

# Human Health and Ecological Risk of Contaminated Lands Under Climate Change: A Case Study of Oil Fields of Northern British Columbia

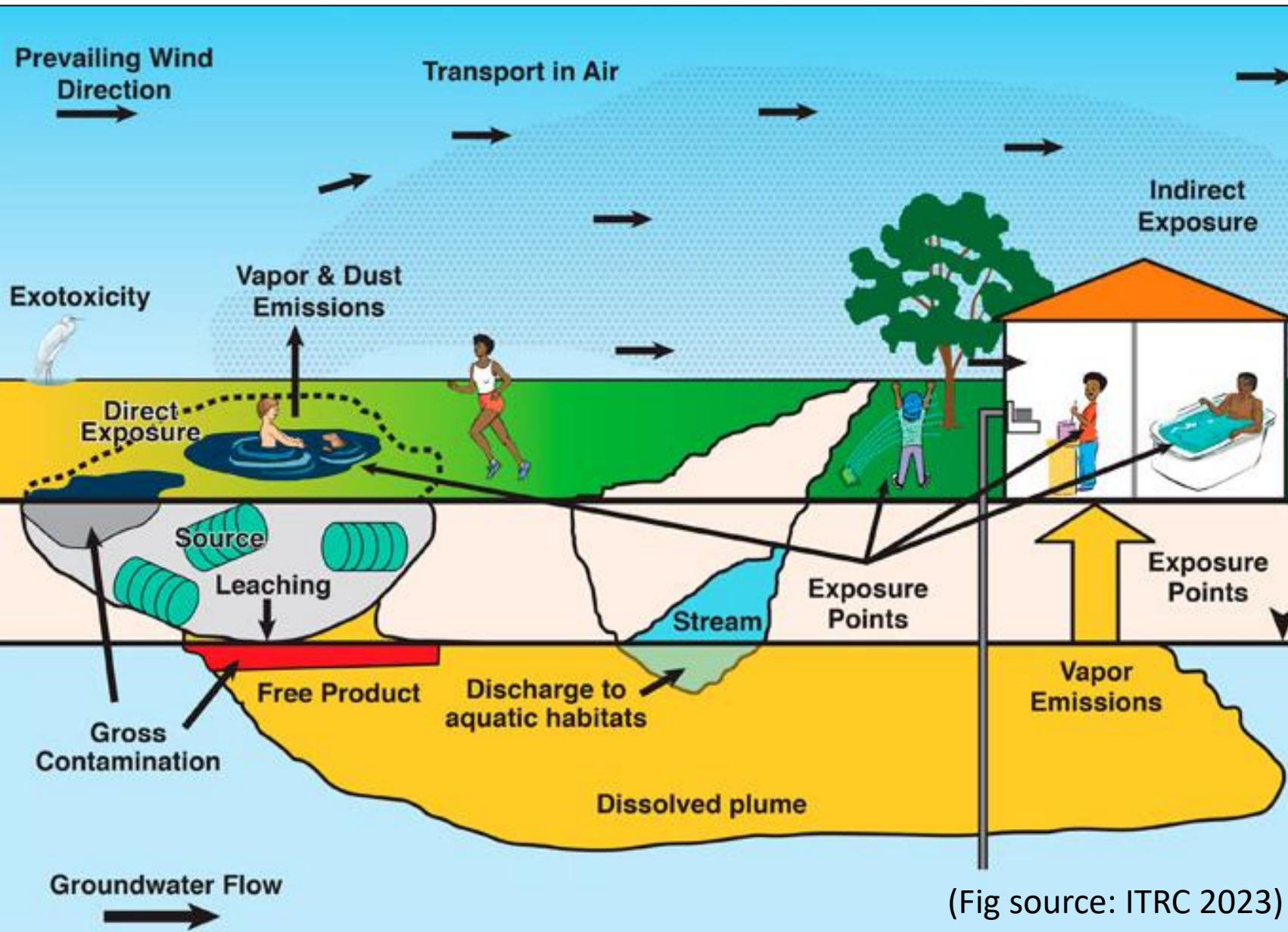
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## Climate Change Impact?

- Increased temperature (Human activities, Vegetations, Agriculture, Geochemical processes etc.)
- Changing precipitation (flooding, desertification)
- Wildfires
- Sea level rise, etc.



# Content

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1. Introduction
2. Objectives
3. Methodology
4. Results and Discussion
5. Conclusions and Recommendations



# Introduction

- ❑ Northern British Columbia (BC) comprises of **vast area of oil fields.**
- ❑ These **oil fields are drilled** for advancing wells for producing oil and gas (well sites).
- ❑ Drilling for producing oil and gas uses different types of **chemicals.**
- ❑ **Drilling wastes** thus generated are necessary to be properly managed.



Source: Sharif et al. 2017

# Introduction ...

- ❑ Improper management of drilling waste **contaminates** the soil and/or groundwater and pose **human health and ecological risks**.
- ❑ These risks may further be **altered by climate change**.
- ❑ Contaminated sites are regulated by **BC CSR** under BC EMA.
- ❑ **CSR is yet to endorse** legislation to deal with climate change in contaminated lands.

\*CSR: Contaminated Sites Regulation, EMA: Environmental Management Act



# Climate Change Impacts on Contaminated Sites

- Increase in number of growing days - agriculture and natural vegetation
- Increase in vegetable consumption onsite
- Decrease in freezing days
- Decrease in depth of frozen ground
- Increased microbial activity (if water is present) – Natural Attenuation
- Enhanced geochemical reactions
- Others: flooding/desertification, wildfires, sea level rise, etc.



# Objective

Study the impacts of climate change on human health risk and ecological risk of contaminated lands in the oil fields of northern BC.



