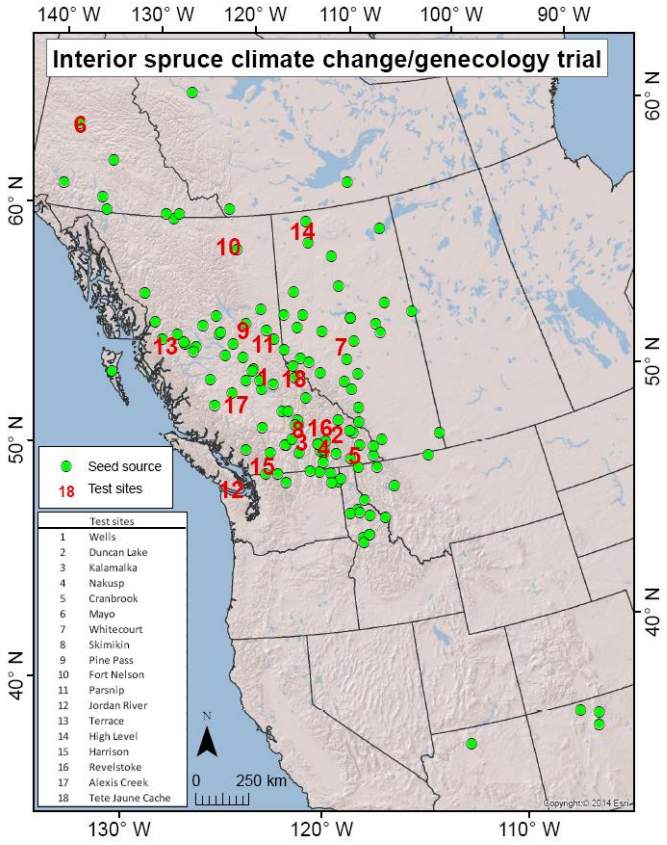
Climate Change Adaptation Research

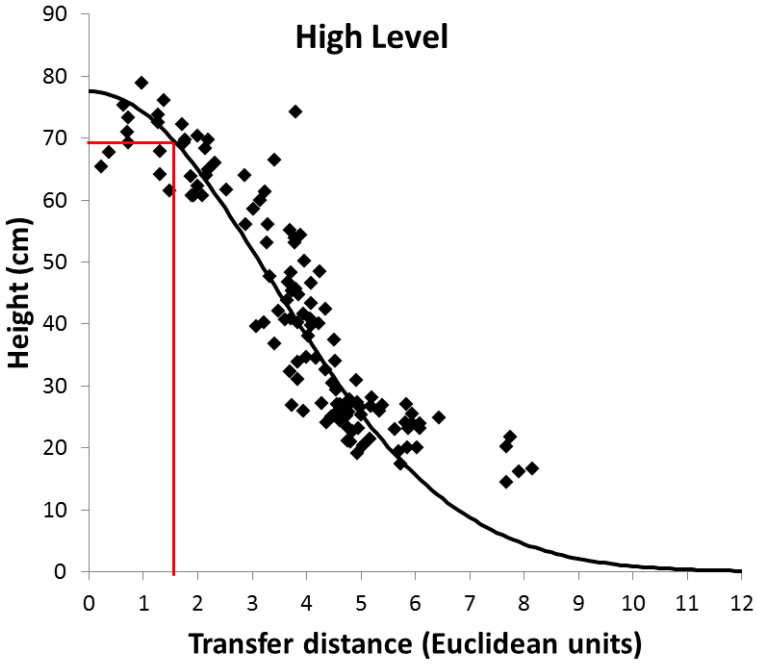
1. Sx genecology/CC field trial maintenance
2. Assisted Migration Adaptation Trial (AMAT)
3. Climate Based Seed Transfer (CBST)
4. Climate sensitive mortality function (internal review)
5. CC impacts to forest productivity
6. Assisted range expansion (new!)
7. Species transferability
8. Multispectral imaging in prov trials (internal review)
9. Local adaptation to forest pests
11. Weather station assessment (published!)
12. Trends in extreme minimum temperature

Climate Change Adaptation Research

1. Sx genecology/CC field trial



Seedlot transferability → CBST



- Established 2005
- 127 pops at 17 test sites

Climate Change Adaptation Research

1. Sx genecology/CC field trial


Forest Ecology and Management 328 (2014) 122–130

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

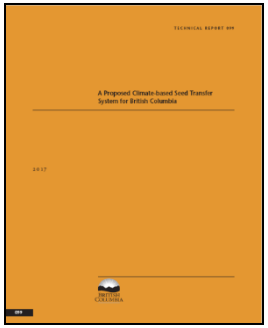
ELSEVIER

Quantifying safe seed transfer distance and impacts of tree breeding on adaptation

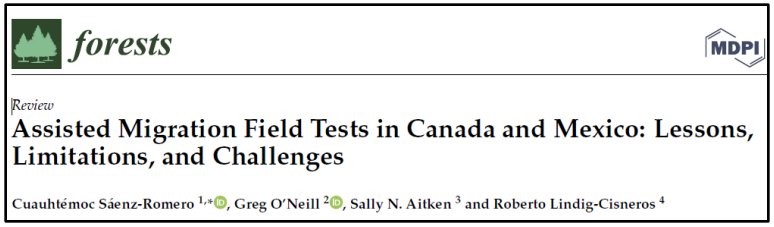
Gregory A. O'Neill [a,*], Michael Stoehr [b], Barry Jaquish [a]

[a] BC Ministry of Forests, Lands and Natural Resource Operations, Kalamalka Forestry Centre, 3401 Reservoir Road, Vernon, BC V1B 2C7, Canada
[b] BC Ministry of Forests, Lands and Natural Resource Operations, PO Box 9525, Stn. Prov. Govt., Victoria, BC V8W 9C2, Canada

- Justification for merging A and B seed transfer systems



- Safe seed transfer distances for Sx
- Distances shorter in north interior


forests

MDPI

Review

Assisted Migration Field Tests in Canada and Mexico: Lessons, Limitations, and Challenges

Cuauhtémoc Sáenz-Romero [1,*], Greg O'Neill [2], Sally N. Aitken [3] and Roberto Lindig-Cisneros [4]

- Assisted migration can help mitigate CC impacts on productivity


Canadian Journal of Forest Research

Article

Climate data for field trials: onsite micro stations versus ClimateNA

Zhengyang Ye [a], Gregory A. O'Neill [b], and Tongli Wang [a]

[a]Department of Forest and Conservation Sciences, University of British Columbia, 2424 Main Mall, Vancouver, BC V6T 1Z4, Canada; [b]BC Ministry of Forests, Lands and Natural Resource Operations, Kalamalka Forestry Centre, 3401 Reservoir Road, Vernon, BC V1B 2C7, Canada

- ClimateBC data is superior to on-site stations.

1. Sx genecology/CC field trial

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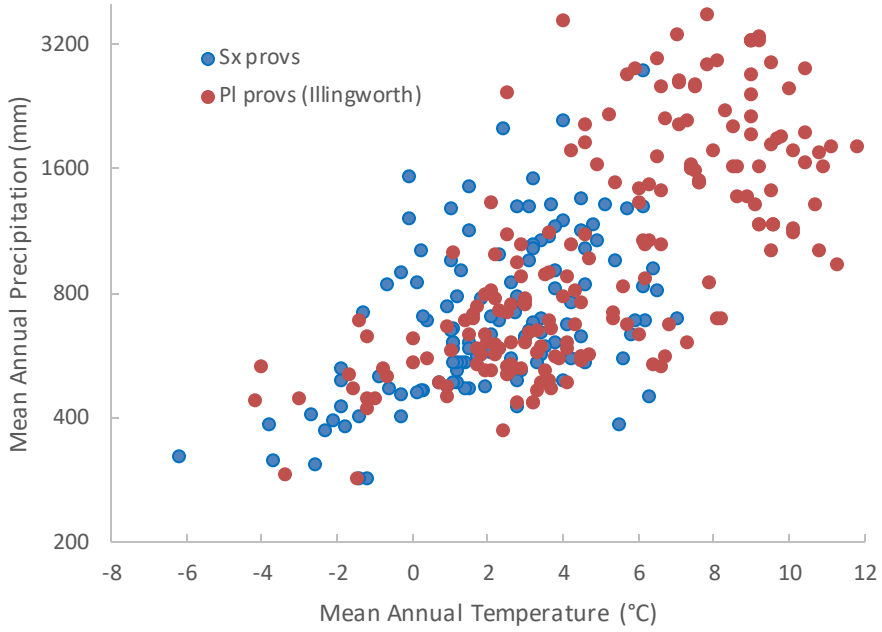
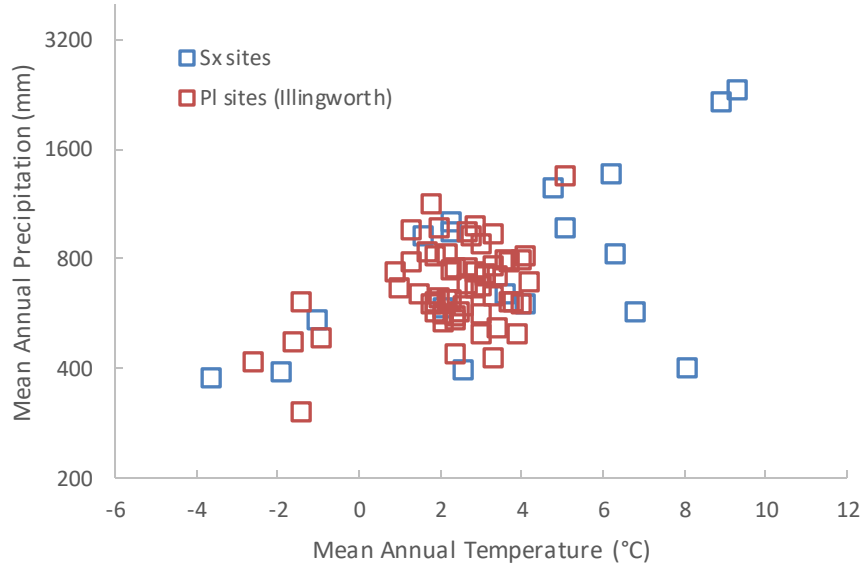
9. Local adaptation to forest pests
11. Weather station assessment
12. Trends in extreme minimum temperature

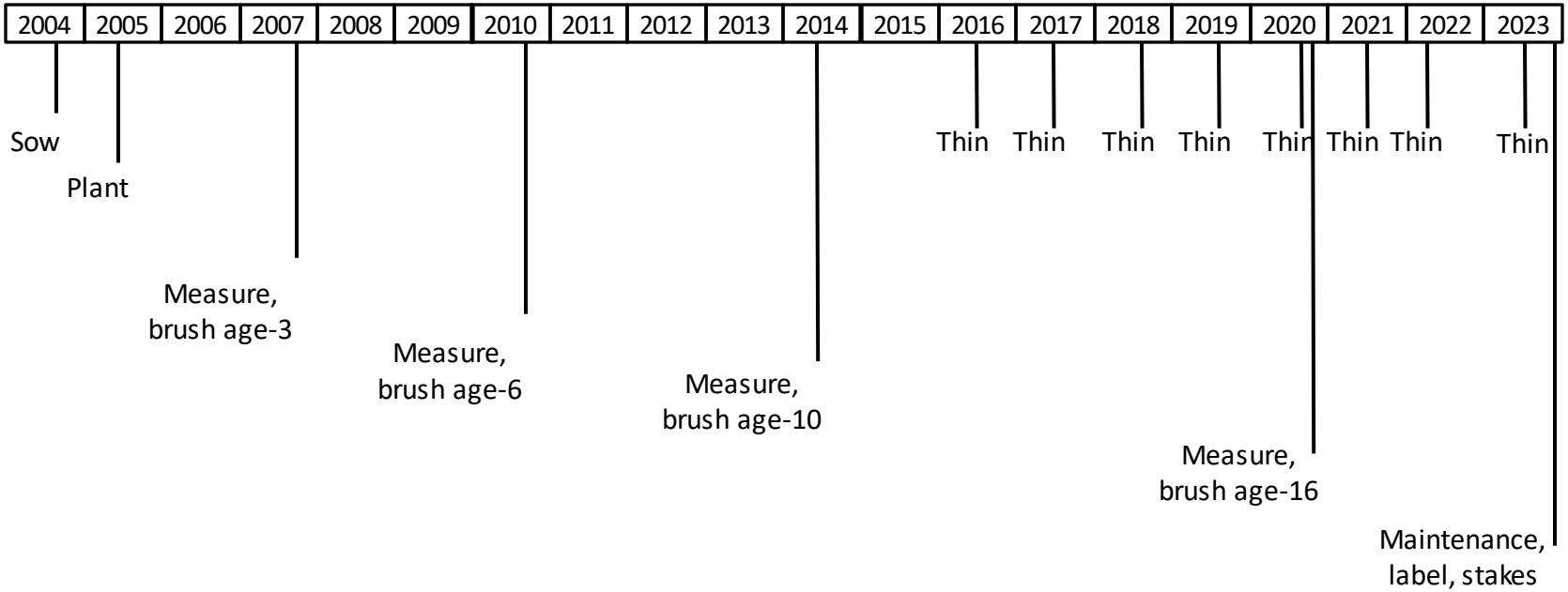
Provs


Sx provs
Pl provs (Illingworth)
Mean Annual Precipitation (mm)
3200
1600
800
400
200
-8
-6
-4
-2
0
2
4
6
8
10
12
Mean Annual Temperature (°C)

