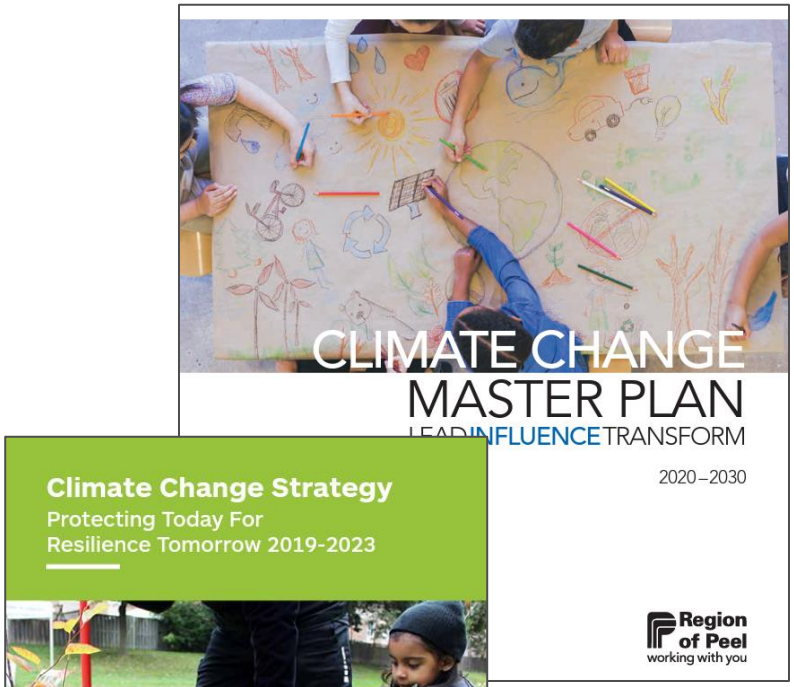
Credit Valley Conservation
inspired by nature

Identifying woodlands with high vulnerability to climate change in the Credit River Watershed

Laura Timms
October 18, 2022
Latornell Symposium

Vulnerability to climate change

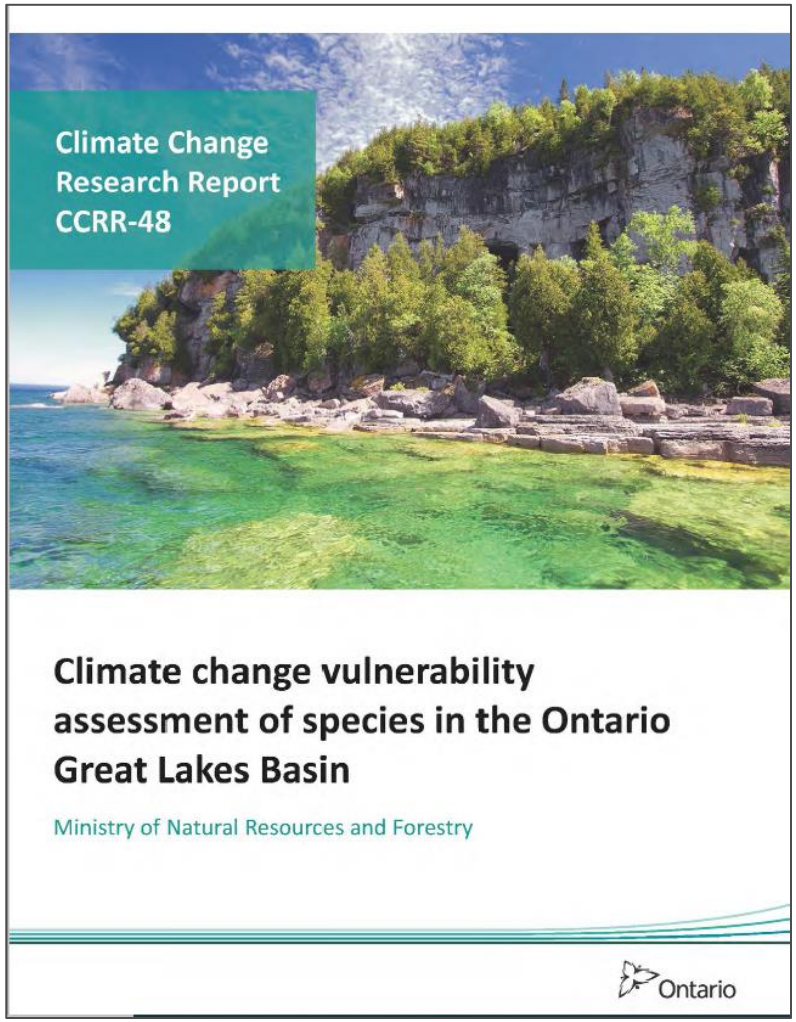
- Climate change is affecting the natural systems of the Credit River Watershed
- Broad-scale strategies and tools help us plan for mitigation and adaptation
- Also need fine-scale information on species and community responses to changing climatic conditions



Trait based vulnerability assessments

Exposure	How much of a change in climate, and associated problems, a species or system is likely to experience
Sensitivity	Degree to which a system is or is likely to be affected by, or responsive to, climate change
Adaptive capacity	Opportunities that may exist to ameliorate the exposure or sensitivity of a species or system

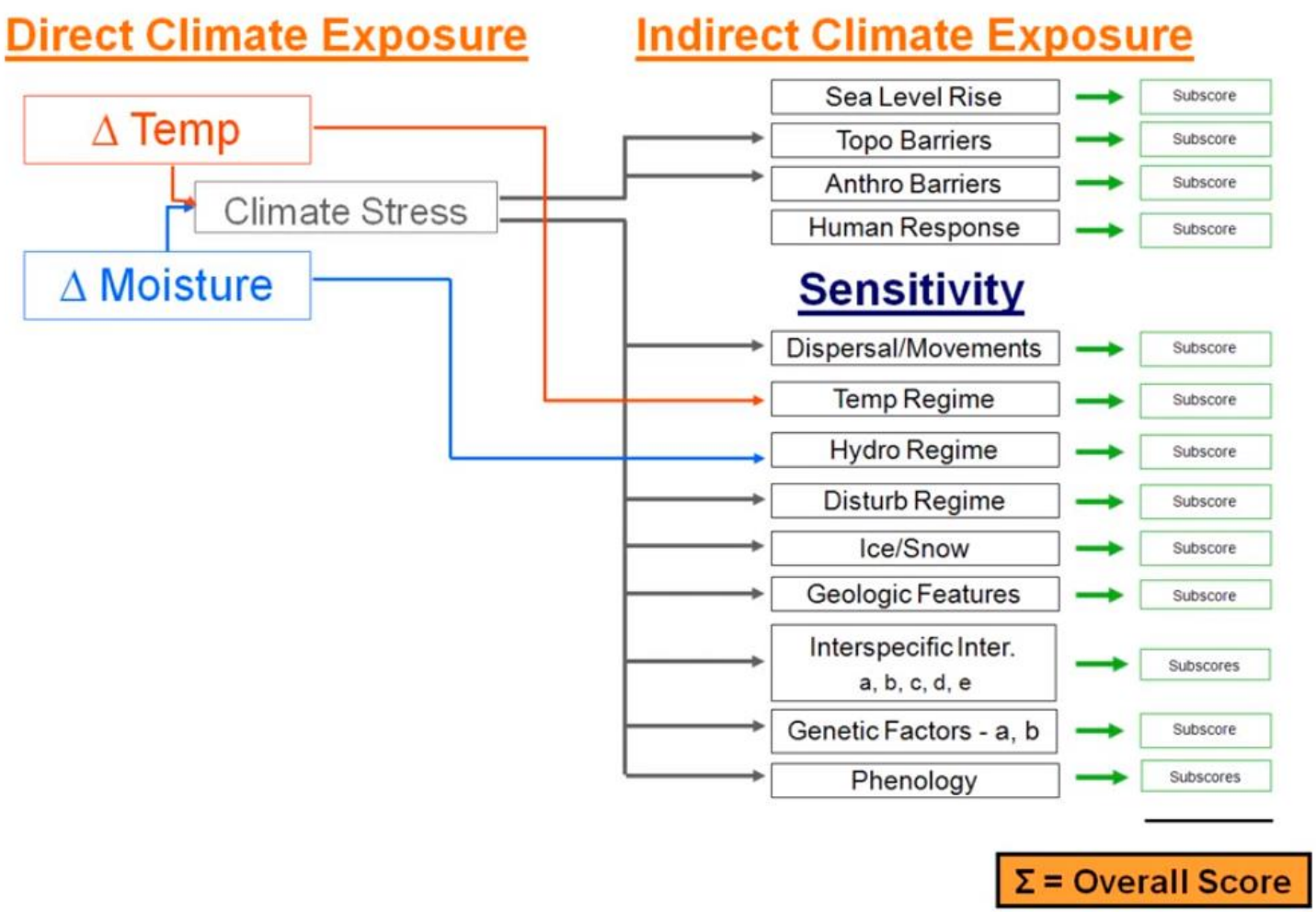
NatureServe CCVI



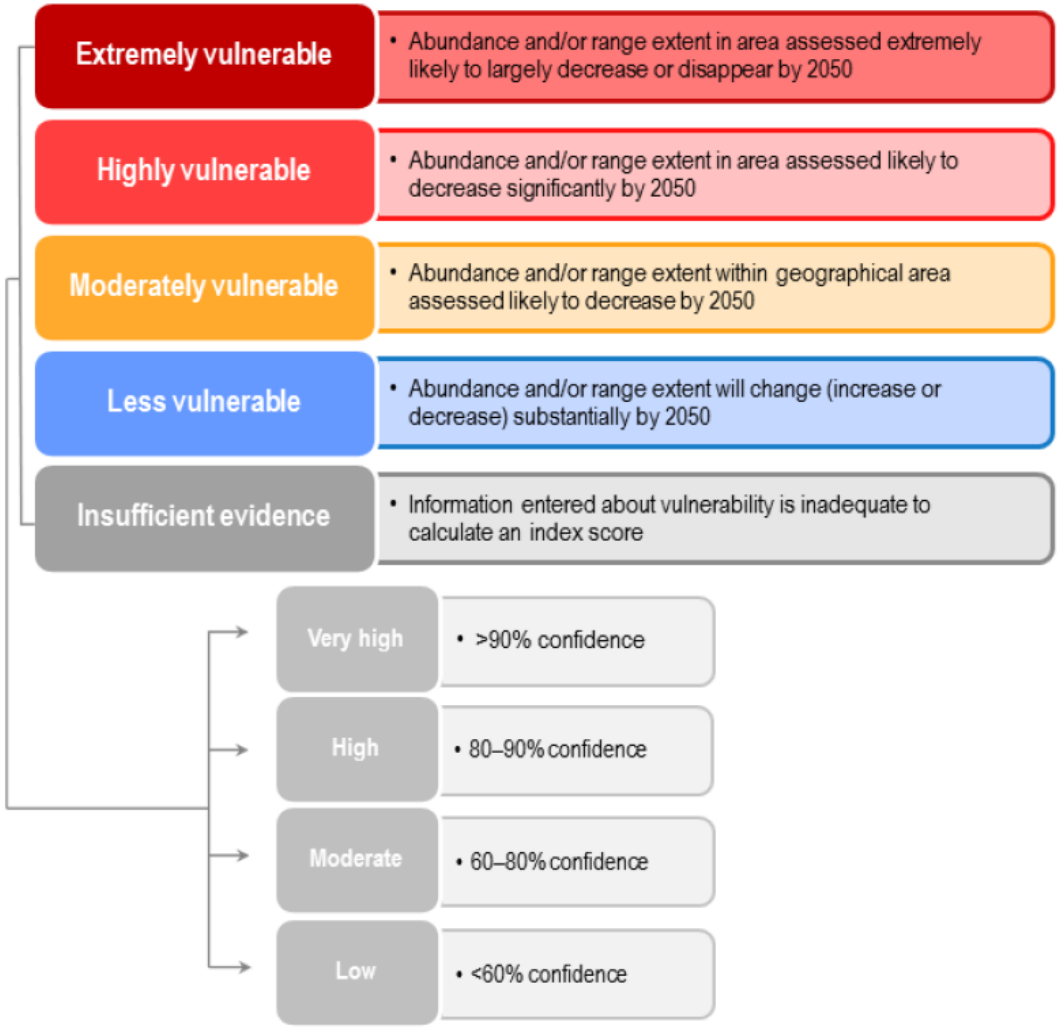
- Open source
- Any taxonomic group
  - Terrestrial & aquatic
- Used by the MNRF and in U.S. State action plans
- Canadian-specific version
- Regularly updated

NatureServe®

CCVI assessment categories & factors



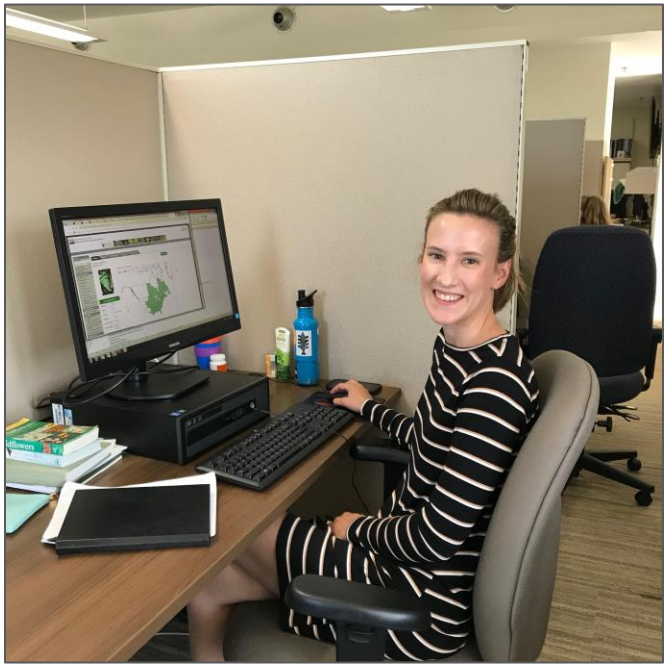
Possible CCVI outcomes



CVC CCVI project

- Internship at CVC (2019)
- Used CCVI tool to assess vulnerability of 30 forest plant species
- Consultant contract to complete rankings for 55 tree species (2020)

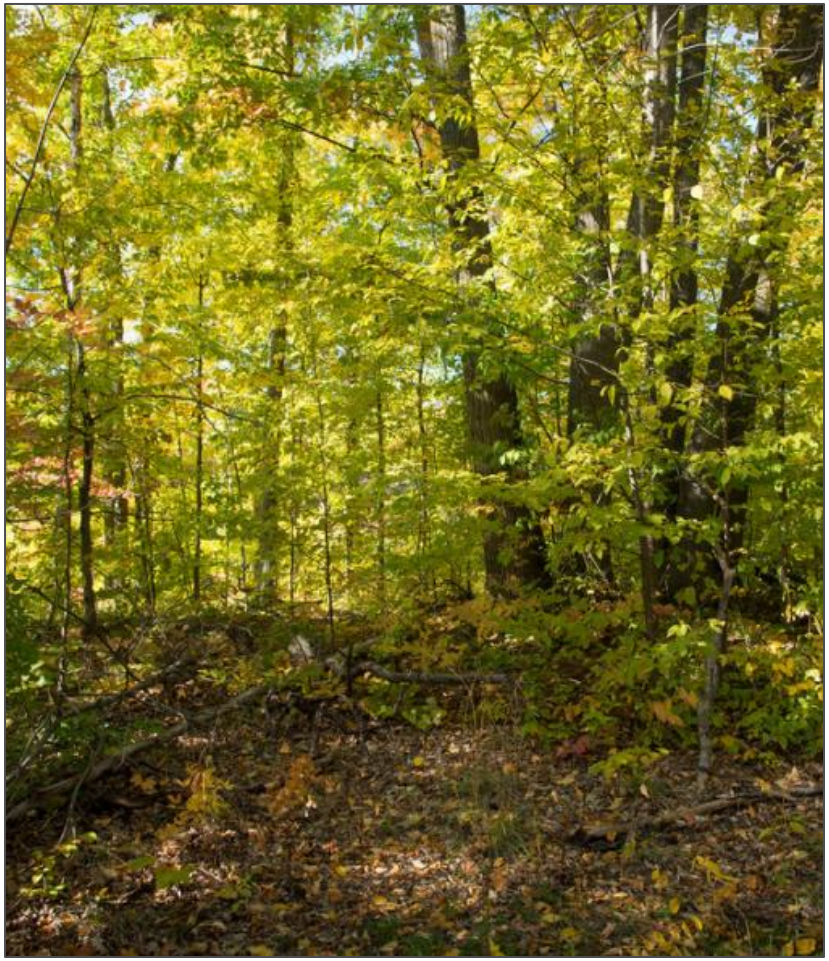
UNIVERSITY OF TORONTO
JOHN H. DANIELS FACULTY OF
ARCHITECTURE, LANDSCAPE, AND DESIGN



