Phytoremediation of salt-affected soils in the Toronto region

Lauren Nawroth, MES Candidate
Queen's University

Lyndsay Cartwright, PhD
Senior Research Analyst, Toronto and Region Conservation Authority

Barb Zeeb, PhD
Professor and Canada Research Chair in Biotechnology and the Environment
Royal Military College

Partners in Project Green Executive Management Committee Meeting

April 23, 2024

Toronto and Region Conservation Authority

Acknowledgements

Toronto and Region Conservation Authority

Partners in Project Green
A Program of Toronto and Region Conservation Authority

Sustainable Technologies EVALUATION PROGRAM

TRUTH · DUTY · VALOUR
VÉRITÉ · DEVOIR · VAILLANCE

Toronto Pearson

407 ETR Express Toll Route

McMaster University

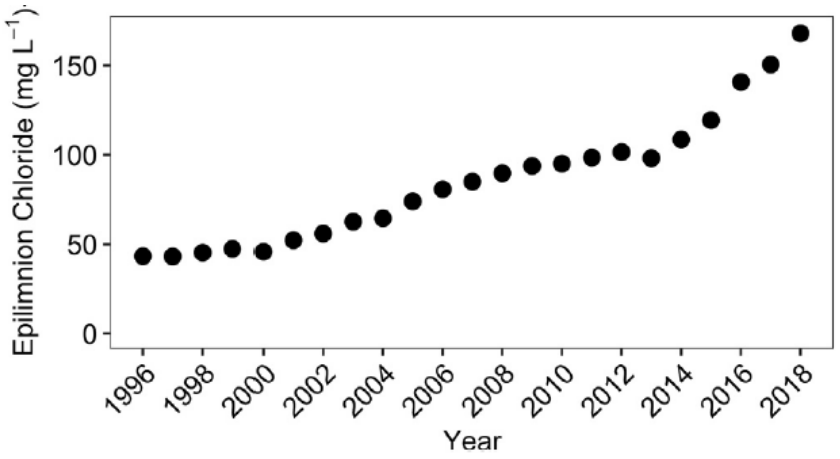
Ontario

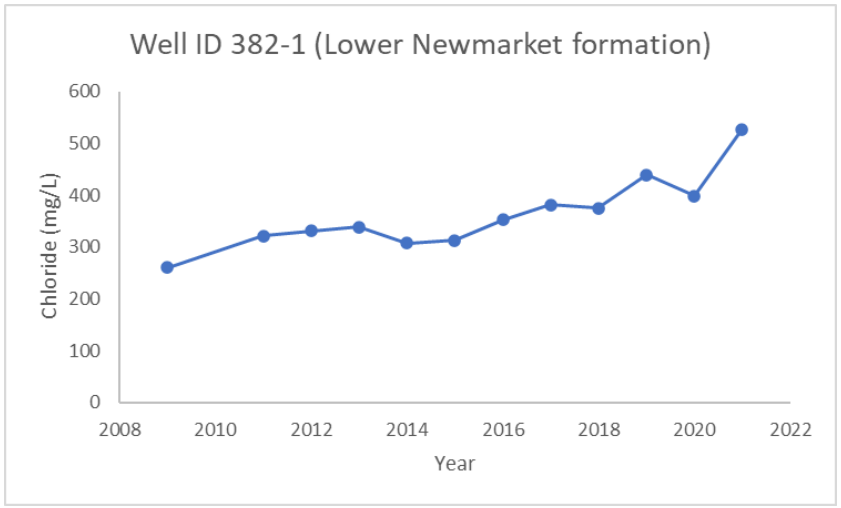
TERRERA

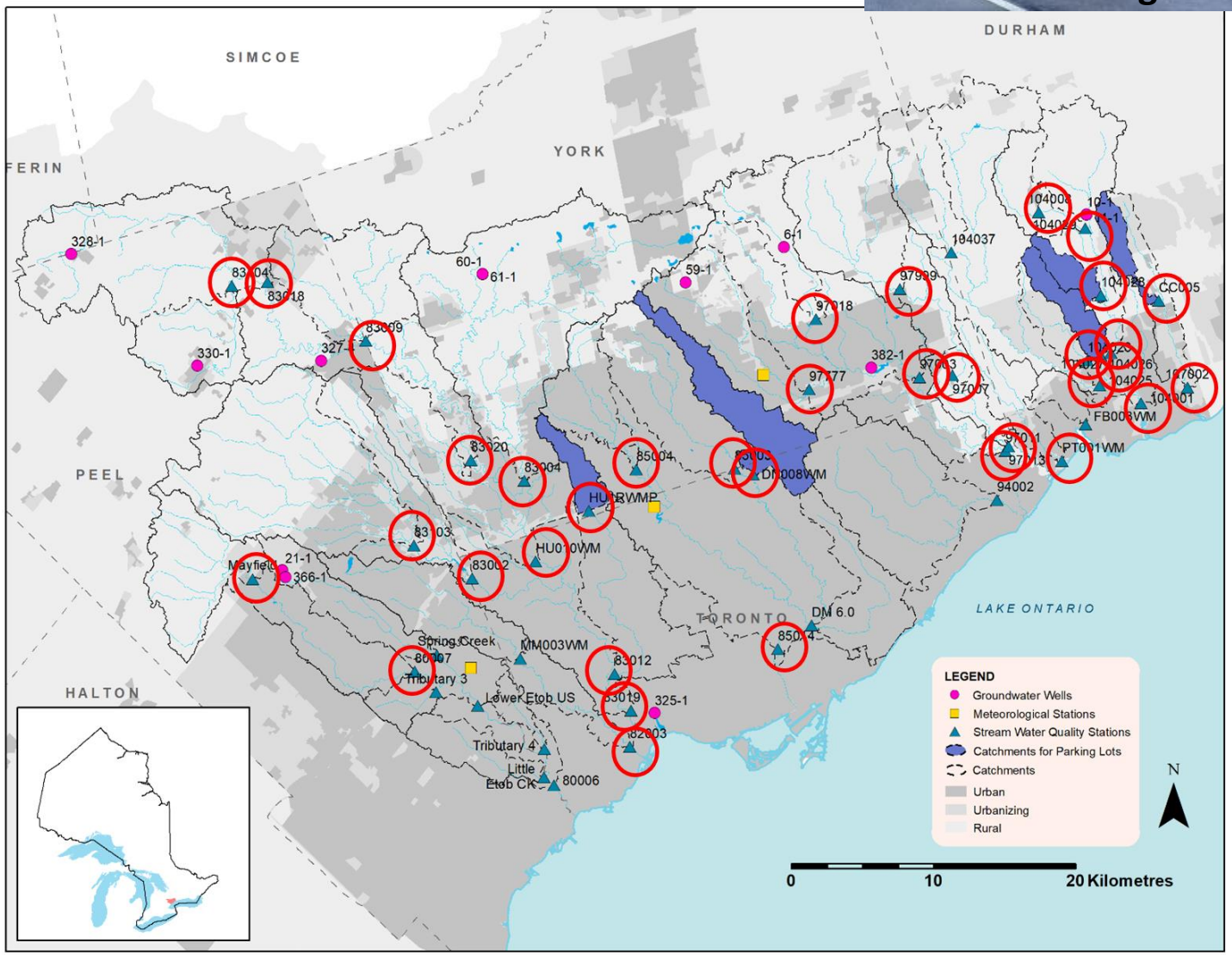
Queen's University

Chloride levels in freshwater continue to rise

Lake Wilcox

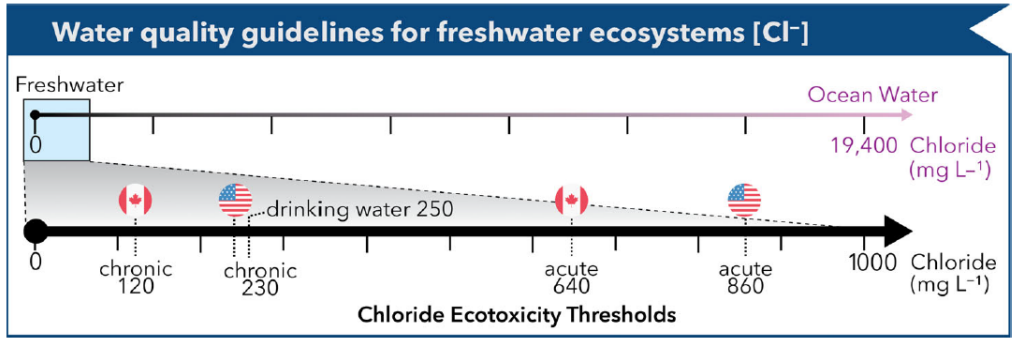


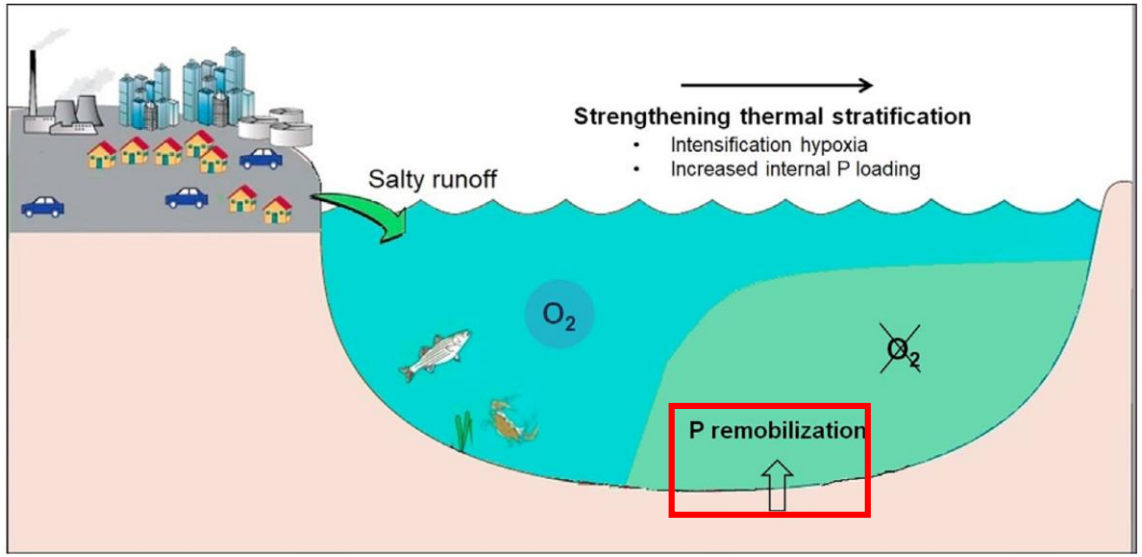


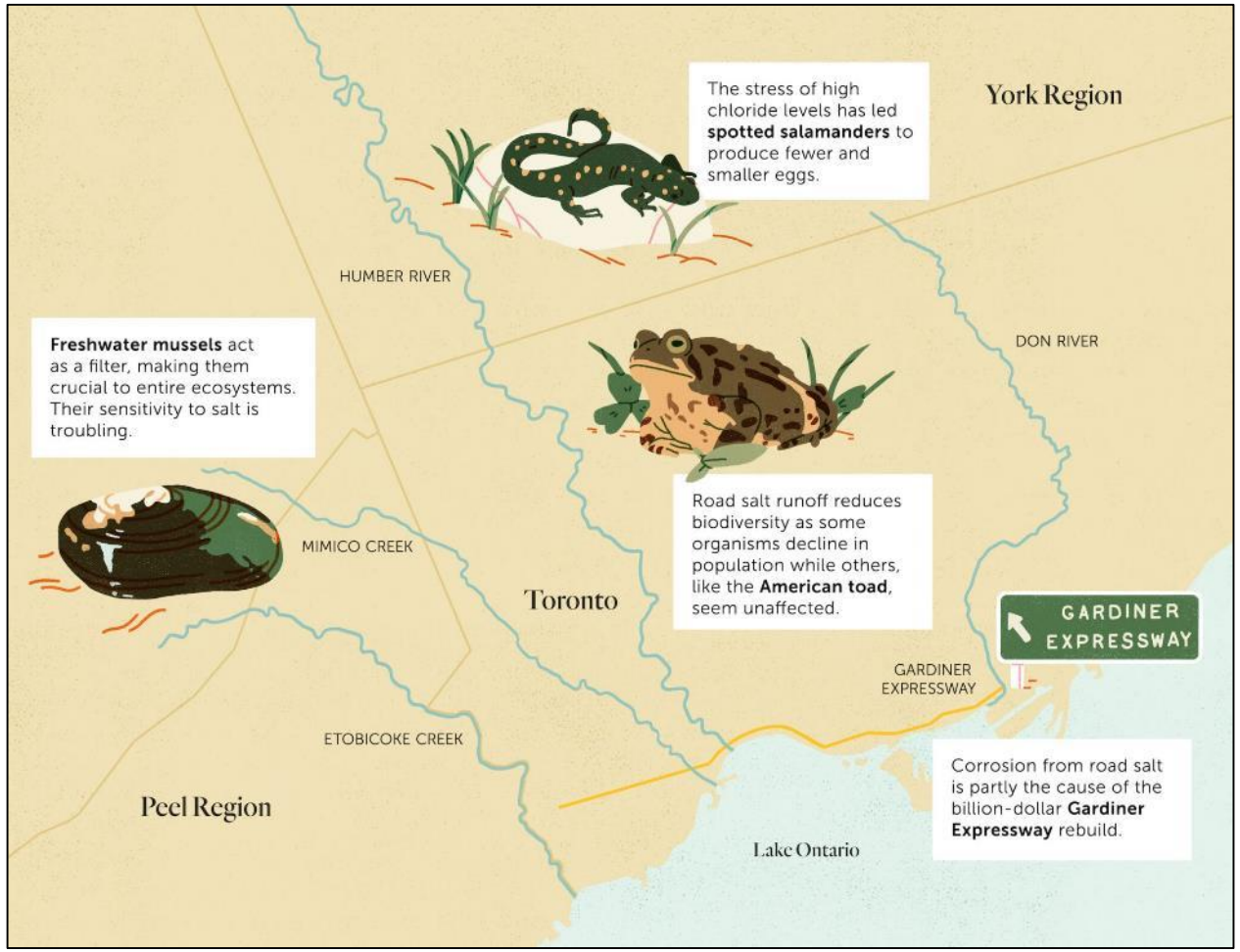


Radosavljevic et al. (2022), TRCA (2021), Cartwright et al. (2023)

Moving towards, or already exceeding, thresholds to protect aquatic life & human well-being

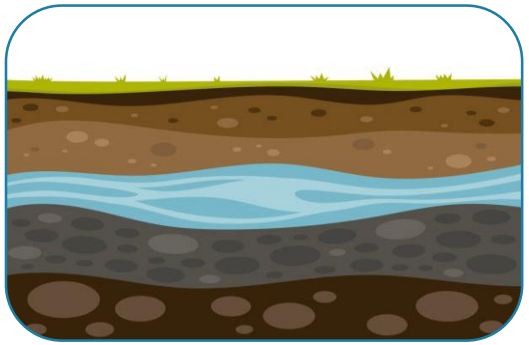






Dugan & Arnott (2022), Lawson & Phan (2022), Radosavljevic et al. (2022)

Legacy Chloride



Legacy Chloride

Salinity Stress

Healthy Spreading Orache leaf[1]

