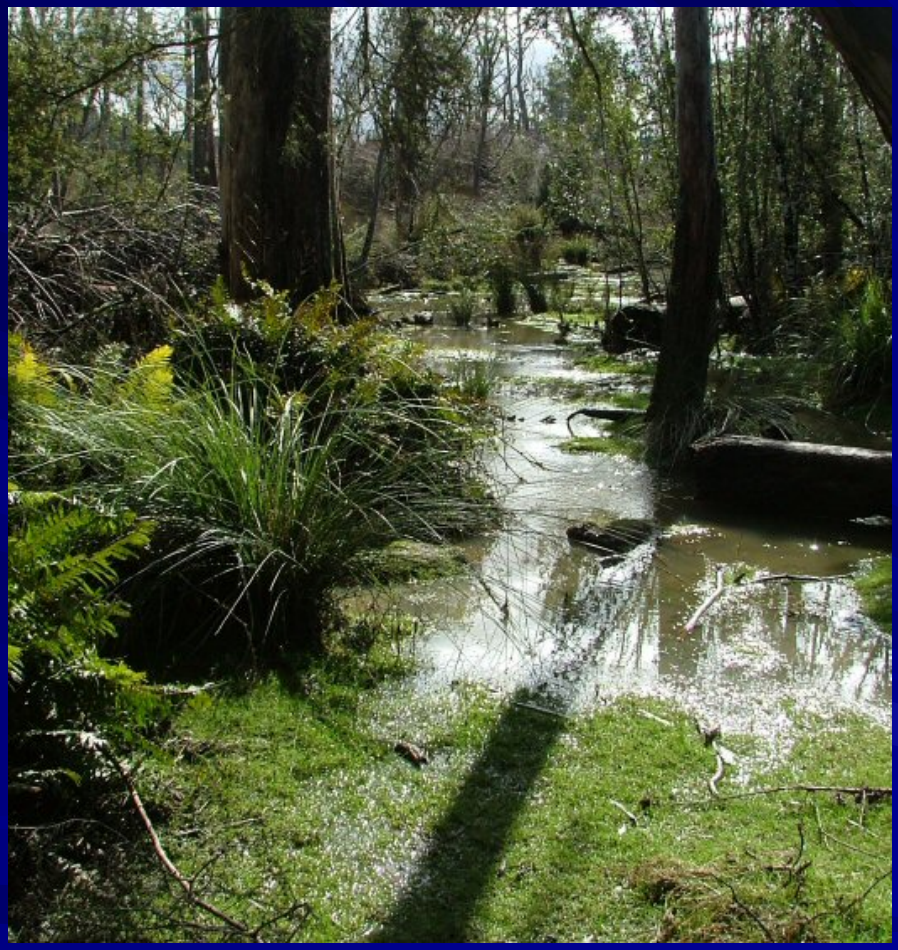
Developing a Wetland Scenario



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What is a Wetland?

"… areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres"

(Ramsar Convention)

Relevance

- Wetlands are interface ecosystems.
- Globally, cover >1,280 million hectares.
- Highly biologically productive.
- High biodiversity.
- There is a diversity of wetland types, which may create variability in contaminant exposure.
- Historically, some wetlands have received radiological discharges.

Summary of Available Wetland Data for a Proposed Modeling Scenario

Focus will be placed on wetlands at the freshwater:terrestrial interface in temperate ecosystems.

Validation of the Carbon-14 Specific Activity Model in a Canadian Wetland Environment for Application in Biota Dose Assessment

