An Overview of Climate Change and Related CFS Tools for Forest Adaptation

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Eastern Ontario Model Forest & CIF (Ottawa Valley Section)

Virtual Forest Seminar

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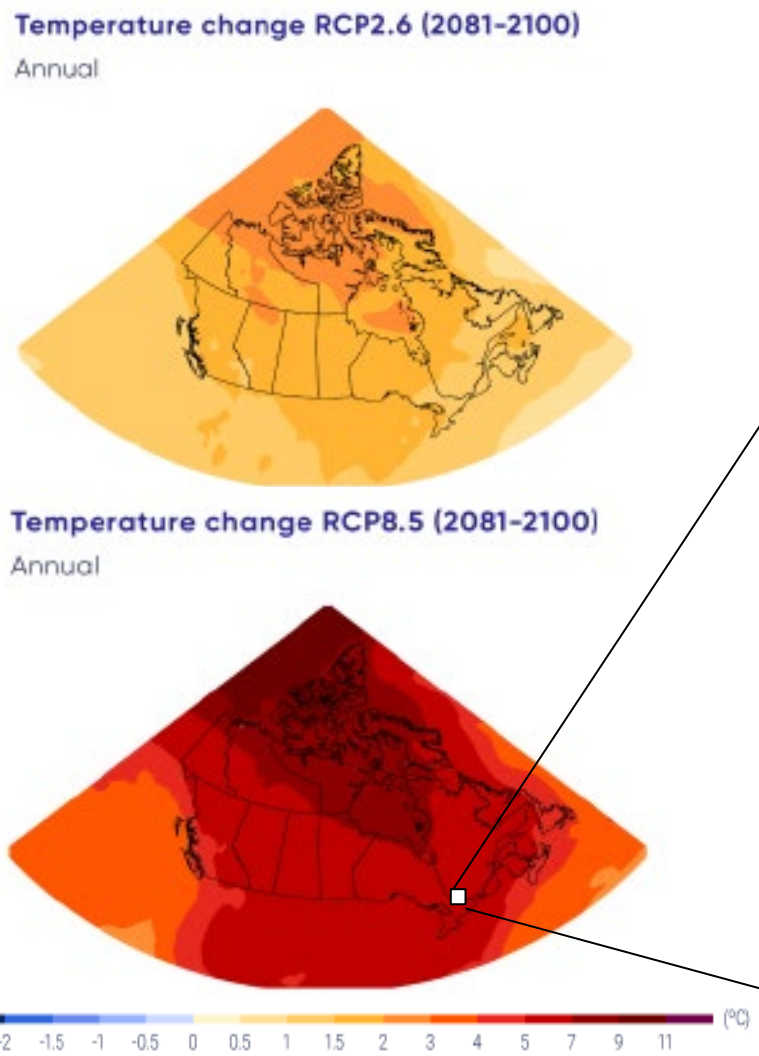
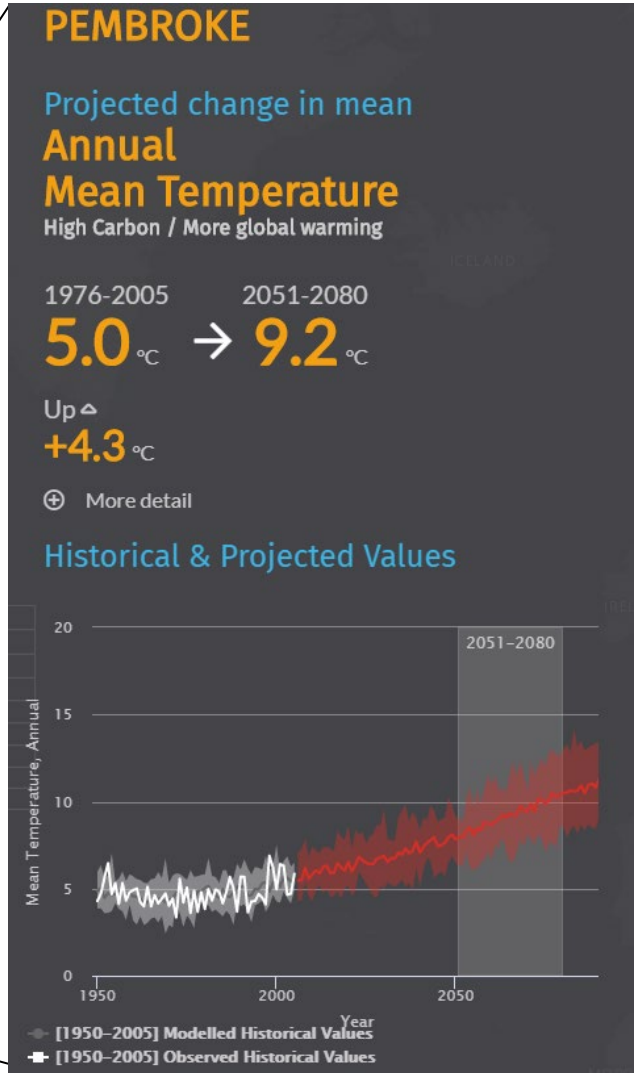
Context

- Multidisciplinary Group at GLFC: Integrated Ecology and Economics section
- Spatial climate data is the foundation for much of the work we do
- Research topics includes: plant hardiness modelling, species distribution modelling, invasive species risk assessments, and climate change impacts and adaptations
- Today's Talk:
  - Brief overview of climate change at national and regional scales
  - CFS climate change adaptation tools

