Hemlock Woolly Adelgid: An invasive threat to Atlantic Canada's hemlock

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Atlantic Forestry Centre, Fredericton, NB

2025 Canadian Woodlands Forum Spring Meeting

Thursday, April 10/25

Nationwide Project

Provincial

Nova Scotia Natural Resources and Renewables

New Brunswick / Nouveau Brunswick Canada — Department of Energy and Resource Development

Nova Scotia Environment

First Nations

The Confederacy of Mainland Mi'kmaq

Federal

Canada

Canadian Food Inspection Agency / Agence canadienne d'inspection des aliments — Canada

Natural Resources Canada / Ressources naturelles Canada — Canadian Forest Service / Service canadien des forêts

Academic

Acadia University

University of Toronto

NGO

Nova Scotia Nature Trust

Mersey Tobeatic Research Institute

Nature Conservancy Canada

Medway Community Forest Cooperative

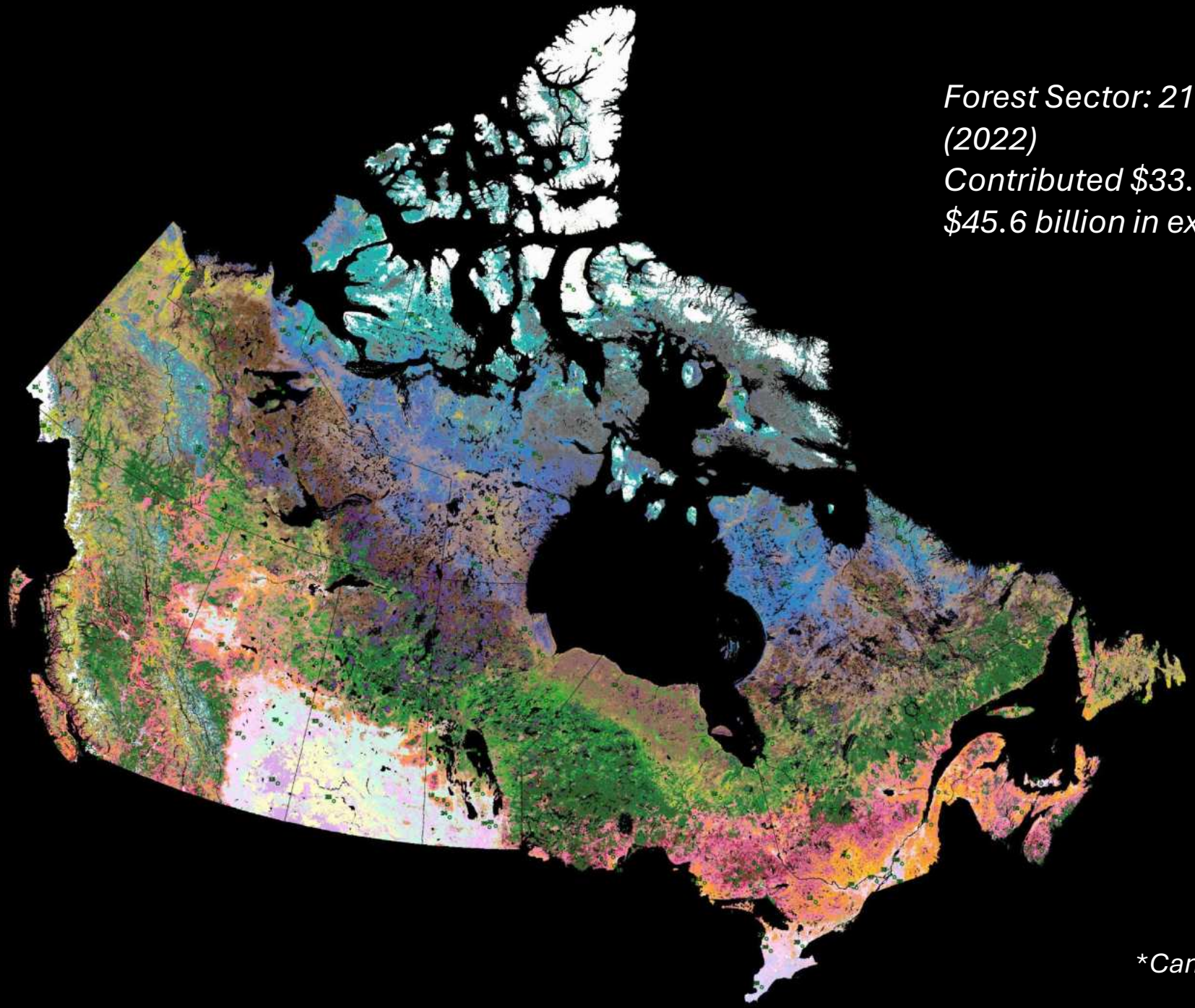
Municipal

Town of Bridgewater — Established 1899

Kentville

Truro — make the connection

Halifax



Forest Sector: 212 000+ people employed (2022)
Contributed $33.4 billion to GDP
$45.6 billion in exports

**Canada's State of the Forests, 2023*

Ecological Importance

- Biodiversity
- Carbon ‘sink’
- Water filtration; aquatic ecosystem function
- Climate moderation; ‘shade’
- Recreation

Threats to Canadian Forests

https://www.vicnews.com/news/b-c-wildfire-season-now-second-worst-in-provinces-history-42442

Invasive Species

Insects, pathogens, plants

No (or little) shared history; no predators, no defense

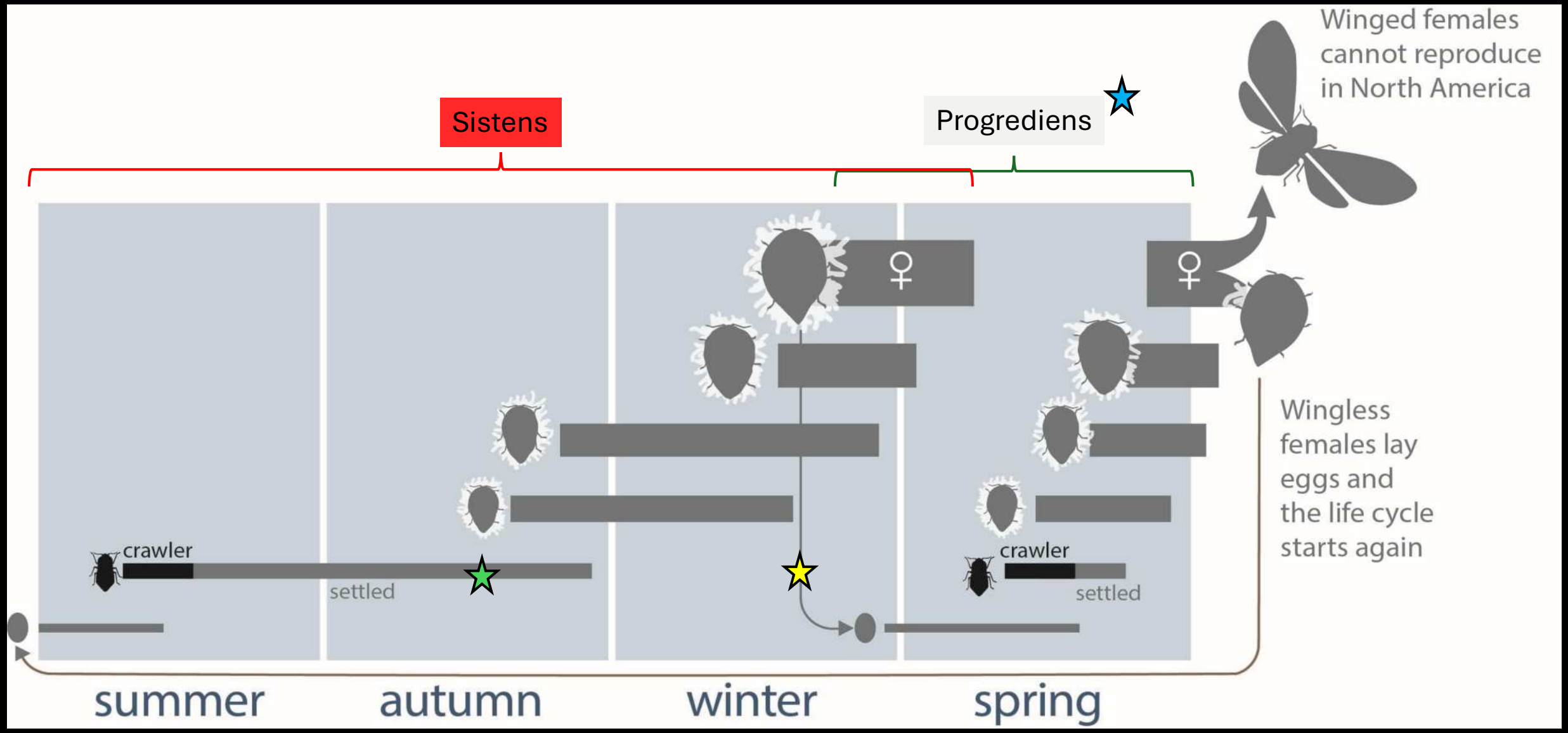
Adelges tsugae (Hemlock woolly adelgid, HWA)

