Integrated Assessment of Canadian Forest Vulnerability to Climate Change

Isabelle Aubin, Laura Boisvert-Marsh, Hedi Kebli, John Pedlar, Dan McKenney, Catherine Ste-Marie & coll.

Canadian Forest Service - NRCan

Great Lakes Forestry Centre, Sault Ste-Marie, Ontario

January 2019

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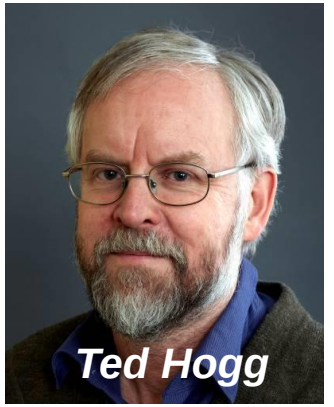
Tree traits and climate change working group



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FORÊT S'ADAPTER

cef Centre d'étude de la forêt

CRÉ Vallée-du-Haut-Saint-Laurent

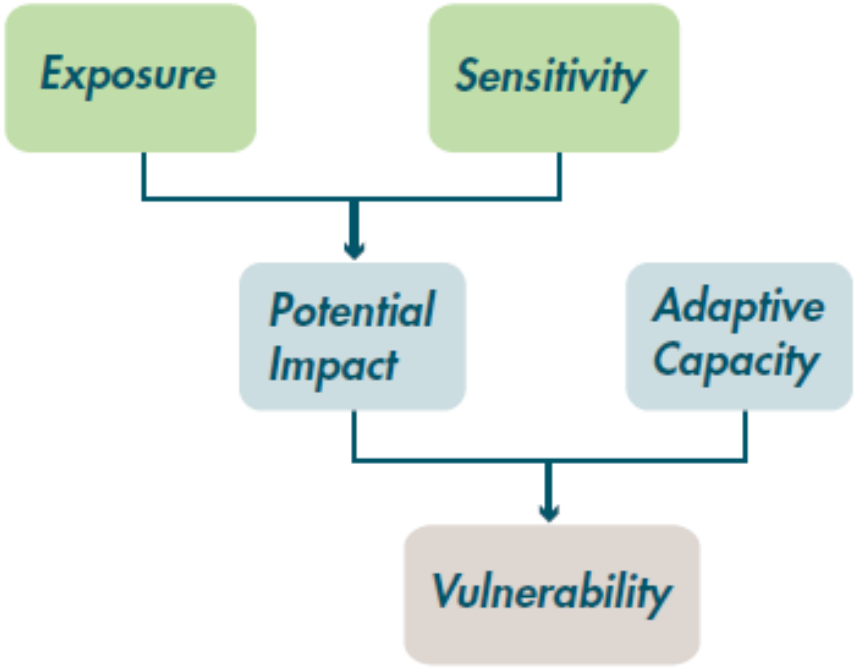
Institut des Sciences de la Forêt tempérée

Modélisation de la Complexité de la Forêt

Université du Québec en Outaouais

and several other collaborators…

The components of vulnerability to climate change



Glick et al. 2011. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment.*

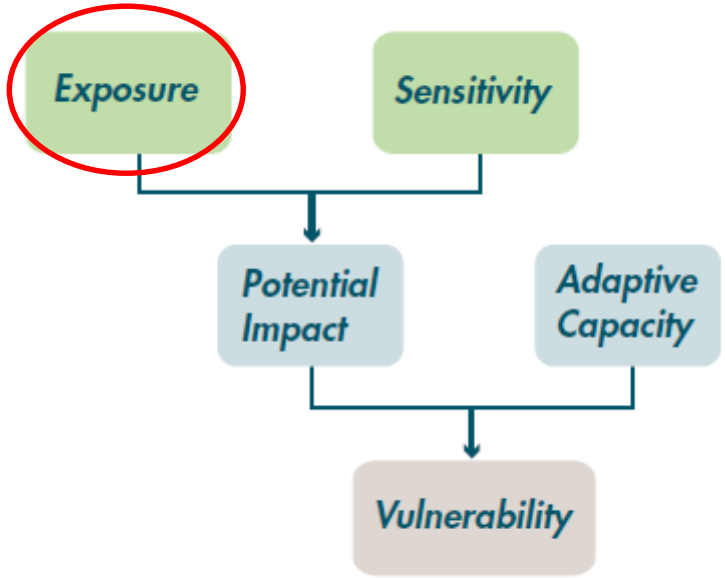
Exposure: Degree of environmental change a species will experience (character, magnitude, and rate)

Sensitivity: degree to which that species is likely to be affected by or responsive to those changes

Adaptive capacity: ability to accommodate or cope with climate change impacts (via intrinsic and/or extrinsic means)

Vulnerability is function of the *sensitivity* of a species, its *exposure* to environmental changes, and its *capacity to adapt* to those changes

Exposure is well predicted using climatic variables: e.g. climate envelope



Sugar maple potential for range shifts?

Current climate envelope models provide solid information on the degree to which species are likely to be exposed to climatic changes, but rarely incorporate species' individual sensitivity or its adaptive capacity.

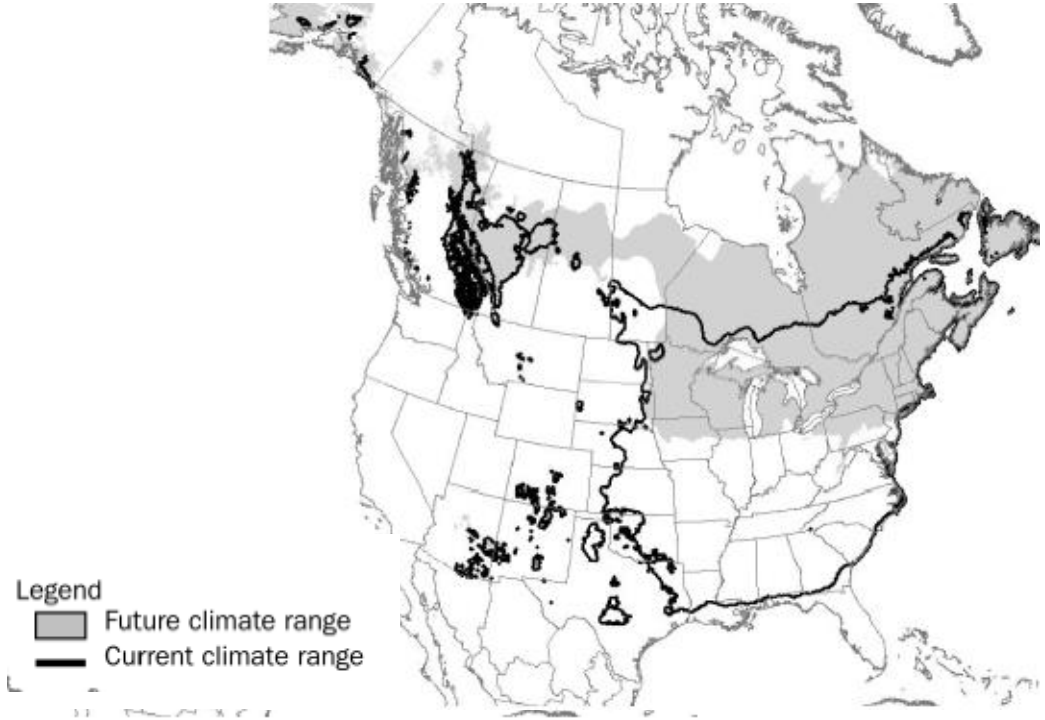
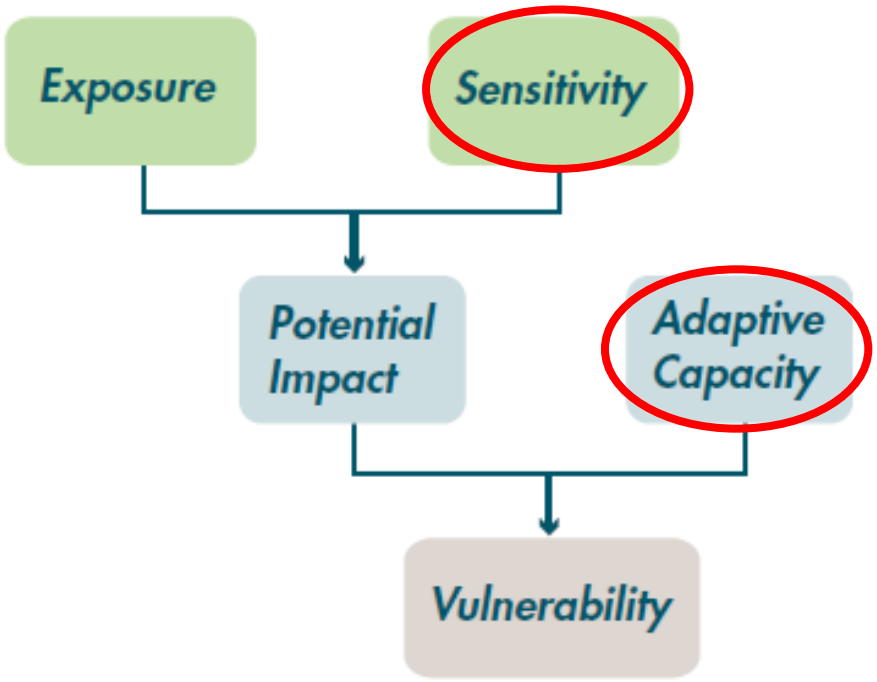


Figure 5. Current and future climate envelopes for sugar maple under the nonirrigated scenario. The future climate envelope is based on projected climate conditions for the period 2071–2100, using the Canadian Centre for Climate Modelling and Analysis's second-generation coupled global climate model and the A2 emissions scenario outlined by the Intergovernmental Panel on Climate Change.

McKenney et al. 2007. Bioscience (57): 929-937

A missing piece: integrate ecological knowledge on species sensitivity and adaptive capacity to biophysical predictions



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Vulnerability is function of the *sensitivity* of a species, its *exposure* to environmental changes, and its *capacity to adapt* to those changes

Trait-based approach

Trait: Characteristic measurable on an individual that **respond** to an environmental filter and/or **affect** an ecosystem process

