Contamination and effects on the environment

Karolina Stark

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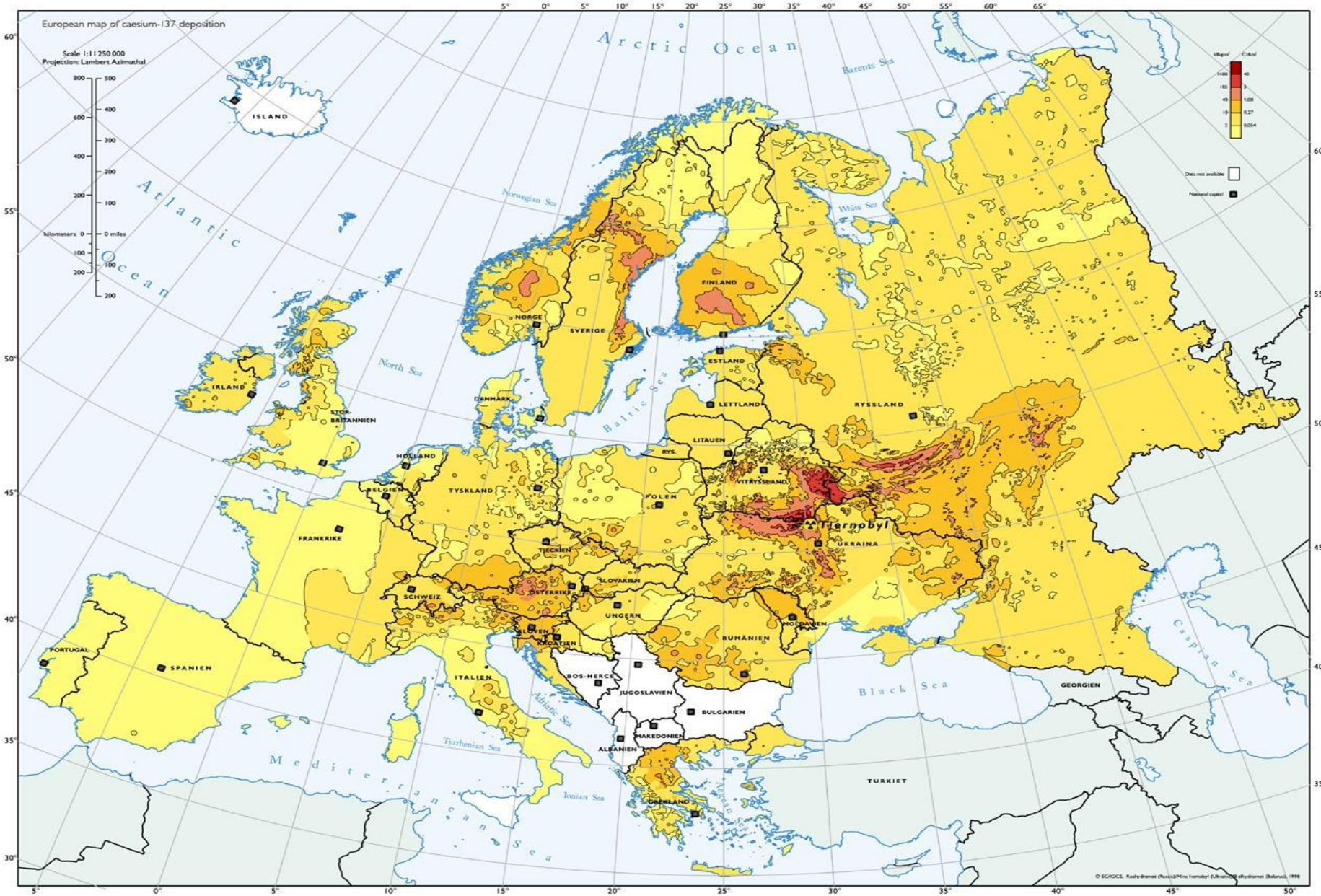
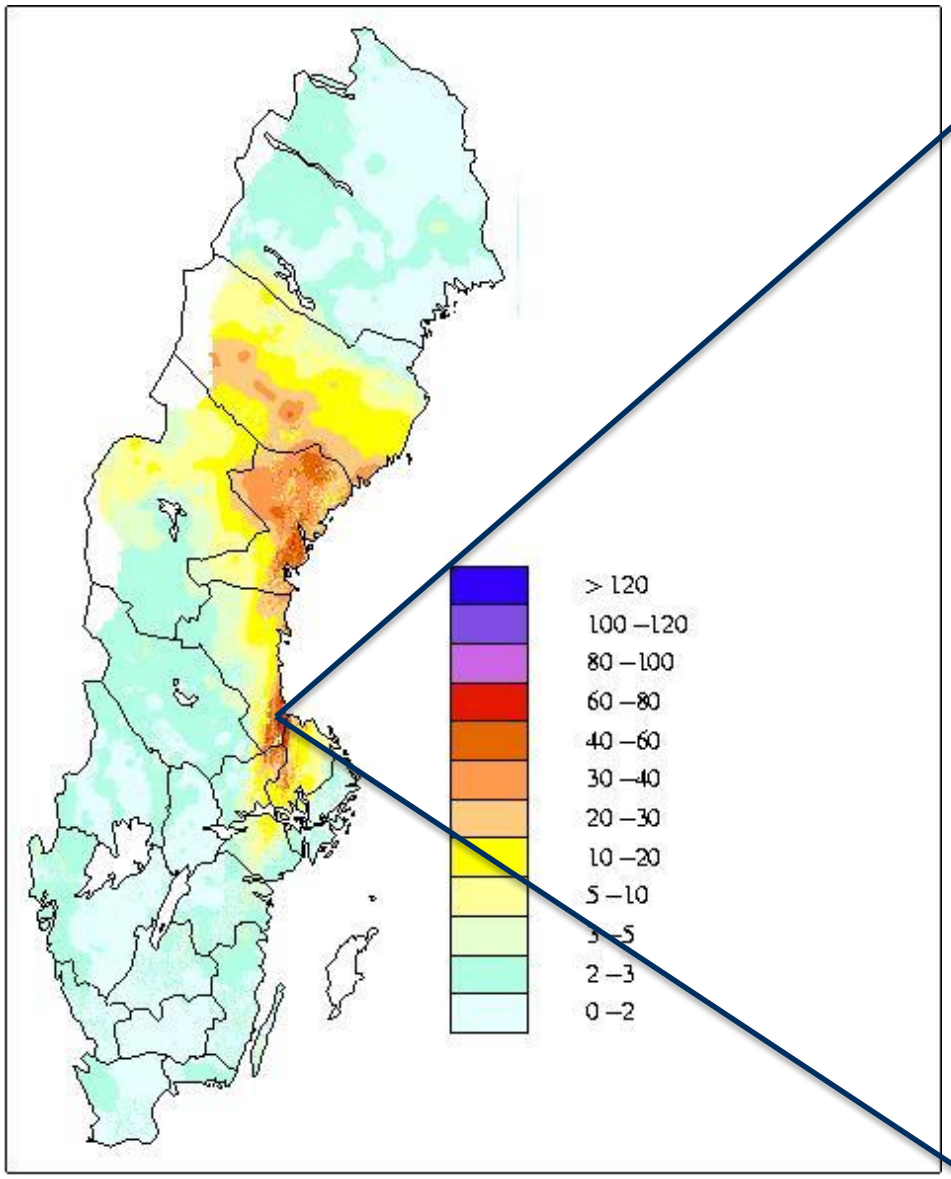
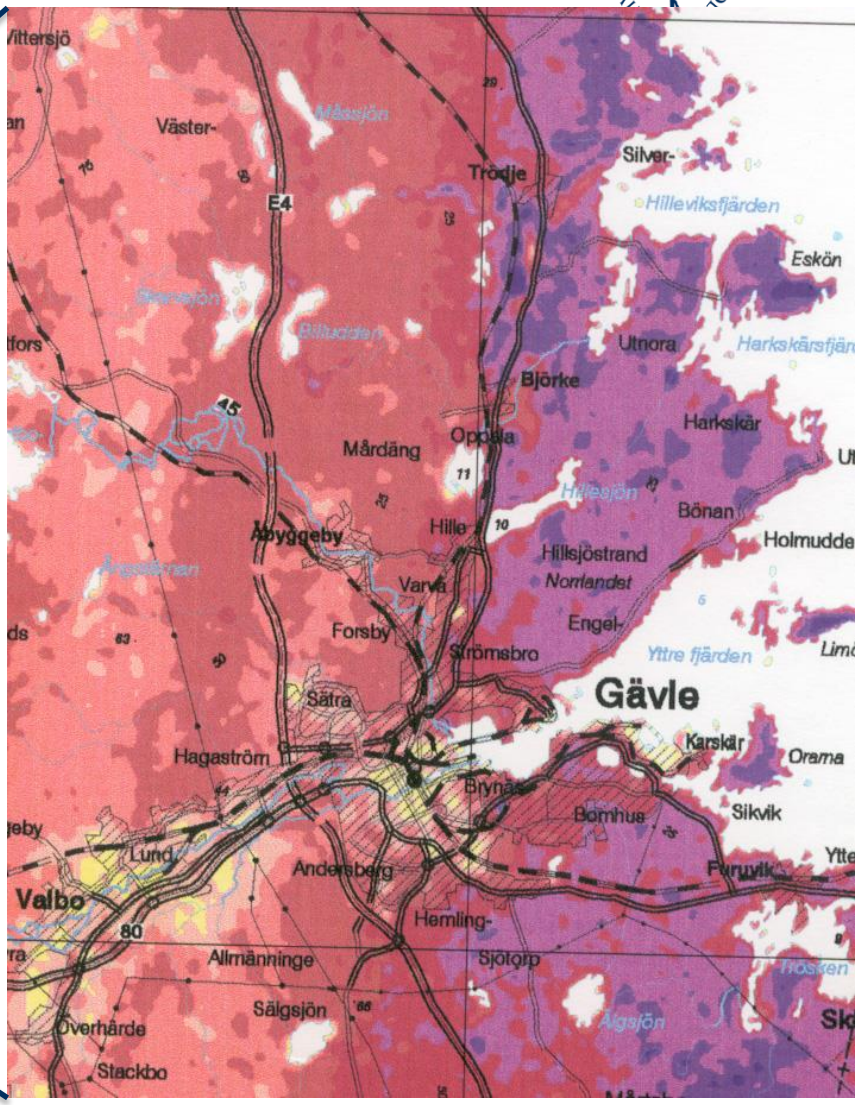
^{137}Cs fallout over Europe from the Chernobyl accident







