Towards phytoremediation projects in Fukushima?
Collaborations between LSCE and BIAM

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LSCE, Paris-Saclay

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LSCE

LABORATOIRE DES SCIENCES DU CLIMAT & DE L'ENVIRONNEMENT

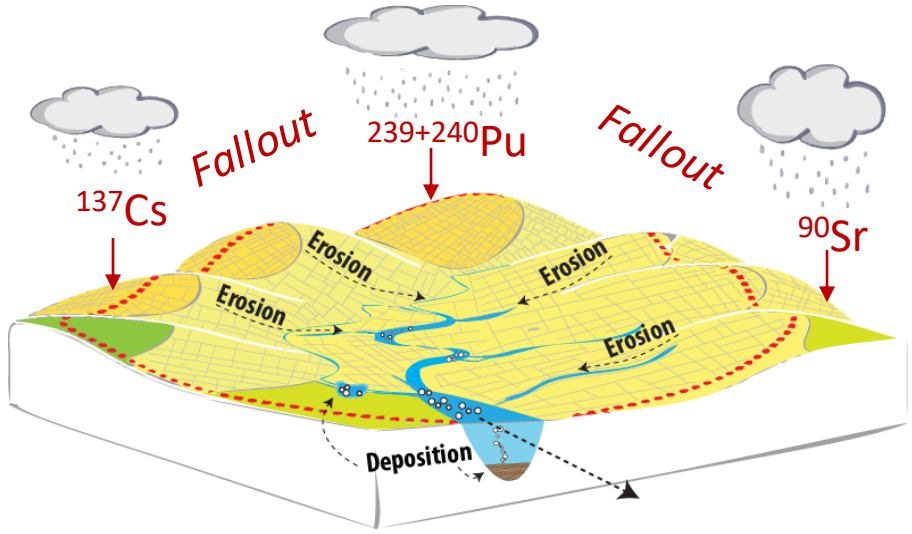
Institut de biosciences et biotechnologies (BIAM)

^{137}Cs and the *Great Acceleration*

Anthropogenic radionuclides detectable at the global scale in **1954**…

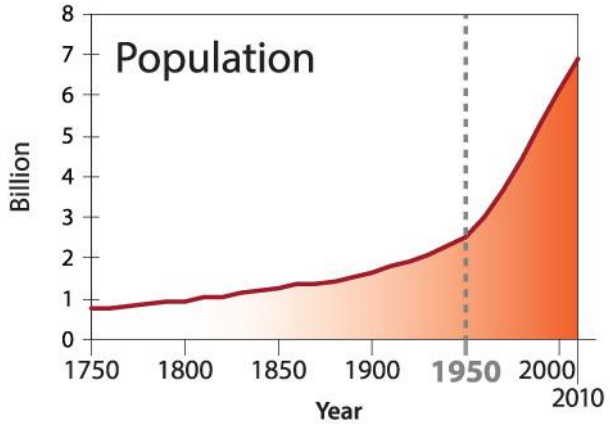
Zalasiewicz et al. (2015)

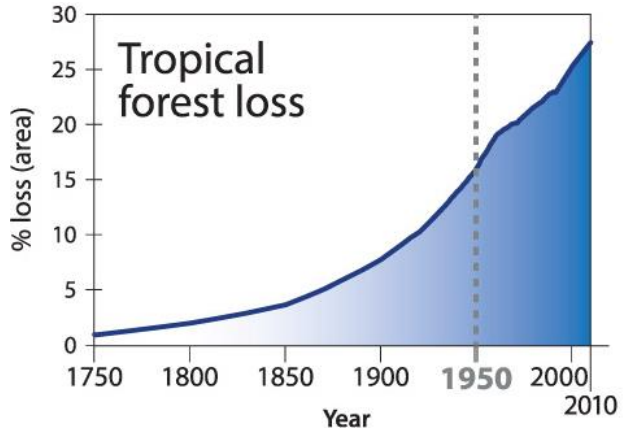
Caesium-137
Strontium-90
Plutonium isotopes
…

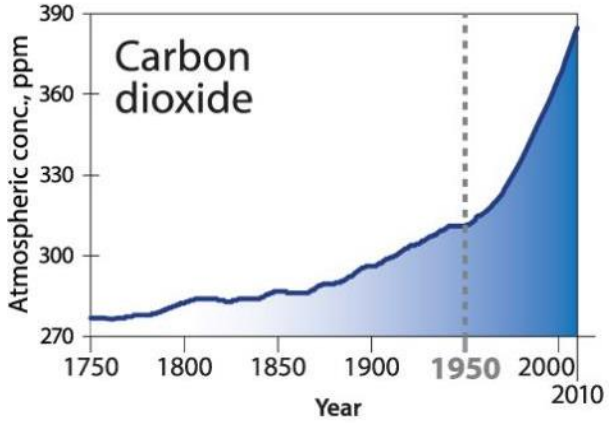


… coincides with the beginning of the « **Great Acceleration Period** »

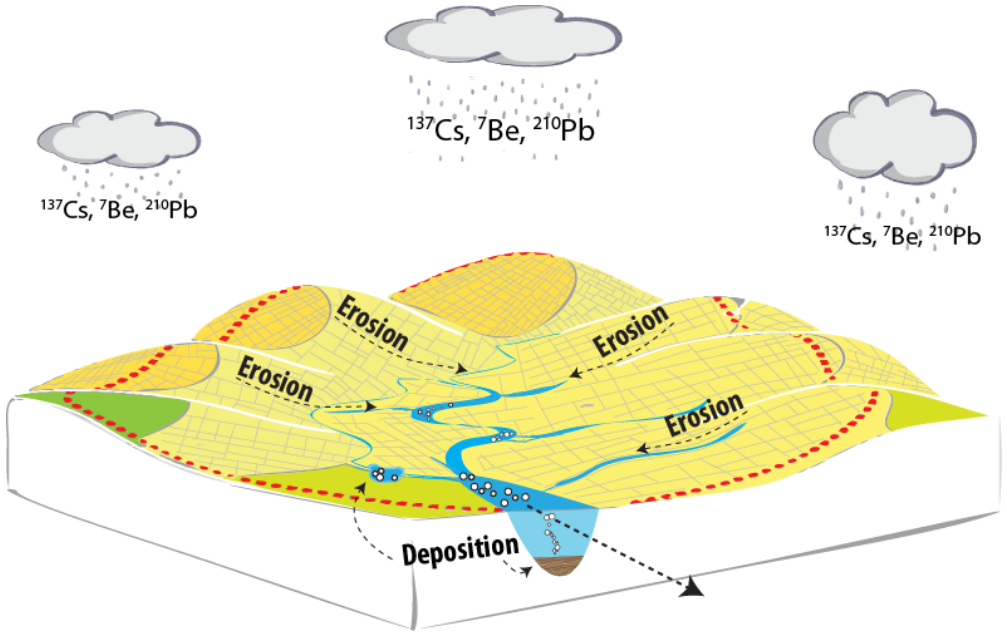
Steffen et al. (2015)







Impact of global change/human activities on sediment and contaminant transfers in river systems along the continent-to-ocean continuum