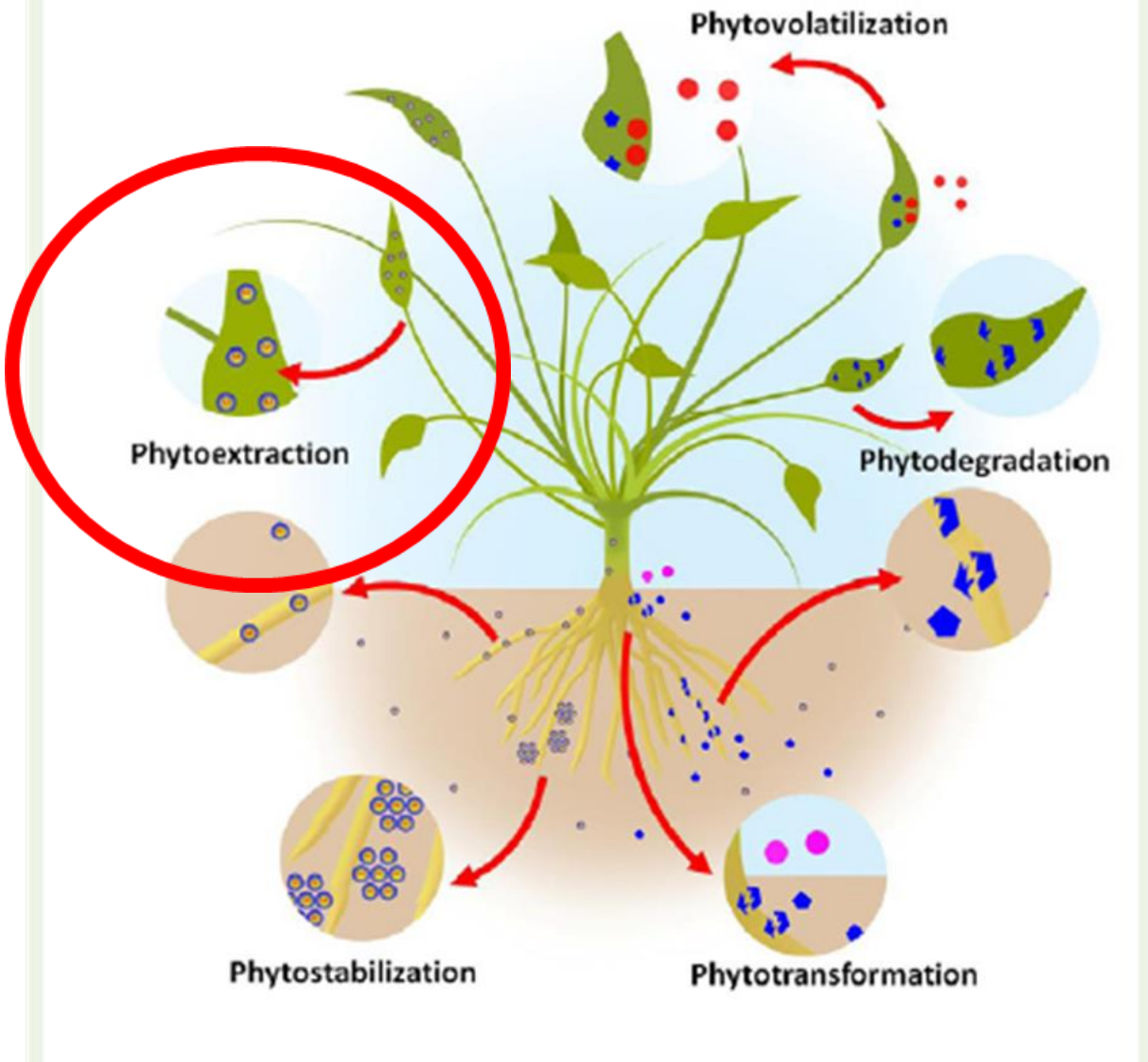
Salt stressed Spreading Orache leaf

1. https://identify.plantnet.org/el/the-plant-list/species/Atriplex%20patula%20L./data