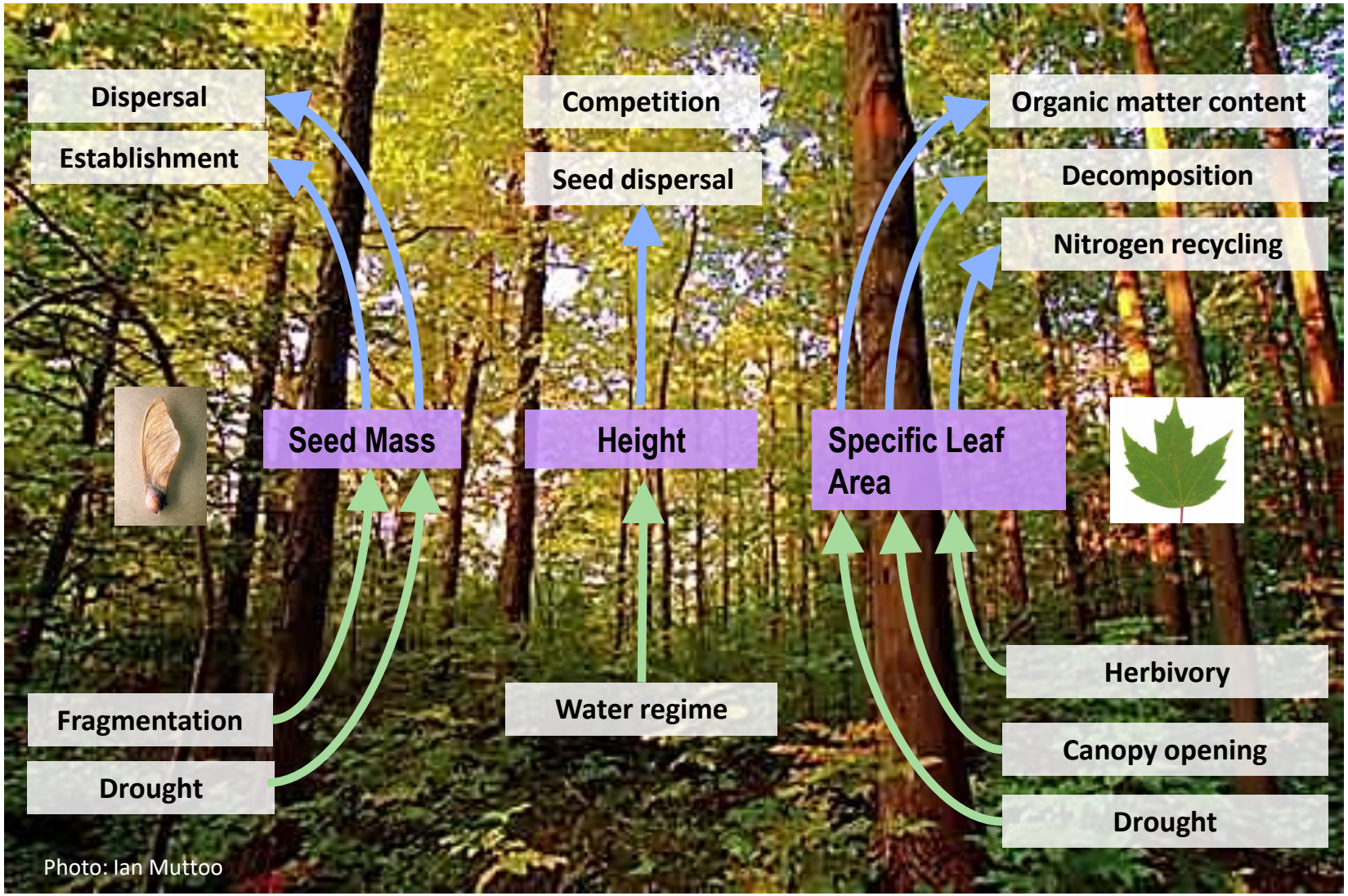
Seed size

Height

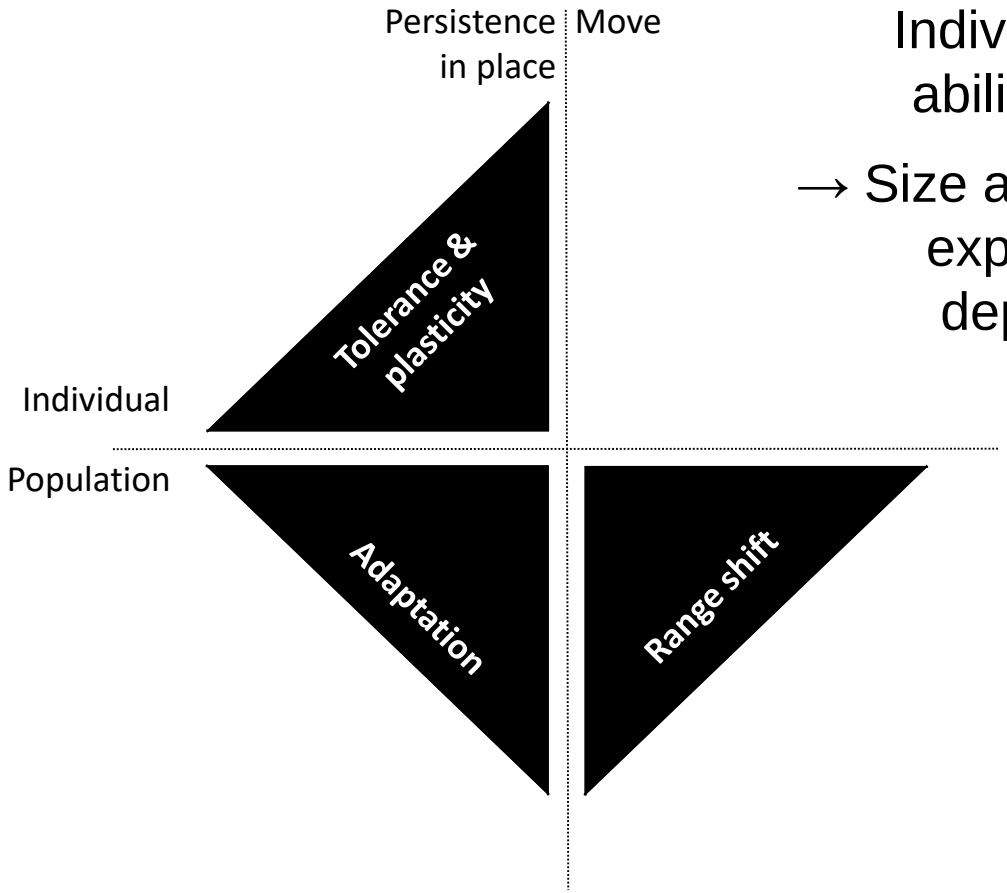
Specific leaf area

Photo: Ian Muttoo

Trait based approach: Ecosystem Function



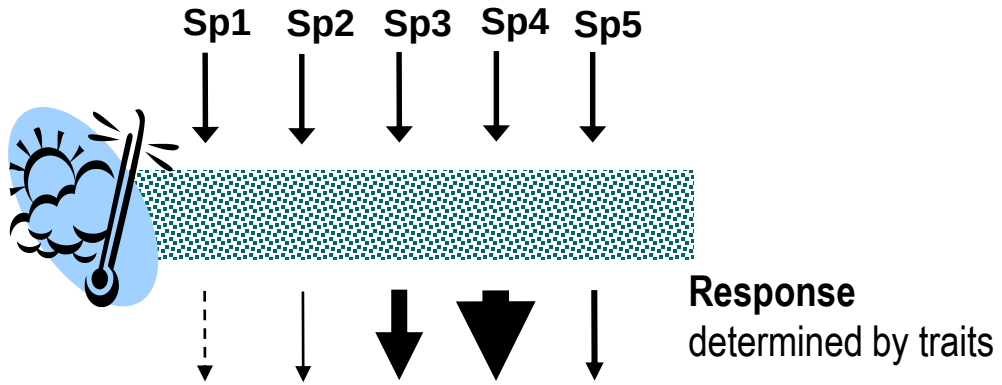
Species response to Climate Change



Individual tree species vary in their ability to tolerate, adapt and move

→ Size and nature of the response are expected to be quite variable and dependent on the characteristics (traits) of individual species

Traits: A quantitative approach to characterize this differential sensitivity



Aubin et al. 2016. Environ. Rev. 24: 164-186

1. Identify traits and mechanisms behind sensitivity

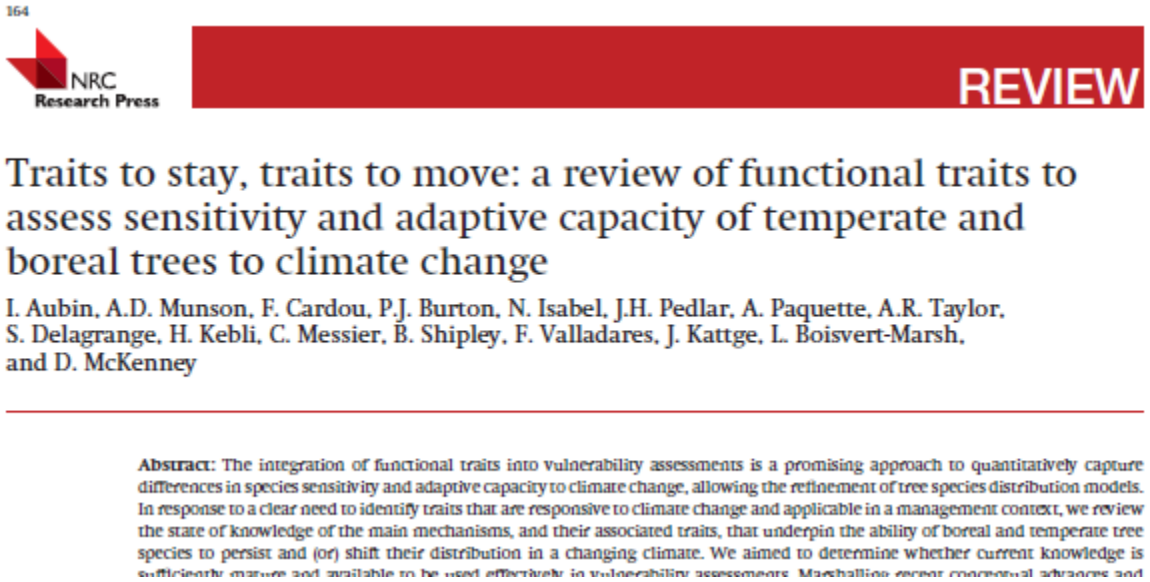
Traits and Climate Change

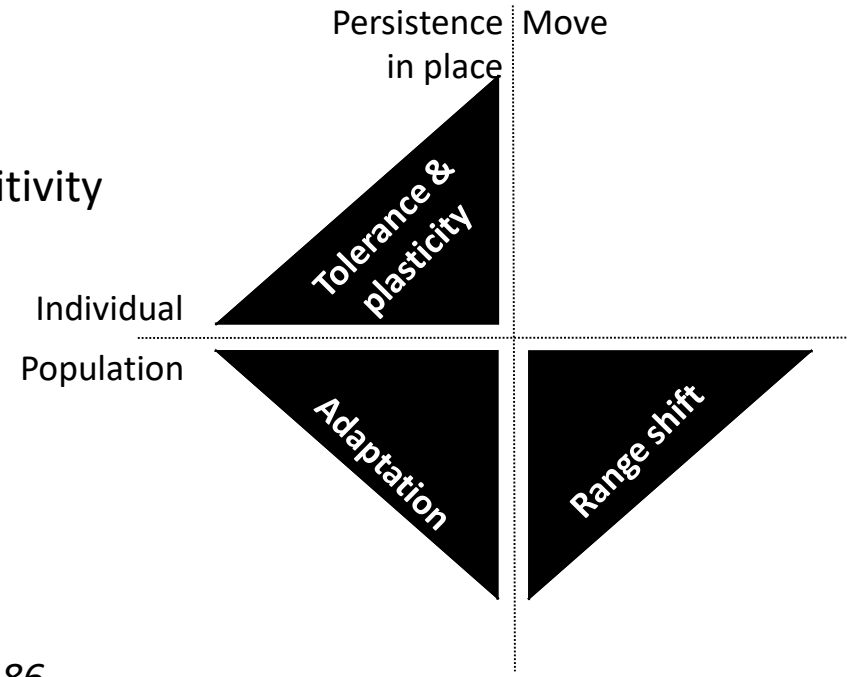
Data integration workshop St-Hilaire April 2013