^{137}Cs deposition (kBq/m^2) in Sweden.
Air gammaspectrometry measurements from SSM

Contamination of human food stuff and natural environments

- At the time no explicit protection of the environment
- Consequences for agriculture, hunting, lake fishing, mushroom picking
- Countermeasures undertaken such as action levels for food, changes in harvesting, moving reindeers to other areas, changes of fodder

Photo Birgitta Åhman, SLU

From SSM

Seasonal variation in uptake of ^{137}Cs in Reindeer

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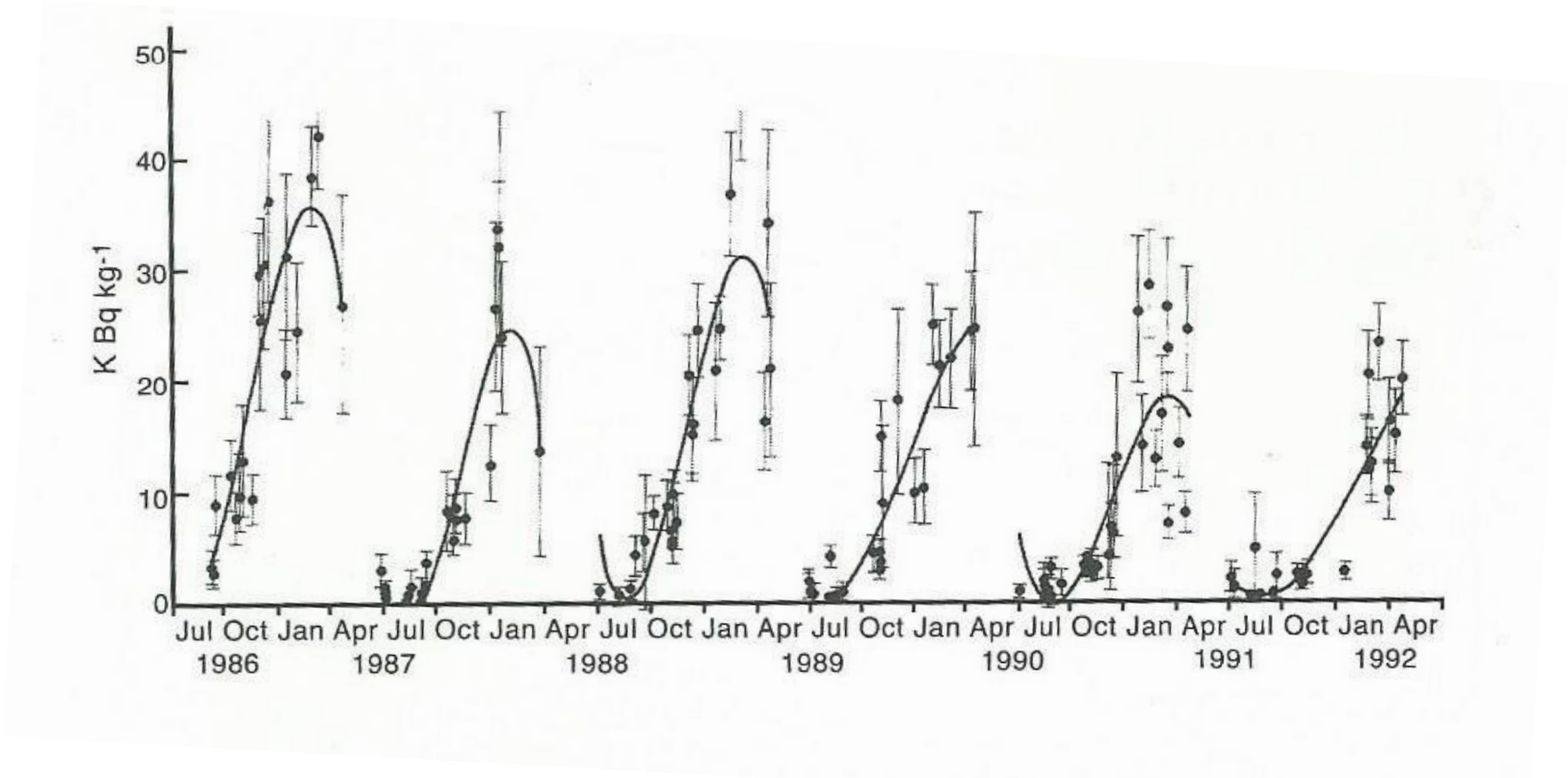
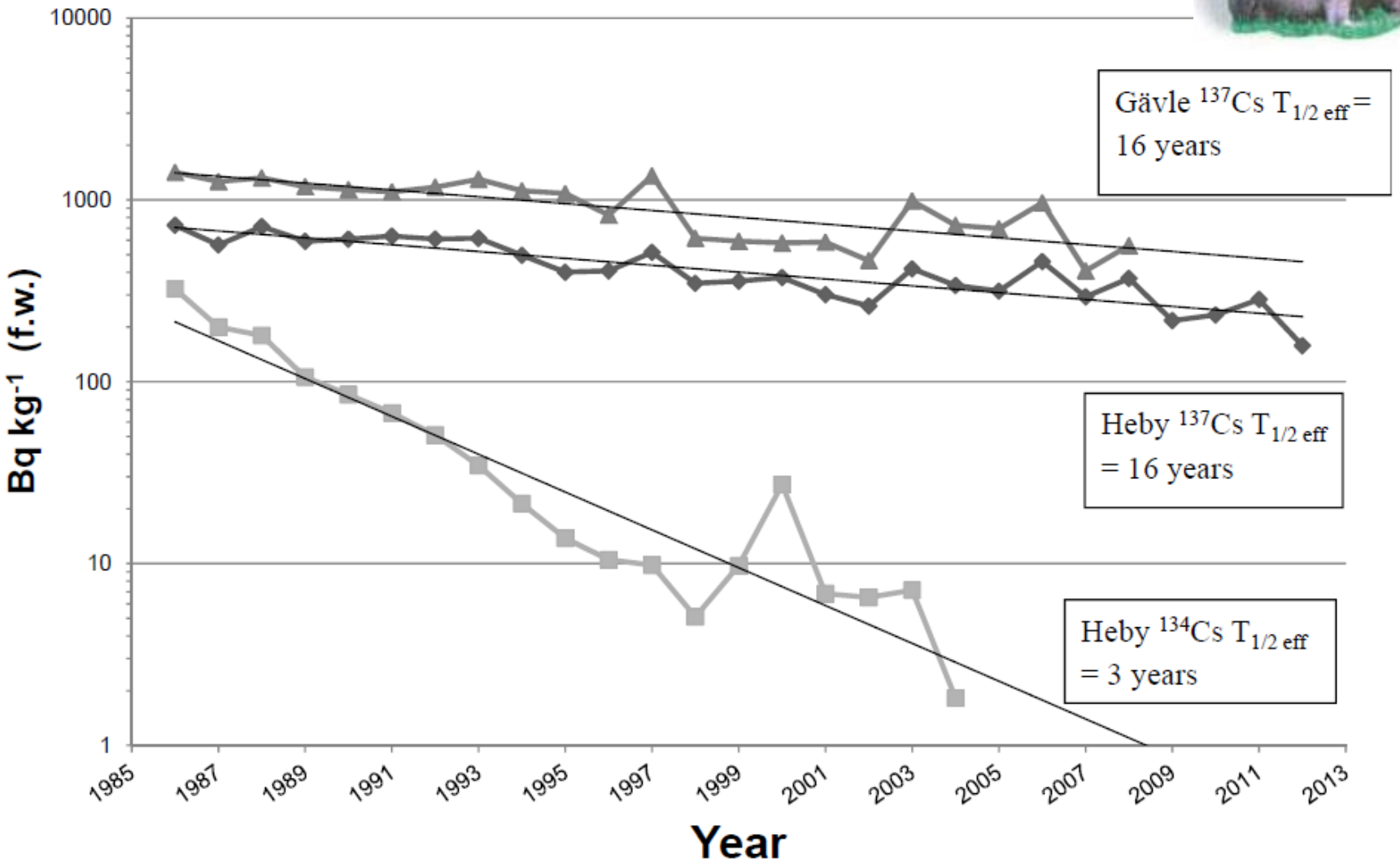


Cs-137 in Reindeer, Vilhelmina, Sweden. From Åhman & Åhman, 1994. Health Physics.