Maddy Sansom

Methods: CCVI

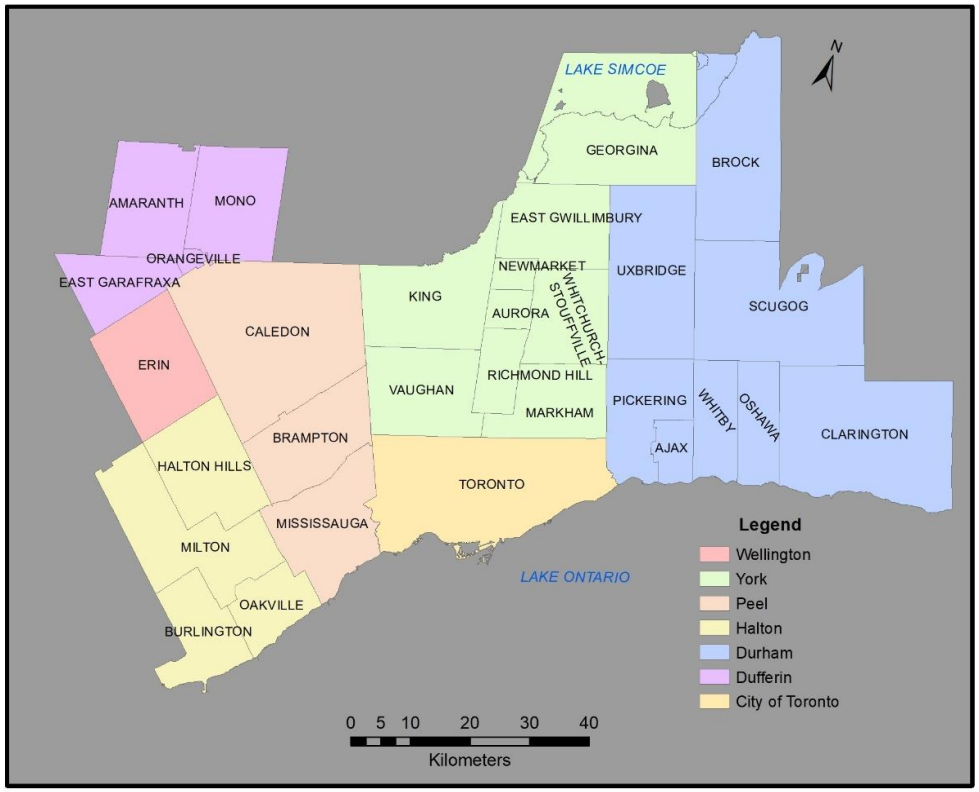
CCVI methods: Species selection



- 55 species
- All native tree species found naturally (not planted) in the Credit River Watershed
- Non-native species that are commonly dominant in forest patches (e.g., Norway Maple)

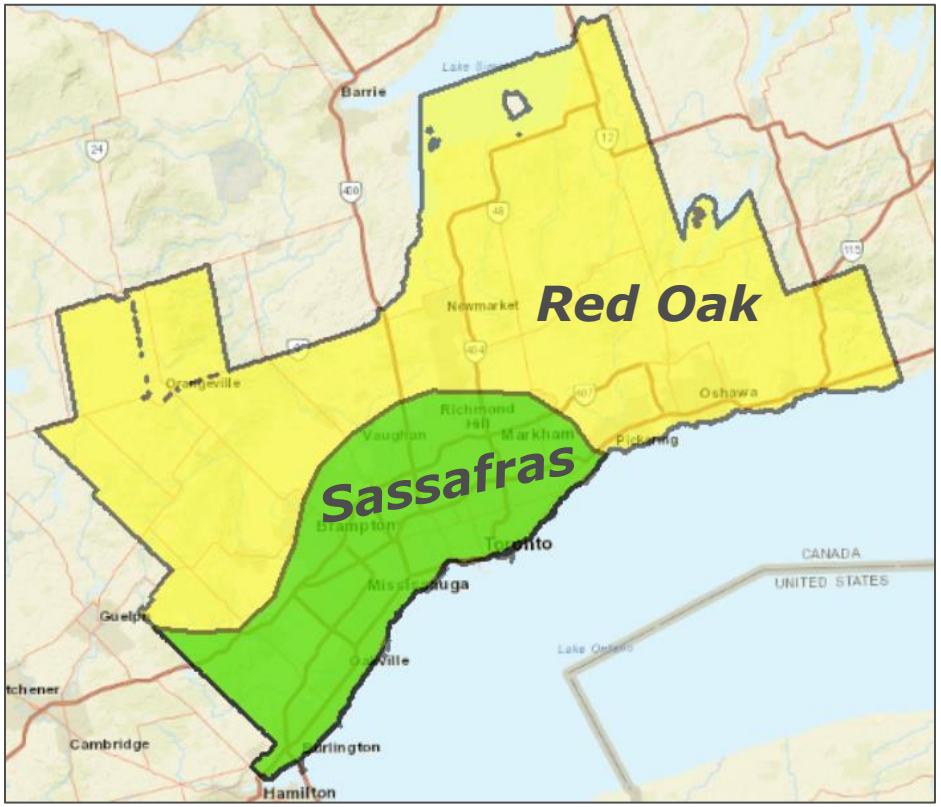
CCVI methods

- Greater Toronto Area plus lower tier municipalities in the Credit River Watershed



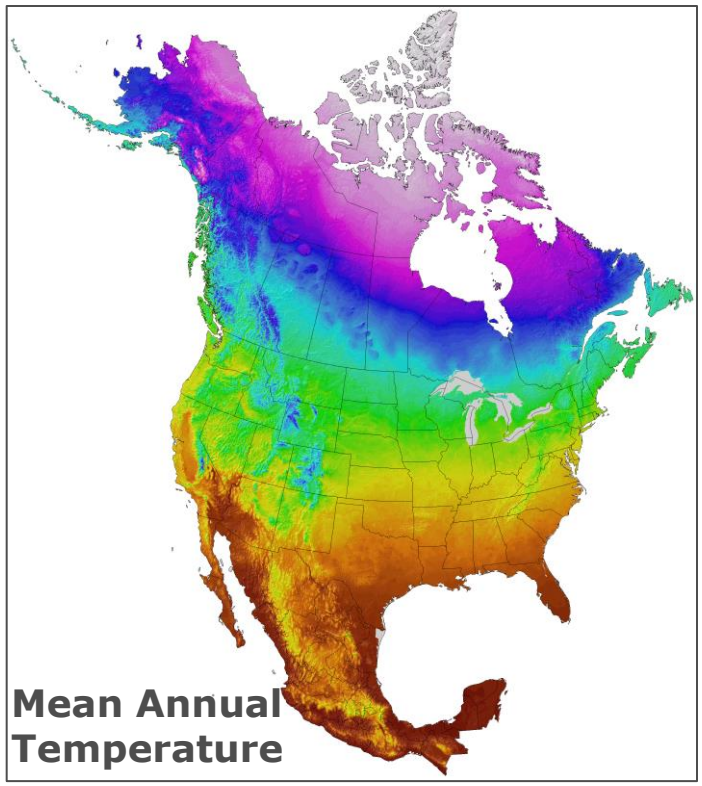
CCVI methods

- 55 tree species
- Used Little's range maps; online version at USFS
- Clipped to study area



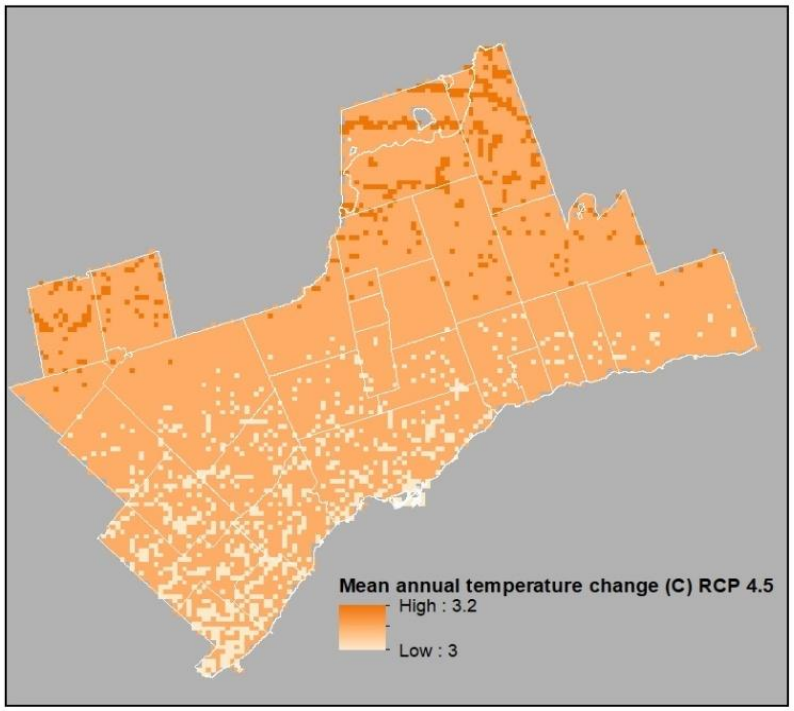
CCVI methods

Define geographic assessment area → Acquire species distribution data → **Acquire or calculate climate projections** → GIS analysis of species data with climate projections



- Data *via* AdaptWest, from ClimateNA database:
  - Output of 15 GCMs
  - downscaled to 1 km
  - RCP 4.5 and RCP 8.5*

CCVI methods



- Using temperature & precipitation for historical (1961-1990) & future (2050s) periods for both scenarios
- Calculated:
  - Change in mean annual temperature
  - Climate moisture deficit

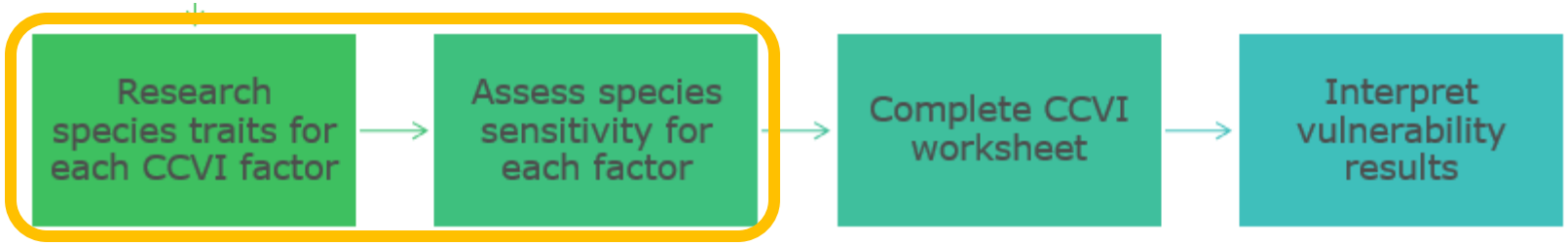
CCVI methods

- Calculated what proportion of each species' range falls into set categories of temperature increase and drying

Example: Black Ash

Temperature increase	RCP 4.5
> 3.80 °C	.
3.49 - 3.80 °C	.
3.17 - 3.48 °C	4.44
2.85 - 3.16 °C	95.56
2.53 - 2.84 °C	.
< 2.53 °C	.

CCVI methods

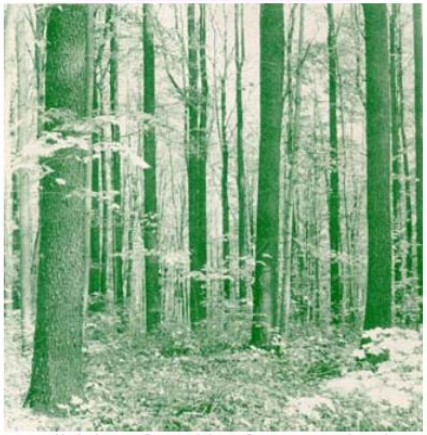


Silvics of North America

Volume 1: Conifers

Click here for Table of Contents

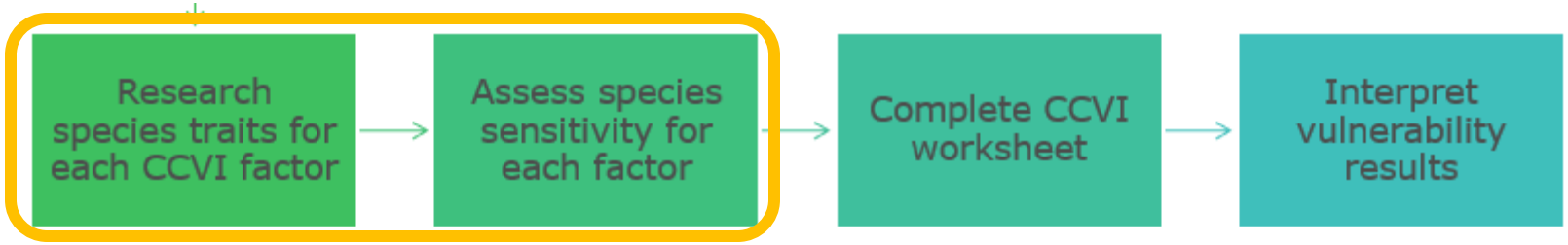
Volume 2: Hardwoods



Click here for Table of Contents-html

- Researched species traits for CCVI factors
- Determined how each trait may affect vulnerability to climate change:
  - Neutral
  - Somewhat increase
  - Increase
  - Greatly increase
  - Unknown

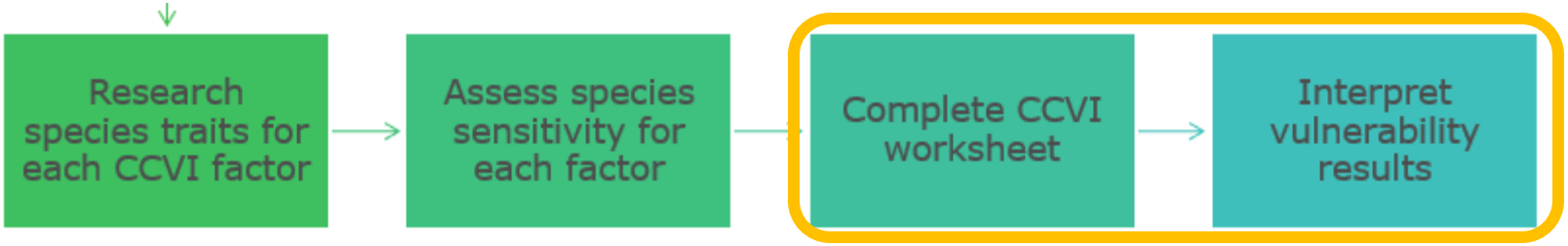
CCVI methods



- **Example:** Black Ash

Factor C5: Genetic Factors	Score	Details
a) Measured genetic variation	Unk	
b) Occurrence of bottlenecks in recent evolutionary history (use only if 5a is unknown)	Inc	EAB killed large proportion of ash in many areas; e.g. Iverson et al. 2006, 99% mortality in MI
c) Reproductive system (plants only; use only if C5a and C5b are unknown)	n/a	