# Methodology

- Study Area: Dormant well site in northern BC
- ❑ Wellsite drilled in 1960s.
- ❑ **GPRS survey, advance boreholes, and collect soil** from various boreholes around wellhead (2023)
- ❑ **Lab analysis** of soil samples
- ❑ Collect data on **normal climate** (1950 - 2070) (min, max temp.)
- ❑ Collect **future climate** (2040 – 2060) under climate change using downscaled data for wellhead site using BCCAQv2 model under RCP 8.5 (min, max temp.) (Pacific Climate Impacts Consortium 2023)
- ❑ Determine **number of growing days** (starts  $\geq 5^{\circ}\text{C}$  for 5 continuous days for cold season crops)
- ❑ Determine **number of freezing days**





# Methodology ...

- ❑ Assessed **human health risks** using Human Health Risk Assessment Framework (4 steps):
  - a) Hazard identification – e.g., heavy metals
  - b) Exposure assessment – estimate amount of chemicals entered to body (soil ingestion, dermal contact, food ingestion etc.) using concentration data
  - c) Dose-response assessment – toxicity evaluation of doses
  - d) Risk Characterization: Non-Cancer risk (Hazard Quotient  $\leq 1$  acceptable) and Cancer risk ( $\leq 1 \times 10^{-6}$  acceptable)
- ❑ Health Risk: **Farm workers**



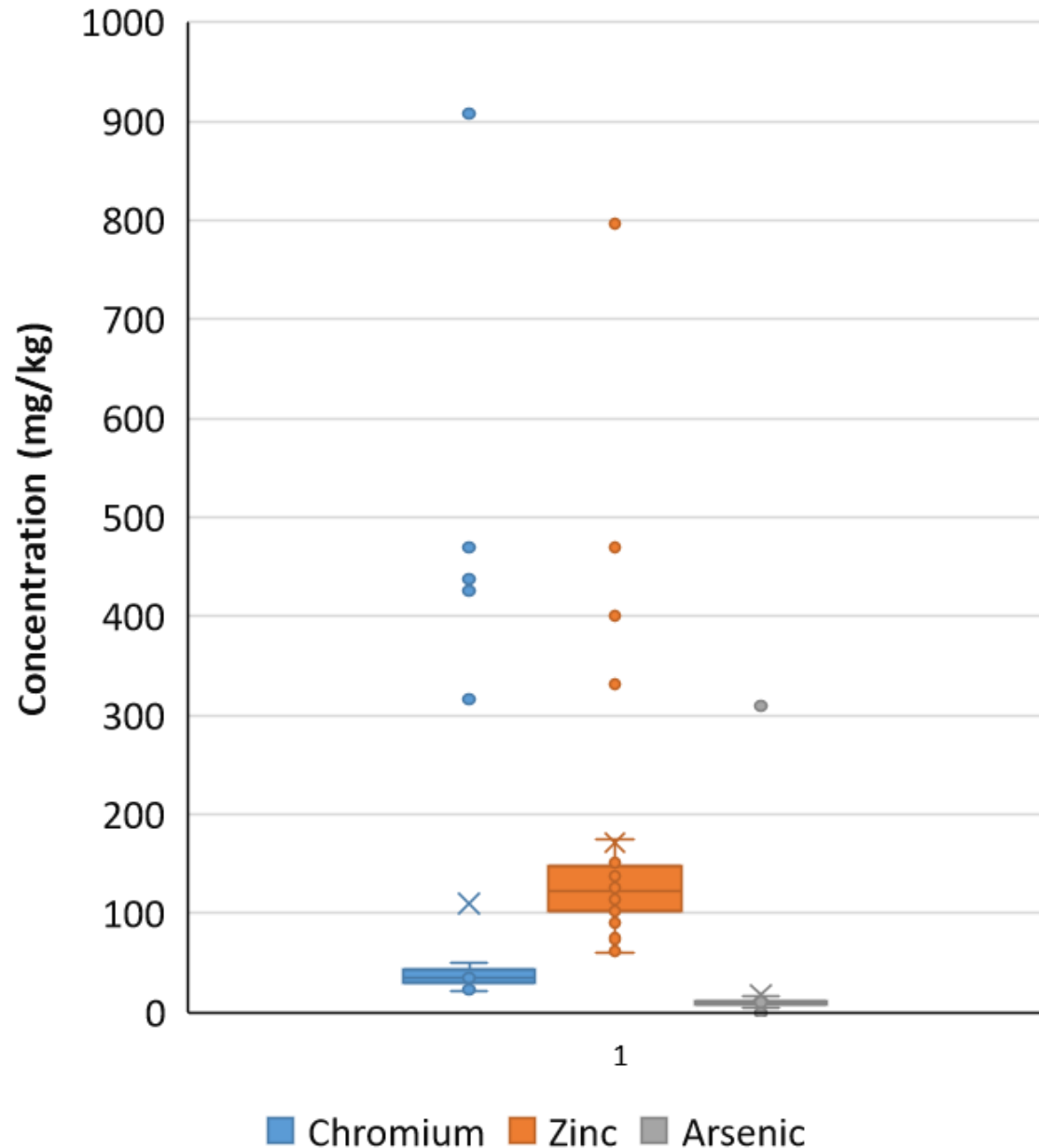
# Methodology ...

- Assessed **ecological risk** using the Ecological Risk Assessment Framework (Govt of Canada 2012) (4 steps):
  - a) Problem Formulation – e.g., identification of heavy metals
  - b) Exposure assessment – estimate amount of chemicals entered to body (soil ingestion, food ingestion, water ingestion etc.) using concentration data
  - c) Effects assessment – ecotoxicity evaluation of doses
  - d) Risk Characterization: Ecological risk (Hazard Quotient  $\leq 1$  acceptable)
  
