs-137 and Cs-134 activities (Bq/kg) which have been decay corrected to March 20, 2011 for soil are plotted against March 2011 rainfall (mm).

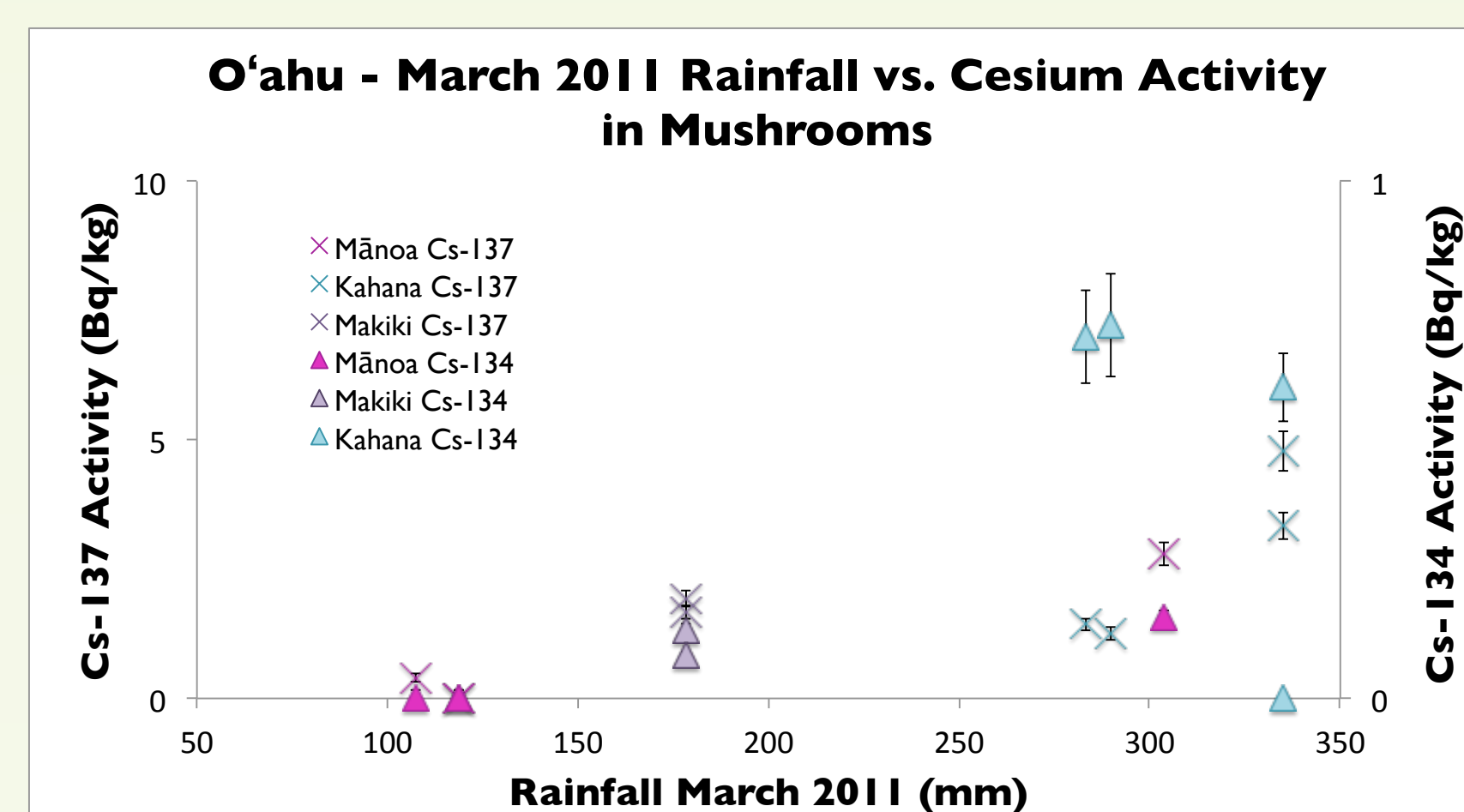


Figure 3: Cs-137 and Cs-134 activities (Bq/kg) which have been decay corrected to March 20, 2011 for mushrooms are plotted against March 2011 rainfall (mm).

### Discussion

Figure 4: Radiocesium decay corrected to March 2011 radiocesium (Bq/kg) vs. yearly rainfall (mm). Activities from Cox<sup>5</sup> have been decay corrected to March 2011 to reflect Cs-137 activities from nuclear weapons testing which still remain today. Activities from this study were also decay corrected to March 2011, the month of the Fukushima nuclear disaster and peak wet deposition in Hawai'i. Cs-137 activities measured in this study largely are a product of nuclear weapons testing, and not the Fukushima disaster. Because Cs-134 and Cs-137 were released from Fukushima in a near 1:1 ratio, Cs-134 activities best reflect Fukushima-derived cesium wet deposition.

