Arctic Scenario

Bliss L. Tracy

Canada

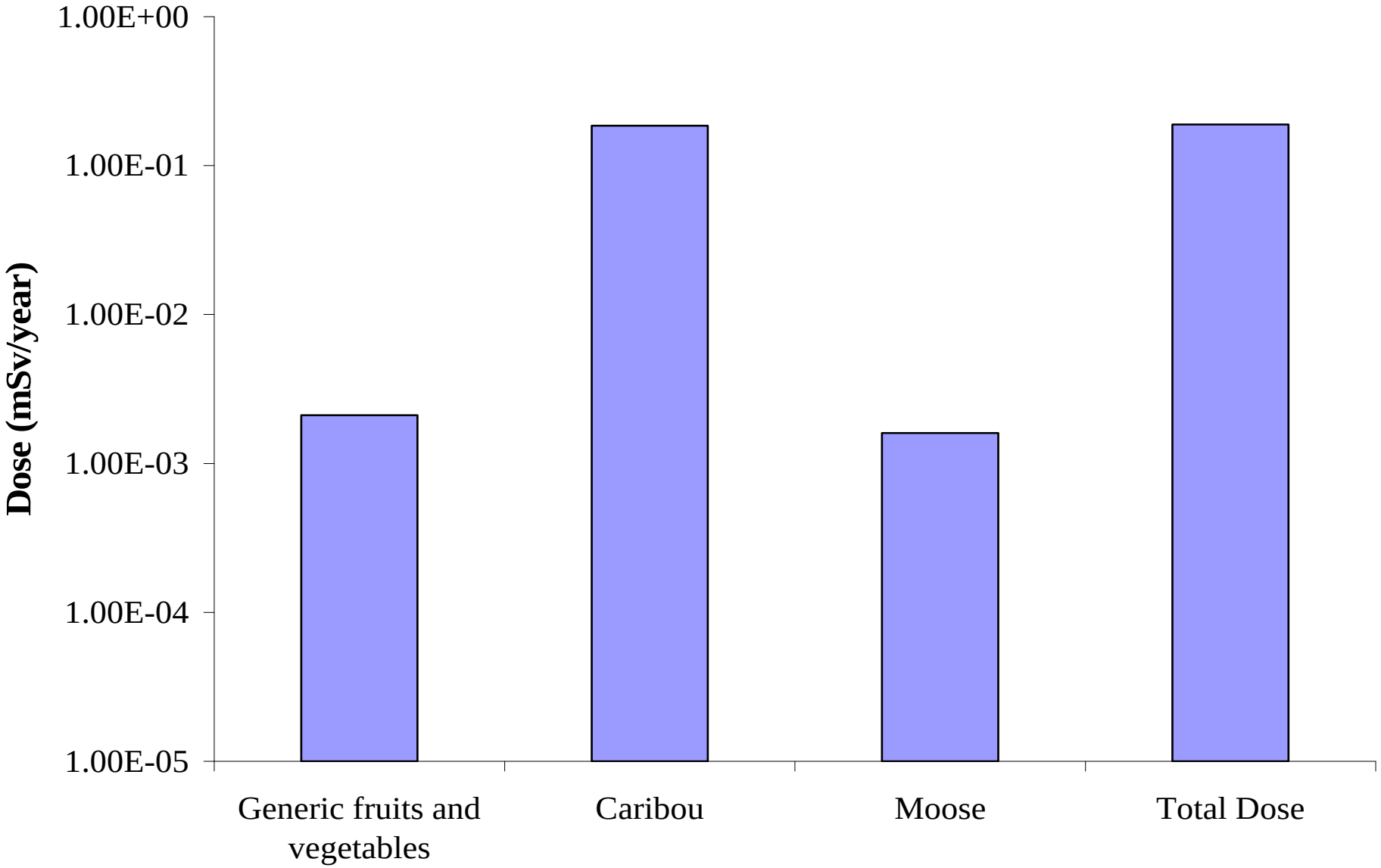
5th Meeting of EMRAS-II Working Group 8

“Environmental Sensitivity”

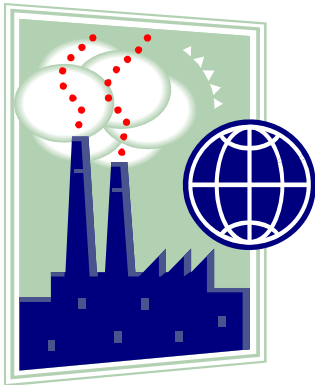
Brussels

27-28 September 2011

Arctic scenario -- Cs-137 adult doses



Lichen → Caribou Pathway



Radionuclide source

Long range transport

Deposition

Humans

Wolves, etc.