- Ecological risks – Ruffed grouse, Meadow Vole and White tailed deer

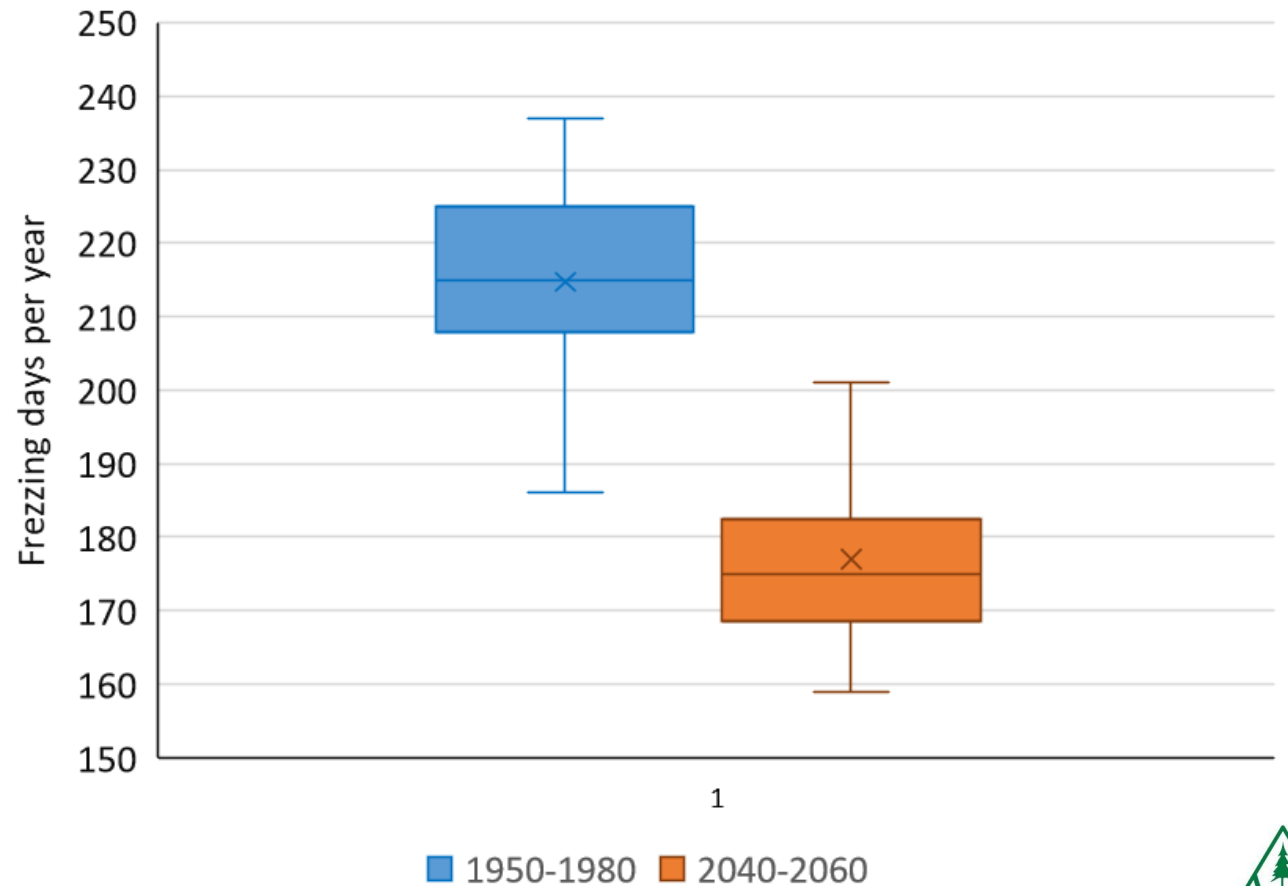
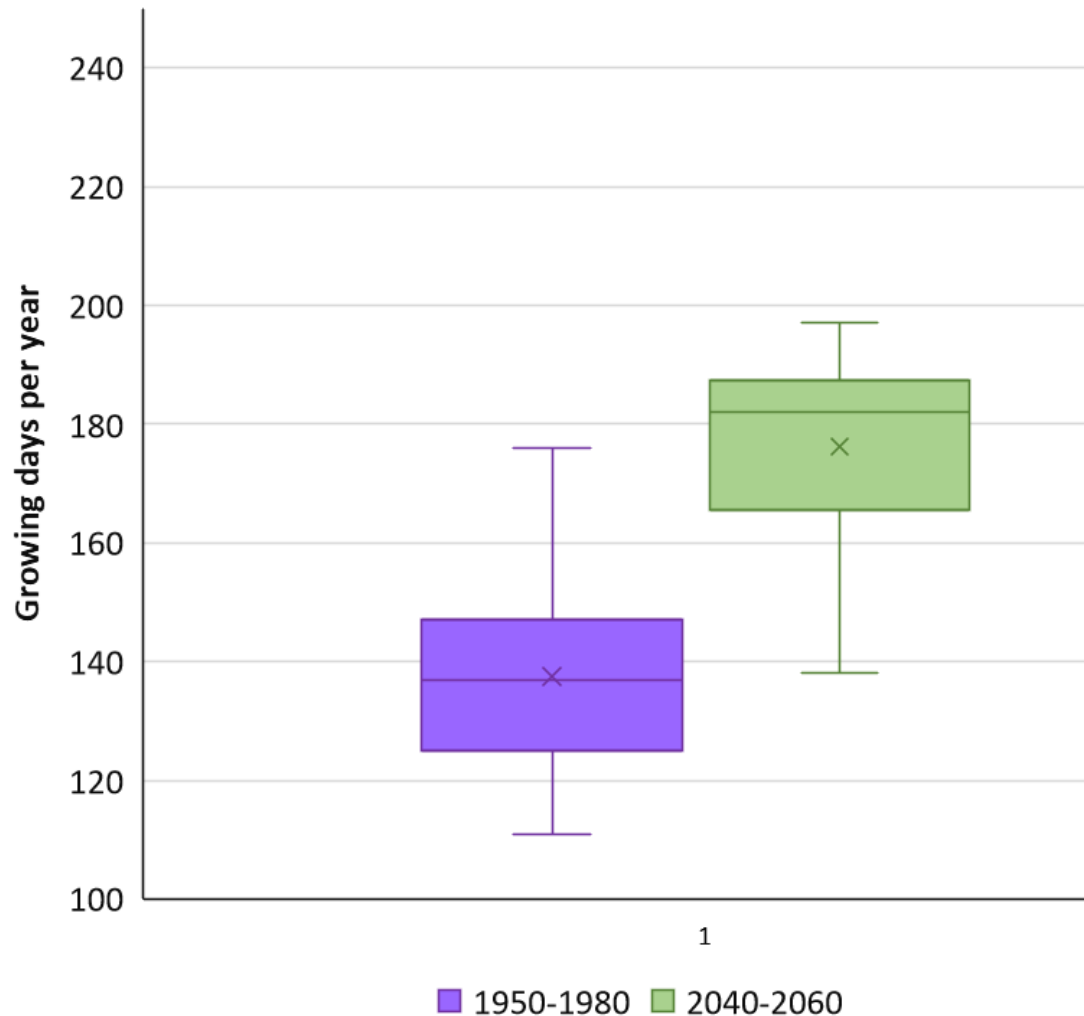


# Results and Discussion

- ❑ Chemical Concentration in soil (Figure)
- ❑ Future land use of the well site is Agriculture land use (AL)
- ❑ Per CSR, AL applies near well site for depth  $\leq 2$  m

