Quantifying Dose from External Irradiation--

Tools for Use on Free-Ranging Wildlife

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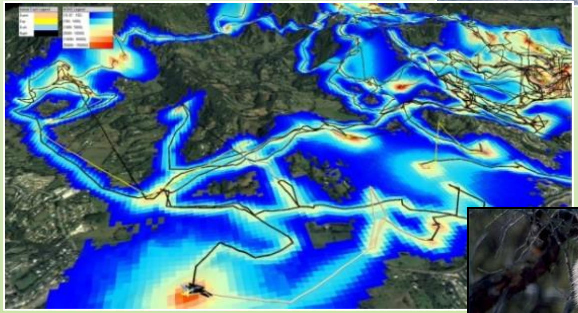

OUTLINE of TALK

- Need for improved radiation dosimetry with wildlife
- Passive dosimeters (TLD, OSL)
- New tool: GPS-electronic dosimeter
- Electronic Spin Resonance of teeth for life time dose estimates
- Molecular methods (frequency of dicentrics)
- Dose – Effects and challenges in determining environmental risks from radiation exposures

Animals can receive a radiation dose from:

(1) ingesting contaminated food or water,

(2) inhaling radioactive material, or

(3) external irradiation

Accurate quantification of dose is among the greatest challenges in field research of free-ranging animals

Dose is the measurement most lacking in many of the controversial papers regarding radiation effects to wildlife at Chernobyl and Fukushima

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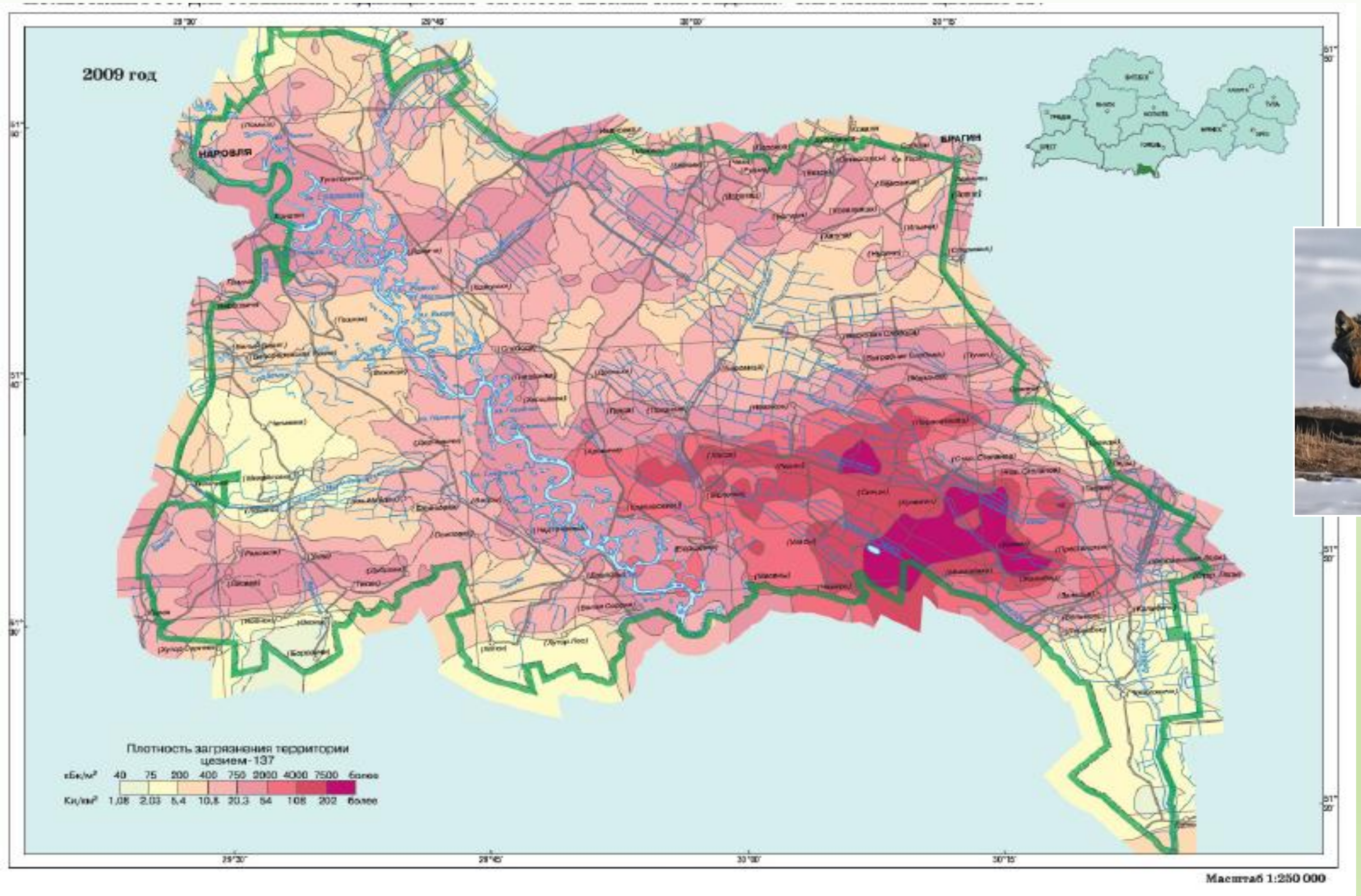
Current models do not assess external dose realistically because they do not consider an animal’s spatial and temporal use of habitats, or the habitat’s large heterogeneity in levels of radioactive contamination

Polessye State Radiation Ecological Reserve, BELARUS

2160 km ^{2}



Home range
~ 100 km ^{2}

Determining external dose is particularly challenging because radiation deposition is not uniform among the many, many different habitats available to animals….

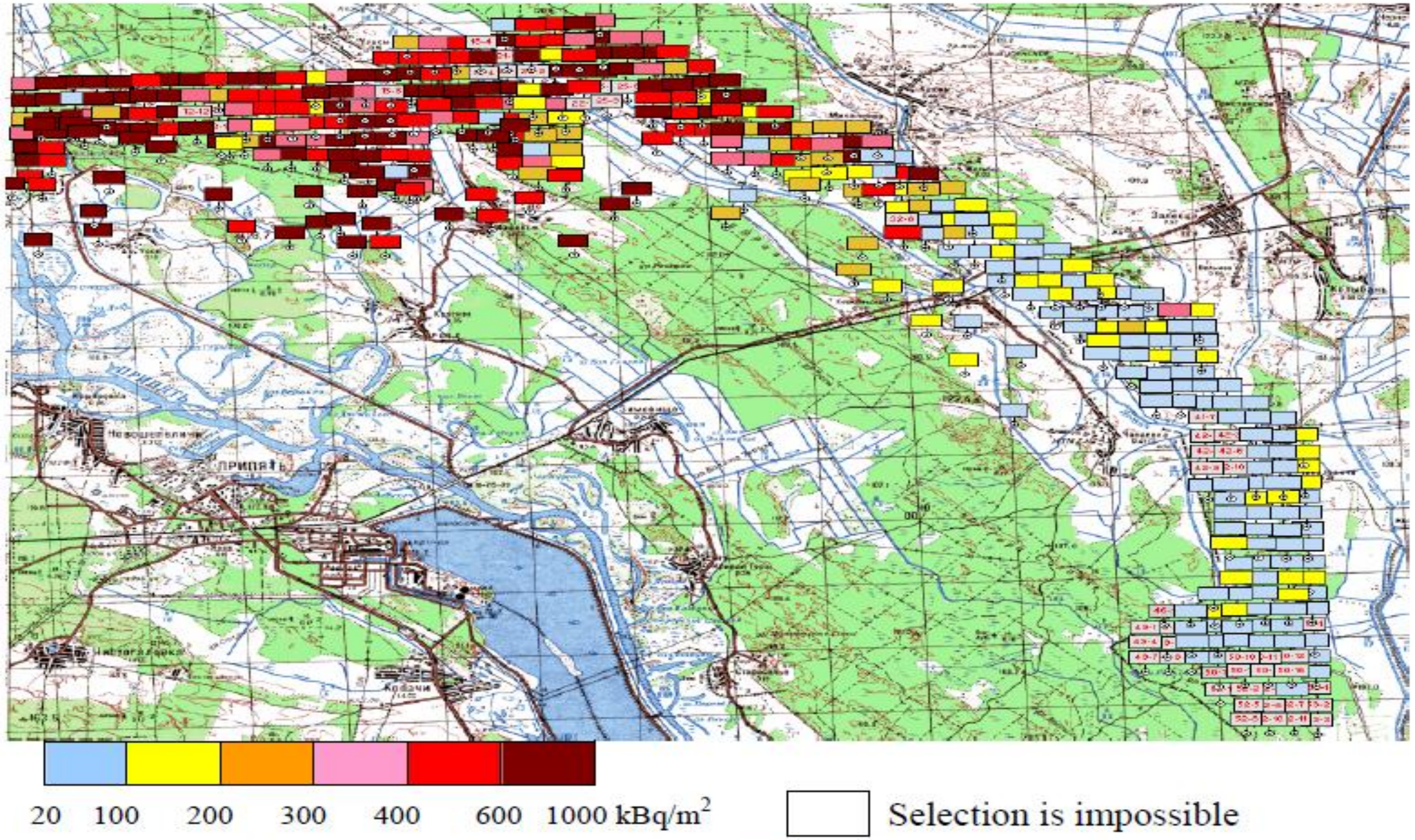
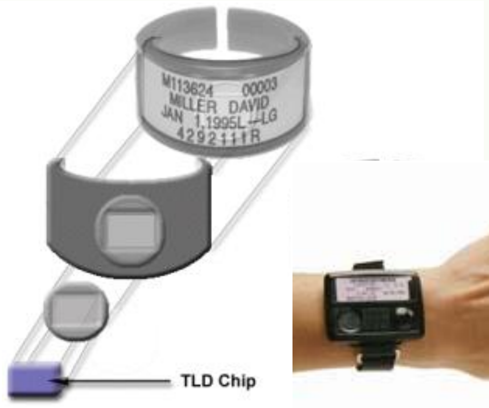