Long-term Decline of Radiocaesium in Moose



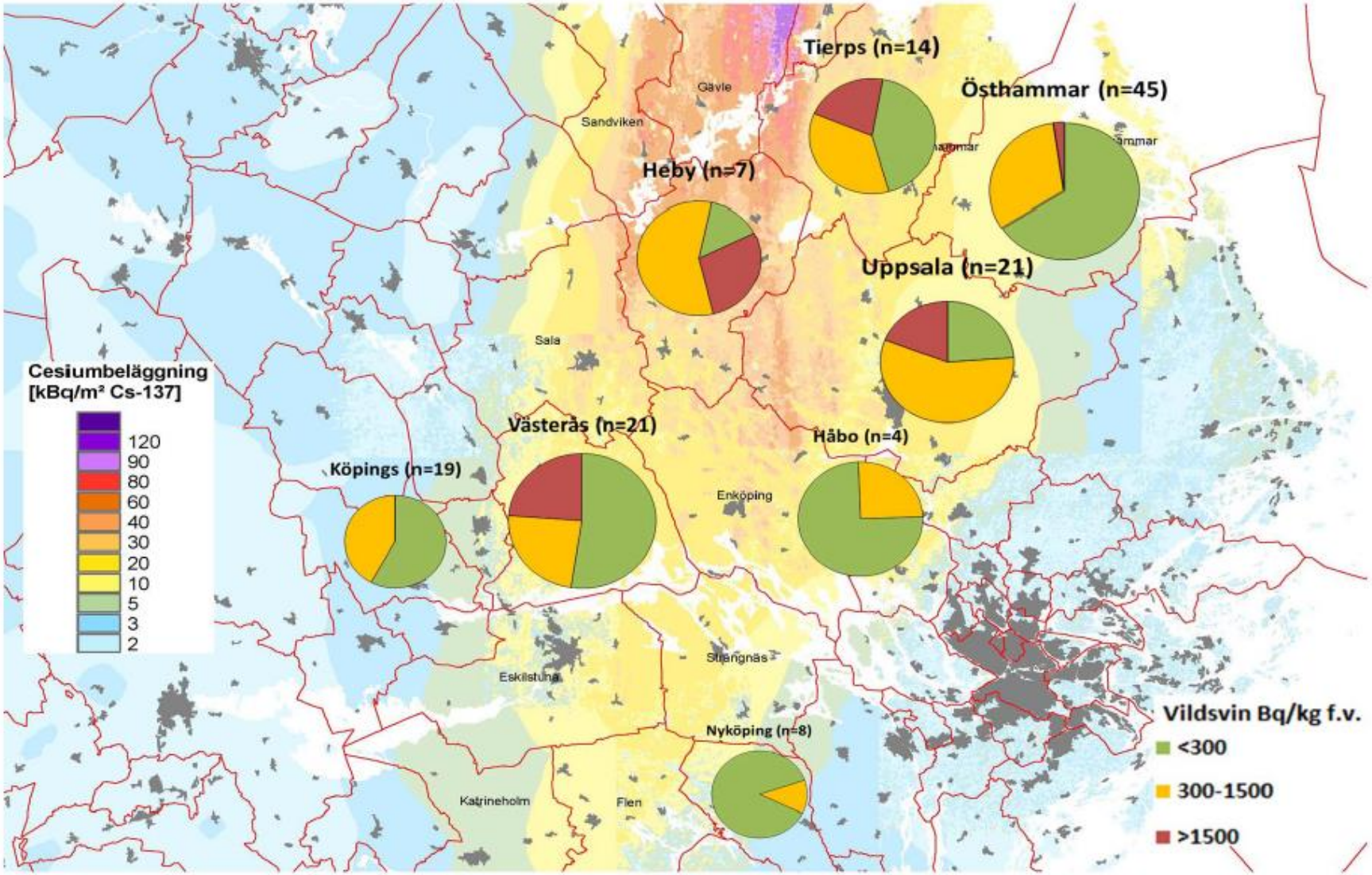
From R. Weimer Lic-thesis 2015

^{137}Cs in Wild Boars in East-central Sweden, 2010-2014

- ~170 muscle samples
- High variation CV=162%
- ex, 100 and 4900 Bq kg^{-1} ,same date and place
- Lowest levels in autumn

2 x BSc-thesis, Hallqvist, E. 2013 and Frtitzon, K. 2013

^{137}Cs in Wild Boars 2010-2014



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Journal of Environmental Radioactivity 87 (2006) 175–187
JOURNAL OF ENVIRONMENTAL RADIOACTIVITY
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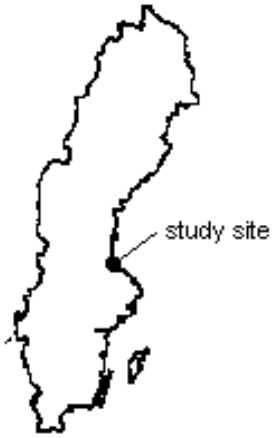
Post-depositional redistribution and gradual accumulation of ^{137}Cs in a riparian wetland ecosystem in Sweden