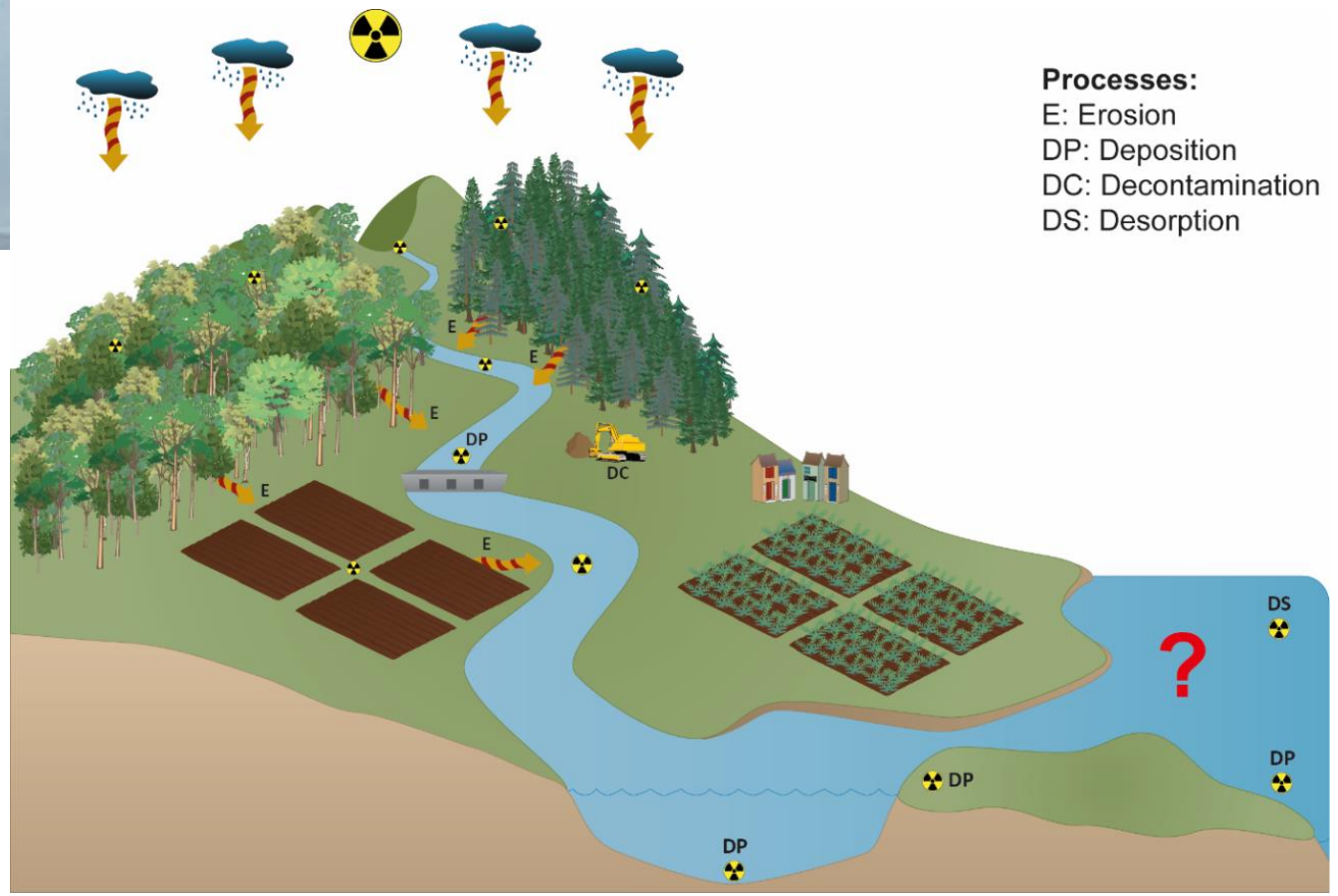


GEDI Team

Geochemistry of Impacts

Quantifying the post-accidental redistribution of ^{137}Cs in Fukushima coastal catchments

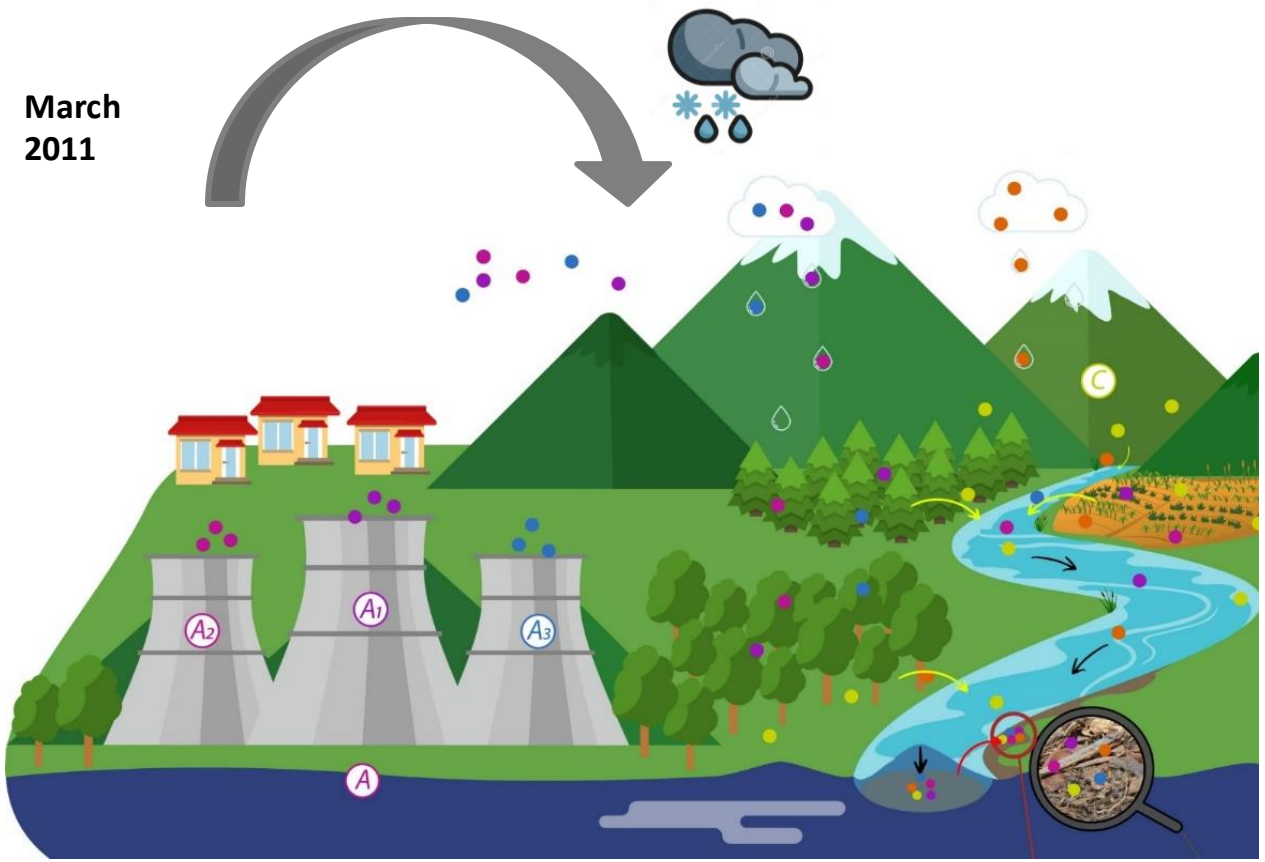
March 2011



Evrard et al. (2015)

Emissions of radionuclides following FDNPP accident

March 2011



Diacre et al. (2022)