Figure 1.4 - Density of soil pollution ^{90}Sr on a site № 1



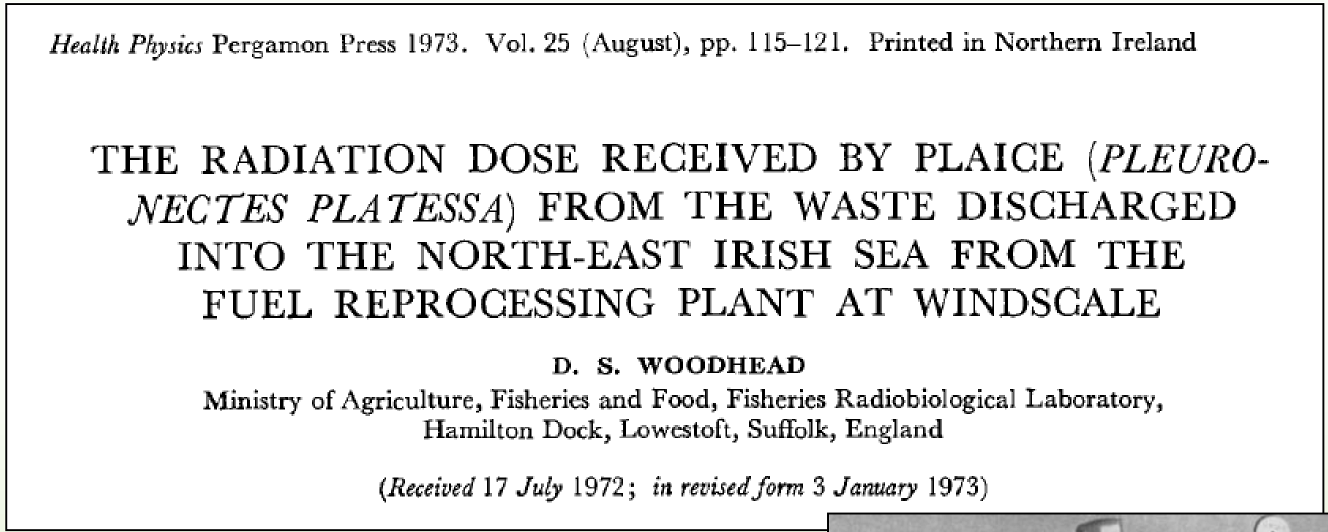
Thermoluminescent Dosimeters (TLDs)…

- Integrate dose over the entire time that they are on the animal

- Recapture of the animal and laboratory analyses of TLD is required

3580 fish captured, tagged and released;

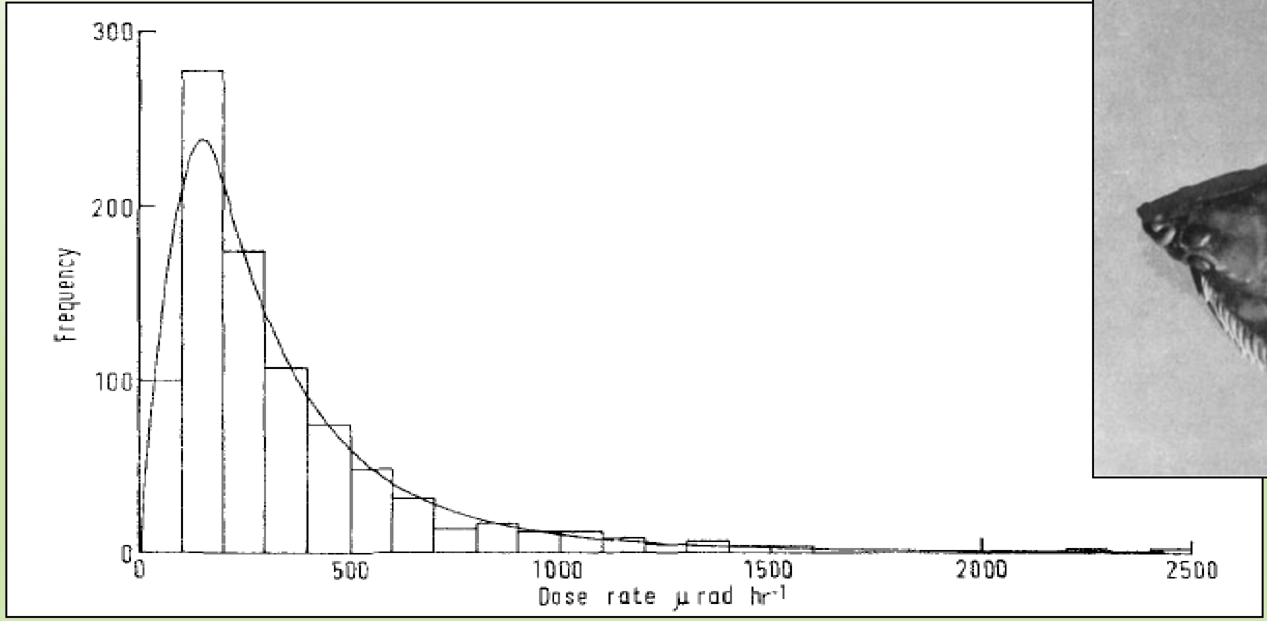
29% recaptured

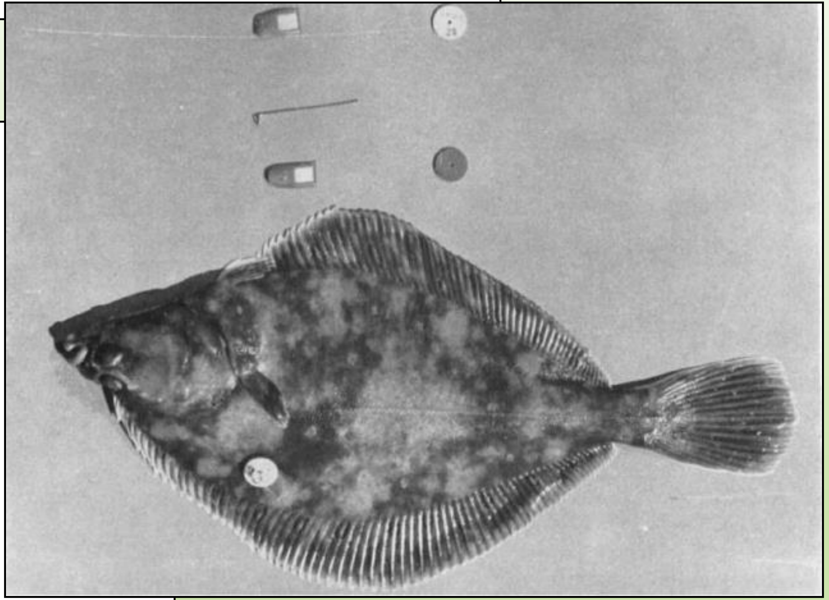

Health Physics Pergamon Press 1973. Vol. 25 (August), pp. 115–121. Printed in Northern Ireland

THE RADIATION DOSE RECEIVED BY PLAICE (*PLEURONECTES PLATESSA*) FROM THE WASTE DISCHARGED INTO THE NORTH-EAST IRISH SEA FROM THE FUEL REPROCESSING PLANT AT WINDSCALE

D. S. WOODHEAD
Ministry of Agriculture, Fisheries and Food, Fisheries Radiobiological Laboratory, Hamilton Dock, Lowestoft, Suffolk, England

(*Received* 17 *July* 1972; *in revised form* 3 *January* 1973)