K. Stark [a,*], P. Wallberg [b], T. Nylén [c]



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- Wetland area in Utnora, Sweden
- Alder forest swamp and a marsh dominated by reed
- Depositon >100 kBq/m^2
- Average inventory 1 MBq/m^2 in wetland in 2001

Radiat Environ Biophys (2008) 47:481–489
DOI 10.1007/s00411-008-0185-9

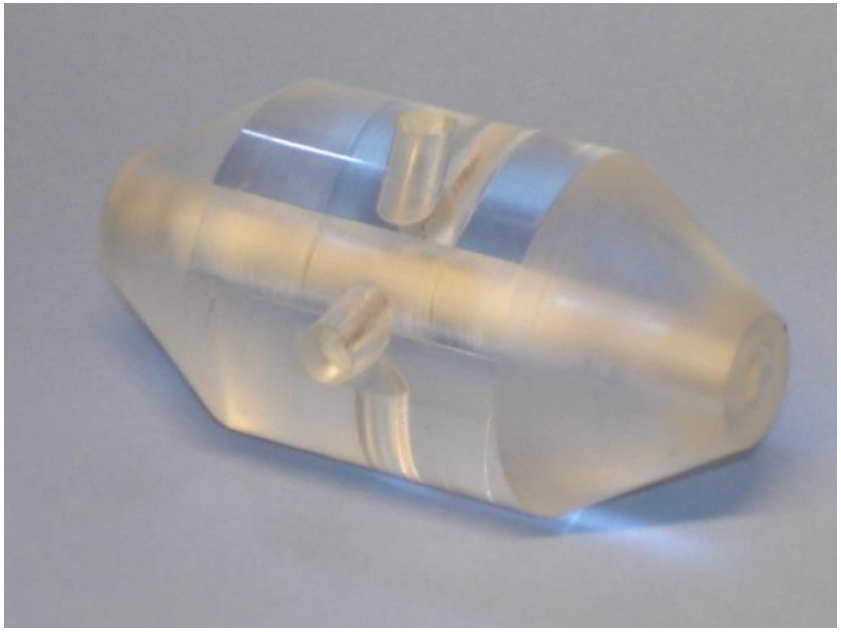
ORIGINAL PAPER

External radiation doses from ^{137}Cs to frog phantoms in a wetland area: in situ measurements and dose model calculations

K. Stark · H. B. L. Pettersson

Stockholm University

- Constructed frog phantoms of PMMA containing thermoluminescence (TL) chips



Cs-137 in amphibians in the Gävle area

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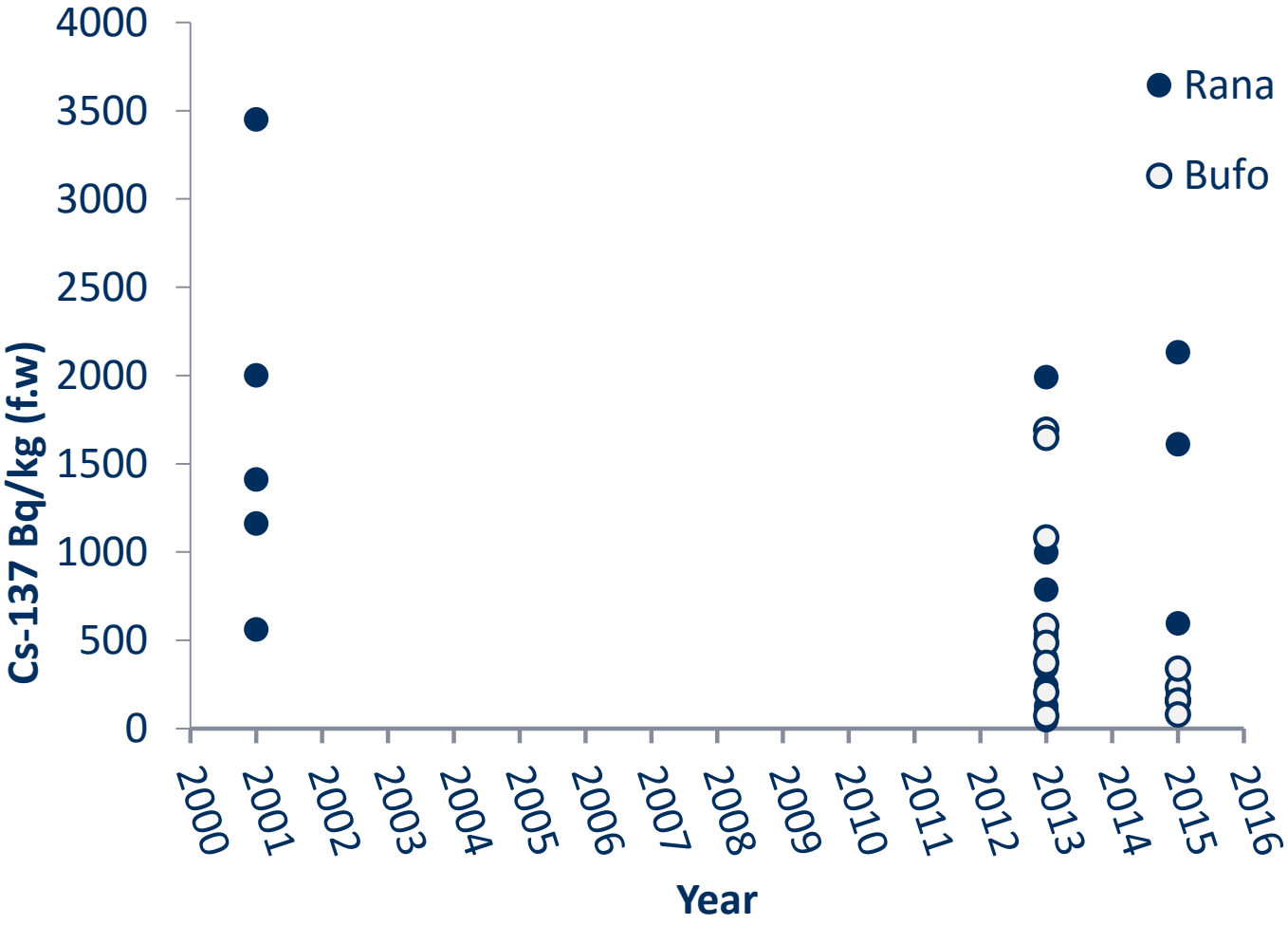

