Sensitivity of Canadian tree species to climate change

Isabelle Aubin
Canadian Forest Service, NRCan
Great Lakes Forestry Centre, Sault Ste. Marie, Ontario

Coll: Françoise Cardou, Hedi Kebli, Kevin Lawrence, Alison Munson, Dan McKenney

Sault Ste-Marie, Michigan – April 2013

Natural Resources Canada
Ressources naturelles Canada

Canada

CFS Forest Change Program

A focal point for information and tools on forest and forest sector adaptation to CC in Canada

Tracking System

Reports on a **logical and cohesive set of *indicators*** that reflect the effects of climate change on the forests and forest sector of Canada.

Adaptation Toolkit

A range of knowledge products designed to **inform adaptation decision-making** for sustainable forest management under a changing climate.

Integrated Assessment

Examines the **implications of climate change on Canada's forests and forest sector** under a range of future climate scenarios, focused on key policy questions and designed to directly inform policies and investment.

CFS Forest Change Program

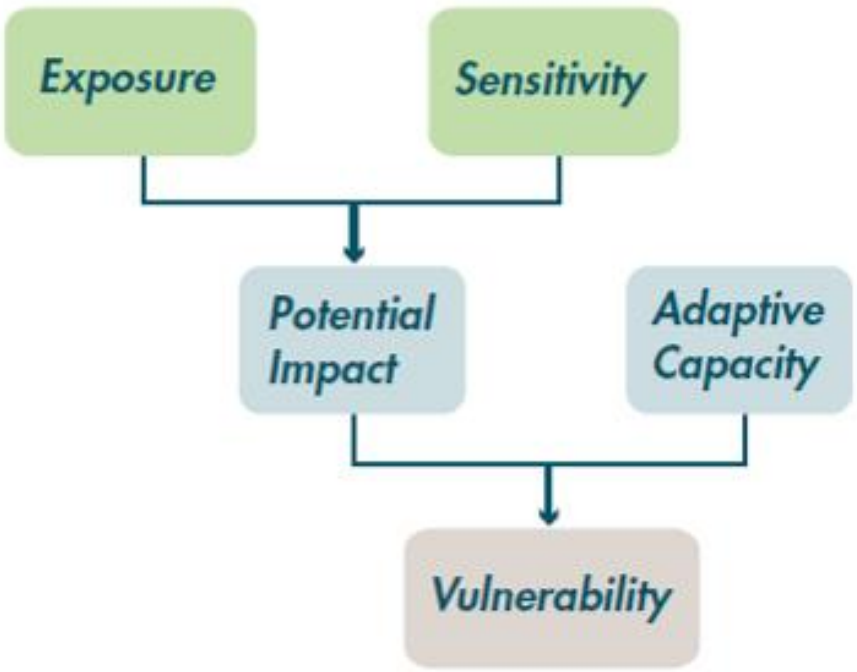
Adaptation Toolkit

A range of knowledge products designed to **inform adaptation decision-making** for sustainable forest management under a changing climate.

→ One project :

Sensitivity assessment of Canadian trees to CC using a trait approach

Components of vulnerability



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)

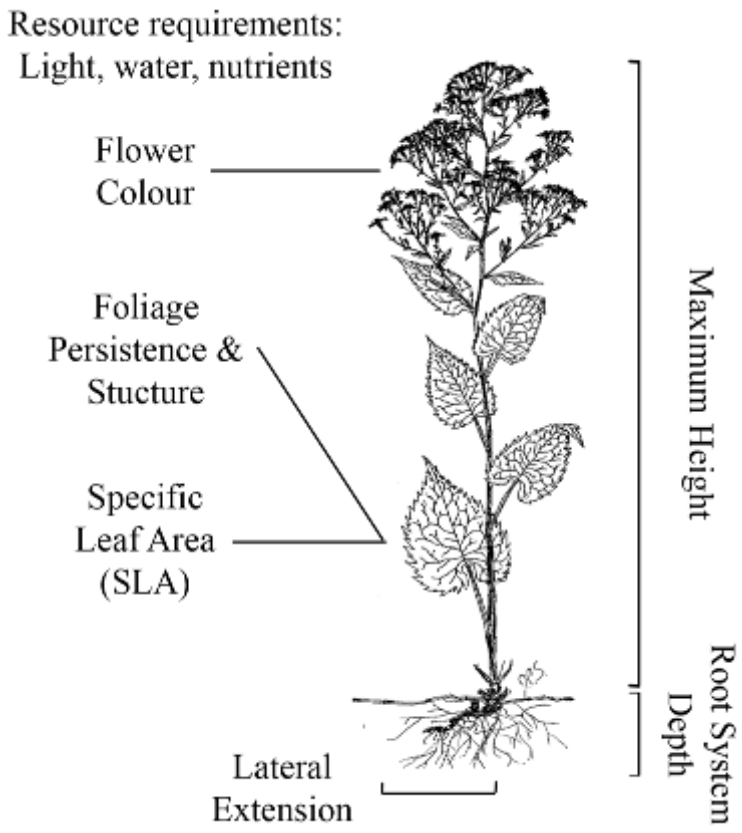
From Glick et al. 2011. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment.*

Functional traits approach

Response is individualistic

(Tingley et al. 2009)

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



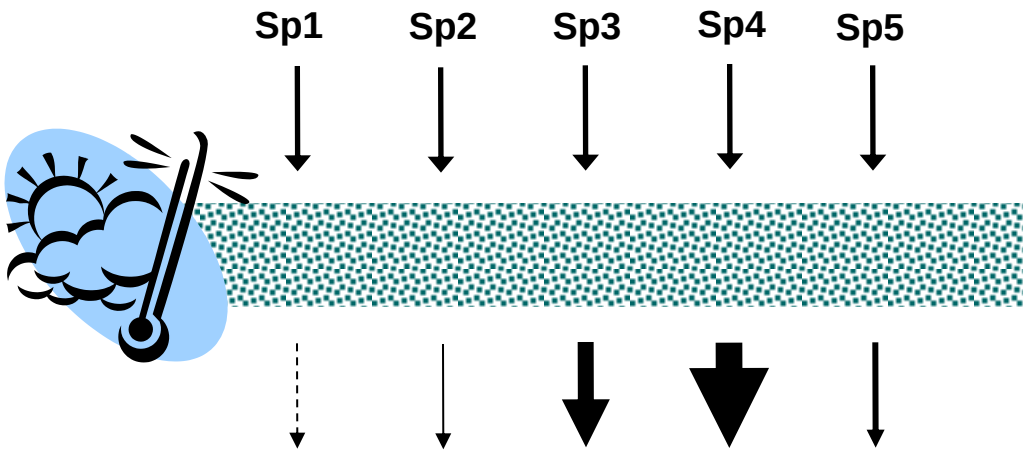
What are functional traits?

