

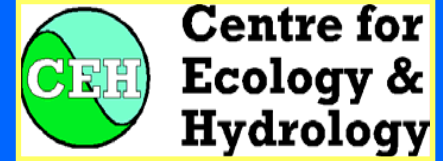
# Radioecological sensitivity



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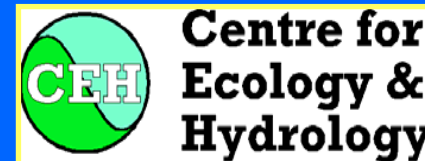
Brenda Howard

# Outline



- Background
- Exposure pathways
- Quantification of radioecological sensitivity
  - Four quantities
- Examples
- Application

# Background



- Prior use of critical group approach
  - critical pathways
- Post-Chernobyl focus on certain key exposure routes and their spatial attribution
- application of GIS allows spatial analysis

# Why?

Considerable variability in radiation doses



Generalizations can mask high individual exposure



Factors leading to high exposure need identification,  
quantification and locating



Enabling improved preparedness and response

# Criteria

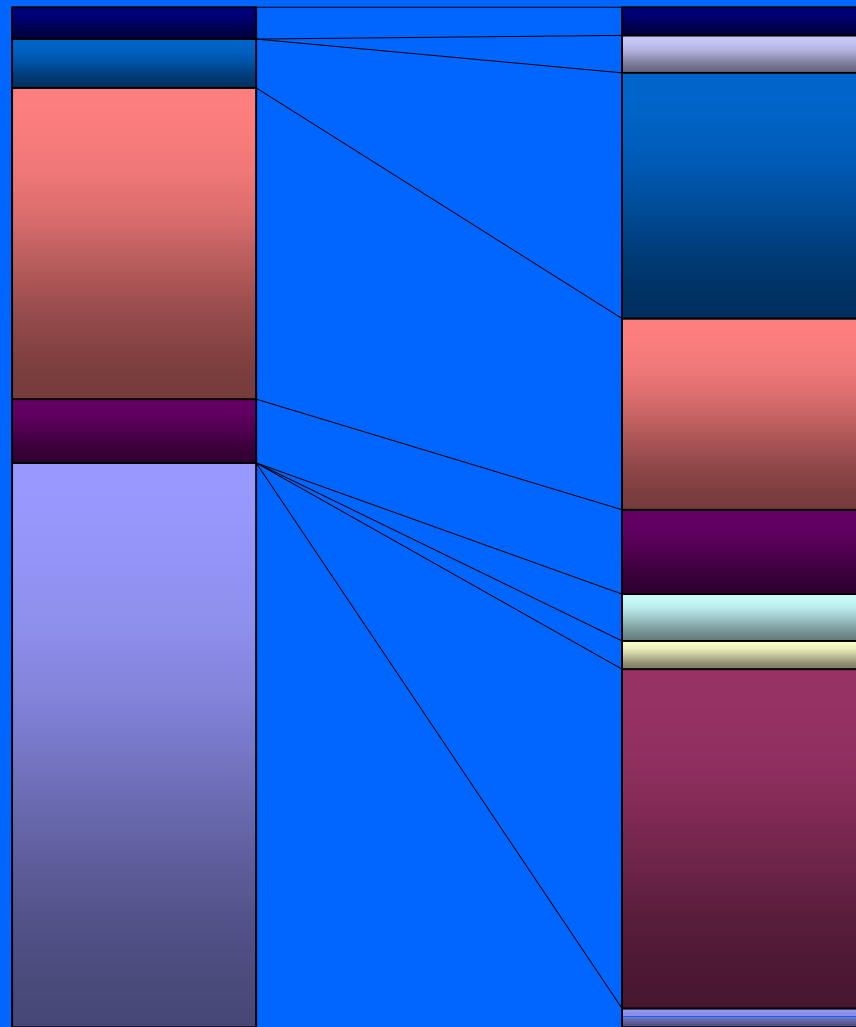
- pathways
  - high transfer capacity
  - need to identify “sensitive” parts of pathways
  - habits effects (occupancy, self-sufficiency, diet)
- regions
  - proximity to nuclear sites
  - presence of “sensitive” features
- social
  - Economic and social costs



## Vulnerable (or sensitive) ecosystems

- vulnerability to radioactive contamination can be considered in terms of the extent of radiation dose to man or biota
- regions, pathways or communities can all be considered to be vulnerable to radioactive contamination if they give rise to, or receive relatively high radiation doses

# Comparison of indigenous peoples in the Arctic

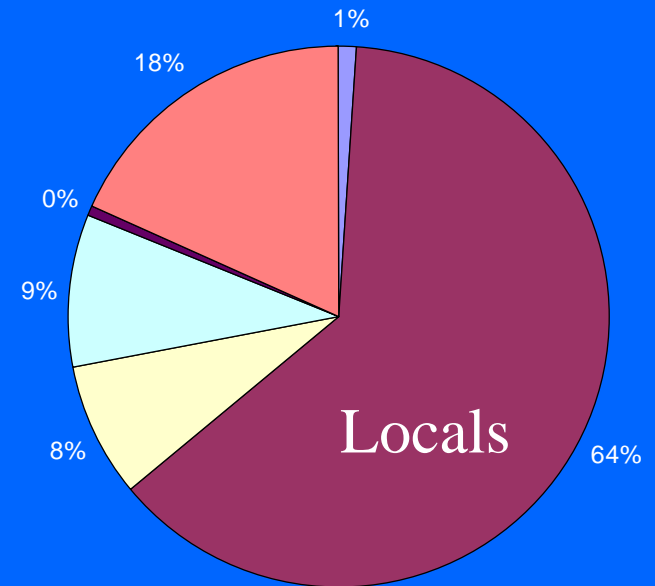
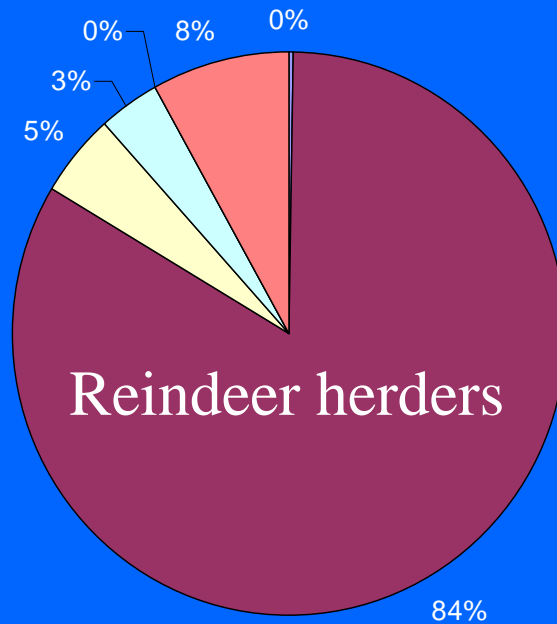


AMAP -Norway

AMAP - Russia

- Berries
- Mushrooms
- Fish
- Reindeer and wild Meat
- Meat (other)
- Fruit and vegetables
- Potatoes
- Cereals and Flour
- Milk and Cheese