^{133}**Xe** $T_{1/2}$= 5 days

^{131}**I** $T_{1/2}$= 8 days

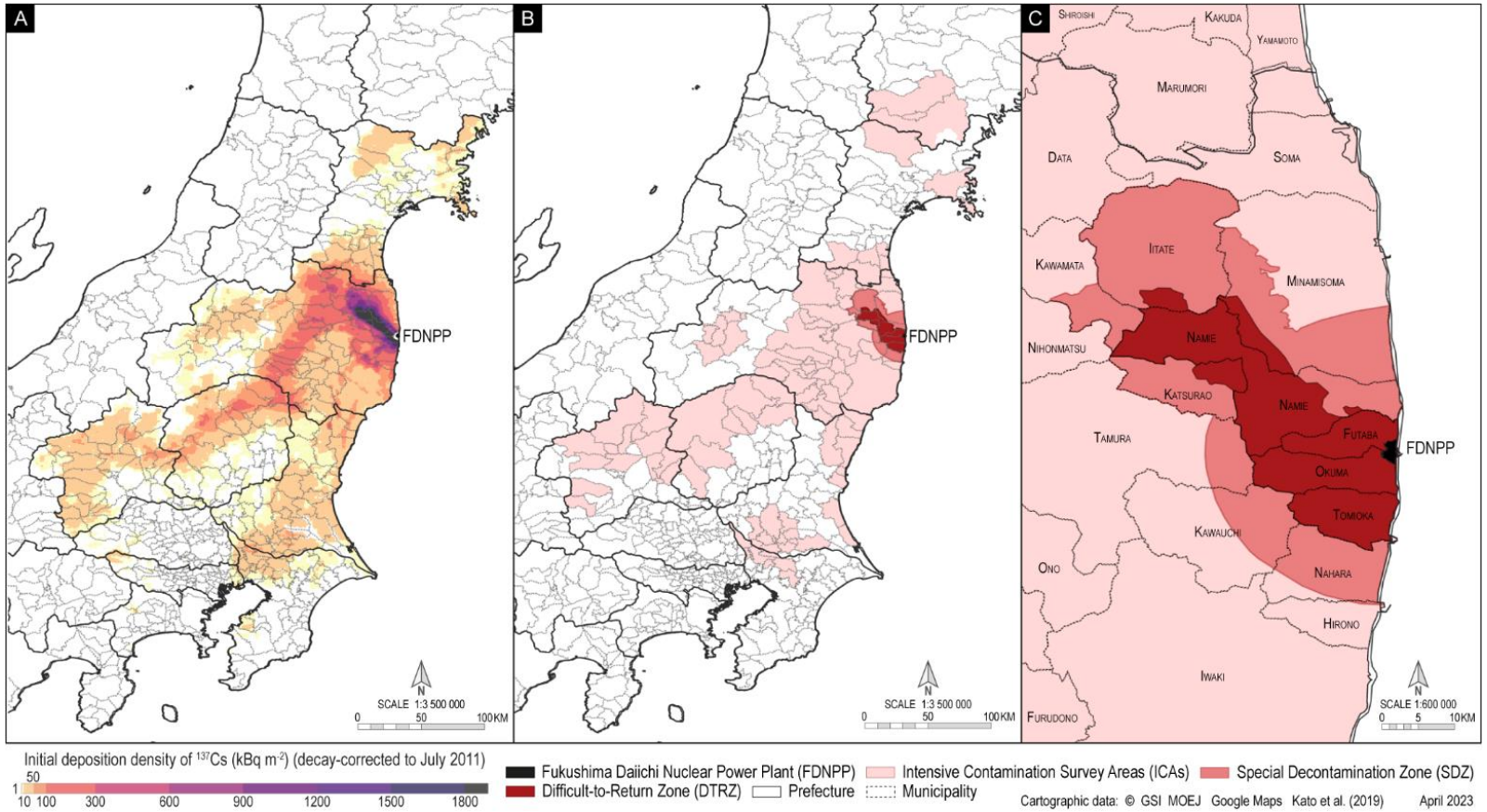
^{134}**Cs** $T_{1/2}$= 2 years

^{137}**Cs** $T_{1/2}$= 30 years

$^{239+240}$**Pu** 6500 ≤ $T_{1/2}$ ≤ 24,100 years

Steinhauser (2014)

Soil contamination following FDNPP accident in March 2021



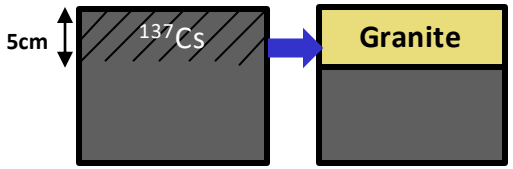
Evrard et al. (2023)

Intensive Contamination Survey Areas – ICAs – 7836 km²
(40 non-evacuated municipalities)

Special Decontamination Zone – SDZ – 1117 km²
(11 municipalities evacuated after the accident)

Difficult-To-Return Zone
– DTR – 337 km² (part or totality of 6 municipalities all evacuated after the accident)

How was soil decontamination conducted ?



Topsoil in which ^{137}Cs is concentrated is removed and replaced with **crushed granite/saprolite**

- Decrease of ^{137}Cs levels by ~80% on average;
- 9000 km² remediated (2013-2019), 20 millions m³ of waste, cost estimated to 3 trillion JPY

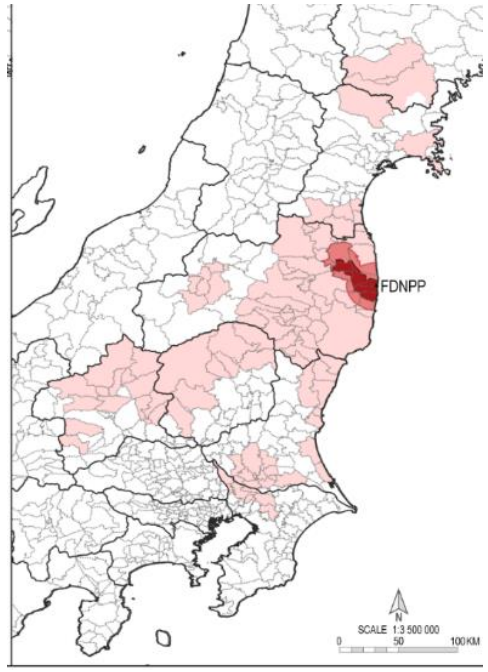
Evrard et al. (2019)

How much material was removed and at which cost?