Environmental Pollution 196 (2015) 201–213

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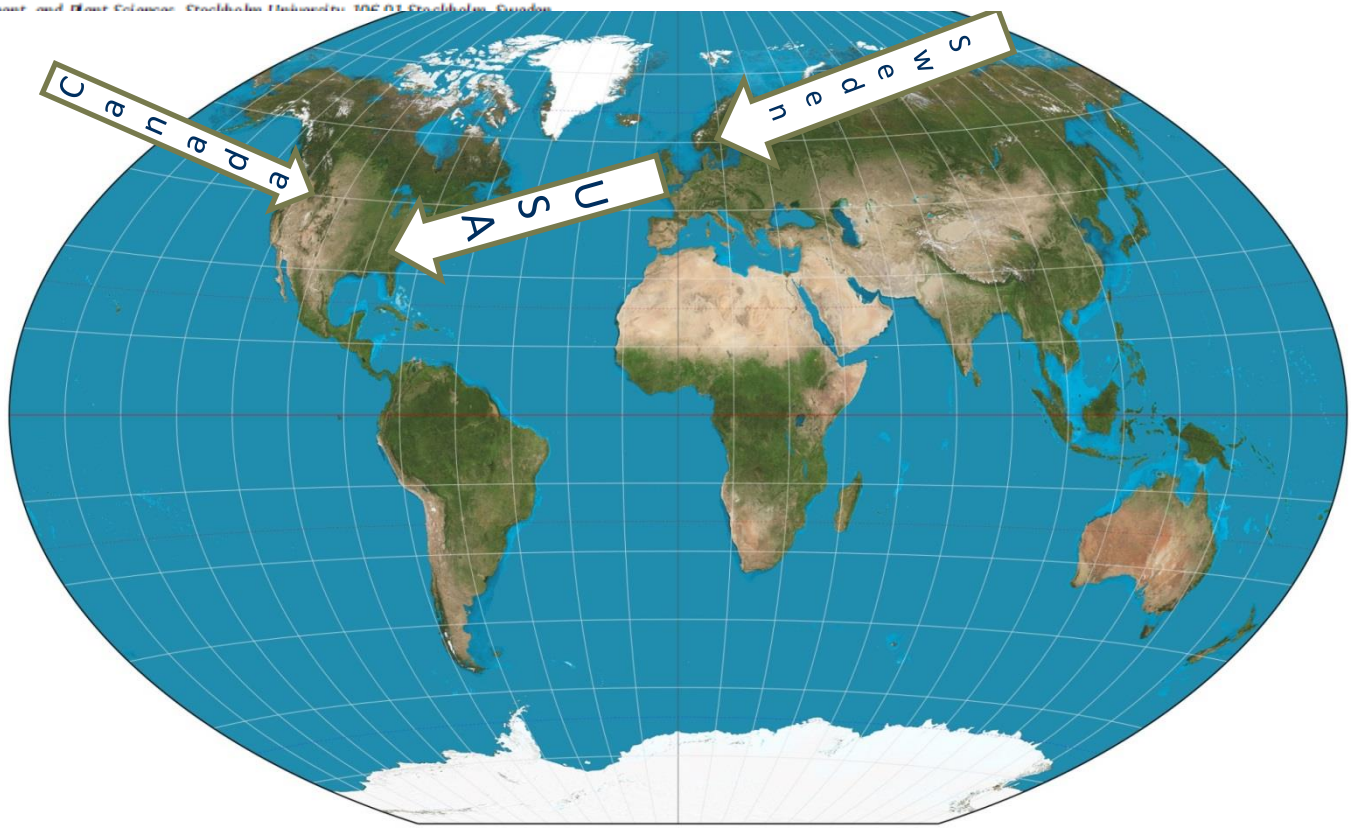
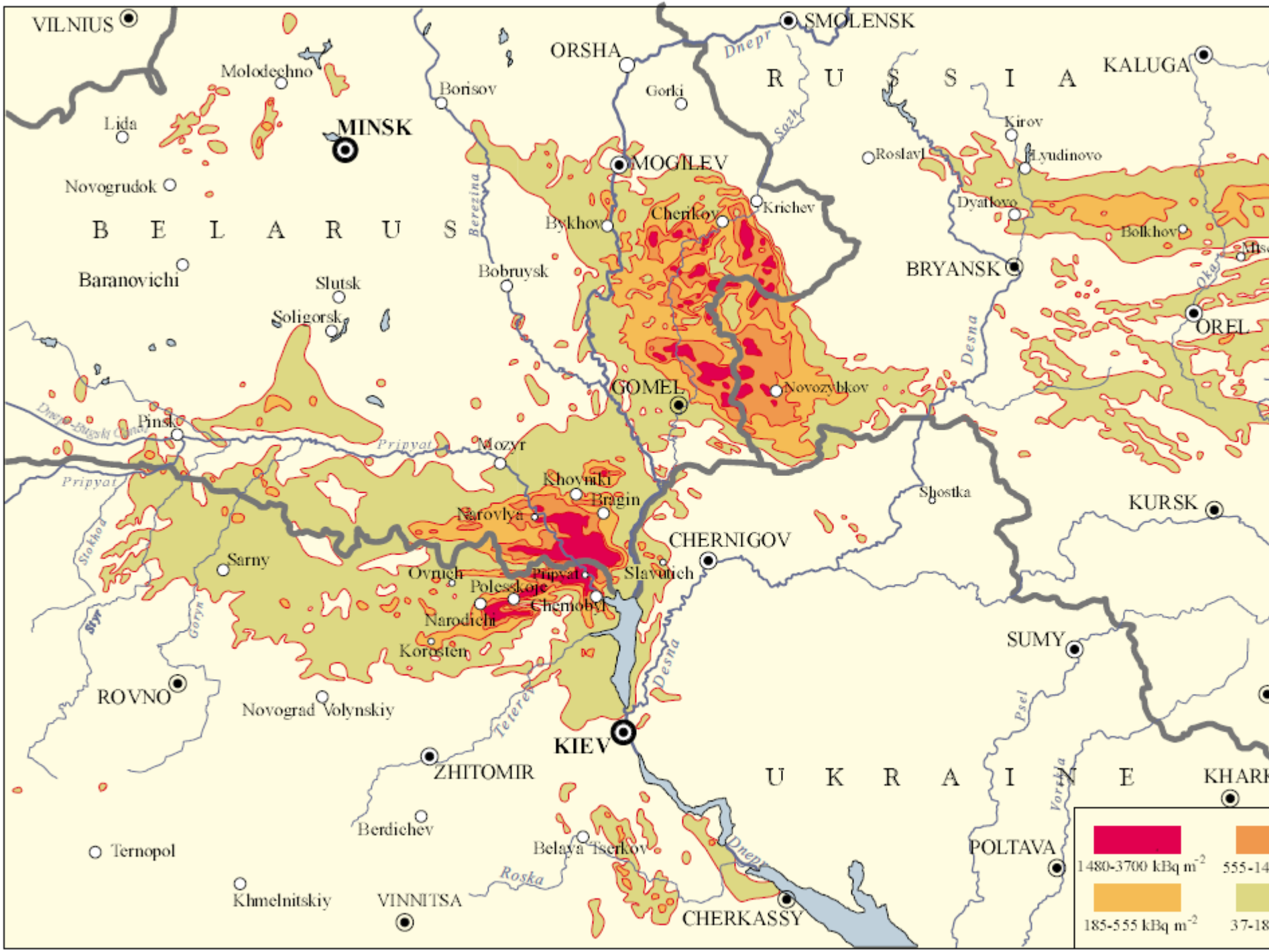
Predicting exposure of wildlife in radionuclide contaminated wetland ecosystems