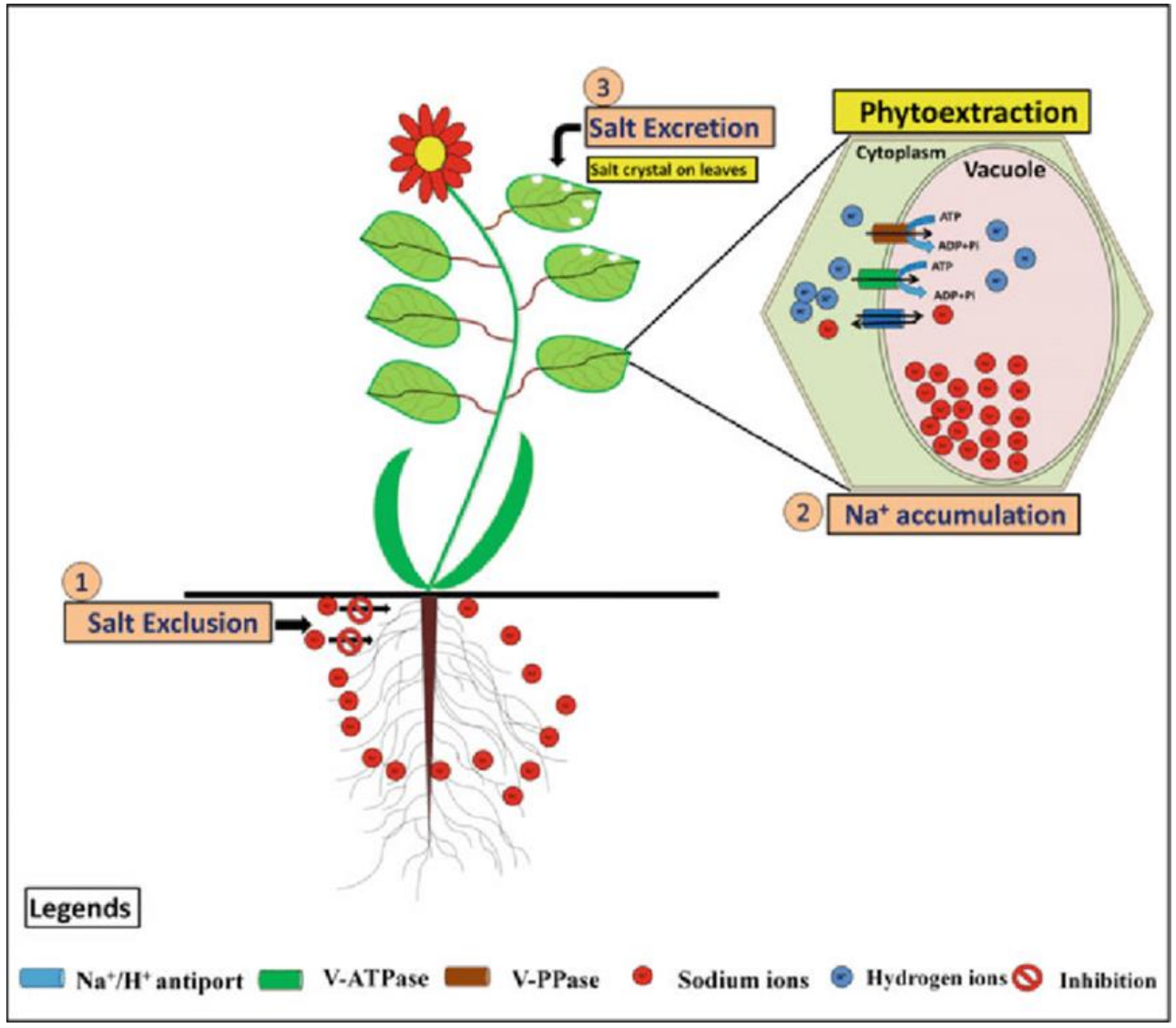
Phytoremediation

- Using plants to clean up contaminated environments

- **Phytoextraction** = removal of contaminants through root system & stored in above ground shoots



Halophytes



- Plants adapted to grow in saline conditions
- **Accumulators** = take-up salt through roots and sequester in leaves and stem
  - Requires harvesting
- **Excretors** (recretohalophytes) = take-up salt through root system and translocate it to the above ground parts of the plant, then excrete the salts through specialized salt glands on the leaf surfaces

1. https://link.springer.com/referenceworkentry/10.1007/978-3-030-17854-3_92-1 2. https://www.sciencedirect.com/science/article/pii/S0048969716317144

Halophytes

- Plants adapted to grow in saline conditions
- **Accumulators** = take-up salt through roots and sequester in leaves and stem
  - Requires harvesting
- **Excretors** (recretohalophytes) = take-up salt through root system and translocate it to the above ground parts of the plant, then excrete the salts through specialized salt glands on the leaf surfaces