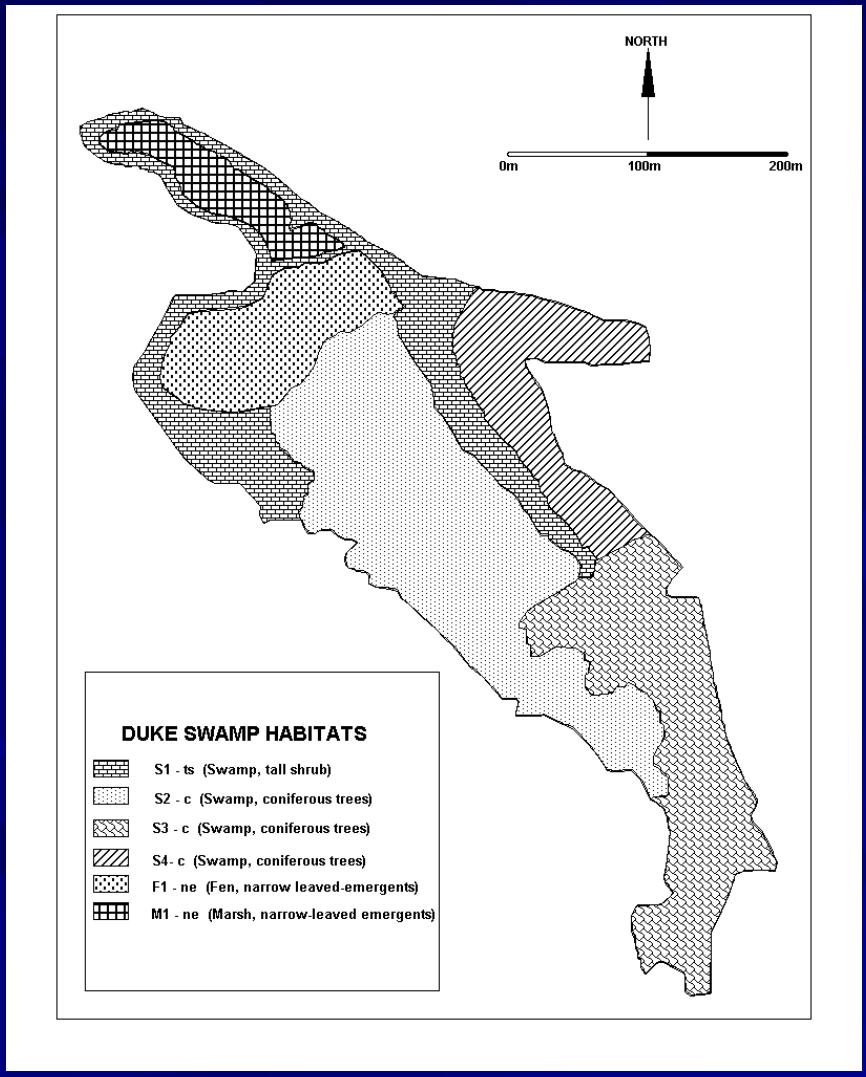
The Duke Swamp Study System

- **Duke Swamp is a 0.102 km^2 wetland that has received historical inputs of radionuclides, including ^{14}C and tritium, from an up-gradient Waste Management Area.**
- **Past assessments of the area have indicated that the primary contributor to dose to resident flora and fauna is likely ^{14}C.**
- **As a result, a study was undertaken to characterize ^{14}C in the swamp.**

Study Objectives

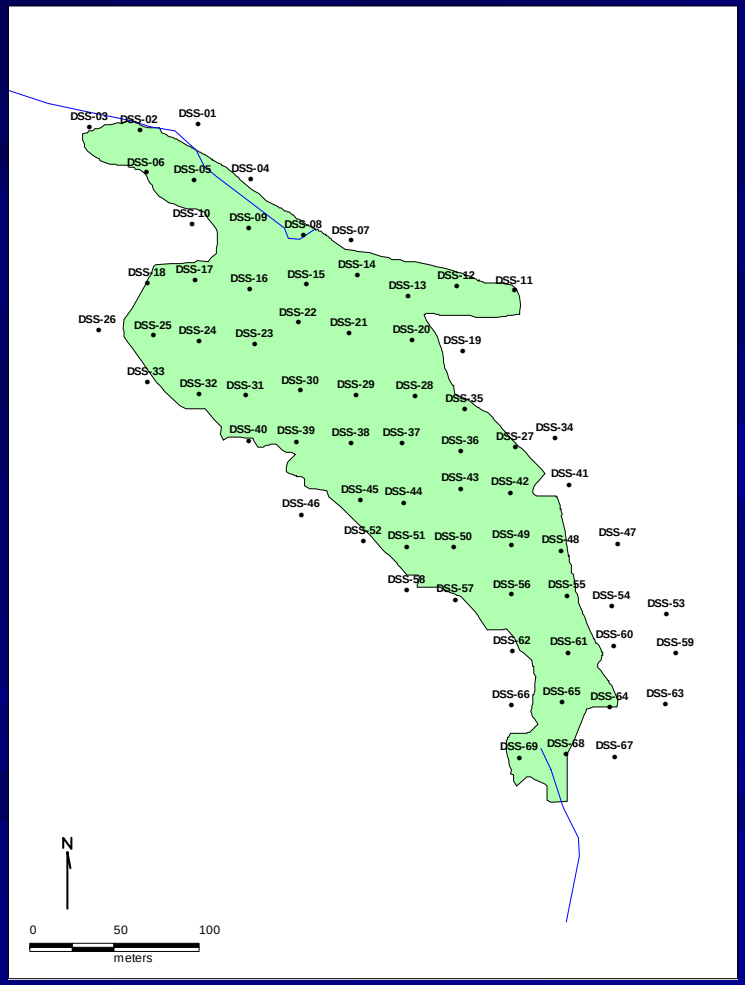
- **To conduct a field survey in a wetland ecosystem to characterize the spatial distribution of carbon-14 (^{14}C), a radionuclide with dynamics in natural systems that can be described using a specific activity model; and**
- **To determine whether ^{14}C concentrations in environmental media reflect those measured in tissues of resident flora and fauna.**