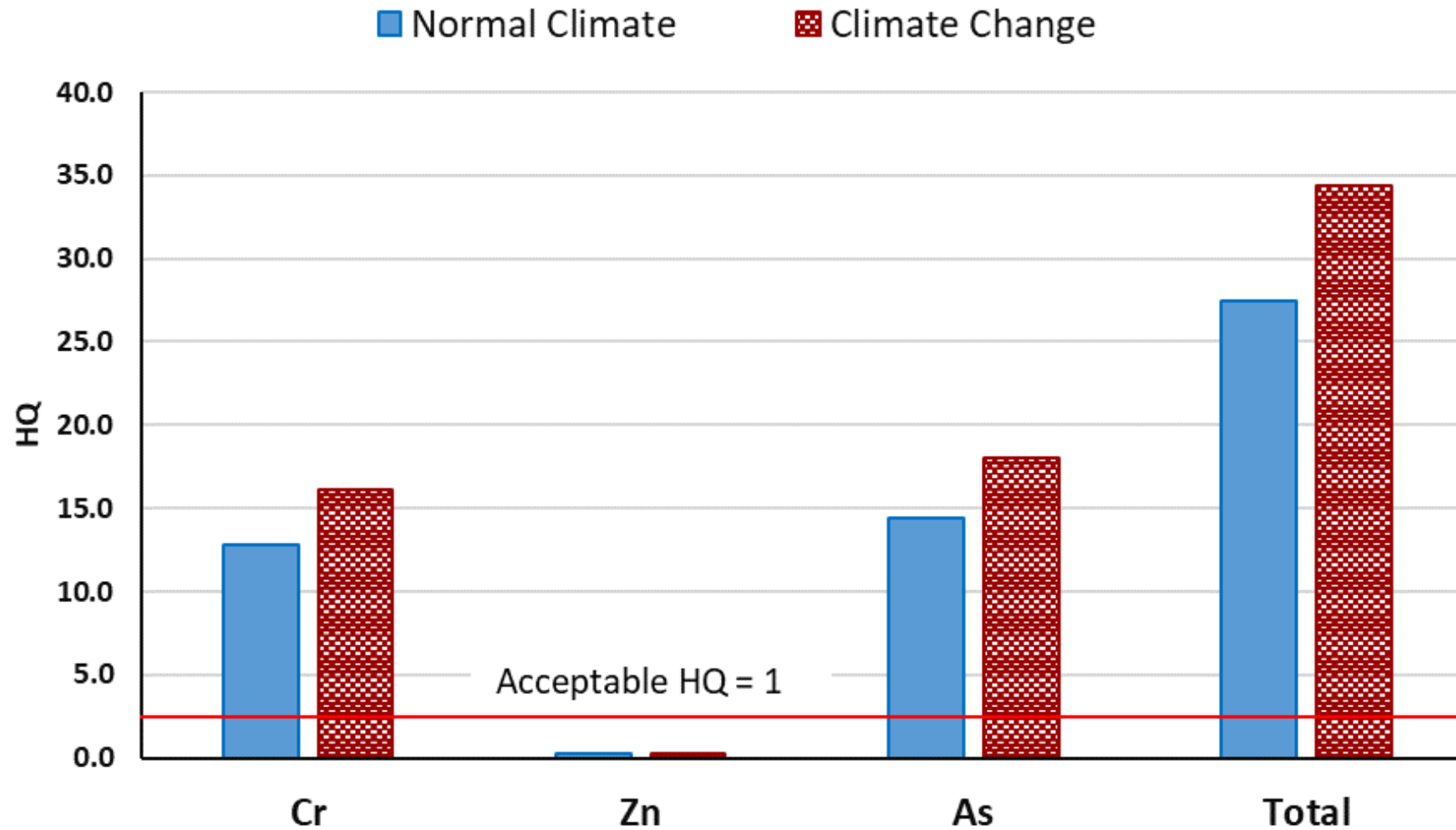


# Growing Days and Freezing Days under Climate Change

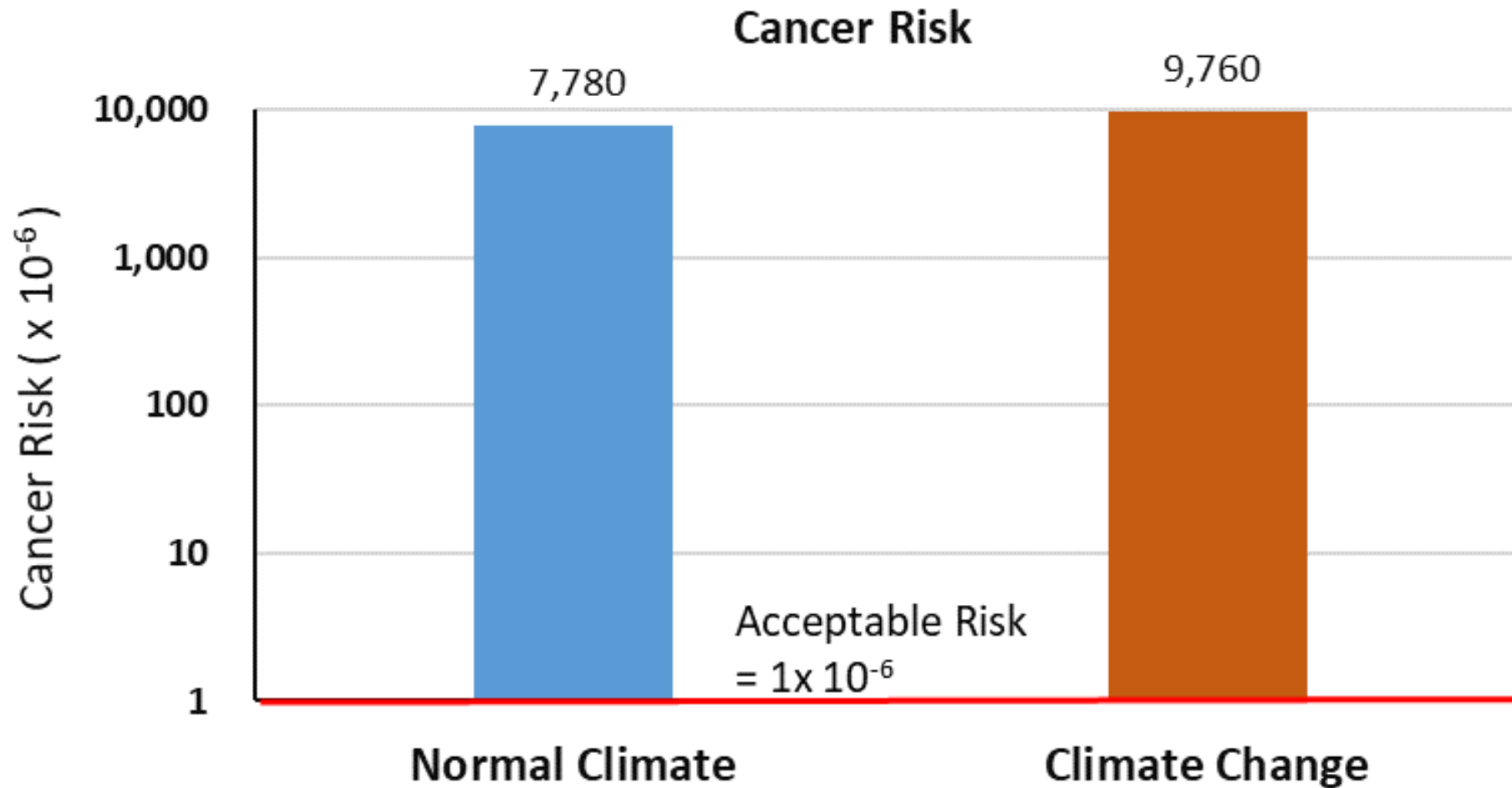




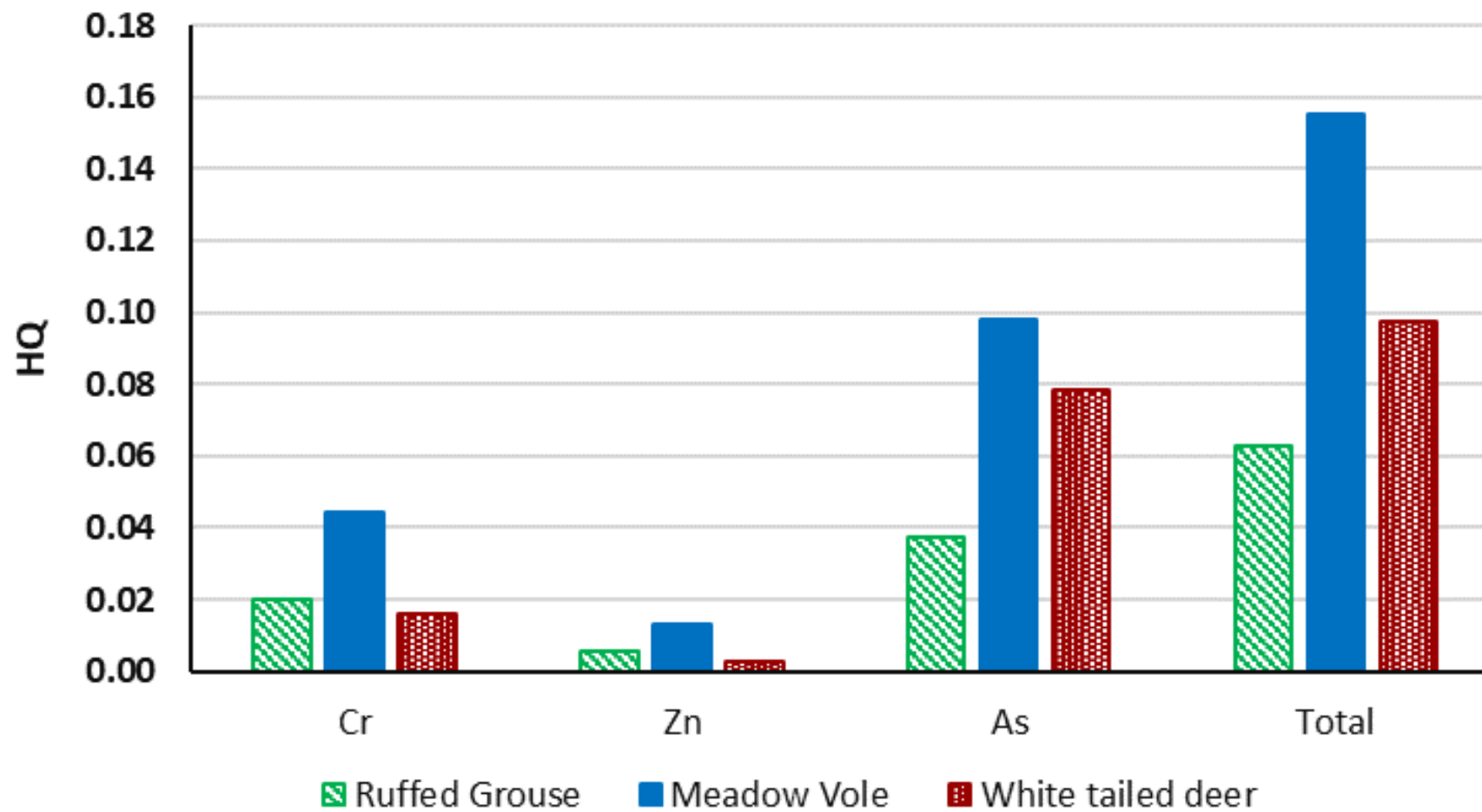
# Human Health: Non-Cancer Risk



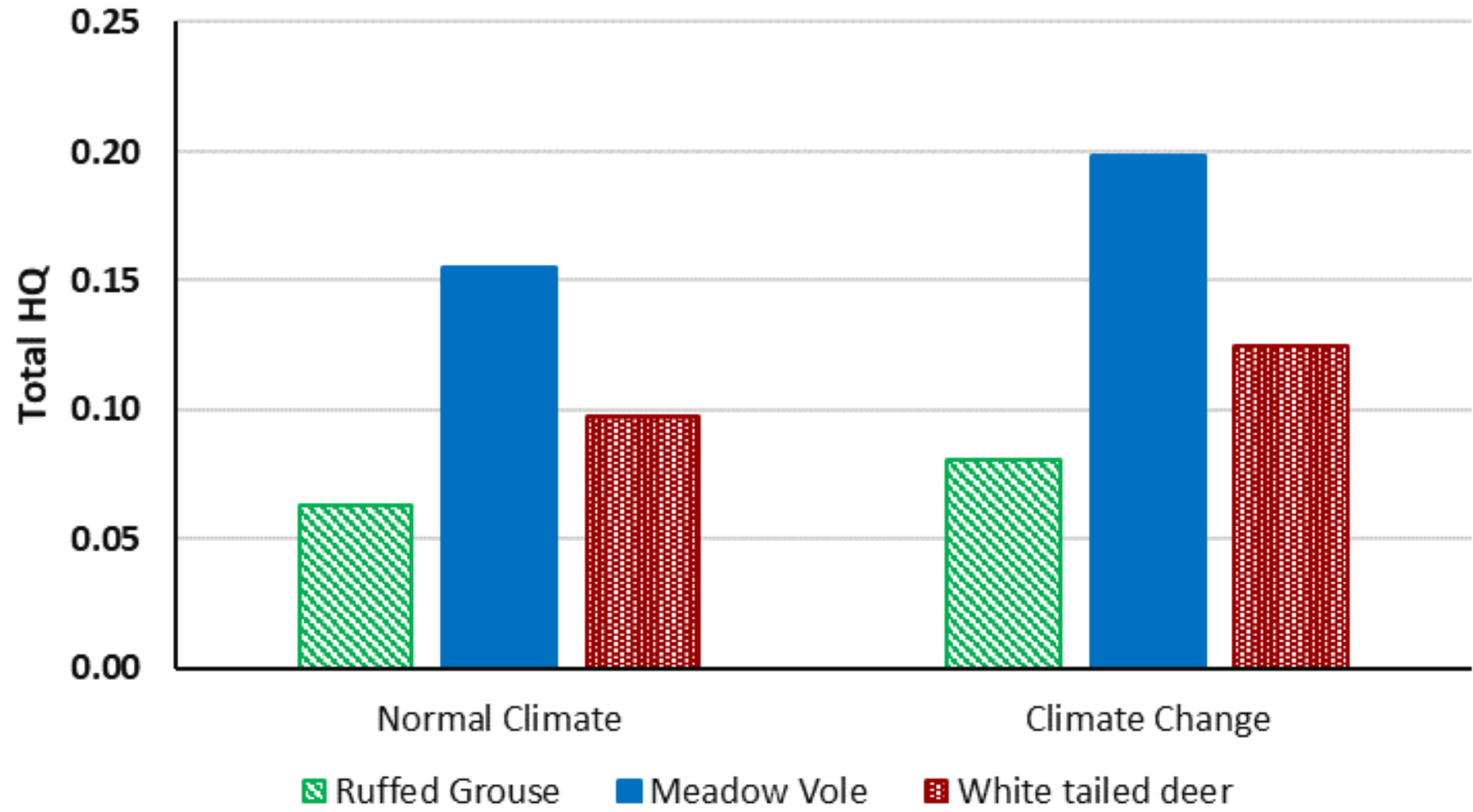