CCVI methods



- Used CCVI calculator to score each species

The NatureServe Climate Change Vulnerability

GI = Greatly Increase
Inc = Increase
SI = Somewhat Increase
N = Neutral

Copy Data to Calculator for Editing

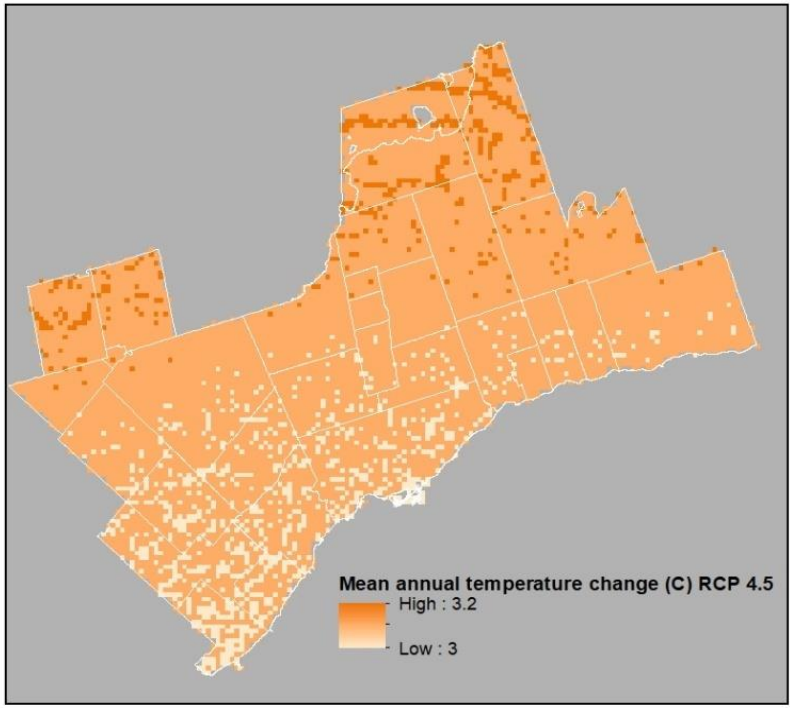
Warning: Do not edit data on this tab. Instead:
1. Put your cursor in the row you want to edit.
2. Click the button above.
3. Edit your data on the Calculator tab.
4. Use button to Copy Data to Results.
   It will paste as a new row in the Results Table.
5. Delete the row of old data.

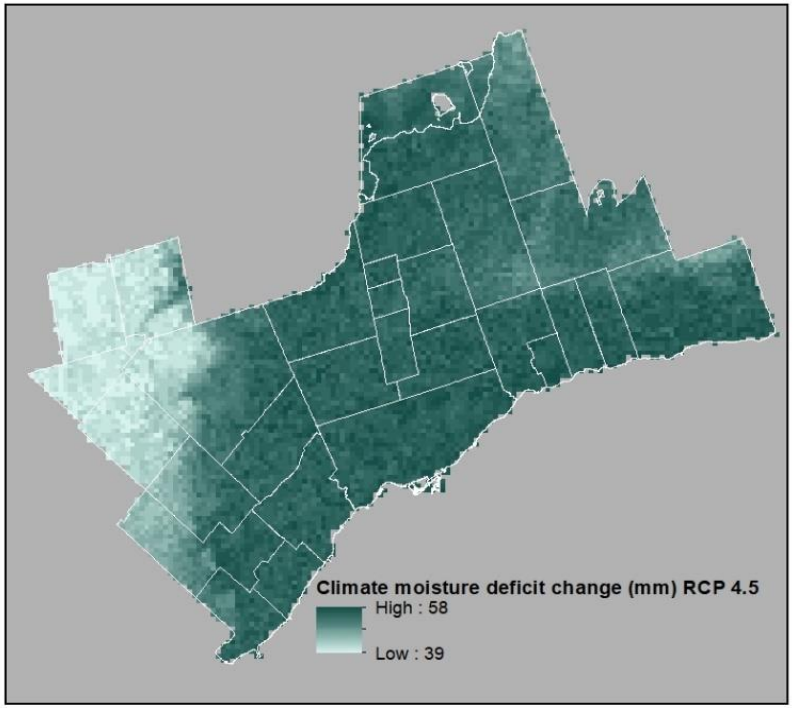
Taxonomic Group	Species	Migratory Exposure >7	6-7	4-5	2-3	Sea level B1	Comments B1	Natl barriers B2a	Comments B2a	Anth barriers B2b	Comments B2b	Land Use Change B3	Comments B3	Dispersal/Movement C1	Comments C1	Hist. thermal niche C2ai	Comments C2ai	Physiol. thermal niche C2aii	Comments C2aii	Hist. hydrol. niche C2bi	Comments C2bi
Vascular Plant	*Fagus grandifolia (RCP 8.5) w/ D*					N		N		N		U		SI		SI		N		Inc	
Vascular Plant	*Ostrya virginiana (RCP 4.5) w/ D*					N		N		N		U		Inc-SI		SI		N		Inc	
Vascular Plant	*Ostrya virginiana (RCP 8.5) w/ D*					N		N		N		U		Inc-SI		SI		N		Inc	
Vascular Plant	*Thuja occidentalis (RCP 4.5) w/ D*					N		N		SI		U		Inc		SI		Inc-SI		Inc	
Vascular Plant	*Thuja occidentalis (RCP 8.5) w/ D*					N		N		SI		U		Inc		SI		Inc-SI		Inc	
Vascular Plant	*Abies balsamea (RCP 4.5) w/ D*					N		N		N		U		Inc		SI		Inc		Inc	
Vascular Plant	*Abies balsamea (RCP 8.5) w/ D*					N		N		N		U		Inc		SI		Inc		Inc	
Vascular Plant	*Betula alleghaniensis (RCP 4.5) w/ D*					N		N		N		U		SI		SI		SI		Inc	
Vascular Plant	*Betula alleghaniensis (RCP 8.5) w/ D*					N		N		N		U		SI		SI		SI		Inc	

Calculator | Calculations | Results Table | Import from 2.01 | A. Climate Exposure | B. Climate-Indirect | C. Sens & AC | D. Docum | License

Results: CCVI

Temperature and moisture RCP 4.5

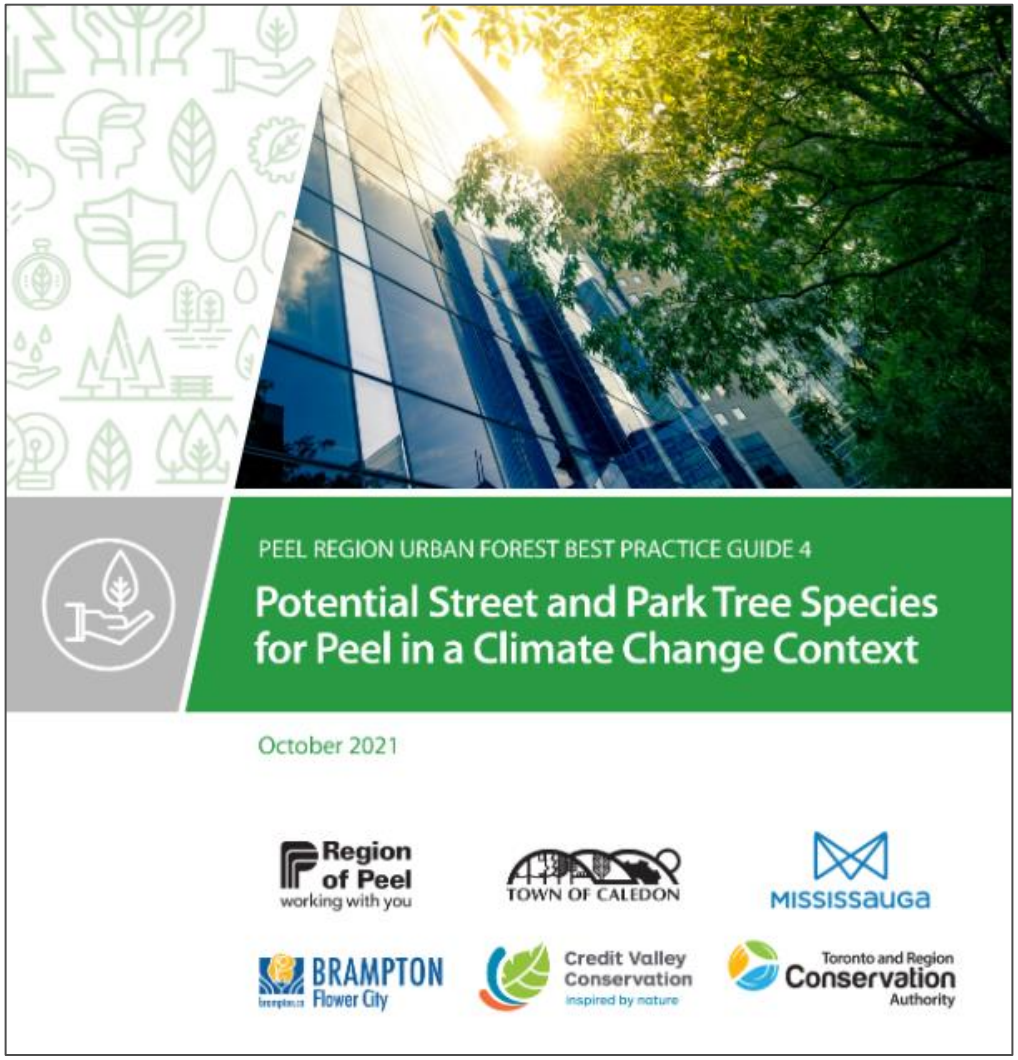




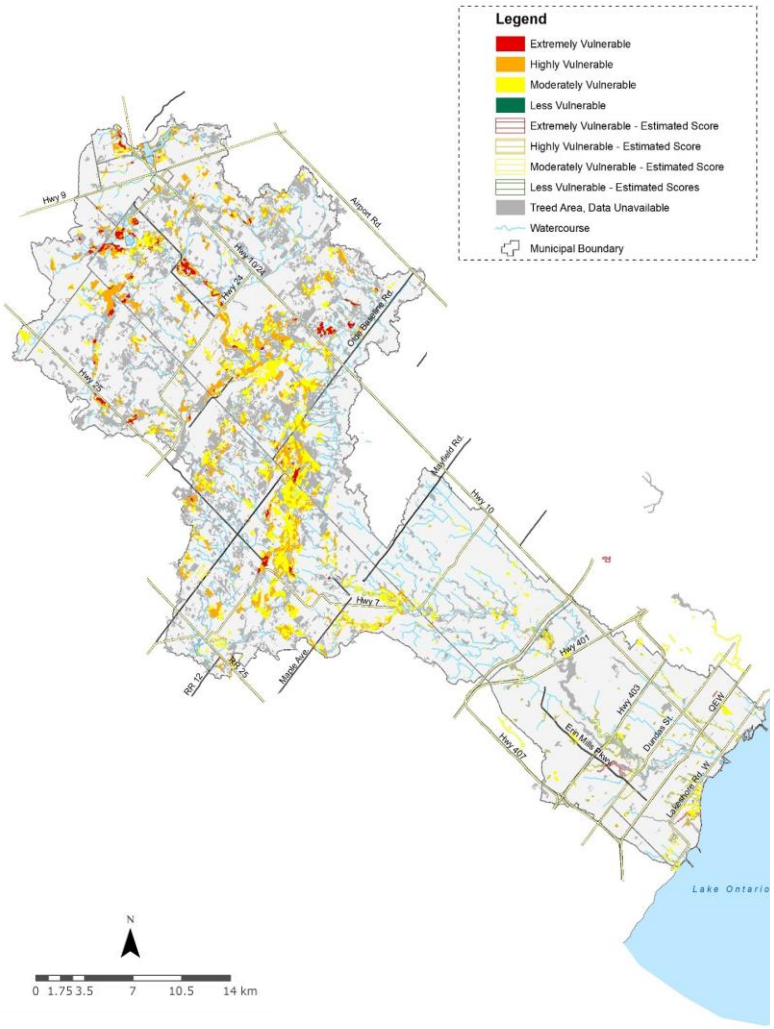
Less Vulnerable	Moderately Vulnerable	Highly Vulnerable	Extremely Vulnerable
Common Buckthorn Glossy Buckthorn Freeman's Maple	Ironwood Gray Birch Sugar Maple Blue Beech American Basswood Northern Red Oak Eastern Red Cedar Trembling Aspen Black Cherry Red Maple Balsam Poplar Bigtooth Aspen Rock Elm Manitoba Maple Sassafras Green Ash American Sycamore	Black Maple Mountain Maple Silver Maple American Beech Slippery Elm Norway Maple White Pine Bitternut Hickory Black Walnut Bur Oak Paper Birch Pignut Hickory Eastern Cottonwood Yellow Birch Peachleaf Willow Shagbark Hickory White Ash White Oak American Elm Tulip Tree American Chestnut Red Pine Eastern Hemlock Eastern White Cedar Chinquapin Oak	Black Willow Red Mulberry Black Oak Black Ash White Spruce Swamp White Oak Balsam Fir Butternut Black Spruce Larch
6%	***31%***	***45%***	***18%***
RCP 4.5			

What are we doing with this information?