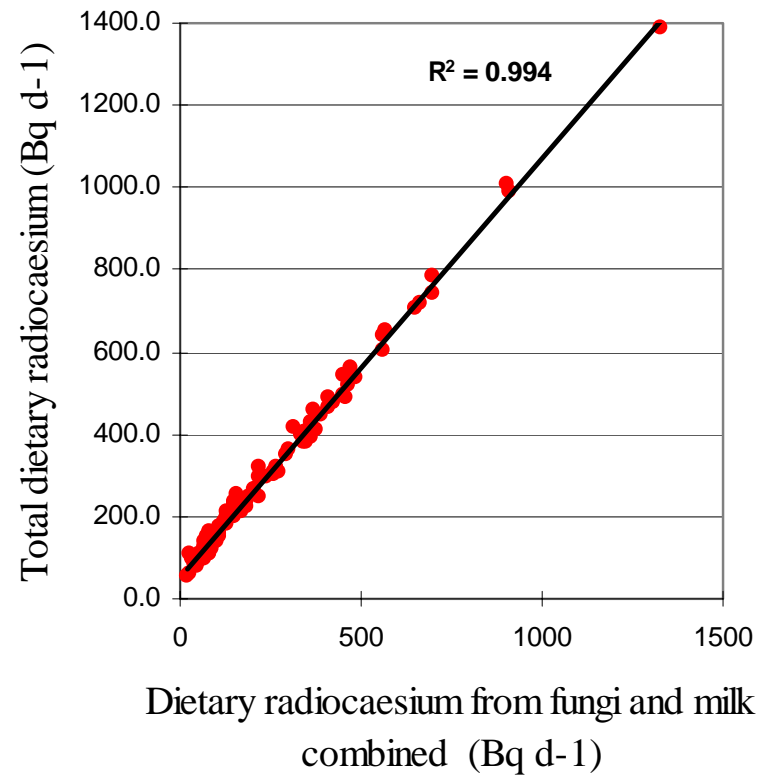
# Comparison of $^{137}\text{Cs}$ Dose in Lovozero



- |         |               |                 |
|---------|---------------|-----------------|
| Milk    | Reindeer meat | Mushrooms       |
| Berries | Potatoes      | Freshwater fish |

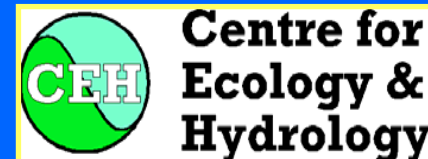


# Sources of $^{137}\text{Cs}$ for rural people in Chernobyl affected areas



# Vulnerability

## - quantification



### ☉ SPECIFIC

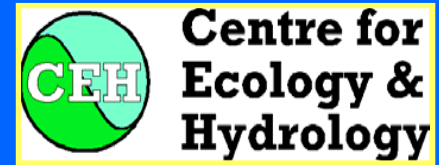
- **specific activity (Bq/kg) in a product**
  - **predicted using deposition, transfer coefficients and effective ecological half-lives**

### ☉ FLUX

- **total Bq output in a product (Bq)**
  - **needs estimates of production or rates of harvesting**

# Vulnerability

## -Spatial analysis



- compiling variation in food production and harvesting rates
- mapping the distribution of food products, especially wild foods
- quantification of transfer, relevant to soil type and species
- incorporating changes with time in contamination of important foodstuffs



## Vulnerable areas or groups

- **proximity to potential sources**
- **high precipitation rate**
- **high milk production rate dominance of “small” animals**
- **presence of semi-natural ecosystems**
  - **organic soils, forests**
- **special groups, with high consumption rates of contaminated products**
  - **mushroom foragers, game consumers**

# Vulnerability

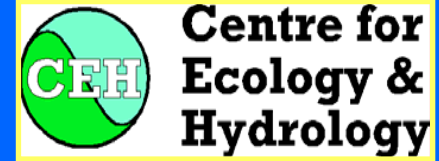
Generalizations can mask high individual exposure

Consideration of vulnerability at a small spatial scale can improve estimates of:

- collective dose
- individual dose
- provide guidance on uncertainties


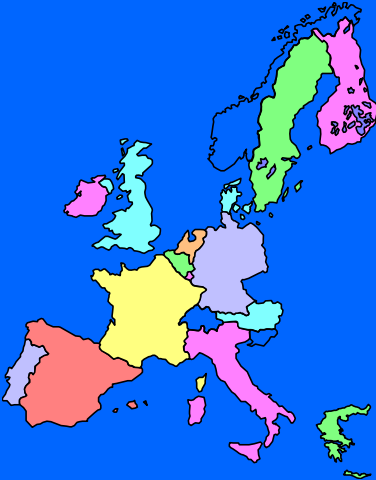

# Vulnerability

- emergency response



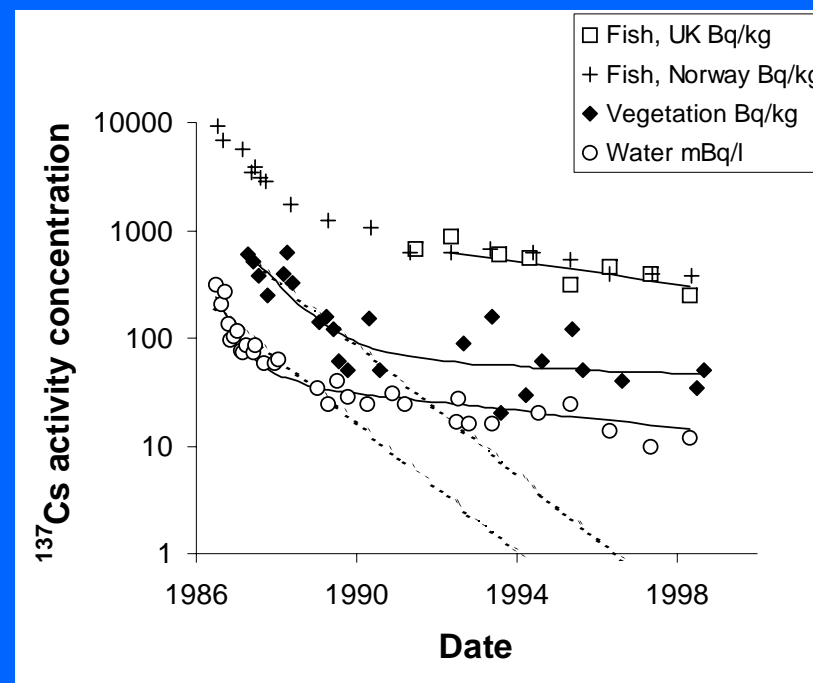
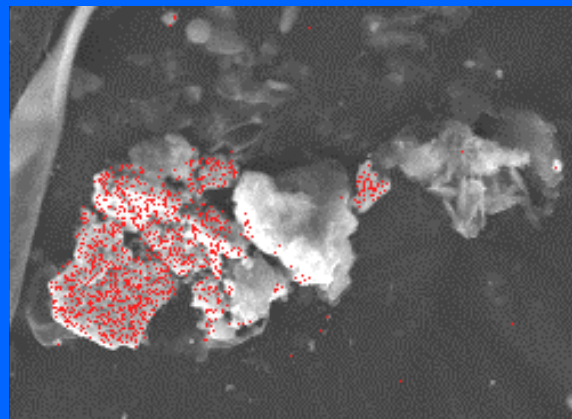
- prior studies of vulnerability and its spatial and temporal variation can identify areas, and types of foods which would be contaminated above intervention limits
- Identification of vulnerable areas, combined with contamination maps can guide monitoring and implementation of countermeasures