Board of Audit of Japan
会計検査院

環境省
Ministry of the Environment

Report as of February 2023

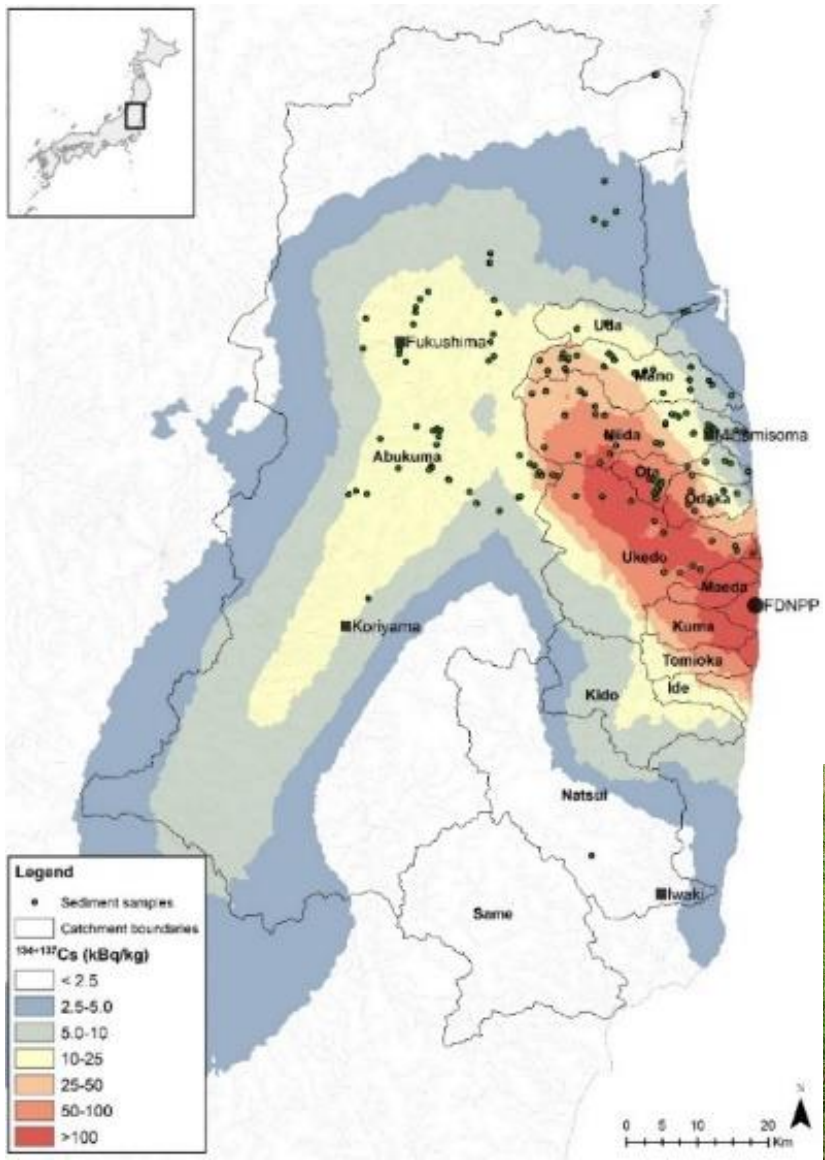


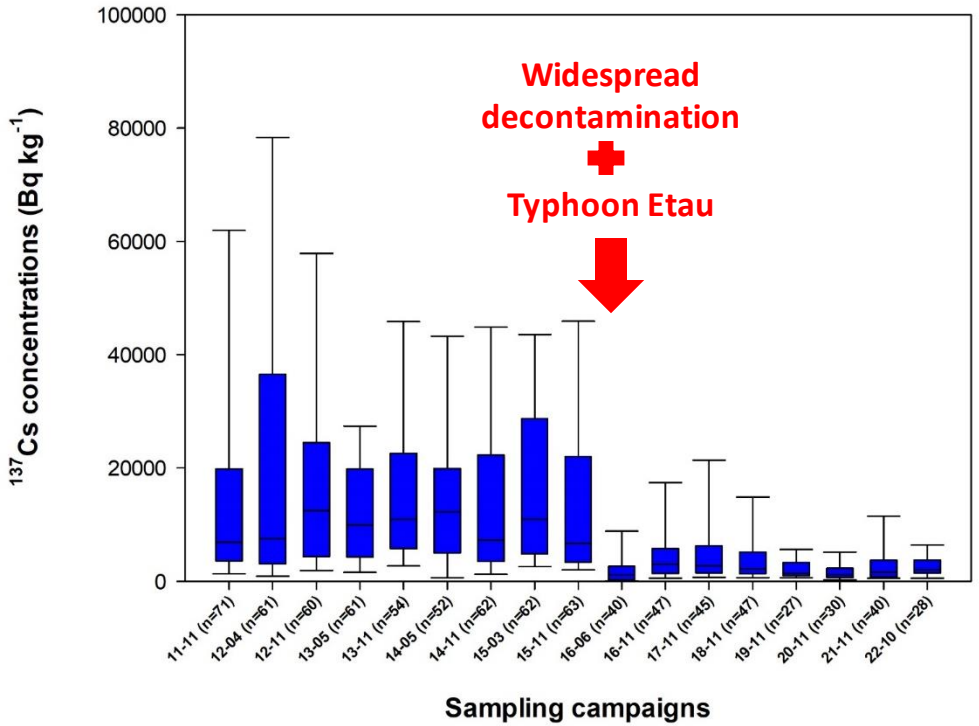
13.4 million m^3 transported to interim facilities
1.4 million ton of incinerated waste

6122 billion YEN/44 billion EURO spent for the '*nuclear recovery policy*' including decontamination (2011-2020)

29.9% of the 147,443 inhabitants returned by 2020

Evolution of river contamination across Fukushima Prefecture

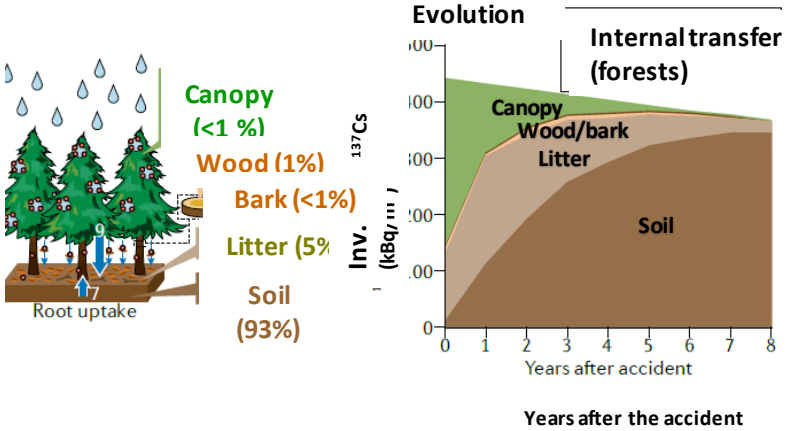




Adapted from
Evrard et al. (2021)

Radionuclide cycling in forests

70-80% of the surface area contaminated in Fukushima under forest (~1 million ha).



After Onda et al., Nature Reviews (2020)

Erosion / source of contamination?

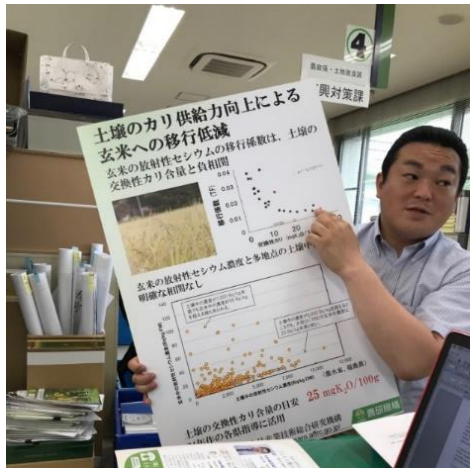
Despite low transfer factors, activities too high in wood.

Debarking is suggested to produce cedar wood shingles

After Hashimoto et al. (2022)

Recultivation of cropland

Ploughing for diluting the residual contamination with ‘fresh’ soil



Potassium (K) fertilization to limit transfer to plants

Transfer of ^{137}Cs with irrigation water

Avoiding food crops

After collaborations with A. Nakao (KPU) and T. Shinano (Hokkaido Univ.)

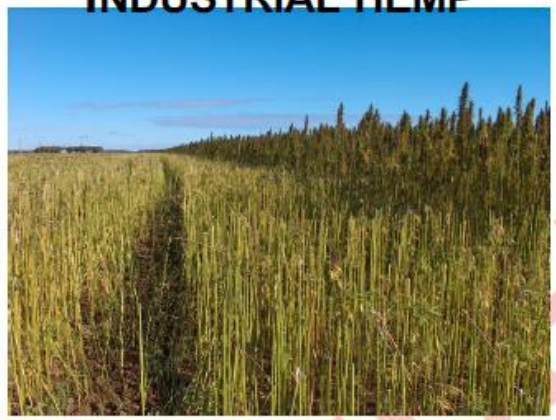
Rationale for the project

- The Demeterres - Agro project aims to revitalise the contaminated areas of the Fukushima region by creating agro-industrial activities based on "**safe use**" technologies that **exclude caesium** from the biomass produced and exploited. The types of crops targeted are not food crops and allow for significant value creation thanks to the existing high-tech outlets for the biomass produced.

PARTNERSHIPS: CANDIDATE FIELD CROP SPECIES FOR SAFE-USE:

FIBRE FLAX

INDUSTRIAL HEMP



MISCANTHUS GIGANTEUS

Bioplastic

Bioenergy

Partnership

- Complementarity of approaches

HOKKAIDO UNIVERSITY

Kyoto Prefectural University KPU founded 1895

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cea cnrs UNIVERSITÉ DE VERSAILLES ST-QUENTIN-EN-YVELINES université PARIS-SACLAY