- Small, adelgid defoliator of *Tsuga* spp.
- Native range: Asia (Japan, China), Pacific NW (British Columbia, Washington, Oregon)
  - Genetically-distinct

HWA Damage

- Stylet inserted into needle; mult. HWA
- Damages parenchyma; xylem rays

- Disruption of nutrient movement
- Desiccation -> needle loss-> branch death
- Tree death: 4 years

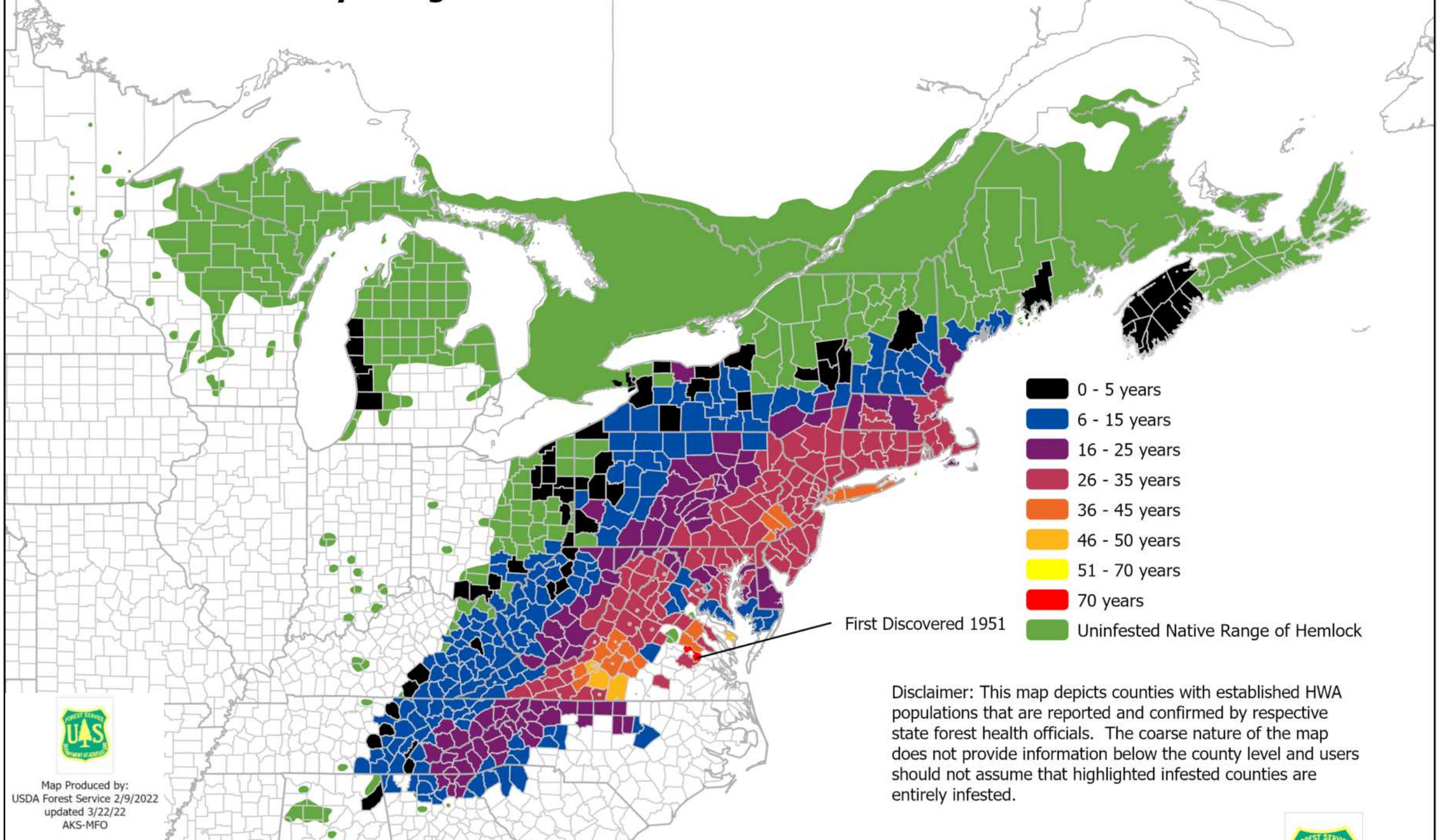


- Nova Scotia (Roscoe et al. *In Prep*)

★ Sistens adults with eggs beginning early-April

★ Progrediens develop from mid-May to mid-July

★ Aestival break in late-October, remain as 3rd-instar until late-March



Map Produced by:
USDA Forest Service 2/9/2022
updated 3/22/22
AKS-MFO

Disclaimer: This map depicts counties with established HWA populations that are reported and confirmed by respective state forest health officials. The coarse nature of the map does not provide information below the county level and users should not assume that highlighted infested counties are entirely infested.

Hemlock Woolly Adelgid | *Adelges tsugae* | Puceron lanigère de la pruche

Infested Places | Lieux infestés

Infested Places | Lieux infestés

Produced by the Canadian Food Inspection Agency,
Plant Health Surveillance Unit, Ottawa, Ontario
Préparée par l'Agence canadienne d'inspection des aliments,
Unité de surveillance phytosanitaire, Ottawa, Ontario

Data Sources | Sources des données:
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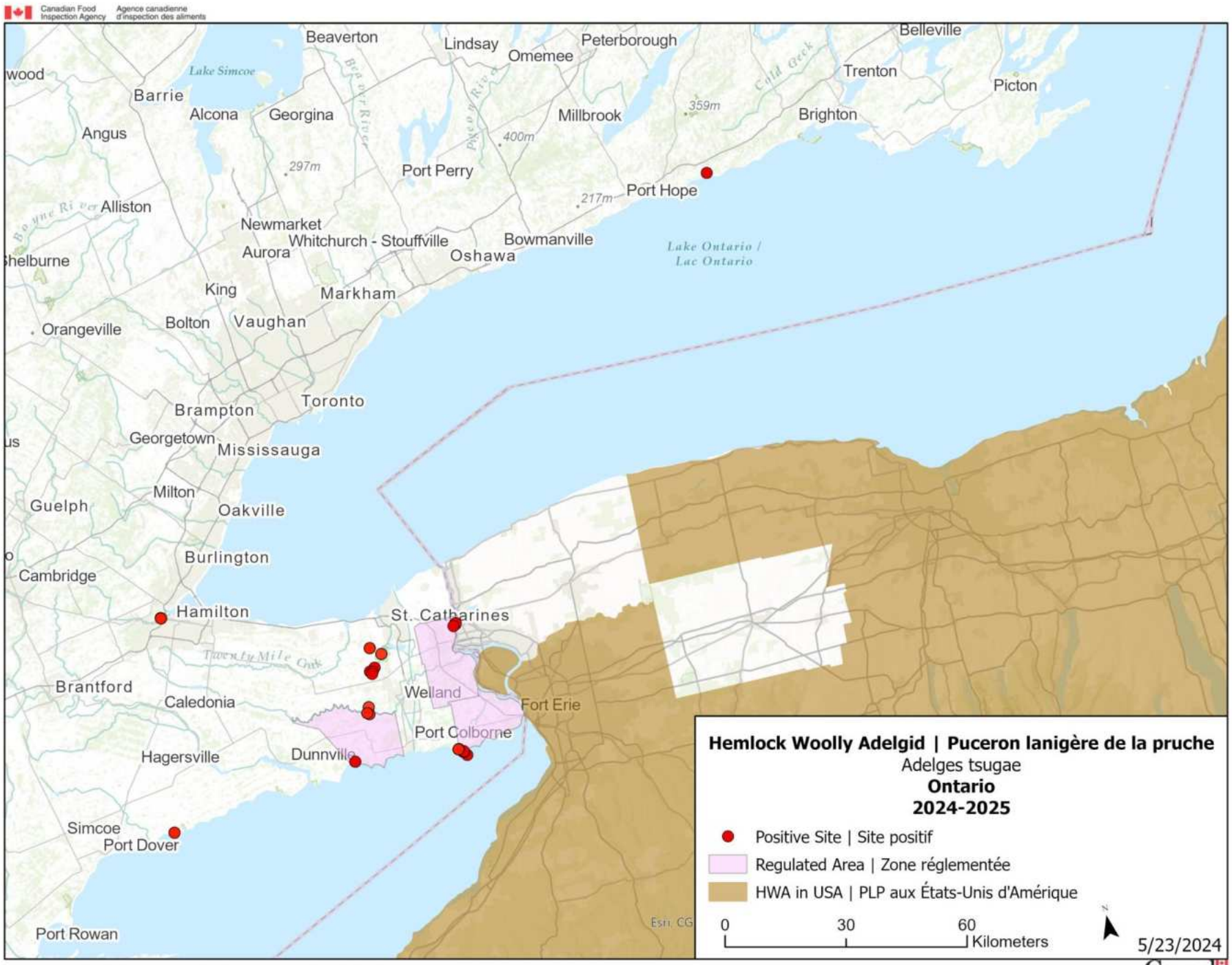
0 240 480 mi
0 390 780 km