Sites


Sx sites
Pl sites (Illingworth)
Mean Annual Precipitation (mm)
3200
1600
800
400
200
-6
-4
-2
0
2
4
6
8
10
12
Mean Annual Temperature (°C)

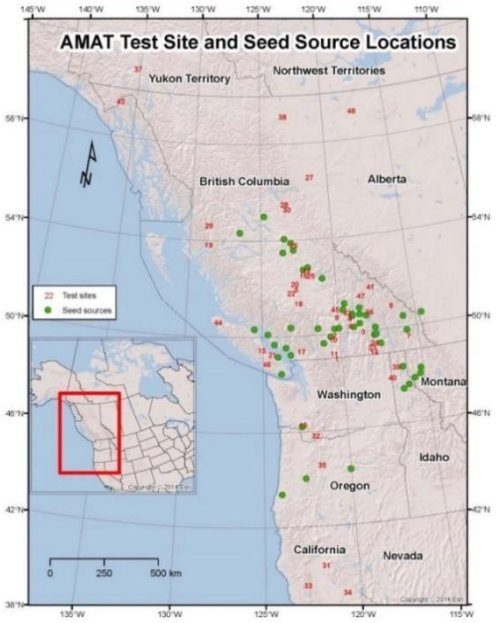
1. Sx genecology/CC field trial



2. Assisted Migration Adaptation Trial (AMAT)

- Established 2009-12
- 48 test sites
- 15 species, 47 seedlots (mostly Class A)

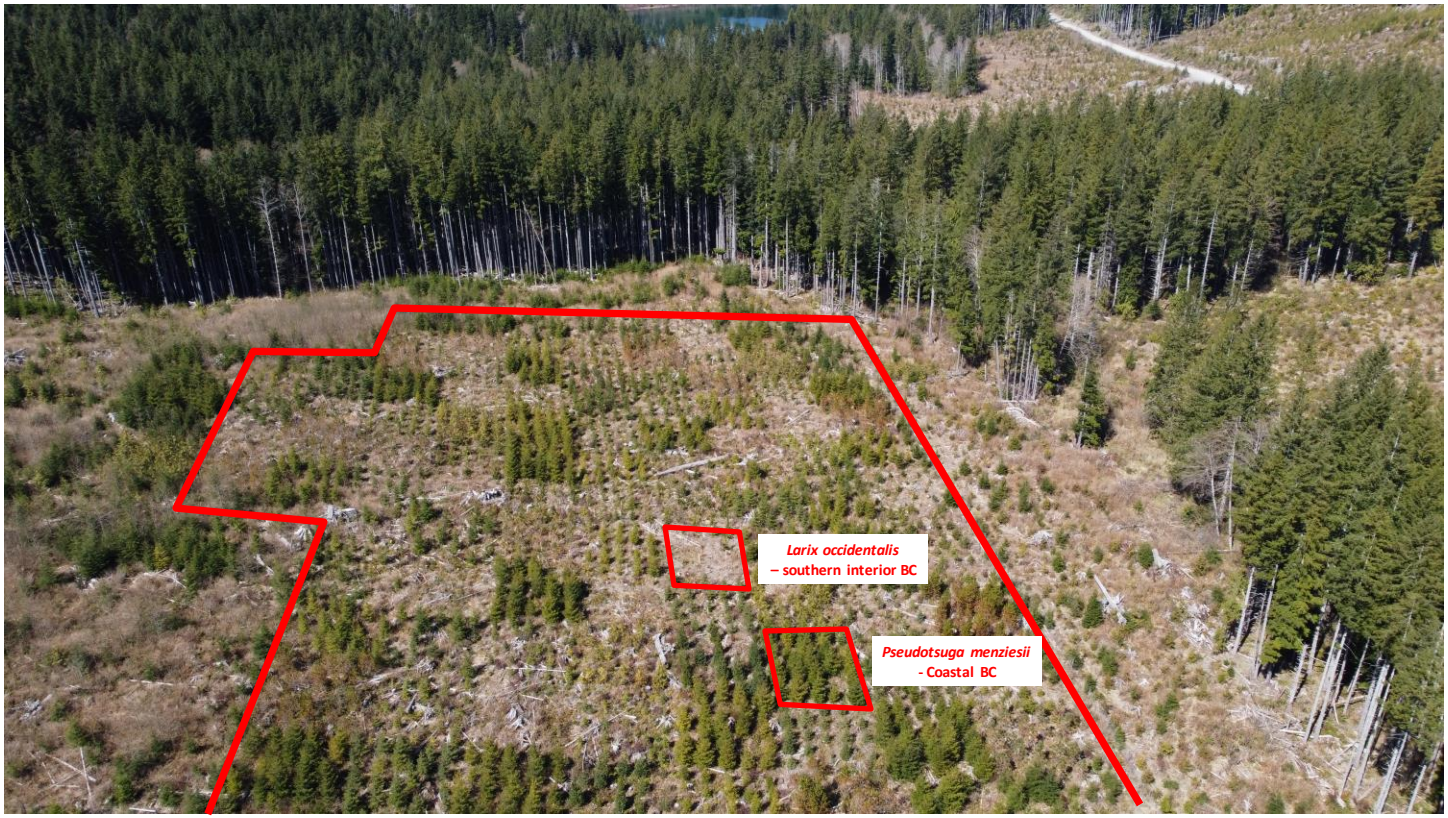
Photo: Ward Strong



Map: Amy Vallarino

- Seedlot transferability → CBST
- Calibrating CCISS

2. Assisted Migration Adaptation Trial (AMAT)



Nitinat AMAT, Vancouver Island, BC

2. Assisted Migration Adaptation Trial (AMAT)

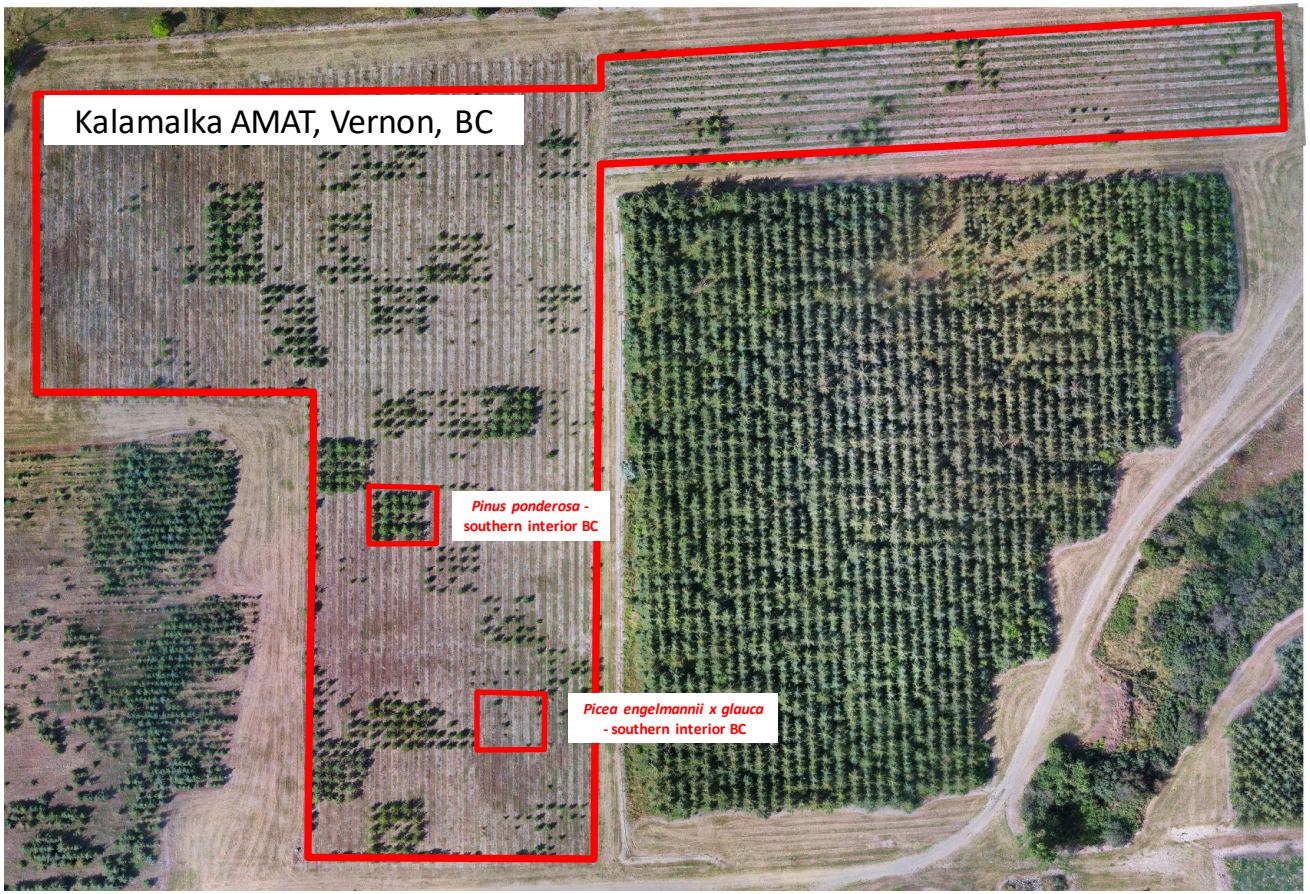


Photo: Sam Grubinger

Climate Change Adaptation Research

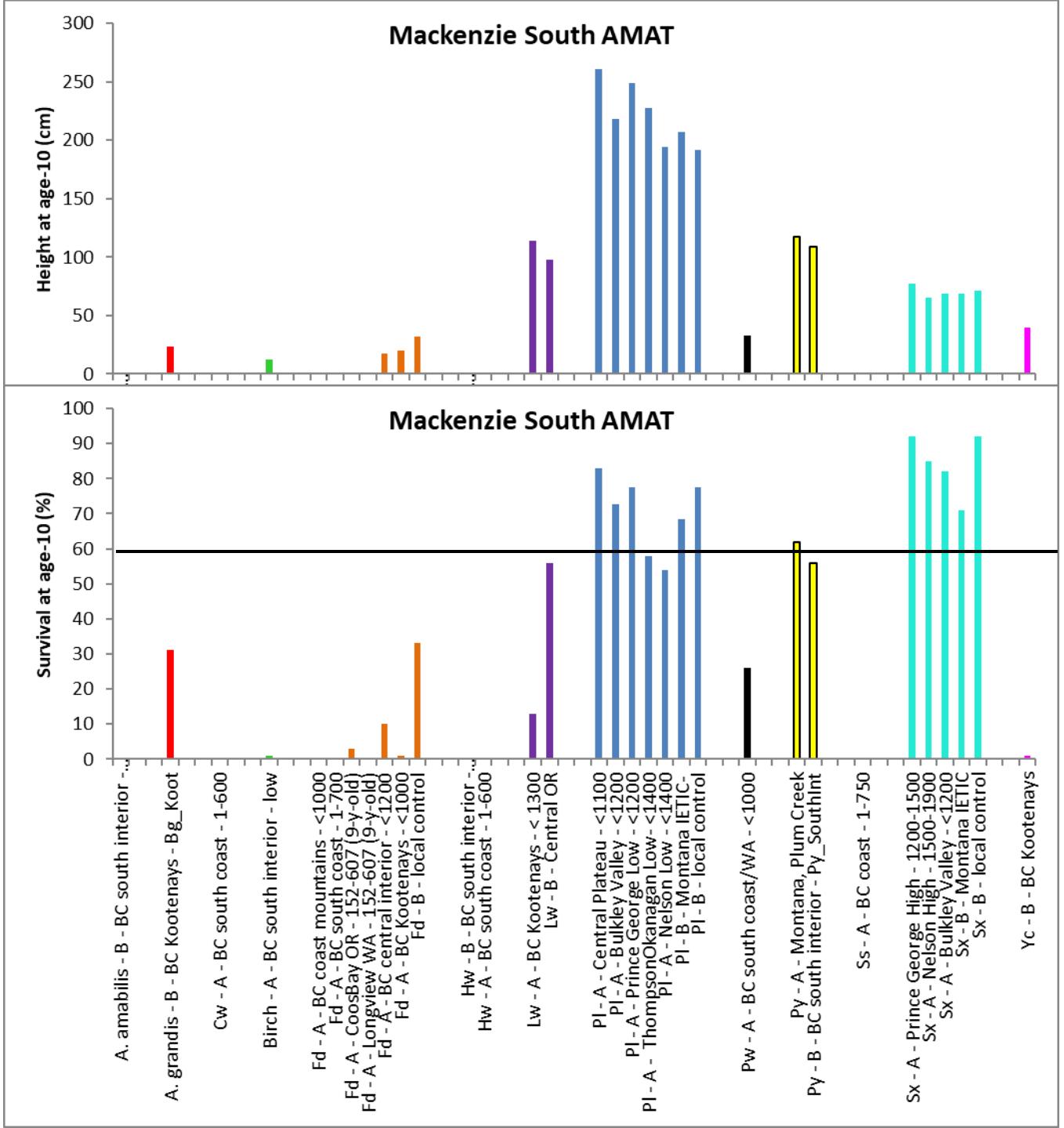
2. Assisted Migration Adaptation Trial (AMAT)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Project design	X																			
Proposal review		X																		
Seed procurement		X																		
Locate sites/grow seedlings - series 1			X																	
Locate sites/grow seedlings - series 2				X																
Locate sites/grow seedlings - series 3					X															
Locate sites/grow seedlings - series 4						X														
Plant - series 1				X																
Plant - series 2					X															
Plant - series 3						X														
Plant - series 4							X													
Weather station\site maintenance - series 1					X	X	X	X	X	X		X		X		X		X		X
Weather station\site maintenance - series 2						X	X	X	X	X	X		X		X		X		X	
Weather station\site maintenance - series 3							X	X	X	X	X	X		X		X		X		X
Weather station\site maintenance - series 4								X	X	X	X	X	X		X		X		X	
Assess - series 1								X					X					X		
Assess - series 2									X					X					X	
Assess - series 3										X					X					X
Assess - series 4											X					X				
Extension				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