Woodhead, 1973

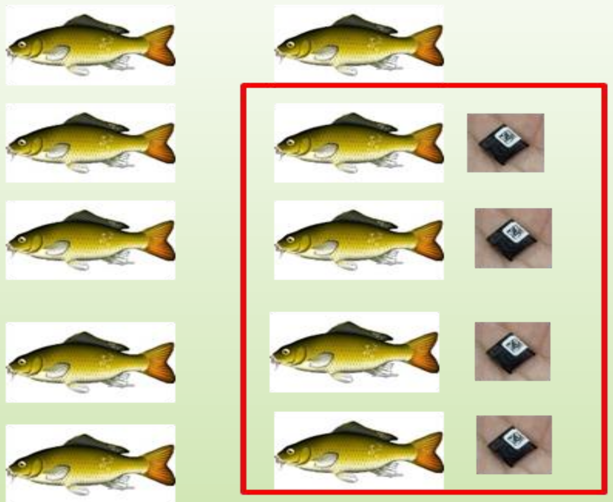
【研究の準備状況】

各種の被ばく線量評価に関する
基本的な手法は確立済み！

魚類の研究状況

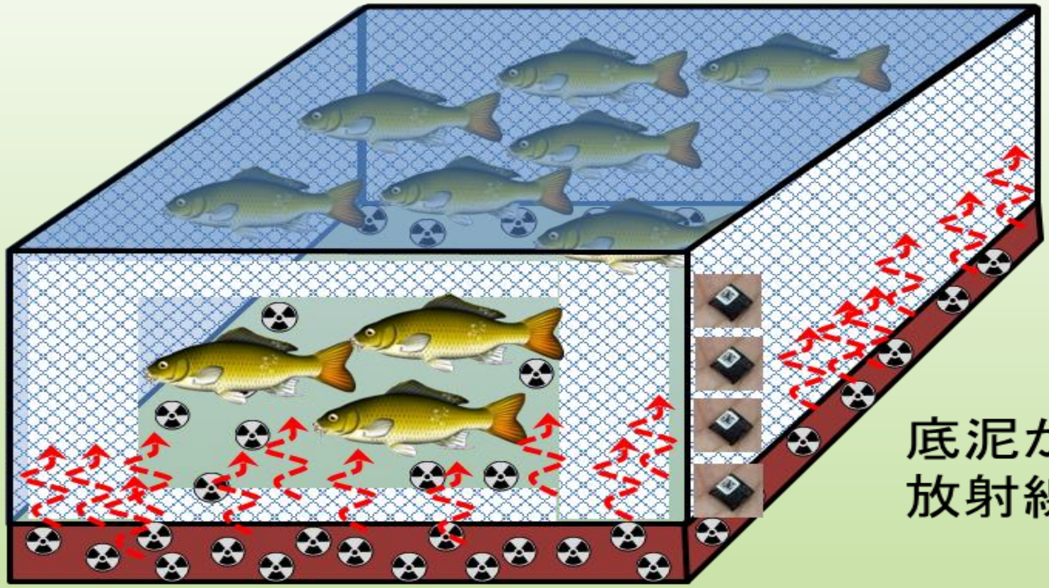
- 小型線量計を装着したコイのケージ試験により、被ばく線量を推定

非汚染の養殖コイに小型線量計を装着



ナノドット
小型線量計

ケージ (100 × 100 × 50 cm)

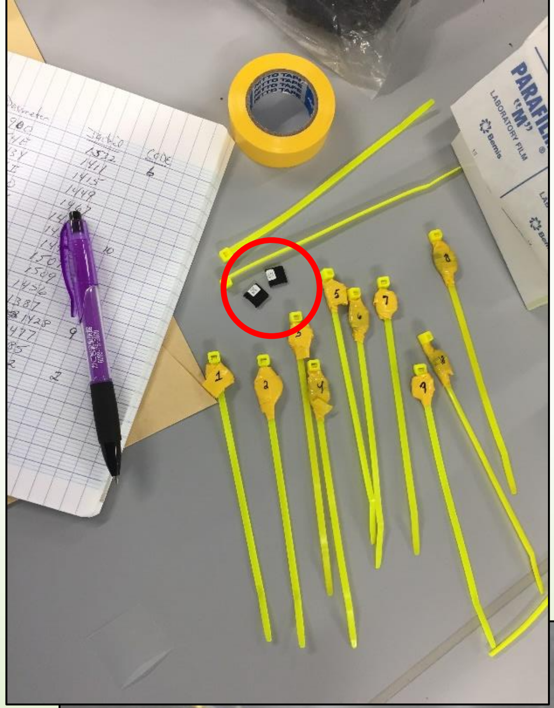


底泥からの
放射線（γ線）

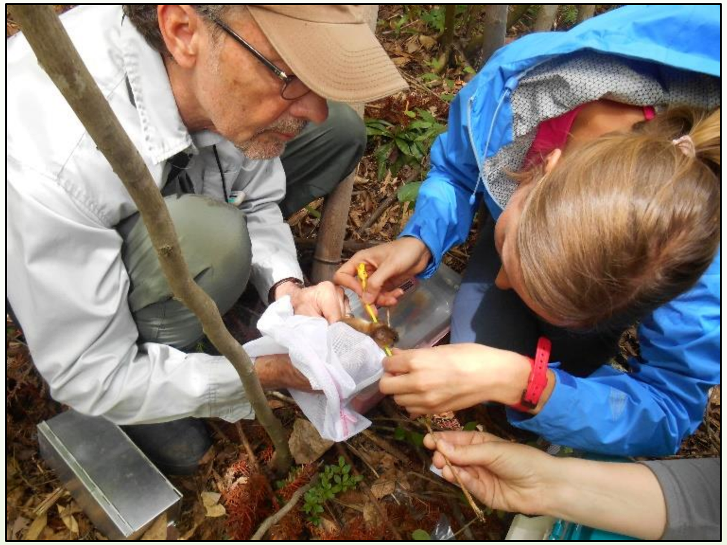
ケージ試験のイメージ図

- 大熊町の貯水池で行ったケージ試験により、コイの被ばく線量は、主に底土からの外部被ばくの影響を受け、7.3μGy/時 と推定

T. WADA



OKUMA TOWN----
Large Japanese Field Mice
(*Apodemus specious*)



- Age of mouse estimated from tooth characteristics
- Internal dose estimated from Cs-134 and Cs-137 concentrations in tissues
- External dose estimated from OSL nanoDot dosimeter

Lifetime dose ranged from 52 to 340 mGy;

External doses 5 to 95 times > than Internal.

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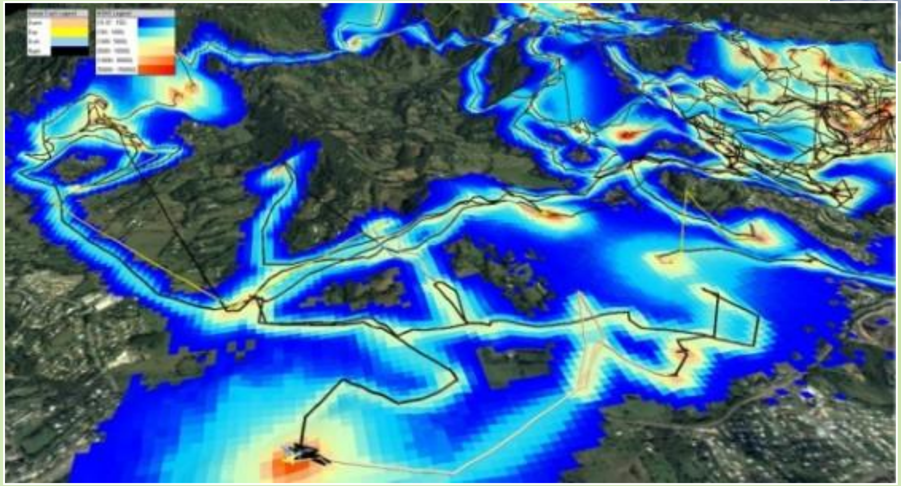
With Vectronic Aerospace and Mirion, we produced a new scientific tool that permits an animal's location and short-term integrated dose to be periodically sent, via satellite, to the investigator



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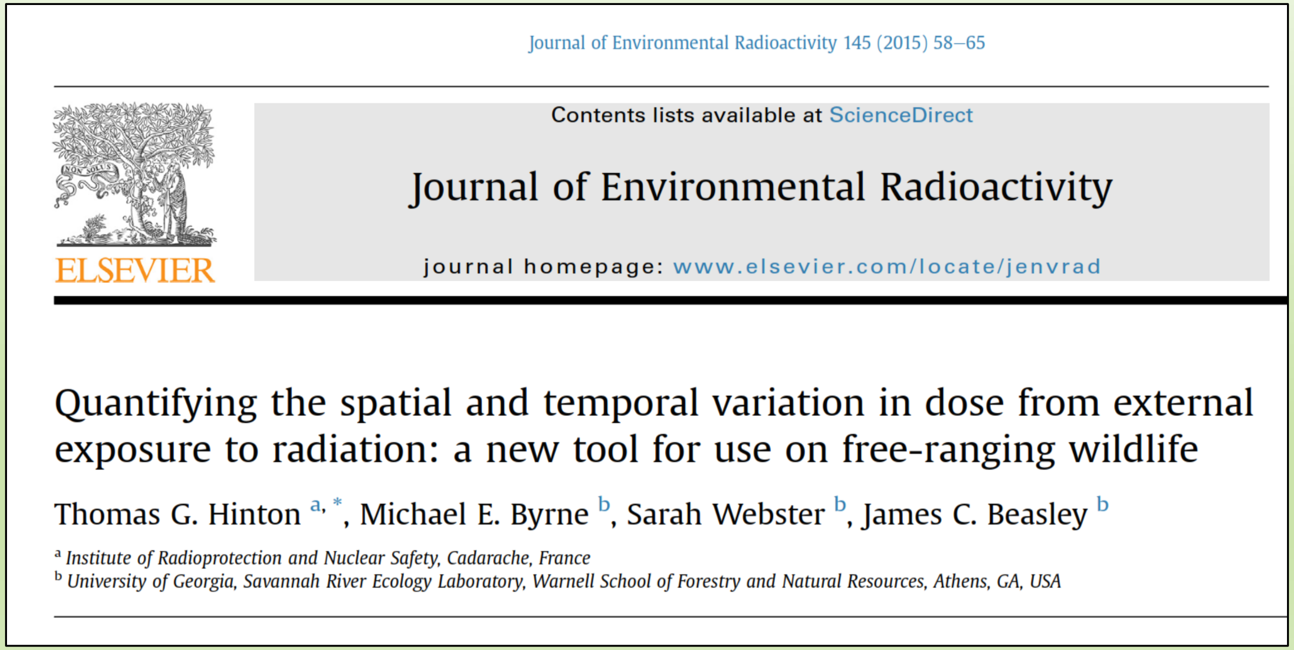
We merged two existing technologies (Wildlife Tracking Collars that use GPS) and Electronic Dosimeters (designed for determining dose to humans)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ELSEVIER