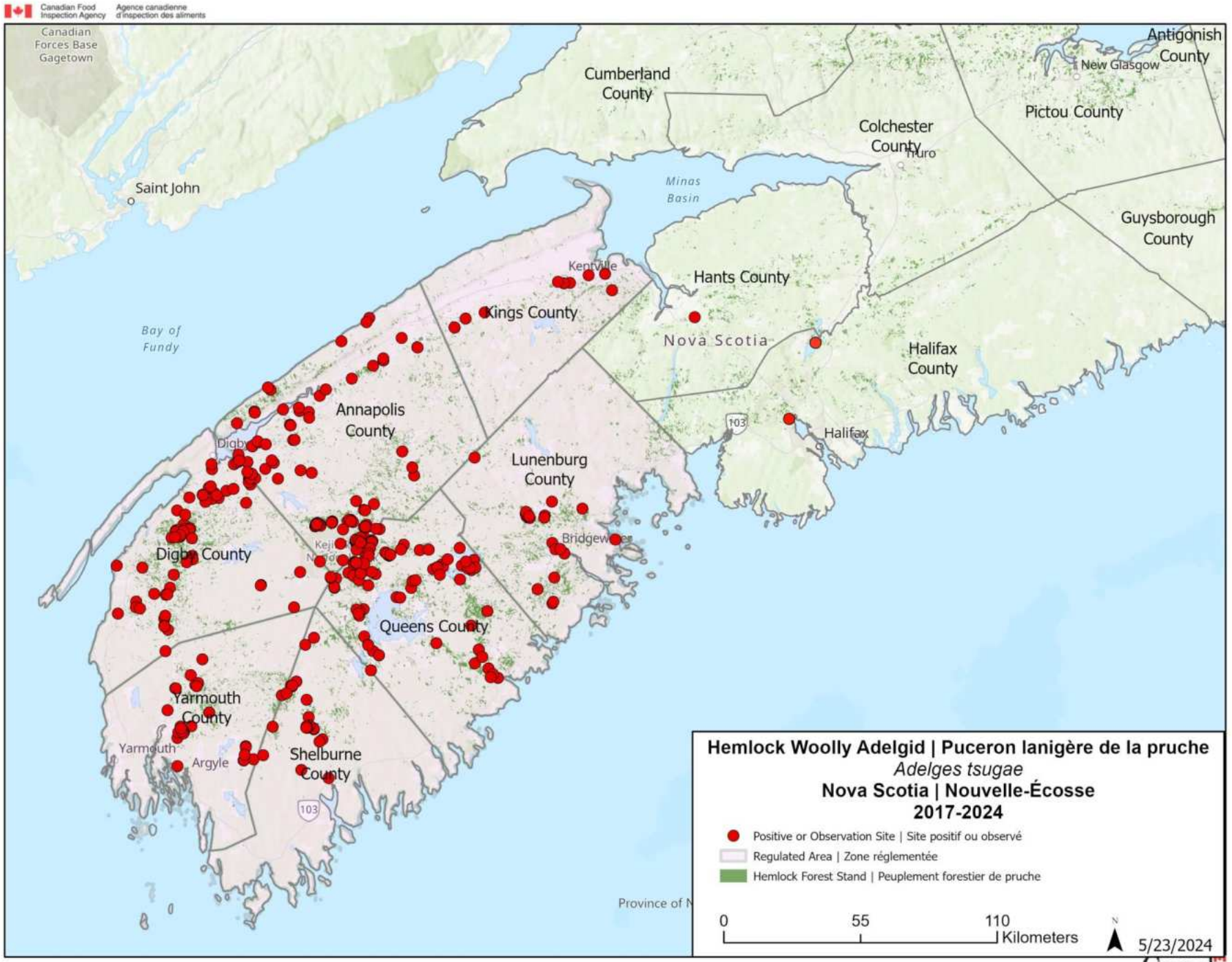
N

2022-04-19

Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

Canada

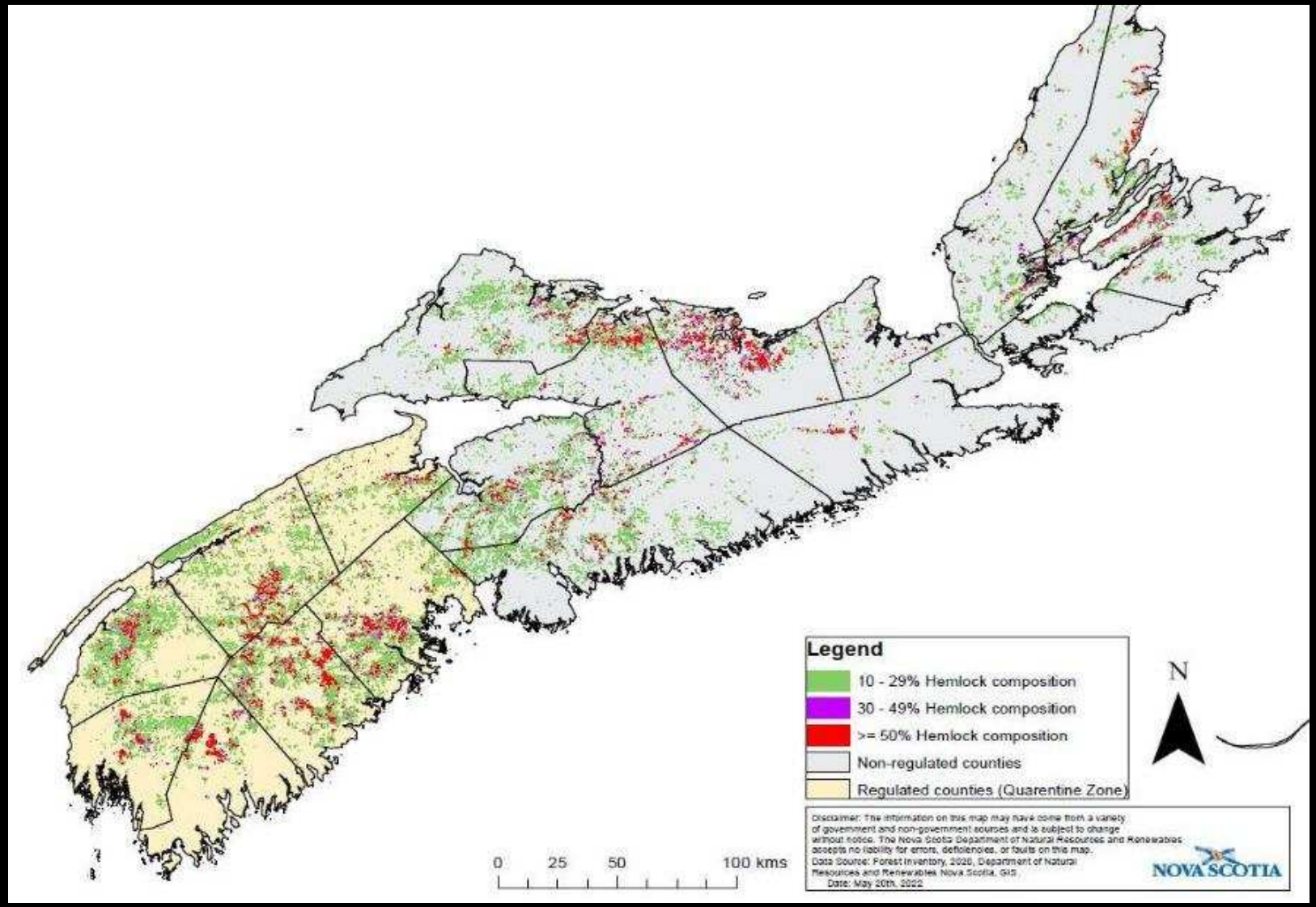

Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments
Beaverton
Lindsay
Omemee
Peterborough
Belleville
Trenton
Picton
Brighton
Millbrook
359m
400m
297m
217m
Port Perry
Port Hope
Lake Simcoe
Barrie
Alcona
Georgina
Angus
Alliston
Newmarket
Whitchurch - Stouffville
Aurora
Bowmanville
Oshawa
Lake Ontario / Lac Ontario
King
Markham
Orangeville
Bolton
Vaughan
Brampton
Toronto
Georgetown
Mississauga
Milton
Guelph
Oakville
Burlington
Cambridge
Hamilton
St. Catharines
Twenty Mile Creek
Brantford
Caledonia
Welland
Fort Erie
Port Colborne
Dunnville
Hagersville
Simcoe
Port Dover
Port Rowan
Hemlock Woolly Adelgid | Puceron lanigère de la pruche
Adelges tsugae
Ontario
2024-2025
Positive Site | Site positif
Regulated Area | Zone réglementée
HWA in USA | PLP aux États-Unis d'Amérique
0
30
60
Kilometers
5/23/2024
Canada


Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments
Canadian Forces Base Gagetown
Saint John
Cumberland County
Colchester County
Truro
Antigonish County
New Glasgow
Pictou County
Guysborough County
Minas Basin
Bay of Fundy
Kentville
Kings County
Hants County
Nova Scotia
Halifax County
Halifax
103
Annapolis County
Digby
Lunenburg County
Bridgewater
Digby County
Queens County
Yarmouth County
Yarmouth
Argyle
Shelburne County
Province of N
Hemlock Woolly Adelgid | Puceron lanigère de la pruche
Adelges tsugae
Nova Scotia | Nouvelle-Écosse
2017-2024
Positive or Observation Site | Site positif ou observé
Regulated Area | Zone réglementée
Hemlock Forest Stand | Peuplement forestier de pruche
0
55
110
Kilometers
N
5/23/2024
Canada

Great Smoky Mountains National Park

Landscape Effects

- Stand decline variable, but not related to slope, aspect, tree density, elevation (Orwig et al. 2002)
- Winter temperature important to HWA mortality, but ‘rebound’ in following year (Tobin et al. 2014)
- Can be spread via birds, mammals
- 12.6 - 20.5 km/year; up to 30 km/year (McClure 1989, 1990)



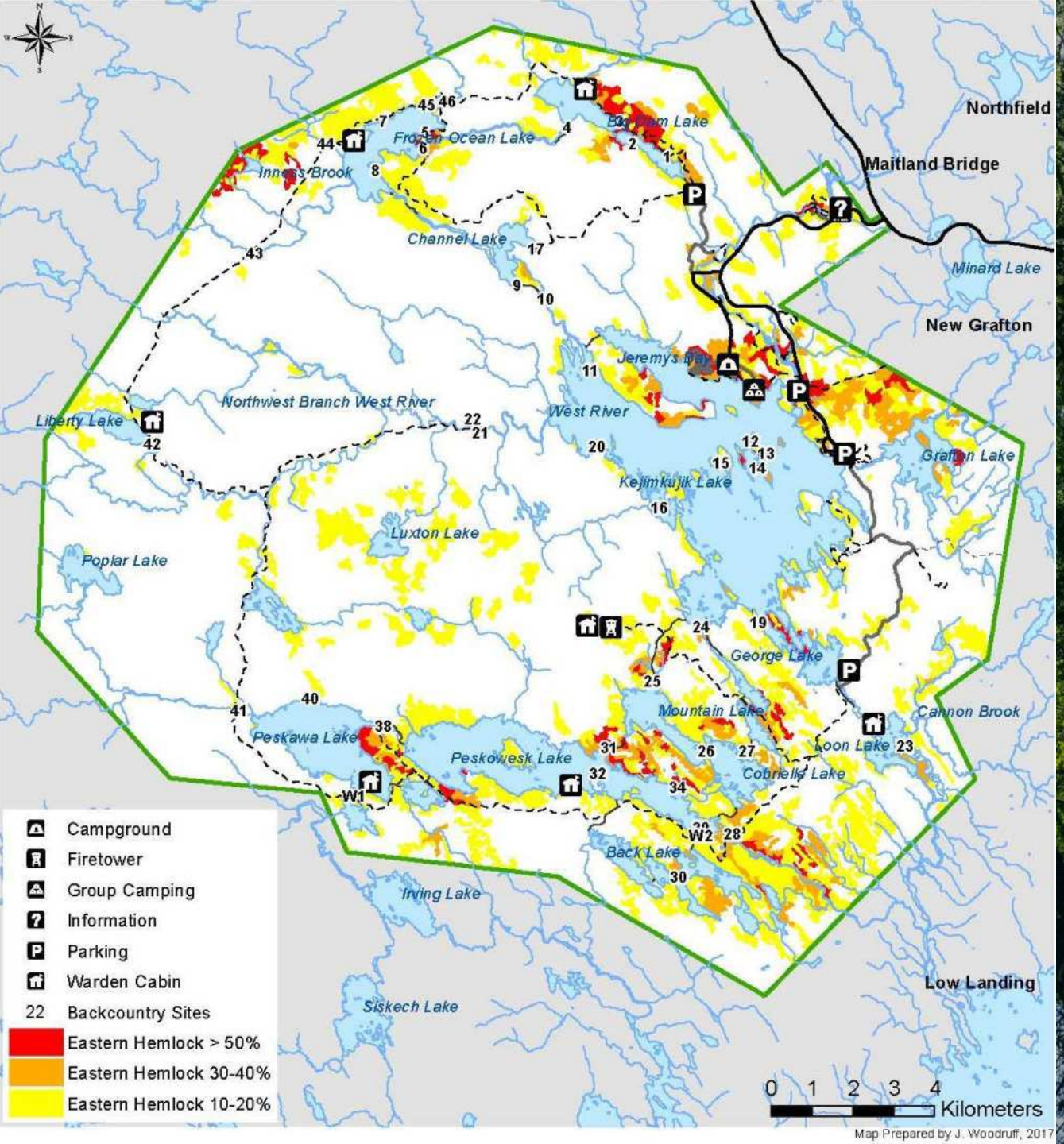
Hemlock in Nova Scotia

- 216,000 ha (8%) contain hemlock
  - ~15% in parks/pa
  - ~19% on Crown
  - ~66% on private
- Regulated areas = 50%
- HWA in NS = 85000 ha

Steve Lawerence/CBC

Ecological significance of hemlock

- Foundation species; important component of old growth forests
- Specialized habitats for animals (esp. overwintering) & other biodiversity
- Key role in riparian function & hydrology
  - HWA impacts on fish through stream warming
- Large carbon store → HWA modelled to cause a shift from C sink to C source
- Fire risk under hemlock decline



Cultural significance

- Component of Mi'kimaq old growth forests
  - Wapane'kati Old Growth Forest
  - Land-based healing, cultural centres, traditional medicine and crafts
- Kejimkujik National Park
  - Key recreational areas in hemlock stands
  - Backcountry hiking trails & portages
- Common along lakeshores in NS
  - Impacts on cottage properties, recreation

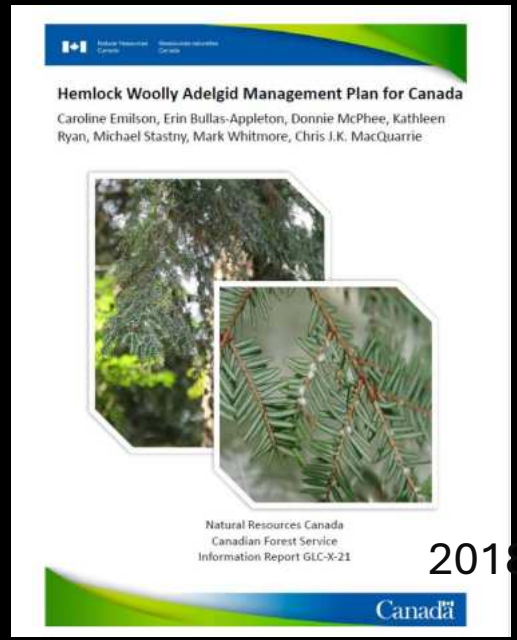
HWA Management in Nova Scotia

- Biological control (+ Silviculture and Insecticide Strategies) identified as long-term tactic in IPM strategy (Emilson and Stastny 2019)

'Building on the research done in the eastern US' (Onken and Reardon 2011, Havill et al. 2014, Letheren et al. 2017)

'…emphasis on collection of predators from western North America…'

'Field trials and research should begin in southwestern Nova Scotia where there are currently established HWA populations.'



2018

Natural Resources Canada | Ressources naturelles Canada

Canadian Forest Service / Service canadien des forêts

Utilize expertise and scientific knowledge

Develop research programs that will contribute to tools for end-users

CFS HWA Research

1. **Insecticides**

- Imidacloprid (5-7 year protection)
  - Xytect 2F (Emerg. Reg., Nova Scotia, Ontario)
    - Basal-bark spray
  - IMA-jet/IMA-jet-10
    - Stem injection
- Starkle 20 SG (Dinotefuran)
  - Combine w/Xytect 2F (faster uptake in tree)
  - Shorter protection time

- Uptake (active ingredients and derivatives) by water, soil, organisms
- Effects (multi-year study; tree health, growth, etc.)