Selected Species for Remediation

Side Oats Grama
Bouteloua curtipendula

Prairie Cordgrass
Sporobolus michauxianus

Switchgrass
Panicum virgatum

Sand Dropseed
Sporobolus cryptandrus

Excretors

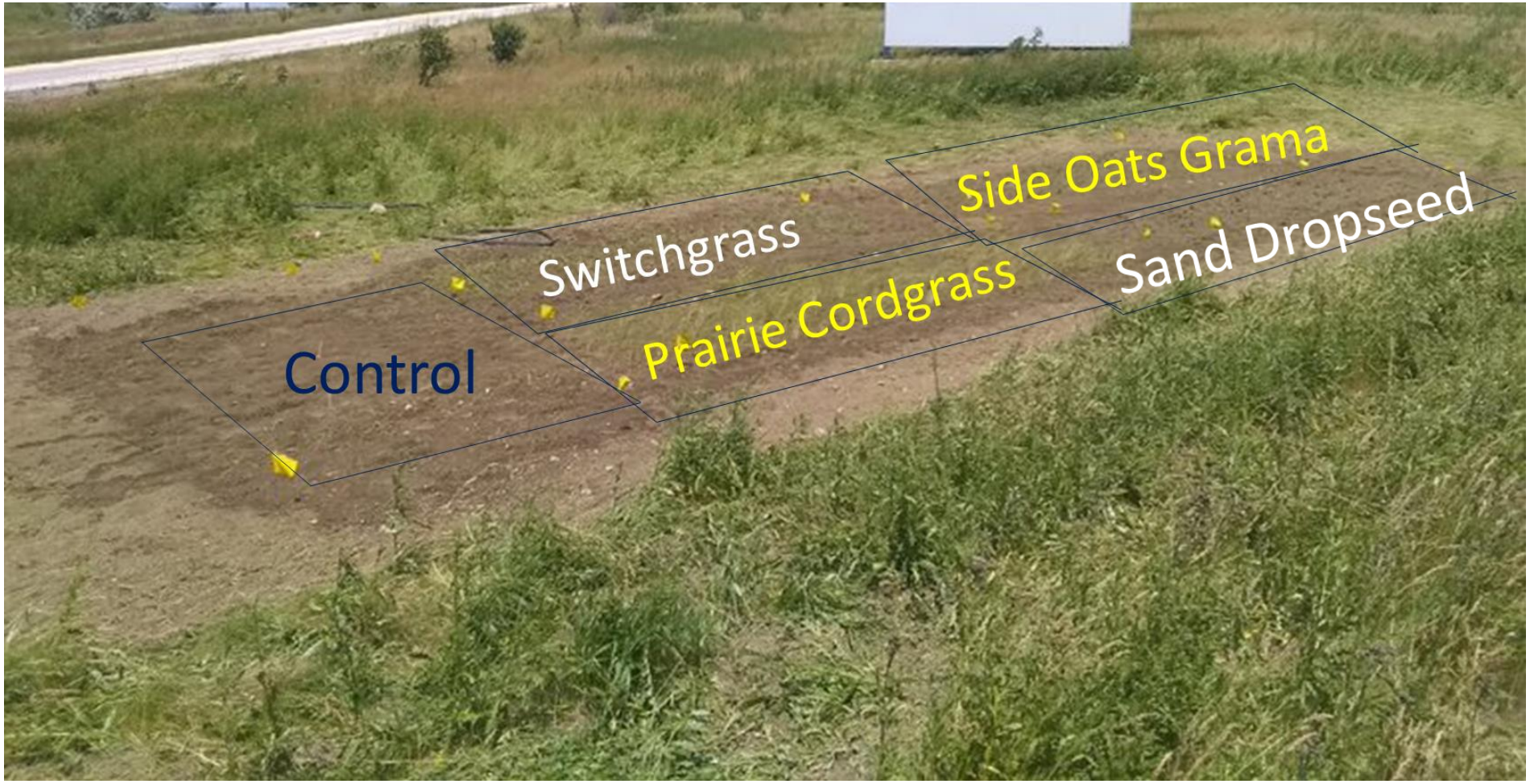
Accumulators

Experimental Plots

Established background:
Cl^- levels = 20 mg/kg

In plot:
Cl^- levels = mean 365 mg/kg

Experimental Plots



Halophyte Type

Excretor

Accumulator

Halophyte Type

Excretor

Accumulator


Prairie Cordgrass
Switchgrass
Sand Dropseed
Side Oats Grama
July 21st, 2022


August 18, 2022
Prairie Cordgrass
Switchgrass
Side Oats Grama
Sand Dropseed

End of Season

Halophyte Type

Excretor

Accumulator

Composting - Switchgrass

September 30th, 2022

April 11th 2023

- 74% reduction in switchgrass biomass
- 60% reduction in side oats grama biomass

Regrowth of harvested material

June 1, 2023

Regrowth of Switchgrass

Un-harvested Switchgrass

Halophyte Type

Excretor

Accumulator

Halophyte Type

Excretor

Accumulator

Halophyte Type

Excretor

Accumulator

Phytoremediation timelines (2023)

Species	Literature biomass production g DW /m^2	Observed biomass production g DW/m^2	Average Chloride uptake mg/m^2	Years for Remediation
Prairie Cordgrass				
Side Oats Grama				
Switchgrass				
Sand Dropseed				