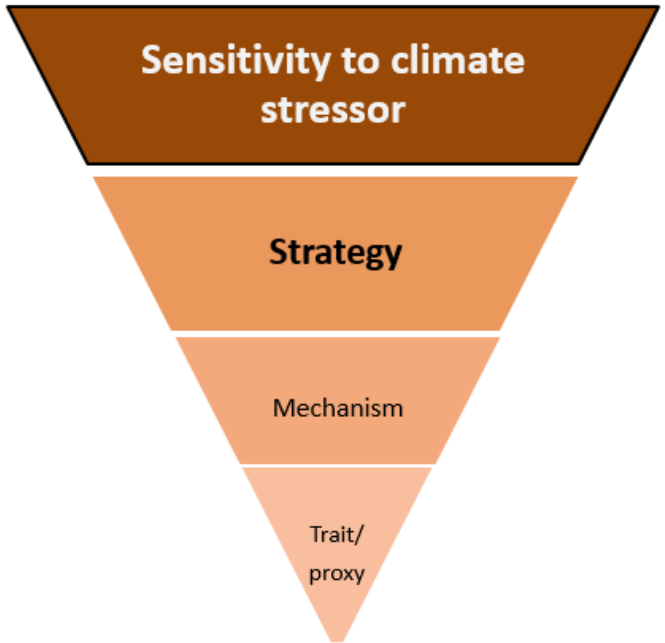


Participants: ecophysiologists, population geneticists, community ecologists and modellers

- Provide a framework to quantify sensitivity
- Identify key metrics and proxies
- Identify gaps of knowledge
- Accelerate data availability