# Radioecological sensitivity

-  Radionuclide specific
- Spatially variable 
-  Time dependent

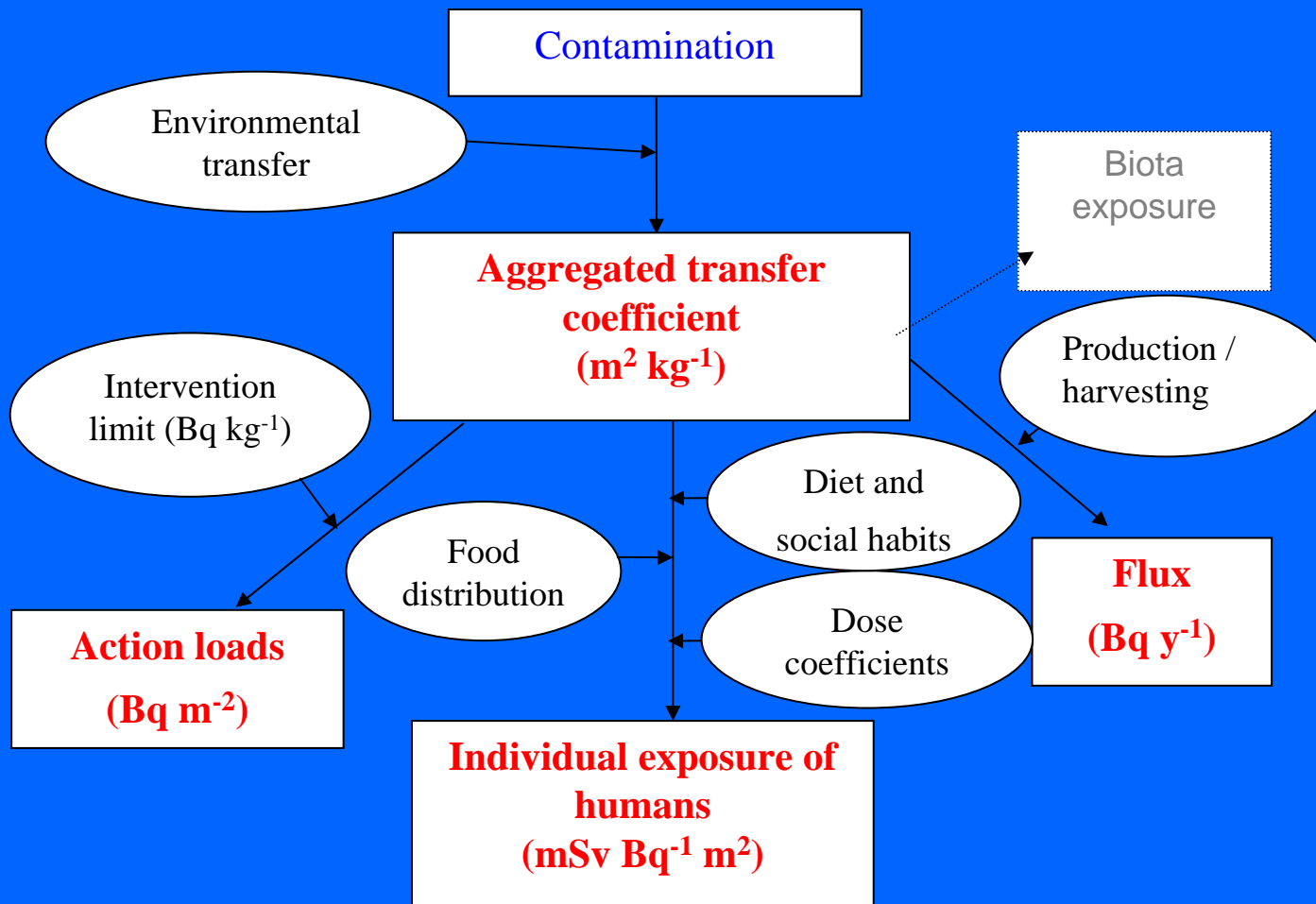
# Time dependency

- speciation effects
- ecological half-lives
- acute vs mid-long term
  - surface effects
  - seasonality