National Institute for Environmental Studies

Fukushima University

Géosciences pour une Terre durable
brgm

Funding

INVESTIR L'AVENIR

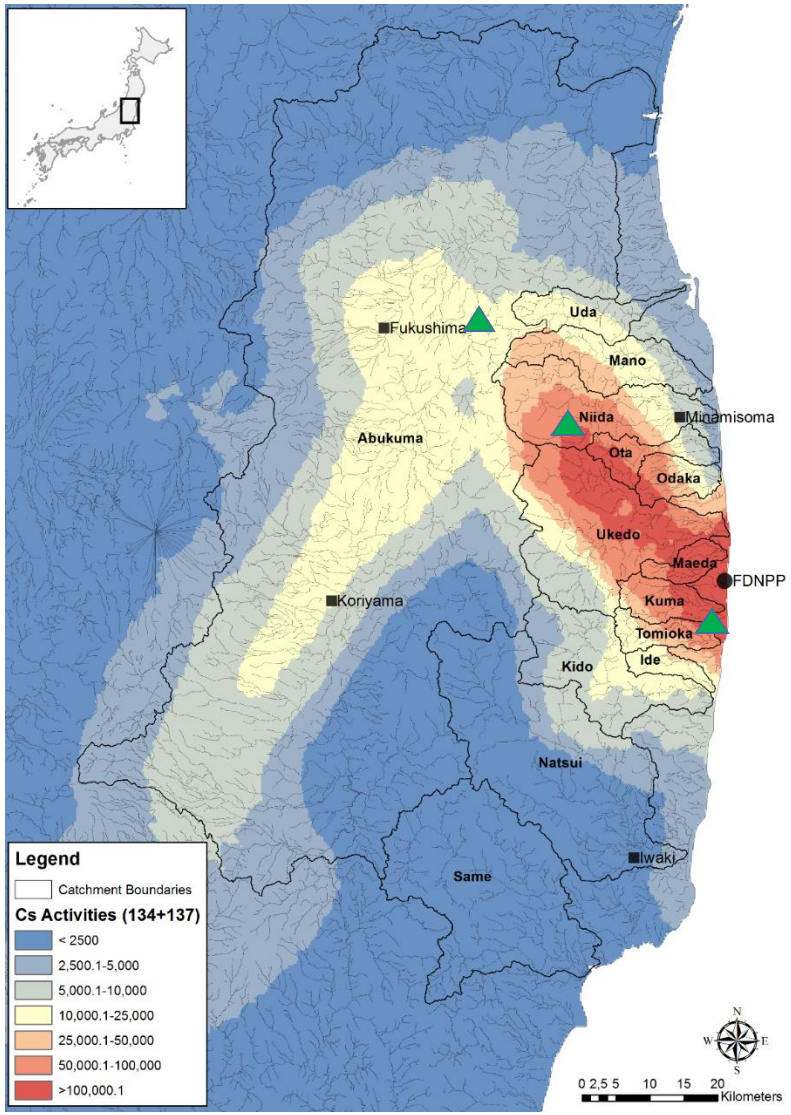
bpifrance

METI
Ministry of Economy, Trade and Industry

anr agence nationale de la recherche

F-REI
Fukushima Institute for Research, Education and Innovation
福島国際研究教育機構

Field sites of interest

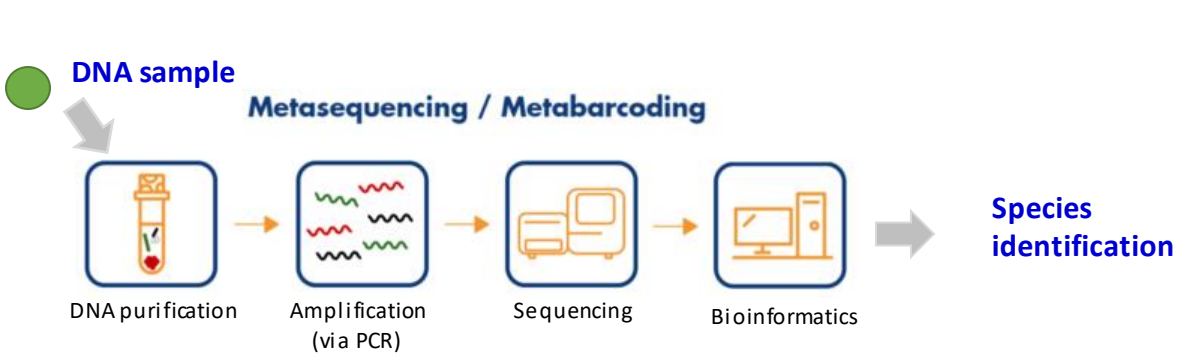


- Test-site (*Date*)
- Decontaminated site with soils enriched in K (*Iitate*)
- Non-decontaminated site with soils depleted in K (*Tomioka*)

- The municipality of *Futaba* may also be interested

Developing environmental DNA (eDNA) techniques

DNA metabarcoding to detect different communities of taxa
(Plants/Fungi/Metazoa/Eukaryotes/Vertebrates)



e-biom
YOUR PARTNER IN BIOLOGICAL MONITORING

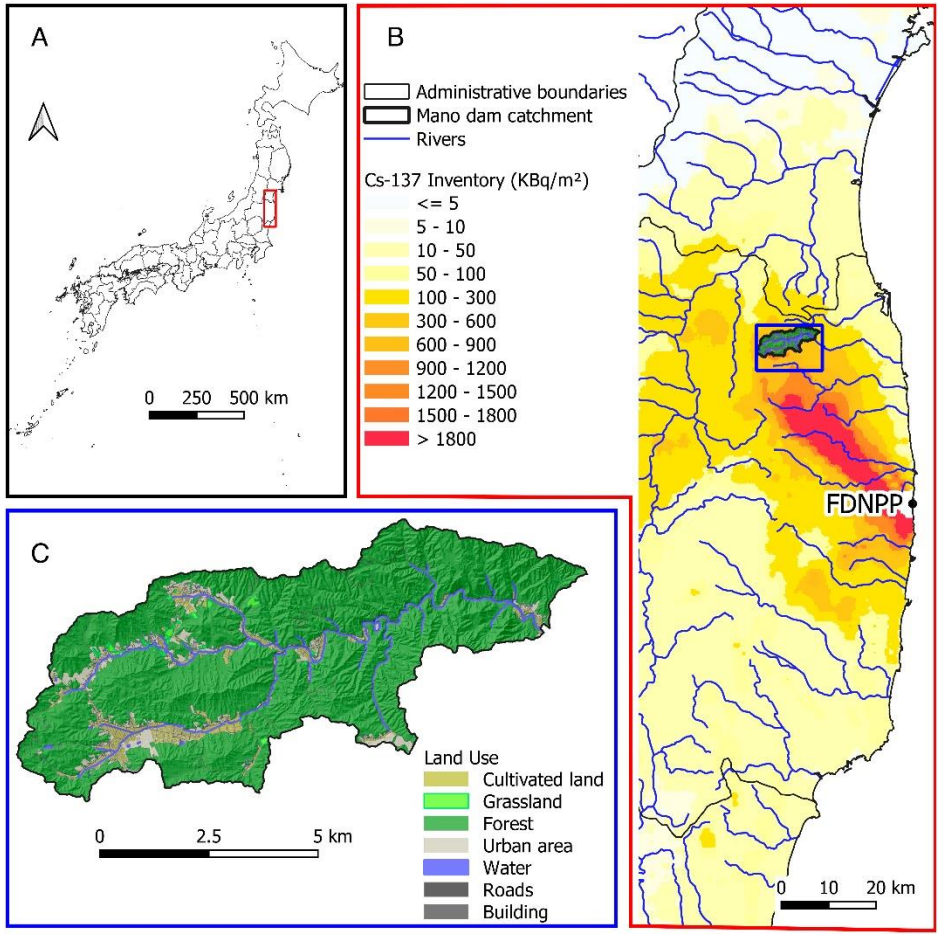
eDNA in soil

eDNA in lake water

eDNA in sediment

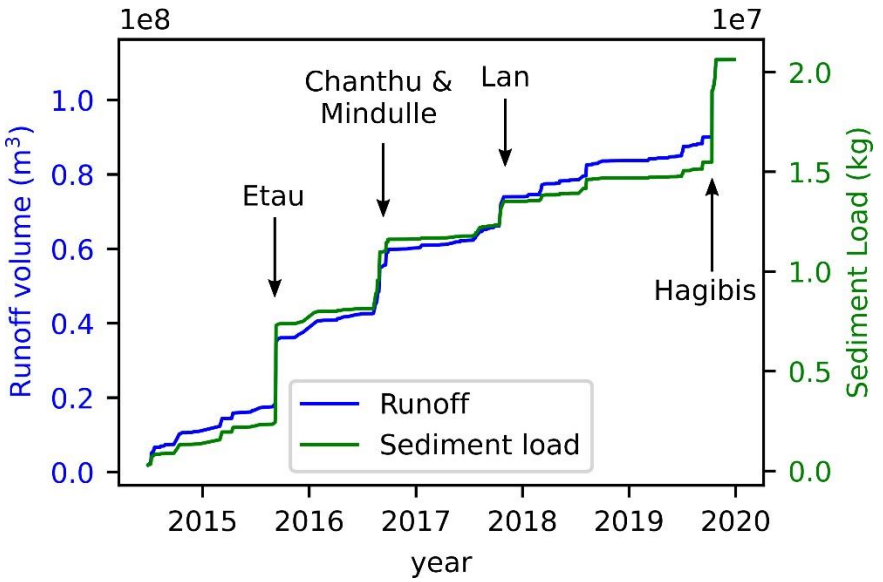
Investigating the redistribution of sediment contaminated with ^{137}Cs