Quantifying the spatial and temporal variation in dose from external exposure to radiation: a new tool for use on free-ranging wildlife

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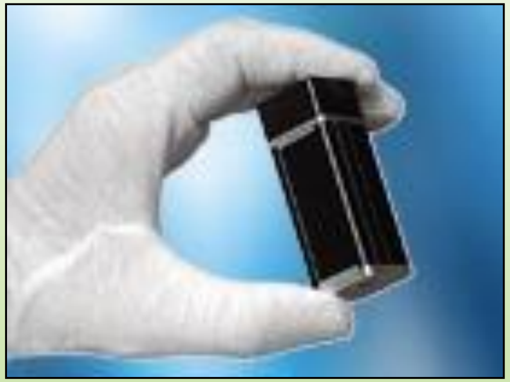
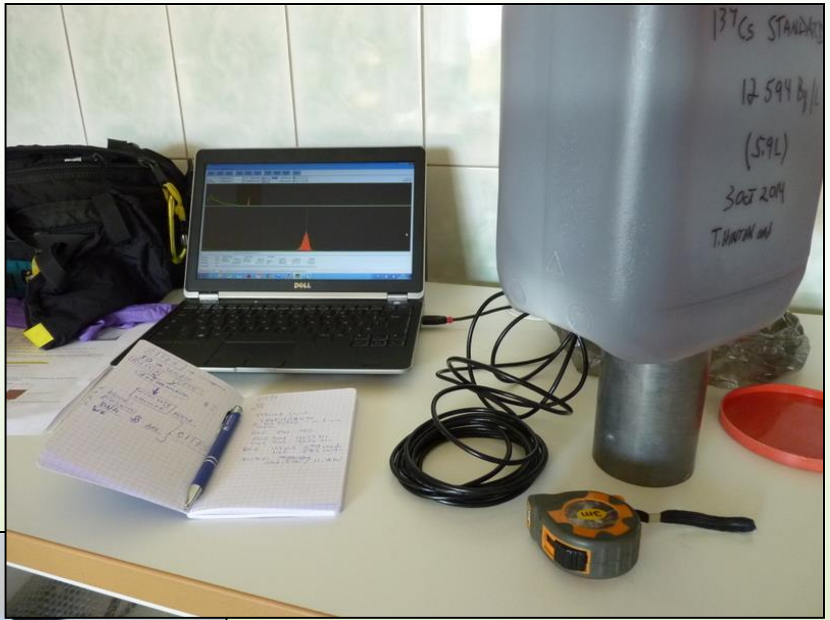
[a] Institute of Radioprotection and Nuclear Safety, Cadarache, France
[b] University of Georgia, Savannah River Ecology Laboratory, Warnell School of Forestry and Natural Resources, Athens, GA, USA

Hinton, et al. (2015) JER 145:58-65

Developed a whole-body, field assay method to determine gamma emitting radionuclides internal to live animals

CZT spectroscopy Cd, Zn and Te composition





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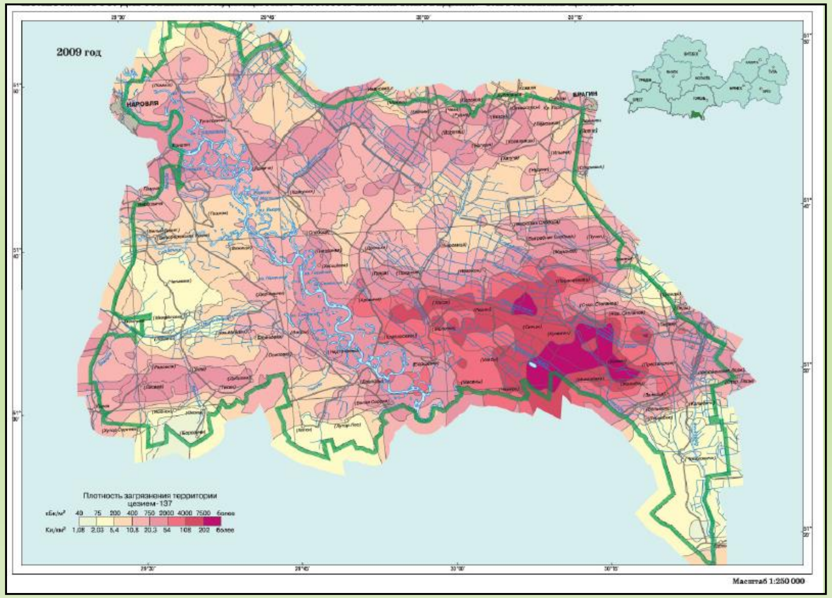
Field tested the GPS-dosimeter and whole body assay methods at Chernobyl



Chernobyl Wolves

Collaboration with Dr. Jim Beasley

The University of Georgia
Savannah River Ecology Laboratory

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Obtained a GPS location and dose every 35 minutes