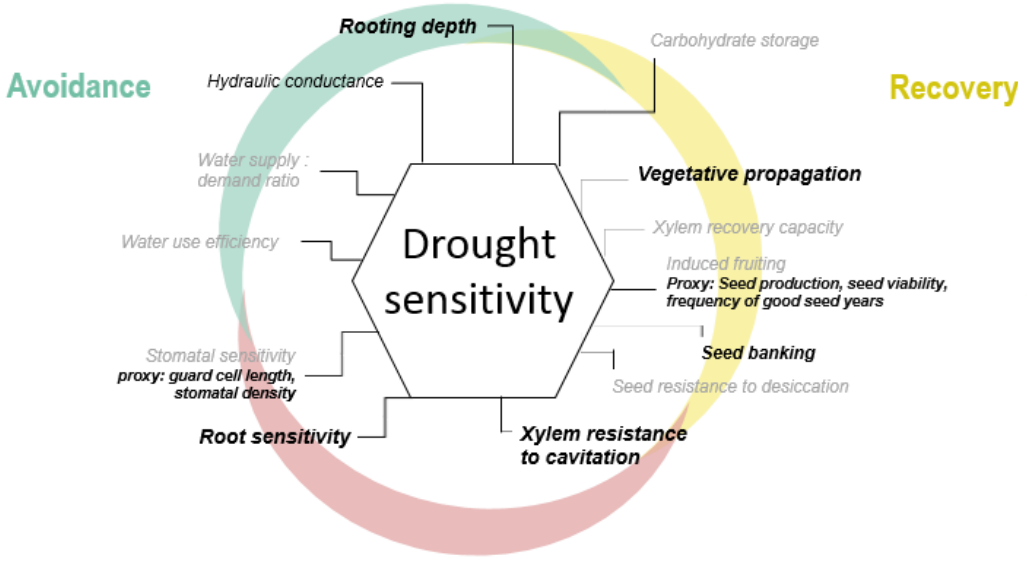


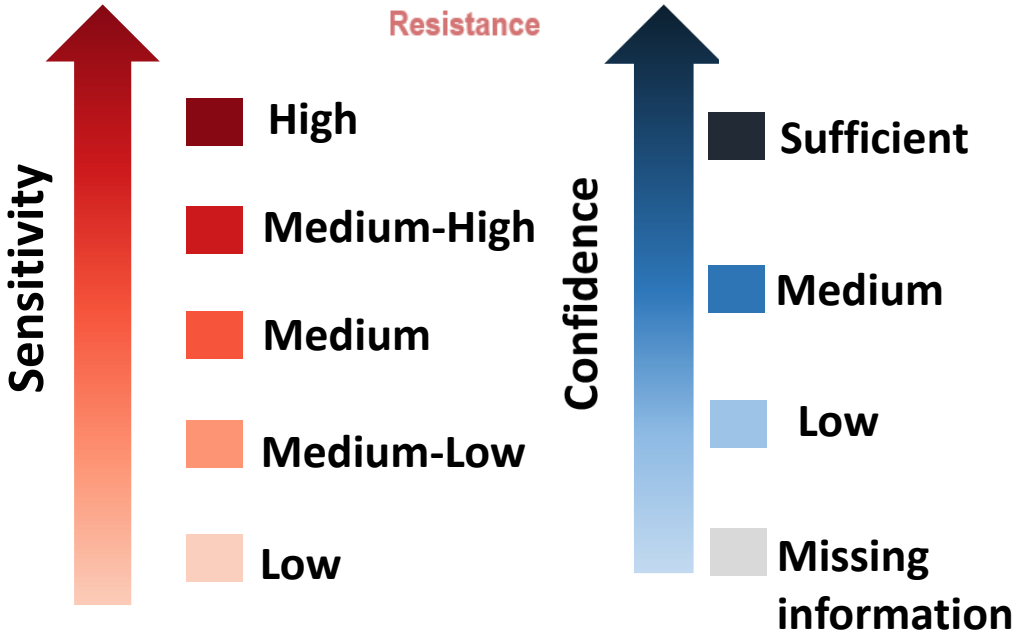


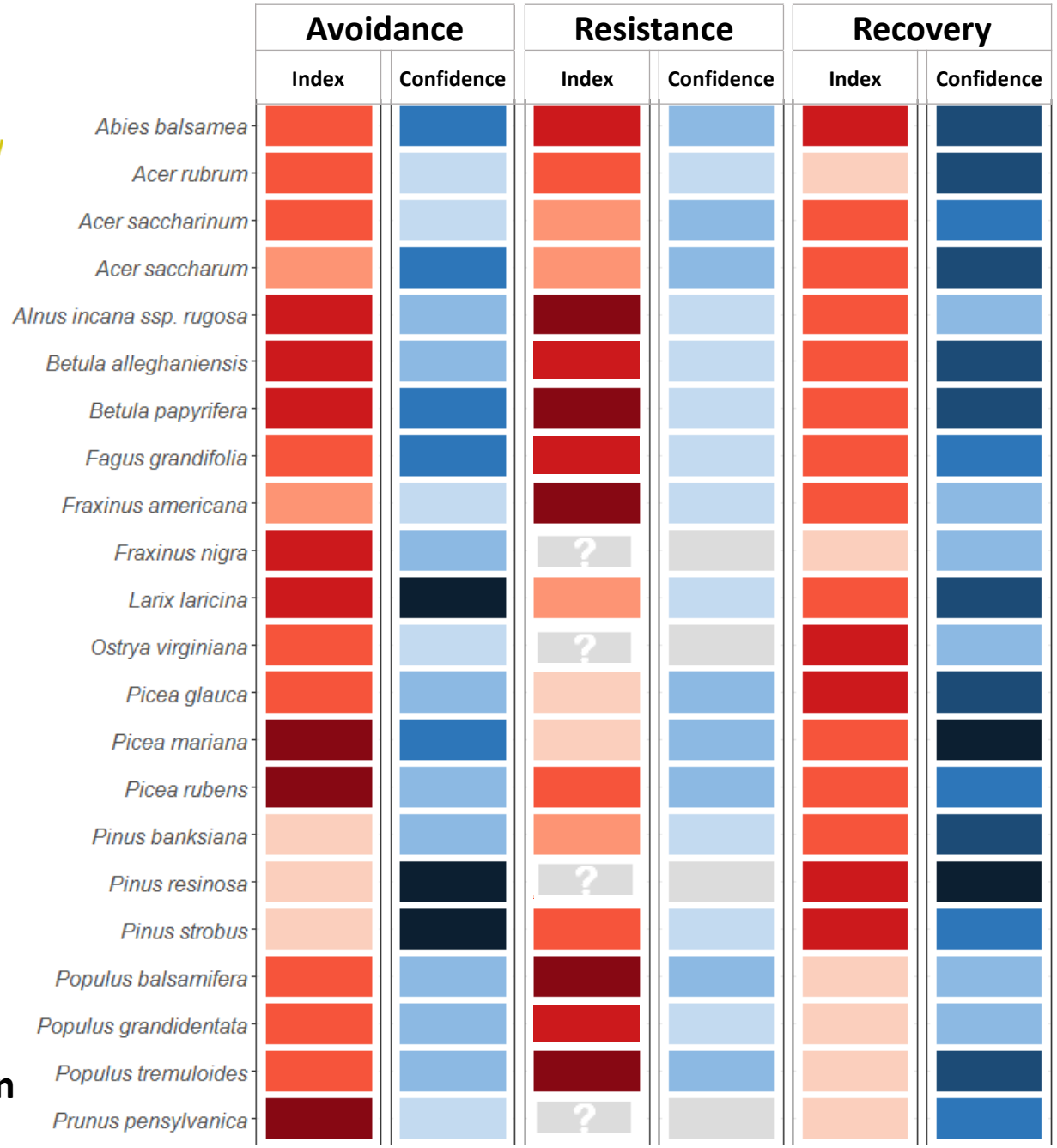


Aubin et al. 2016. Environ. Rev. 24: 164-186

2. Document species sensitivity to drought

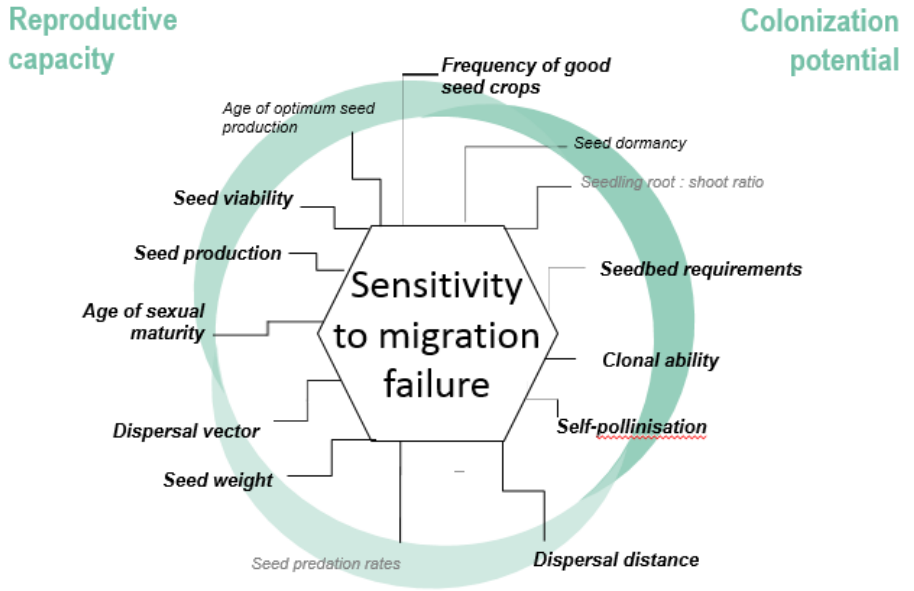


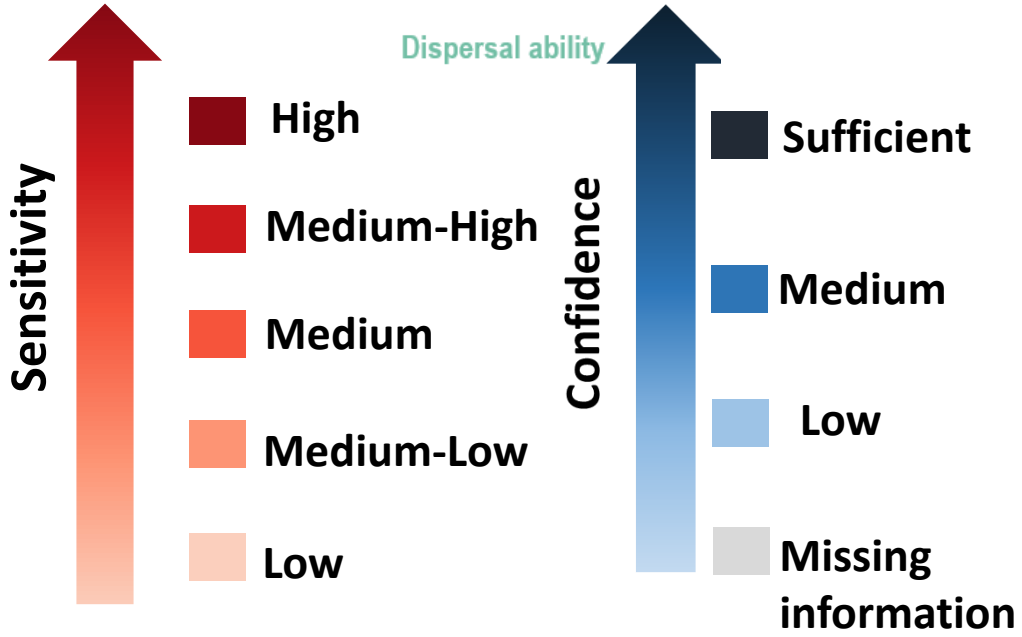


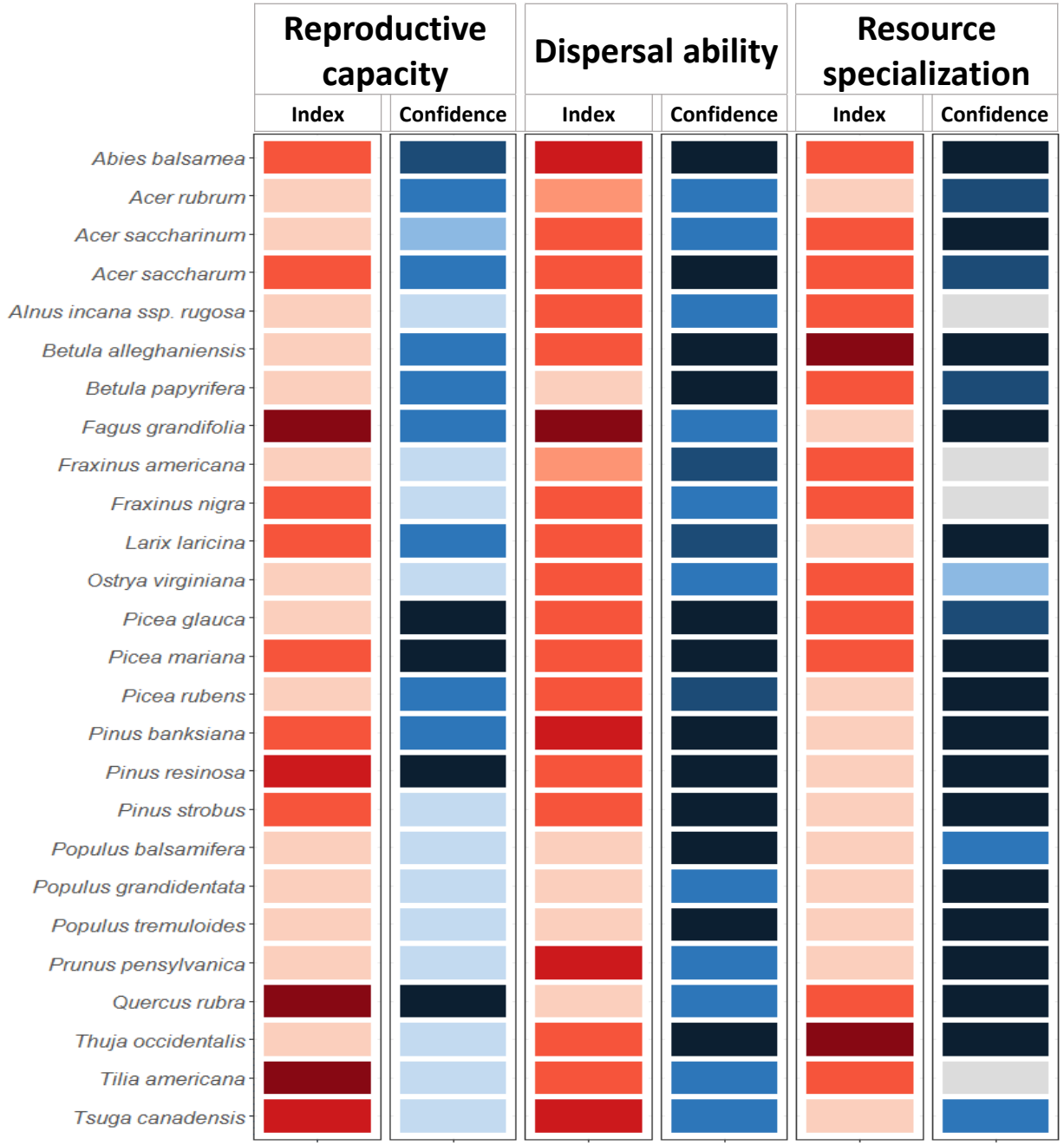


Boisvert-Marsh & coll in prep.

2. Document species sensitivity to migration failure

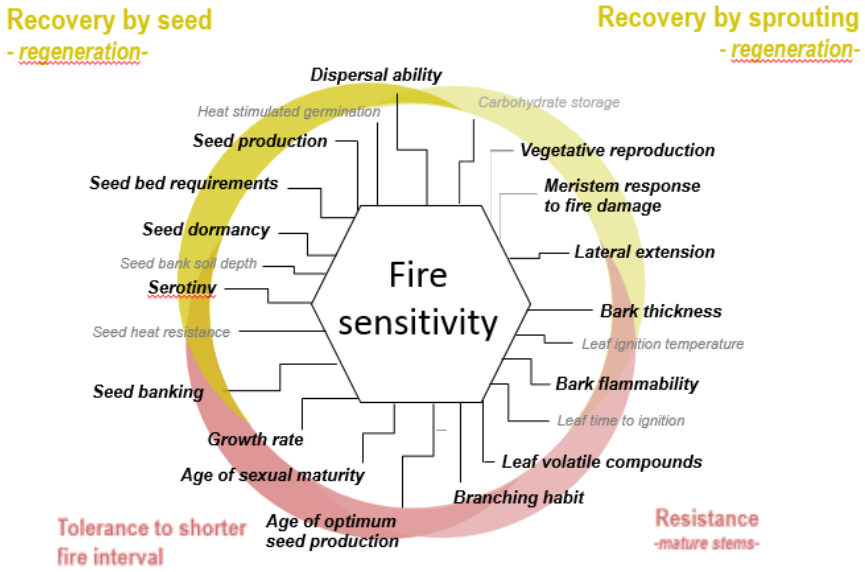


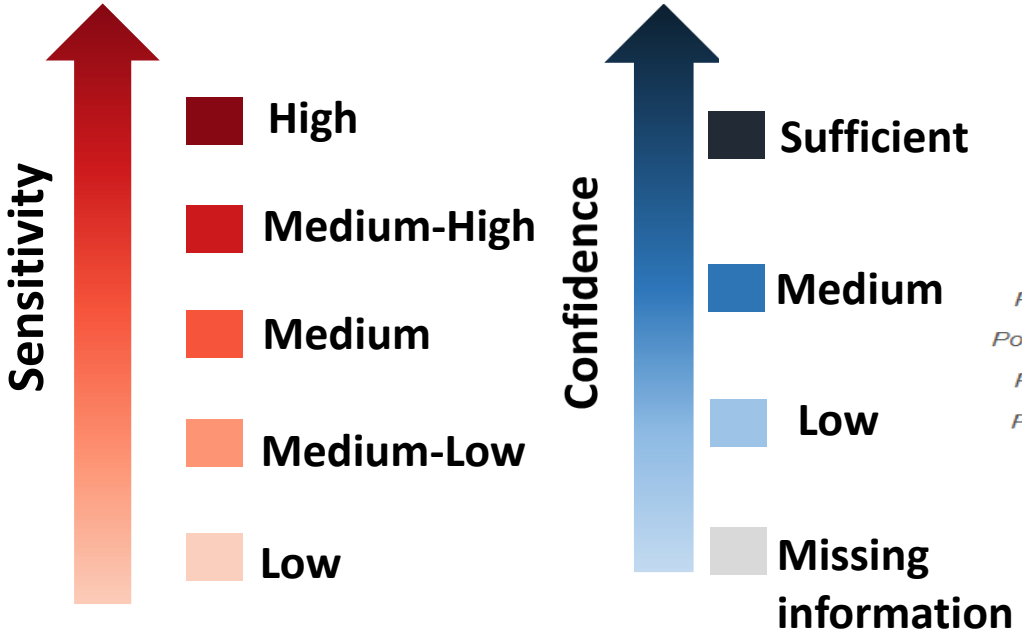


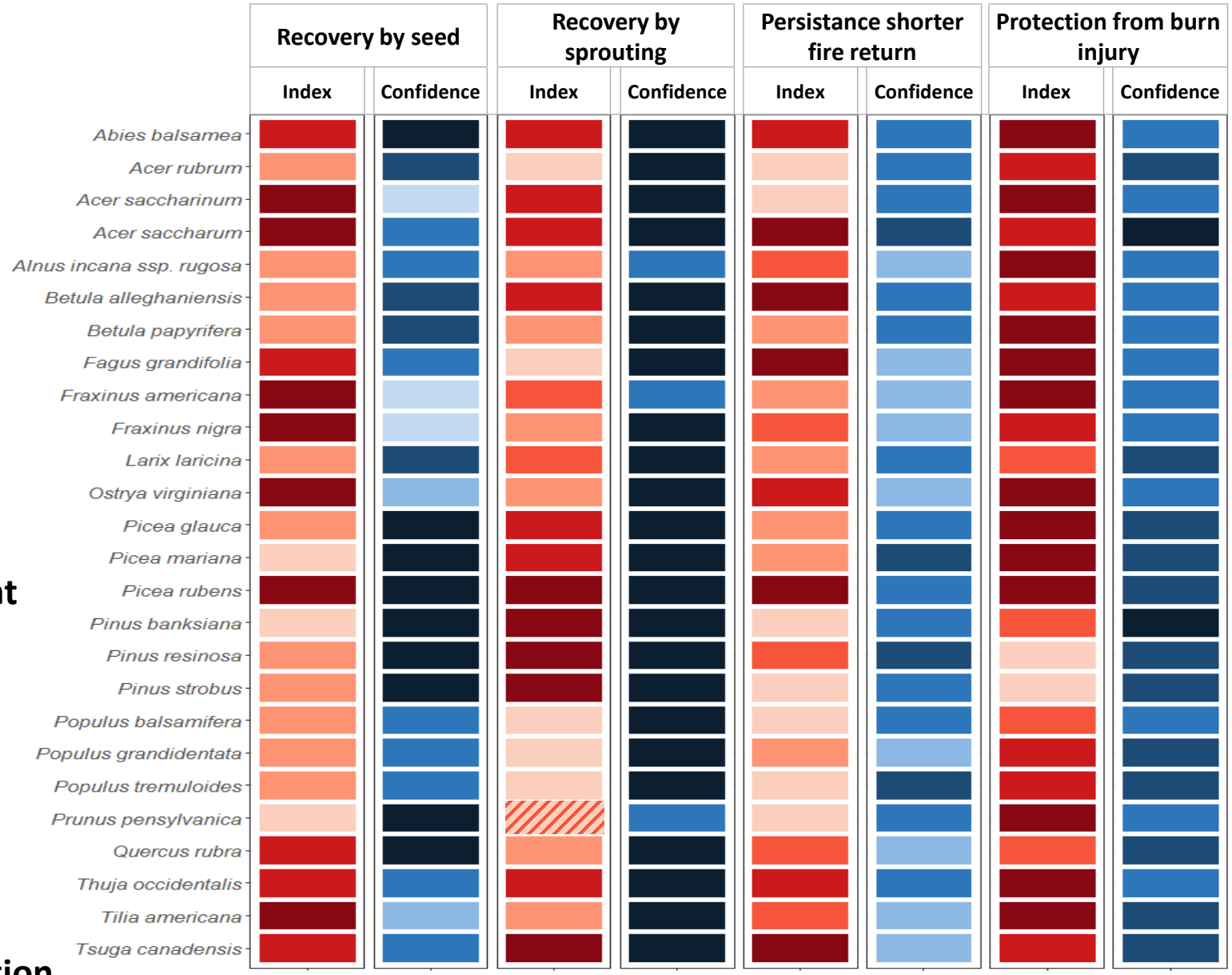


Boisvert-Marsh & coll in prep.