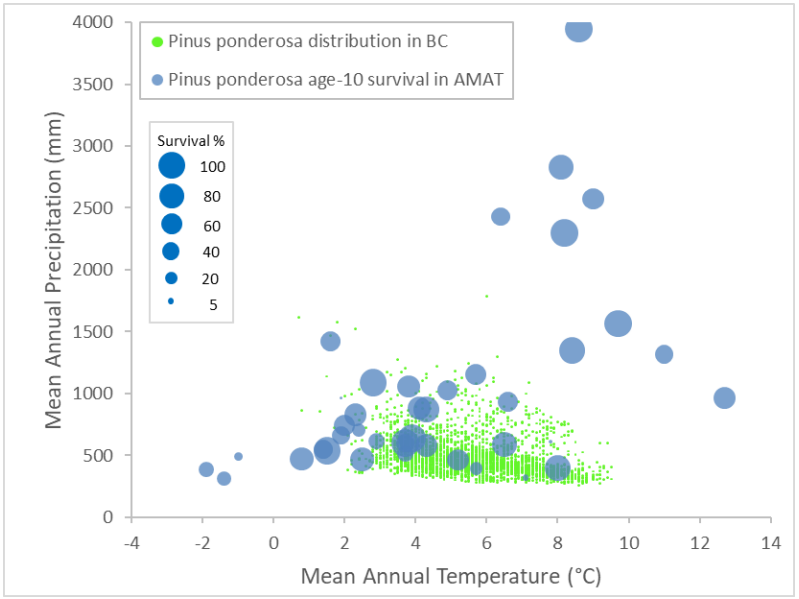
Climate Change Adaptation Research

2. Assisted Migration Adaptation Trial (AMAT)

			2023		
Site Name	centre stake	tag trees	wildlings	brush	measure
Placer Mountain		Y		g	Y
Loon Lake		Y		Y	Y
Winnifred Creek		Y		Y	Y
Deep Creek		g		g	Y
Riske Creek		Y	Y	Y	Y
Kalamalka		MoF			MoF
Cranbrook		Y		Y	Y
Spillimacheen		Y	Y	Y	Y
Barnhartvale	MoF	MoF	MoF	MoF	MoF
Shrimpton		Y	Y	Y	Y
Lynx Creek		Y		Y	Y
Likely		Y	Y	Y	Y
Mt St Helen WA		g	Y	Y	Y
Glenmerry					
Port Alberni					
McLeese Lake					
Malcolm Knapp					
Churn Creek					
Kitimat					
Strouse Lake					
Parksville					
Fletcher Lake					
Bulldog			Y	Y	
Ladybird			Y	Y	
Gavin Lake					
PGTIS					
Ft St John		Y		Y	
Mackenzie North					
Kitsumkalum					
Mackenzie South Hwy39					
Lyman Springs CA					
Wind River WA					
Mendocino NF CA					
Forest Hill CA					
Sisters OR					
Revelstoke South					
Whitehorse ResFor YK		Y		Y	
Fort Nelson		Y		Y	
Priest River ID					
Spirit Lake ID					
Golden					
Haines					
Skimikin			Y	Y	
Holberg					
McLure			Y	Y	
Nitinat	fence				
Revelstoke North			Y	Y	
High Level AB					


Mackenzie South AMAT
Height at age-10 (cm)
300
250
200
150
100
50
0
Mackenzie South AMAT
Survival at age-10 (%)
100
90
80
70
60
50
40
30
20
10
0
A. amabilis - B - BC south interior -...
A. grandis - B - BC Kootenays - Bg_Koot
Cw - A - BC south coast - 1-600
Birch - A - BC south interior - low
Fd - A - BC coast mountains - <1000
Fd - A - BC south coast - 1-700
Fd - A - CoosBay OR - 152-607 (9-y-old)
Fd - A - Longview WA - 152-607 (9-y-old)
Fd - A - BC central interior - <1200
Fd - A - BC Kootenays - <1000
Fd - B - local control
Hw - B - BC south interior -...
Hw - A - BC south coast - 1-600
Lw - A - BC Kootenays - < 1300
Lw - B - Central OR
Pl - A - Central Plateau - <1100
Pl - A - Bulkley Valley - <1200
Pl - A - Prince George Low - <1200
Pl - A - ThompsonOkanagan Low - <1400
Pl - A - Nelson Low - <1400
Pl - B - Montana IETIC-
Pl - B - local control
Pw - A - BC south coast/WA - <1000
Py - A - Montana, Plum Creek
Py - B - BC south interior - Py_SouthInt
Ss - A - BC coast - 1-750
Sx - A - Prince George High - 1200-1500
Sx - A - Nelson High - 1500-1900
Sx - A - Bulkley Valley - <1200
Sx - B - Montana IETIC
Sx - B - local control
Yc - B - BC Kootenays

2. Assisted Migration Adaptation Trial (AMAT)



Range map: Little

2. Assisted Migration Adaptation Trial (AMAT)

Do not go to bank with age-10 results

- 10 years → insufficient extreme climate events
- Hare vs tortoise species & seedlots
- Need to consider all sites simultaneously

- Cautious support for AM of species and populations.

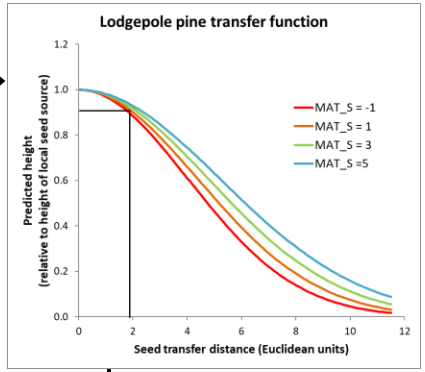
3. CBST

Plantation \ Seed source	BAFAun	BGxh1	BGxw2	BWBSdk	BWBSmk	BWBSmw	BWBSvk	BWBSwk1	BWBSwk2
BAFAun	0.00	9.23	6.20	2.69	3.69	3.71	3.00	3.29	2.90
BGxh1	9.23	0.00	3.17	7.24	7.46	6.20	7.58	6.29	6.79
BGxw2	6.20	3.17	0.00	4.16	4.54	3.14	4.86	3.28	3.69
BWBSdk	2.69	7.24	4.16	0.00	1.63	1.41	2.52	1.77	0.73
BWBSmk	3.69	7.46	4.54	1.63	0.00	1.60	3.16	2.60	1.85
BWBSmw	3.71	6.20	3.14	1.41	1.60	0.00	2.67	1.30	0.99
BWBSvk	3.00	7.58	4.86	2.52	3.16	2.67	0.00	1.96	2.26
BWBSwk1	3.29	6.29	3.28	1.77	2.60	1.30	1.96	0.00	1.08
BWBSwk2	2.90	6.79	3.69	0.73	1.85	0.99	2.26	1.08	0.00

Climate distance matrix

3. CBST

Provenance data



Climate means of plantation BECvars

Climate means of seed BECvars

Seed source

Plantation	BAFAun	BGxh1	BGxw2	BWBSdk	BWBSmk	BWBSmw	BWBSvk	BWBSwk1	BWBSwk2
BAFAun	0.00	9.23	6.20	2.69	3.69	3.71	3.00	3.29	2.90
BGxh1	9.23	0.00	3.17	7.24	7.46	6.20	7.58	6.29	6.79
BGxw2	6.20	3.17	0.00	4.16	4.54	3.14	4.86	3.28	3.69
BWBSdk	2.69	7.24	4.16	0.00	1.63	1.41	2.52	1.77	0.73
BWBSmk	3.69	7.46	4.54	1.63	0.00	1.60	3.16	2.60	1.85
BWBSmw	3.71	6.20	3.14	1.41	1.60	0.00	2.67	1.30	0.99
BWBSvk	3.00	7.58	4.86	2.52	3.16	2.67	0.00	1.96	2.26
BWBSwk1	3.29	6.29	3.28	1.77	2.60	1.30	1.96	0.00	1.08
BWBSwk2	2.90	6.79	3.69	0.73	1.85	0.99	2.26	1.08	0.00

Climate distance matrix

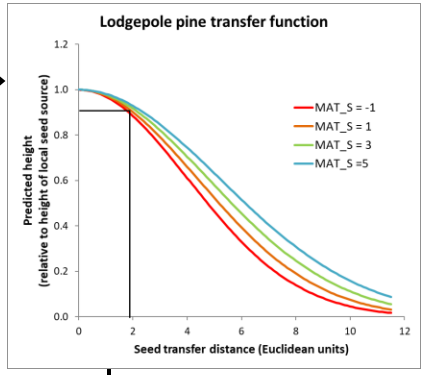
Seed source

Plantation	BAFAun	BGxh1	BGxw2	BWBSdk	BWBSmk	BWBSmw	BWBSvk	BWBSwk1	BWBSwk2
BAFAun	1.00	0.02	0.17	0.72	0.53	0.53	0.66	0.61	0.68
BGxh1	0.36	1.00	0.89	0.54	0.52	0.63	0.51	0.63	0.58
BGxw2	0.50	0.83	1.00	0.73	0.69	0.84	0.65	0.82	0.78
BWBSdk	0.78	0.17	0.55	1.00	0.91	0.93	0.80	0.90	0.98
BWBSmk	0.60	0.12	0.46	0.90	1.00	0.91	0.69	0.78	0.88
BWBSmw	0.68	0.34	0.76	0.95	0.93	1.00	0.82	0.95	0.97
BWBSvk	0.81	0.27	0.58	0.86	0.80	0.85	1.00	0.92	0.89
BWBSwk1	0.77	0.38	0.77	0.93	0.85	0.96	0.91	1.00	0.97
BWBSwk2	0.77	0.25	0.66	0.98	0.90	0.97	0.86	0.96	1.00

Relative height matrix

3. CBST

Provenance data



Climate means of plantation BECvars + Climate migration distance

Climate means of seed BECvars

Plantation	Seed source: BAFAun	BGxh1	BGxw2	BWBSdk	BWBSmk	BWBSmw	BWBSvk	BWBSwk1	BWBSwk2
BAFAun	0.58	8.78	5.77	2.34	3.39	3.28	2.44	2.78	2.48
BGxh1	9.95	1.01	3.97	7.97	8.12	6.88	8.11	6.94	7.49
BGxw2	6.92	2.49	0.85	4.84	5.08	3.74	5.34	3.90	4.37
BWBSdk	3.25	6.65	3.62	0.71	1.58	0.92	2.39	1.48	0.66
BWBSmk	4.01	6.95	4.11	1.81	0.72	1.30	2.90	2.33	1.81
BWBSmw	4.19	5.75	2.80	1.99	2.05	0.68	2.66	1.35	1.49
BWBSvk	3.60	7.28	4.68	2.81	3.23	2.68	0.64	2.05	2.48
BWBSwk1	3.94	5.84	2.98	2.35	2.91	1.54	2.07	0.74	1.68
BWBSwk2	3.39	6.32	3.30	1.36	2.13	0.89	2.01	0.69	0.73

Climate distance matrix

Plantation	Seed source: BAFAun	BGxh1	BGxw2	BWBSdk	BWBSmk	BWBSmw	BWBSvk	BWBSwk1	BWBSwk2
BAFAun	0.99	0.05	0.27	0.81	0.64	0.65	0.79	0.74	0.78
BGxh1	0.37	0.99	0.86	0.53	0.52	0.62	0.52	0.62	0.57
BGxw2	0.48	0.91	0.99	0.69	0.67	0.80	0.64	0.79	0.74
BWBSdk	0.73	0.27	0.68	0.99	0.93	0.98	0.84	0.94	0.99
BWBSmk	0.60	0.22	0.59	0.90	0.98	0.95	0.77	0.84	0.90
BWBSmw	0.66	0.45	0.83	0.91	0.90	0.99	0.84	0.96	0.95
BWBSvk	0.77	0.34	0.64	0.85	0.81	0.86	0.99	0.92	0.88
BWBSwk1	0.72	0.49	0.83	0.89	0.84	0.95	0.91	0.99	0.94
BWBSwk2	0.74	0.36	0.76	0.95	0.89	0.98	0.90	0.99	0.99