Soil-to-Plant Carbon-14 Transfer by Wetland Type



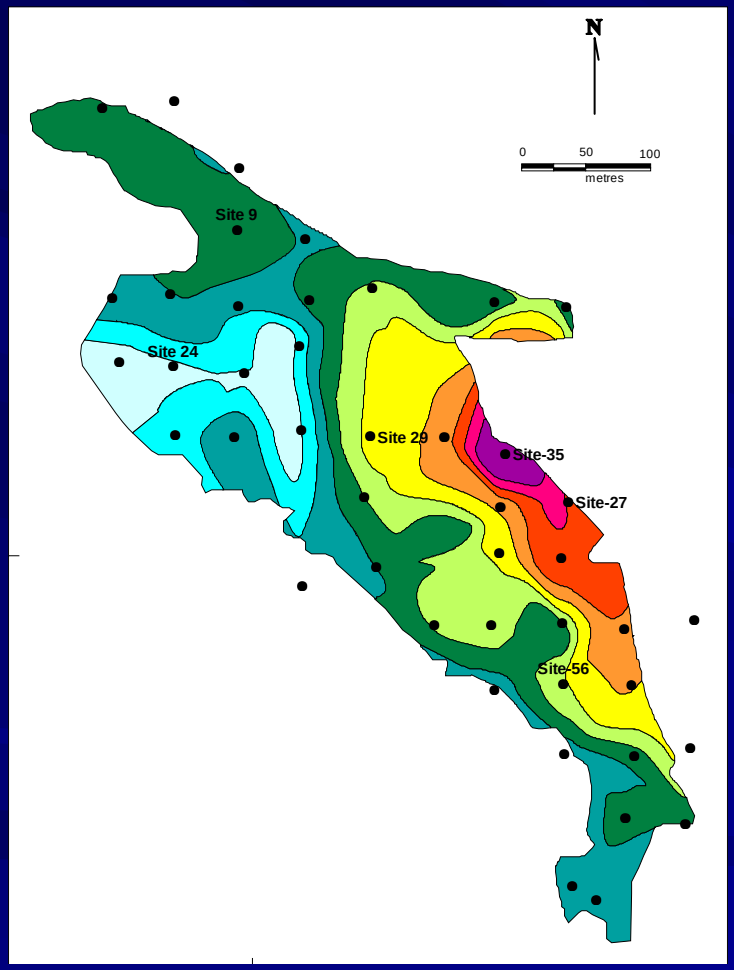
- **Different wetland types comprising Duke Swamp were characterized, along with resident species to gain an understanding of potential pathways in various areas of the swamp.**
- **Carbon-14 activity concentrations were measured in different wetland types over the range of exposure concentrations present in the swamp.**

Characterization of Spatial Carbon-14 Distribution



- A comprehensive survey of Duke Swamp was conducted to measure ^{14}C levels in environmental media (moss and soil) at 69 locations to reflect the spatial distribution.
- Based on these data, a contour plot depicting the spatial extent of ^{14}C in the swamp was generated.
- The data from this survey were then compared with previous measurements that had been taken in the early 1990s to determine whether ^{14}C levels in the swamp have been changing over time.