# Quantification



# Radionuclide transfer

- Environmentally mobile radionuclides

- Cs, Sr, I



- Radionuclide with high accumulation factors

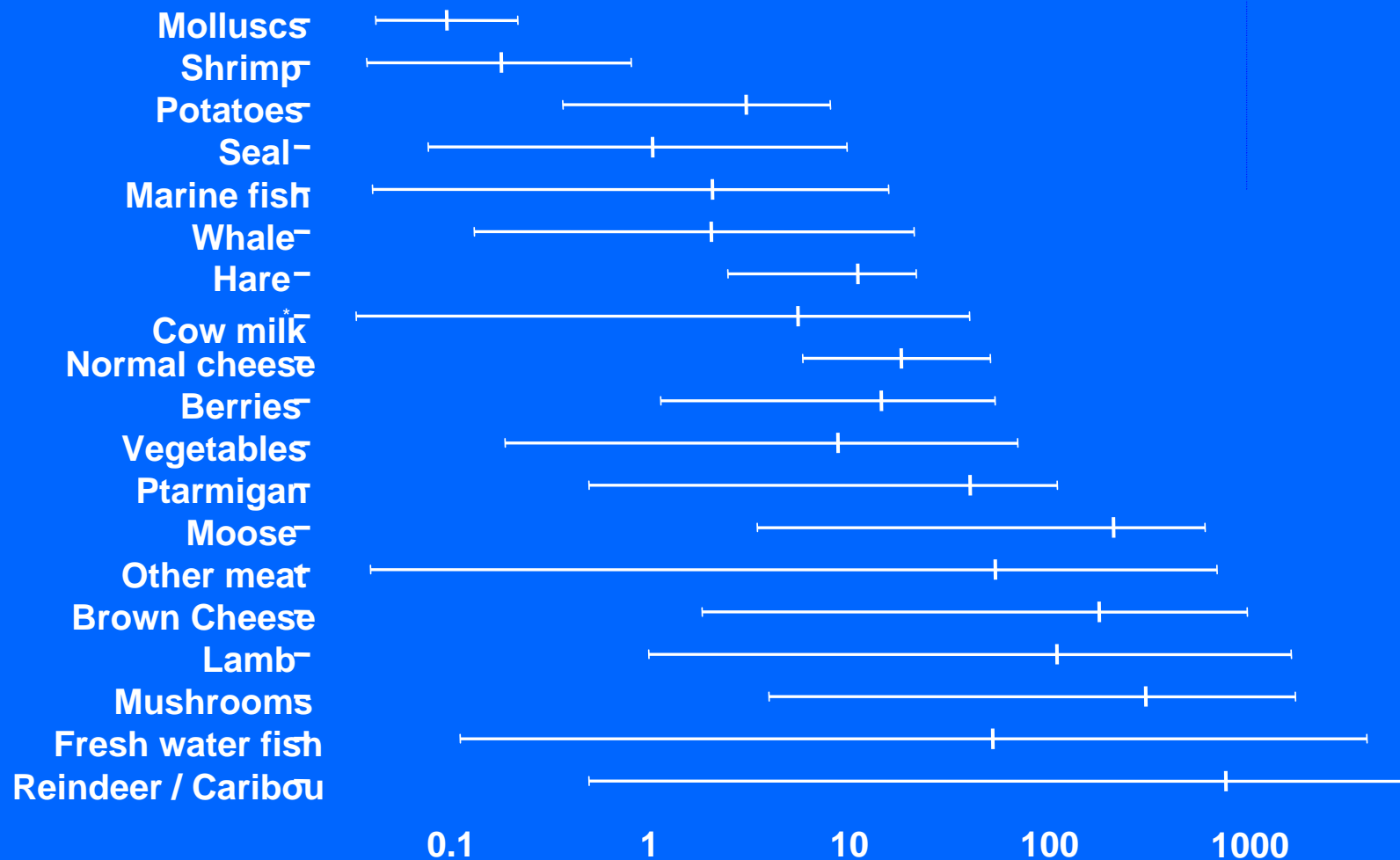
- Tc and lobsters



- Ru/Tc and seaweed

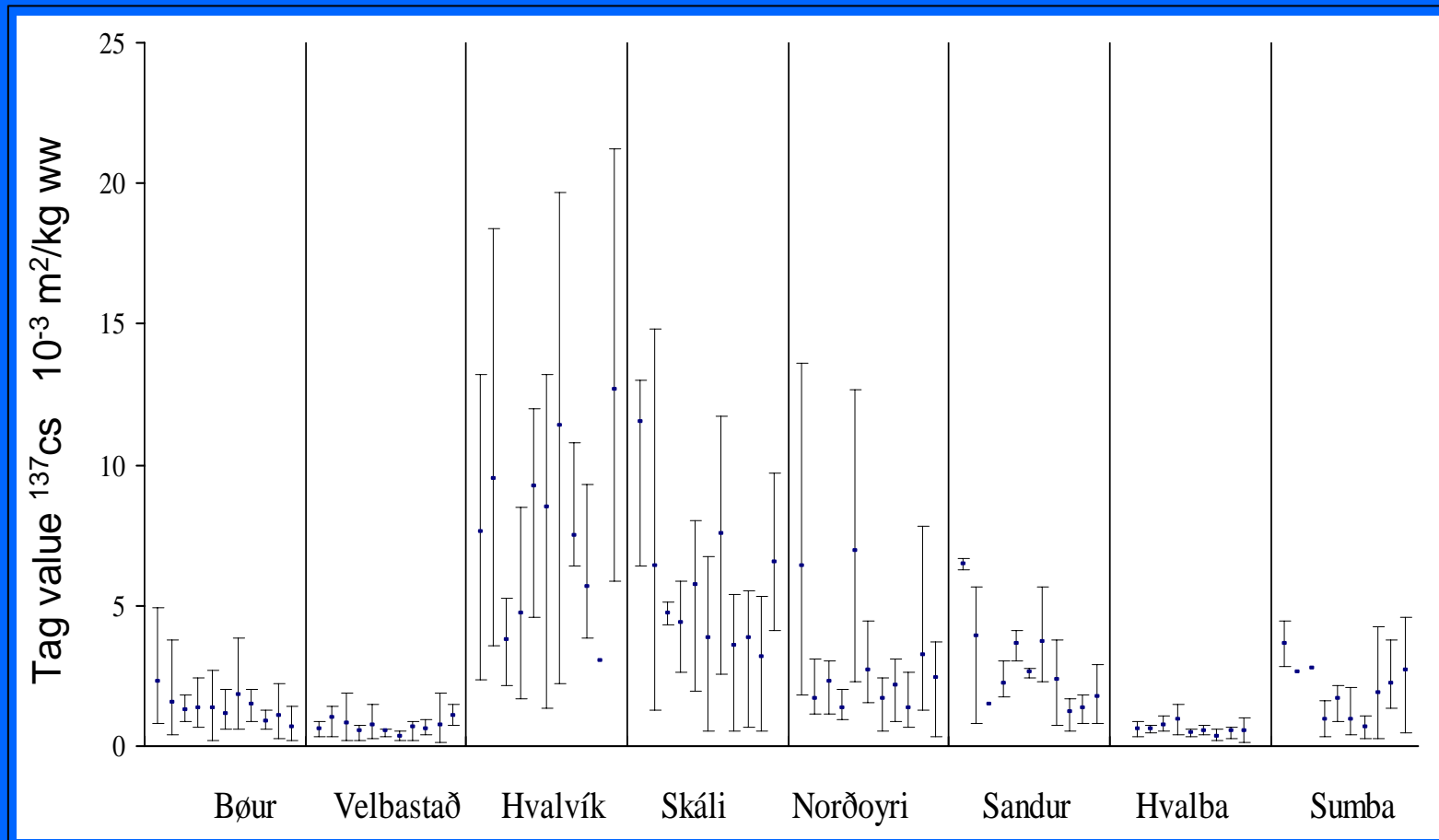


# Radiocaesium contamination of Arctic foodstuffs

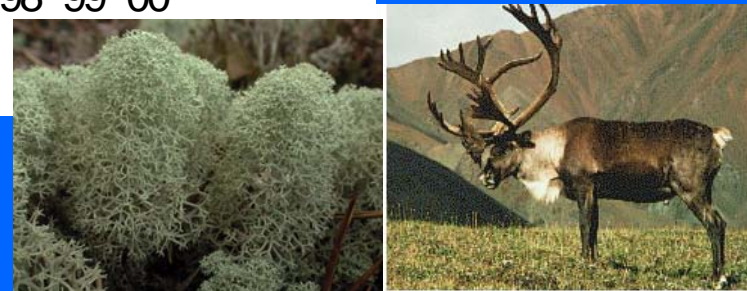
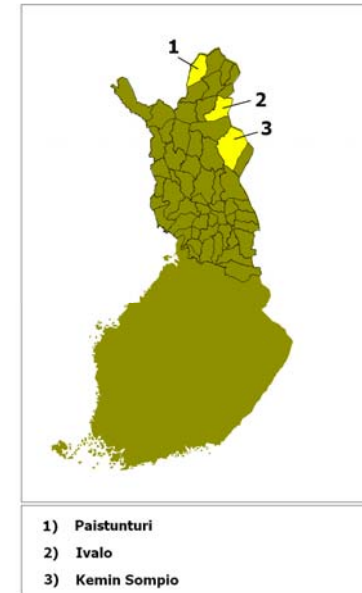
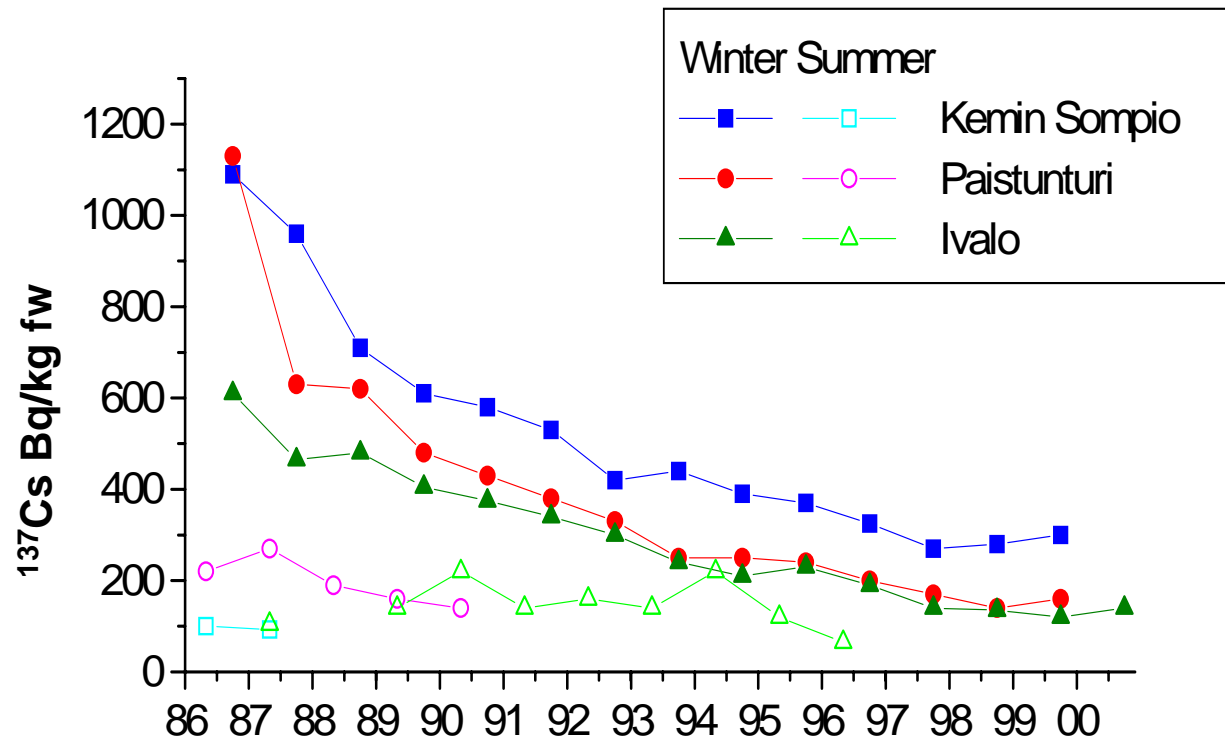


# Site studies – Faroe Islands

## Cs-137 transfer to lamb meat, 1990-2000



# Reindeer- Finland



# Fluxes

- Activity concentrations **and** production rates
- Fluxes
  - The total amount of radioactivity transferred to Man or leading to exposure of biota

$$\text{Flux: Bq m}^{-2} * \text{m}^2 \text{ kg}^{-1} * \text{kg y}^{-1} \Rightarrow \text{Bq y}^{-1}$$

- Dependent on
  - transfer rates
  - production
    - Intensive, extensive
    - quantities

# Critical load concept

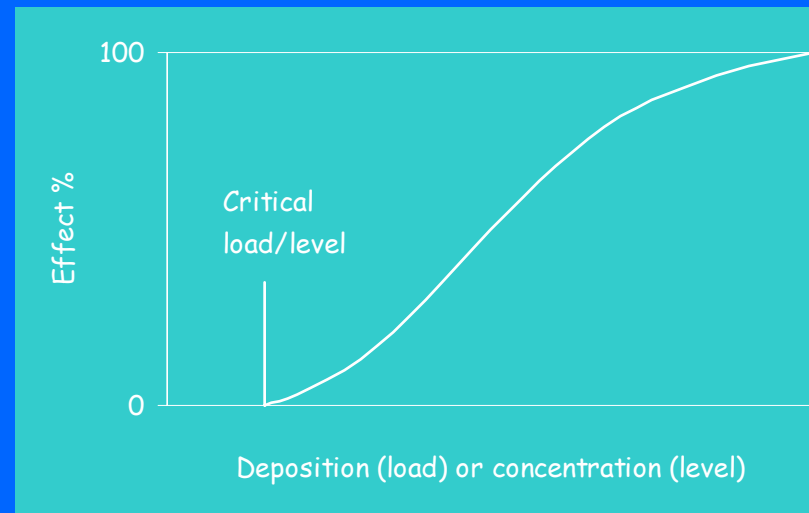
The highest pollution load for which there are  