Relative height matrix
Genetic suitability

3. CBST

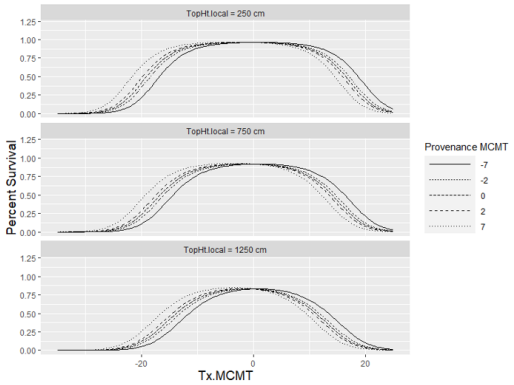
Considerations

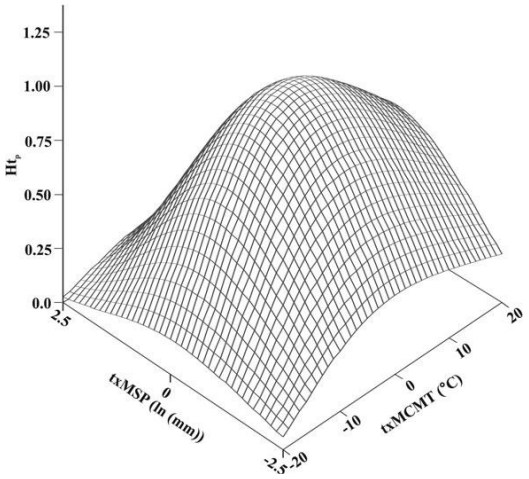
- longer migration distance
- new measurement data (Sx)
- ClimateBC update
- BEC 12
- +/- drop PAS
- +/- weight climate variables (temp > precip)
- orphaned plantation BECvars

Conversations

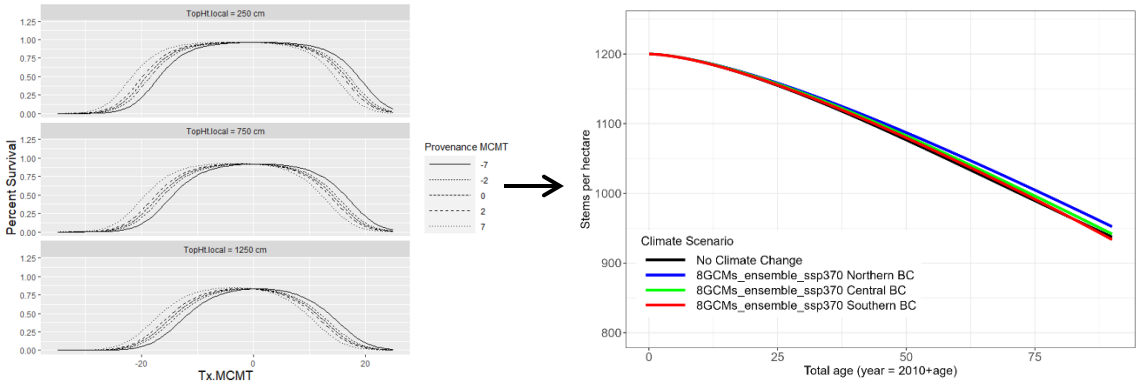
- genetics community
- seed user/producer community.

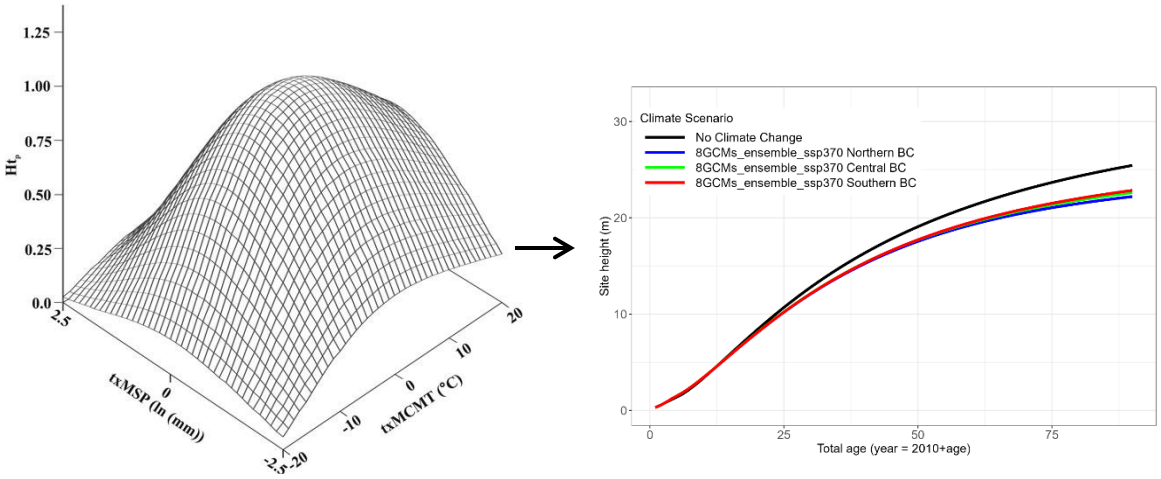
4. Climate Sensitive Mortality Function for TASS



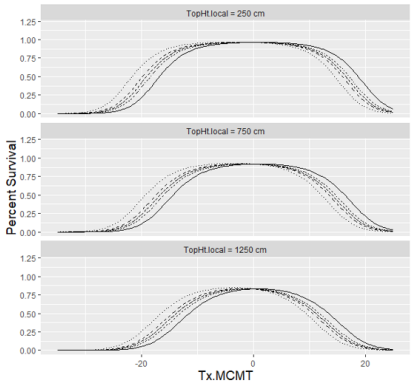


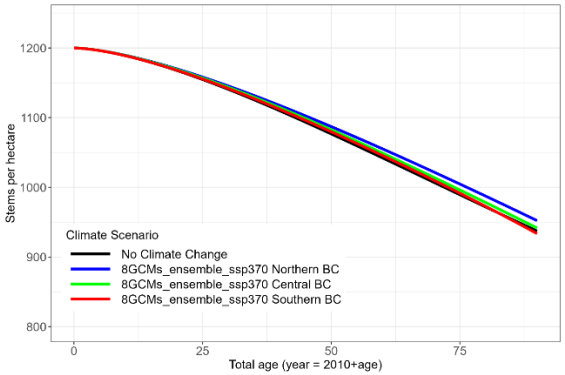
4. Climate Sensitive Mortality Function for TASS





4. Climate Sensitive Mortality Function for TASS





TASS

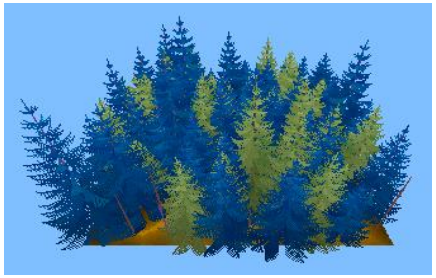
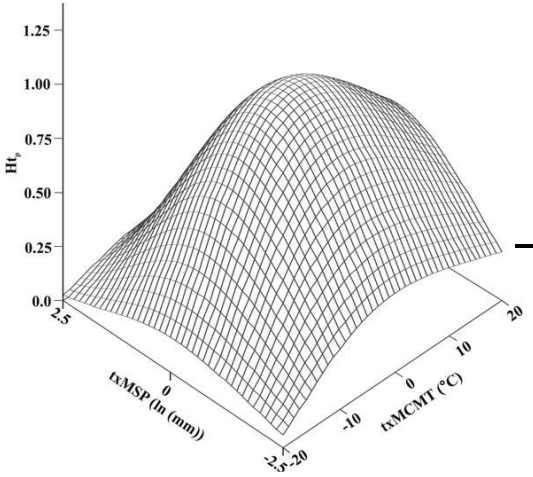
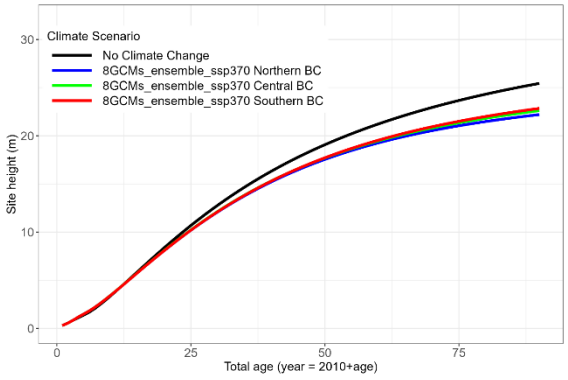
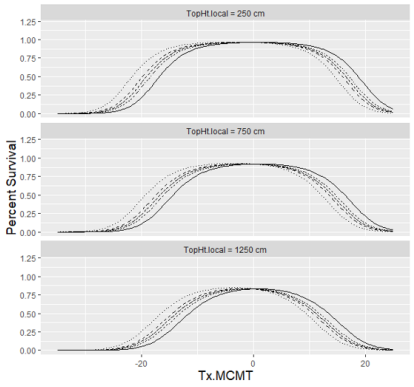


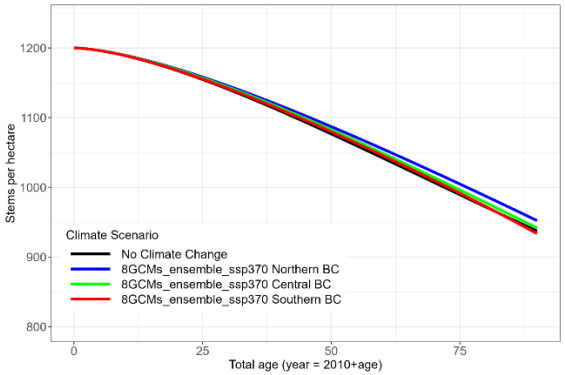
Image: Dave Simpson





4. Climate Sensitive Mortality Function for TASS





TASS

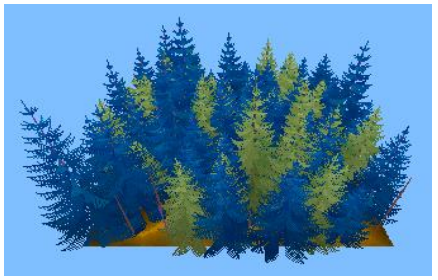
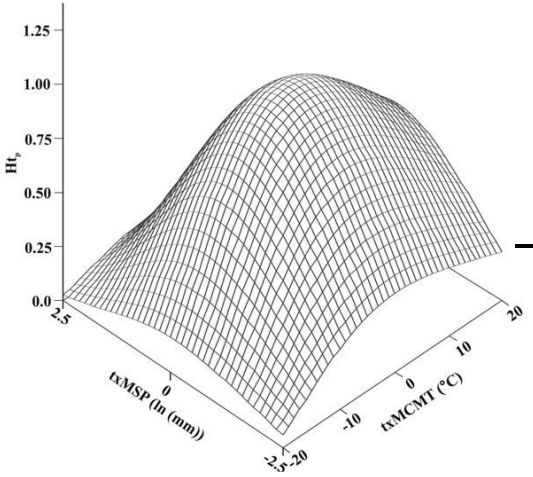
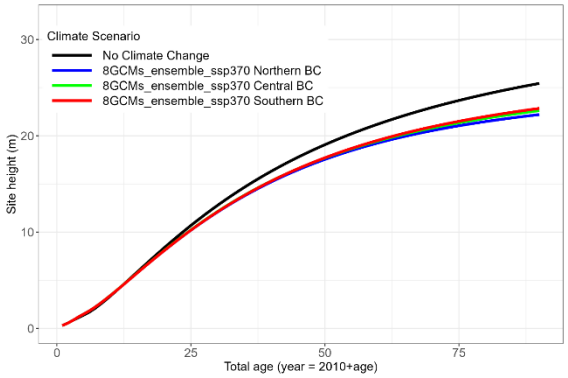
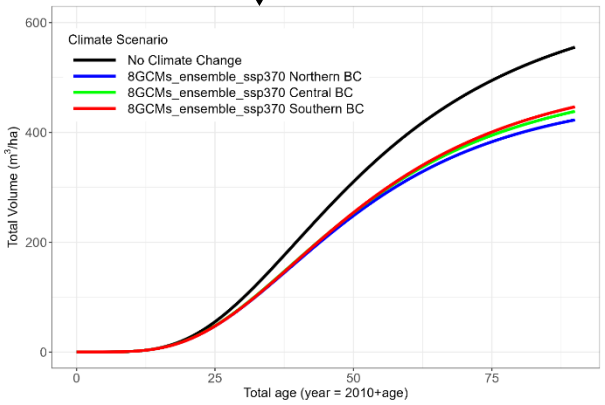


Image: Dave Simpson







4. Climate Sensitive Mortality Function for TASS

Objective

- Simulate climate-induced mortality in lodgepole pine stands and apply to TASS

Funding

- 2019/20 - Forest Enhancement Society ($76,000), FAIB ($25,000)
- 2020/21 - OCF Research Program (Timber Portfolio) ($51,000)
- 2021/22 - OCF Research Program (Timber Portfolio) ($51,000)
- 2022/23 - OCF Research Program (Timber Portfolio) ($51,000)
- 2023/24 – NSERC Student Award ($36,000)

Team

- Kate Peterson, Tongli Wang, Derek Sattler, Greg O'Neill

Deliverables

- Technical Report "Climate Sensitive Mortality functions for TASS" (internal review)

Extension

- Western Mensurationists Conference 2020
- International Boreal Forest Research Association conference 2021
- CFGA/WFGA Symposium 2021