K. Stark [a, *], P. Andersson [b], N.A. Beresford [c], T.L. Yankovich [d], M.D. Wood [e], M.P. Johansen [f], J. Vives i Batlle [g], J. Twining [f, 1], D.-K. Keum [h], A. Bollhöfer [i], C. Doering [i], B. Ryan [j], M. Grzechnik [k], H. Vandenhove [g]

[a] Department of Ecology, Environment and Plant Sciences, Stockholm University, 106 91 Stockholm, Sweden

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VINNITSA
ZHITOMIR
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Teterev
KIEV
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Roska
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U K R A I N E
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Narodichi
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GOMEL
Novozybkov
Shostka
KURSK
Oka
OREL
BRYANSK
Dyatkovo
Bolkhov
Roslavl
Lyudinovo
Kirov
KALUGA
Sozh
Krichev
Cherikov
Bykhov
MOGILEV
Berezina
Bobruysk
Borisov
Gorki
ORSHA
SMOLENSK
Dnepr
R U S S I A
1480-3700 kBq m-2
555-14
185-555 kBq m-2
37-18

Radiation exposure after the accident

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Three phases:

1) First 20 days, acute exposure, many short lived radionuclides, resulted in large doses, effects on biota
2) During the summer+autumn of 1986, longer lived radionuclides, transport processes, doses 10% of initial but still total doses damaging
3) Continuing, chronic dose rates, less than 1% of initial, mainly from ^{137}Cs

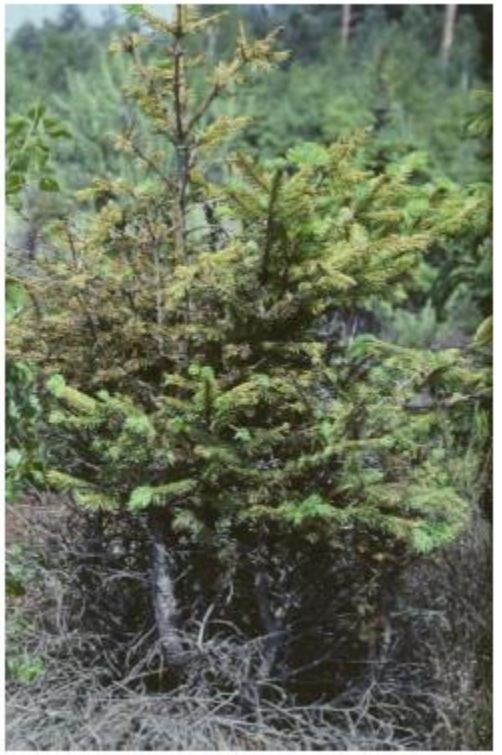
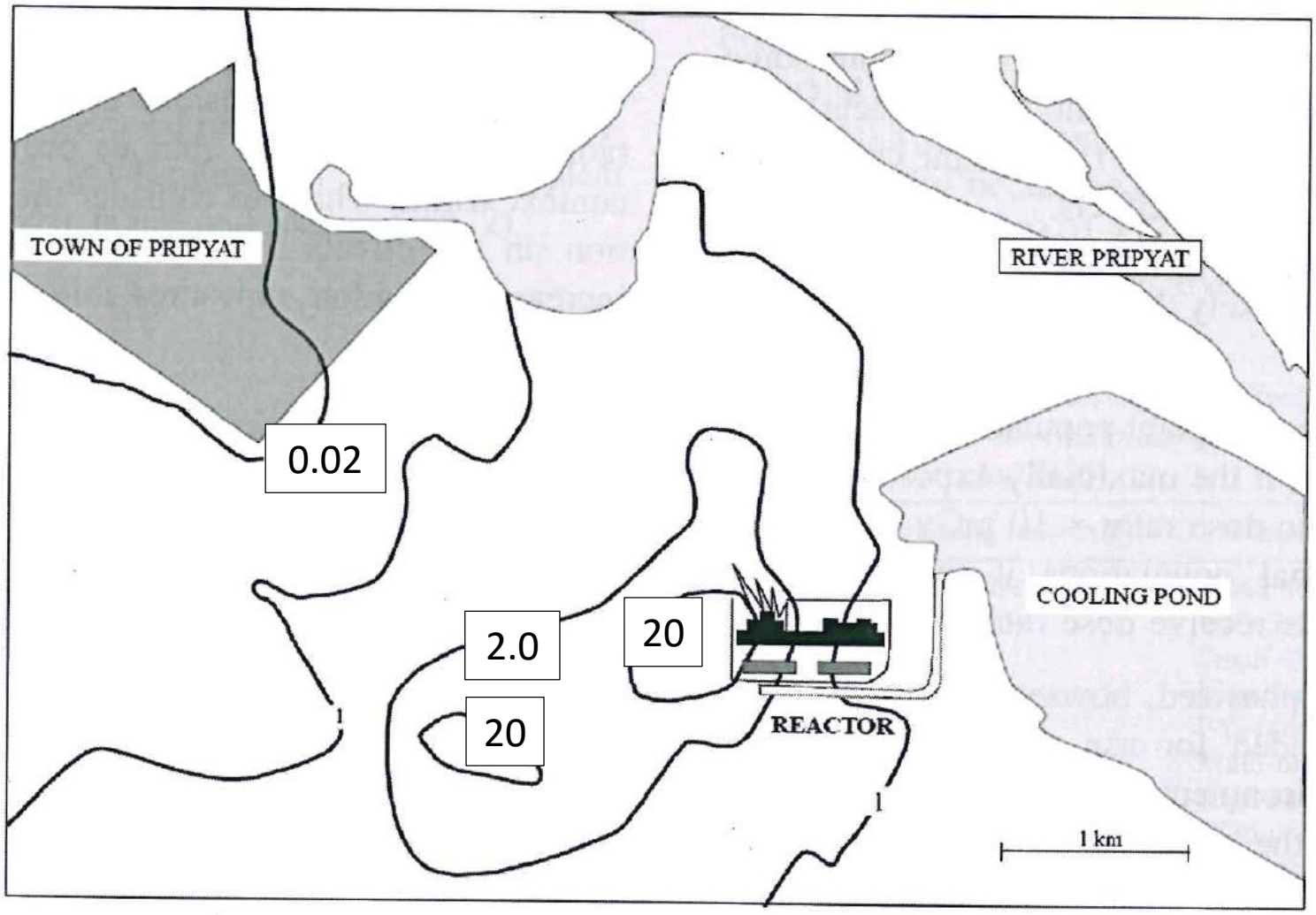