2. Document species sensitivity to increased fire recurrence and intensity







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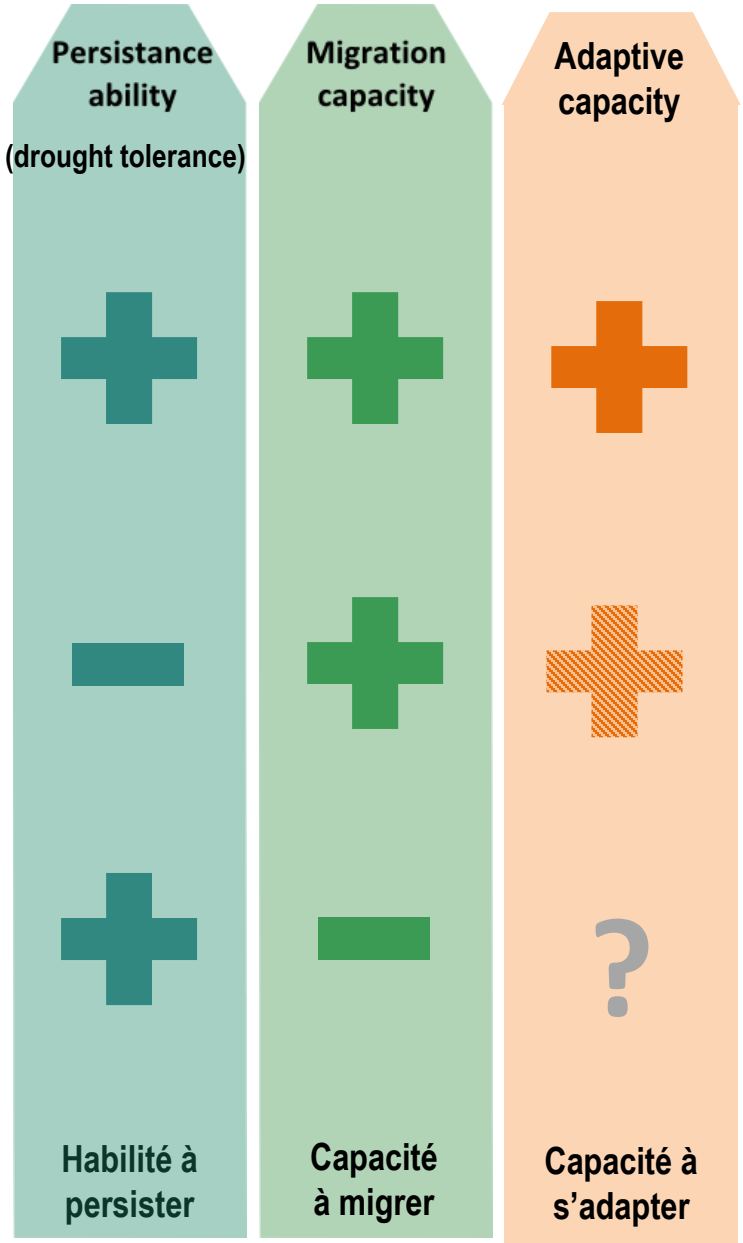


Trembling aspen
Populus tremuloides

Black spruce
Picea mariana

Red hickory
Carya glabra

Low & high drought sensitivity

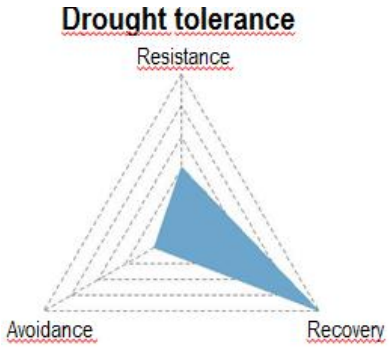
- Low avoidance: superficial rooting
- Good recovery: vegetative reproduction

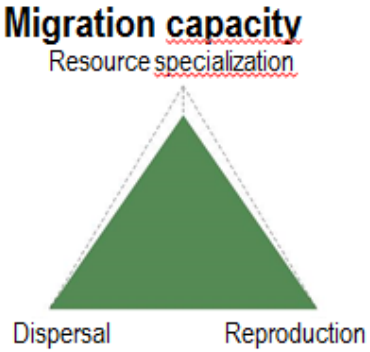
High migration capacity

- Large seed production
- Short time to maturity
- Wind dispersal
- Vegetative reproduction

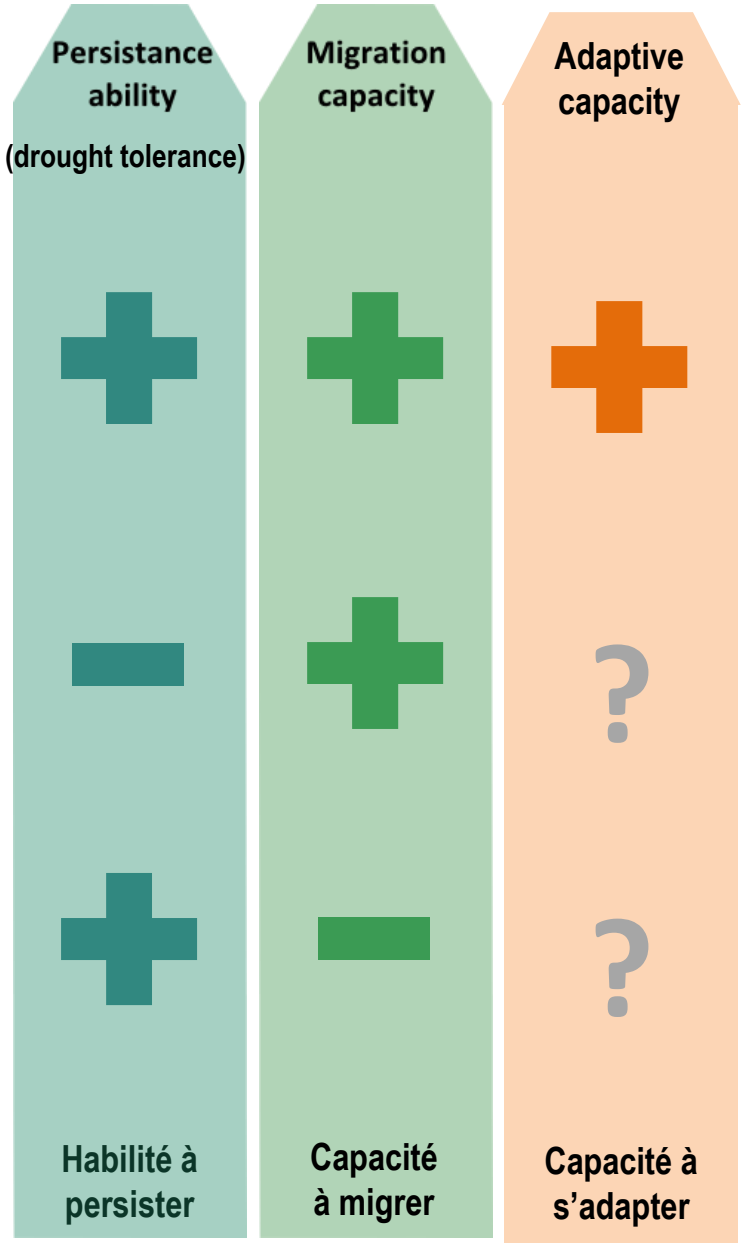
Good adaptive capacity

- Low plasticity
- High population genetic diversity but low genetic differentiation between populations
- High potential of genetic recombination within populations
- Potential of hybridization with P. alba & P. grandidentata





Aubin, Boisvert-Marsh, Royer-Tardif & coll in prep.



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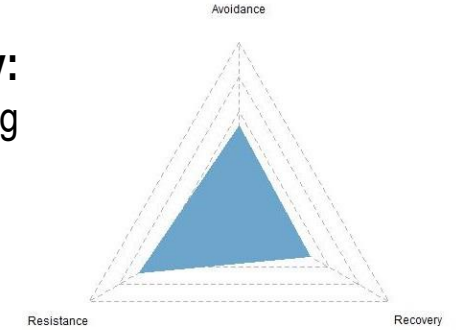
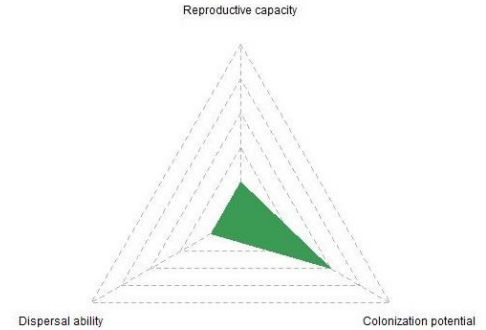
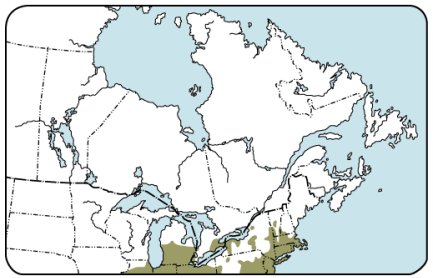
Low drought sensitivity:
- Avoidance - Deep rooting

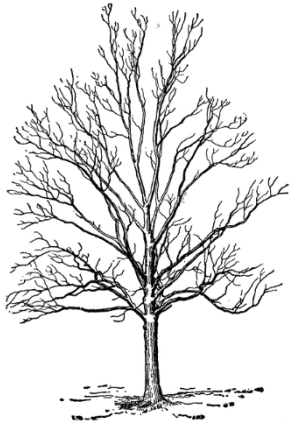


Low migration capacity
- Low production of seeds
- Late maturity



Adaptive capacity?
- Lack of information!