Caribou or reindeer

Lichens

1. Uptake by Lichens

Lichen concentration (Bq/kg dw) =
Deposition (Bq/m^2) x transfer factor (m^2/kg)

Cs-137 deposition = 1000 Bq/m^2
Transfer factor = 1.0 m^2/kg dw

Lichen concentration = 1000 Bq/kg

2. Uptake by Caribou or Reindeer

Concentration in meat (Bq/kg) =

Concentration in lichens (Bq/kg dw)

x lichen forage rate (kg dw/day)

x absorption factor in the animal (dimensionless)

x biological halftime in animal (days)

/{ln(2) x mass of animal (kg)}

Lichen forage rate = 2.5 kg/d (range = 2 – 5)

Absorption factor = 0.65 (range = 0.25 – 0.65)

Half-time in the animal = 20d (range =10-35)

Mass of animal = 80 kg

Concentration in meat = 586 Bq/kg

As a reality check, we note that measurements in Finnish reindeer herds (TRS472, page 362) taken during the winter following the Chernobyl accident (when lichen feeding would have been greatest) showed aggregated transfer coefficients for ^{137}Cs reindeer of 0.15 to 0.84 m^2/kg, with a geometric mean of 0.46 m^2/kg. If this value is applied to our given deposition of 1000 Bq/m2, then the concentration in reindeer meat would be **460 Bq/kg**, close to our model estimate above.

3. Dose to Humans

Adult dose (mSv/year) =

Concentration in meat (Bq/kg)x human consumption rate (kg/year)

ingestion dose coefficient (mSv/Bq)

Consumption rate = 23.7 kg/year

(Baker Lake, males, 1989-90)

Dose coefficient = 1.3 x 10^{-5} mSv/Bq (ICRP-72)

Dose = 0.181 mSv during year following deposition

Assumptions

- **The deposition occurs in late winter or early spring when caribou are still feeding on lichens**
- **By the time of harvest, the caribou have been feeding long enough (several half-times) for their body burdens to reach equilibrium.**
- **These concentrations are maintained in the animals for the entire year. This would be true if the caribou meat from a good harvest were frozen and consumed over an entire year**.

Cs-137 adult doses from various pathways

Caribou	**0.181**
Moose	**0.0016** (*aggregate transfer*)
Fruit & berries	**0.0021** (*aggregate transfer*)

Forest scenario -- Cs-137 doses

(Bliss Tracy & Lauren Bergman, Health Canada)

Adult dose during first year (μSv/year)

Environment	Cs-137	Sr-90	I-131
Agricultural (CHERPAC)	1931	288	467
Agricultural (RODOS)	148	161	42
Arctic (Health Canada)	2050	1010	2.6
Forest (Health Canada)	31	3	0.09
Forest (CHERPAC)	23	0.50	0.51
Freshwater Heimdalsvatn	2.9 (1.6)†	420 (0.67)	-------
Freshwater Bracciano	2 (0.12)	150 (0.025)	-------
Marine coastal (Ob Bay)	2.86	0.51	10

† numbers in brackets do not allow for irrigation of agricultural land

Animal product showing highest concentration

Environment	Cs-137	Sr-90	I-131
Agricultural (CHERPAC)	beef	milk	----
Agricultural (RODOS)	lamb	milk	milk
Arctic (Health Canada)	caribou	----	----
Forest (HC terrestrial)	caribou	moose	
Forest (CHERPAC)	fish	fish	fish
Freshwater Heimdals	fish	fish	----
Freshwater Bracciano	fish	fish	----
Marine coastal	fish	fish	sea weed