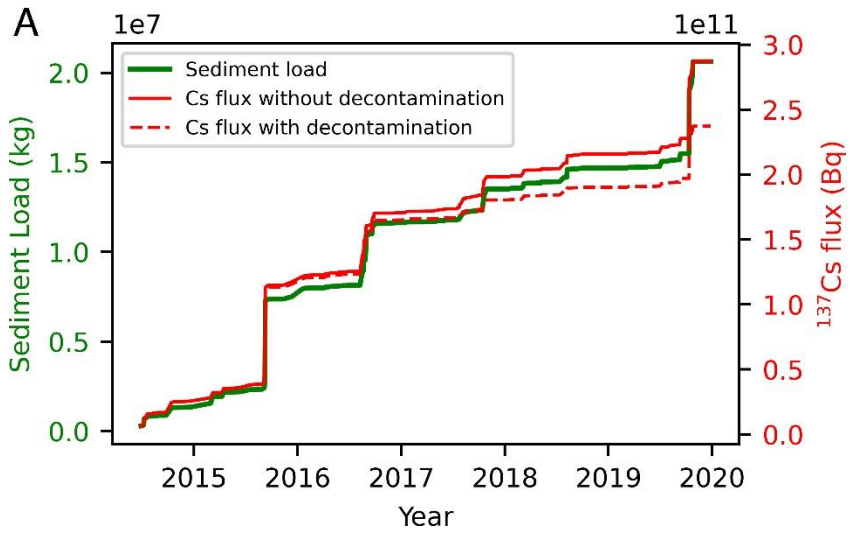
Investigation of erosion/sedimentation processes in Mano Dam and its drainage area to understand and reconstruct the impact of decontamination

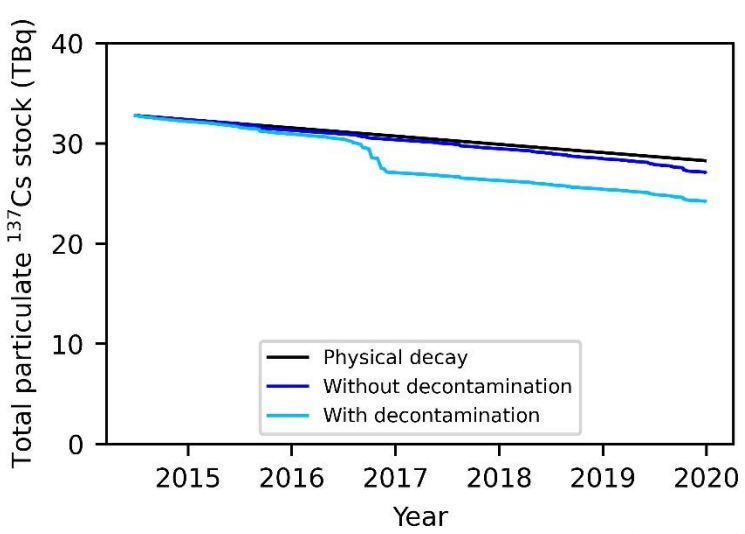


Vandromme et al. (2023)

Modelling the impact of decontamination







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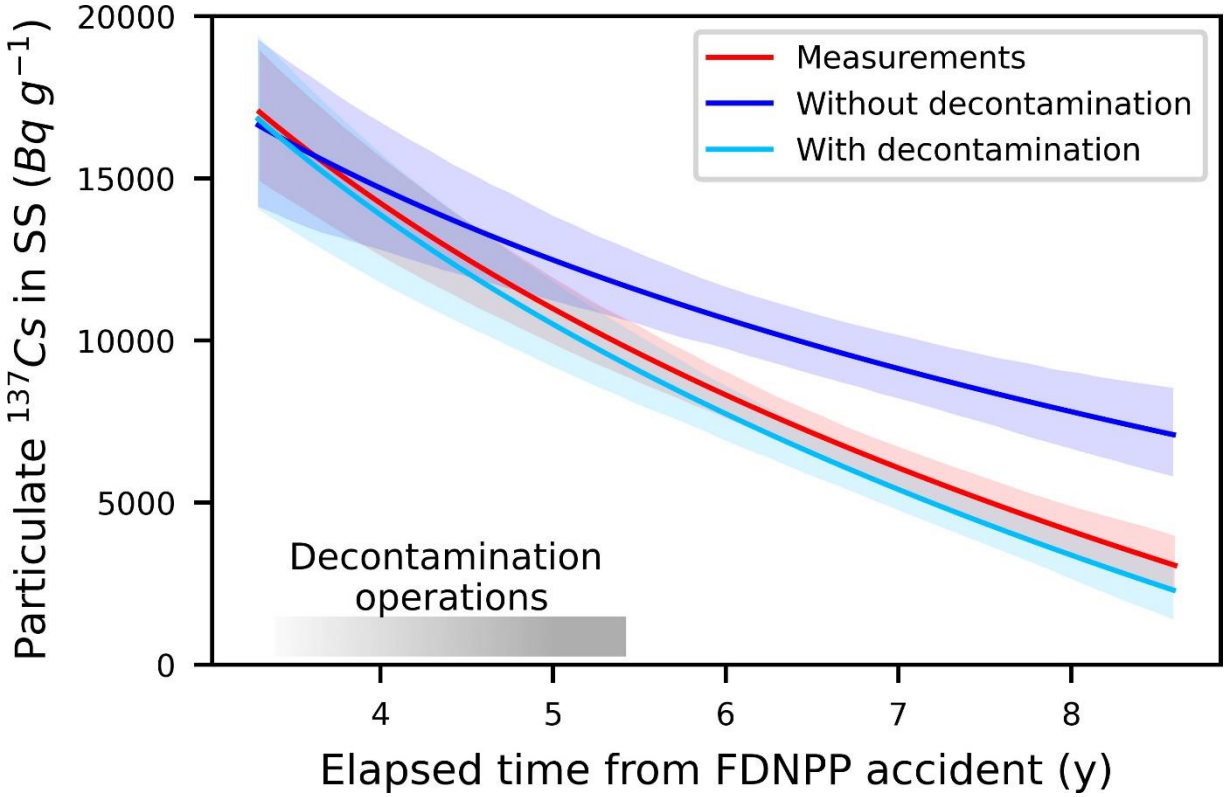

OPEN ACCESS

Vandromme et al. (2023)

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Japan Society for the Promotion of Science

CNRS international cooperation tools

International Emerging Actions (IEA)	International Research Networks (IRN)	International Research Projects (IRP)	International Research Laboratories (IRL)
Bottom-up exploration tool	Strengthening a collaboration		Enlightening emblematic actions decided at a strategic level with a strong local presence
Building a capacity to develop our strategic orientations	Simplifying international agreement processes		

Nathalie Prat-Leonhardt

SOIL, 9, 479–497, 2023
https://doi.org/10.5194/soil-9-479-2023

OPEN ACCESS

Research and management challenges following soil and landscape decontamination at the onset of the reopening of the Difficult-to-Return Zone, Fukushima (Japan)

Olivier Evrard[1], Thomas Chalaux-Clergue[1], Pierre-Alexis Chaboche[2,3], Yoshifumi Wakiyama[3], and Yves Thiry[4]

Many thanks for your attention!
ありがとうございます

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Changes in radiocesium contamination with time in Mano Dam