CFS HWA Research

2. Silviculture to mitigate HWA impacts?

- HWA affects hemlock's water relations and photosynthesis
- → physiological stress, growth rate

- ***<u>Can stand thinning help maintain hemlock vigour under HWA?</u>***

- Anticipated benefits:
  - improve light & water availability to hemlock
  - boost tree growth to tolerate HWA infestations
  - promote stand resilience → buy time for other tactics
  - manage forest proactively → plan regeneration & restoration

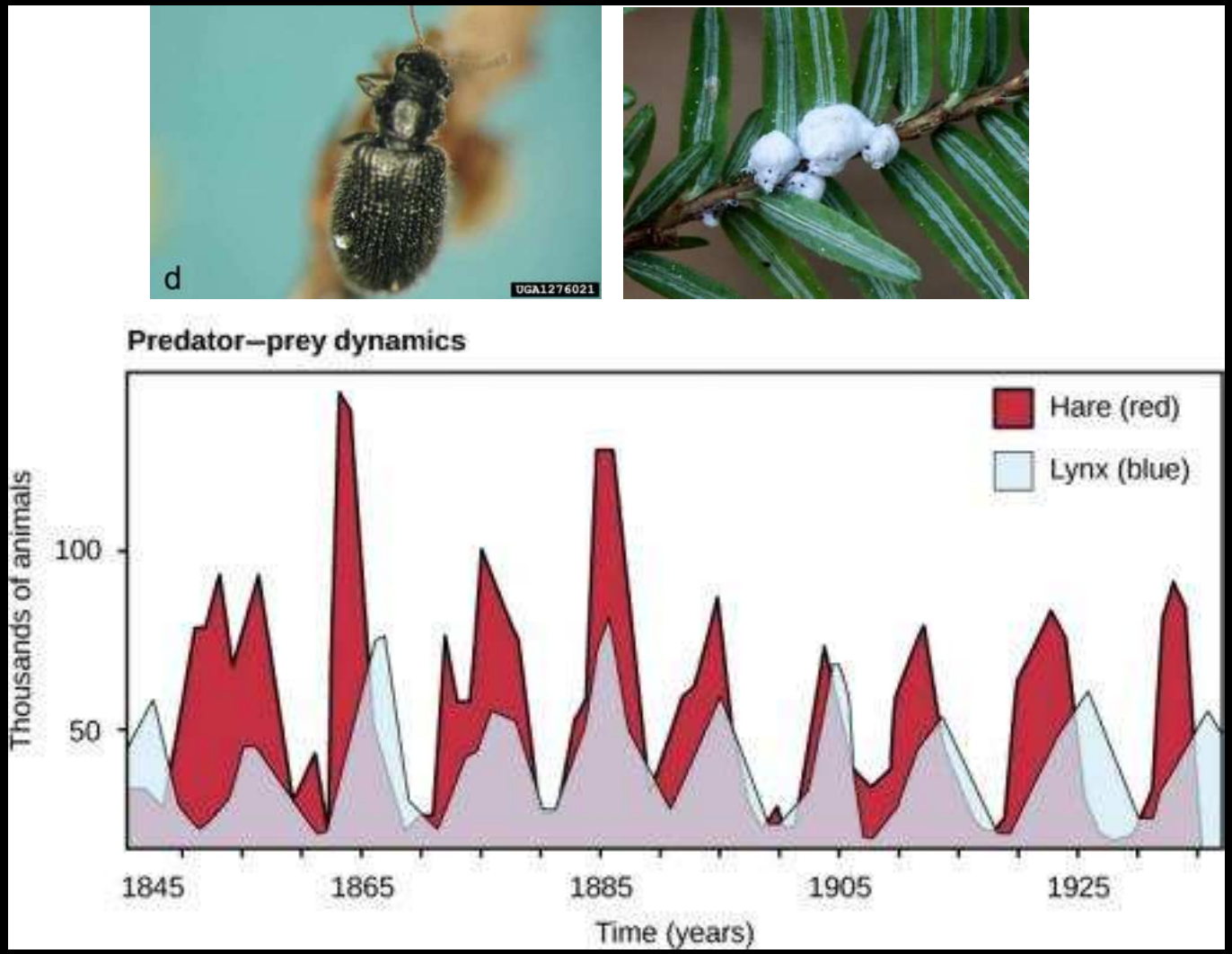
CFS HWA Research

- **Field trials of silvicultural tactics** (NS, est. 2020)
- (*Michael Stastny, Jeff Fidgen)*

- Trial A: Small-scale thinning (individual tree selection) in 3 private woodlots

- Trial B: Commercial operation (strip shelterwood cut) in replicate plots on crown land

→ early result: slower hemlock decline in thinned stands *in spite of* equal HWA levels



CFS HWA Research

3. Biological Control

- ‘Prey’ regulated by ‘Predator’
- Pacific NW:
  - Predators play major role in HWA populations
  - HWA outbreaks are rare
- Biological Control
  - Selection, sourcing, purifying, release of safe agents to invaded range

Elements of a biocontrol programme

Justification

- unacceptable damage
- top-down control in native range, but not in invaded range
- other tactics insufficient

* Based on existing / ongoing research

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Safety *

- evidence of safety before release
- specificity to target pest

Approvals

- has to be approved for release federally – if not native to Canada
- other jurisdictional requirements / consultations

Efficacy *

- demonstrated population regulation in invaded range
- suitable given climate, pest phenology etc. in invaded range

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Feasibility *

- adoption / adaptation of existing programmes and protocols
- operational mass releases / rearing
- scaling up: recovery, establishment, spread

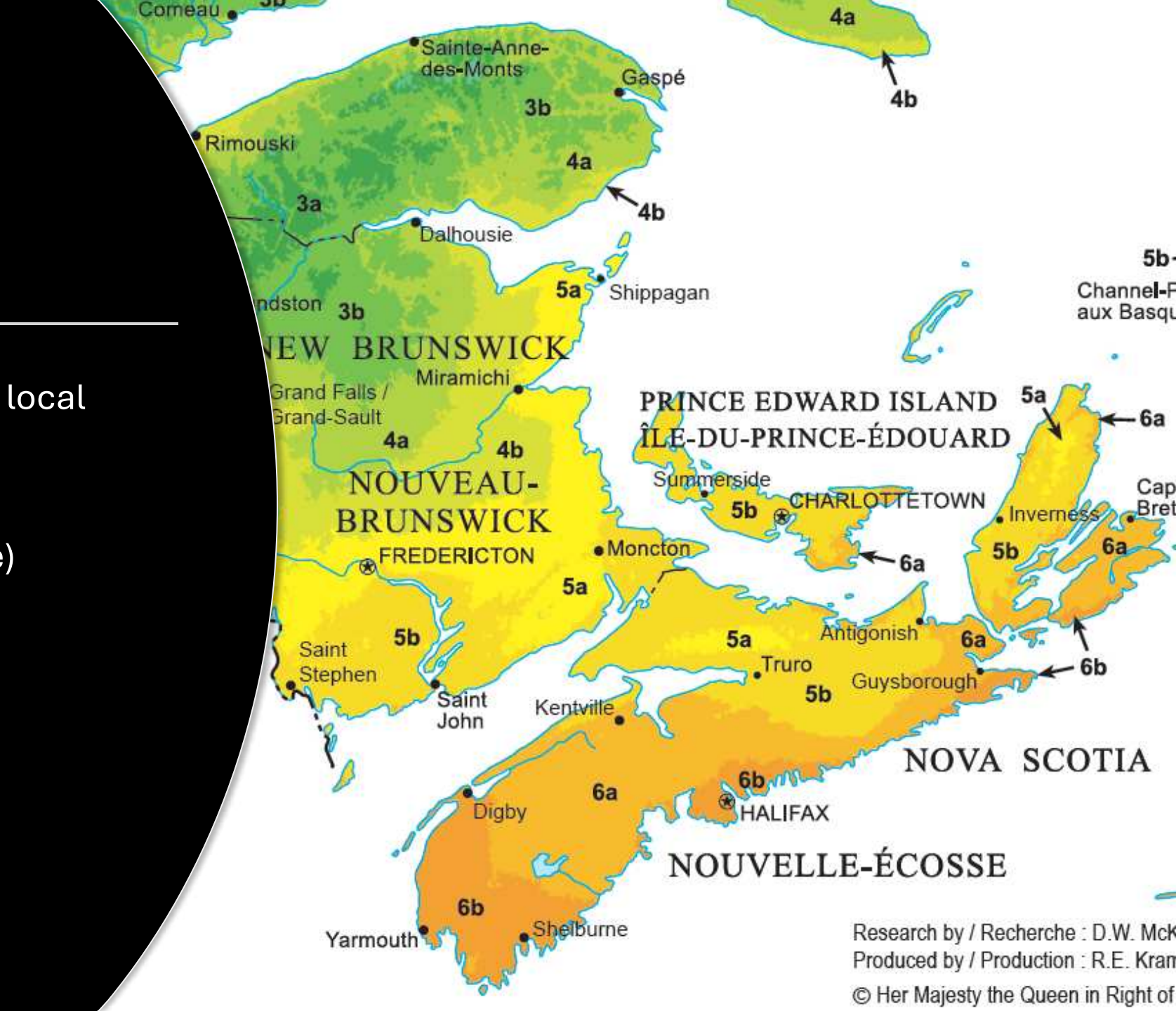
Impacts *

- pest population control
- reduction in tree mortality / decline
- monitoring of non-target effects