Climate Change Overview

- National and Regional Temperature Change -



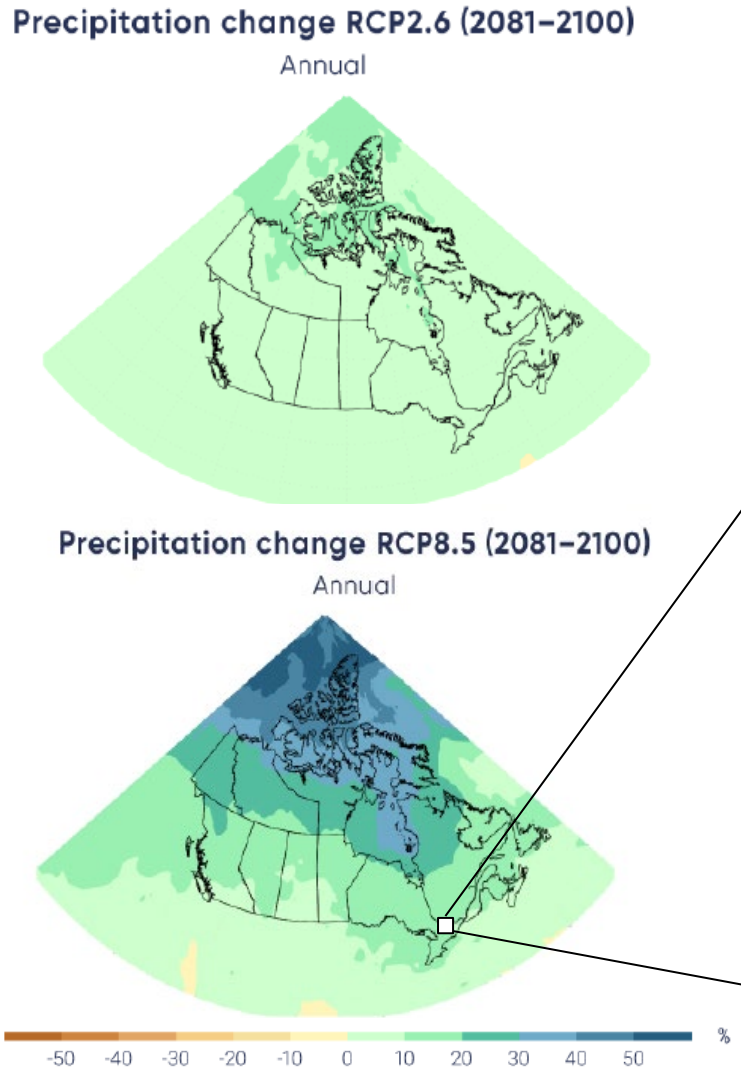


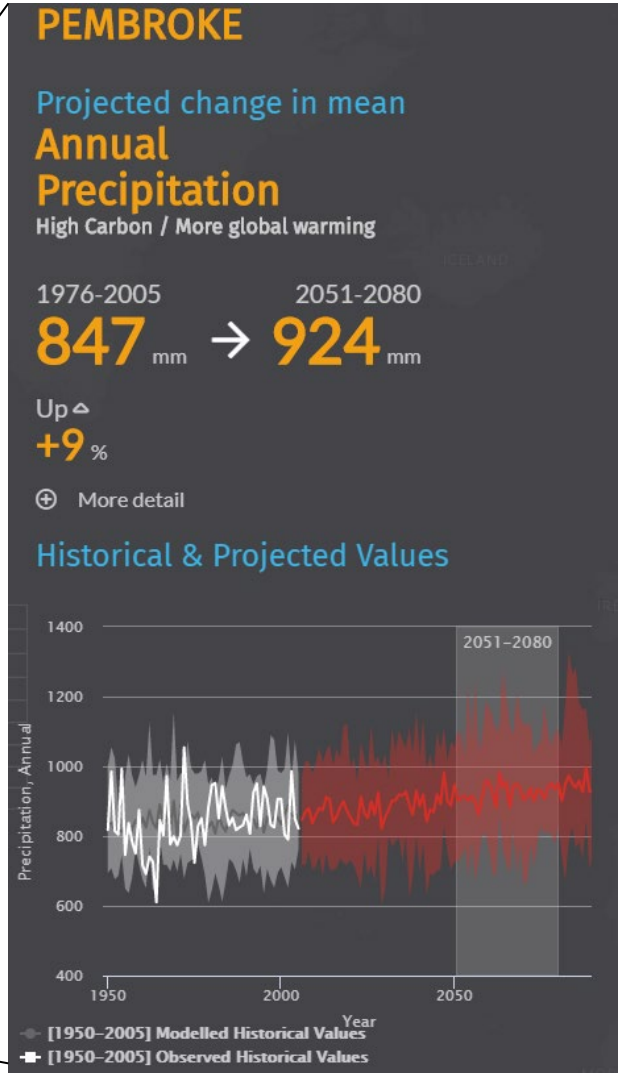
https://changingclimate.ca/CCCR2019/

https://climateatlas.ca

Climate Change Overview

- National and Regional Precipitation Change -





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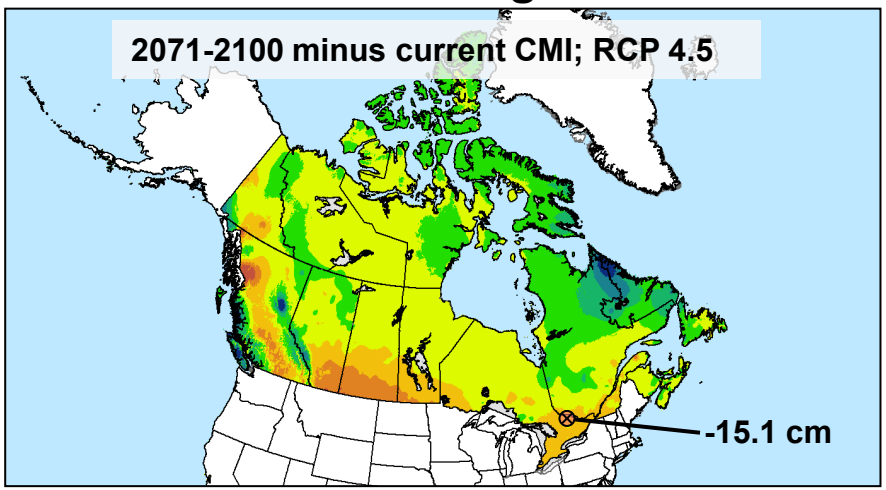
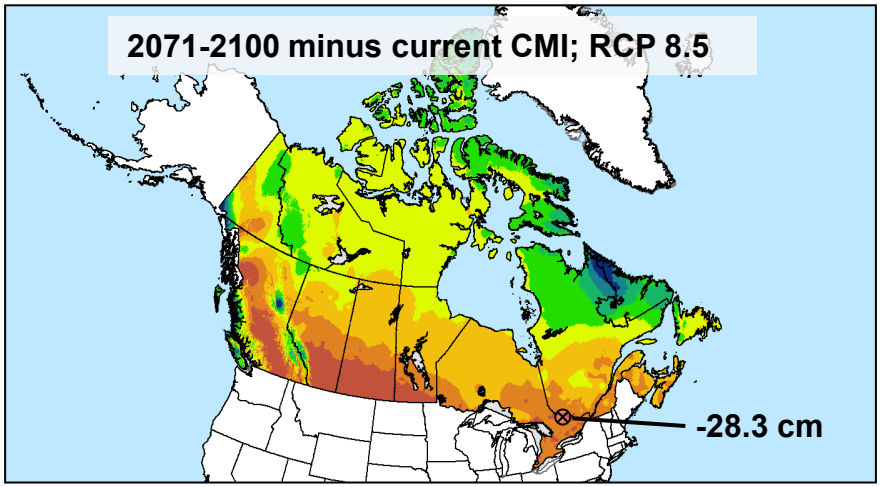
Climate Change Overview