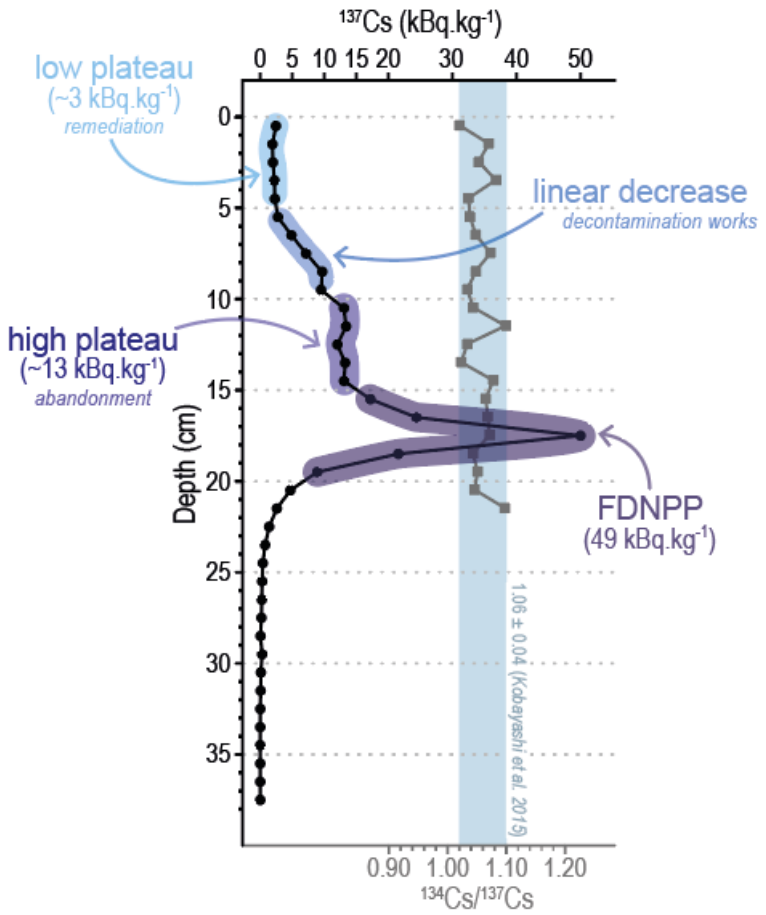
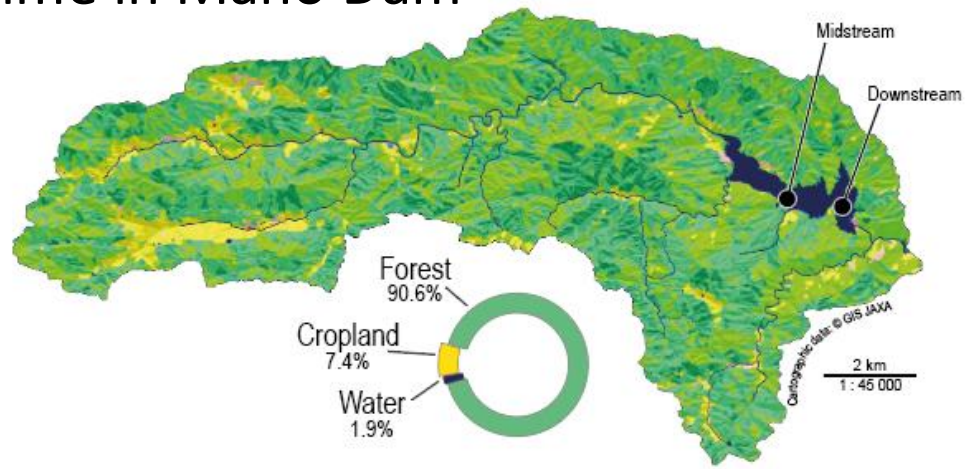


Fig.8. ^{137}Cs activity (08/2021) and ^{134}Cs/^{137}Cs ratio (decay-corrected to March 11th 2011) along Hayama lake downstream core.

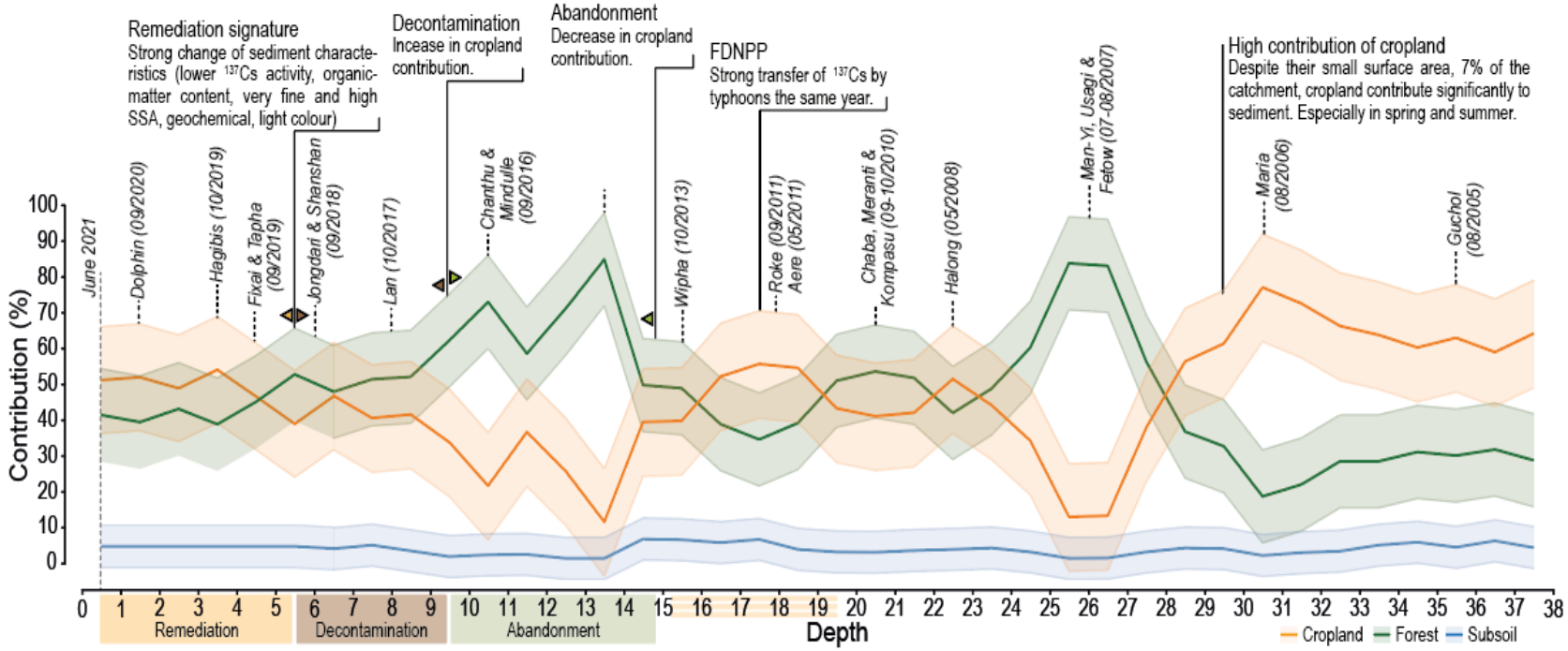
Thomas Chalaux
(PhD student)
[Oct. 2021 – Sept. 2024]



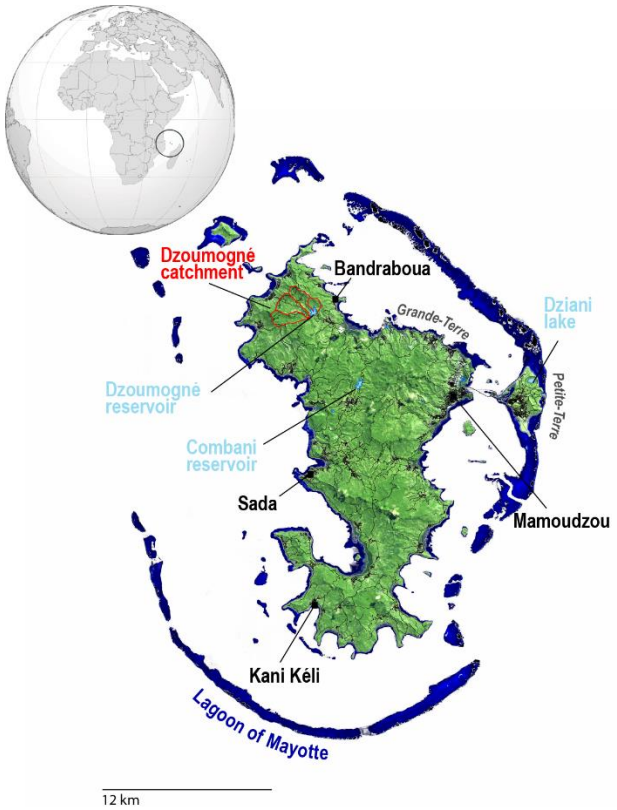
Land uses

Fig.2. Main land uses in the Hayama lake catchment over the 2014-2016 period.