5. CC Impacts to Forest Productivity

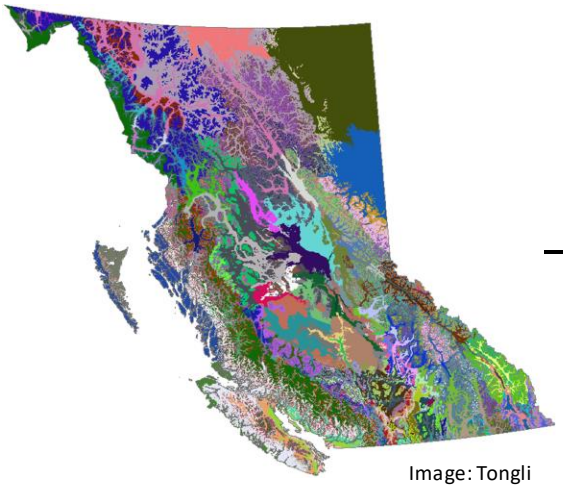


Image: Tongli Wang

Climate-sensitive TASS

Factors

SI

Planting density

RCP

Seedlot diversity

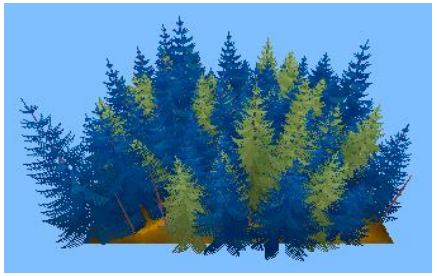


Image: Dave Simpson

6. Assisted Range Expansion

Objective

- To assess the productivity of Lw, Py and Fd when planted outside of its current geographic range

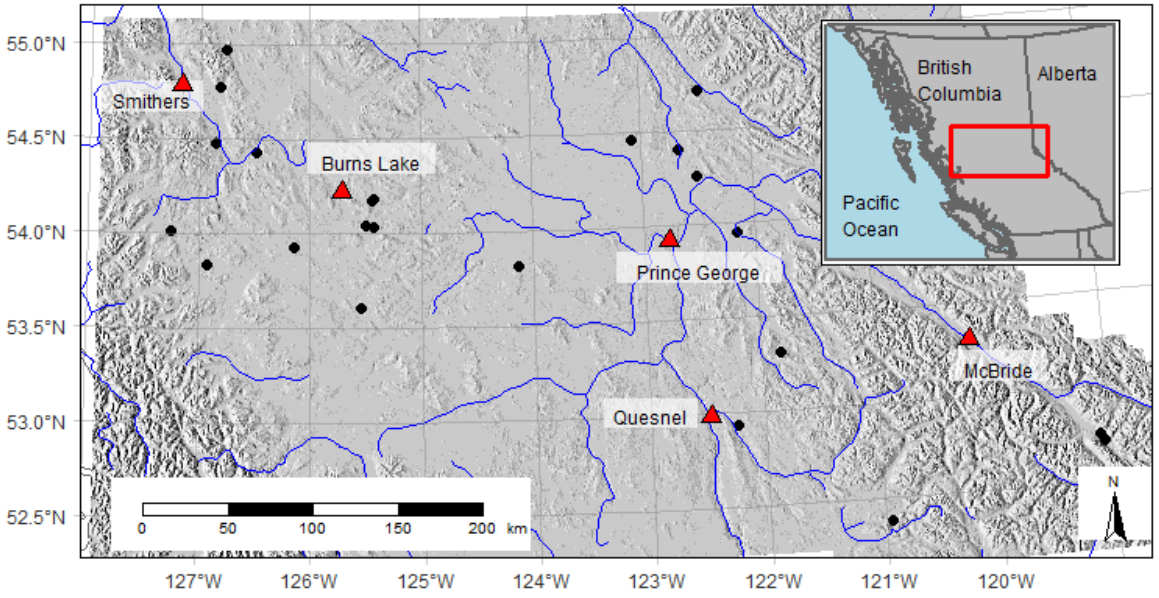
Funding 2022/23

none

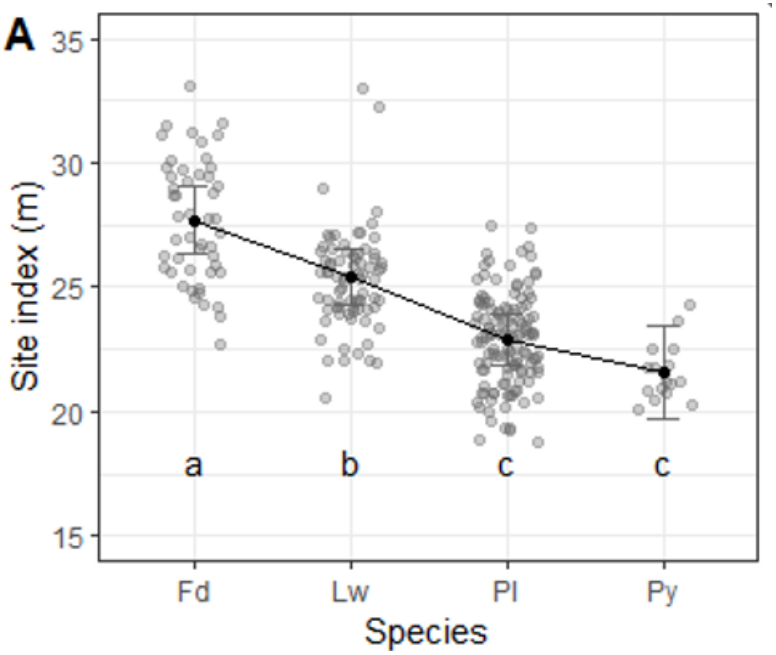
Team

- Hardy Griesbauer, Will Mackenzie, Greg O'Neill

6. Assisted Range Expansion



6. Assisted Range Expansion



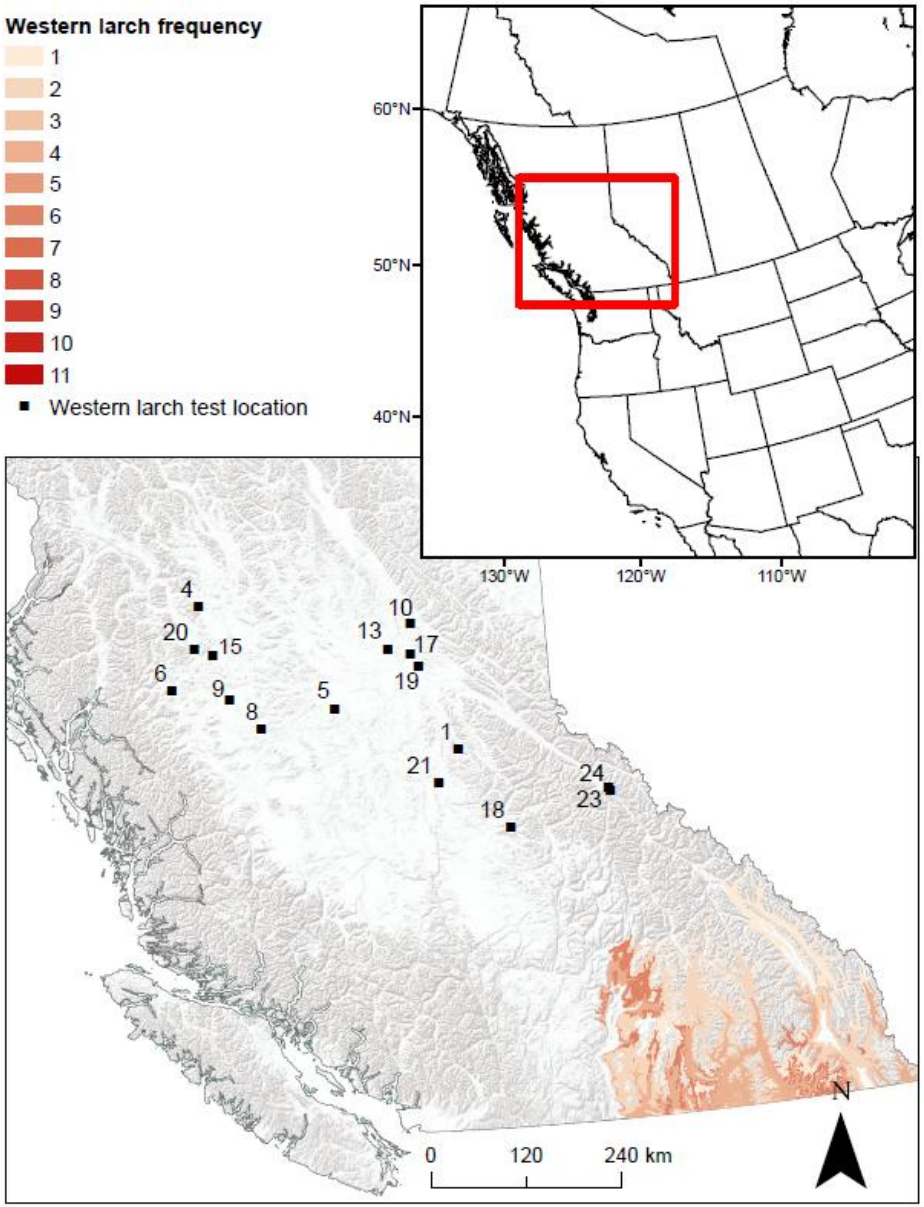


Image: Amy Vallarino

7. Species transferability (on hold)

Objective

- To what extent do species differ in their safe seed transfer distance and CC sensitivity?
- At what age can safe seed transfer distance be calculated?
- Develop CBST for California

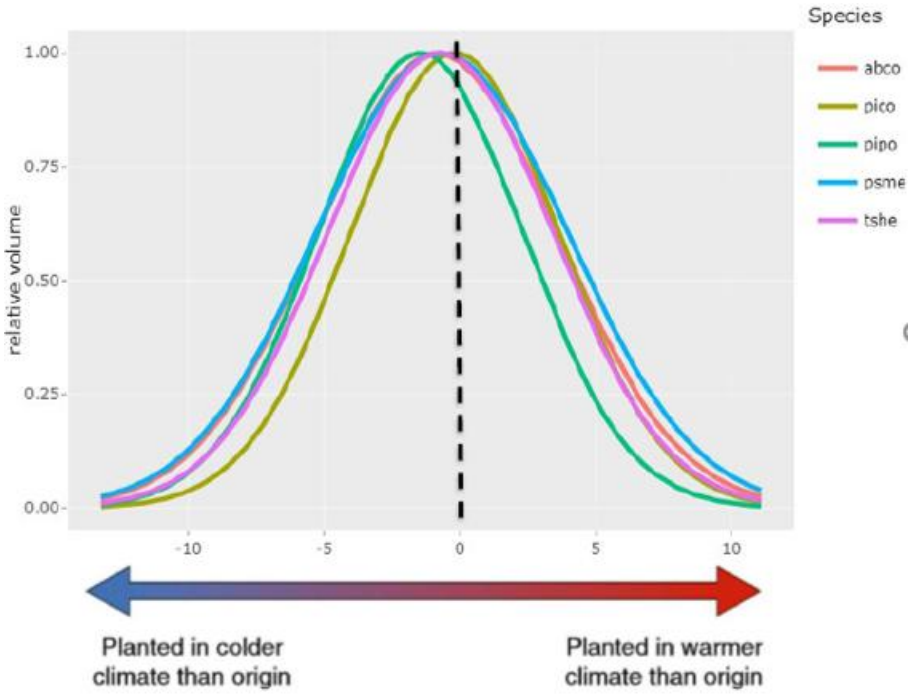
Funding

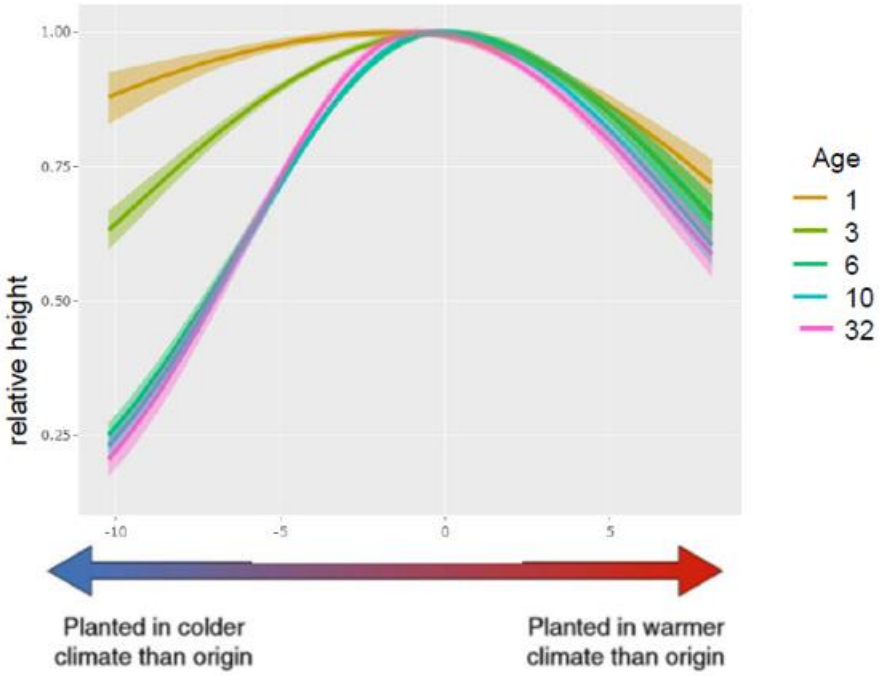
- 2020/21 - $40 000 (UC Davis)
- 2021-22 - $60 000 (CalFire)
- 2022-23 - $60 000 (CalFire) (requested)

Team

- Joseph Stewart (UCD) , Jessica Wright (USDA FS), Greg O'Neill

7. Species transferability





8. Multi-spectral imaging in forest genetics trials

Objective

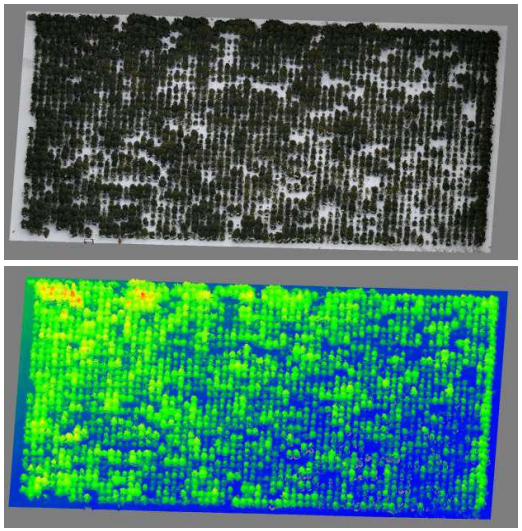
- What opportunities exist for multispectral imaging from drones to contribute to assessment of genetics field trials?