- ***Plant characteristics that matter to ecosystem processes/ that have implication for the fitness of an individual***

Functional traits

A quantitative approach to characterize species sensitivity to CC

Species response to climate change is the result of complex interactions between traits & environment

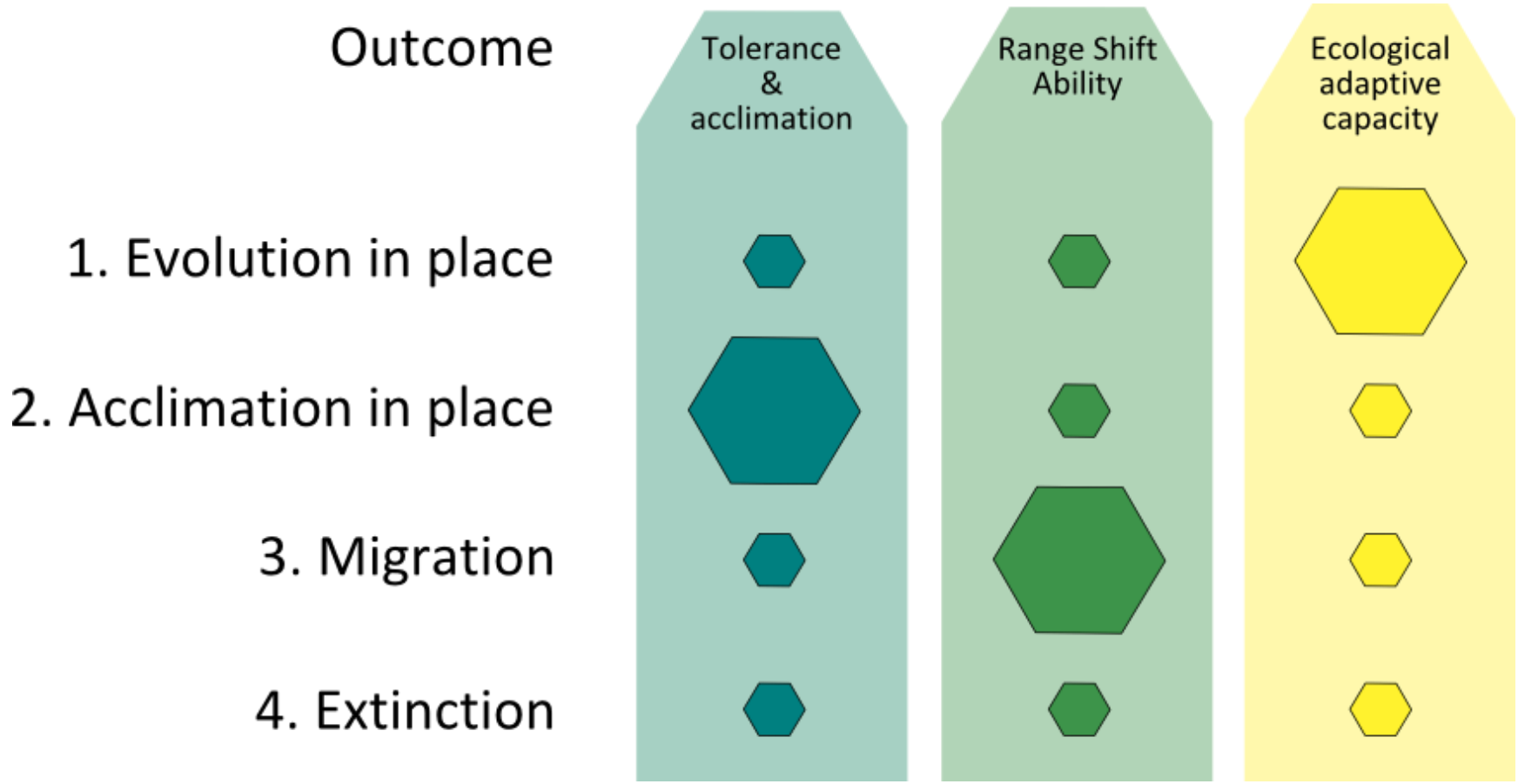


Filter: drought, heat, fire, insect

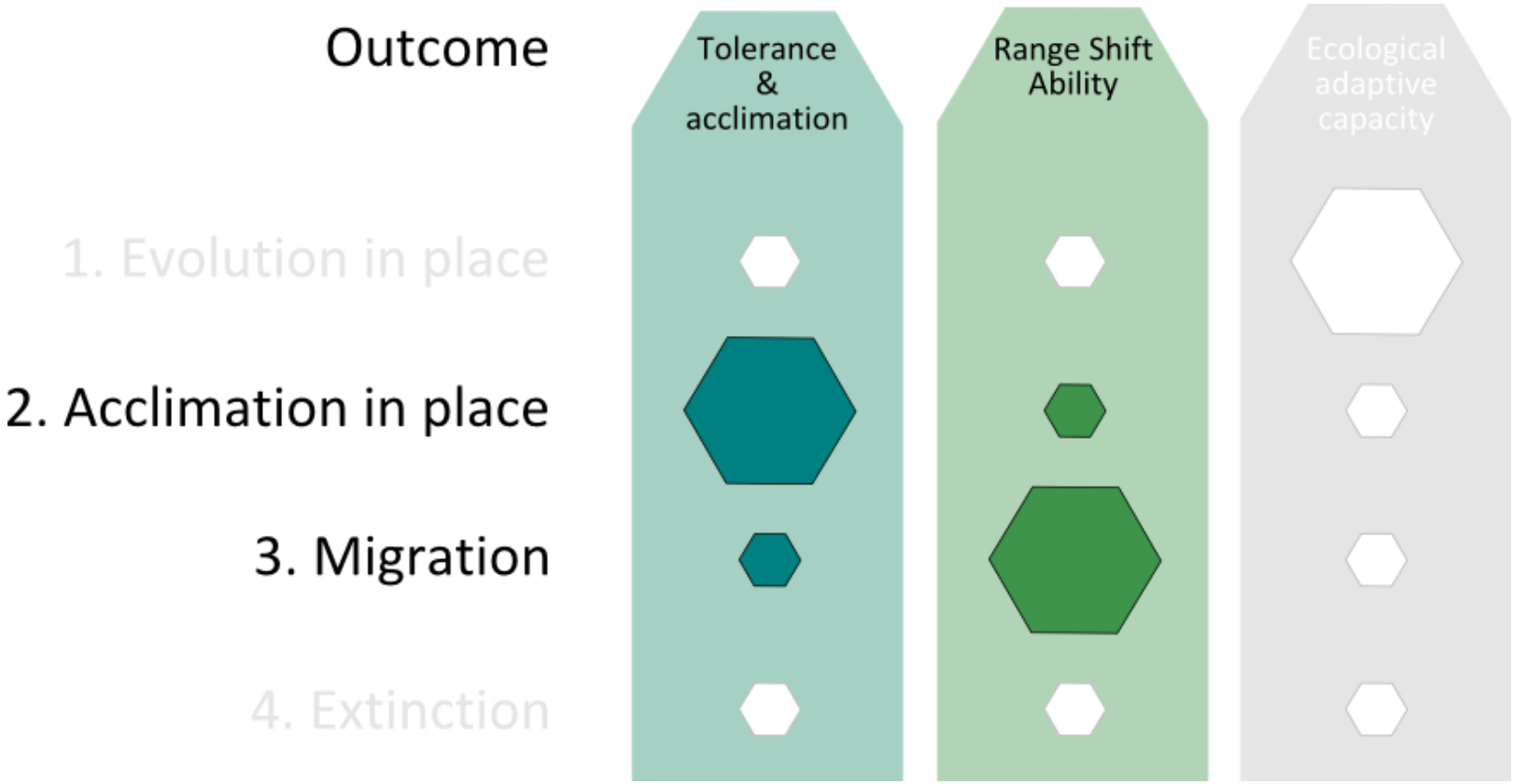
Response - determined by traits

e.g. seed mass
height
rooting depth
vegetative reproduction

Species response to Climate Change

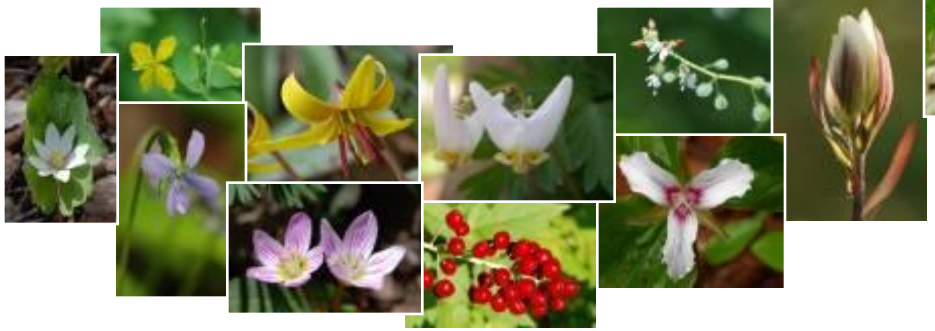


CC: Species ability to persist (acclimate) and migrate is determined by traits



The TOPIC Network

http://topic.nrcan.gc.ca/



Traits of Plants in Canada

A Canadian network of plant functional trait data

Goals:

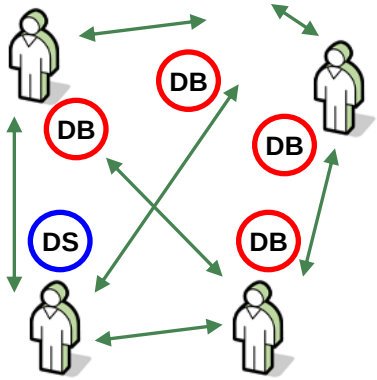
- Integrate trait data into a national database

- Help trait data exchange and sharing

- Increase collaboration between researchers

- Promote the use of the functional trait approach in Canada

What is TOPIC?