Inform restoration and management



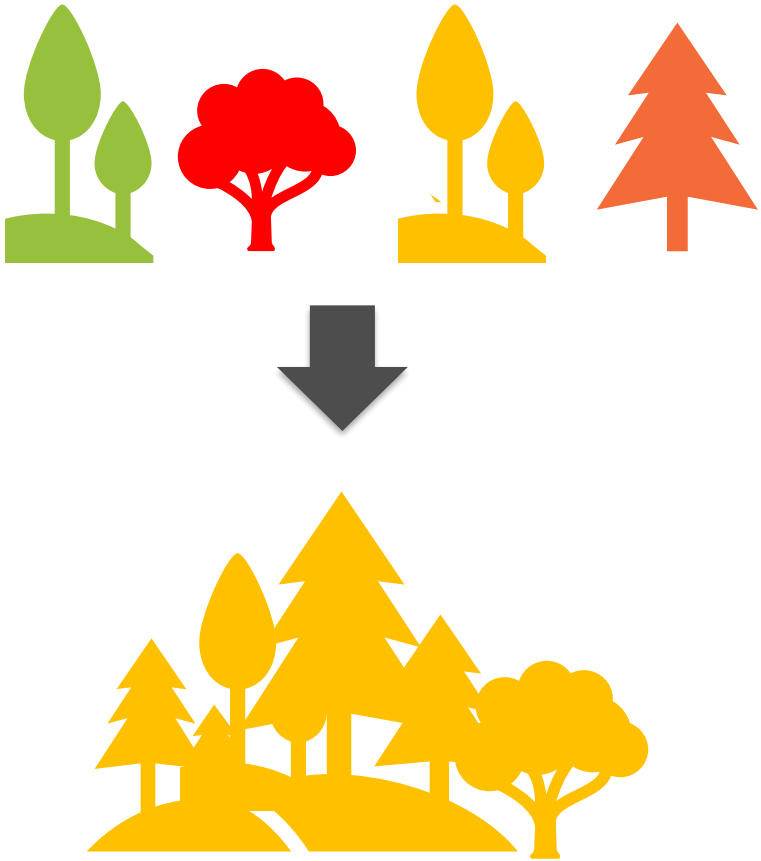
Climate change vulnerability for communities



- **Project:** Assign cumulative climate change vulnerability scores to treed polygons in the watershed
- **Deliverables:** Scores and heat map of vulnerability
- **Goal:** Guide targets for management action that will increase long term resilience and ecosystem health

Methods: Cumulative vulnerability

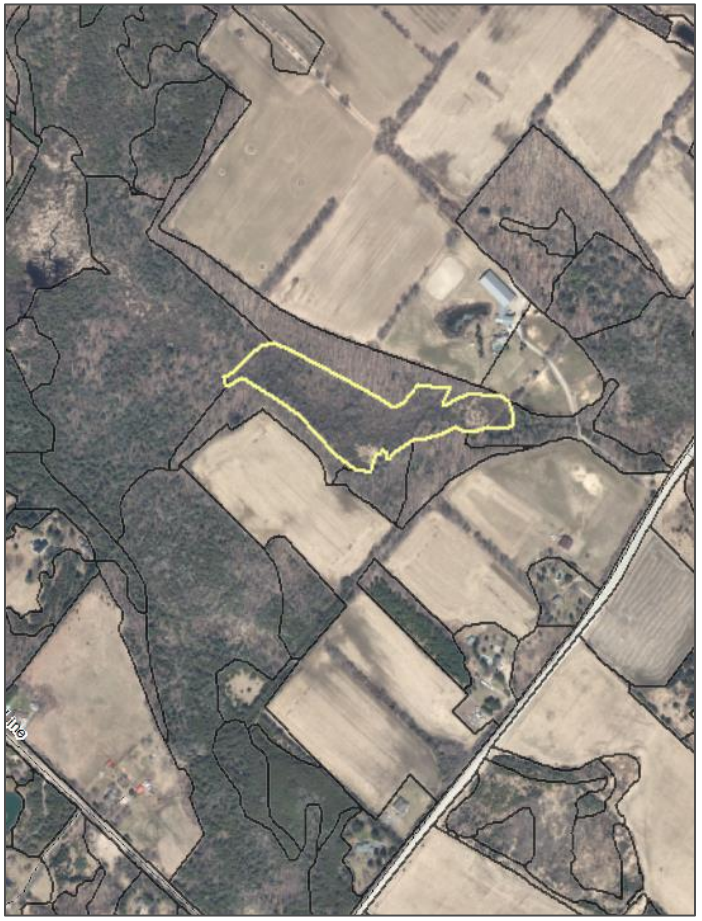
Data sources: CCVI Scores



- Categorical rank scores also have numerical values
  - < 4 Less Vulnerable
  - 4-7 Moderately Vulnerable
  - 7-10 Highly Vulnerable
  - > 10 Extremely Vulnerable
- Combine numerical values for dominant species in each polygon to get overall score
  - Different weightings
  - RCP 4.5

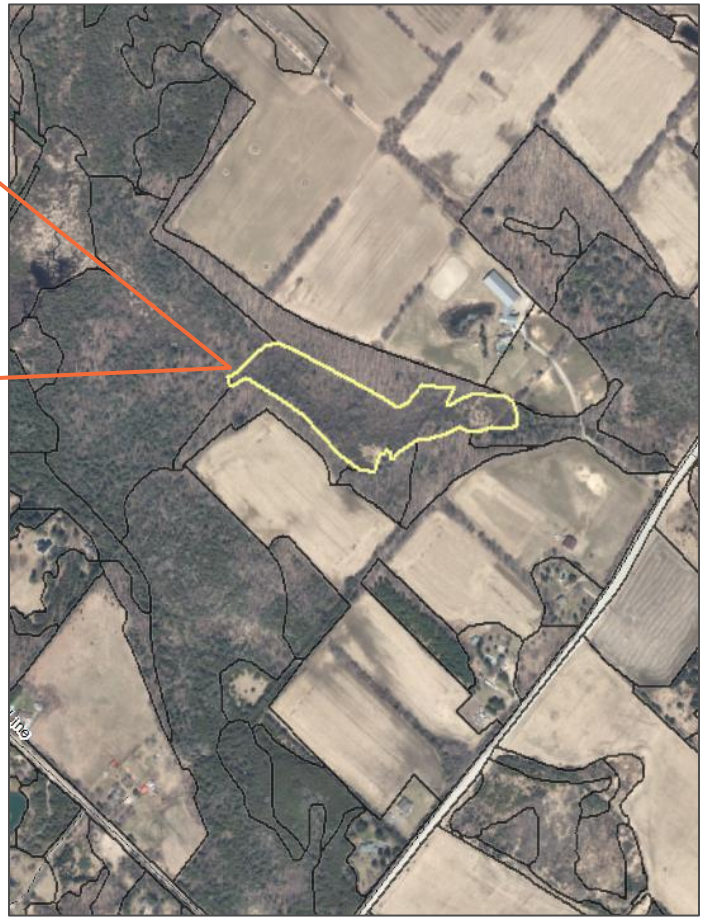
Data sources: species composition

- CVC Ecological Land Classification (ELC) field data
  - ~40% of watershed surveyed
  - Includes vegetation type (e.g., FOD5-1) and four most common species found in canopy and subcanopy
- Mississauga Natural Areas Survey data
  - Includes vegetation type



Example data

- Polygon 1222025
- Black Ash Mineral Deciduous Swamp (SWD2-1)
- Canopy:
- FRANIGR > POPTREM > POPBALS
- Cover value = 2
- Subcanopy:
- FRANIGR >> BETALLE > SAL_SPP > ABIBALS
- Cover value = 3



Example calculations

CANOPY	Species 1		Species 2		Species 3		Species 4
	FRANIGR	>	POPTREM	>	POPBALS	.	.
CCVI score	10.43		5.35		6.15		
Weighting	0.65		0.35				
Layer score	(0.65 x 10.43) + (0.35 x ((5.35+6.15)/2)) = 8.79						
SUBCANOPY	**Species 1**		**Species 2**		**Species 3**		**Species 4**
	FRANIGR	>>	BETALLE	>	SAL_SPP	>	ABIBALS
CCVI score	10.43		7.89		N/A		11.43
Weighting	0.75		0.25				
Layer score	(0.75 x 10.43) + (0.25 x ((7.89+11.43)/2) = 10.24						

Example calculations

CANOPY	Species 1		Species 2		Species 3		Species 4
	FRANIGR	>	POPTREM	>	POPBALS	.	.
CCVI score	10.43		5.35		6.15		
Weighting	0.65		0.35				
Layer score	(0.65 x 10.43) + (0.35 x ((5.35+6.15)/2)) = 8.79						
SUBCANOPY	**Species 1**		**Species 2**		**Species 3**		**Species 4**
	FRANIGR	>>	BETALLE	>	SAL_SPP	>	ABIBALS
CCVI score	10.43		7.89		N/A		11.43
Weighting	0.75		0.25				
Layer score	(0.75 x 10.43) + (0.25 x ((7.89+11.43)/2) = 10.24						

Dominant species are weighted by 65% of score, while subdominants by 35%

Example calculations

CANOPY	Species 1		Species 2		Species 3		Species 4
	FRANIGR	>	POPTREM	>	POPBALS	.	.
CCVI score	10.43		5.35		6.15		
Weighting	0.65		0.35				
Layer score	(0.65 x 10.43) + (0.35 x ((5.35+6.15)/2)) = 8.79						
SUBCANOPY	**Species 1**		**Species 2**		**Species 3**		**Species 4**
	FRANIGR	>>	BETALLE	>	SAL_SPP	>	ABIBALS
CCVI score	10.43		7.89		N/A		11.43
Weighting	0.75		0.25				
Layer score	(0.75 x 10.43) + (0.25 x ((7.89+11.43)/2) = 10.24						

Extra-dominant species are weighted by 75% of score, and subdominants in this case by 25%

Example calculations

Layer	Cover value	Layer score	Weighted layer score
Canopy	2	8.79	17.58
Subcanopy	3	10.24	30.72
		Overall	(17.58 + 30.72) / 5
			9.66
			Highly Vulnerable

Only including the canopy and subcanopy

Cover value indicates the percent vegetation closure of the layer

1: 0 to ≤ 10%
2: 10 to 25%
3: > 25 to ≤ 60%
4: > 60%

Example mapping

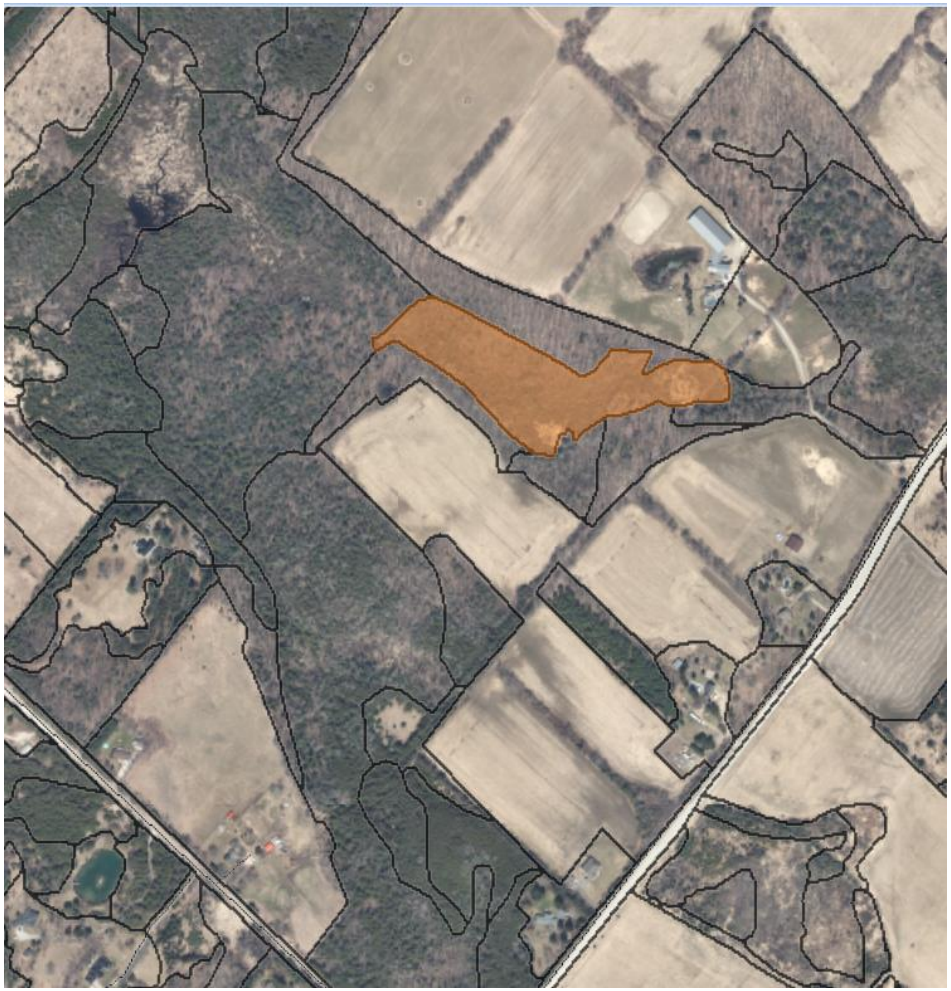
- Polygon 1222025 = HV

LV: less vulnerable

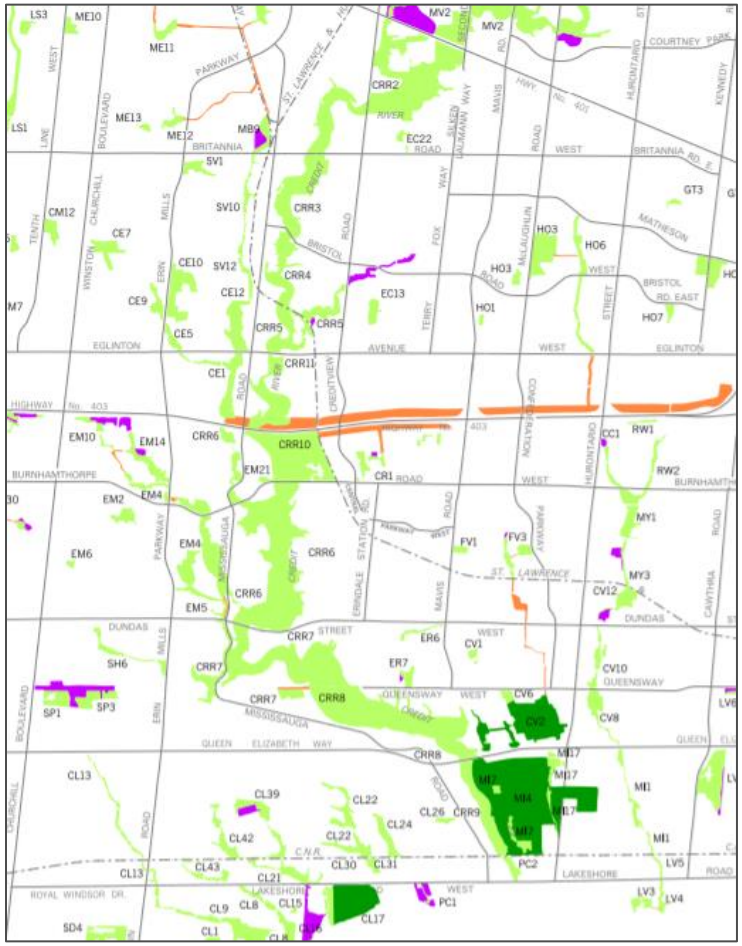
MV: moderately vulnerable

HV: highly vulnerable

EV: extremely vulnerable

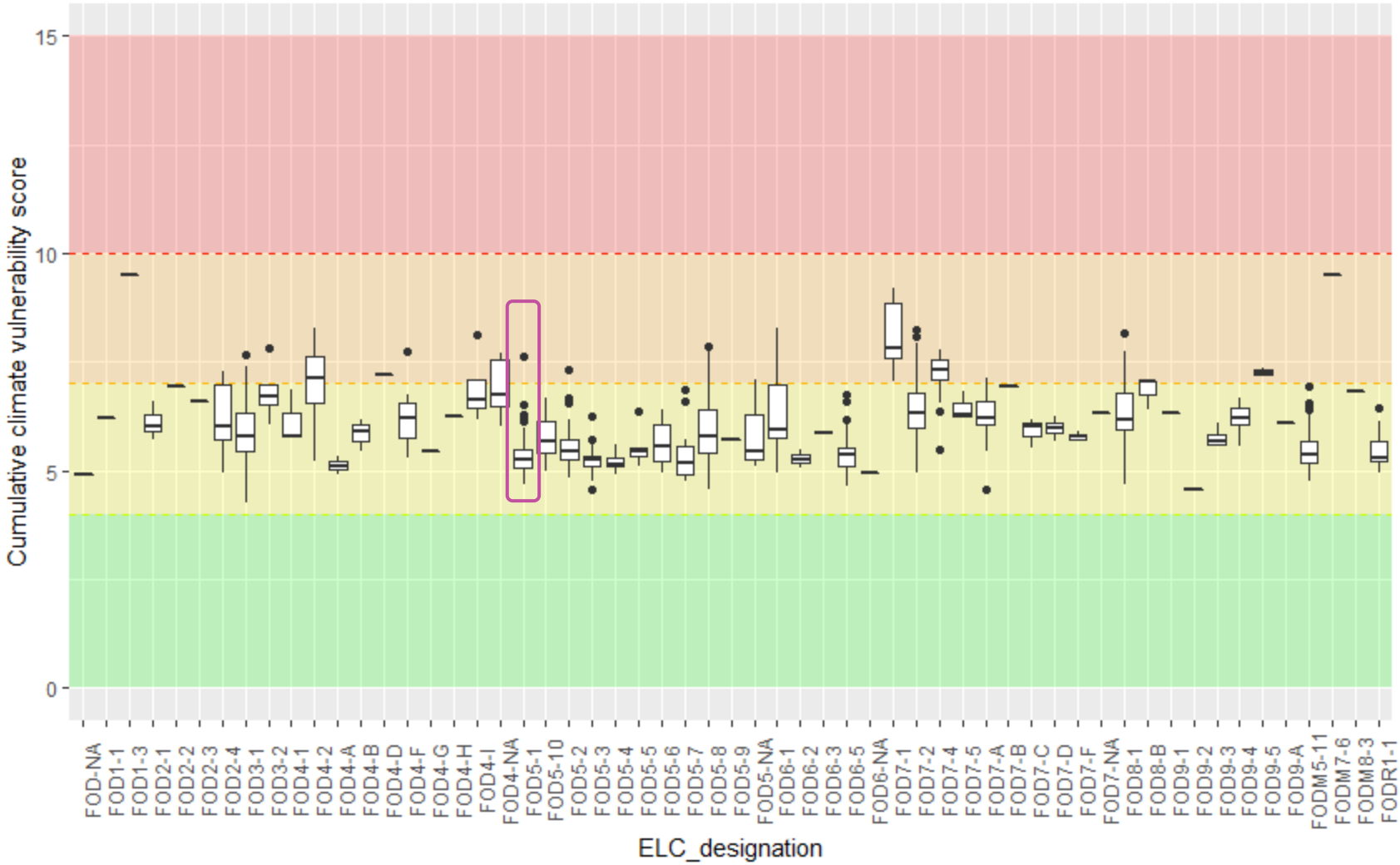


Estimating scores



- ELC data from Mississauga gives community vegetation type (e.g., FOD5-1) but not species lists
- Some CVC-surveyed polygons had dominant species without CCVI scores (e.g., *Salix* sp.)
- Estimated cumulative vulnerability scores for these polygons using average score for vegetation type
  - e.g., FOD5-1 = MV (5.29)