no **negative** effects on the environment

Considers deposition, transport and retention

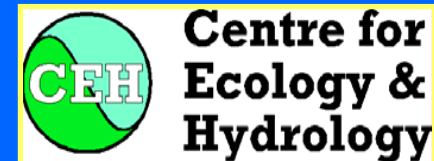
Comparison with standard values characterising impact (or upper acceptable limits)

- uses “significant harmful effects” concept

- emphasis on  
ecosystem functioning  
/population interactions



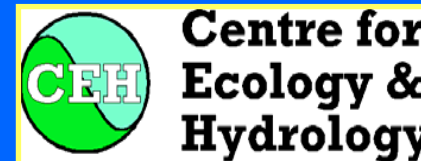
# Intervention limits in the EC



Radionuclides	Maximum Permissible activity levels in foodstuffs (Bq kg <sup>-1</sup> )			
	Baby Food	Dairy Products	Other Products	Liquid food
Caesium	400	1000	1250	1000
Iodine	150	500	2000	500
Strontium	75	125	750	125
Plutonium	1	20	80	20



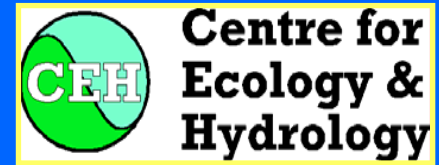
# Action or Critical loads



- The amount of radionuclide deposition necessary to produce radionuclide concentrations in food products exceeding intervention limits for areas used in the production or harvesting of foodstuffs
- Action load– short term (surface)
- Critical load – mid-long term