Chernobyl Wolves

Collaboration with
Dr. Jim Beasley

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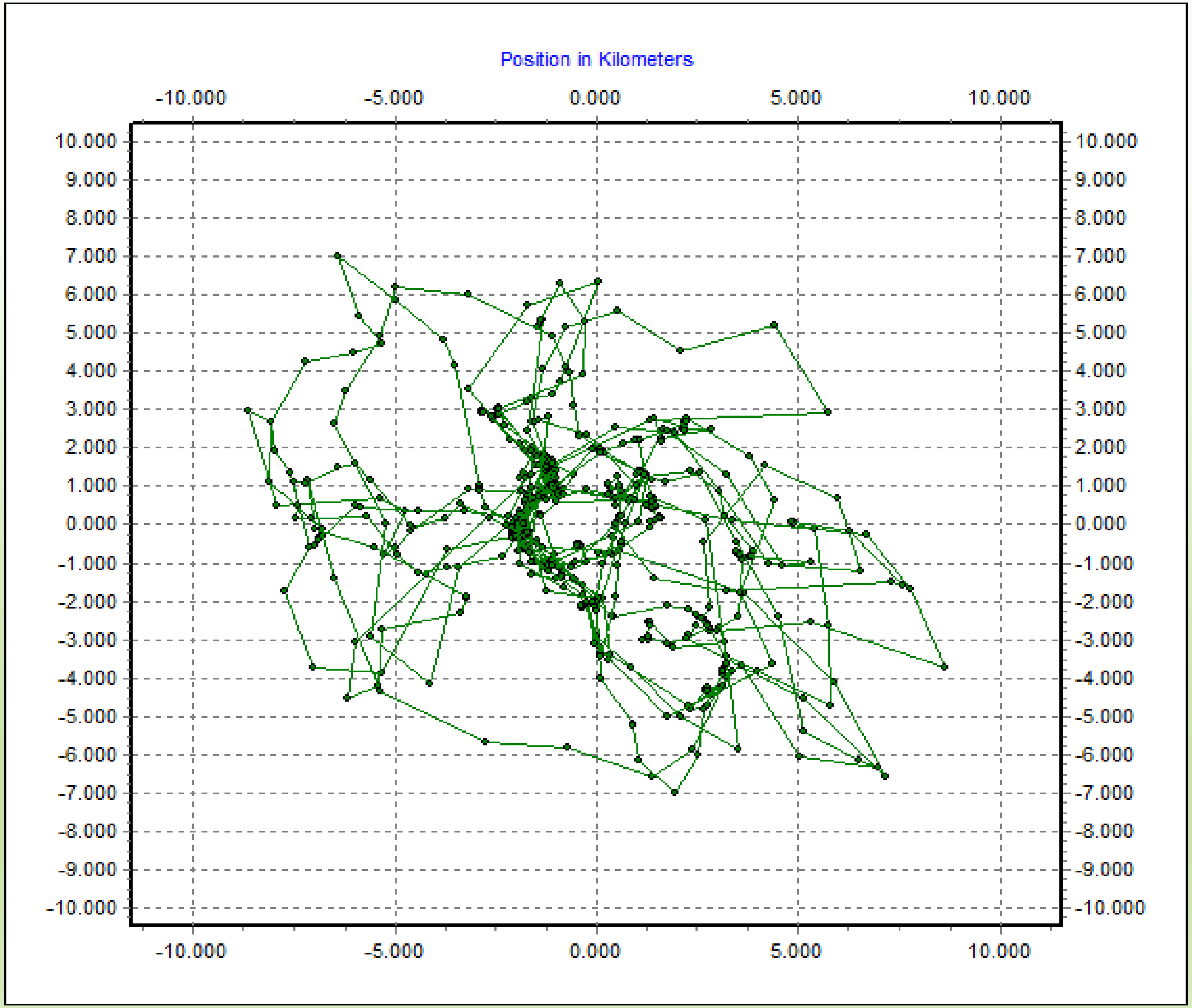
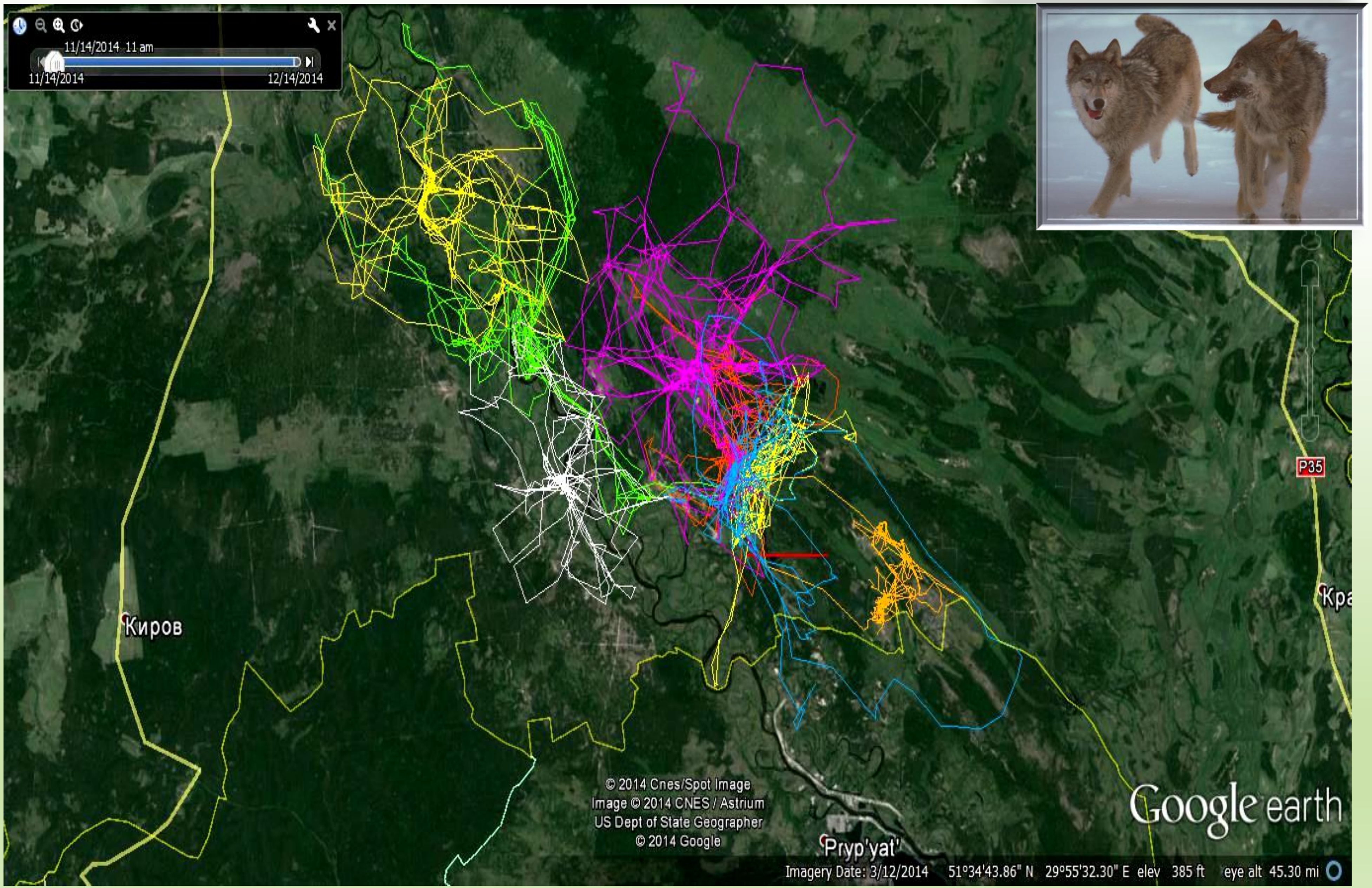


GPS track of a Chernobyl wolf over 400 km^2 area

GPS tracks of 8 Chernobyl Wolves



Collaboration with Dr. Jim Beasley

The University of Georgia
Savannah River Ecology Laboratory

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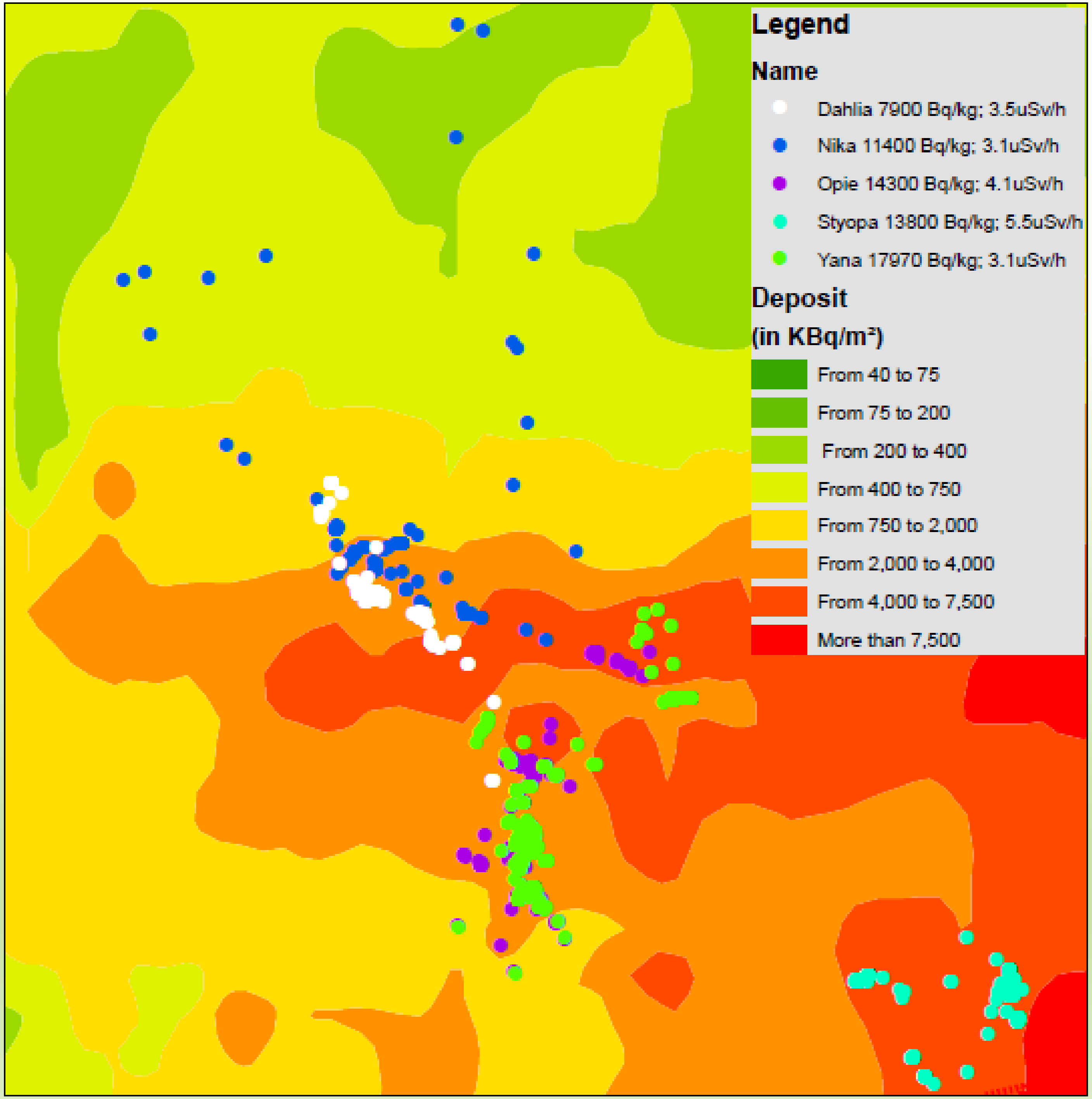
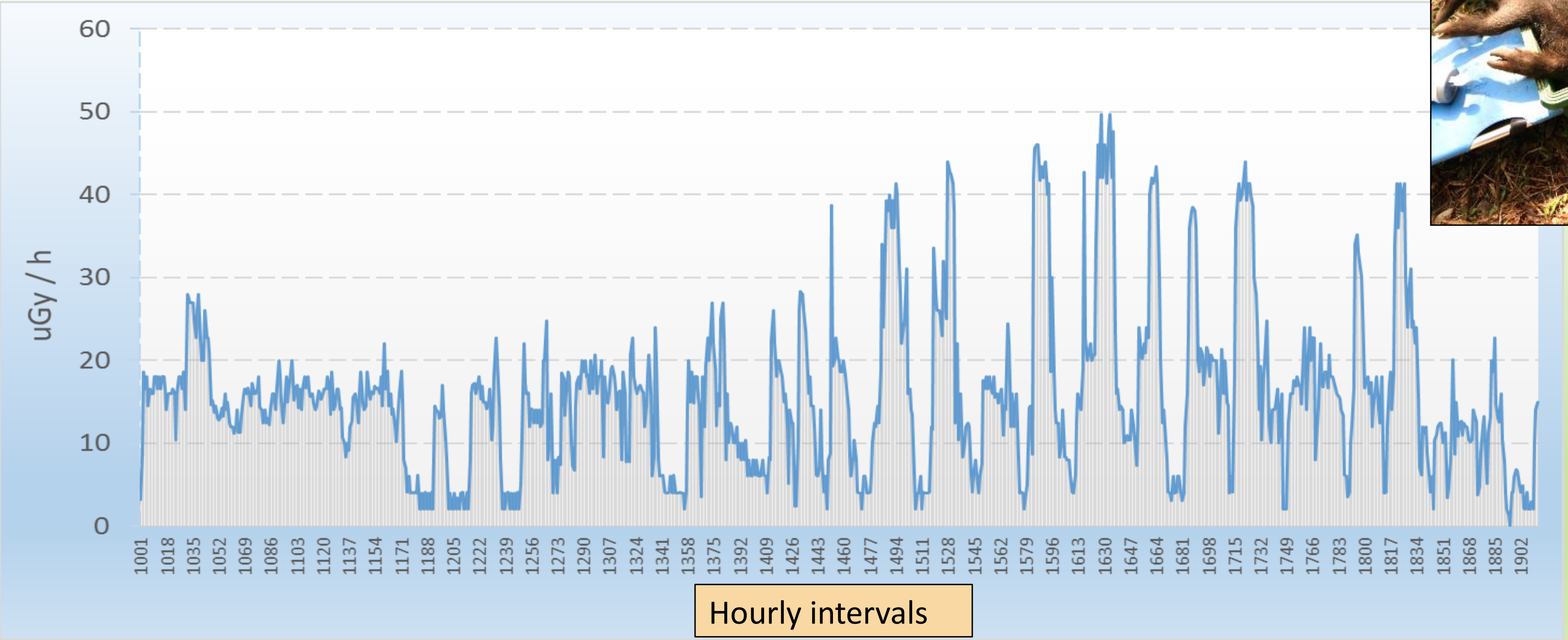
Obtained dose rate data and whole-body radiocesium concentrations of the animals, as a function of radionuclide deposition data.