- A network of research scientists aiming to **stimulate, promote and facilitate research** involving the plant functional trait approach.
- The core of the network is a database that contains **data of functional traits of the vascular flora of Canada**.
- Data are provided by the members of the network and are available to anyone interested in contributing to the network.
- **Hosted by:**

CFS CANADIAN FOREST SERVICE
SCF SERVICE CANADIEN DES FORÊTS

Partners and members include representatives from:

- Universities
- Provincial and national agencies
- Industry

TREE TRAITS AND CLIMATE CHANGE

Data Integration Workshop

Mont Saint-Hilaire, March 2013

Theme: Key traits in the vulnerability assessment of Canadian tree species to CC

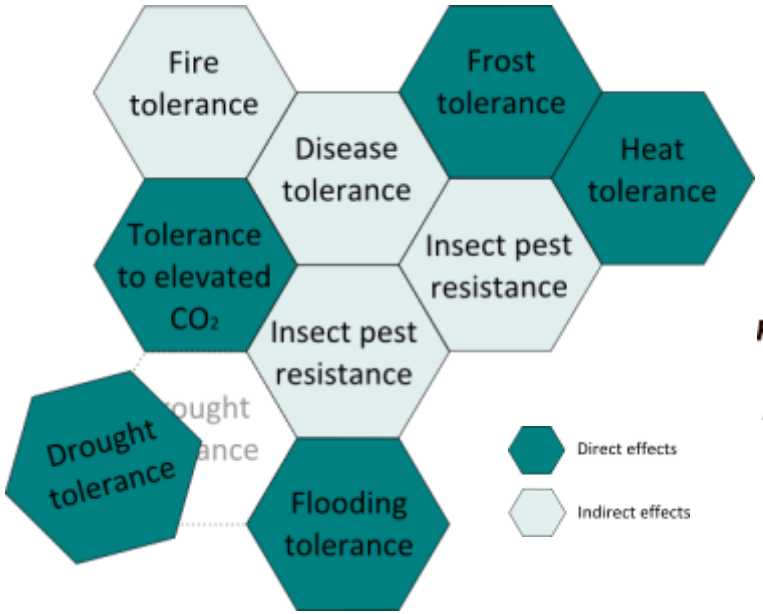
Participants: bring together ecophysiologists, population geneticists, community ecologists and modellers

Objectives:

- Develop a conceptual understanding of the relationship between traits and the main drivers of CC
- Identify traits key to modelling vegetation response to CC
- Accelerate the availability of data
- Identify opportunities and challenges in using traits to model vulnerability