- National and Regional Water Balance -

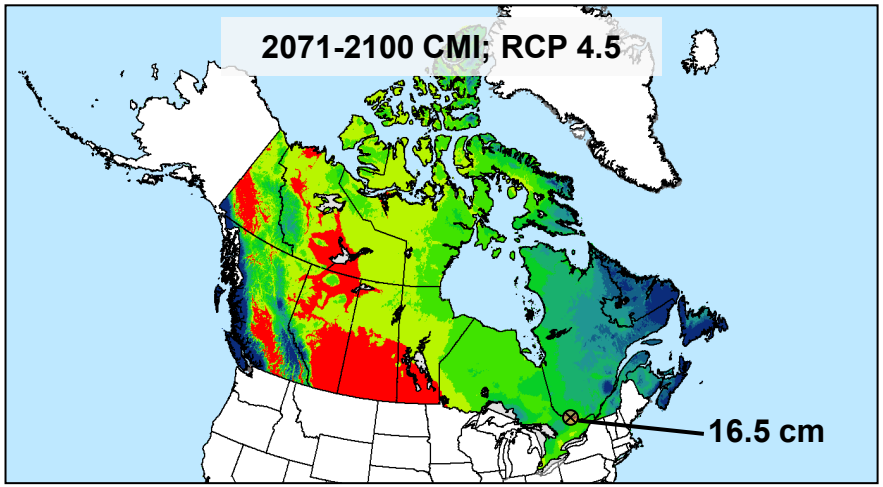
CMI Change



Change in Climate Moisture Index (cm/yr)

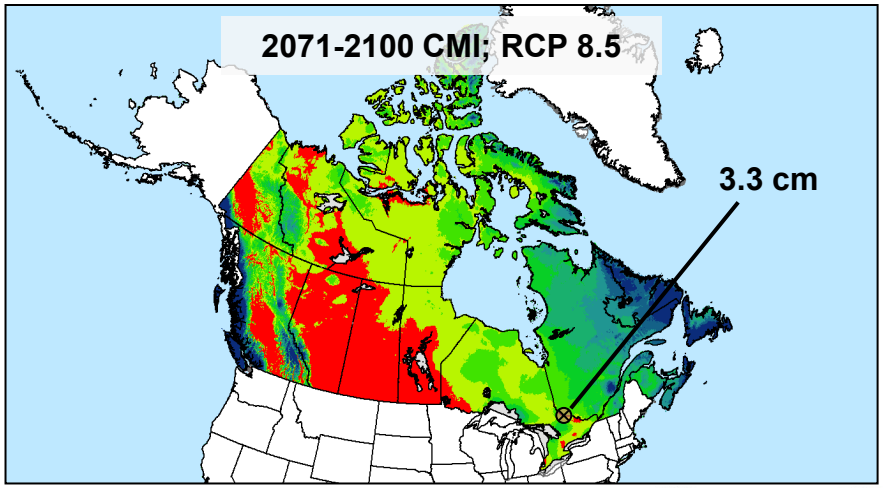


Future CMI



Future Climate Moisture Index (cm/yr)

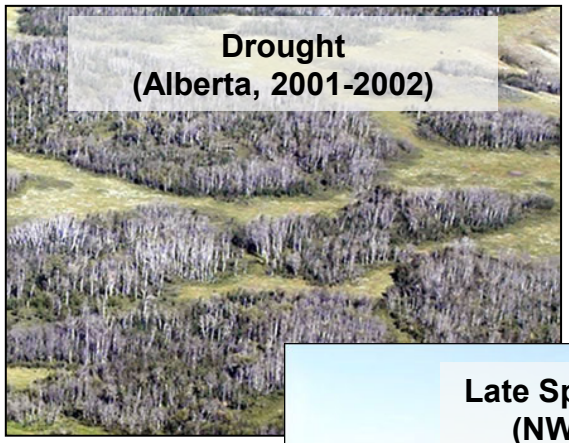
< 0 | 0 - 15 | 15 - 30 | 30 - 45 | 45 - 60 | 60 - 90 | > 90