Deciduous forests



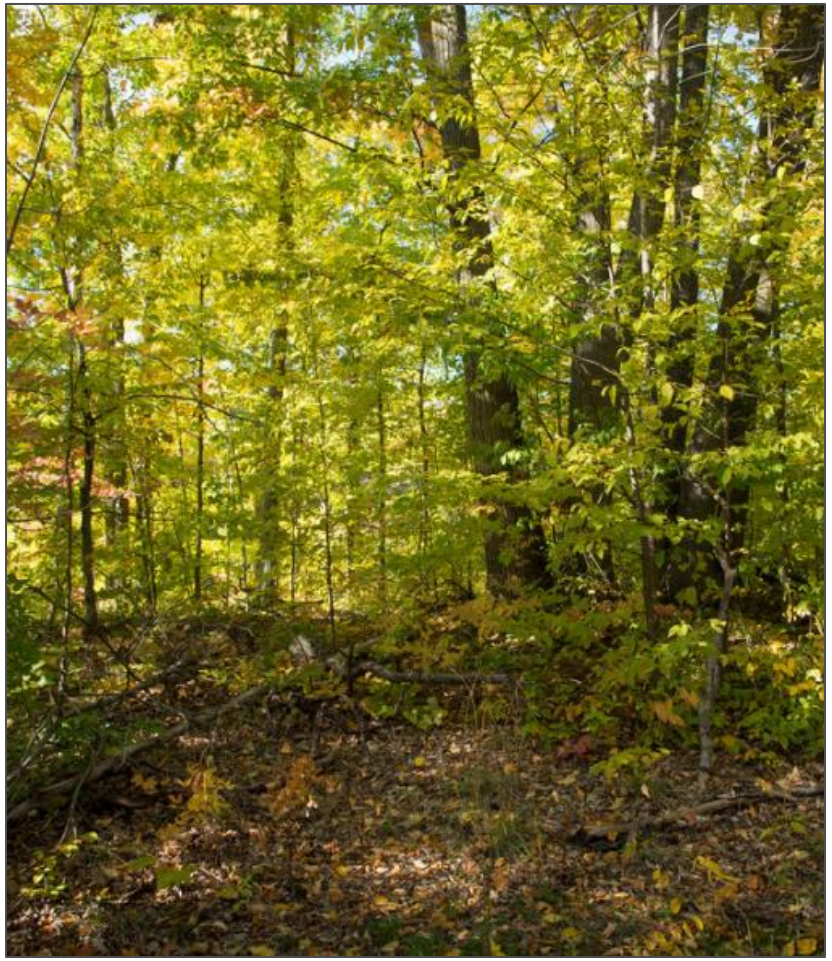
Final data set

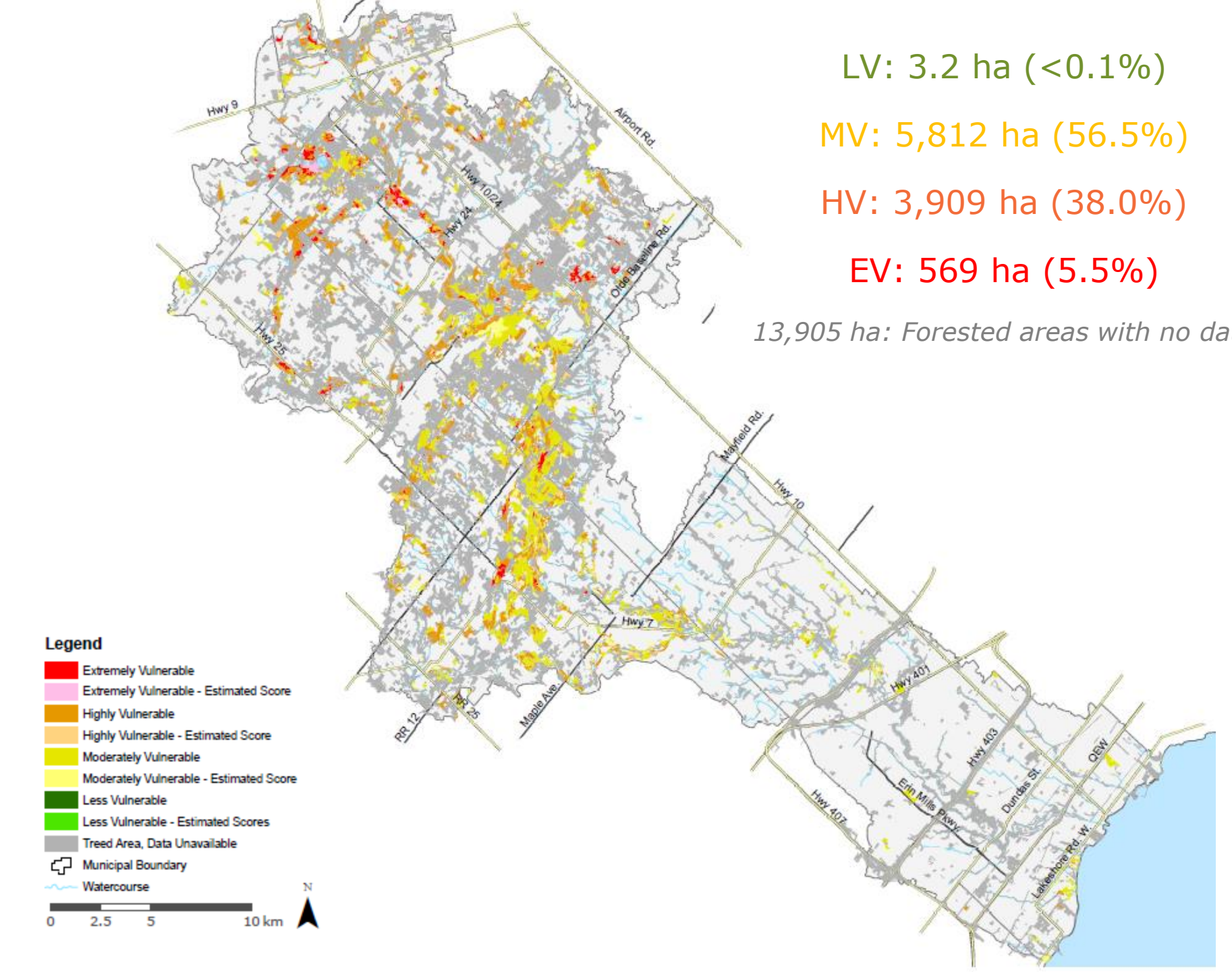
- CVC ELC data, 3490 polygons:
  - deciduous, coniferous, and mixed forests
  - deciduous, coniferous, and mixed swamps
  - cultural woodlands and plantations
  - treed talus slopes, beach bars, bluffs, cliffs, bogs, & fens
- Mississauga Natural Areas Survey data, 438 polygons:
  - deciduous, coniferous, and mixed forests
  - deciduous, coniferous, and mixed swamps
  - cultural woodlands and plantations

Results: Cumulative vulnerability

Overall cumulative climate vulnerability scores

- 3,928 treed polygons with an overall CCV score
  - 3085 direct calculations
  - 843 estimated scores
- Sensitivity analysis for different weightings
  - majority of polygons had consistent category scores
  - 2724/3085; 88%





LV: 3.2 ha (<0.1%)

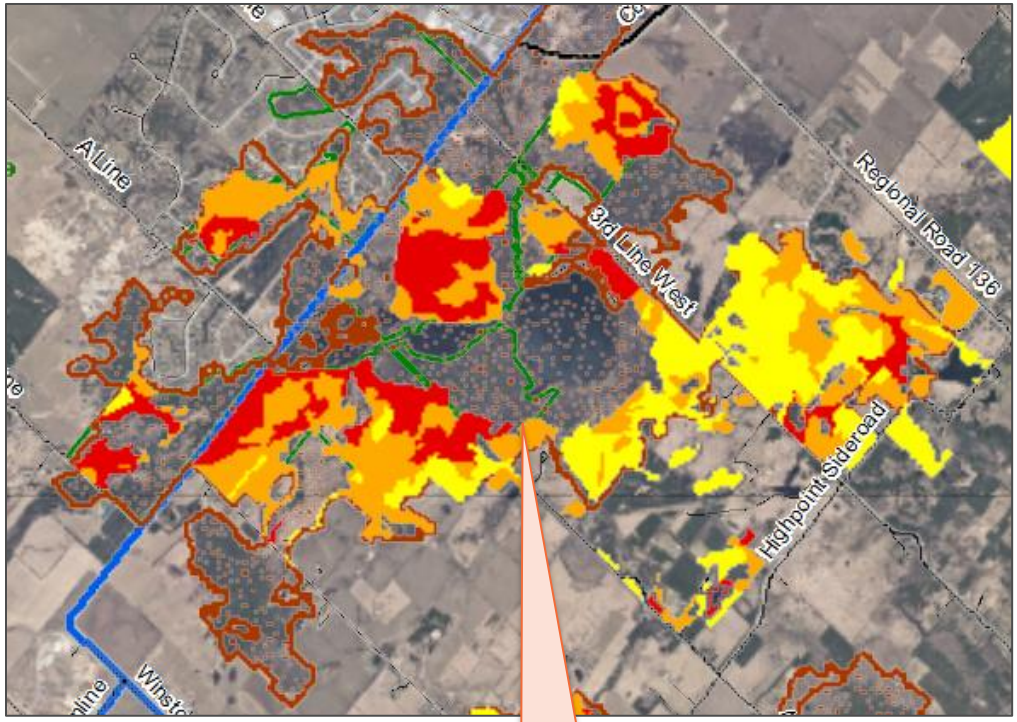
MV: 5,812 ha (56.5%)

HV: 3,909 ha (38.0%)

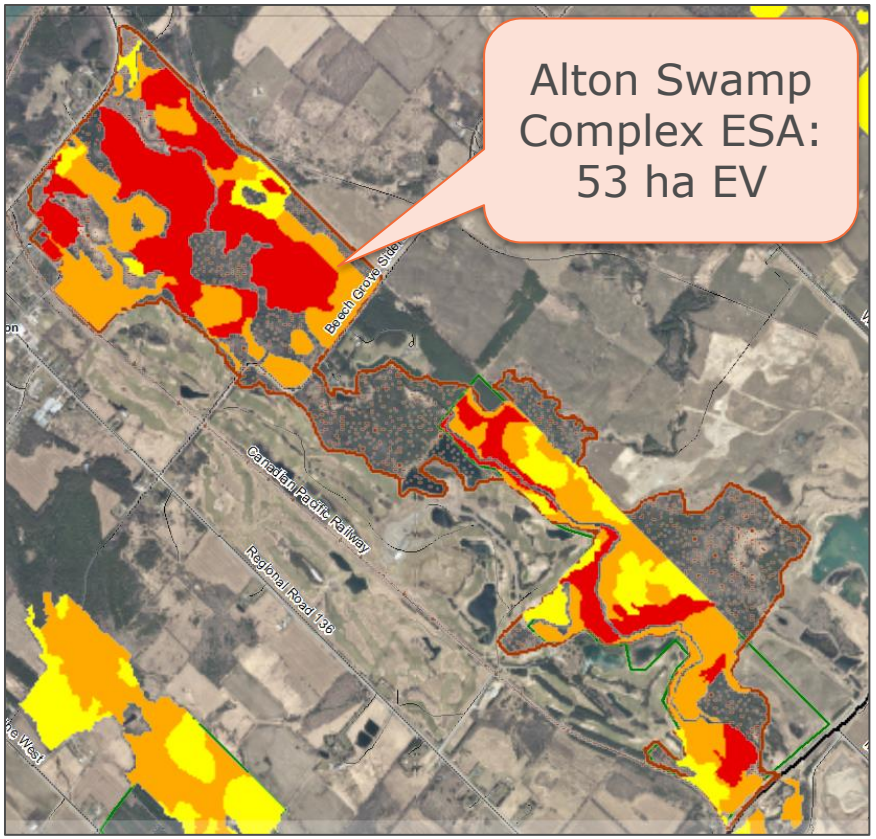
EV: 569 ha (5.5%)

13,905 ha: Forested areas with no data

Patches of high vulnerability



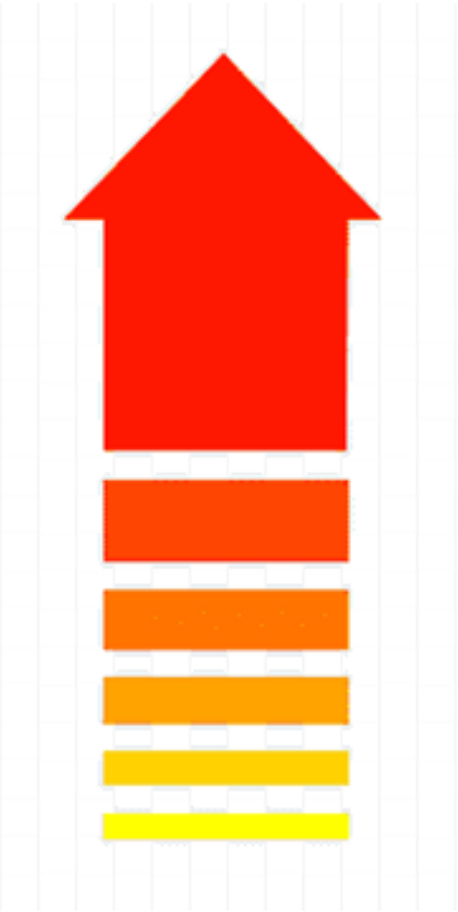
Caledon Lake ESA: 110 ha EV



Alton Swamp Complex ESA: 53 ha EV

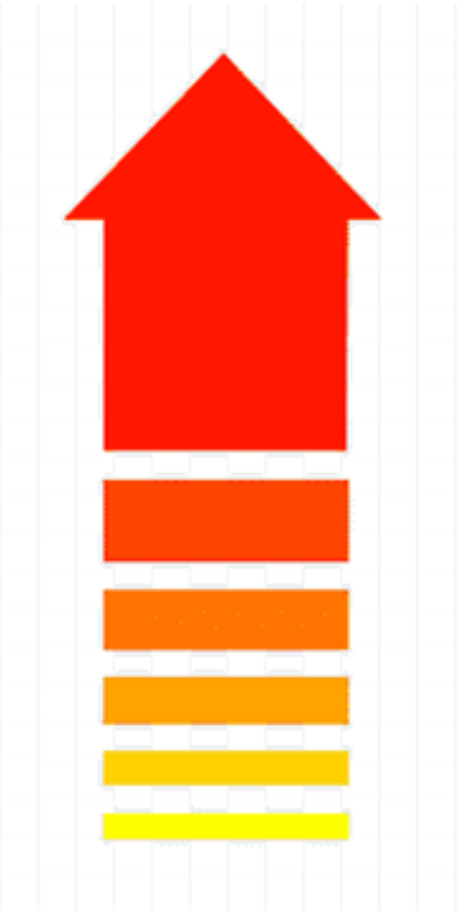
Average vulnerability scores by ELC group