Phytoremediation timelines (2023)

Species	Literature biomass production g DW /m^2	Observed biomass production g DW/m^2	Average Chloride uptake mg/m^2	Years for Remediation
Prairie Cordgrass	1000			
Side Oats Grama	1100			
Switchgrass	1500			
Sand Dropseed	25			

Phytoremediation timelines (2023)

	Species	Literature biomass production g DW /m^2	Observed biomass production g DW/m^2	Average Chloride uptake mg/m^2	Years for Remediation
	Prairie Cordgrass	1000	8904		
Excretor	**Side Oats Grama**	1100	454.3		
	Switchgrass	1500	7568		
Accumulator	**Sand Dropseed**	25	-		

Phytoremediation timelines (2023)

Species	Literature biomass production g DW /m^2	Observed biomass production g DW/m^2	Average Chloride uptake mg/m^2	Years for Remediation
Prairie Cordgrass	1000	8904	41,052	
Side Oats Grama	1100	454.3	1,317	
Switchgrass	1500	7568	16,967	
Sand Dropseed	25	-	12,124	

Excretor

Accumulator

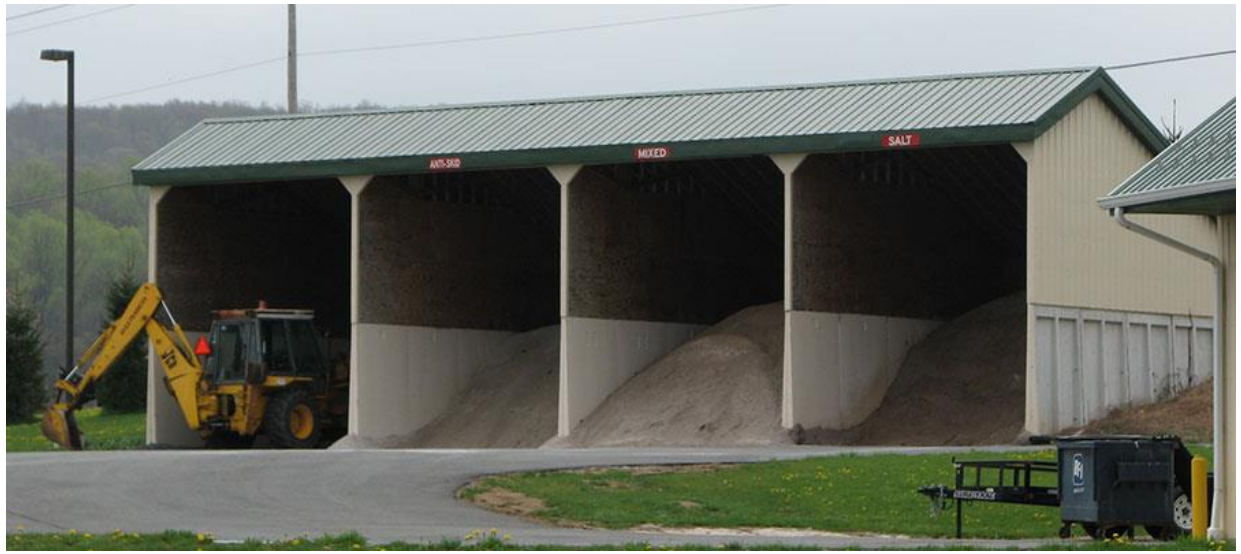
Phytoremediation timelines (2023)

	Species	Literature biomass production g DW /m^2	Observed biomass production g DW/m^2	Average Chloride uptake mg/m^2	Years for Remediation
Excretor	**Prairie Cordgrass**	1000	8904	41,052	1.9 years
Excretor	**Side Oats Grama**	1100	454.3	1,317	13.3 years
Accumulator	**Switchgrass**	1500	7568	16,967	2.3 years
Accumulator	**Sand Dropseed**	25	-	12,124 (2022)	3.5 years (2022)

Future research

- Analyze wet candle data for salt dispersion of excretor halophytes
- Mow parts of each plot to simulate roadside conditions
- Endophytes

Next steps



Thank you!

lauren.nawroth@queensu.ca
lyndsay.cartwright@trca.ca
zeeb-b@rmc.ca

Toronto and Region Conservation Authority