Climate Change Overview

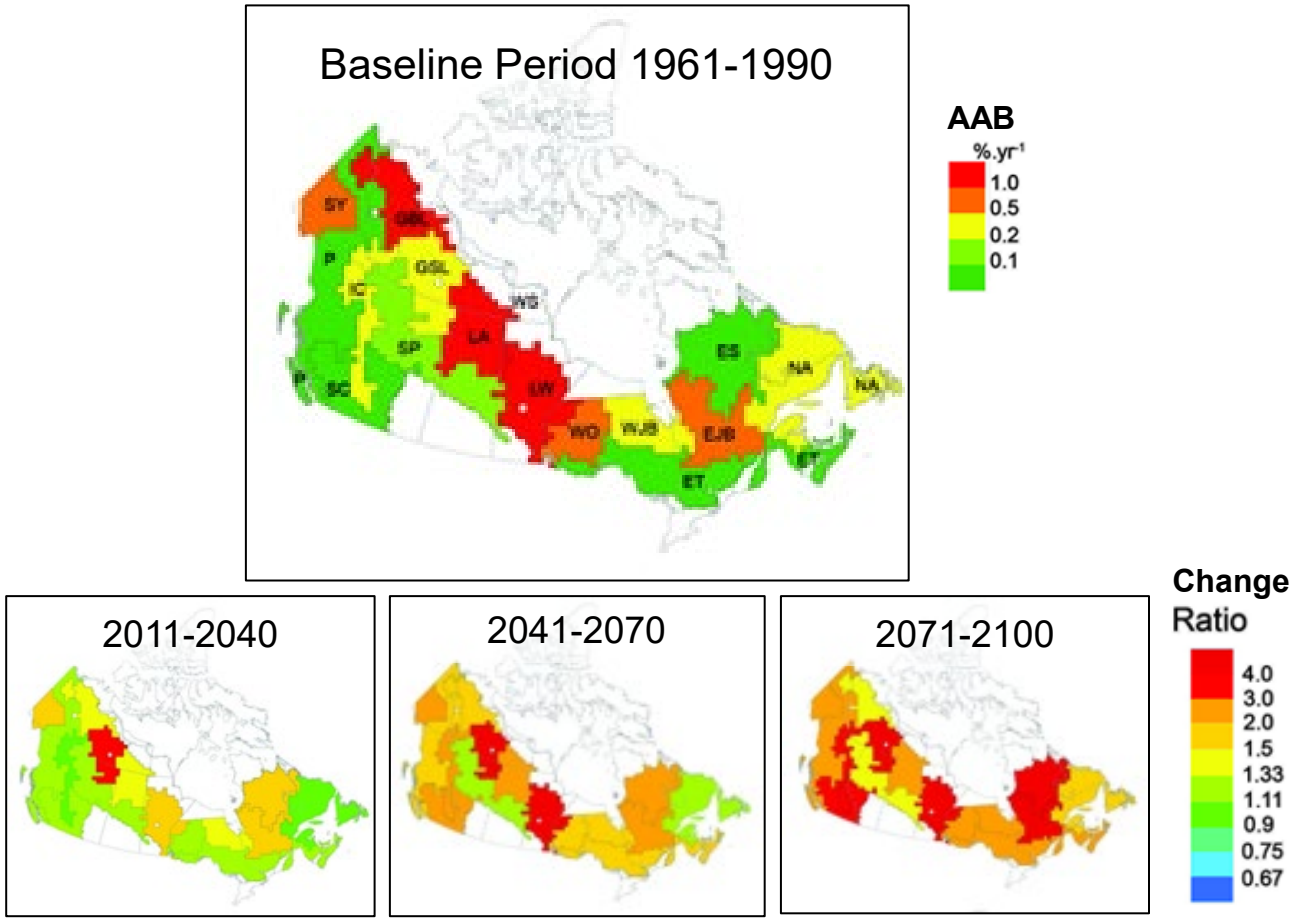
- Direct Impacts on Forest Growth and Mortality -

- Direct impacts on forest health by climate/weather events include:
- Growth declines/increases
- Mortality due to droughts, late spring freezes, floods, wind events, etc.
- Reproductive declines (flowering asynchrony, reduced seed/seedling success)



Climate Change Overview

- Indirect Impacts on Forests via Fire -



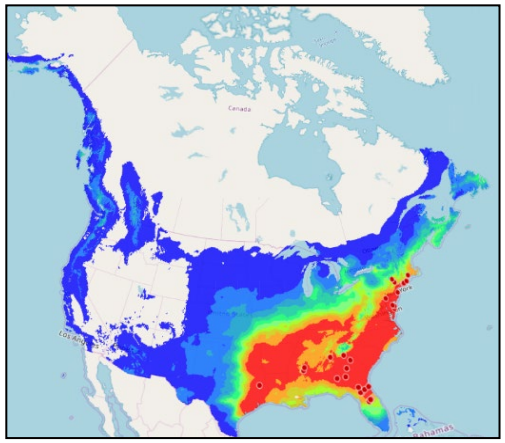
Source: Boulanger, Y., Gauthier, S., & Burton, P. J. (2014). A refinement of models projecting future Canadian fire regimes using homogeneous fire regime zones. Canadian Journal of Forest Research, 44(4), 365-376.

Climate Change Overview

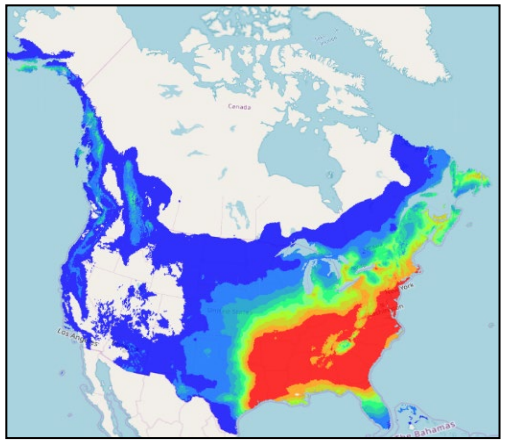
- Indirect Impacts on Forests via Pests -

Southern Pine Beetle

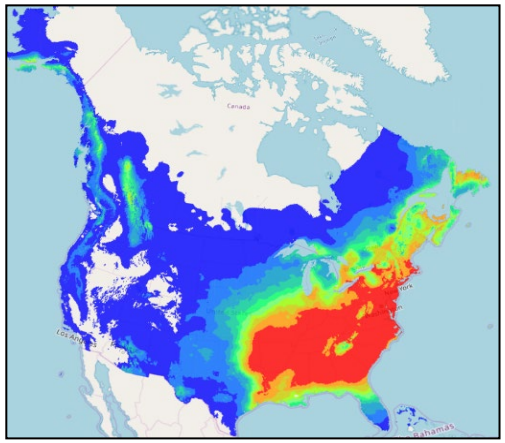
(*Dendroctonus frontalis*)