Funding 2020/21

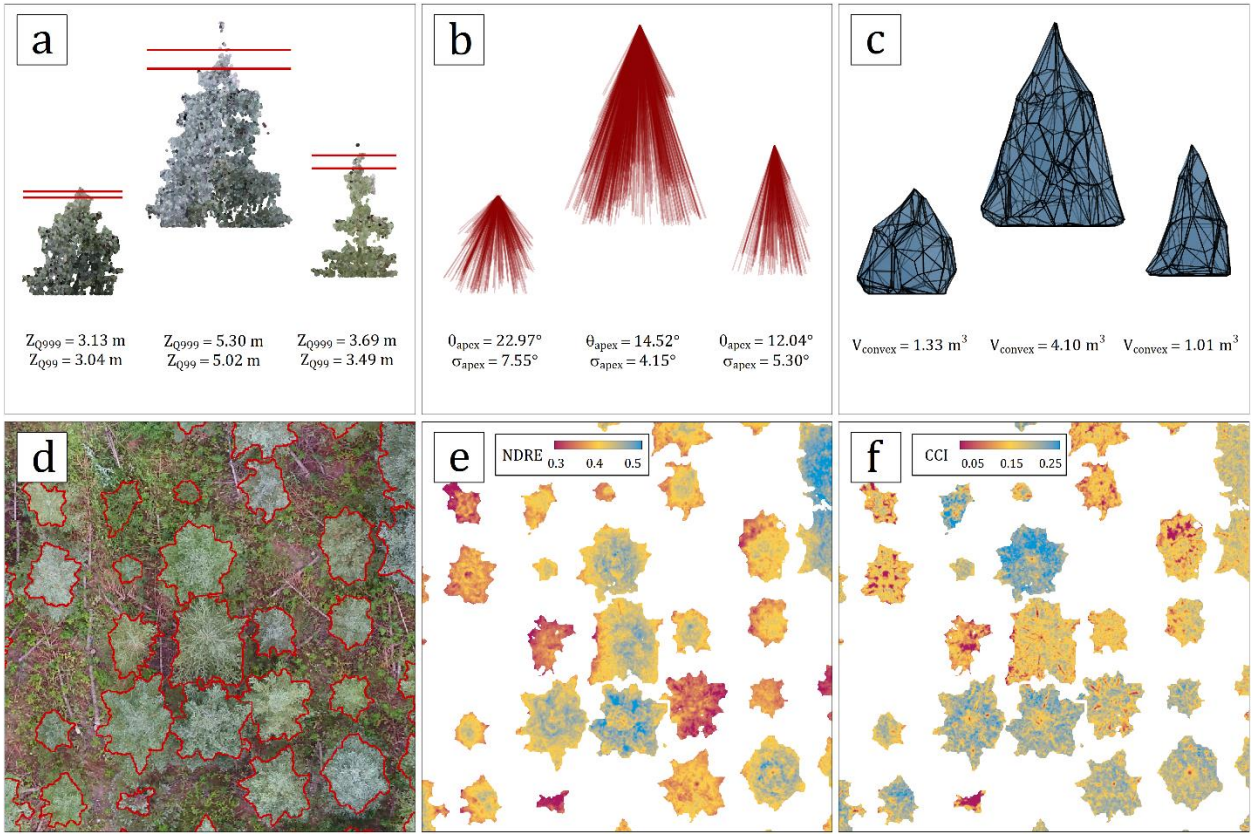
- MoF $30,000
- NSERC $60,000

Team

- Sam Grubinger, Nicholas Coops, Greg O'Neill

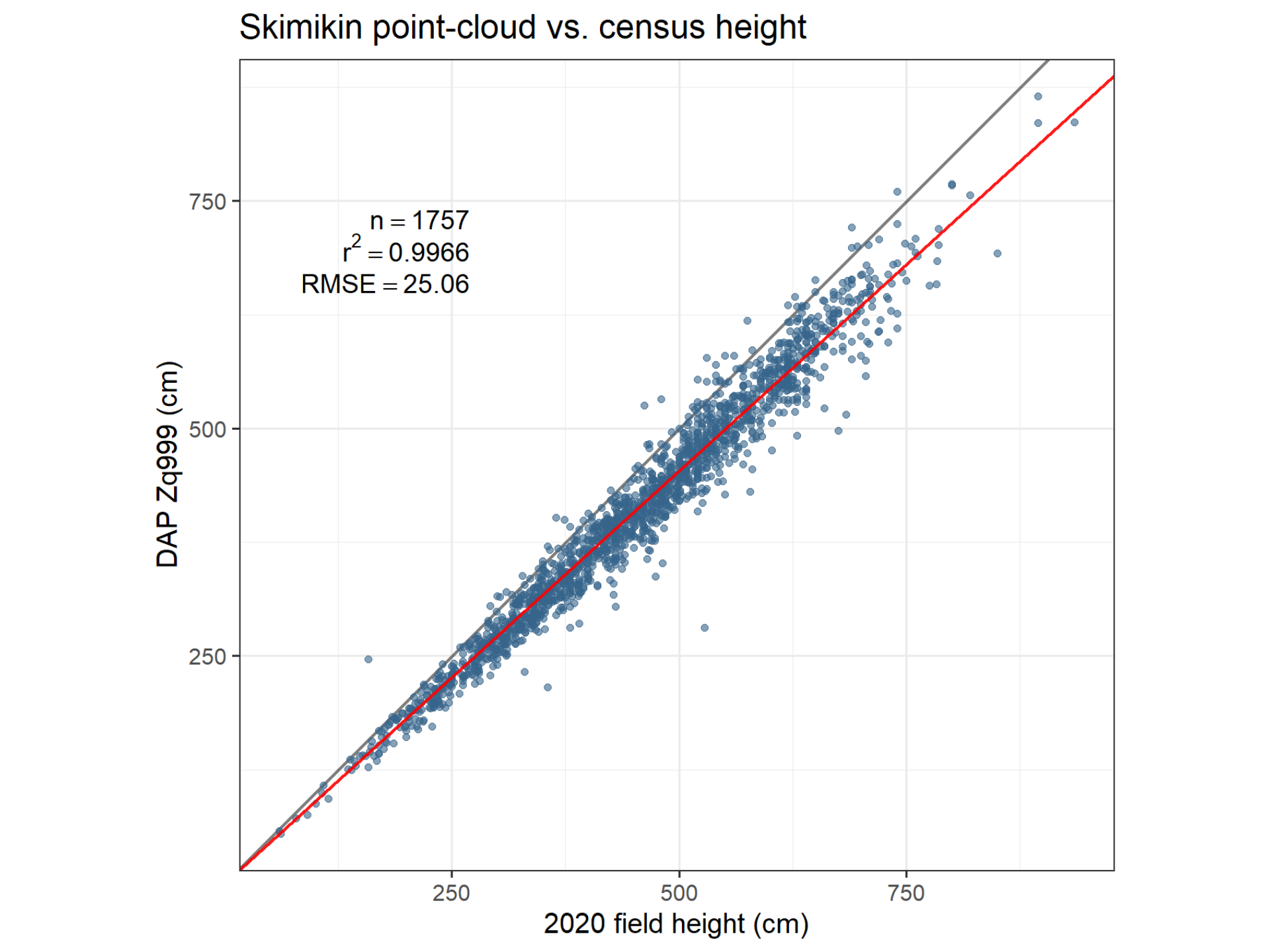


8. Multi-spectral imaging in genetics trials

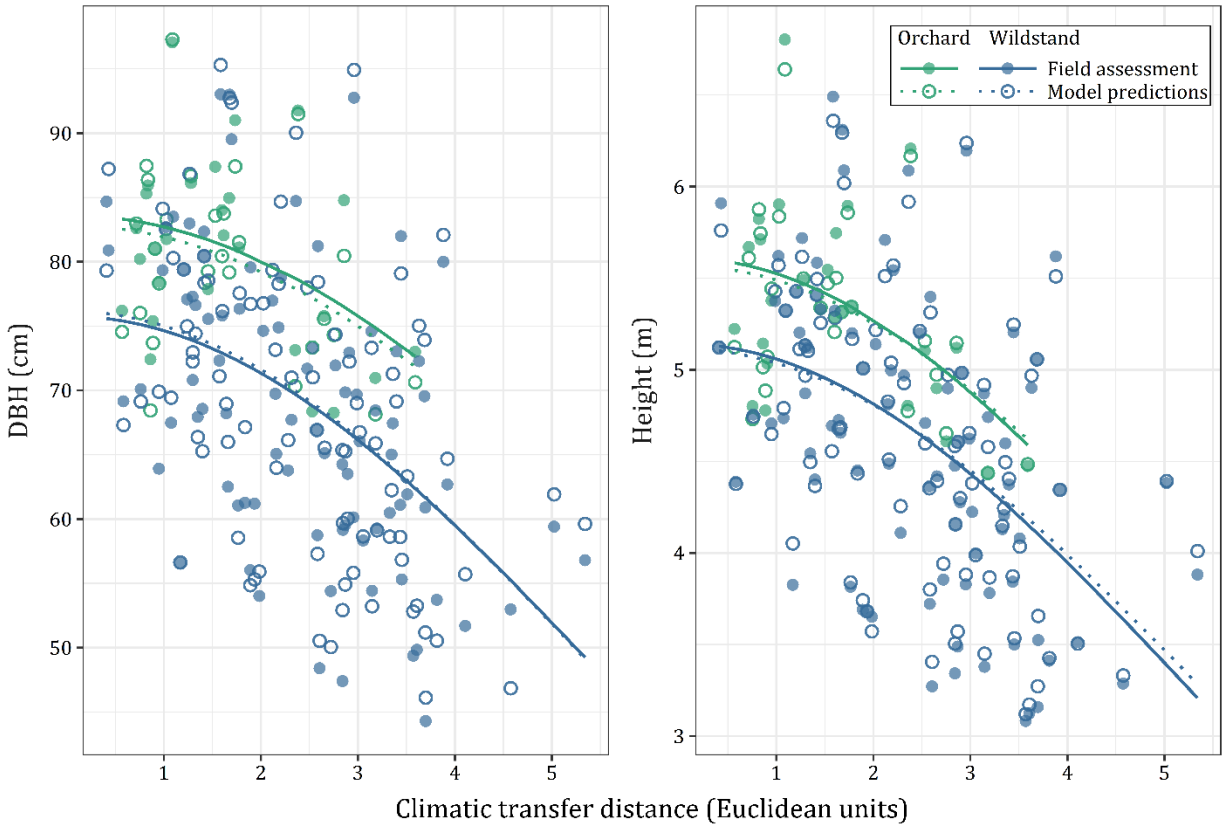


Structural traits

Spectral traits


Skimikin point-cloud vs. census height
n = 1757
r2 = 0.9966
RMSE = 25.06
DAP Zq999 (cm)
2020 field height (cm)
250
500
750
250
500
750

8. Multi-spectral imaging in genetics trials



8. Multi-spectral imaging in forest genetics trials

Objective

- What opportunities exist for multispectral imaging to contribute to assessment of genetics field trials?

Funding 2020/21

- MoF $30,000
- NSERC $60,000

Team

- Sam Grubinger, Nicholas Coops, Greg O'Neill

Conclusions

Yes, MSI can assess HT accurately.
Yes, MSI can assess local adaptation.

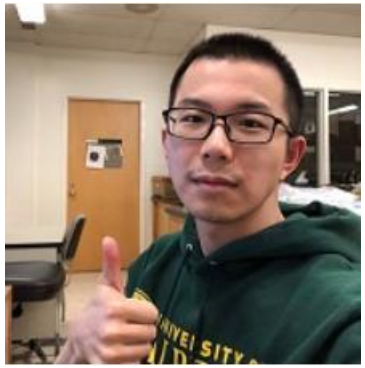
Questions

How much does it cost?
Does the height model need to be trained on each plantation, at each age, or in each season?
Do the findings translate to other species?