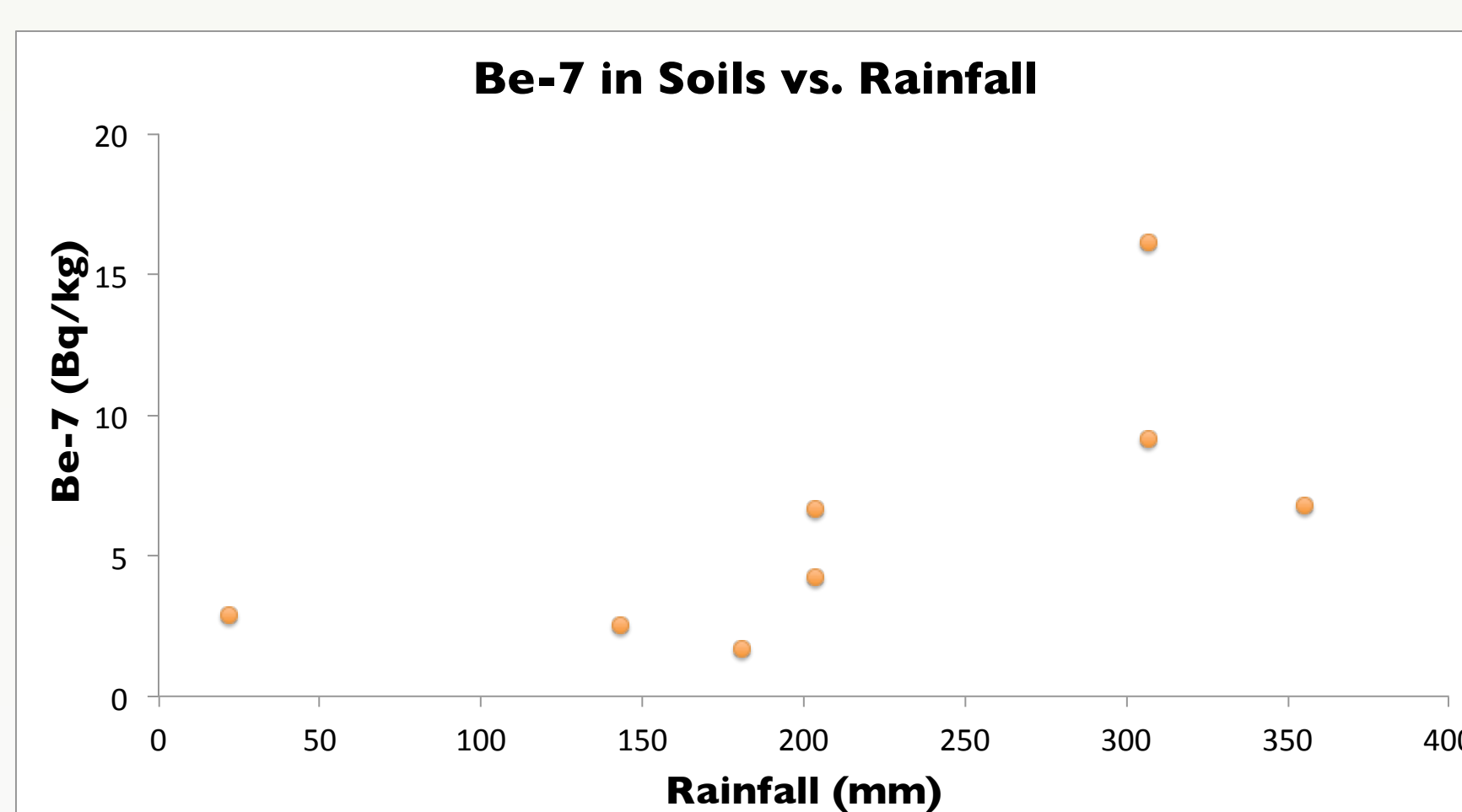
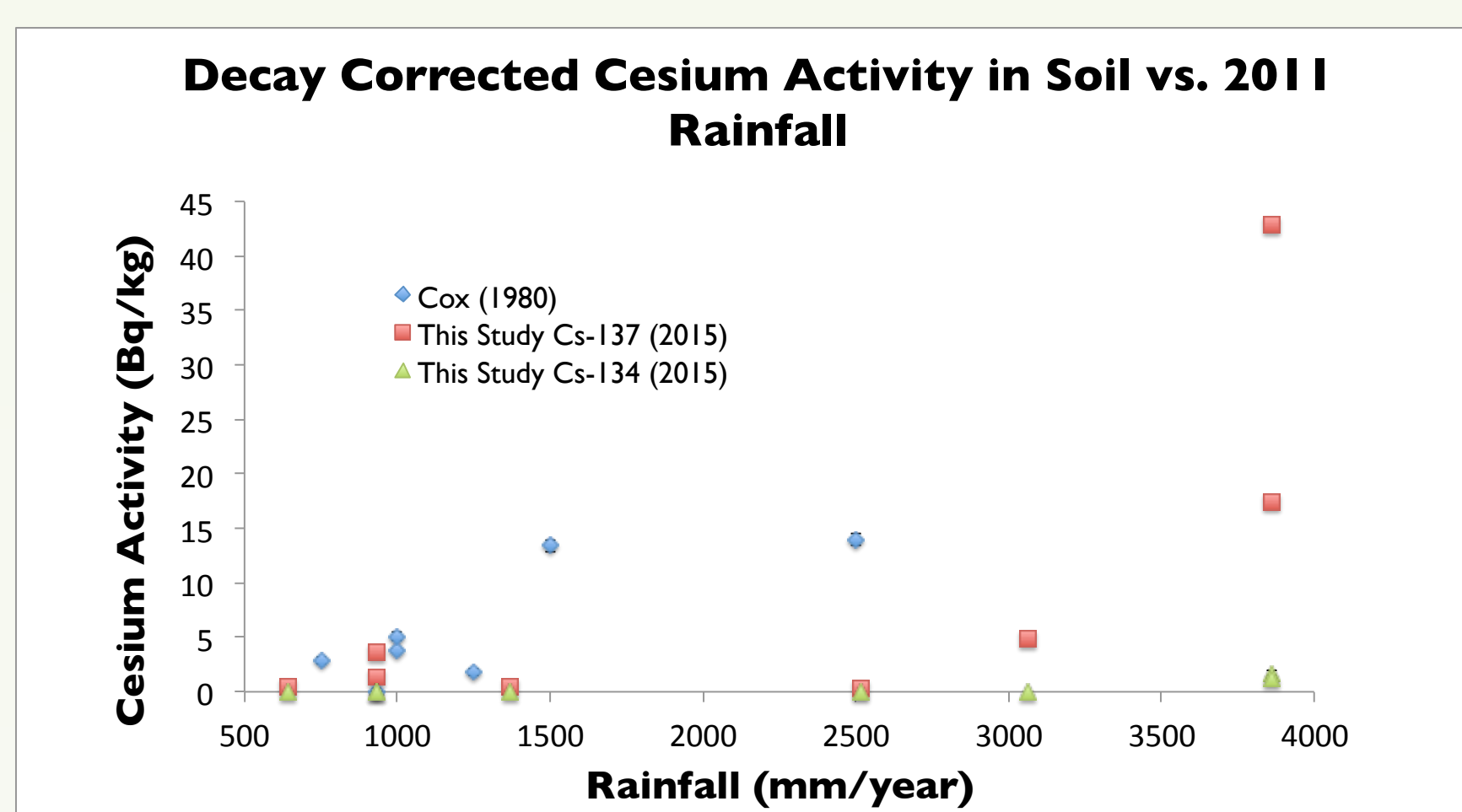