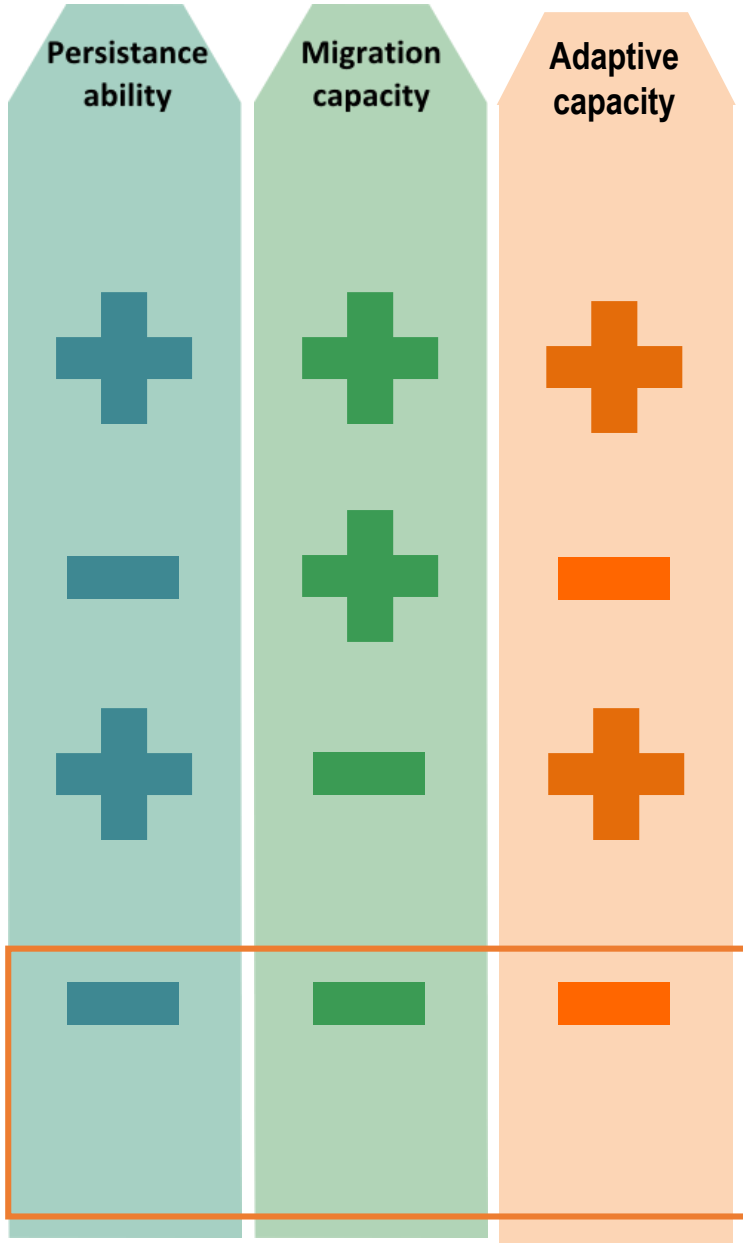




Aubin, Boisvert-Marsh, Royer-Tardif & coll in prep.

Inform management decision

Identify which species require management considerations



Low sensitivity

Low sensitivity in forested landscapes
Strategy: Increase connectivity in fragmented landscapes

Strategy: conservation in its current habitat

High sensitivity
Priority in conservation plan
Candidate for assisted migration

Aubin, Boisvert-Marsh, Royer-Tardif & coll in prep.

Species vary in their exposure to climate change

Percentage of species distribution projected to be outside current species distribution for the 2071-2100 time period

using temperature and precipitation projections from the Canadian Earth System Model (CanESM2) under a high carbon emission scenario (RCP 8.5)

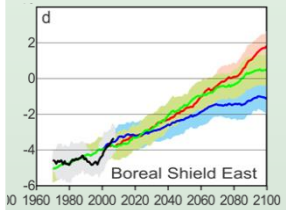
Species	Hydric envelope turnover	Climate envelope turnover
Sugar maple	49%	57%
Red maple	40%	50%
Yellow birch	40%	64%
White birch	19%	34%

Aubin et al. 2018. Ecosphere. 9 (2): e02108

Vulnerability assessment

Integration of ecological knowledge on tree sensitivity to biophysical predictors of exposure

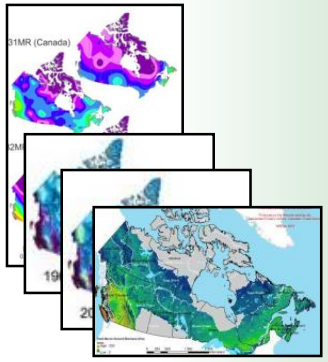
1. **CLIMATE SCENARIOS**

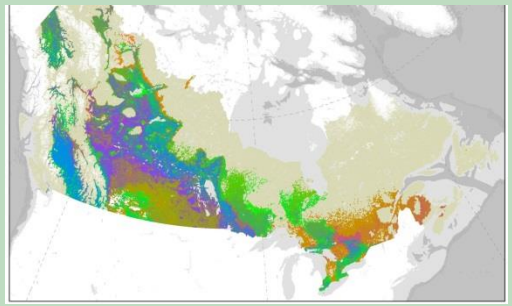


2. **DROUGHT IMPACT**

3. **STAND COMPOSITION**

4. **SPECIES TRAITS**





Map of Canadian tree vulnerability to drought

Integration of projected tree exposure & sensitivity to drought 2071-2100

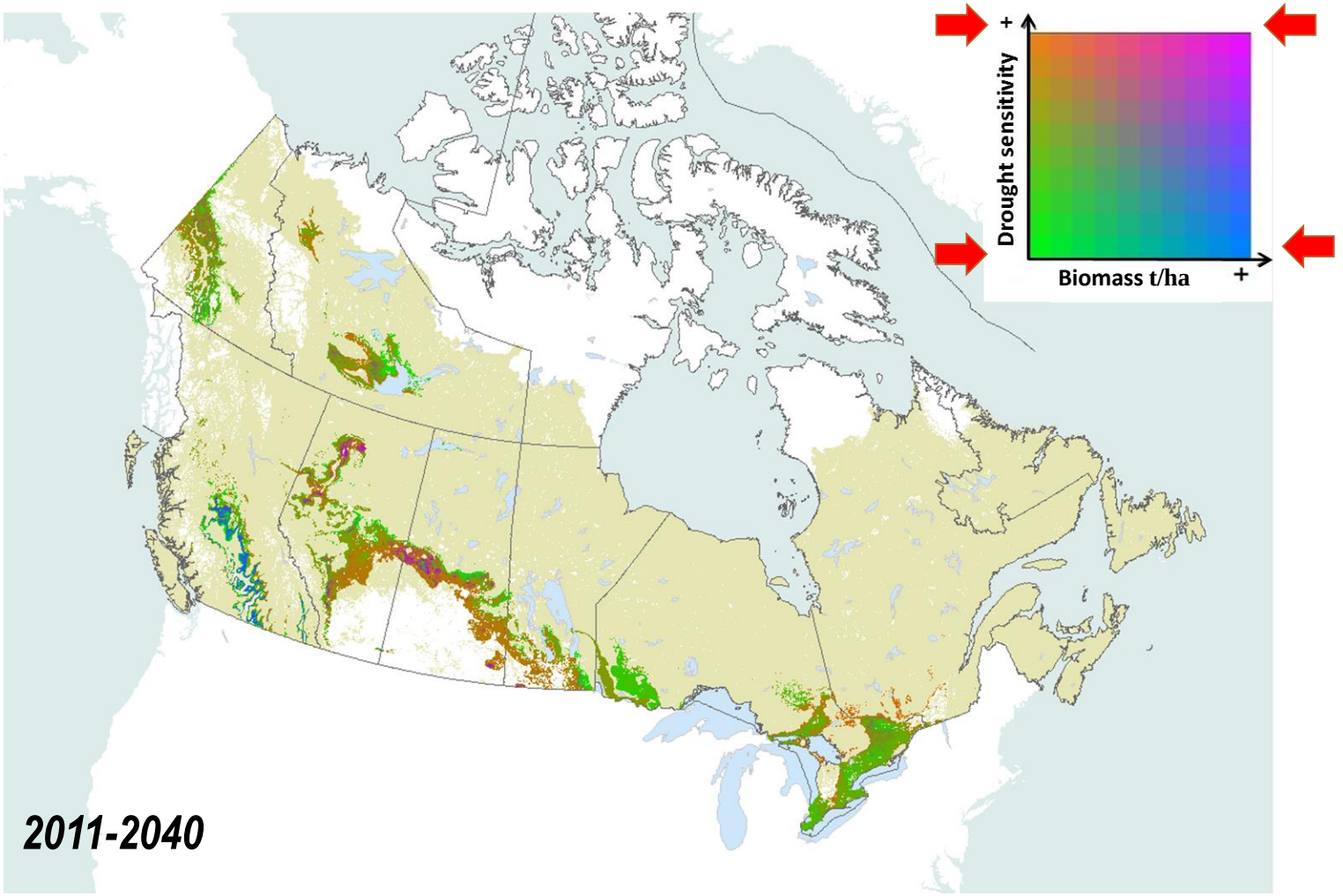
Aubin et al. 2018. Ecosphere. 9 (2): e02108

Tree vulnerability to drought

Exposure (x axis): Stand tree biomass expected to experience conditions below its current hydric envelope

Sensitivity (y axis): stand drought sensitivity based on traits

Using temperature and precipitation projections from the Canadian Earth System Model (CanESM2) under a high carbon emission scenario (RCP 8.5)



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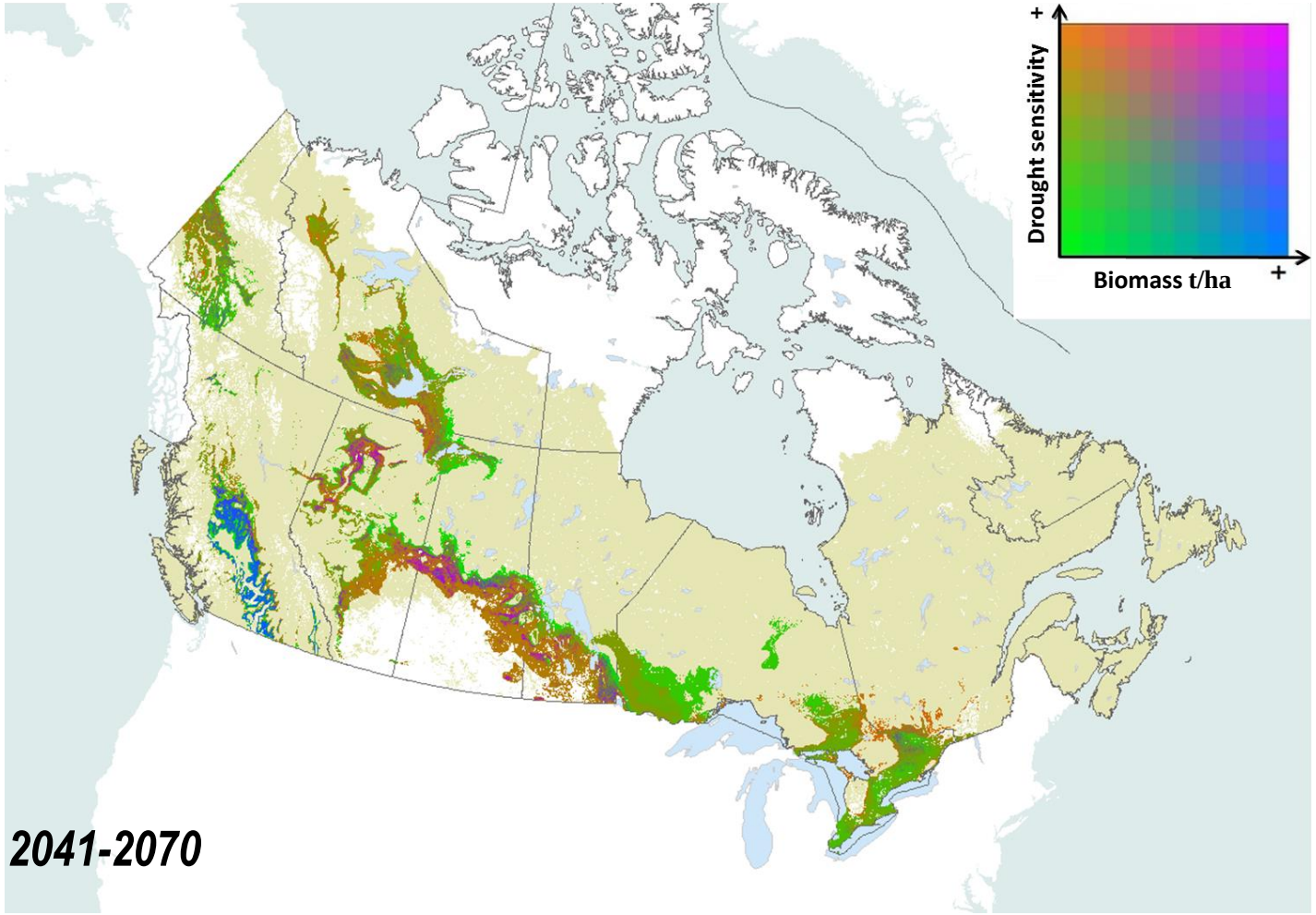