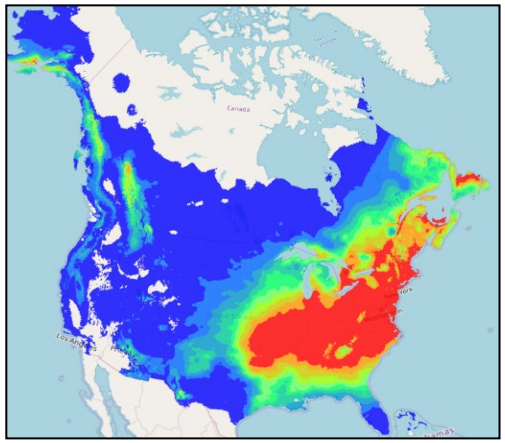
1971-2000



2011-2040



2041-2070

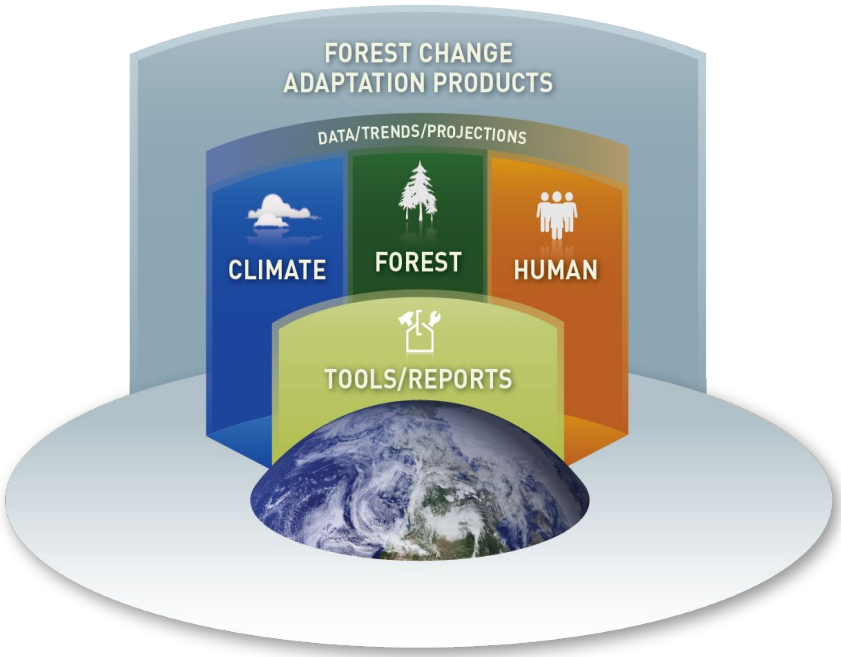


2071-2100

Climate Change Adaptation Tools

- The Forest Change Program -

- A CFS program initiated in 2010 that features:
  - **A Tracking System** that reports on indicators of climate change relevant to the forest sector
  - **An Adaptation Toolkit** of science tools and related resources for sustainable forest management under a changing climate
  - **Regional and Integrated assessments** of CC impacts on forests and potential adaptation responses



- All resources can be accessed at:

https://www.nrcan.gc.ca/climate-change/impacts-adaptations/impacts-forests/forest-change-adaptation-tools/17770

Climate Change Adaptation Tools

- Assisted Migration -

- involves movement of organisms to locations outside traditional range limits in response to climate change.

- First attributed to Peters and Darling, 1985:

"If reserves do not retain necessary thermal or moisture characteristics, individuals of disappearing species may have to be transferred to new reserves. For example, warmth adapted ecotypes or subspecies may have to be transplanted to reserves nearer the poles."

"Such transplantations, particularly involving complexes of species, will often be difficult, but applicable technologies are being developed…"

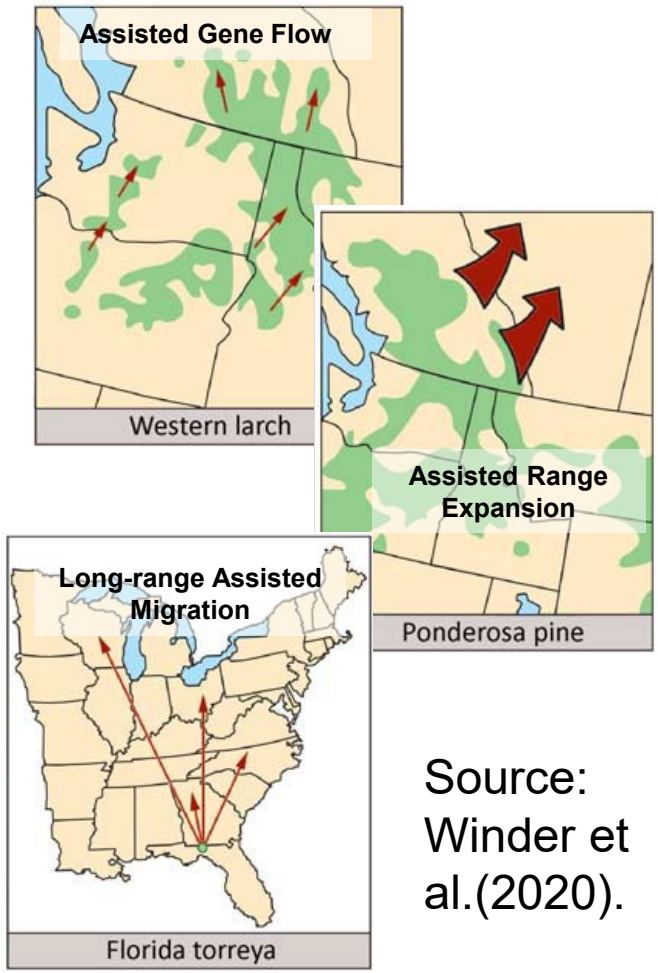
Johnny Appleseed

Peters, R. L., & Darling, J. D. (1985). The greenhouse effect and nature reserves. Bioscience, 707-717.