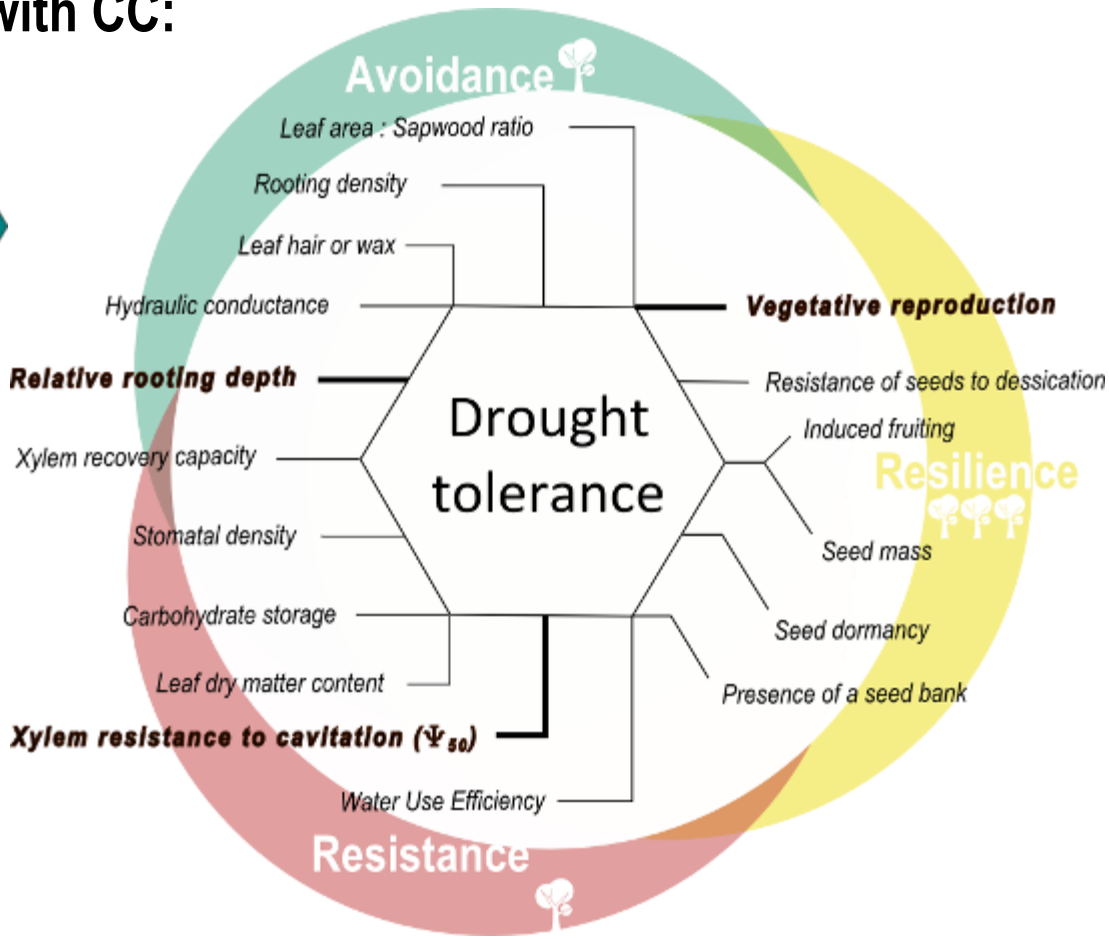
Species capacity to persist

Environmental filters associated with CC:



© EOL Tomas Castelazo

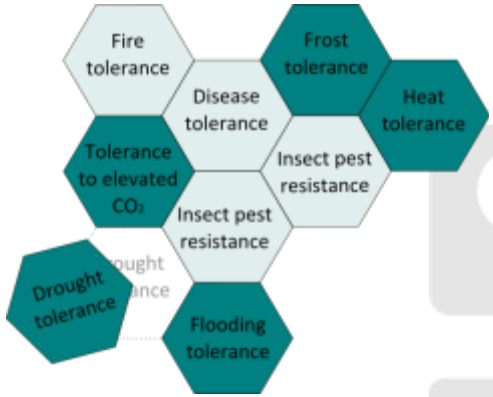
A key filter: drought

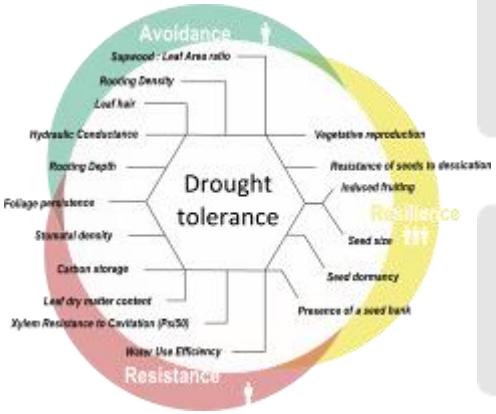


Schematic representation of mechanisms and key traits behind drought tolerance

Species capacity to persist

Tree sensitivity to drought

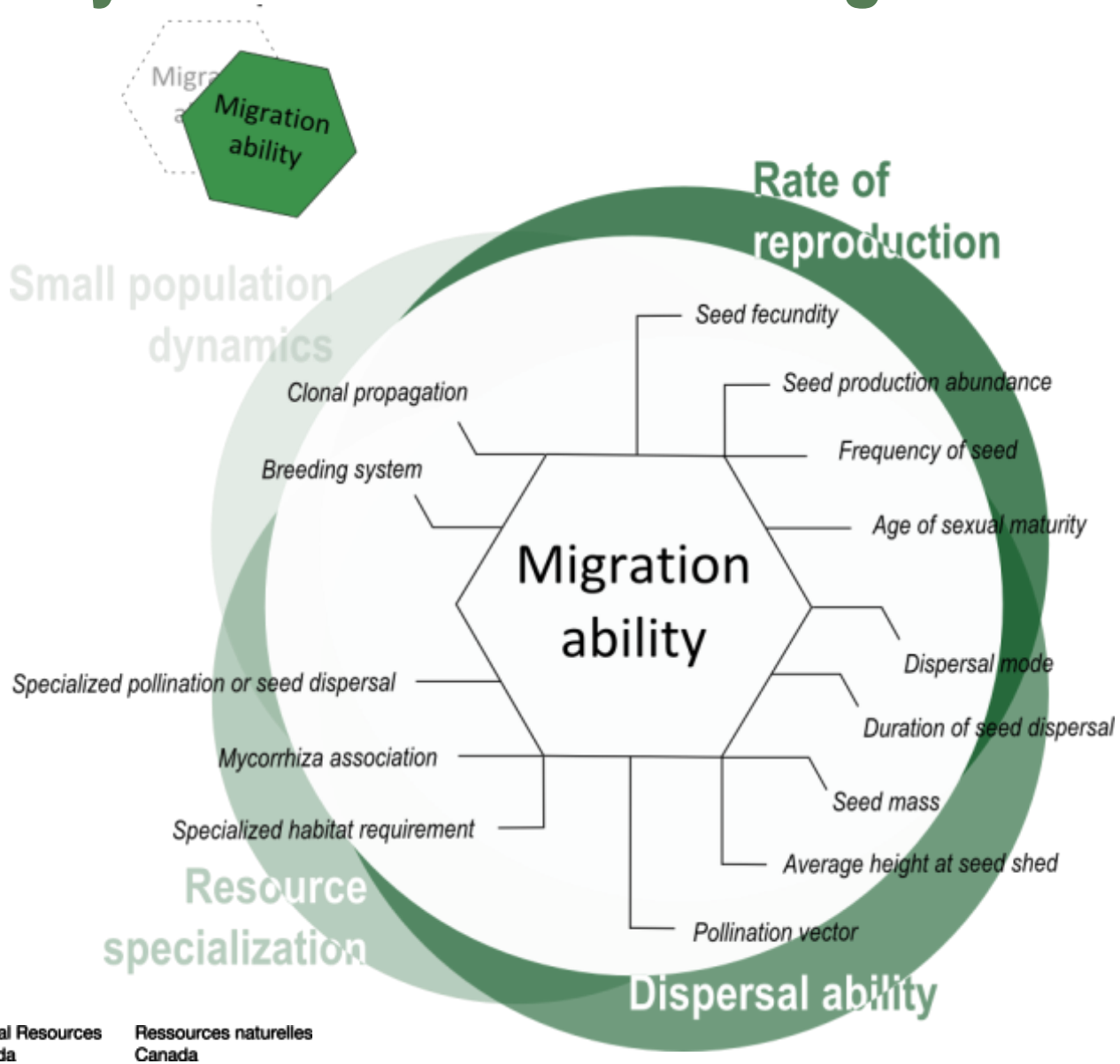




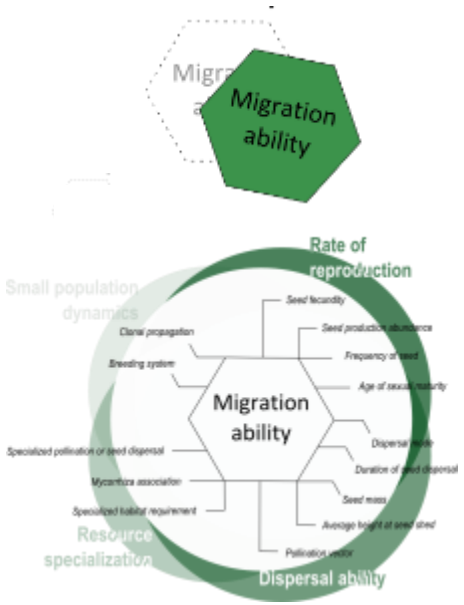
	Acer saccharum	Carya glabra	Fraxinus americana	Picea mariana	Pinus banksiana	Pinus ponderosa	Populus tremuloides	Quercus rubra
Avoidance								
Leaf Area : Sapwood ratio	1.22	?	?	?	0.11	0.15	0.19	0.8
Leaf hair or wax	n	y	n	y	y	y	n	n
Relative rooting depth	deep	deep	med	shallow	med	deep	shallow	deep
Resistance								
Xylem recovery capacity	y	y	y	weak	weak	weak	y	y
Stomatal density	260	?	190	?	?	?	160	440
Specific leaf area	23	?	?	?	6.5	?	17.6	15.2
Xylem resistance to cavitation	- 3.8	- 2.1	- 1.9	?	?	-2.6	?	- 1.6
Resilience								
Vegetative reproduction	med	med	med	med	none	none	high	med
Seed resistance to dessication	14 400	440	2 200	890 000	290 000	26 500	7 200 000	280
Presence of a seed bank	n	n	semi	n	aerial	?	n	n

Legend : Sensitive Tolerance ? Not documented

Ability to track climate change

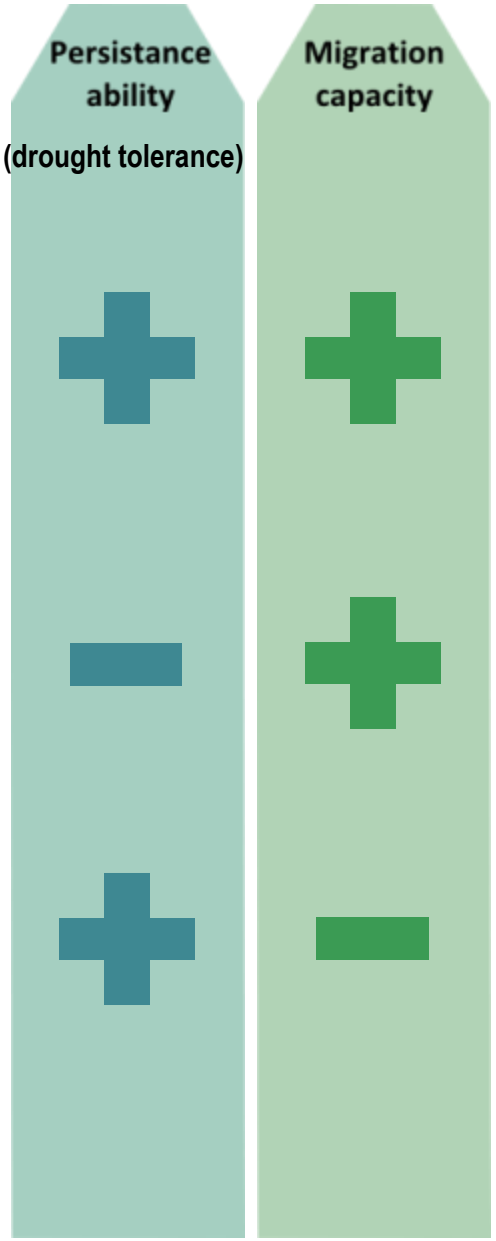


Tree migration potential



	Acer saccharum	Carya glabra	Fraxinus americana	Picea mariana	Pinus banksiana	Pinus ponderosa	Populus tremuloides	Quercus rubra
Rate of reproduction								
Seed crop frequency	3-5	1-2	3	4	1	8	4-5	2-5
Age of sexual maturity	5	30	10	10	5	7	2	25
Dispersal ability								
Dispersal vector	wind	bird mammal	wind	wind	wind bird mammal	wind bird	wind	bird mammal
Seed mass (seeds/kg)	14 400	440	2 200	890 000	290 000	26 500	7 200 000	280
Height at seed shed	35	30	30	25	24	72	27	30
Pollination vector	abiotic biotic	?	abiotic	abiotic	abiotic	?	abiotic	abiotic
Resource specialization								
Seedbed requirement	n	n	n	y/n	y	n	y	n
Small population dynamics								
Clonal propagation	med	med	med	med	none	none	high	med
Breeding system	2	2	1	2	3	2	1	2

Legend : Sensitive | Ability | ? Not documented



This approach helps identify under which mechanism a given species is sensitive

Trembling aspen
Populus tremuloides

Drought tolerance:
- Low avoidance - shallow rooted
- High resilience - vegetative reproduction