- Fens and coniferous swamps (9.83)
- Mixed swamps (9.00)
- Coniferous forests (8.95)
- Cultural woodlands and plantations (7.74)
- Mixed forests (7.46)
- Deciduous swamps (7.35)
- Bluffs, cliffs, and talus slopes (7.06)
- Deciduous forests (5.89)



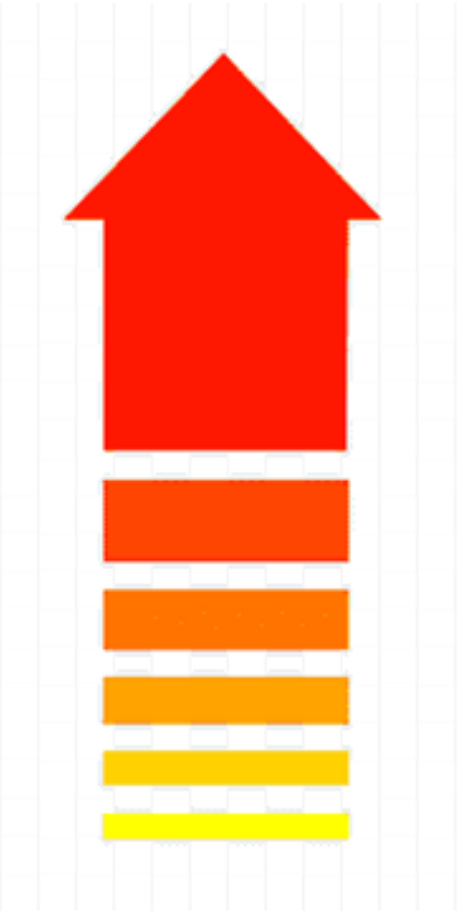
Average vulnerability scores by ELC group

- Fens and coniferous swamps (9.83)
- Mixed swamps (9.00)
- Coniferous forests (8.95)
- Cultural woodlands and plantations (7.74)
- Mixed forests (7.46)
- Deciduous swamps (7.35)
- Bluffs, cliffs, and talus slopes (7.06)
- Deciduous forests (5.89)



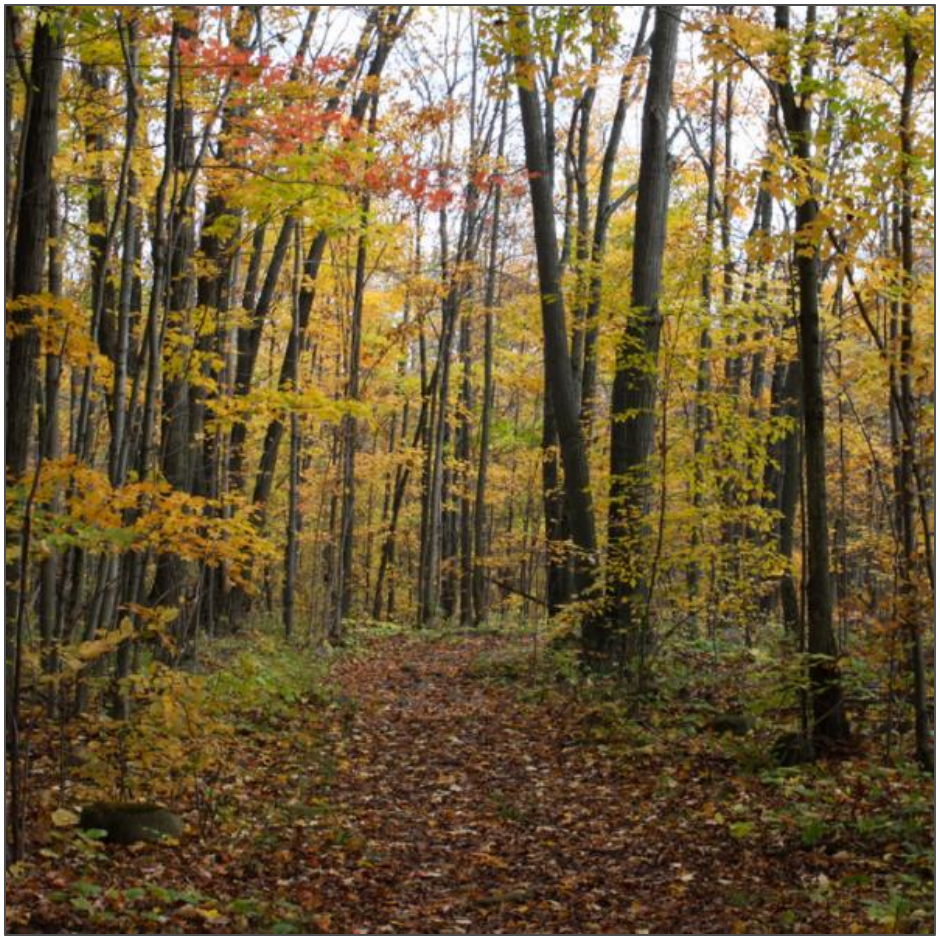
Average vulnerability scores by ELC group

- Fens and coniferous swamps (9.83)
- Mixed swamps (9.00)
- Coniferous forests (8.95)
- Cultural woodlands and plantations (7.74)
- Mixed forests (7.46)
- Deciduous swamps (7.35)
- Bluffs, cliffs, and talus slopes (7.06)
- Deciduous forests (5.89)



Summary: cumulative vulnerability

- Over half of the area with data (56.5%) has been assessed as less vulnerable or moderately vulnerable
  - Large areas of deciduous forest in the watershed
  - Most maple and poplar species, red oak = MV



Terra Cotta CA

Summary: cumulative vulnerability

Scotsdale Farm

- Swamps, fens, and forests dominated by some coniferous species are the most vulnerable to climate change
- Also: plantations dominated by white spruce or white cedar

Summary: cumulative vulnerability

- A relatively small area (5.5%) has been assessed as extremely vulnerable to climate change
- BUT many of these polygons coincide with ESAs and other sensitive areas
  - Old growth forests
  - Wetlands
  - Rare species habitats

Alton Grange

Applications and next steps

- Prioritize areas for forest management
  - In combination with other data, e.g., rare species
  - May include actions in the categories of resist, direct, or accept
- Inform future scenario planning for the Credit River Watershed Plan

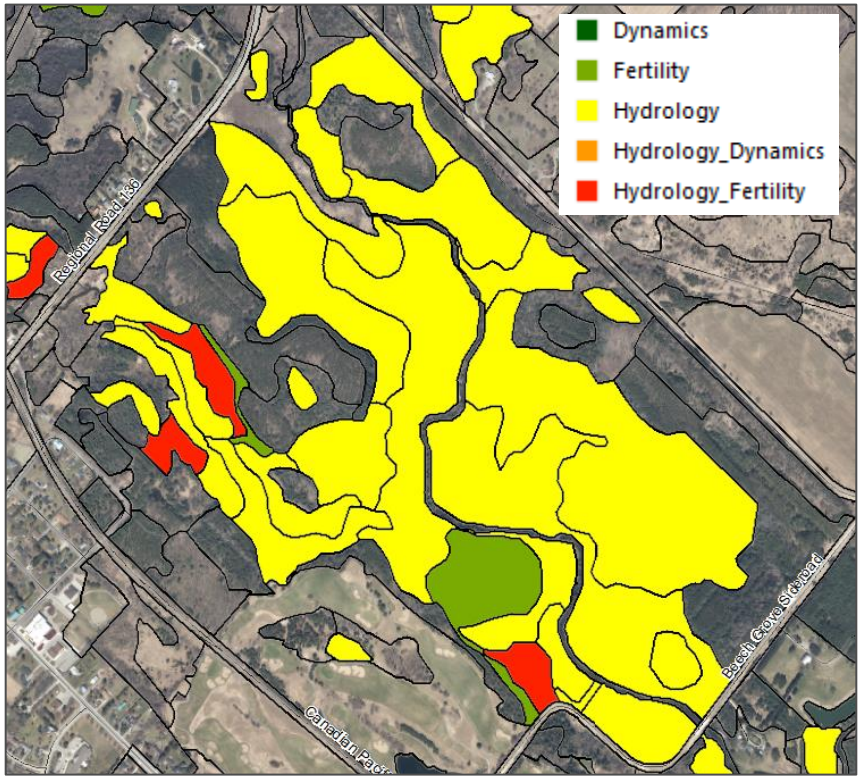
questions?

Potential management actions

- Monitor for early detection of climate change impacts
- Reduce the impacts of other stressors, such as trails, roads, water takings, and forest pests
- Evaluate the existing understorey and underplanting where necessary, using species that perform ecologically similar roles but have been identified as less vulnerable to climate change
- Set targets for genetic, species, structural, and functional diversity
- Control invasive species
- Protect and enhance corridors to facilitate species movement
- Enhance water retention on conservation lands and other lands in the NHS
- Secure lands that have potential for attenuating more stormwater to enhance infiltration and evapotranspiration climate change mitigation on adjacent lands

Comparison with Peel NSV

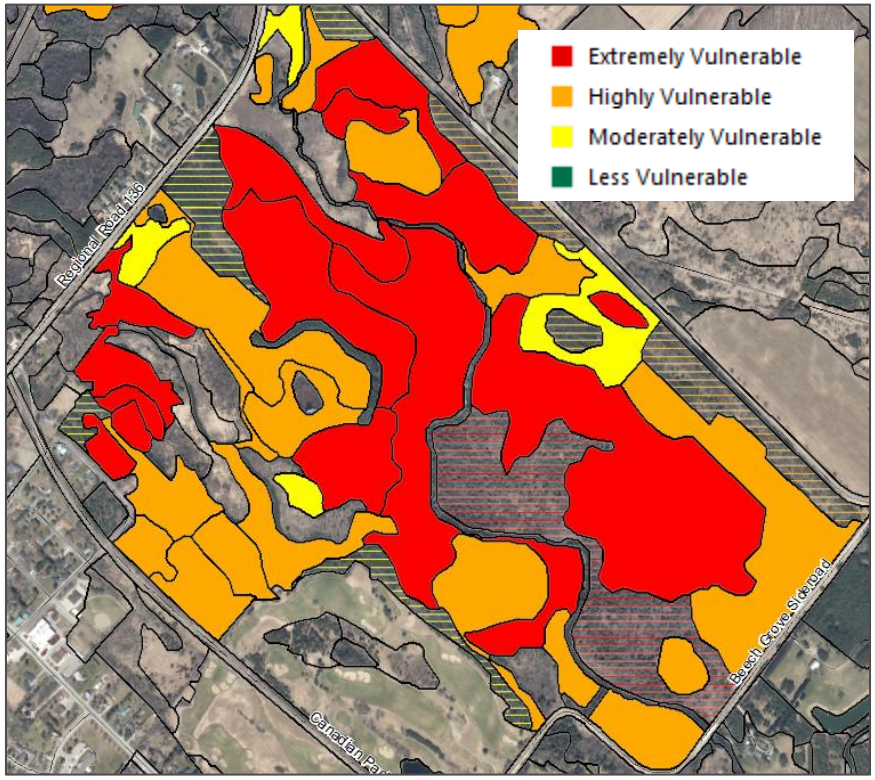
Climate sensitive native vegetation



83 hectares assessed:

- Green 5%
- Yellow 91%
- Red 4%

CVC cumulative climate vulnerability



120 hectares assessed:

- Yellow 9%
- Orange 38%
- Red 53%

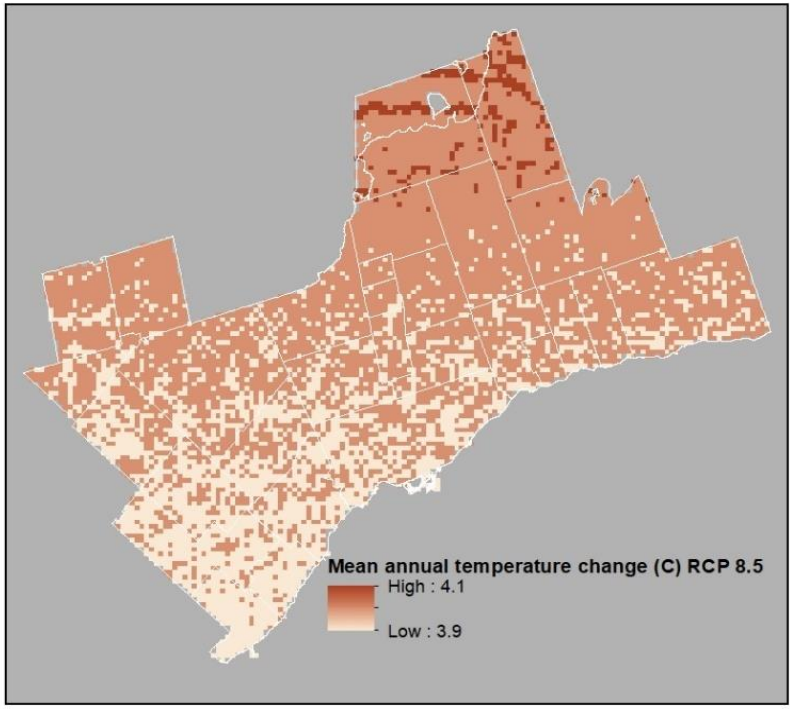
CCVI methods

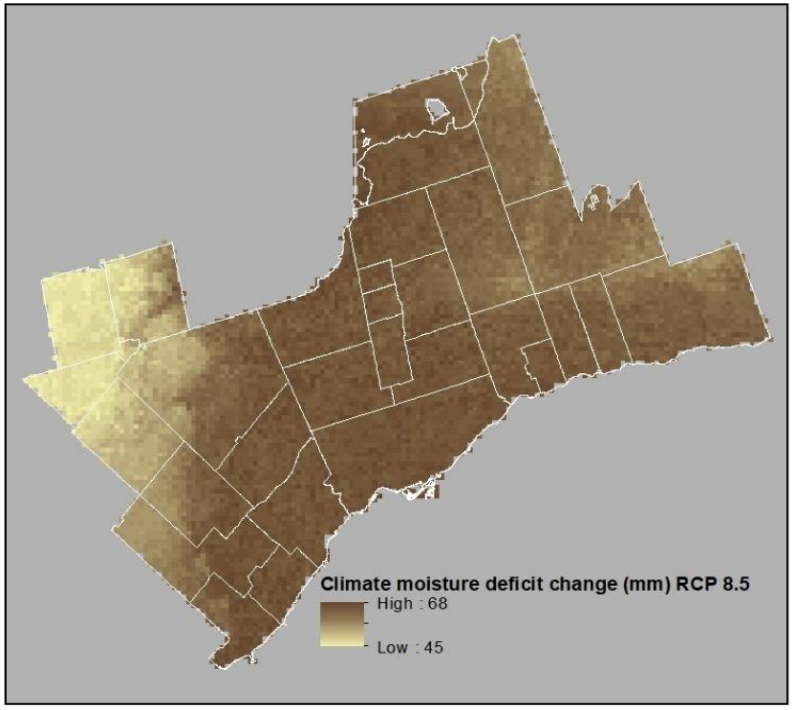
- Calculated what proportion of each species' range falls into set categories of temperature increase and drying
- **Note:** CCVI tool designed for use with RCP 4.5 scenario

Example: Black Ash

Temperature increase	RCP 4.5	RCP 8.5
> 3.80 °C	.	100.00
3.49 - 3.80 °C	.	.
3.17 - 3.48 °C	4.44	.
2.85 - 3.16 °C	95.56	.
2.53 - 2.84 °C	.	.
< 2.53 °C	.	.