* Based on existing / ongoing research

Benefits of Biological Control

1. Only landscape-level tool (vs. local insecticides)
2. Specific
3. Self-sustaining (cost-effective)
4. Adapt to target
   - Density-dependent
   - Follow across range



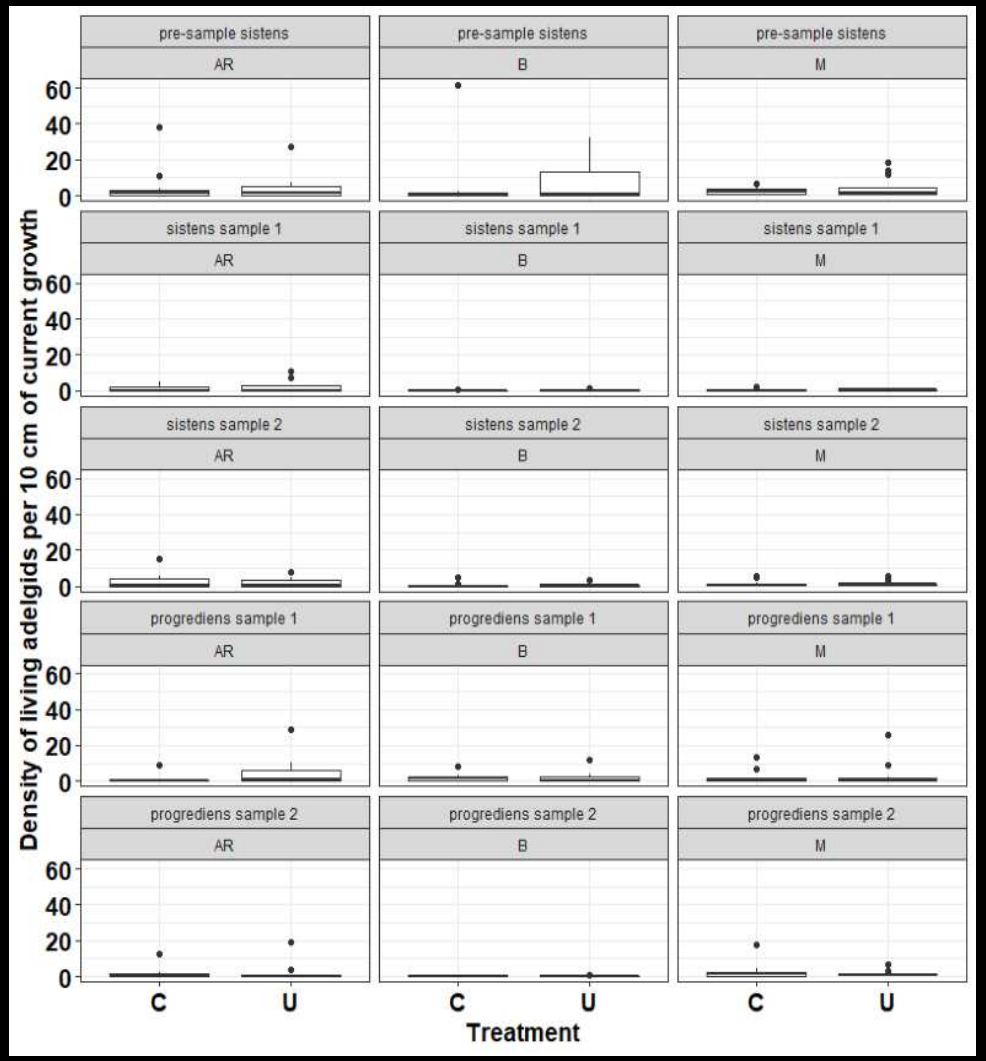
HWA Natural Enemies in Nova Scotia

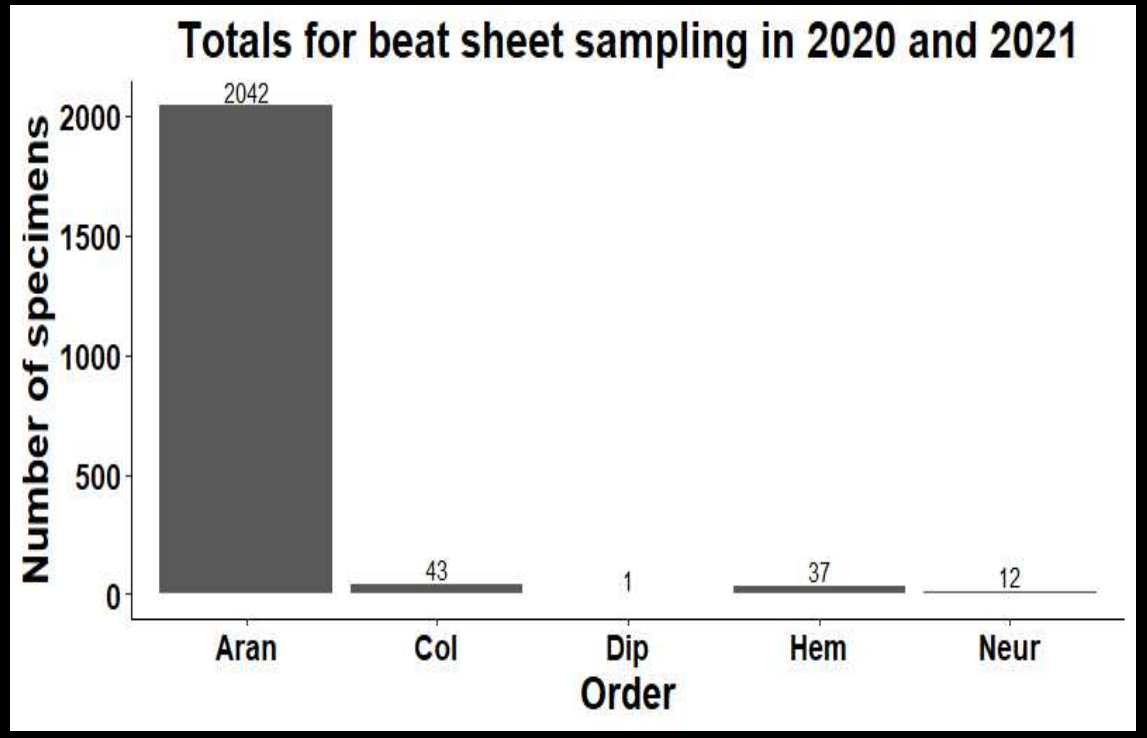
- A: What is the level of mortality?
- B: Which insects are natural enemies?

- 3 year study (2020-2022)
    1. Sleeve cage study (exclusion)
    2. Beat sheet sampling study