FUKUSHIMA

野生イノシシ"グレース"の
1ヶ月間にわたる外部線量率測定

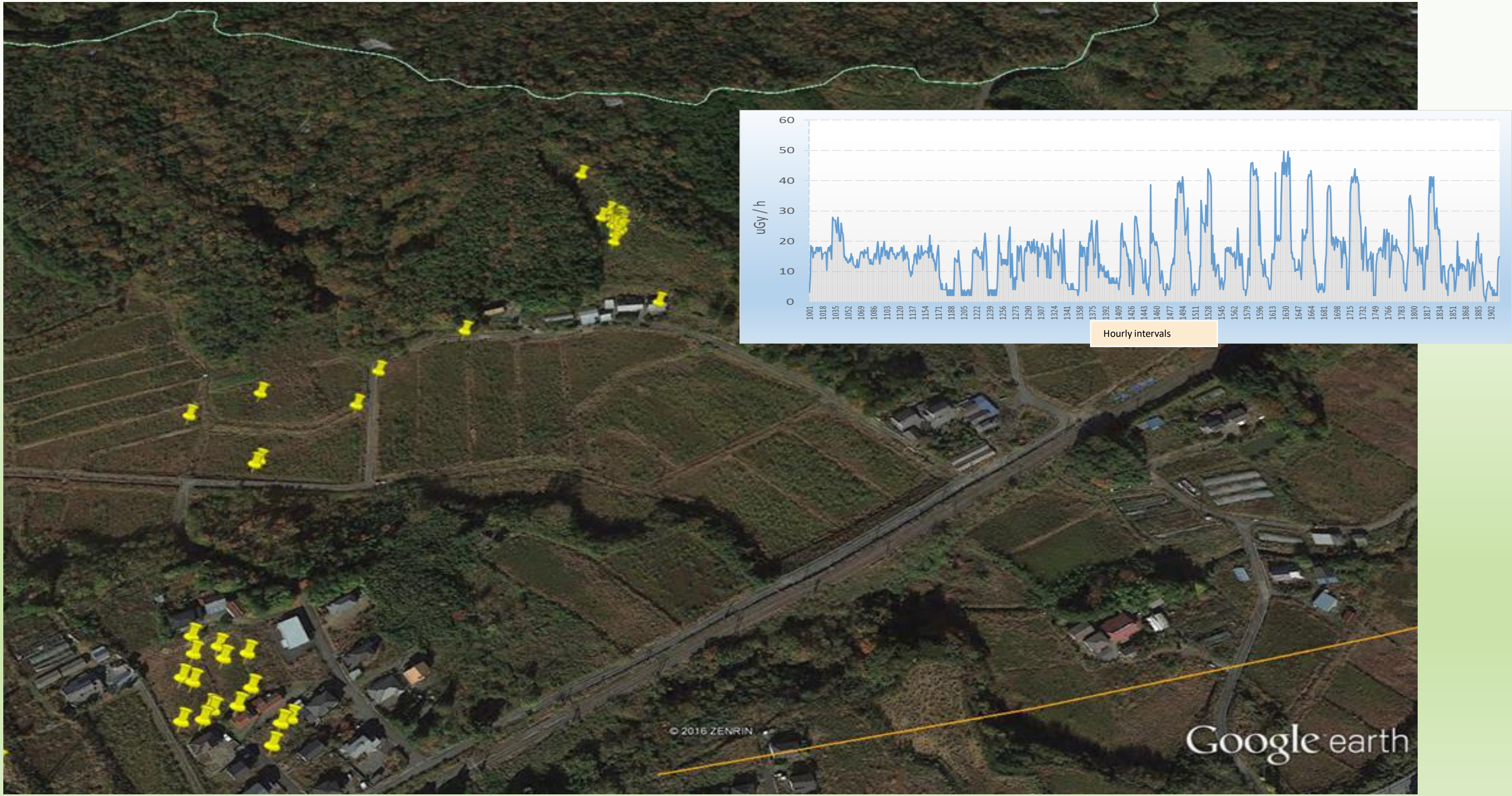
External dose rate measurements from wild boar, “Grace”, over a one-month period



Dr. Kei Okuda

Wild Boar “Grace”….. living 4 km from the FDNPP

野生イノシシ"グレース"の生息地は福島第一原子力発電所から4 km

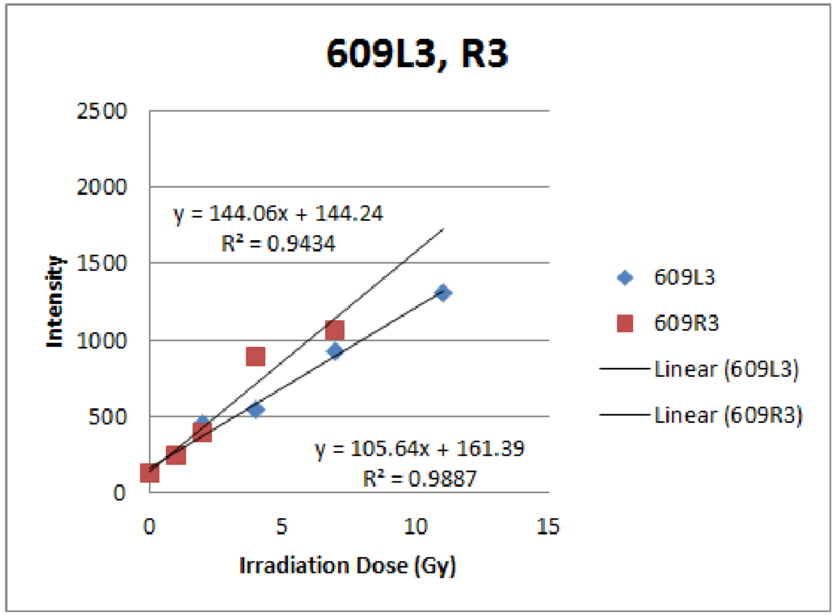


Life Time Dose to Boar
Electron Paramagnetic Resonance Dosimetry

Technique Development Phase

Molars were selected for processing because of their large enamel content

Irradiated samples were measured using the EPR Spectrometer at Okayama University of Science



Colorado State University

Dr. Shin Toyoda

- Okayama University of Science, Department of Applied Physics

iER

- Significant variation in dose response between teeth taken from the same boar
  - 11%-86% variation in teeth from the same boar
    - Possible Causes:
      - Moisture in the sample
      - Small differences in the mass of the samples
      - Condition of the teeth (caries/tooth disease)