# Human Health: Cancer Risk



# Ecological Risk



# Ecological Risk Under Climate Change



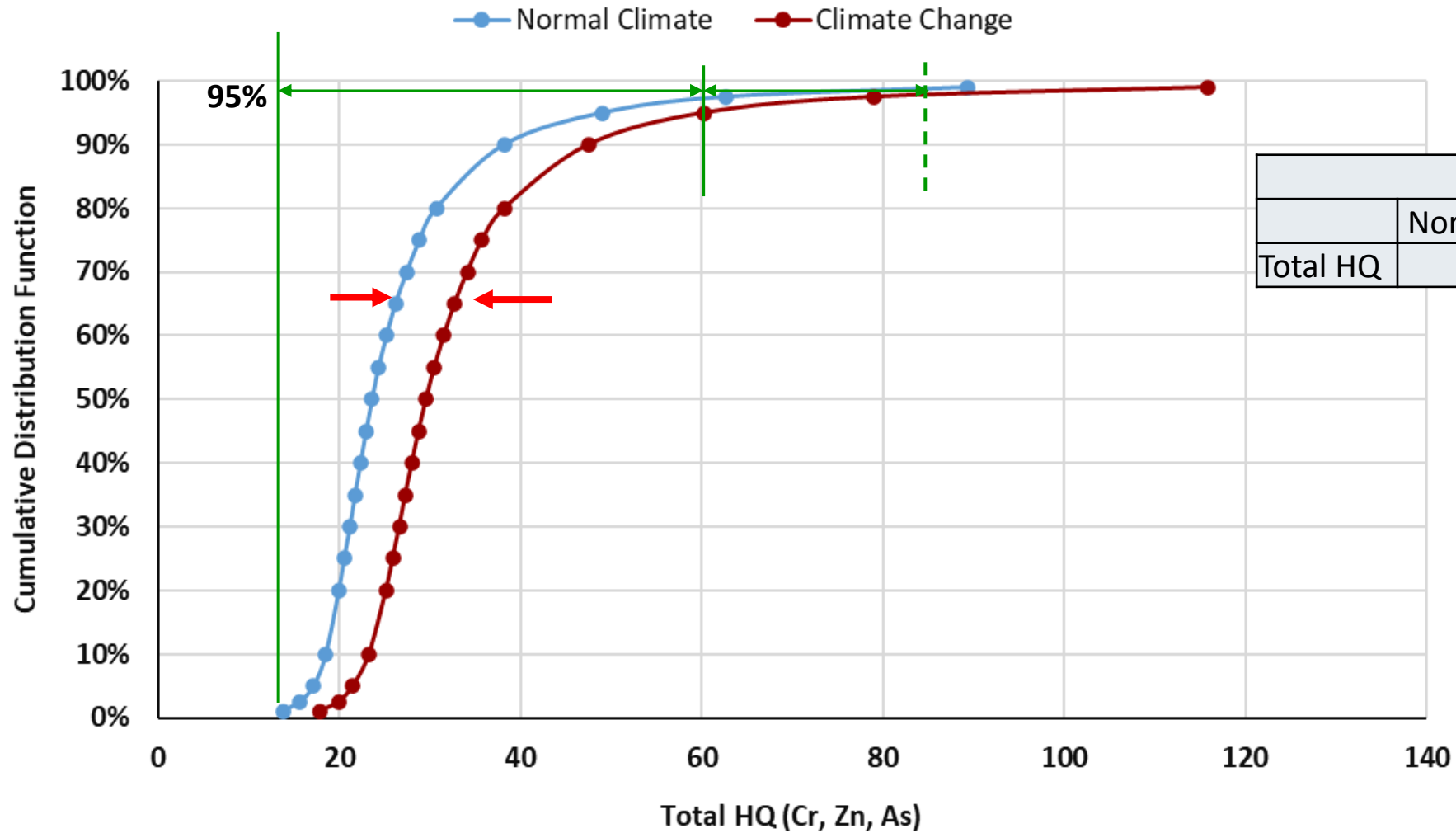


# Uncertainty Analysis

- ✓ **Uncertain/variable parameters**
  - Varying concentrations of Cr, Zn, and As in soil
  - Varying number of growing days
  - Varying number of freezing days
  - Varying body weight of humans and animals
  - Varying amount of foods and water consumed, etc.
  