Aubin et al. 2018. Ecosphere. 9 (2): e02108

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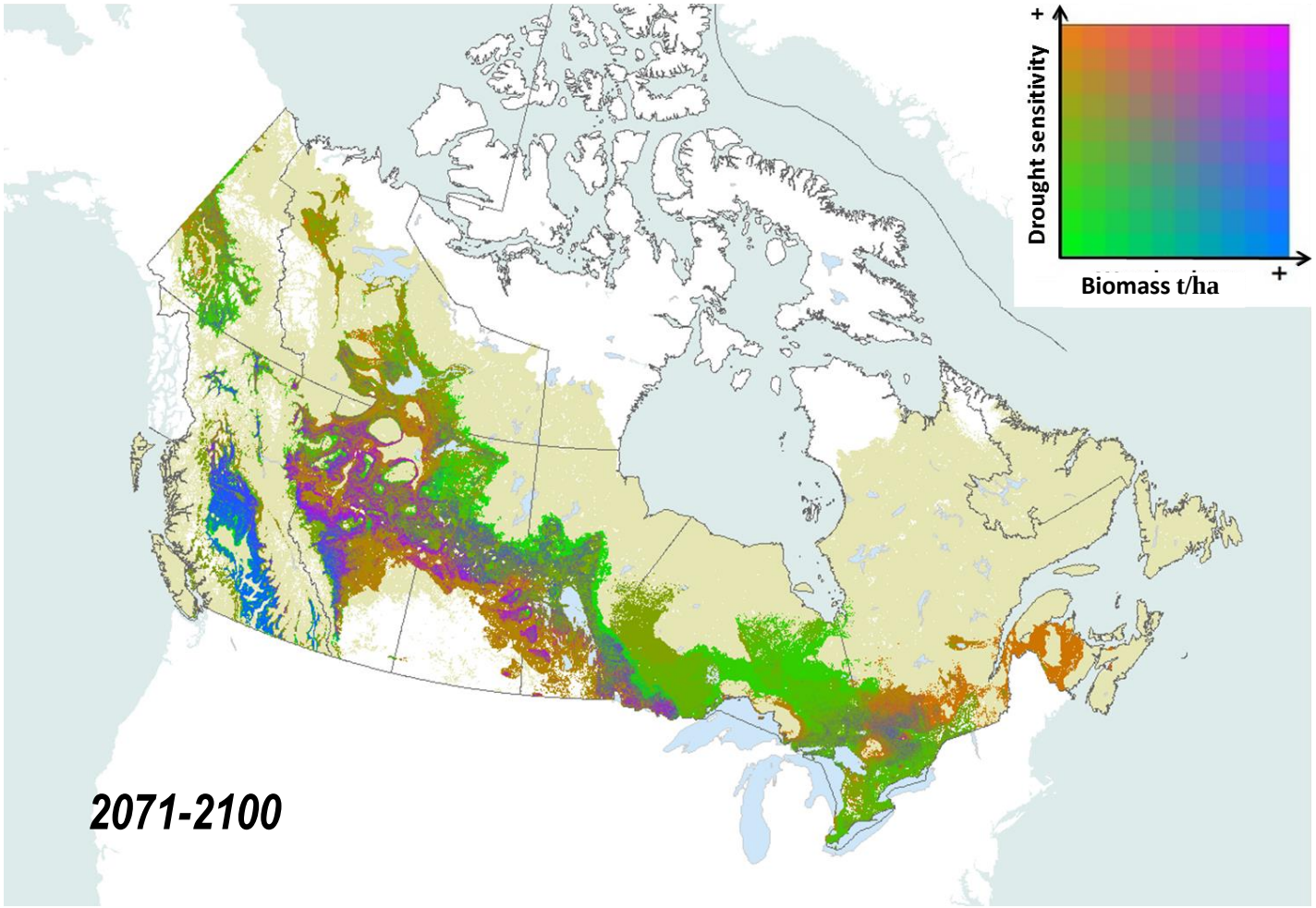


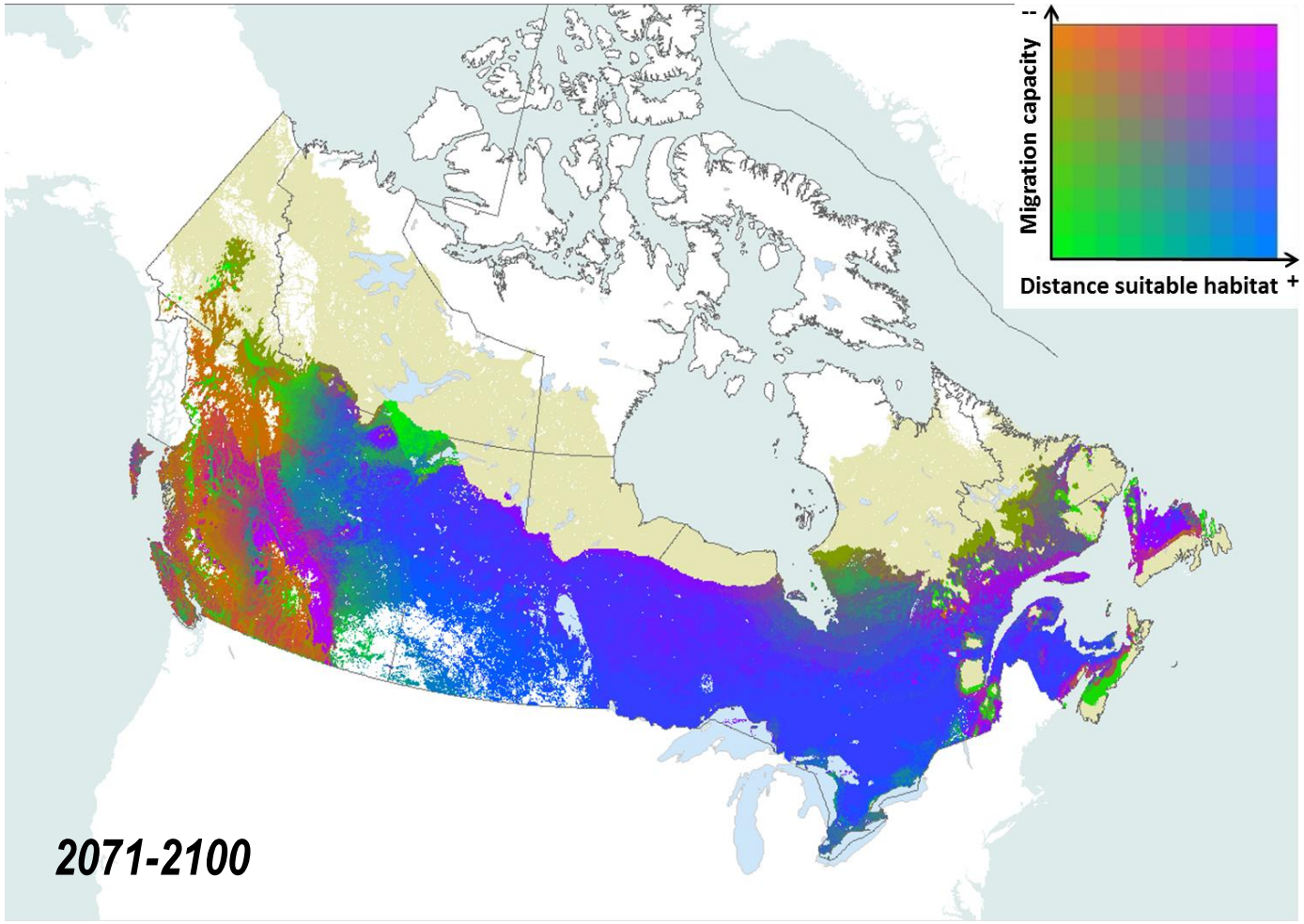
Aubin et al. 2018. Ecosphere. 9 (2): e02108

Tree vulnerability to migration failure

Exposure (x-axis): distance to suitable climatic habitat (in km) for species expected to experience conditions outside their current climatic envelope

Sensitivity (y-axis): stand migration capacity based on traits

Using temperature and precipitation projections from the Canadian Earth System Model (CanESM2) under a high carbon emission scenario (RCP 8.5)