福島大学環境放射能研究所

KELLY CUNNINGHAM,
Veterinarian student,
Colorado State University

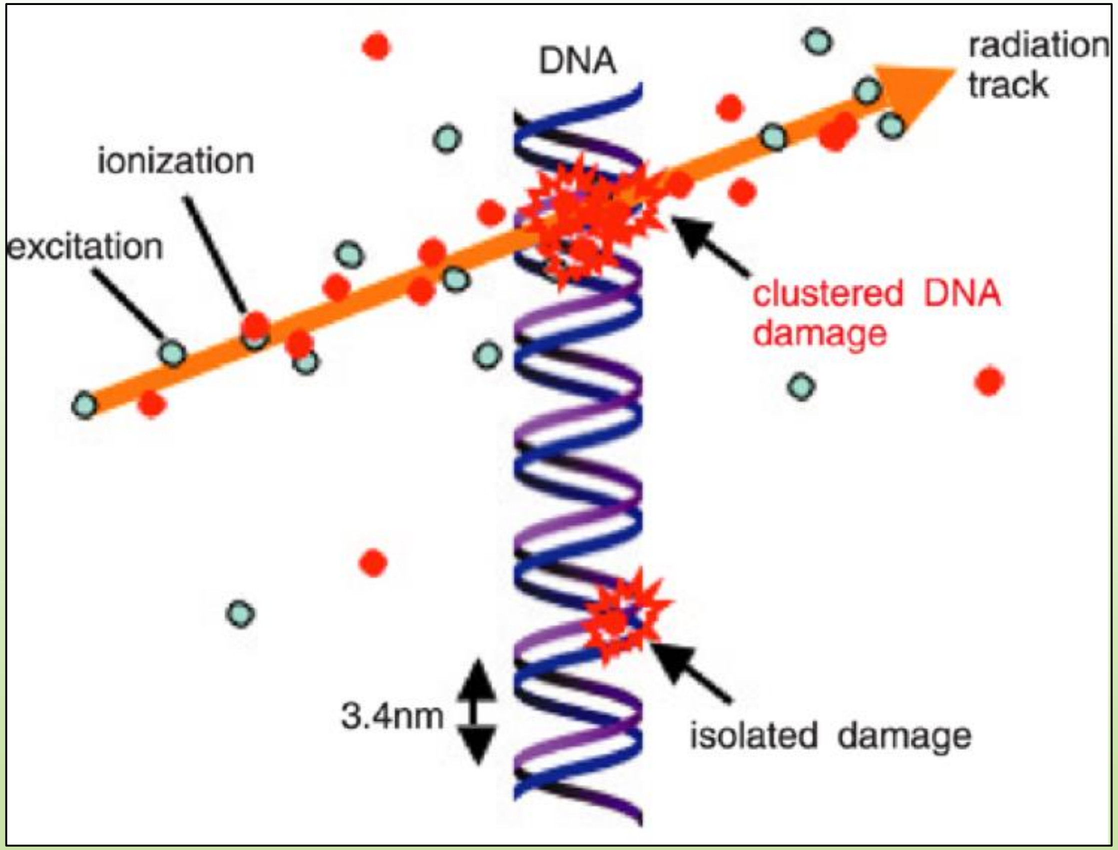
Ecosystems　生態系
↑
Communities　群集
↑
Populations　個体群
↑
Individual　個体
↑
Tissues　組織
↑
Cells 細胞
↑
DNA Molecules　DNA分子

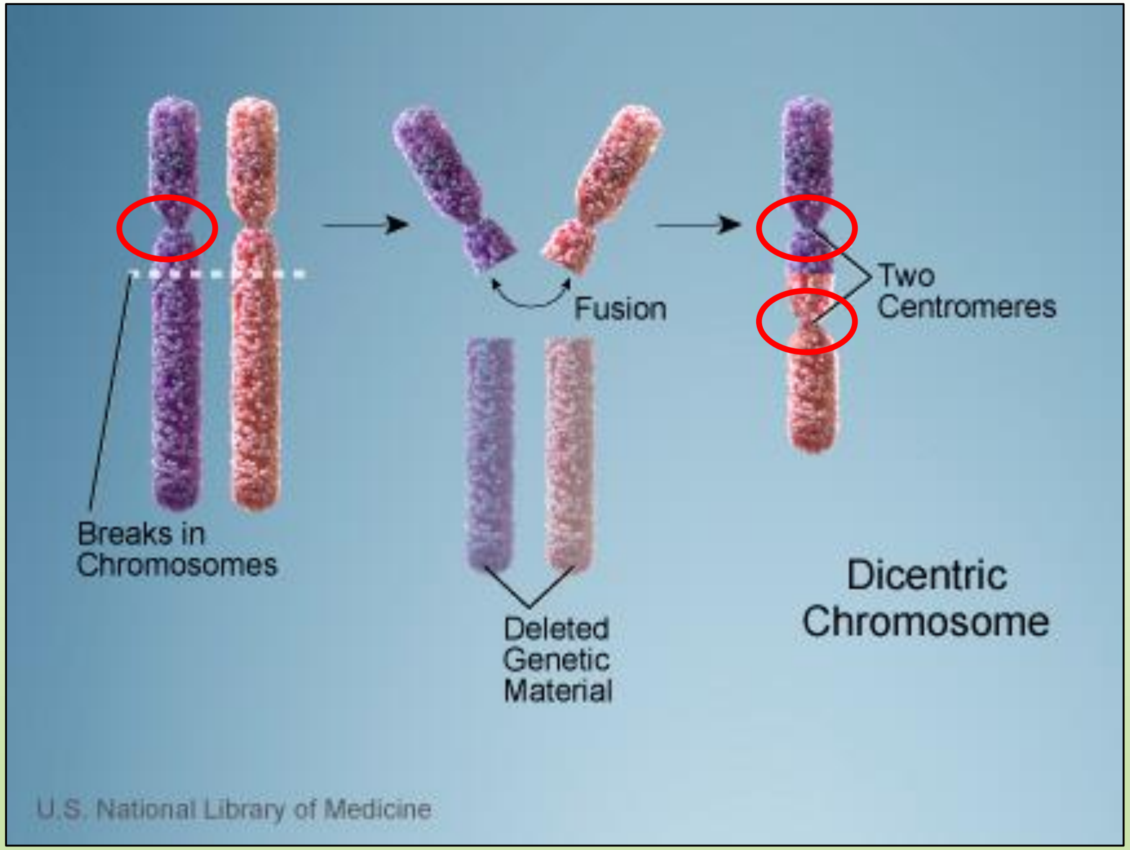
Chromosome damage in cells of wild boar exposed to radiation