9. Local adaptation of trees to forest pests

Objective/Questions

- Does good seed transfer help limit pest damage?
- Identify specific transfers that should be avoided



Funding

2021/22 – 45,000 (FCI)
2022/23 – 65,000 (FCI)

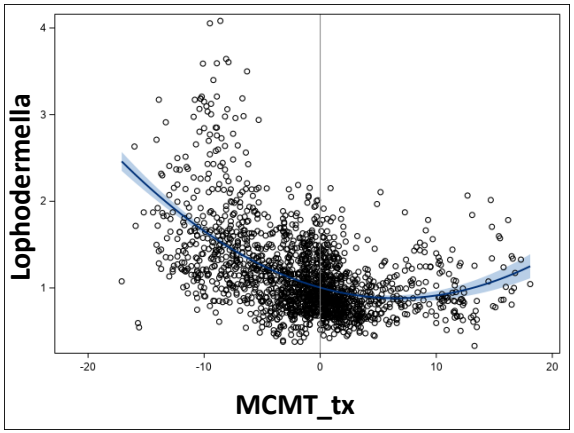
Team

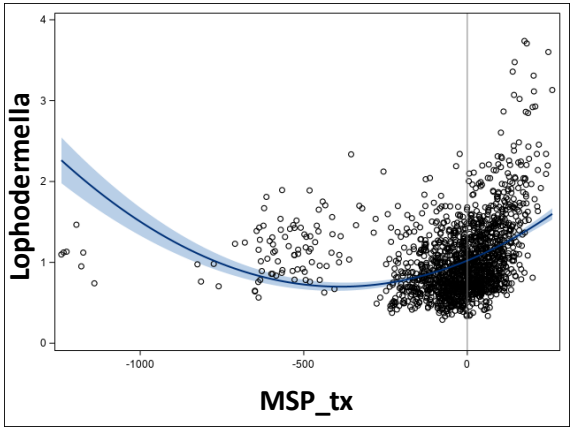
- Dawei Luo, Nick Ukrainetz, Tongli Wang, Peter Ott, Greg O'Neill

Deliverable

- Better forest health through better seed transfer. (in prep)

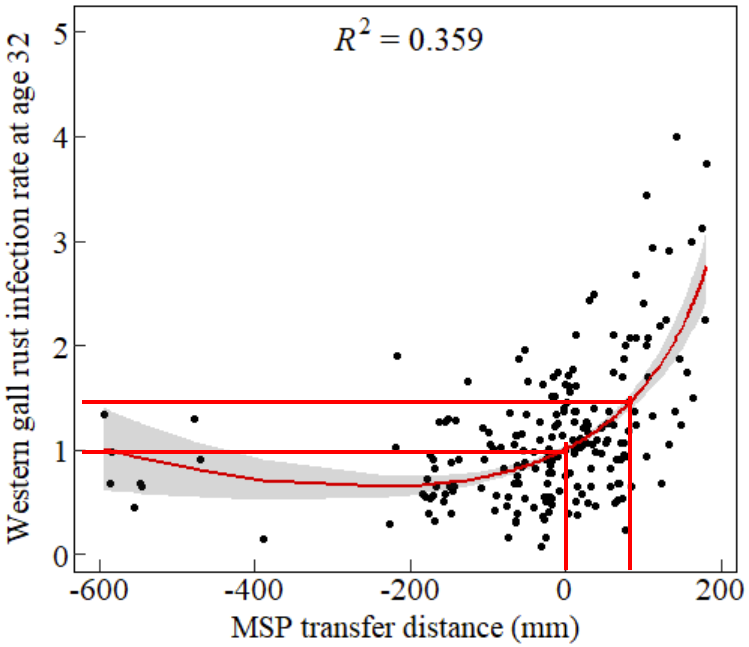
9. Local adaptation of trees to forest pests

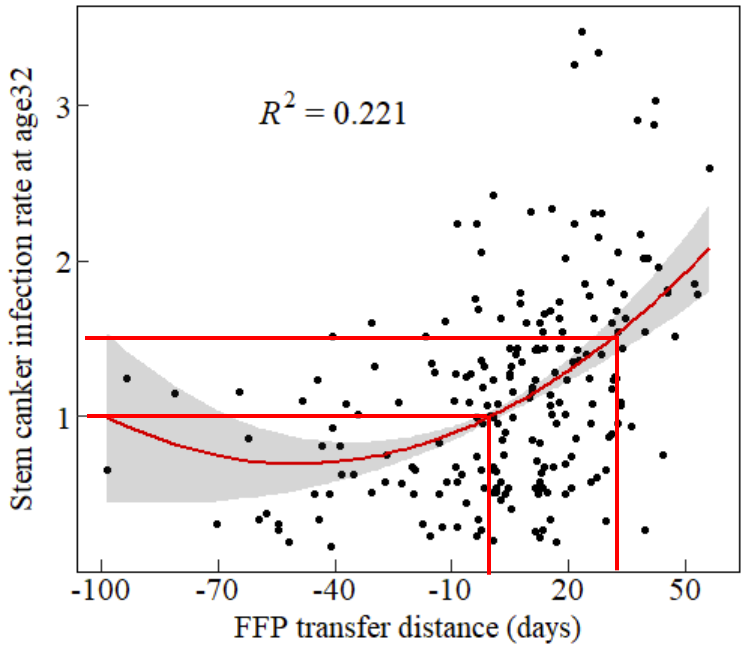




Lophodermella needle cast attack score on lodgepole pine

9. Local adaptation of trees to forest pests





10. Weather station assessments

Objective/Questions

- Are field weather stations accurate?
- Evaluate tradeoffs between ClimateBC and field weather stations.

Funding 2021/22

- NSERC ($18,000)

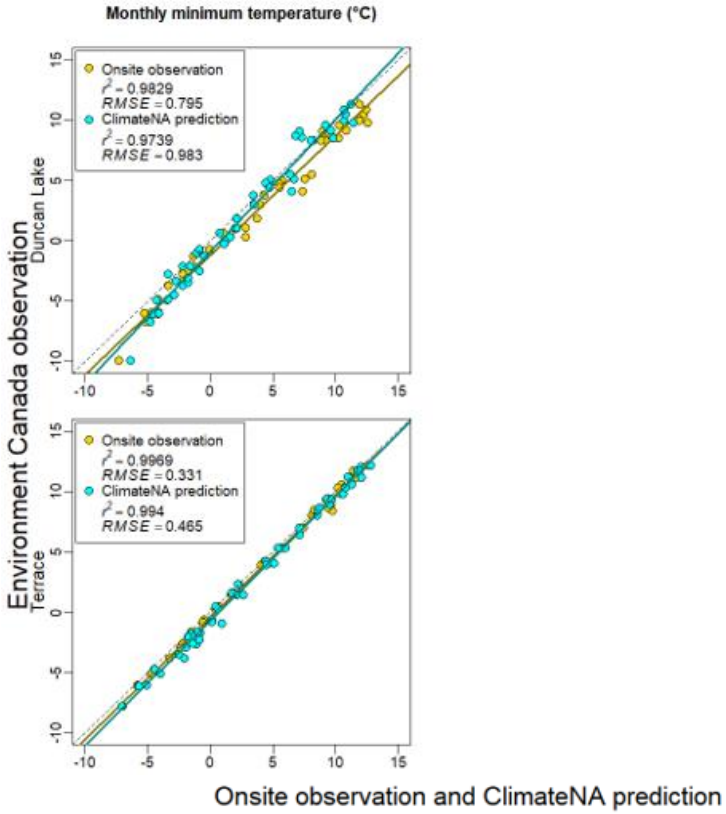
Team

- Lambert Ye, Tongli Wang, Greg O'Neill

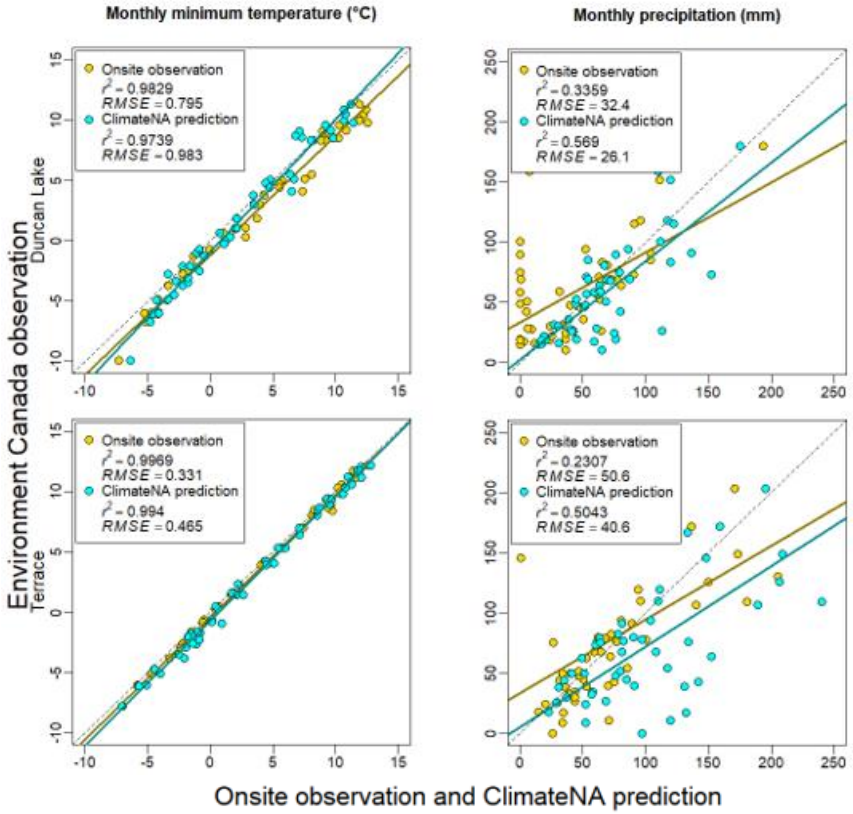
Deliverable

- "Climate Data for Field Trials: Onsite Micro Stations *versus* ClimateNA" (published 2022)

10. Weather station assessments



10. Weather station assessments



Conclusion

- ClimateBC/NA superior to on-site microstations.

11. Trends in extreme minimum temperatures

Objective/Questions

- Characterize trends in extreme minimum temperatures across Canada
- Quantify changes in risk of cold damage with and without AM