- ✓ Applied Monte Carlo Analysis to approximate uncertainties



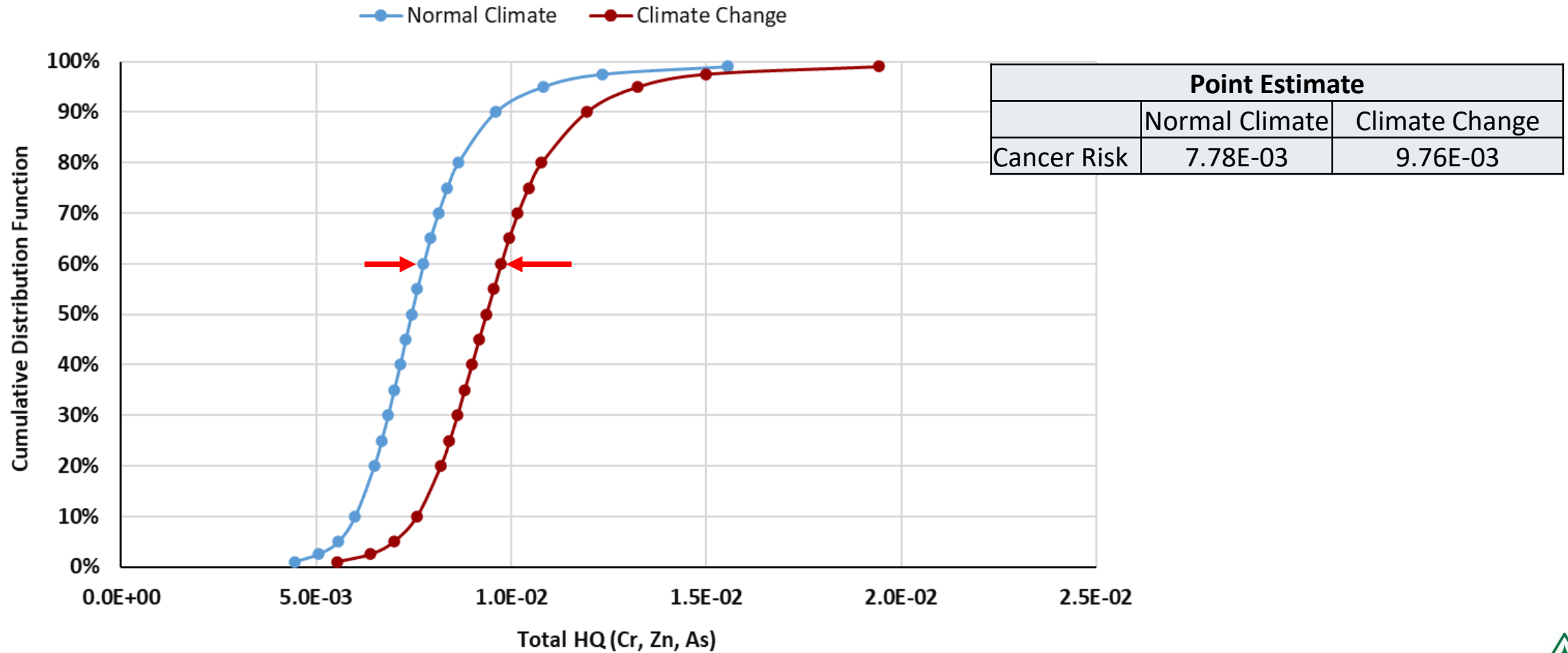
# Human Health: Non-Cancer Risk



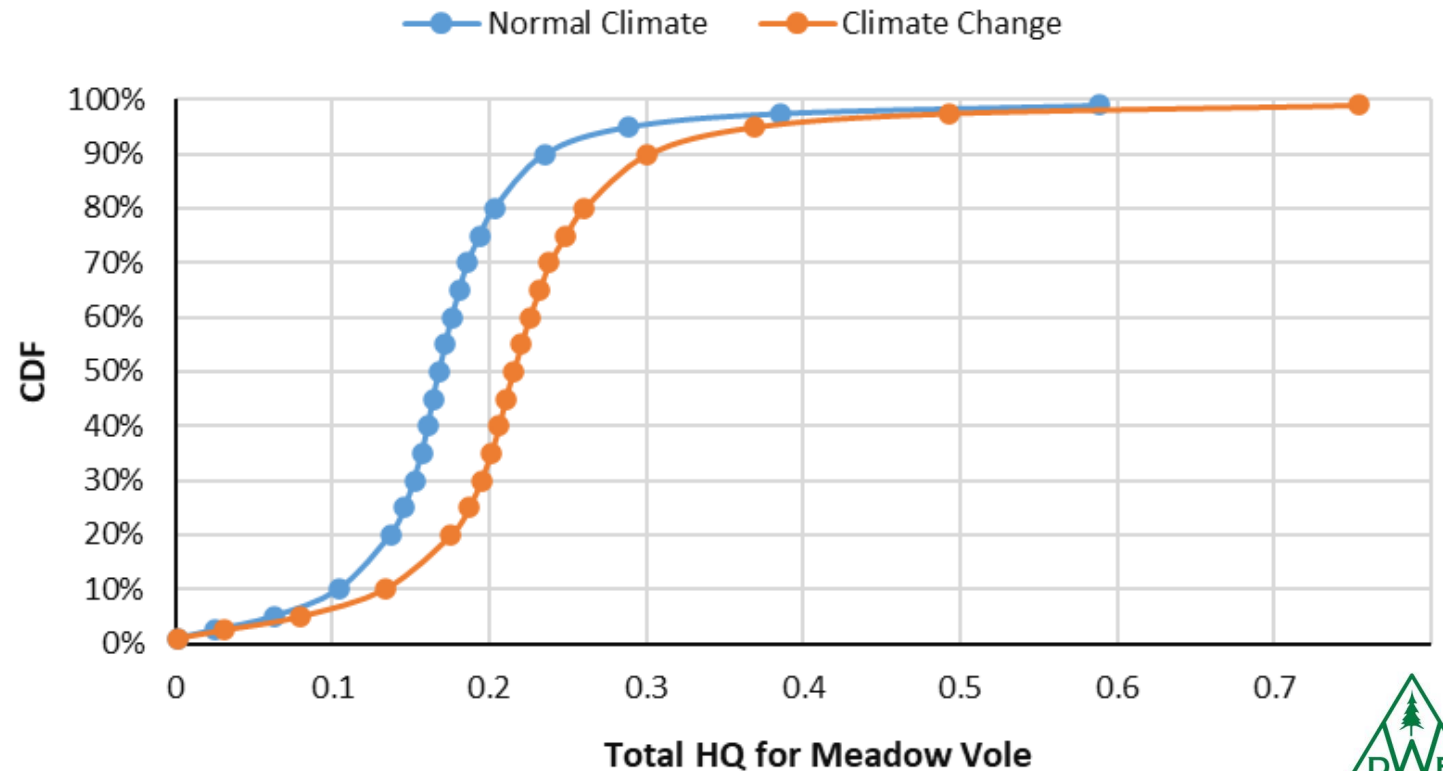
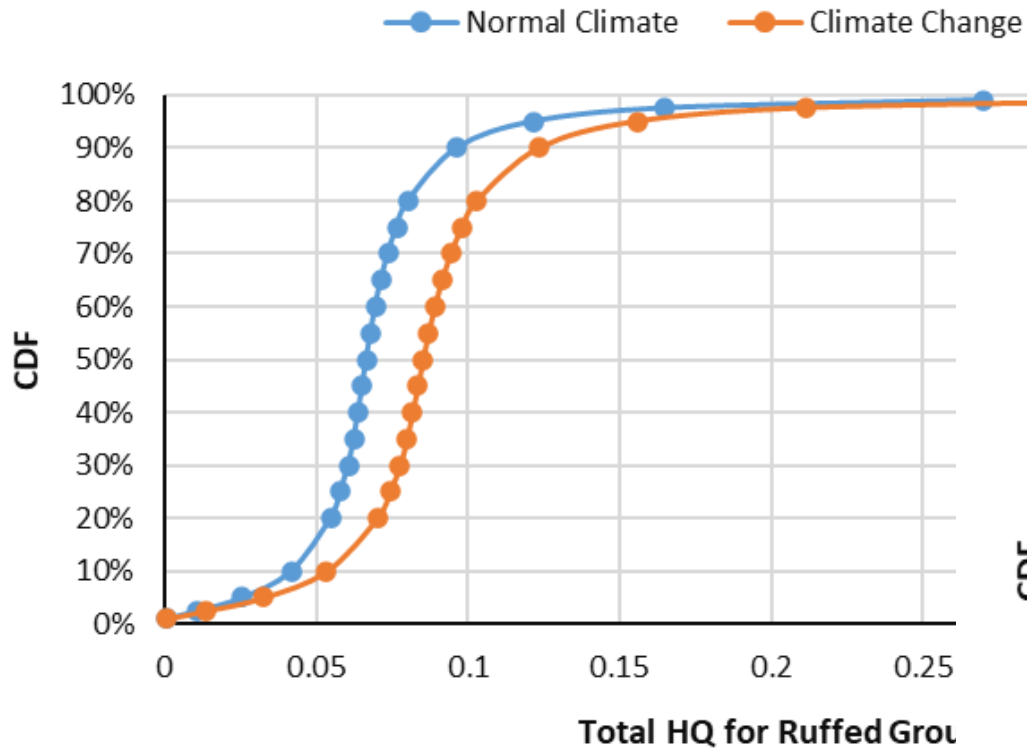
| Point Estimate |                |                |
|----------------|----------------|----------------|
|                | Normal Climate | Climate Change |
| Total HQ       | 27.5           | 34.35          |