放射線被ばくした野生イノシシの細胞内の染色体損傷

電離放射線による染色体のDNA損傷

Ionizing Radiation Causes DNA Damage in Chromosomes

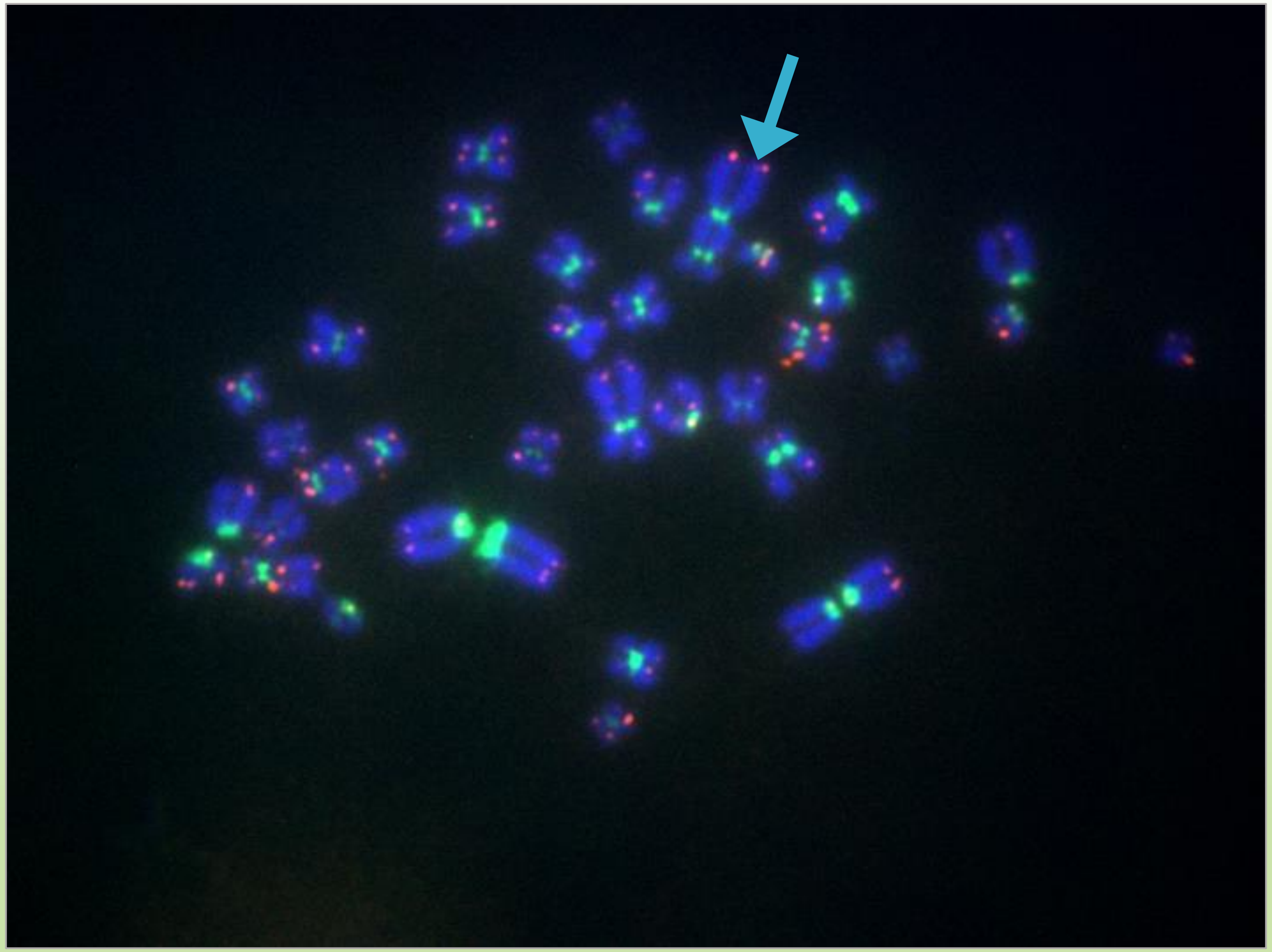




二動原体染色体

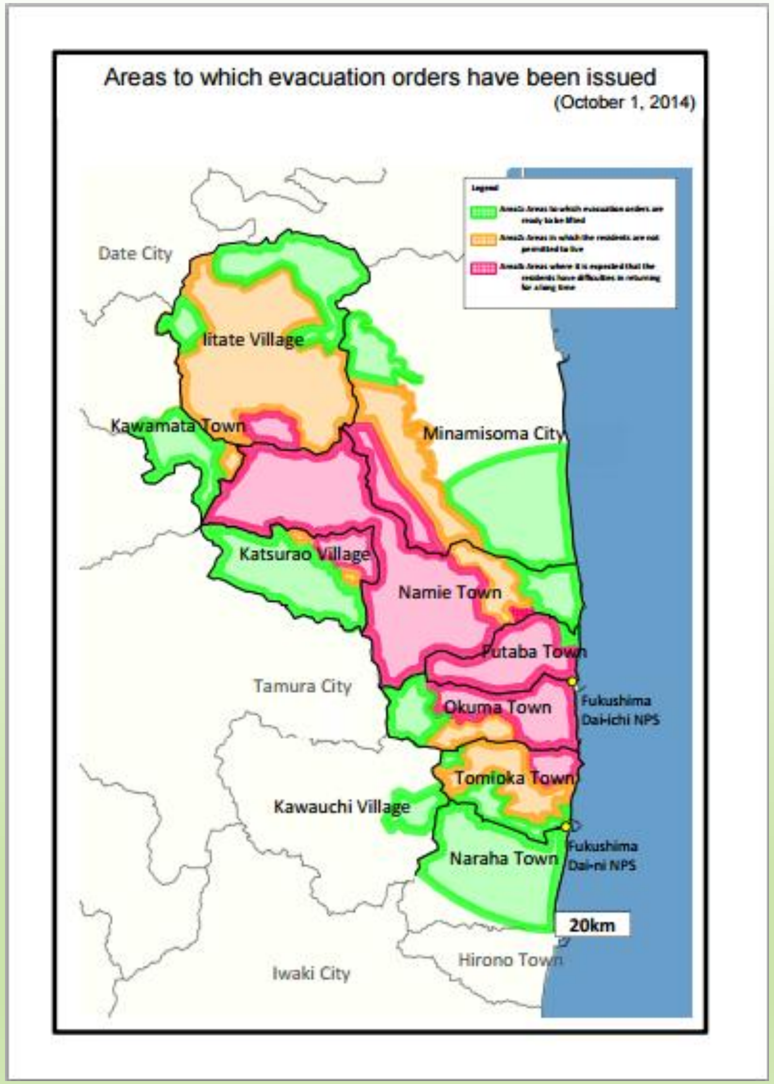
Dicentric Chromosomes

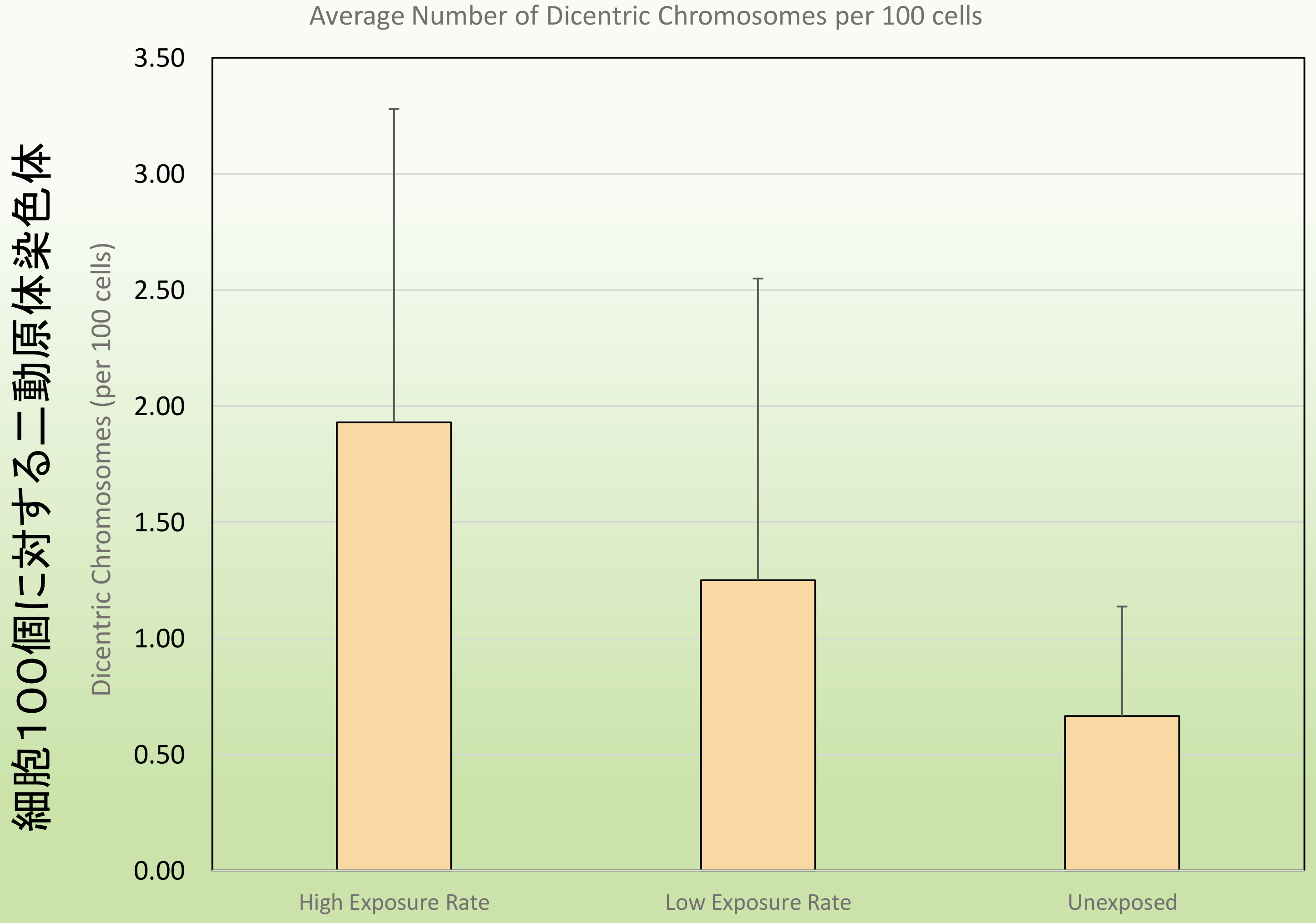
ケリーは、イノシシの染色体と動原体を蛍光染色する高度な方法を用いて、損傷した染色体と二動原体染色体を可視化している。



Kelly uses sophisticated methods that paint chromosomes, and their centromeres….making it easier to visualize the damaged ones and those that have formed dicentrics.

細胞100個に対する二動原体染色体の平均発生数





高線量被ばく ； 低線量被ばく ； 被ばく無し

CHALLENGES 課題

野生生物の状況については、ほとんど知られていない

Because of a lack of appropriate data, there is not an international consensus on how best to measure radiological impacts to wildlife

適切なデータがないため、野生生物に対する放射線影響に関する最適な測定方法についての国際的な合意はない

Ecosystems　生態系

Communities　群集

Populations　個体群

Individual　個体

Tissues　組織

Cells　細胞

DNA Molecules 分子

関連性は？？

relevance

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Fundamental differences in human and ecological risk analyses.

人間と生態系とのリスク分析における基本的な違い

type タイプ	unit of observation, what we are trying to protect 観測単位	endpoint, what we measure 終了点	dose-response 線量反応
人間 Human	個人 individual	生涯発癌リスク lifetime cancer risk	確立されている relationships established
生態系 Ecological	多様 varies	多様 varies	確立されていない not established

個体, 個体群, 群集, 生態系 ??

individual, population, community, ecosystem

死亡, 再生, 染色体損傷 ??

mortality, reproduction, chromosome damage

慢性の, 低レベル被ばく放射線への ??

for chronic, low level exposure to radiation

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Future Work:
Research dose-effects from chronic exposures to radiation