^{14}C Transfer to Biota



^{14}C Contour Plot

- **Overall, the 2001 survey confirmed that the areal coverage of ^{14}C in the Duke Swamp surface environment is highly localized, representing an area of only 146 m^2 (or 0.1% the surface area of the swamp).**
- **Animals were collected at a subset of 6 locations in the swamp representing a range of possible ^{14}C exposure conditions to test whether transfer to biota differed under varying exposure situations.**

Specifically …

- **Air, plants, fungi, invertebrates, amphibians, reptiles and small mammals were collected at a subset of locations in Duke Swamp, which were selected to cover the range of exposure conditions found in the swamp.**
- **The key question being addressed was *'how representative are ^{14}C specific activities in environmental media to those in the animals that consume them?'***

Summary of Samples Taken

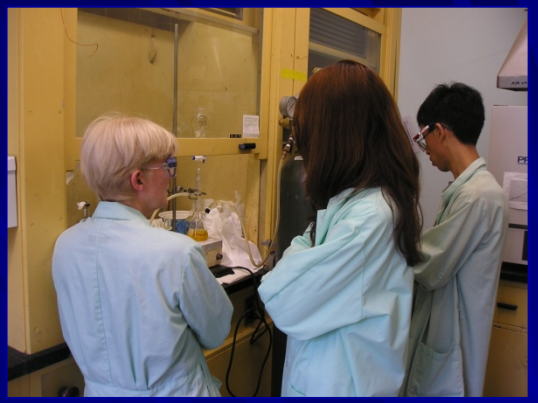
Receptor Species	Sampling Location					
	DSS-9	DSS-24	DSS-27	DSS-29	DSS-35	DSS-56
Air	✓	✓	✓	✓	✓	✓
Soil	✓	✓	✓	✓	✓	✓
Moss	✓	n.d.	✓	✓	✓	✓
Grass	✓	✓		✓	✓	✓
Fern					✓	
Alder	✓	✓		✓	✓	✓
Cedar					✓	
Balsam Fir					✓	
Fungi	✓	✓	✓	✓	✓	✓
Aerial Insects	✓					
Ground Beetles						✓
Amphibians (frogs)	✓	✓	✓	✓	✓	✓
Small Mammals (carcass)			✓	✓	✓	
Small Mammals (stomach contents)			✓		✓	
Snakes (carcass)	✓				✓	
Snakes (eggs)	✓				✓	

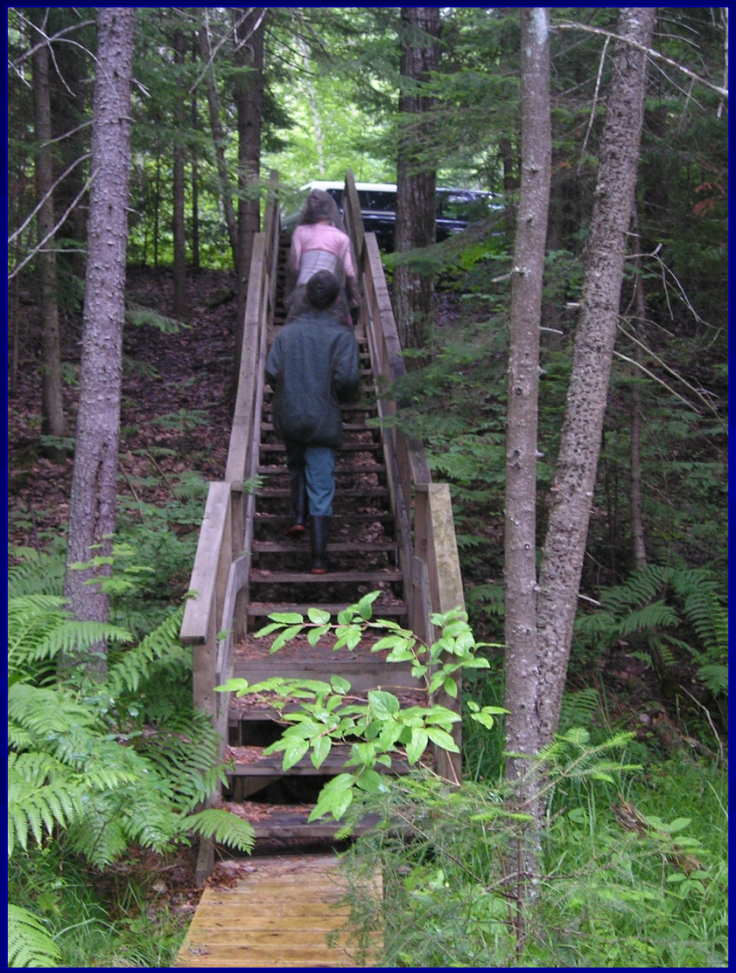
Soil-to-Vegetation 'Pairings'