Photo by T. Hinton

- Approximately 80% of total doses to plants and animals received within 3 months
- Over 95% of these were due to beta radiation

From IAEA, 2006 and UNSCEAR, 1996

Measured exposure on 26 april 1986 in Gy d^{-1} (only gamma)



From Hinton et al., 2007 in *Health Physics* 93(5): 427-440

Effects in the environment after the accident

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Pine trees died in ”The Red forest”, doses 60 - 100 Gy, 600 ha (Geras´kin et al., 2008)

Effects in the environment after the accident

- Soil invertebrates reduced by a factor of 30 after 2 months, doses 30 Gy -recovered after 2.5 years but with lower species diversity
- Small rodent populations decrease by a factor of 2-10 in the autumn 1986, doses 12-110 Gy (gamma) –numbers recovered by 1987 due to immigration
- Morphological abnormalitites apparent in plants in 1987
- No seeds produced 5-7 years in 3800 ha of forest, 40 Gy

From IAEA, 2006; The Chernobyl forum; Geras´kin et al., 2008

No consensus on the effects from chronic field exposures

- In Belarus, chromosome aberrations in bone marrow cells of bank voles were correlated with radiation but constant during 1986-1996, eventhough whole-body dose-rates decreased – difficult to interpret if effect from acute exposure

- In contrast, no increase of micronuclei in erythrocytes of bank voles with dose rates <86 mGy/d in 1997. Also, greater genetic diversity in bank voles populations most likley due to immigration

From Ryabokon and Goncharova, 2006; Rodgers and Baker, 2000; Matson et al., 2000; Beresford and Copplestone, 2011

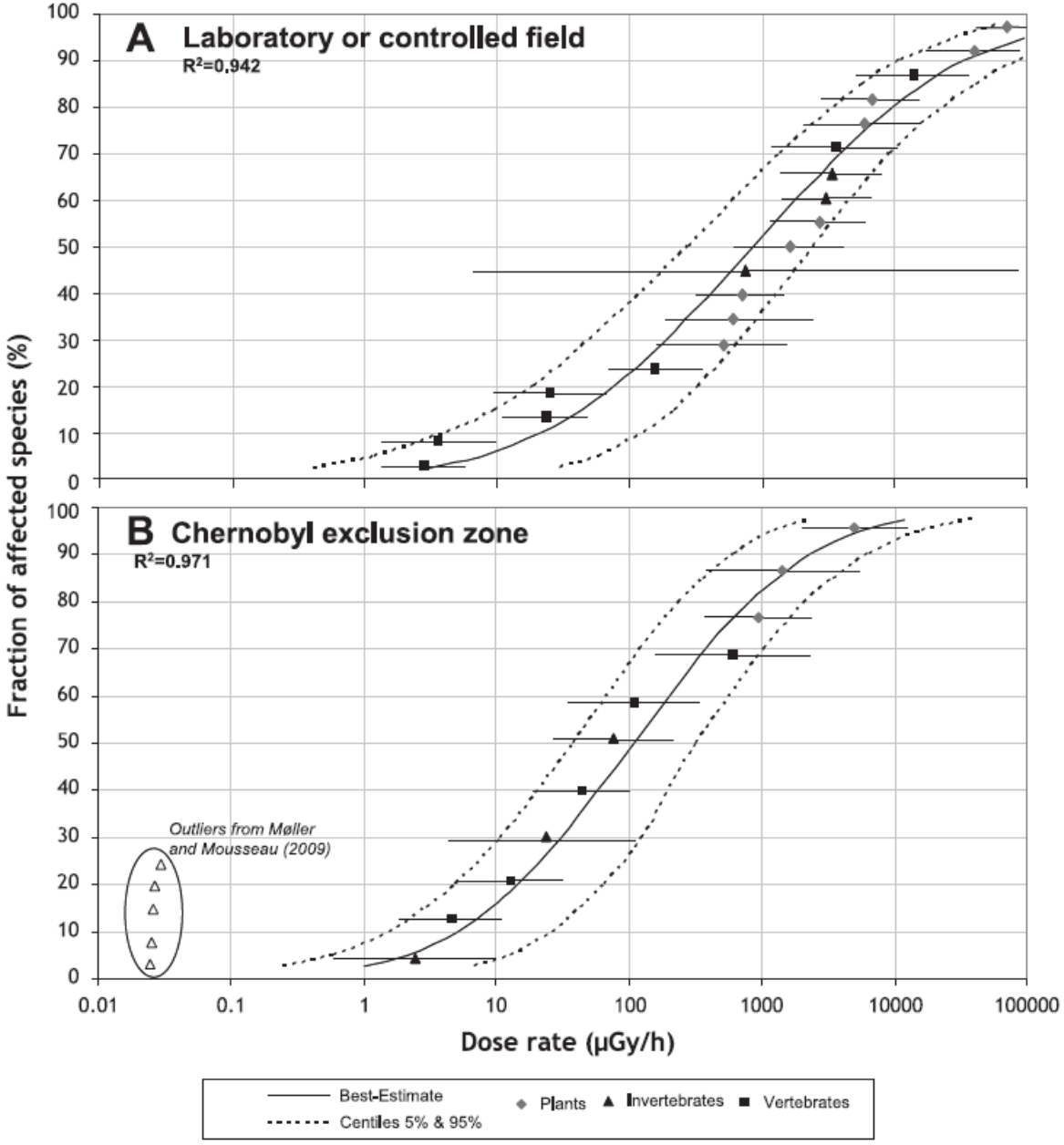
No consensus on the effects from chronic field exposures

- Reportings of reduced number of invertebrates in 2006 and 2008, reduced diversity of forest birds, germline mutations, increased sperm deformities, albinistic feathers of barn swallows at low dose rates (only external considered)

- However, these studies have been criticized due to lack of consideration of confounding factors, poor dosimetry, inappropriate grouping of sites, field methods

- Recently, little effect on soil nematodes in CEZ at dose rates up to 200 μGy h^{-1} and the change in community structure may be due to chronic exposure or the initial exposure

Møller and Mousseau, 2007; 2009; 2011; Beresford and Copplestone, 2011; Lecomte-Pradines et al., 2014



Confounding factors in field studies

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- Human abscence (no agriculture, construction, hunting, forestry etc.)
- Changes in habitats due to human abscence or initial exposures
- Acute effects on biota communities
- Other environmental factors and stressors (in cooling ponds also chemicals)

CEZ turned into a nature reserve?