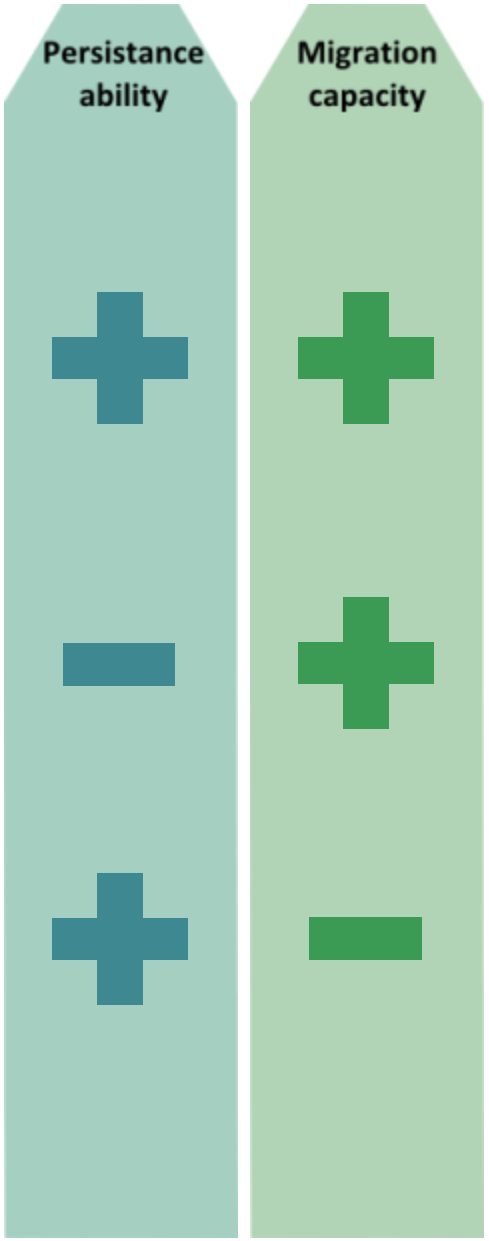
High migration capacity
- Large production of small seed
- Short time to maturity
- Wind dispersal
- Vegetative reproduction

Black spruce
Picea mariana

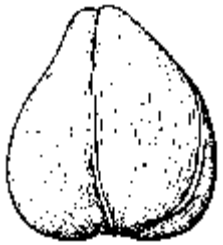
Red hickory
Carya glabra

Photo: USDA / Forest Service

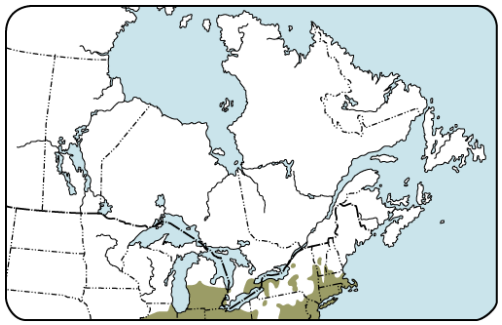
This approach helps identify under which mechanism a given species is sensitive



Trembling aspen
Populus tremuloides



Black spruce
Picea mariana



Images: NRCan / CFS; ClipArtETC

Red/Pignut hickory
Carya glabra

High drought tolerance:

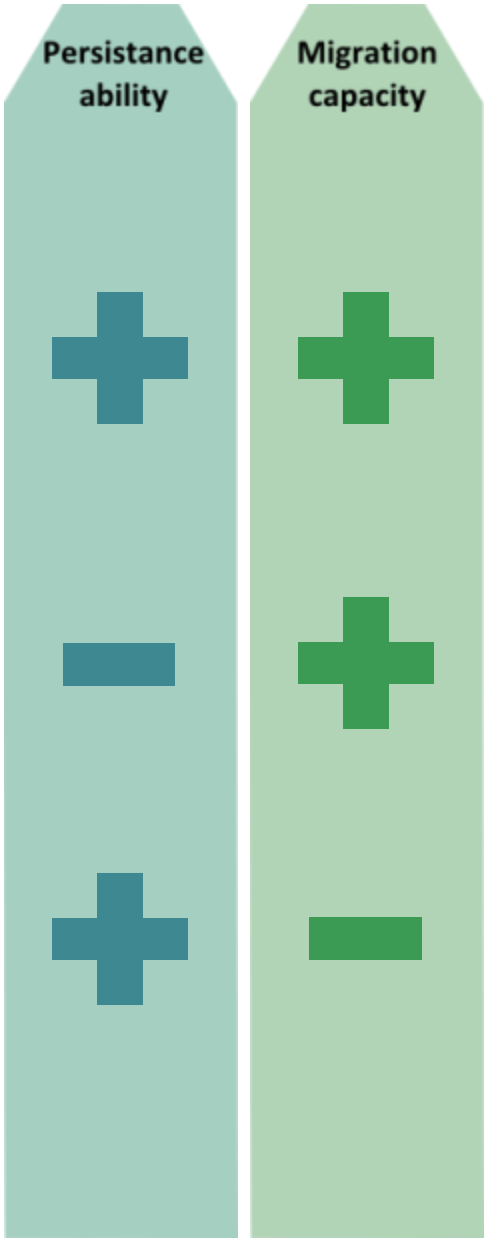
High avoidance - deep rooted

Good resilience - seed resistance to dessication

But low migration capacity

Low production of large seed, long time to maturity

This approach helps identify under which mechanism a given species is sensitive



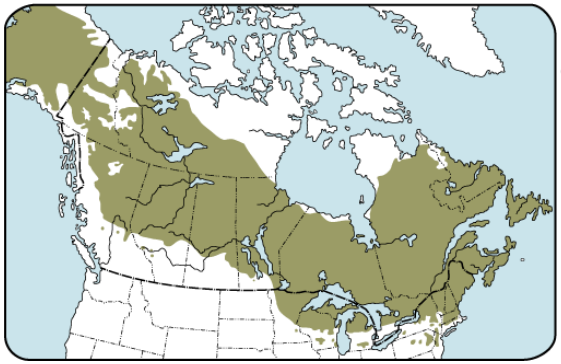
Trembling aspen
Populus tremuloides

Black spruce
Picea mariana

Red hickory
Carya glabra

Low drought tolerance:
Low avoidance - shallow rooted
Low resistance - low xylem recovery capacity