# Human Health: Cancer Risk

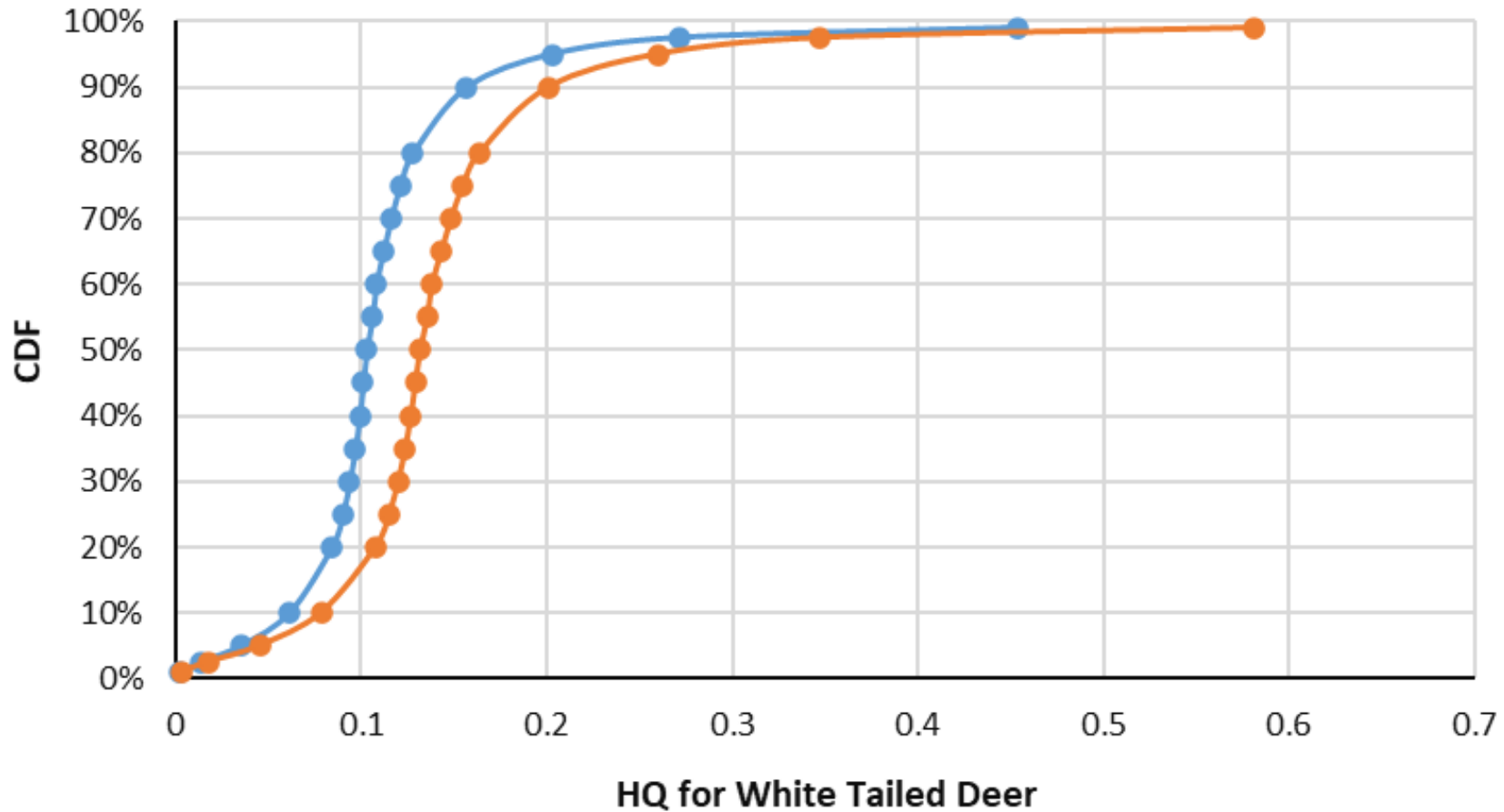


# Ecological Risk: Ruffed Grouse and Meadow Vole





# Ecological Risk: White Tailed Deer



# Conclusions and Recommendations

- ❑ Climate change affects contaminated sites such as **increasing temperature and early thawing of frozen ground.**
- ❑ These processes **increase exposure to contaminants** in near future
- ❑ Increase the **human health risk and potentially ecological risk** of the contaminated lands by about 28%.
- ❑ Such **increased risks are necessary to be managed.**
- ❑ Recommendation – **remediate the contaminated site.**



# References

GoC 2012. Federal Contaminated Sites Action Plan: Ecological Risk Assessment Guidance

GoC 2021. FEDERAL CONTAMINATED SITE RISK ASSESSMENT IN CANADA: Toxicological Reference Values (TRVs)



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# Thank You