Climate Change Adaptation Tools

- Assisted Migration, Cont'd -

- Different types of AM can be discerned along a gradient of movement distances
- Environmental risk increases with distance moved
- Much of the focus to date in Canada has been on assisted gene flow



Source: Winder et al.(2020).

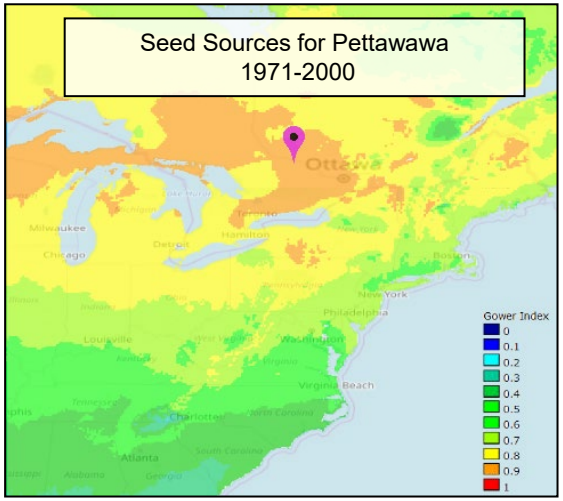
Climate Change Adaptation Tools

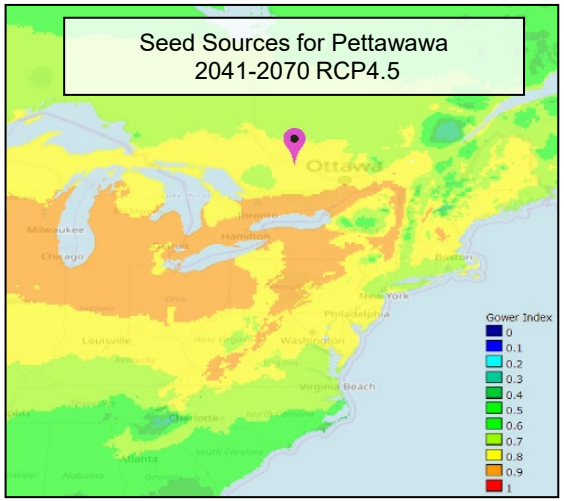
- Seedwhere, Climate Matching -

- SeedWhere is a web application that identifies locations with climate similar to a point of interest

  http://cfs.cloud.nrcan.gc.ca/seedwhere

- employs the Gower Index to calculate climate similarity
- can be used with any number of climate variables
- has been developed to incorporate climate change
- can be used for both seed procurement and deployment

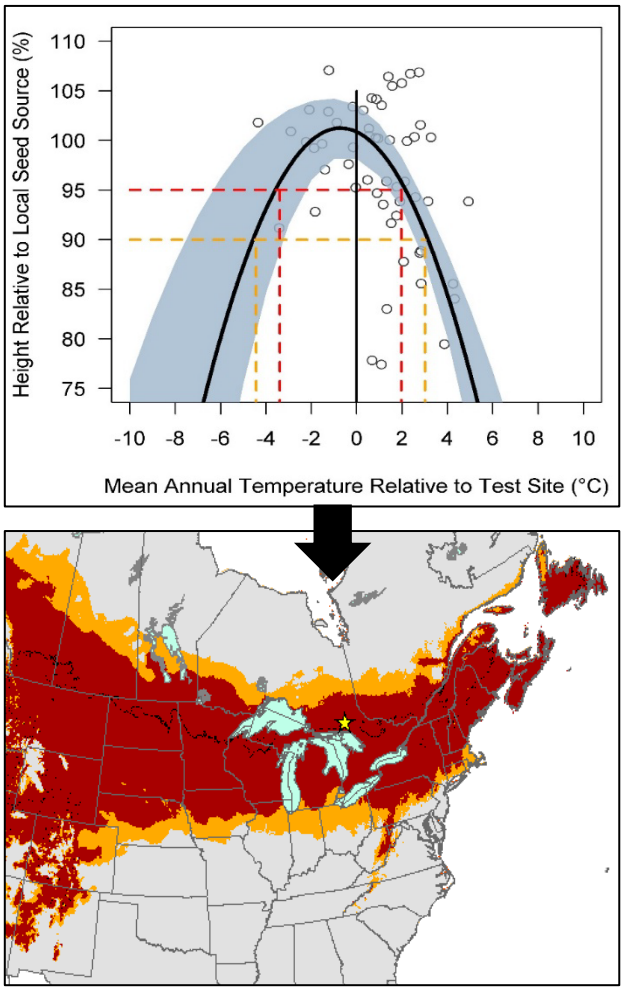




Climate Change Adaptation Tools

- Critical Seed Transfer Distance -

- Provenance data allows for more accurate climate-growth relationships to be developed
- We have gathered provenance data for a number of tree species and generated transfer functions to examine critical seed transfer distances (sensu O'Neill et al. 2014)
- CSTDs indicate how far seeds can be moved before unacceptable growth losses occur
- can be mapped to visualize potential seed sources for a given planting site



Source: Pedlar, McKenney, and Lu. 2020. Journal of Ecology, submitted.