But good migration capacity
Good production of wind dispersed small seed

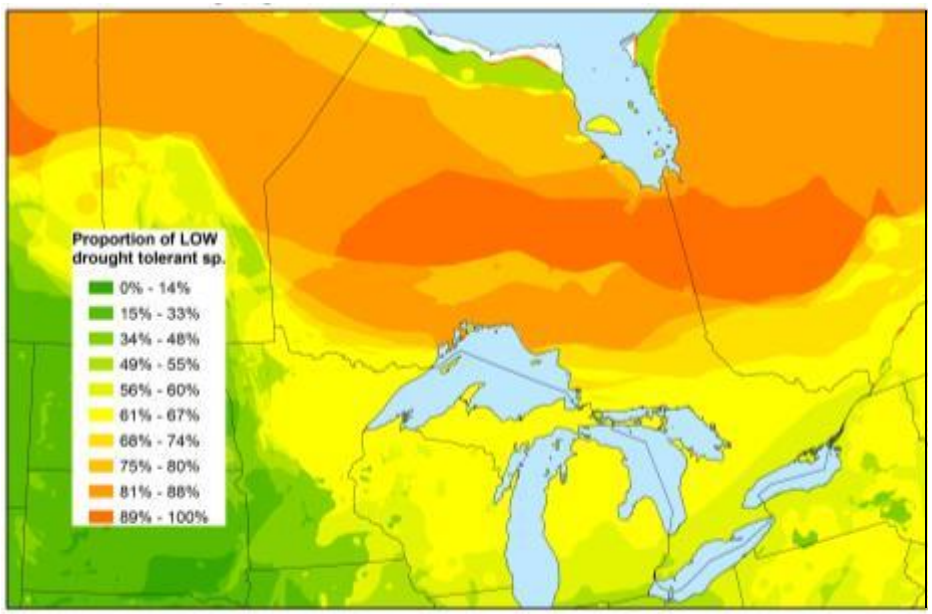


Images: NRCan / CFS

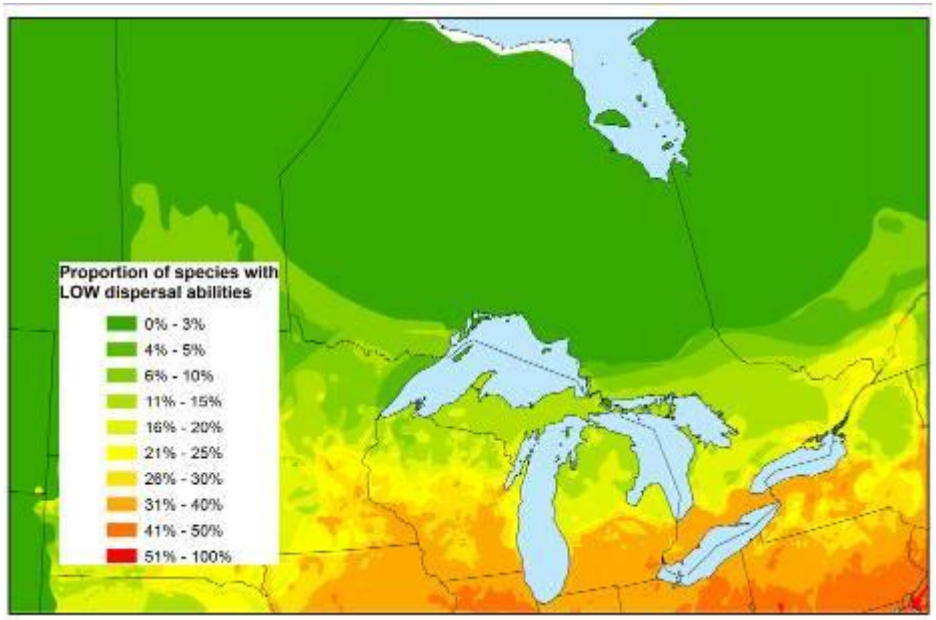
This approach helps identify under which mechanism a given region is sensitive

Distribution of sensitive species

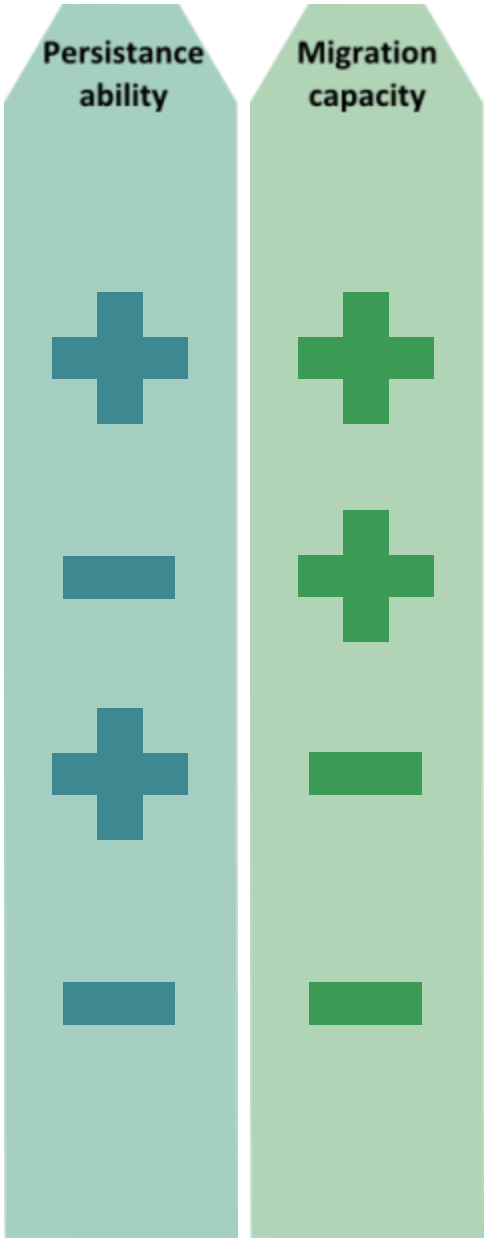
Low drought tolerance



Low migration ability



Map showing the ratio of species sensitive in Great Lakes forests. A ratio of 50% indicates that 50% of all species occuring in the stand are sensitive, independently of species abundance. For example, if black spruce (low drought tolerance) represents 90% of the total basal area and white spruce only 10% (high drought tolerance), the ratio will be 50%.



Toward a decision support tool

Understanding under which mechanisms a species is sensitive helps inform management strategy

$$\frac{\text{Sensitivity} + \text{Exposure}}{\text{Vulnerability}}$$

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

But many uncertainties remains…

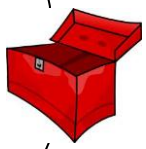
- **The adaptive capacity of trees**
  - "Species that track CC via phenological adapations are more likely to persist under CC than species without plastic phonological response" *(Cleland et al. 2012)*
- **Long generation time & lack of replacement opportunity**
  - Tree adaptive capacity may not be sufficient *(Chmura 2011)*
- **Interactions and confounding factors.**
  - e.g. combination of drought and T° = observed diminution in altitude of alpine species range shift *(Crimmins et al.)*
  - e.g. combination of drought and insect outbreak = extensive dieback of aspen stands in Western Canadian boeral forest *(Hogg & Schwarz 1999)*
- **Rare events**
  - e.g. importance of rare long distance events for species ability to track CC *(Clark 1998)*
- …

CFS Forest Change Program

Goals…

Tracking System 

Reports on a **logical and cohesive set of *indicators*** that reflect the effects of climate change on the forests and forest sector of Canada.