# Critical Load

## - radioecological perspective

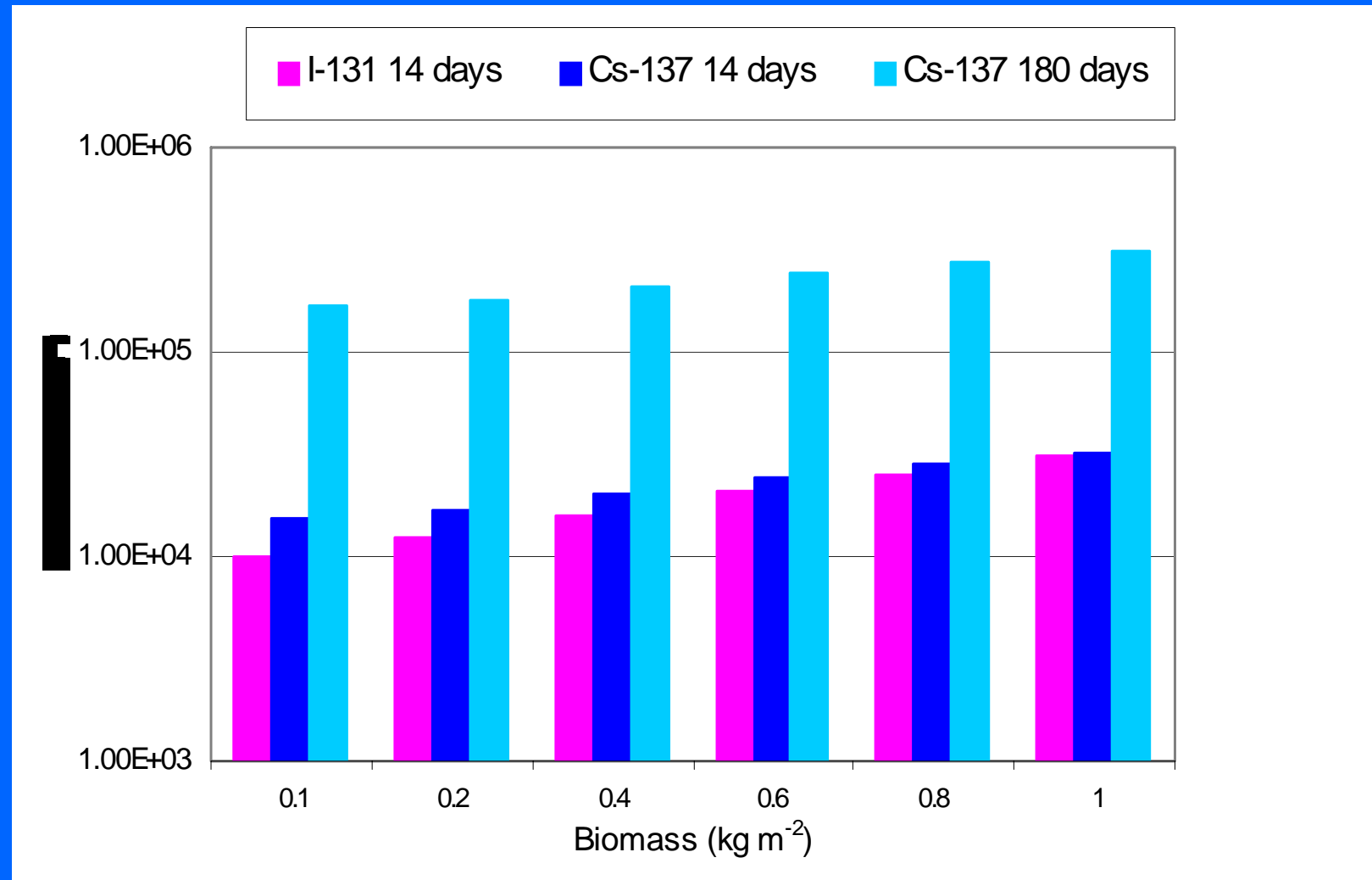


The deposition level of a specific radionuclide which results in an activity concentration in a foodstuff equal to the intervention level

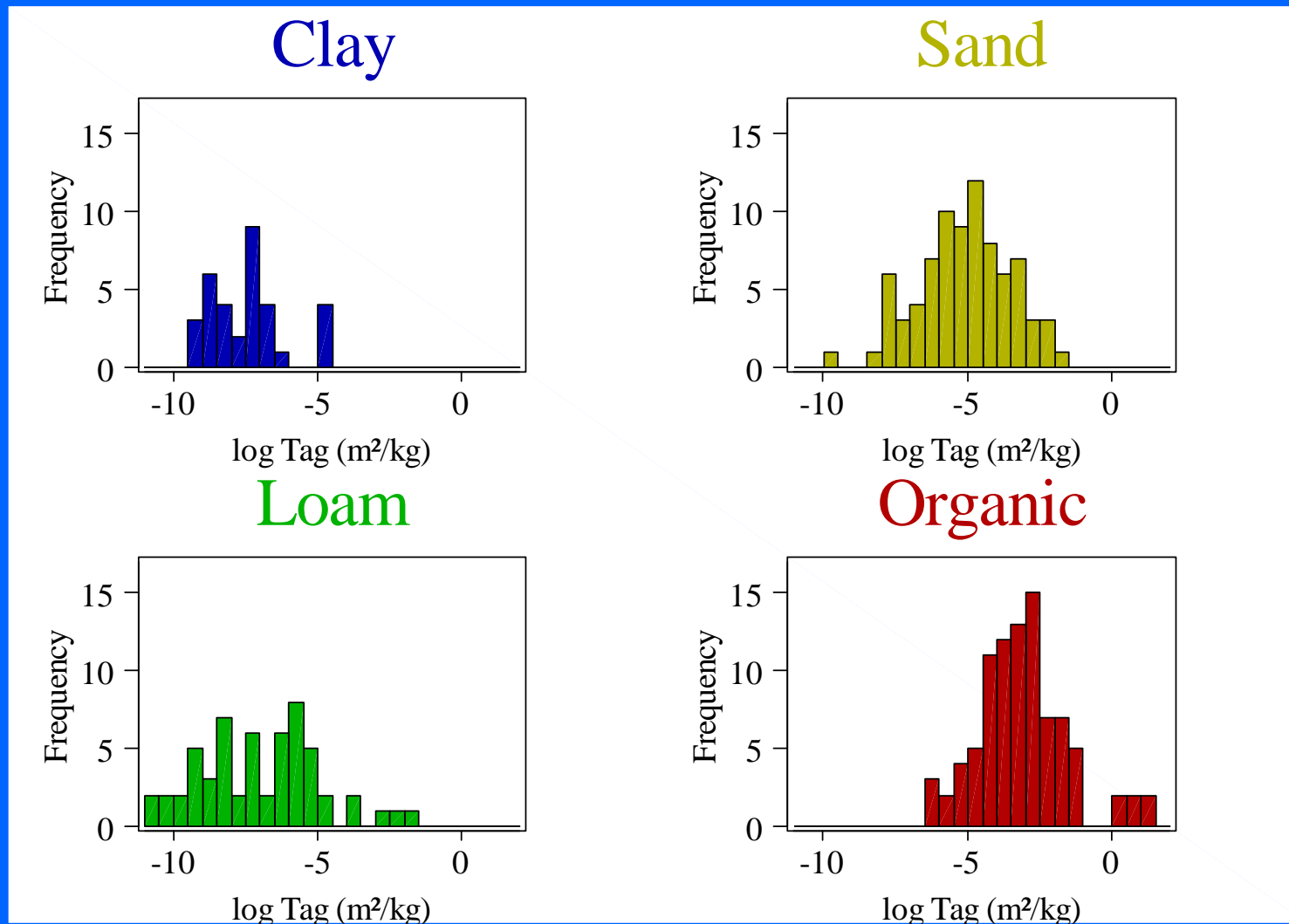
dependent on:

- soil type
- pathway considered
- agricultural practice

# Action loads – Agroland predictions



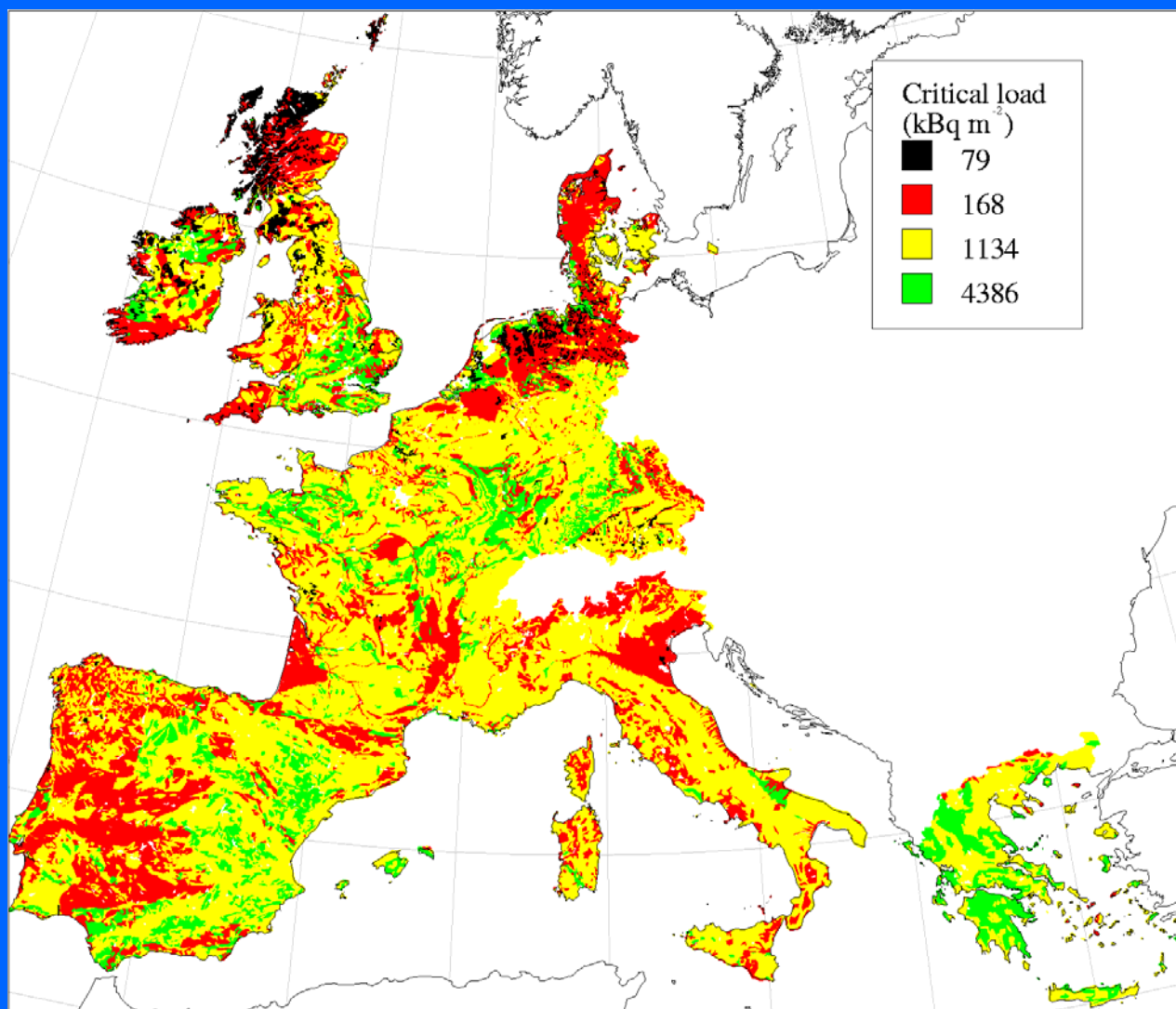
# Variation in radiocaesium Tag with soil category



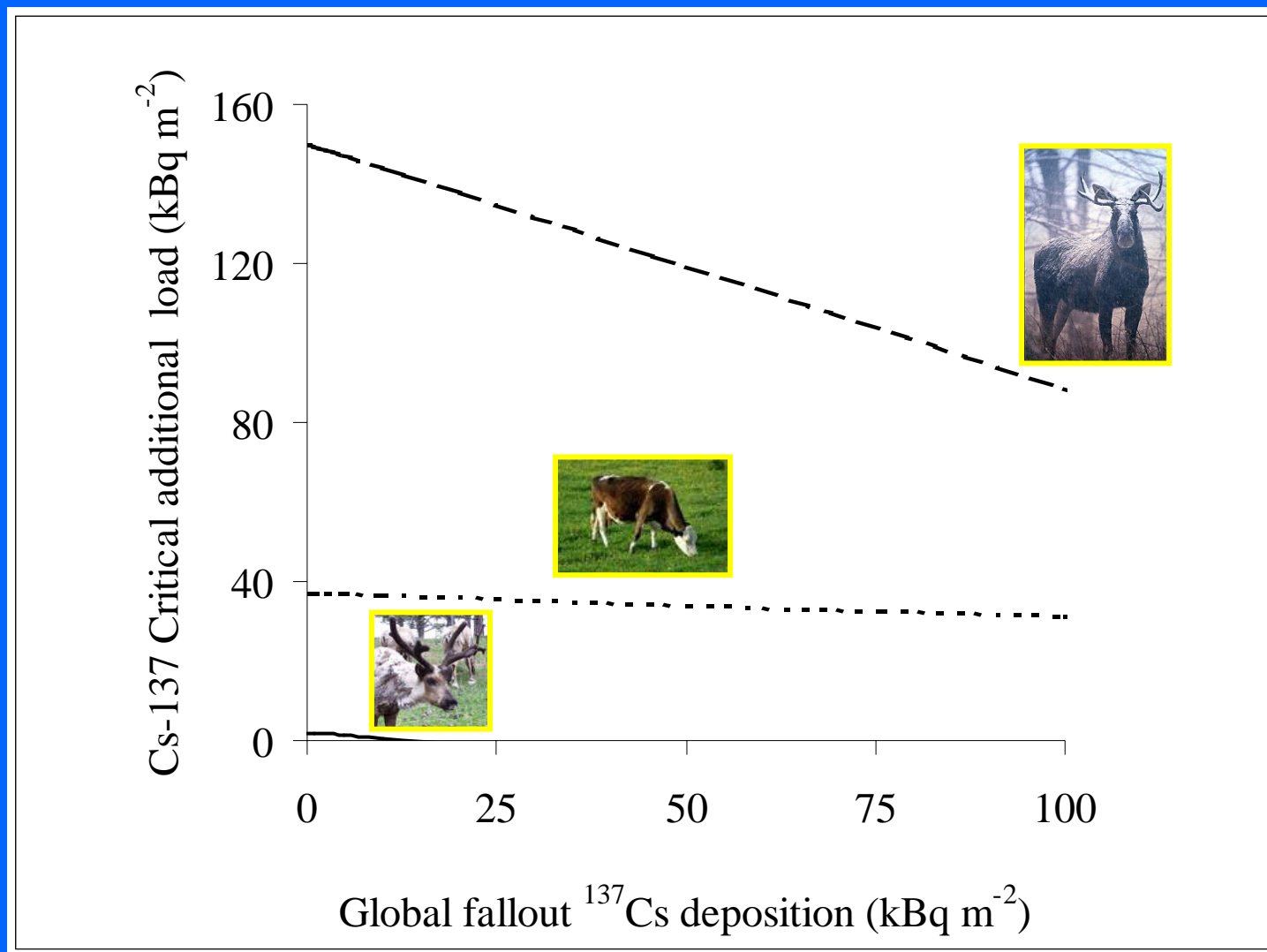
# Critical load for mid-term $^{137}\text{Cs}$ transfer to milk