Climate Change Adaptation Tools

- Critical Seed Transfer Distance, Cont'd -

- We generated transfer functions and CSTDs for 5 tree species
- Results were relatively consistent across species:
  - Transfer functions were not significant at all test sites
  - Relationships were noisy and weak (i.e., low r-square values)
  - Safe seed transfer distances were large (e.g., 5ºC MAT movements ~ 400-500 km in eastern Canada)
- On the plus side, this means seed transfer systems can be relatively coarse and flexible
- Raises concerns re capacity of AGF to buffer climate change

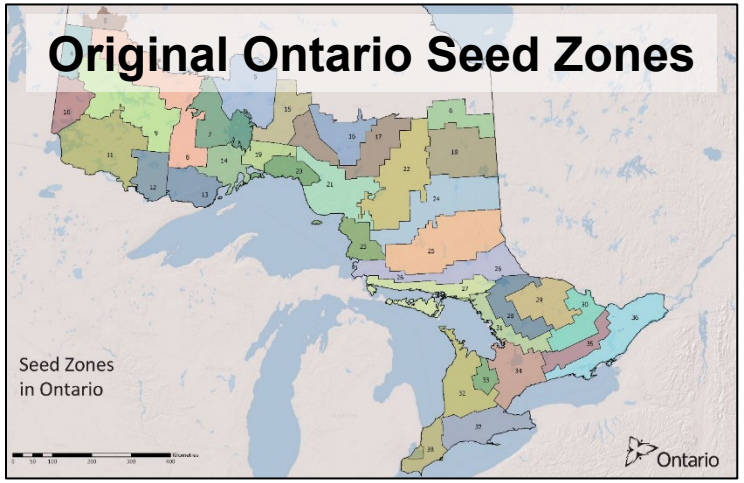
Species	Climate Variable	N Test Sites	N signif-icant	Mean R^2	Growth > 95 % of local	
					Northward Transfers	Southward Transfers
Black Spruce	ANNP	19	15	0.29	-350.4	371.8
	GSLENGTH	19	13	0.22	-40.9	15.7
	MAT	19	13	0.17	-4.9	2.7
White Spruce	ANNP	40	17	0.18	-390.6	213.6
	GSLENGTH	40	17	0.23	-45.0	12.8
	MAT	40	15	0.22	-4.9	1.9
Jack Pine	ANNP	30	14	0.15	-291.2	449.8
	GSLENGTH	30	11	0.21	-44.4	10.2
	MAT	30	12	0.23	-5.5	2.9
White Pine	ANNP	28	12	0.2	-1116.8	129.9
	GSLENGTH	28	13	0.32	-85.4	20.4
	MAT	28	13	0.32	-7.7	2.5
Yellow Birch	ANNP	7	0	.	.	.
	GSLENGTH	7	5	0.19	-58.9	21.7
	MAT	7	3	0.14	-6.7	2.2

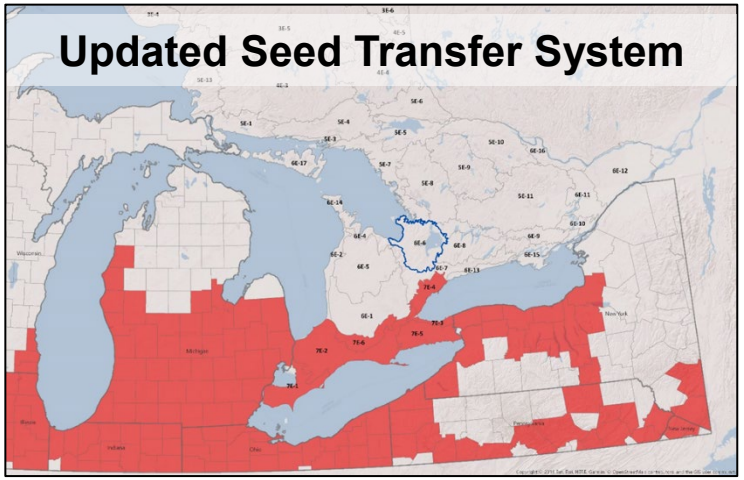
Source: Pedlar, McKenney, and Lu. 2020. Journal of Ecology, submitted.

Climate Change Adaptation Tools

- Application: Updated Ontario Seed Transfer System -

- Updated static seed zones with focal zone system that uses ecodistricts as spatial units
- Identifies potential seed sources or planting sites under climate change
- New system based on SeedWhere and critical seed transfer distance analyses





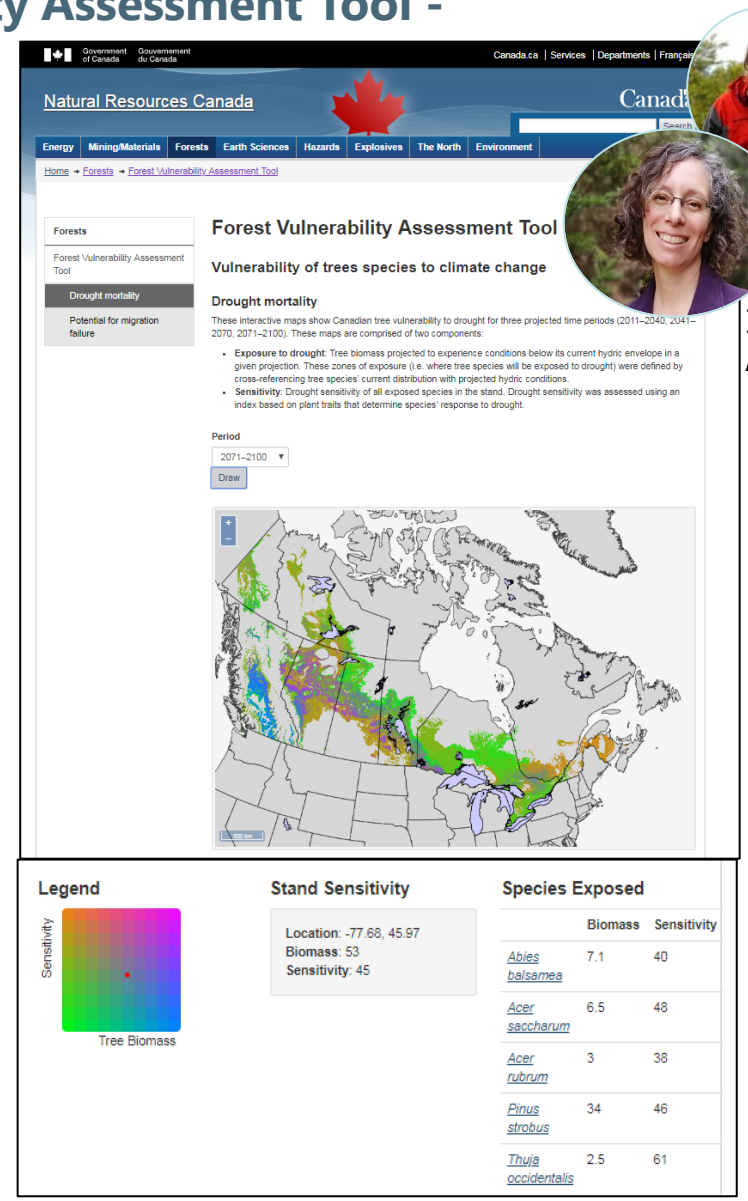
https://www.ontario.ca/page/ontario-tree-seed-transfer-policy