Changes in sediment sources with time



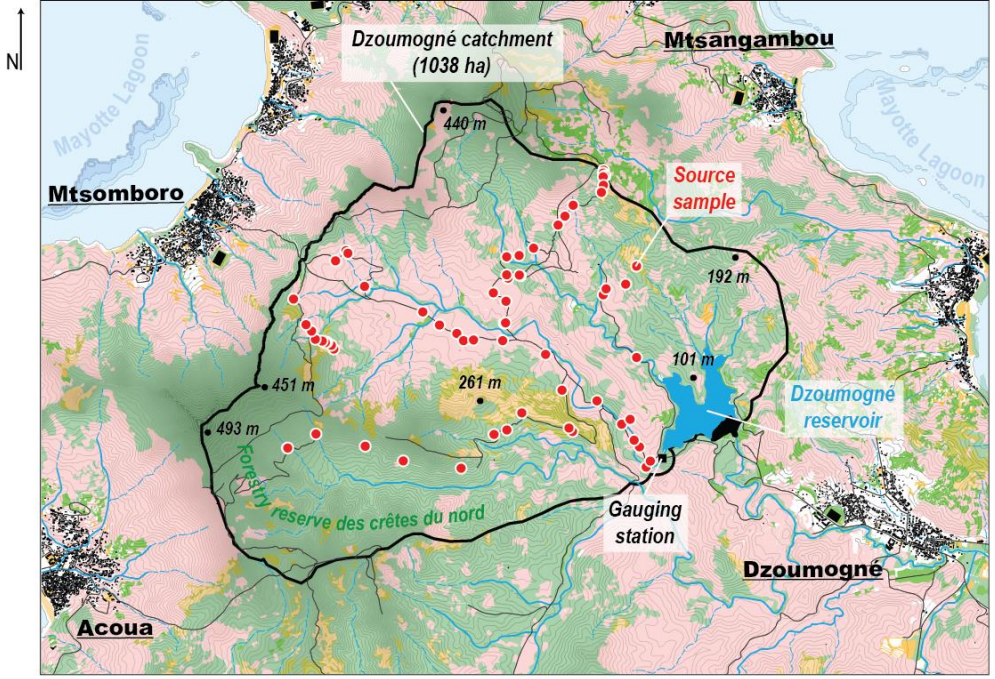
Very rapid degradation of land/water resources of Mayotte Island (French Island, Indian Ocean)

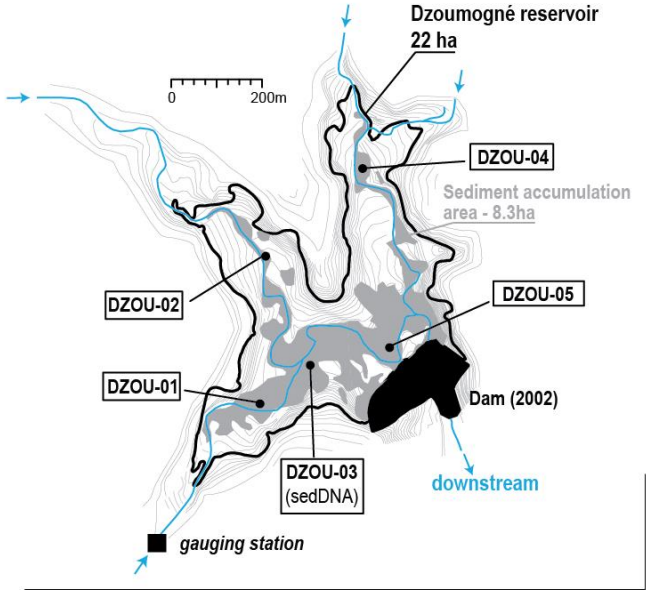


Only island of the Comoros Archipelago that voted to remain French in the 1970s.

Became a *French Oversea Department* in 2011.

Investigating erosion in the drainage area of one of the two reservoirs available on the island





Drinking water is mainly supplied by two hillslide reservoirs that are affected by increasing siltation.

Sediment cores/lake surveys were conducted in 2021.

Impact of deforestation on land and water degradation ?

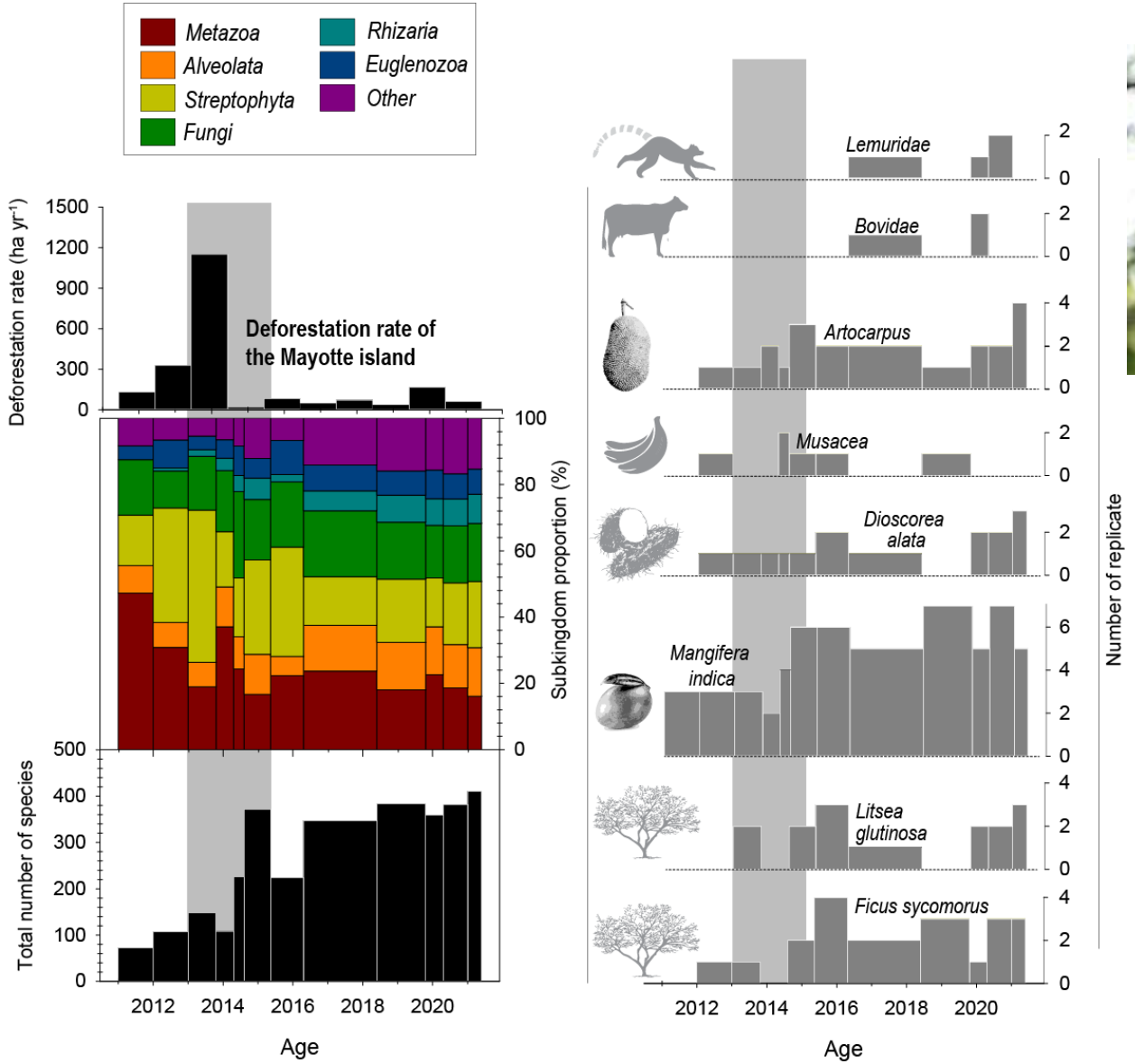
(Dynamics and sources of soil erosion)

Consequences of land use changes on biodiversity ?

Source: LESELAM

Source: Banque d'images de Mayotte

Consequences of deforestation and erosion on biodiversity



Uncontrolled deforestation and population growth threaten a tropical island's water, land and biodiversity resources in only 10 years