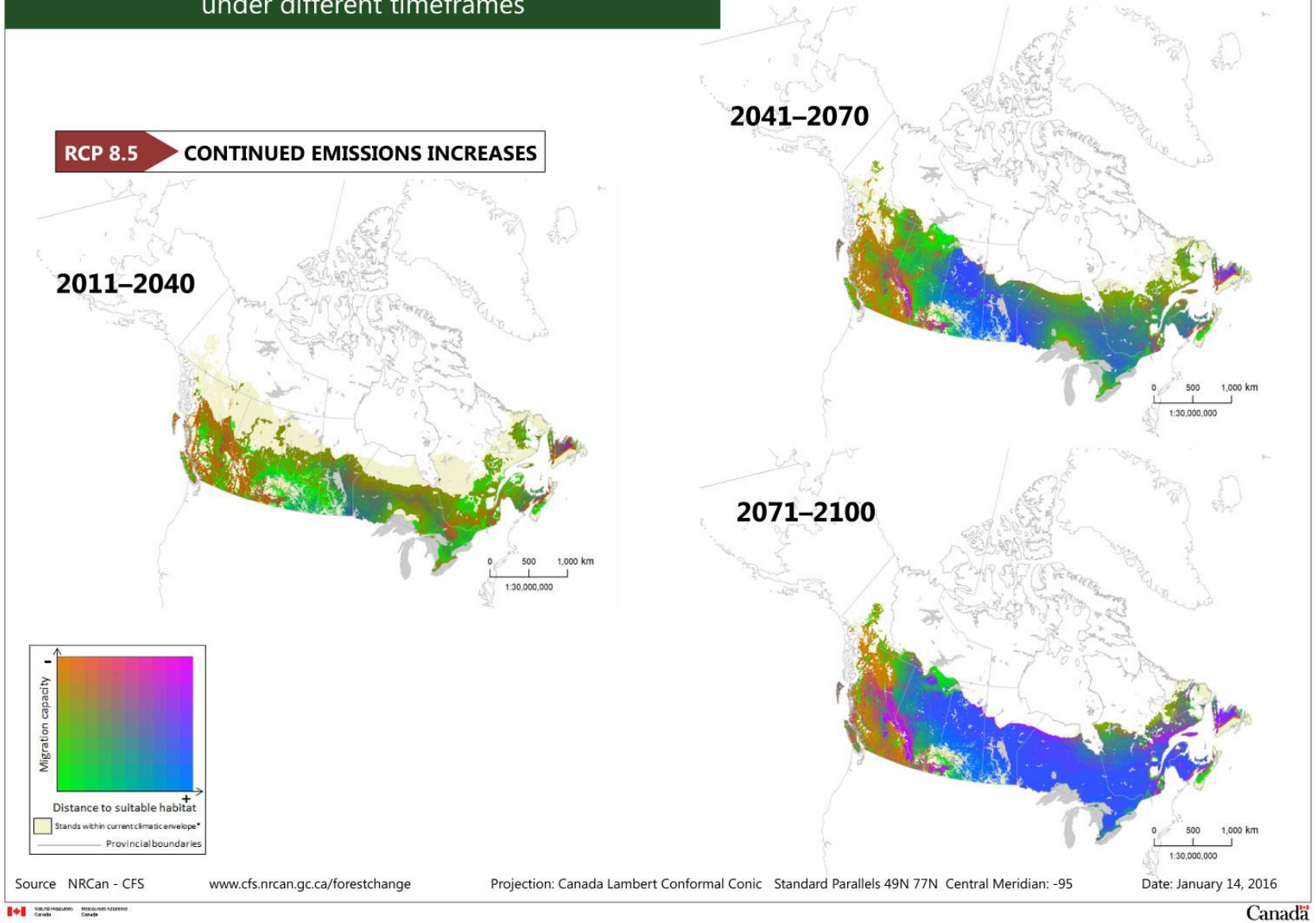


Aubin et al. 2018. Ecosphere. 9 (2): e02108

Tree Capacity to Migrate

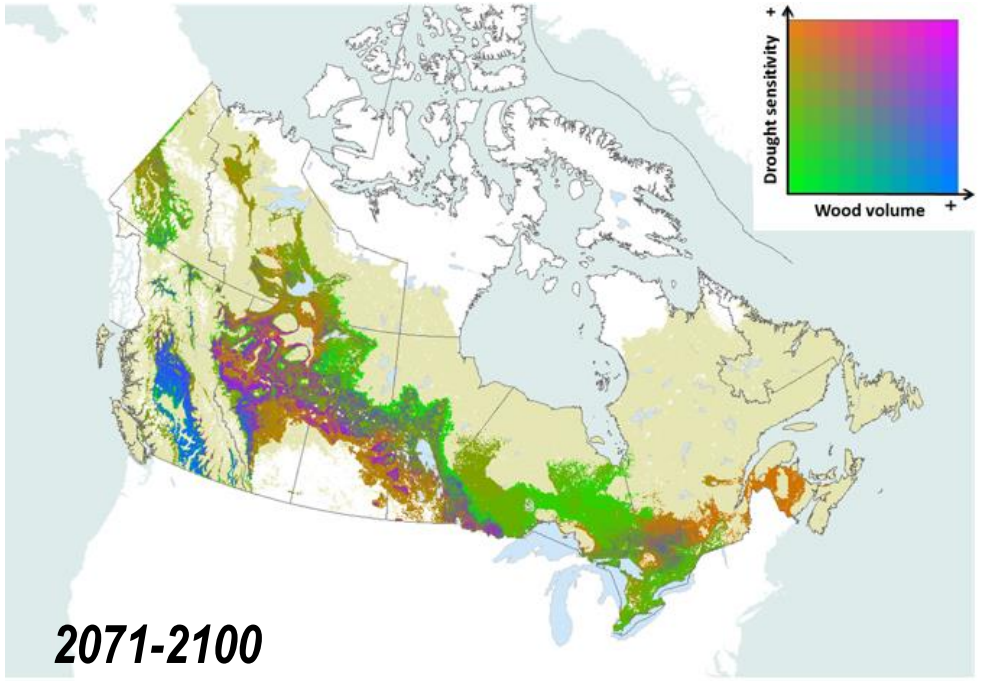
under different timeframes

Aubin et al. 2018. Ecosphere. 9 (2): e02108

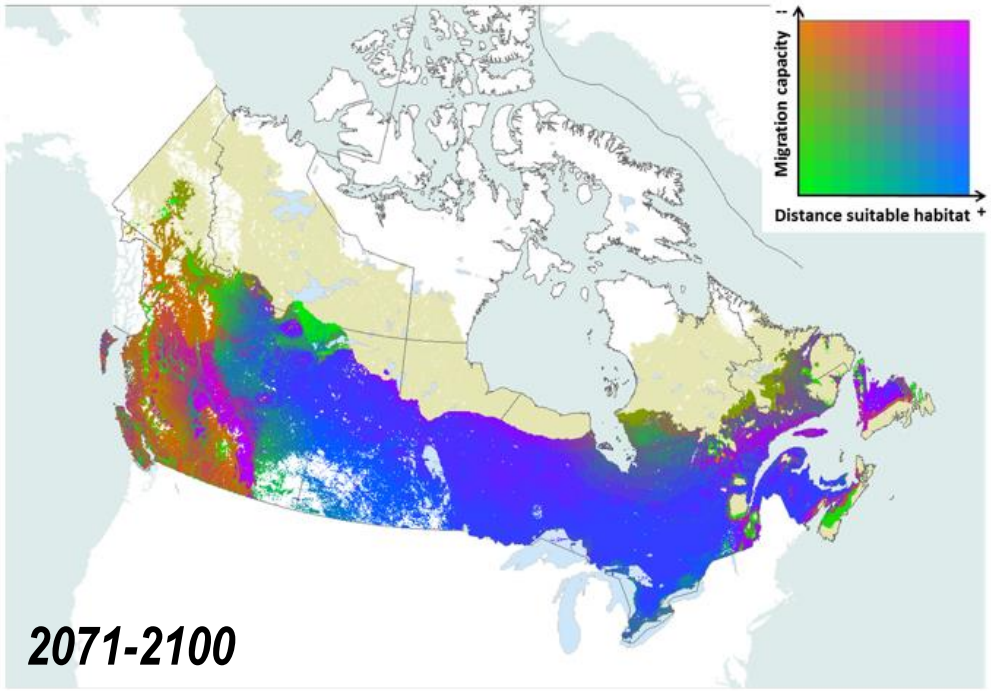


Vulnerability assessment

Exposure and sensitivity to drought



Exposure and sensitivity to migration failure



« Vulnerability hotspots » differ according to the stressor under study

Aubin et al. 2018. Ecosphere. 9 (2): e02108

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Traits of Plants in Canada (TOPIC)

Tree Sensitivity to Drought

About the map data

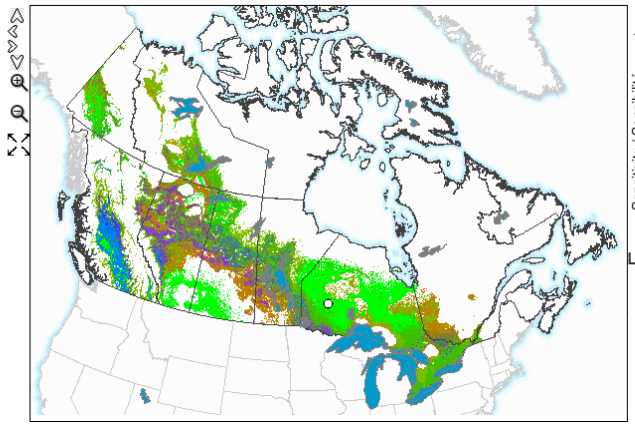
Data are based on the 22 most abundant tree species in Canada (Beaudoin et al., 2014), and the Canadian Moisture Index (CMI: Hogg, 1994). CMI predictions for the 2011-2040, 2041-2071 and 2071-2100 periods were obtained using the RCP 8.5 scenario (projections from McKenney et al., 2011). A trait-based index was used to characterize relative stand sensitivity to drought (Aubin et al. accepted).

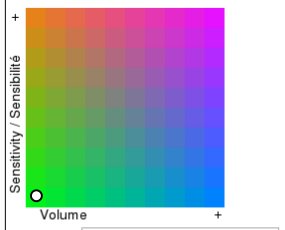
How to read this map

This map is comprised of two components:

- **Exposure** of wood volume projected to experience conditions below its current hydric envelope
- **Sensitivity** to drought for all species in the stand

Period 2071-2100





Location: 245250,6791207.64

Total stand sensitivity

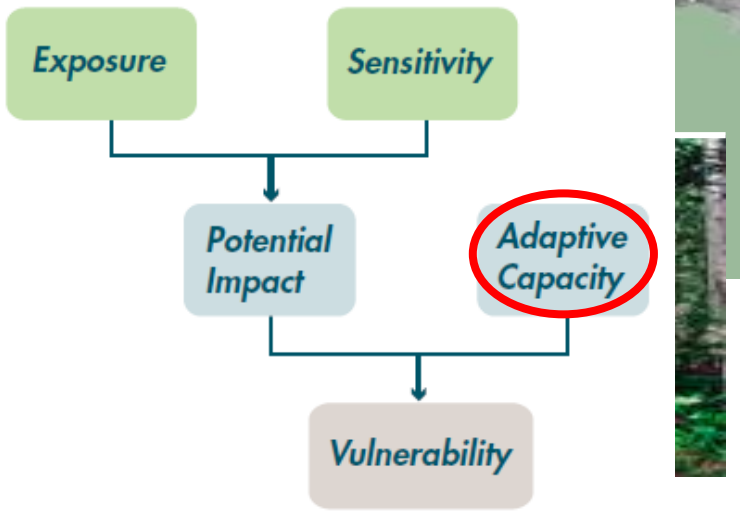
Volume	Sensitivity
<1 t/ha	60

Species outside of hydric envelope

	Volume	Sensitivity
Acer rubrum Red maple	<1	32
Betula alleghaniensis Yellow birch	<1	21
Pinus strobus Eastern white pine	<1	47
Thuja occidentalis Eastern white cedar	<1	61

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

Next Tuesday, seminar from Samuel Royer-Tardif



Quantifying the Adaptive Capacity of Tree Species and Implications for Silviculture

Samuel Royer-Tardif[1,2], Laura Boisvert-Marsh[1], Isabelle Aubin[1]

Canadian Forest Service– NRCan

[1] Great Lakes Forestry Center, Sault Ste-Marie, Ontario

[2] Laurentian Forestry Center, Québec, Québec

January 2019

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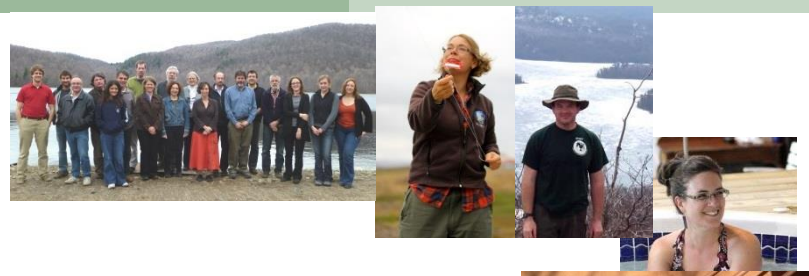
Thanks! Questions?



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TOPIC members

FORÊT S'ADAPTER

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CRÉ Vallée-du-Haut-Saint-Laurent

Institut des Sciences de la Forêt tempérée

Modélisation de la Complexité de la Forêt

Université du Québec en Outaouais