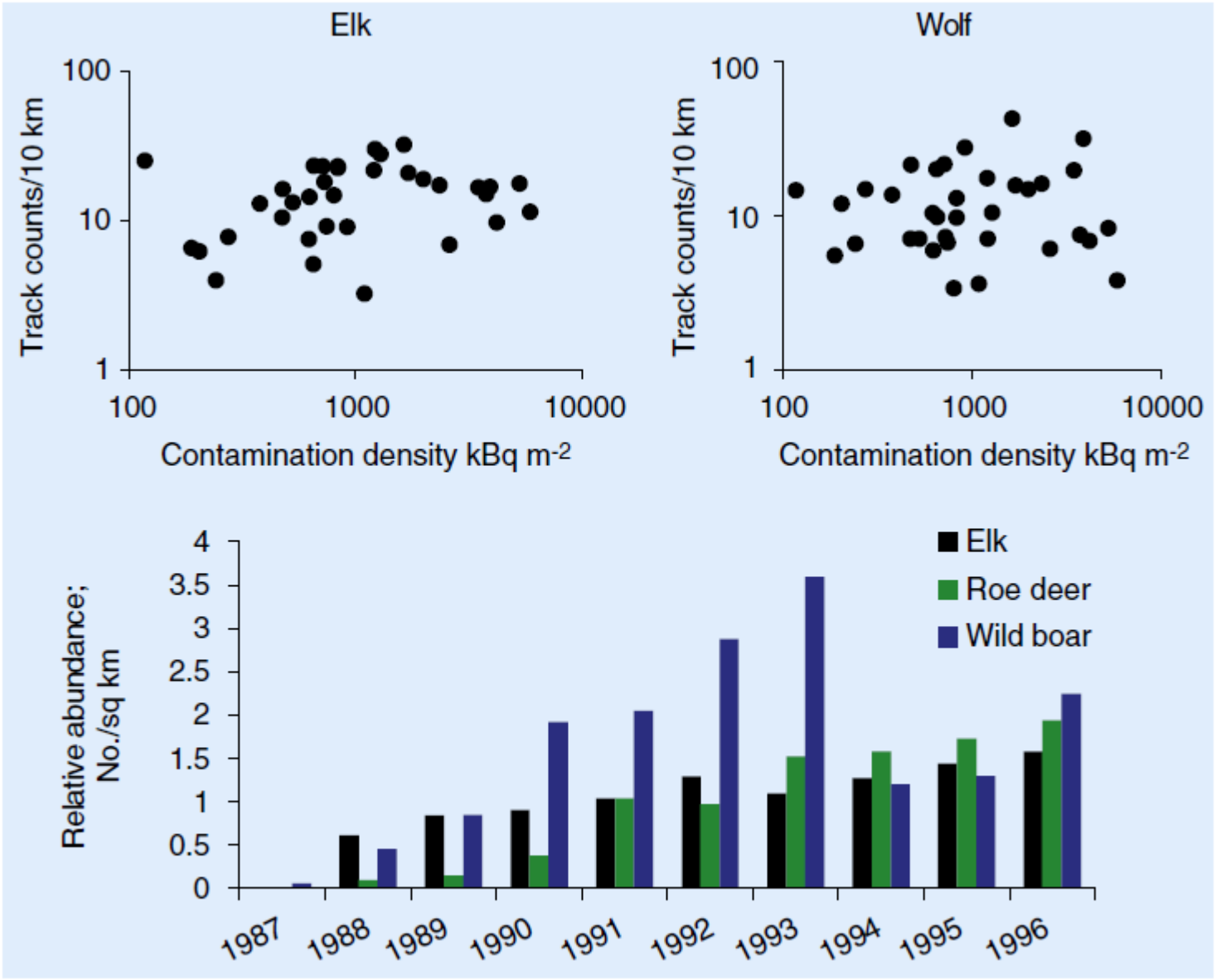

Figure 1. Animal abundances in the Chernobyl exclusion zone.

From Deryabina et al., 2015 in *Current Biology* 25, R811-R826

Chernobyl exclusion zone today

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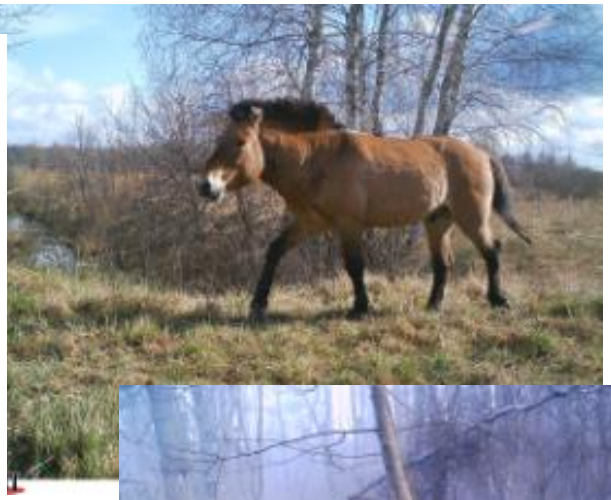
Figure 2. Photographs of several species of carnivores observed visiting scent stations deployed throughout the PSRER during fall 2014: (a and d) gray wolf (Canis lupus), (b) raccoon dog (Nyctereutes procyonoides), and (c) red fox (Vulpes vulpes).



”Radiation did not negatively affect occupancy of gray wolf, raccon dog, red fox and Eurasian Boar”
From Webster et al., 2016 in *Frontiers in Ecology and Environment* 14(4): 1-6

On Twitter:
@drmikewood
@DrSLancelot
@radioecology
@RadioXchange

Ongoing research at SREL (USA), TREE (UK), and COMET, EU-project

Review of the state of wildlife dosimetry

Wildlife radiation dosimetry: State of the art and perspectives

Karolina Stark[a,*], José M.Goméz-Ros[b], Jordi Vives i Batlle[c], Elisabeth Lindbo Hansen[d], Karine Beaugelin-Seiller[e], Lawrence A. Kapustka[f], Michael D. Wood[g], Clare Bradshaw[a], Almudena Real[b], Corynne McGuire[h], Thomas G. Hinton[i]

Submitted to Journal of Environmental Radioactivity

- We have adequate knowledge to perform conservative dose assessments for wildlife
- There is a lack of guidance for dosimetry in detailed assessments and dose-effect studies
- Ecological and physiological differences need further attention in dosimetry research
- Improvement of methods for assessing when doses will be received and what fraction of the population will be exposed

Conclusions

- Use more of our Swedish ”Chernobyl-data” to do international field validations of models and improve assessment tools
- The Chernobyl accident acutely effected wildlife but we are still learning about long-term effects
- Still a debate about effects from chronic low doses- there are ongoing field studies but with few players
- A need for a standardisation of reporting dosimetry to wildlife
- A need for guidance and tools to assess the proportion of a population that is exposed and when the exposure occurs

Thank you for your attention!

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Photo: BBC