Adaptation Toolkit 

A range of knowledge products designed to **inform adaptation decision-making** for sustainable forest management under a changing climate.

Integrated Assessment 

Examines the **implications of climate change on Canada's forests and forest sector** under a range of future climate scenarios, focused on key policy questions and designed to directly inform policies and investment.

The Climate Change Indicator Initiative

- Define a set of indicators
- Provide ideas on criteria and considerations for selecting particular indicators suitable for reporting in a specific tracking system
- Provide forest management agencies and stakeholders a framework to decide what they could monitor to assess the effects of climate change on the forest

Forest Change

Core team:

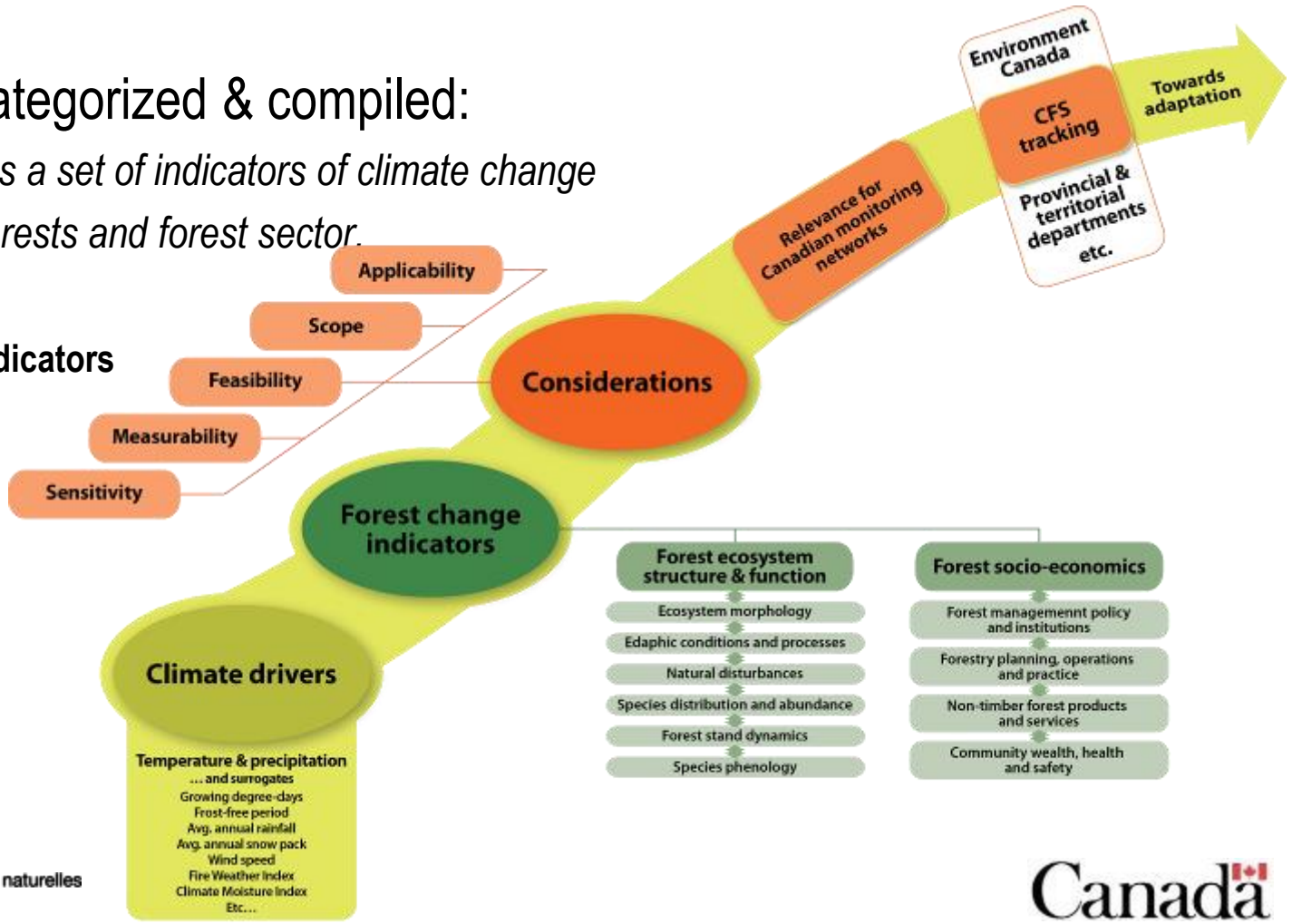
The Climate Change Indicator Initiative

- Workshops held at each regional CFS centre to identify potential CC indicators
- Information categorized & compiled:

Gauthier et al. *Towards a set of indicators of climate change effects on Canada's forests and forest sector.*

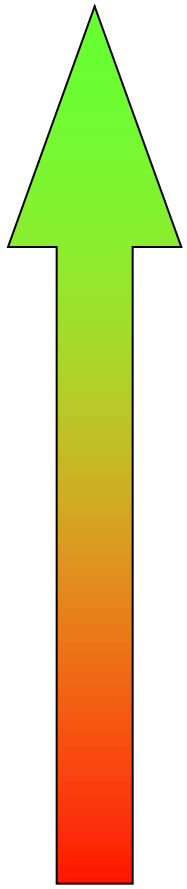
In preparation

Categorization of indicators



Selected Indicators for Forest Change Tracking system

1. Drought (CMI, SMI)
2. Fire weather (Start of Fire Season)
3. Forest cover gain and loss (distribution of major tree species)
4. Fire regime (Area Burned)
5. Pest incidence (major pest species distribution)
6. Phenology of tree species (timing of budburst)
7. Tree mortality
8. Extreme weather consequences
9. Forest growth and productivity (radial growth)
10. Tree regeneration (percentage of young forest)
11. Biodiversity (bird community changes)
12. Socio-economic indicators



Thanks!

Participants to the Tree Traits and Climate Change workshop: **Isabelle Aubin** (CFS-GLFC), **Alison Munson** (Université Laval), **Phil Burton** (UNBC), **Tanya Handa** (UQAM), **Nathalie Isabel** (CFS-CFL), **Hedi Kebli** (CFS-GLFC), **Victor Lieffers** (University of Alberta), **Eliot McIntire** (CFS-PFC), **Alain Paquette** (UQAM), **John Pedlar** (CFS-GLFC), **Cindy Prescott** (UBC), **Bill Shipley** (Université de Sherbrooke), **Anthony Taylor** (CFS-AFC), **Josée Savage** (Université de Sherbrooke) et **Françoise Cardou** (CFS-GLFC).

Questions?