- **In addition to the location-specific transfer-to-animal measurements, work was also done to assess soil-to-plant transfer in various wetland types in Duke Swamp at a subset of locations.**
- **Soil-to-vegetation sample 'pairings' were measured at DSS-9, DSS-14, DSS-24, DSS-27, DSS-28, DSS-29, DSS-30, DSS-31, DSS-35, DSS-36, DSS-42, DSS-43, DSS-45, DSS-55 and DSS-56.**




In Summary, the Prognosis is Good





- ✓ **An extensive survey that was conducted in Duke Swamp confirmed that ^{14}C is highly localized in the swamp (and predictably so).**
- ✓ **In addition, examination of both temporal changes in ^{14}C in environmental media, as well as ^{14}C groundwater inputs to the swamp, reveals declines, which have led to a net loss of ^{14}C from the swamp.**
- ✓ **Based on the study findings, it was possible to improve understanding in terms of what is required to demonstrate environmental protection through monitoring.**
- ✓ **Work conducted on resident biota in the swamp indicates that the swamp is healthy.**

Any Questions?

A sincere thanks goes out to the Deep River Science Academy and all the students who helped place the pieces in the Duke Swamp puzzle.

Perch Lake Wetlands Data

- Sr-90, Cs-137, Co-60
- Surface water, sediments, soils
- Aquatic and emergent vegetation
- Fish, amphibians, reptiles

Cs-137 Data from Savannah River Site (SRS) Wetland

- Soil/sediment
- Vegetation
- Arthropods (aquatic and terrestrial)
- Aquatic and terrestrial snakes
- Green treefrogs
- Alligator
- Turtles
- Raccoon

Wetlands in Sweden

- Cover 20% of Sweden (c. 9 million ha)
- Classified as holding ‘high environmental value’
- Of interest to regulators from point of view of direct discharges and also repositories

Wetland data from Sweden

- **<u>Soil profiles</u>**: ^{137}Cs, ^{90}Sr, ^{40}K

  Sliced, 20 – 40 cm long

  25 samples in the swamp,

  14 in the reed belt,

  10 in the rich fen.

- **Water**: ^{137}Cs,

  2 samples of flooding water in the swamp

Wetland data from Sweden cont.

- **Deposited sediment** after spring flood on stream banks in 2003 & 2004: ^{137}Cs, ^{90}Sr, ^{40}K

- **Sediment**: 8 samples from the estuary (Baltic Sea), ^{137}Cs, ^{90}Sr

Wetland data from Sweden cont.

- **<u>Vegetation:</u>** ^{137}Cs

  Bulk samples above soil profiles

  Fern (*Matteuccia struthiopteris*)

  Alder branch (*Alnus glutinosa*)

  Spruce neddles, shoots (*Picea abies*)

- **Frogs:** 5 whole body measurements of moor frogs

- **Phantom** measurements: 5 phantoms x 2 years in the swamp and in the rich fen.

For soil samples taken in the TLD-phantom study

- Measured Cs-137 and K-40, 2003 and 2004
- Soil moisture % 2003 and 2004

- **New** additional measurements of natural radionuclides in soil (swamp and rich fen) : Uranium- and thorium series.

Soil analysis with ICP-MS

- One soil sample from each site: swamp, fen, reed, spruce forest

  pH, C, N, O, H, CaO, Al_2O_3, SiO_2, Fe_2O_3, K_2O, MgO, MnO, Na_2O, Ba, Cd, Co, Cu, Hg, Pb, S, Sn, Sr, Th, U, Zn

Vegetation inventory 25 x 25 cm squares

- Swamp and fen

Other data

• Earlier published data 1986 – 1991 from Hille Lake, outlet water (Verkmyra stream), model simulation (Sundblad et al. *Studsvik reports*).

•Back-pack measurements and field measurements of ^{137}Cs performed by SSI and FOI in the wetland area

Summary

- No comprehensive data for a single wetland
- BUT data available for different radionuclide-organism combinations in different wetlands
- Combine data to create a ’hypothetical’ wetland
- Provide participants with activity concentrations in soil, sediment, water and air (where available/relevant)
- Predict activity concs in biota
- Predict dose rates for selected biota (for which we have measured dose rates i.e. Sweden)

Thoughts???