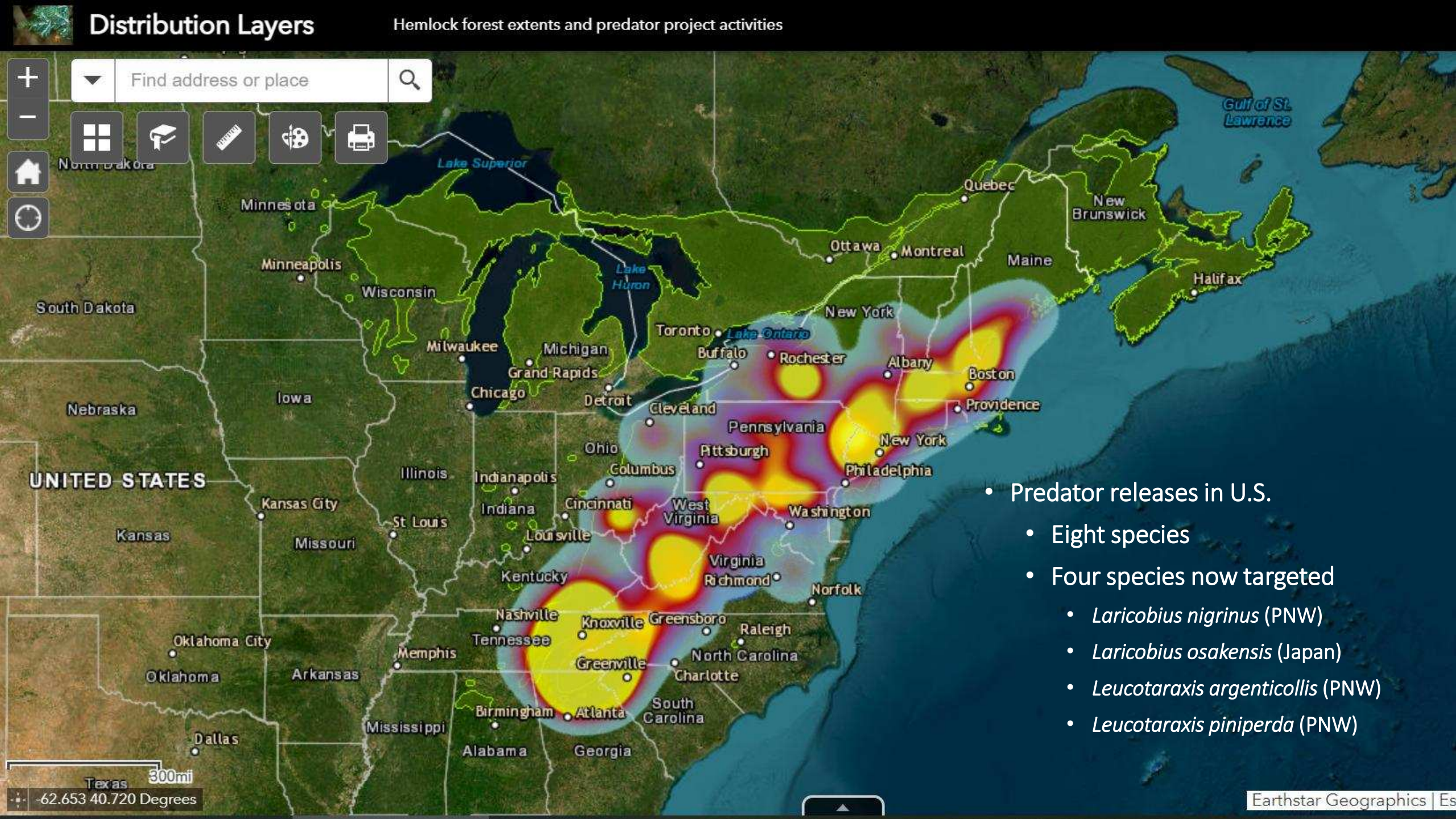
- Multiple sites (Southern Nova Scotia)

Initial Work: Predator regulation in Nova Scotia





No demonstrated population regulation in study sites
No specialist predators (*Leucotaraxis* spp., *Laricobius* spp.) (Roscoe et al. *In prep*)
Top-down regulation most important factor in PNW (Crandall et al. 2022)



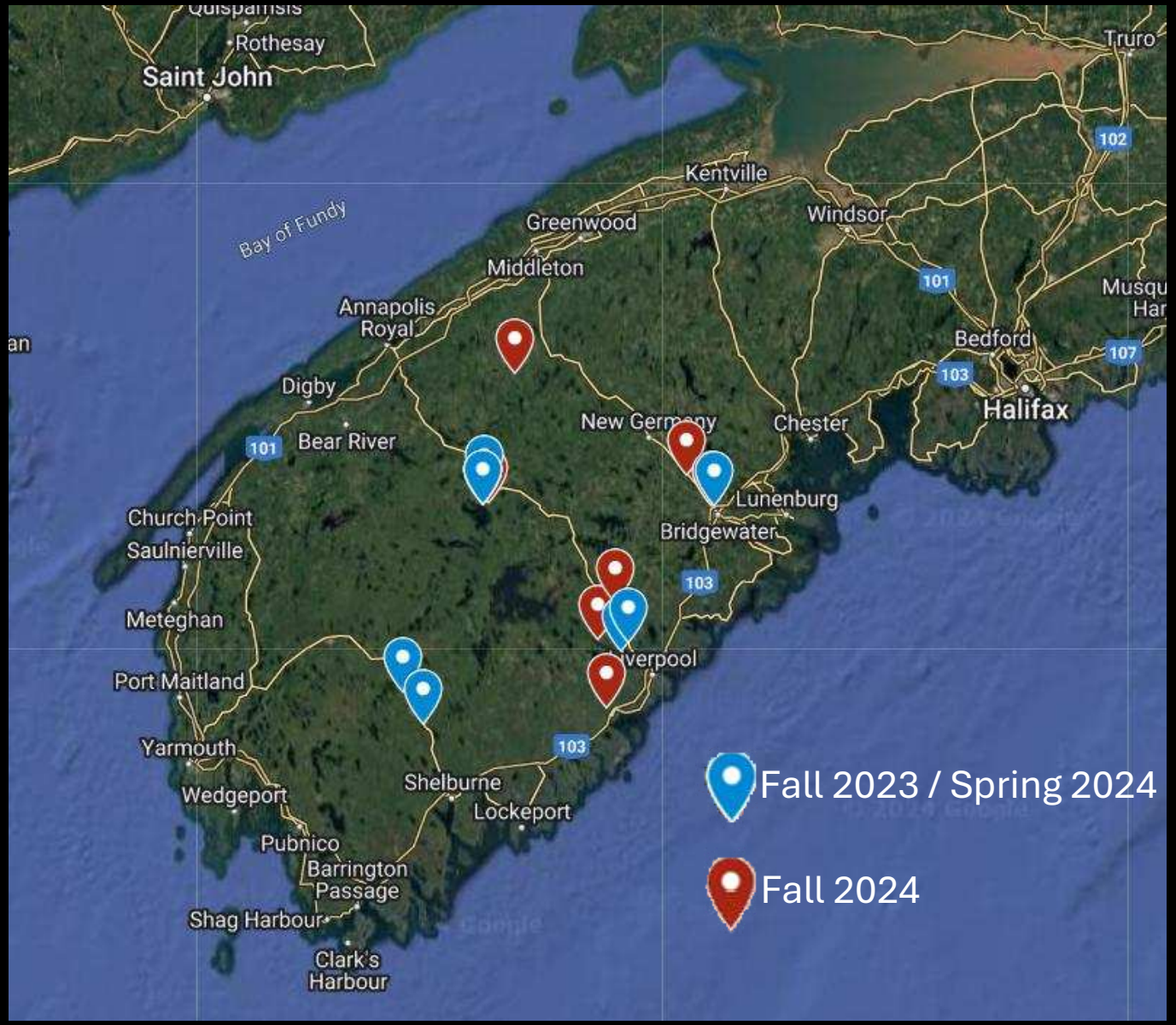
- Predator releases in U.S.
  - Eight species
  - Four species now targeted
    - *Laricobius nigrinus* (PNW)
    - *Laricobius osakensis* (Japan)
    - *Leucotaraxis argenticollis* (PNW)
    - *Leucotaraxis piniperda* (PNW)

Laricobius nigrinus Fender (Col.: Derodontidae)

- Native to Pacific NW (British Columbia, Washington, Idaho)
- Specialized predator of *Adelges* spp. (Zilahi-Balogh et al. 2002)
- Adults active in Nov.-Feb.; larva develop within ovisacs
- Pupate over summer in soil, emergence in October/November