Figure 5: Be-7 ( $t_{1/2} = 53.24$  days) activity (Bq/kg) in soils vs. rainfall (mm) for the month of sample collection. Be-7 is a naturally occurring radioisotope which is primarily deposited by means of precipitation. Measured activities plotted against precipitation confirm the wet deposition trend as seen with cesium, confirming the validity of our method.

### Conclusion

1. Presence of Fukushima-derived fallout in mushrooms and soils on O'ahu has been confirmed. The level of radioactivity detected, however, is many magnitudes lower than a level of health concern.
2. Mushrooms indicated fallout locations, but soil samples were necessary to quantify the deposited amount.
3. Cesium activity between soil and mushrooms were not well correlated. This is due to the difference in bioaccumulation rates between mushroom species.
4. Higher rainfall in March 2011 resulted in elevated Fukushima-derived cesium in both mushrooms and soil.
5. Fukushima-derived cesium levels were much lower than those from nuclear weapons fallout measured by Cox.

### Further Research

Soil collection and analysis will now be extended to the Big Island, where mushroom samples previously collected had higher levels of radiocesium than those analyzed on O'ahu. Additionally, because Fukushima-derived isotopes were previously detected in milk on the Big Island, there is stronger evidence for larger fallout on the Big Island. I expect to see a similar correlation between rainfall, mushrooms, and soil as seen on O'ahu, and that Fukushima-derived fallout will remain negligible in comparison to the fallout resulting from the nuclear weapons testing.



Figure 6: Big Island soil sampling locations

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