Temperature and moisture RCP 8.5

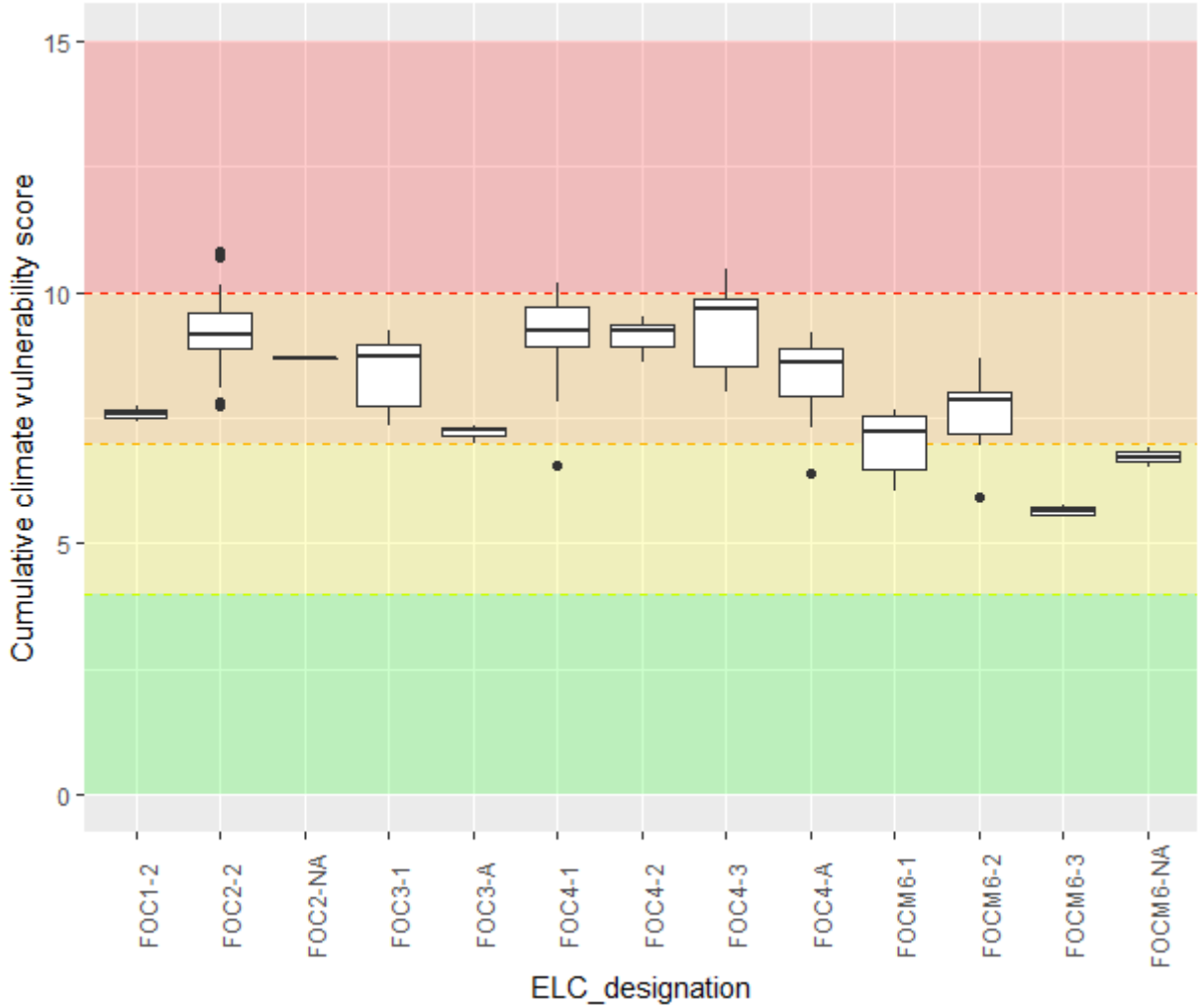




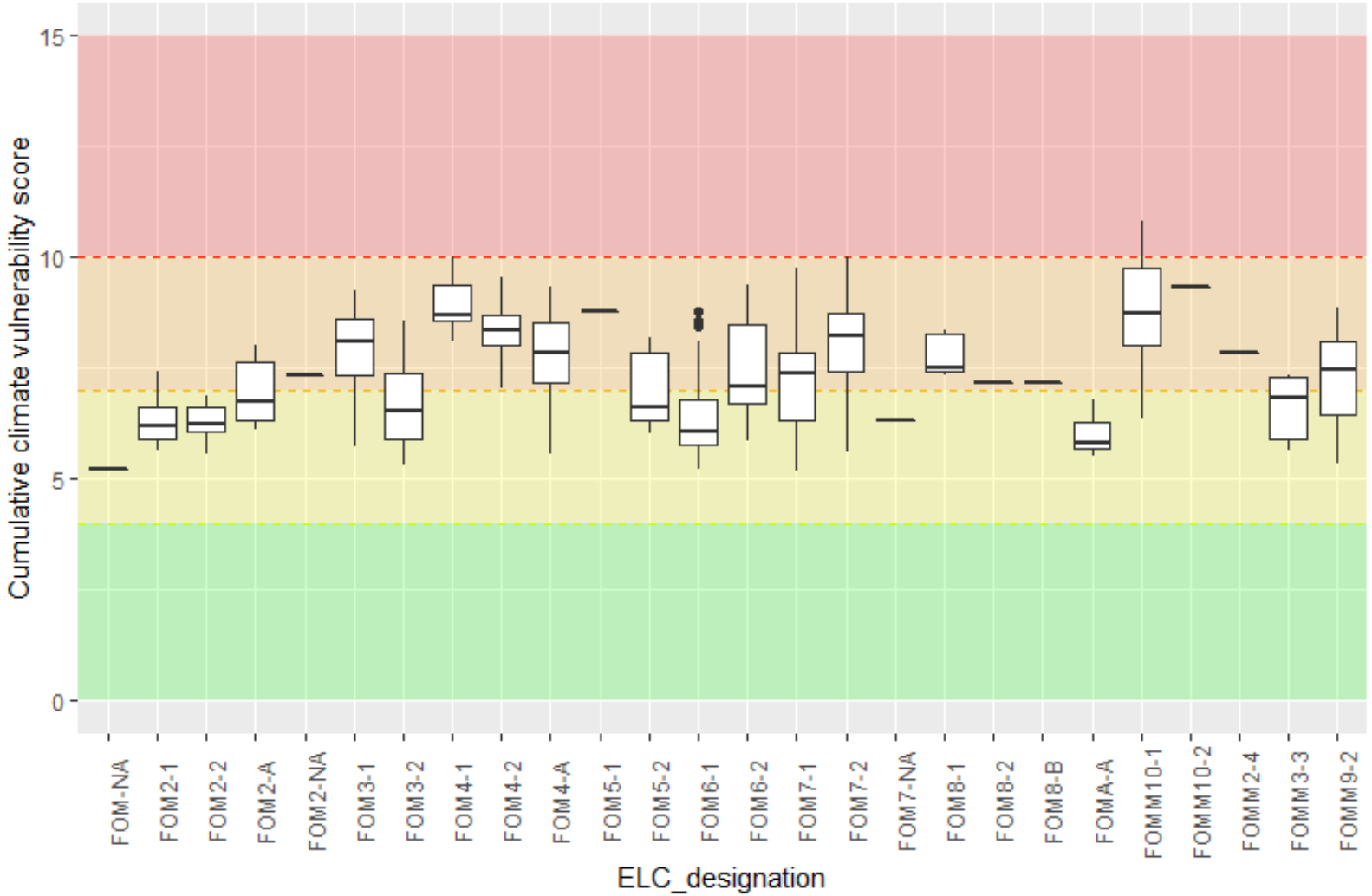
Less Vulnerable	Moderately Vulnerable	Highly Vulnerable	Extremely Vulnerable
	Common Buckthorn Glossy Buckthorn Freeman's Maple Ironwood Gray Birch	Sugar Maple Blue Beech American Basswood Northern Red Oak Eastern Red Cedar Trembling Aspen Black Cherry Red Maple Balsam Poplar Bigtooth Aspen Rock Elm Manitoba Maple Sassafras Green Ash	American Sycamore Black Maple Mountain Maple Silver Maple American Beech Slippery Elm Norway Maple White Pine Bitternut Hickory Black Walnut Bur Oak Paper Birch Pignut Hickory Eastern Cottonwood Yellow Birch Peachleaf Willow Shagbark Hickory White Ash White Oak American Elm Tulip Tree American Chestnut Red Pine Eastern Hemlock Eastern White Cedar Chinquapin Oak Black Willow Red Mulberry Black Oak Black Ash White Spruce Swamp White Oak Balsam Fir Butternut Black Spruce Larch