Climate Change Adaptation Tools

- Forest Vulnerability Assessment Tool -

- Developed by Isabelle Aubin and Laura Boisvert-Marsh at GLFC
- The tool reports biomass and drought sensitivity of the tree species at a selected location
- Sensitivity is based on tree traits (e.g., rooting habit, xylem rigidity, etc.)

https://glfc.cfsnet.nfis.org/fcvul/?&lang=en



Laura Boisvert-Marsh

Isabelle Aubin

Climate Change Adaptation Tools

- Adaptive Silviculture for Climate Change Trial at PRF -

- Create a multi-region study with locally-suited climate change adaptation treatments
- Develop tools and approaches that integrate climate change into forest management
- PRF is the sixth ASCC site to be developed; first outside U.S.
- Project headed up by Mike Hoepting, Jeff Fera, and Trevor Jones (CWFC)

https://www.adaptivesilviculture.org/project-site/petawawa-research-forest

ASCC

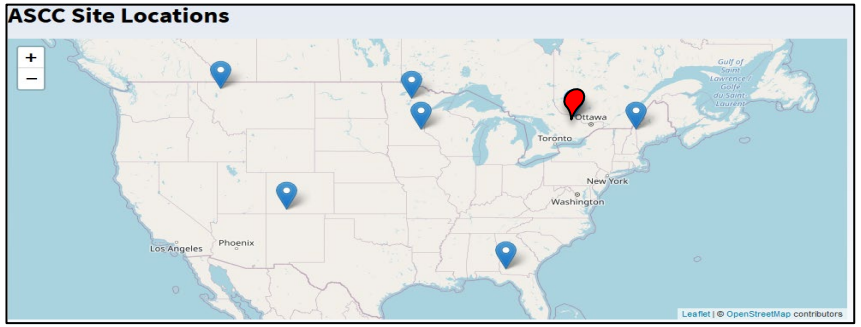
ADAPTIVE SILVICULTURE FOR CLIMATE CHANGE

Adaptive Silviculture for Climate Change: A National Experiment in Manager-Scientist Partnerships to Apply an Adaptation Framework

Linda M. Nagel, Brian J. Palik, Michael A. Battaglia, Anthony W. D'Amato, James M. Guldin, Christopher W. Swanston, Maria K. Janowiak, Matthew P. Powers, Linda A. Joyce, Constance I. Millar, David L. Peterson, Lisa M. Ganio, Chad Kirschbaum, and Molly R. Roske

J.For. 115(3): 167-178

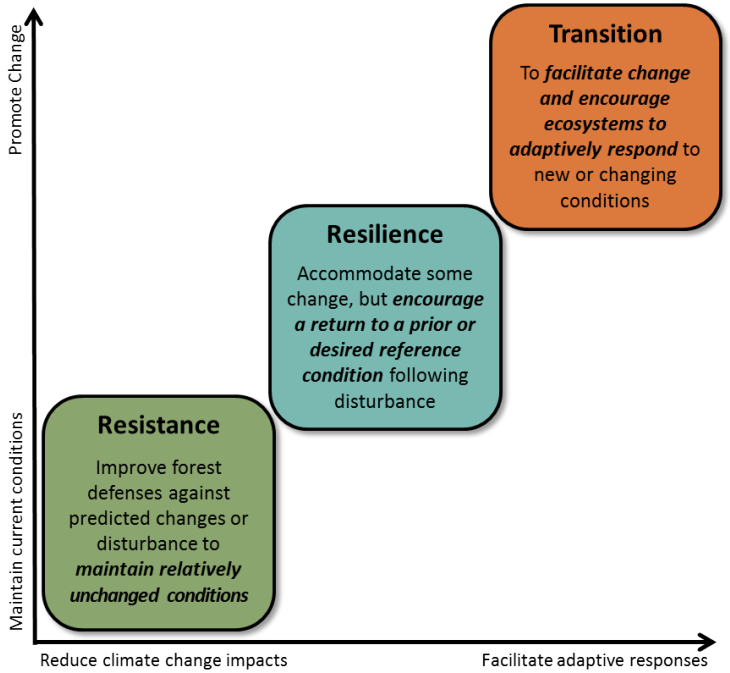
Linda Nagel (Lead & PI); Courtney Peterson (Coordinator); Maria Janowiak (PI)



Climate Change Adaptation Tools

- Adaptive Silviculture for Climate Change Trial at PRF, cont'd -

- ASCC trials require treatments to span resistance, resilience and transition outcomes
- Treatment units must be >8ha in size and replicated 4 times
- At PRF, treatments include:
  - **Resistance –** Uniform shelterwood harvest with modest, within-range seed movements of pine only
  - **Resilience –** Irregular gap shelterwood harvest with within-range seed movements of white pine and oak
  - **Transition –** Clear-cut, leaving 10% residual forest and aggressive species movments including red pine, pitch pine, red oak and white oak
  - **Control –** unharvested reference condition



Pitch Pine at PRF

Summary

- Canada (including eastern Ontario) is projected to experience increased temperature and modest increases in precipitation
- Warmness is expected to outpace wetness, resulting in a drier future (possibly approaching prairie-like conditions in some parts of eastern Ontario!)
- A variety of adaptation tools are available at the CFS Forest Change web portal (including Seedwhere, Species Models, climate data, etc.)
- Aggressive management, such as some of the treatments at the ASCC experiment at PRF are starting to be considered