Photo: John D. Simmons

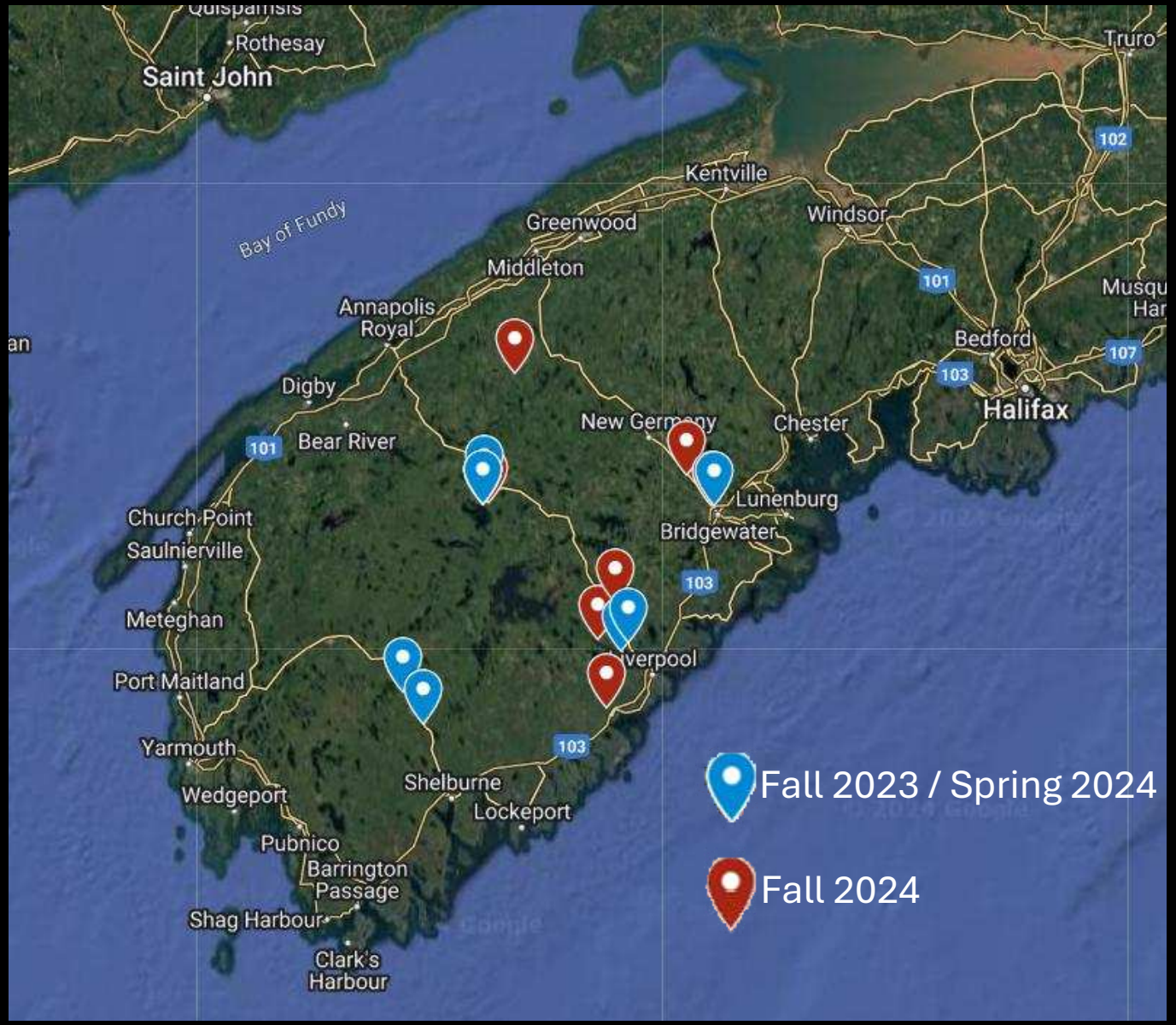
Research Releases, Fall 2023*, Spring 2024**



- Fall 2024 / Spring 2023
  - Two ‘closed’, six ‘open’ (Seven sites)
  - 4173 (Fall) + 877 (Spring) = **<u>5050</u>**
- Fall 2024
  - Six ‘open’ (n = **<u>4135</u>**)

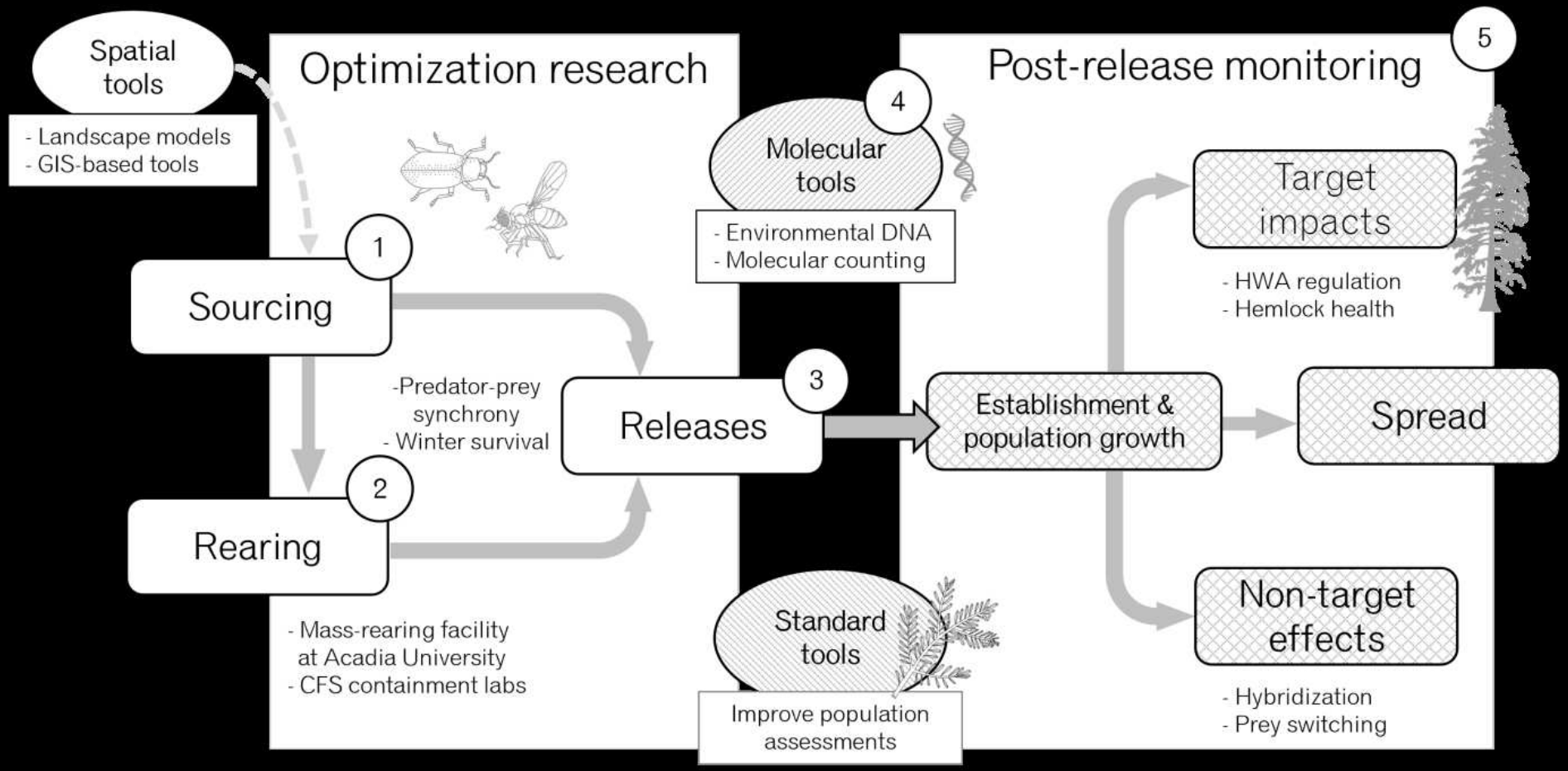
- JBC: + 2061; Acadia U.: 790; GLFC: 100

Research Releases, Fall 2023*, Spring 2024**



- Fall 2024 / Spring 2023
  - ‘F1’ (progeny) collections in 2024
  - Ln recovered at all 6 release sites
    - DNA + SNP (single nucleotide polymorphism), phenological, taxonomic

2025-26



- Assess *L. nigrinus* overwintering survival
- Assess *L. nigrinus* establishment (2023/24 and 2024)

Research projects (collaborators):

- Lab and field cold-tolerance: Prof. N. Kirk Hillier, Prof. Laura Ferguson, Acadia University
- Host location (chemical ecology): Dr. Quentin Guignard, Dr. Jeremy Allison (NRCan-RNCan)
- Research and rearing facility, Acadia University (Prof. N. Kirk Hillier)
  Evaluate non-target effects
  Host range elucidation for *L. osakensis*, *Leu. Argenticollis, Leu. piniperda*

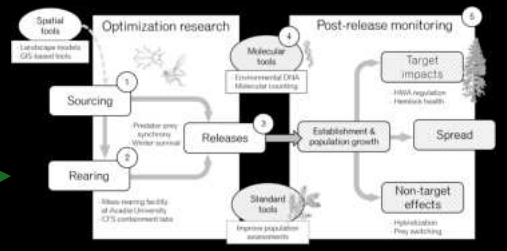
- Develop monitoring methods (NRCan-RNCan) (Source and release)
  - Environmental DNA (Ontario and Nova Scotia)
  - Molecular pipeline (M. Williams)

Orientation ecology (predators)

Non-target effects
Env. tolerances

Canadian Forestry Service (Great Lakes)
Monitoring/detection (Ontario)

Atlantic Forestry Centre (CFS)



Canadian Forestry Service (Pacific)
Sourcing Agents

Releases
Non-target effects
Site selection

Canadian Food Inspection Agency
Agent detection/monitoring

Monitoring/detection

Winter mortality, releases

Agriculture/Agri-Food Canada
Indigenous agent movement

Conclusions

1. HWA is a serious threat; hemlock and biodiversity
2. Multiple partners (gov’t, academic, private, FN)
3. CFS: researching IPM
4. Management research projects: insecticides, silviculture, biocontrol
5. Operations underway (insecticides, biological control, monitoring): NSDNRR, Private, CFIA (Federal)