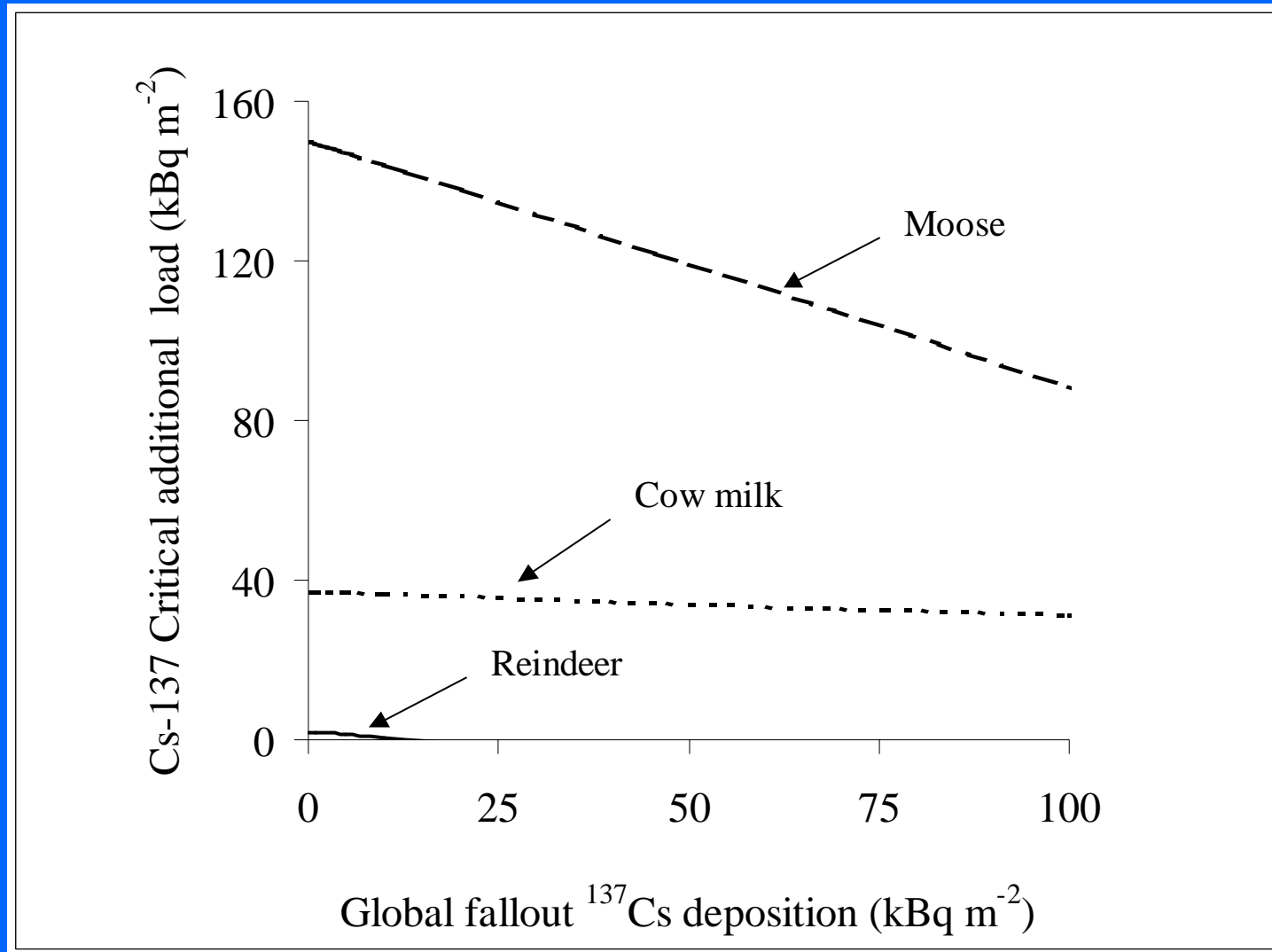
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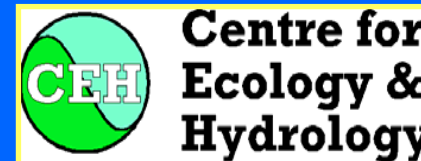
# Additional critical loads for $^{137}\text{Cs}$ in arctic systems



# Additional critical loads



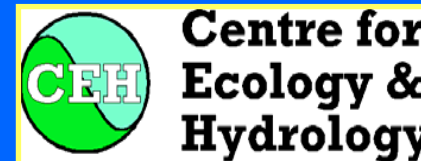
# Action or Critical loads



- Potential method of addressing issues of vulnerability to radionuclide contamination
- Can be defined as the amount of radionuclide deposition necessary to produce radionuclide concentrations in food products exceeding intervention limits for areas used in the production or harvesting of foodstuffs

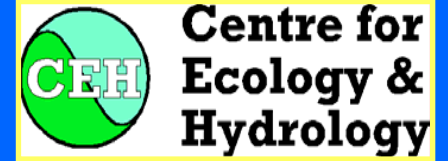


# Application



- Policy and planning
  - Prior identification of “sensitive” pathways, areas, communities and individuals
  - Environmental impact assessment for location of nuclear facilities
- Targeted routine sampling
- Improved, better focused emergency response
- Identify data requirements

# WG 8 ?



- Critical and/or action loads?
- Doses to biota (co-op with Theme 2)