RCP 8.5

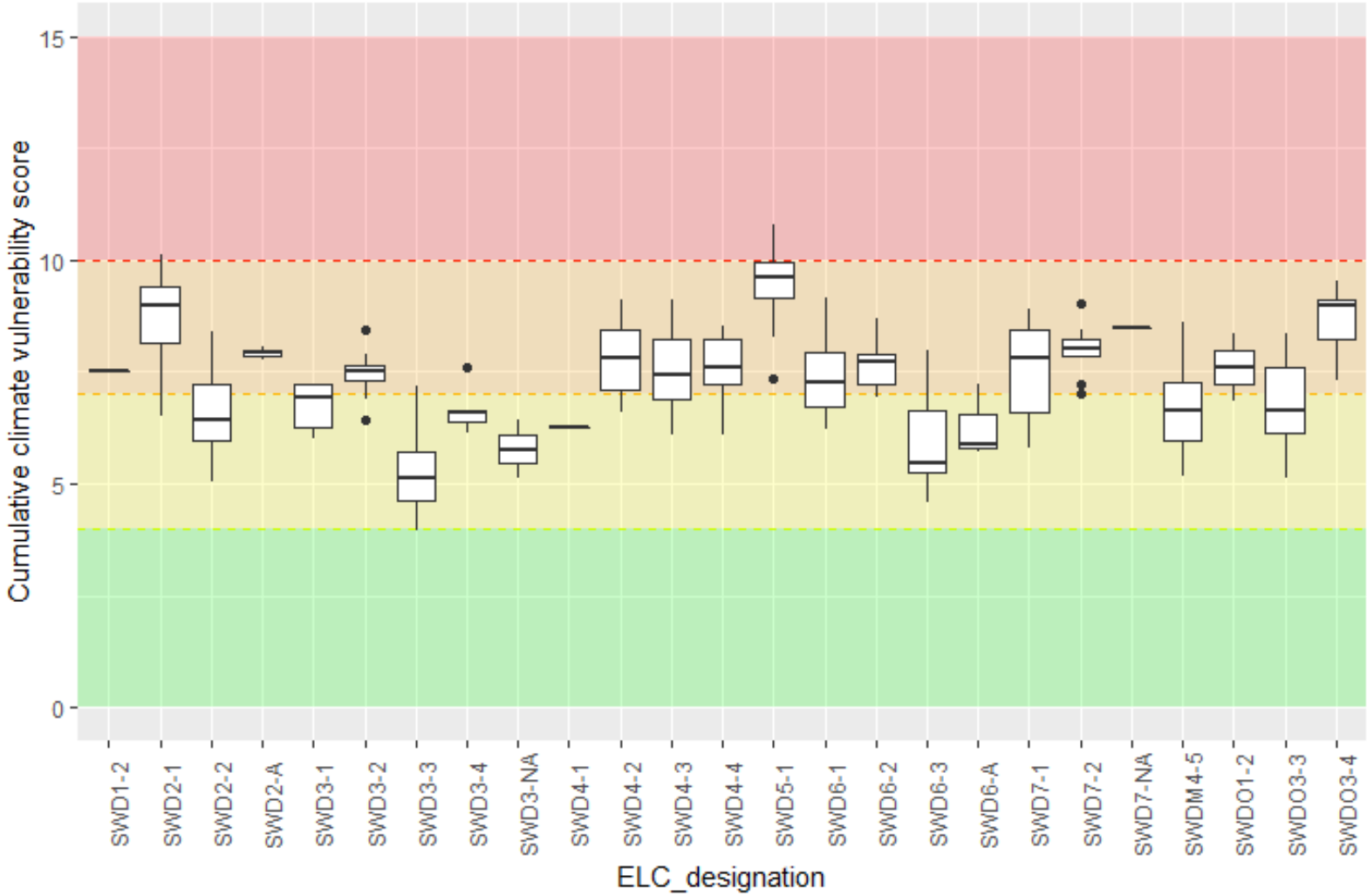
Coniferous forests



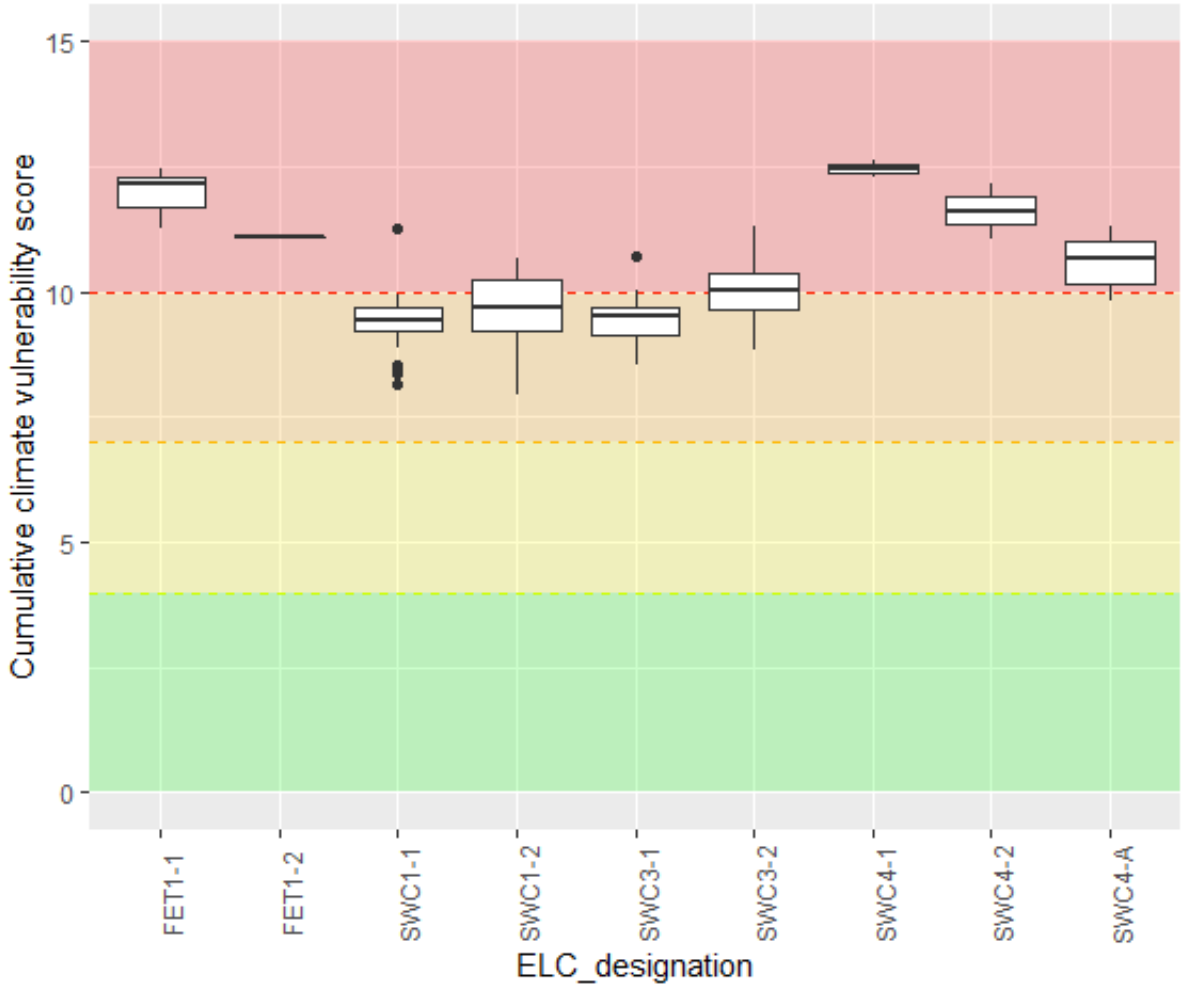
Mixed forests



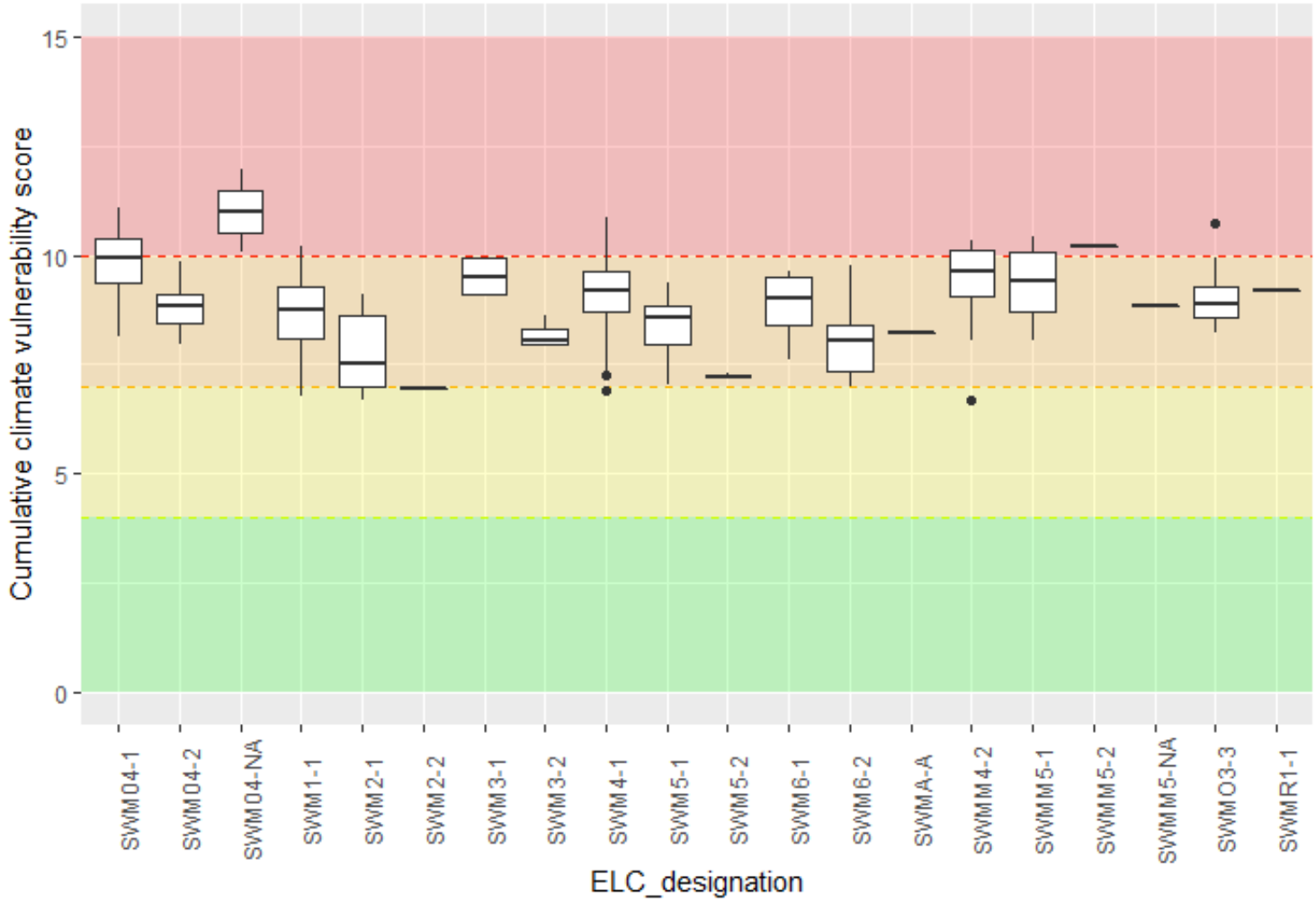
Deciduous swamps



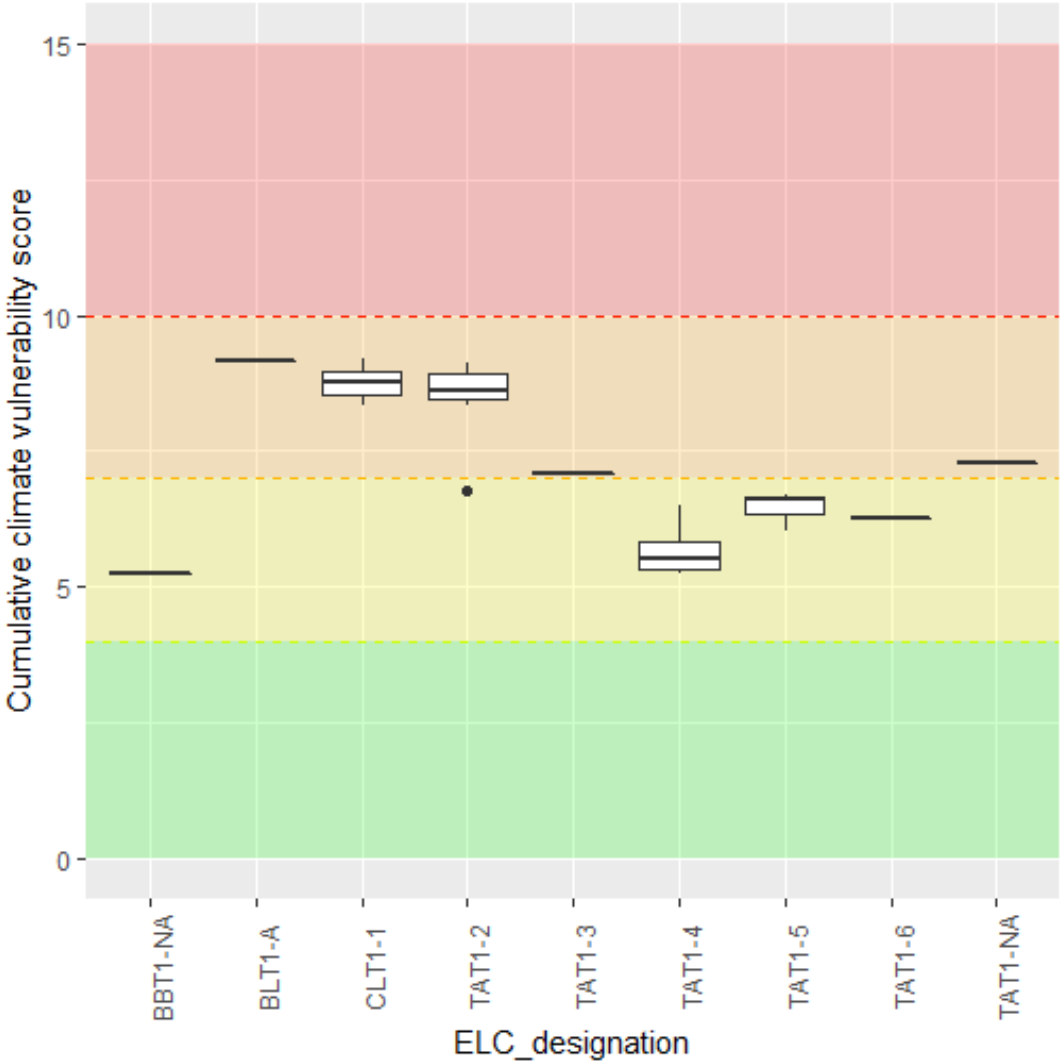
Fens and coniferous swamps



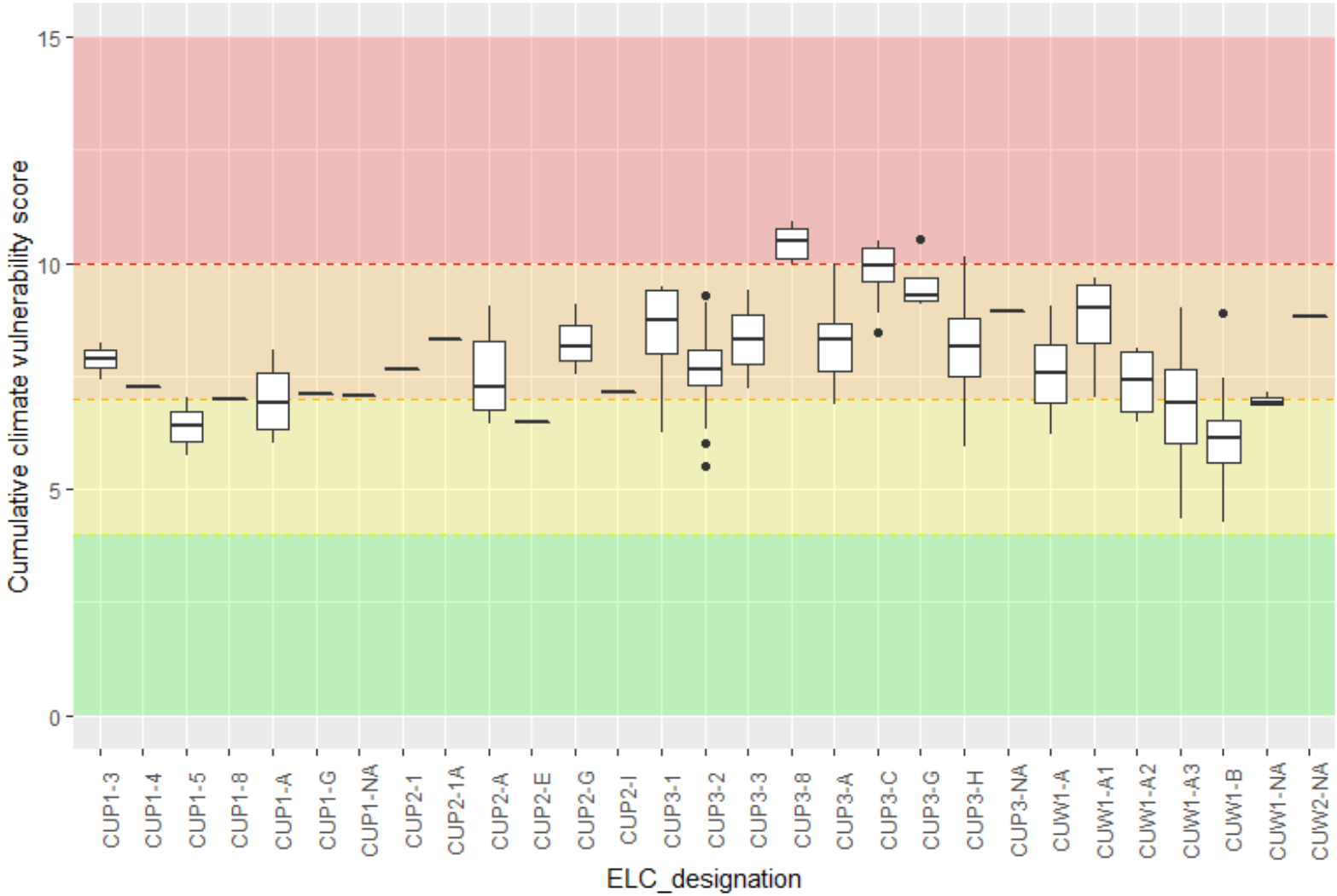
Mixed swamps



Bluffs, cliffs, and talus slopes



Cultural woodlands and plantations



Less Vulnerable	Moderately Vulnerable		Highly Vulnerable		Extremely Vulnerable
	BBT1-NA	FOD6-NA	BLT1-A	FOM6-2	CUP3-8
	CUP1-5	FOD7-2	CLT1-1	FOM7-1	FET1-1
	CUP1-8	FOD7-5	CUP1-3	FOM7-2	FET1-2
	CUP1-A	FOD7-A	CUP1-4	FOM8-1	SWC3-2
	CUP2-E	FOD7-B	CUP1-G	FOM8-2	SWC4-1
	CUW1-A3	FOD7-C	CUP1-NA	FOM8-B	SWC4-2
	CUW1-B	FOD7-D	CUP2-1	FOMM9-2	SWC4-A
	CUW1-NA	FOD7-F	CUP2-1A	FOMM10-1	SWM04-NA
	FOCM6-1	FOD7-NA	CUP2-A	FOMM10-2	SWMM5-2
	FOCM6-3	FOD8-1	CUP2-G	SWC1-1	
	FOCM6-NA	FOD8-B	CUP2-I	SWC1-2	
	FOD-NA	FODM8-3	CUP3-1	SWC3-1	
	FOD1-1	FOD9-1	CUP3-2	SWD1-2	
	FODR1-1	FOD9-2	CUP3-3	SWD2-1	
	FOD2-1	FOD9-3	CUP3-A	SWD2-A	
	FOD2-2	FOD9-4	CUP3-C	SWD3-2	
	FOD2-3	FOD9-A	CUP3-G	SWD4-2	
	FOD2-4	FOM-NA	CUP3-H	SWD4-3	
	FOD3-1	FOM2-1	CUP3-NA	SWD4-4	
	FOD3-2	FOM2-2	CUW1-A	SWD5-1	
	FOD4-1	FOM2-A	CUW1-A1	SWDO1-2	
	FOD4-A	FOM3-2	CUW1-A2	SWD6-1	
	FOD4-B	FOMM3-3	CUW2-NA	SWD6-2	
	FOD4-F	FOM6-1	FOC1-2	SWD7-1	
	FOD4-G	FOM7-NA	FOC2-2	SWD7-2	
	FOD4-H	FOMA-A	FOC2-NA	SWD7-NA	
	FOD4-I	SWD2-2	FOC3-1	SWDO3-4	
	FOD4-NA	SWD3-1	FOC3-A	SWM04-1	
	FOD5-1	SWD3-3	FOC4-1	SWM04-2	
	FOD5-10	SWD3-4	FOC4-2	SWM1-1	
	FOD5-2	SWD3-NA	FOC4-3	SWMR1-1	
	FOD5-3	SWD4-1	FOC4-A	SWM2-1	
	FOD5-4	SWDM4-5	FOCM6-2	SWM3-1	
	FOD5-5	SWD6-3	FOD1-3	SWM3-2	
	FOD5-6	SWD6-A	FOD4-2	SWM4-1	
	FOD5-7	SWDO3-3	FOD4-D	SWM5-1	
	FOD5-8	SWM2-2	FOD7-1	SWM5-2	
	FOD5-9	TAT1-4	FOD7-4	SWM6-1	
	FOD5-NA	TAT1-5	FODM7-6	SWM6-2	
	FODM5-11	TAT1-6	FOD9-5	SWMO3-3	
	FOD6-1		FOM2-NA	SWMA-A	
	FOD6-2		FOMM2-4	SWMM4-2	
	FOD6-3		FOM3-1	SWMM5-1	
	FOD6-5		FOM4-1	SWMM5-NA	
			FOM4-2	TAT1-2	
			FOM4-A	TAT1-3	
			FOM5-1	TAT1-NA	
			FOM5-2		