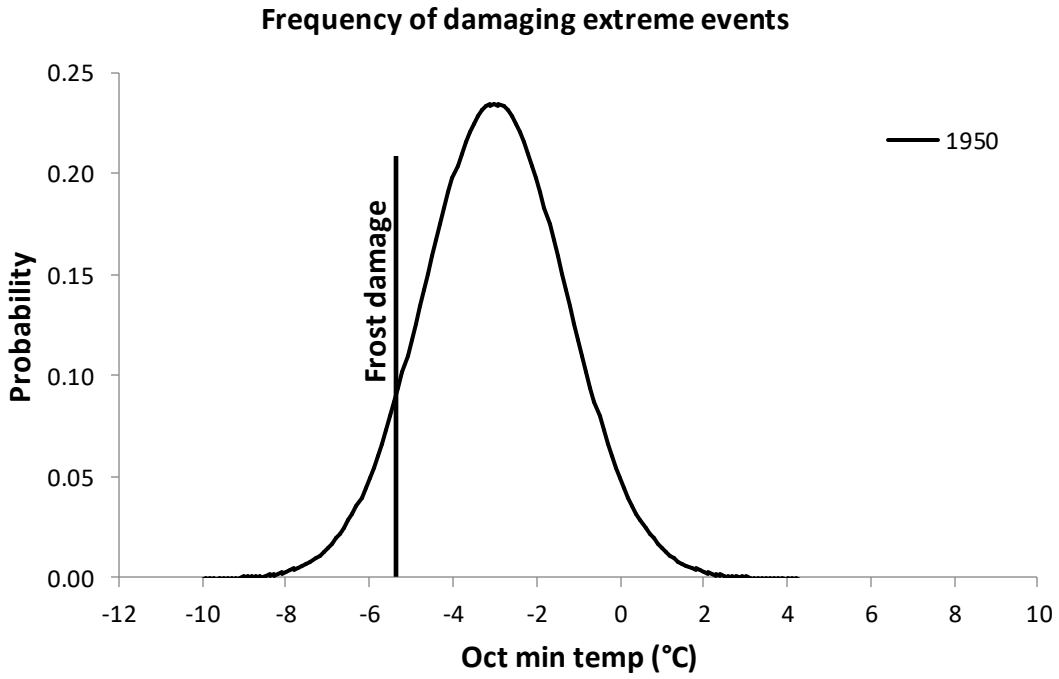
Funding

- none

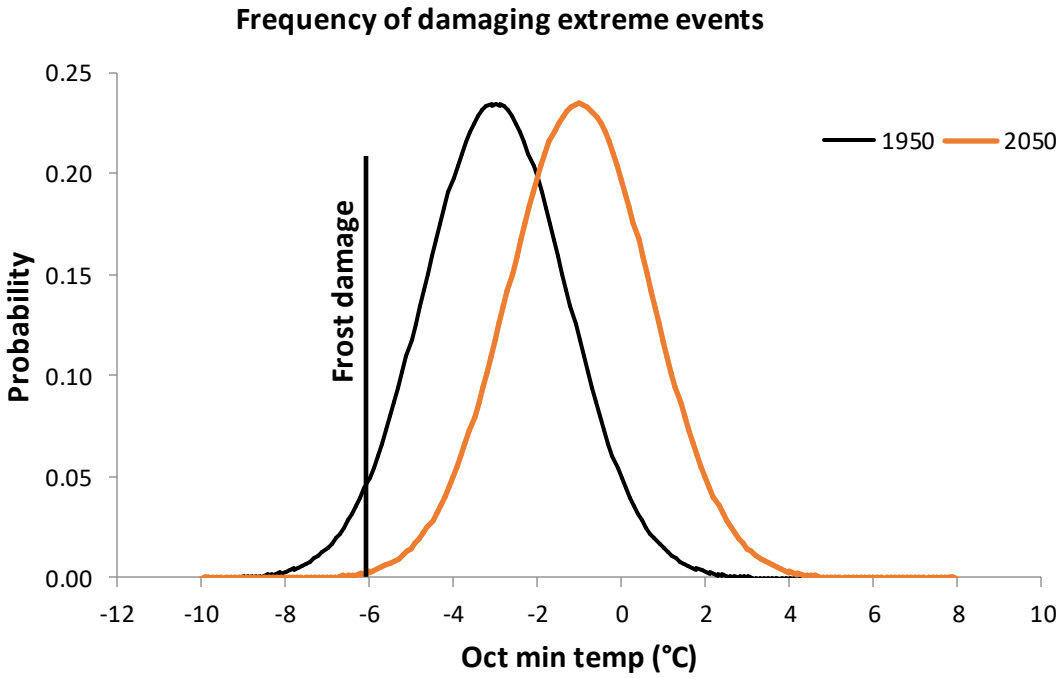
Team

- Jong Leung, Greg O'Neill

5. Extreme event study



5. Extreme event study



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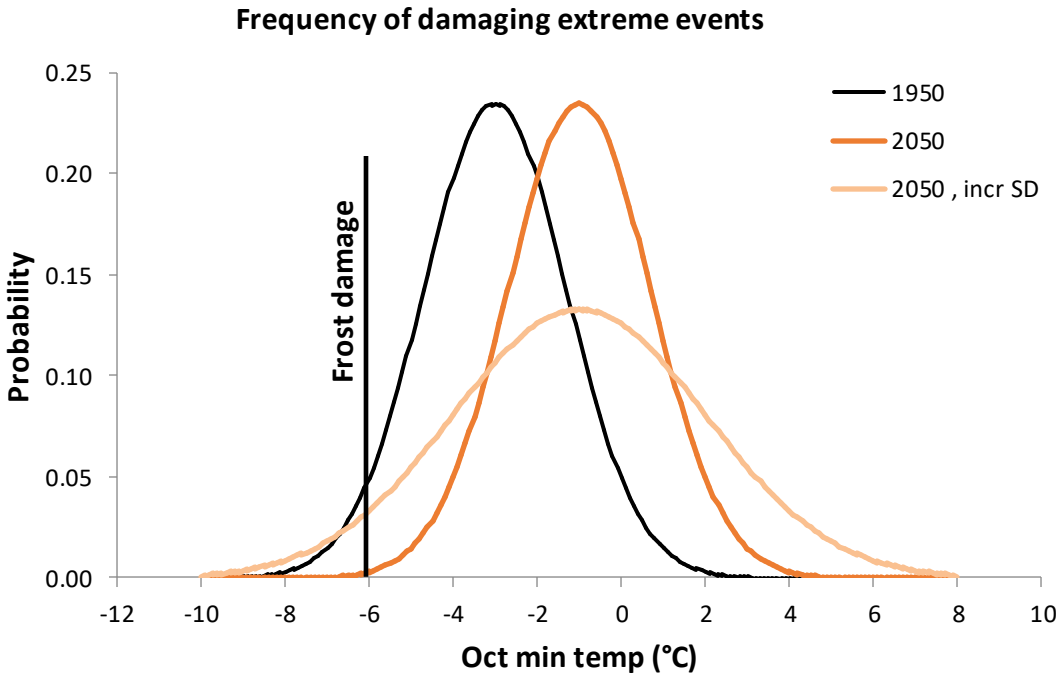
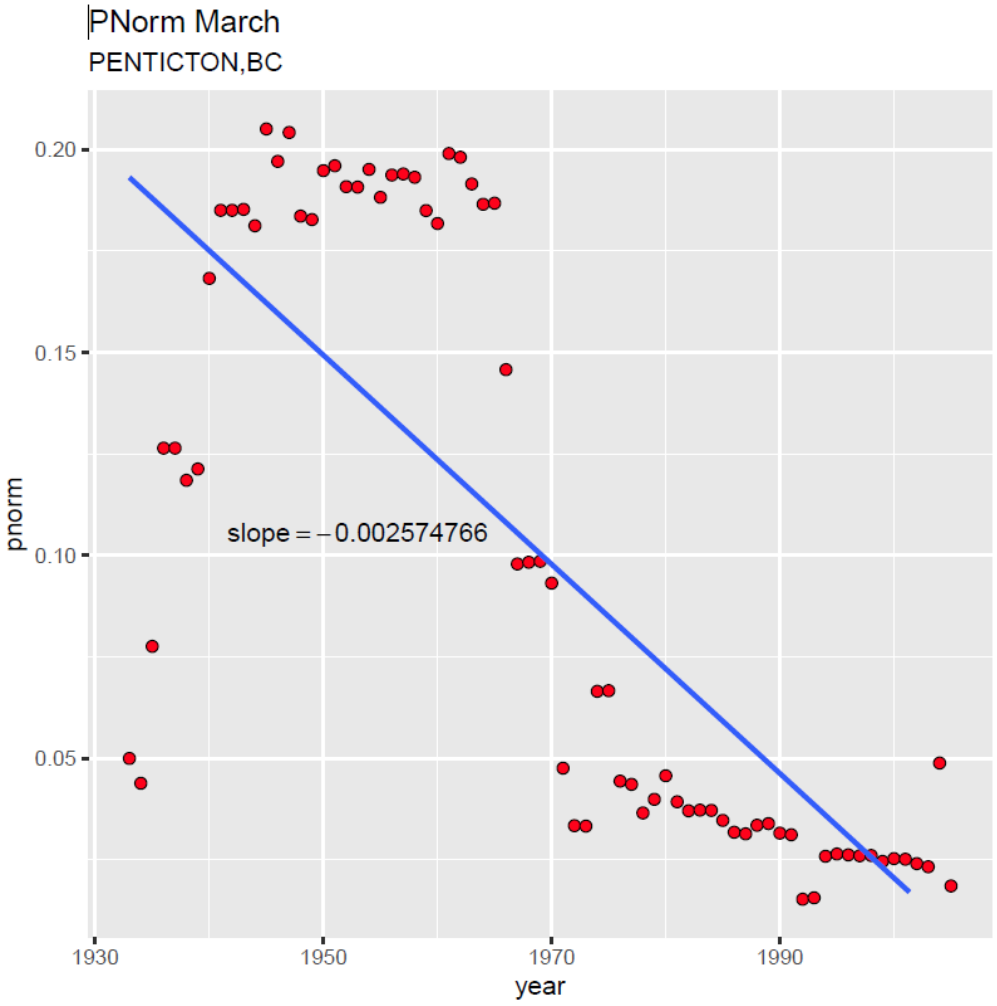
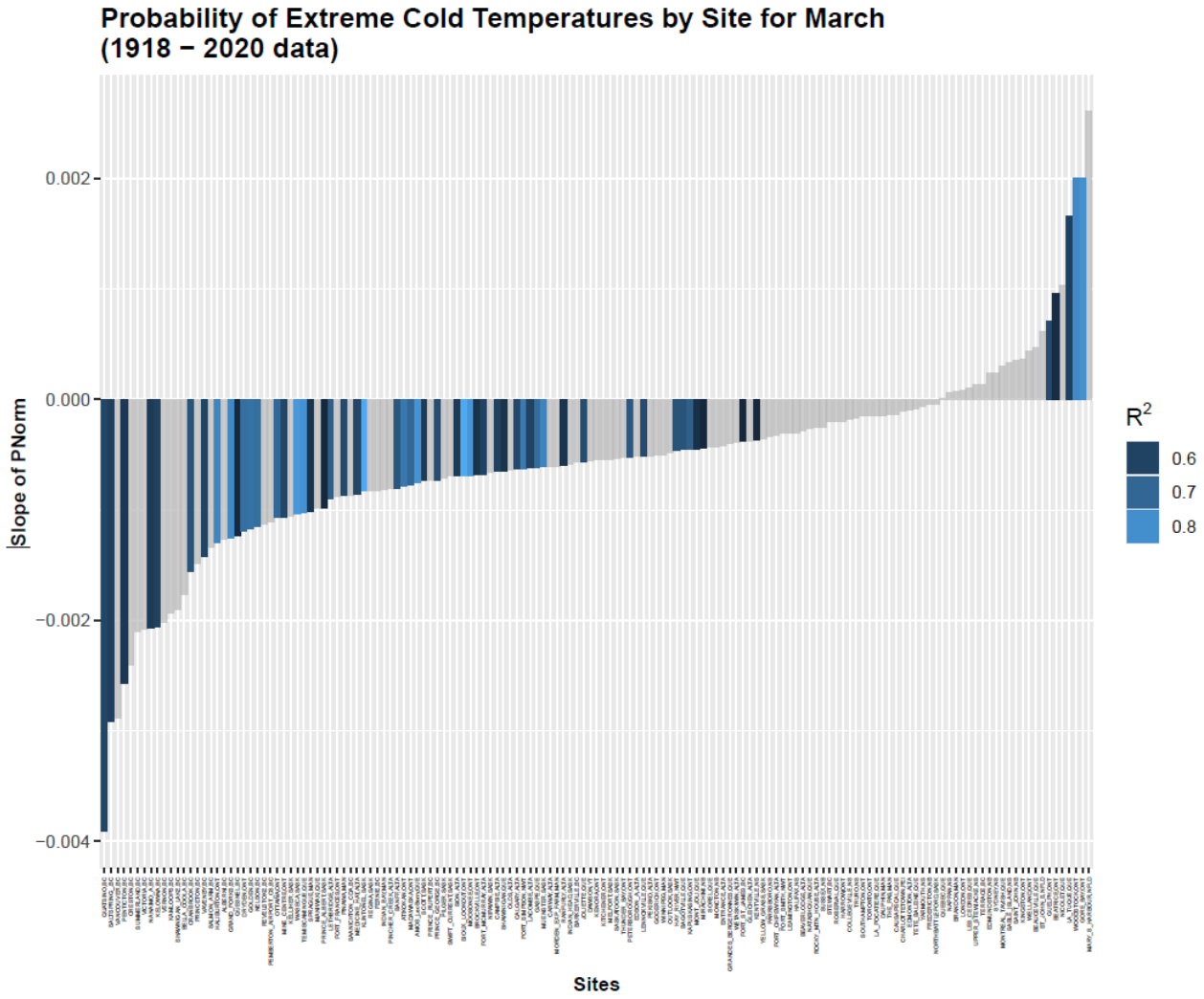


11. Trends in extreme minimum temperatures



11. Trends in extreme minimum temperatures



Climate Change Adaptation Research

Extension

2022 extension			
Date	**Audience**	**Title**	**Format**
2021			
Dec	UBC Forest Policy class	Implementing CBST in BC	classroom presentation (UBC)
Dec	UBC Forest Management class	Understanding assisted migration	webinar presentation
2022			
January	Idaho Woodlot Foresters Conference	AMAT and CBST	webinar presentation
March	Tree Improvement Alberta	Seedlot Selection Systems	webinar presentation
March	Alberta Forest Service	CBST	webinar presentation
March	CTAC	CBST update	webinar presentation
May	National Geographic Magazine	Relocating Trees	Magazine article (quotes)
June	WFGA/CFGA	AMAT	Field tour (Skimikin)
June	BCSOA	CBST/CC adaptation	presentation (Vernon)
June	International Biogeography Symposium	Assisted Migration and Species movement	presentation (Vancouver)
June	NW Tree Improvement Coop	CBST	webinar presentation (coauthor)
June	Tree Seed Working Group	CBST/CC adaptation	presentation (Sydney)
July	University of Idaho - Forestry Extension	Spirit Lake AMAT, Idaho	Field tour (presentation materials)
July	Columbia Insight Magazine	Forest Service Experimenting with relocating trees	Magazine article (quotes)
July	Research Management	AMAT/Sx field trials	Field tour (Kal)
July	Master of Pest Management (SFU)	demo and field trials	Field tour (Kal)
Sept	USA Today	Trees Can't Outrun Climate Change	Newspaper article (quotes)
Sept	UBC students	Illingworth field trip/provenance trial design/management	Field tour (Hado Lake)
Sept	Okanagan College	Provenance trial measurement and analysis	Field tour/lab
Sept	International researchers	Applications of multispectral imaging in Forest Genetics	presentation - Berlin (Grubinger)
Nov	Bulkley Valley Research Centre	CBST CC adaptation opportunities	webinar presentation
Dec	USDA Forest Service Geneticists	CC adaptation - the BC experience	webinar presentation
Dec	Mackenzie Silviculture Working Group	CBST and AMAT	webinar presentation

Thanks!

Photo: Mike Carlson