Climate Change & Emissions Management Corporation (CCEMC) and Tree Improvement Alberta (TIA) Workshop

Tree Improvement Alberta and CCEMC Tree Species Adaptation Risk Management Project Workshop

January 14th, 2015 8:00 AM – 4:00 PM; Jasper Room, Derrick Golf and Winter Club

Agenda:

CCEMC AM – *Moderator Dawn Griffin*

0800-0815	Registration & refreshments
0815-0830	Introductory comments/introductions/welcome – Shane Sadoway (TIA)
0830-0855	Project Highlights – Shane Sadoway (TIA)
0855-0955	Updates on provincial and controlled parentage program-specific climate change modeling and analysis – Laura Gray (CCEMC/TIA)
0955-1010	**Refreshment Break**
1010-1040	Mass propagation of trembling aspen project – intro by Barb Thomas (TIA) followed by Larry Lafleur (SLFN)
1040-1110	The effects of selective breeding on climate-related traits in spruce in Western Canada – Ian MacLachlan (AdapTree - UBC)
1110-1140	Social acceptance of assisted migration – Kevin Jones (AdapTree – UofA)
1140-1150	Overview of AB Innovates current funding initiatives – Cornelia Kreplin (AB Innovates)
1150-1200	Overview of CCEMC climate change mitigation and adaptation initiatives – Kirk Andries (CCEMC)
1200-1245	**Lunch (group photo)**

TIA PM – *Moderator Barb Thomas*

1245-1315	MPB genetics and climate change – Janice Cooke (UofA)
1315-1345	Diseases and climate change – Tod Ramsfield (CFS)
1345-1415	G&Y and genetic gain – issues and challenges – Darren Aitken (ESRD)
1415-1445	Updates on tree improvement initiatives, Forest Genetic Resource Management & Conservation Standards (FGRMS) review, and Alberta Forest Genetic Resources Council (AFGRC) – Deogratias Rweyongeza (TIA/ESRD)
1445-1500	**Refreshment Break**
1500-1515	FRIAA projects updates – Shane Sadoway & Kim Rymer (TIA)
1515-1525	TI Chair – Barb Thomas (UofA)
1525-1600	TIA next steps (summary of Business meeting) – Dawn Griffin (TIA)
1600	Wrap up.

Attendees:

Jean Brouard (WBAC), Jodie Krakowski (ESRD), Barb Thomas (UofA/TIA), Shane Sadoway (BRL/TIA), Dawn Griffin (Canfor/TIA), Christine Quinn (Canfor), Steve Blanton (MDFP), Peggy Pike (DMI), Deogratias Rweyongeza (ESRD/TIA), Bill Tinge (fRI), Diane Renaud (HWP), Garry Ehrentraut (NFPL), Greg Behuniak (Weyer), Dave Swindlehurst (Weyer), Kim Rymer (Al-Pac/TIA), Tim McCready (MWFP), Bob Winship (Weyer), Cornelia Kreplin (AB Innovates), Sharon Meredith (Sugarloaf/fRI), Terry Kristoff (WF), Andy Benowicz (ESRD), Katherine Spencer (ESRD), Sally John (HASOC), J.P. Bielech (HASOC), Laura Gray (CCEMC/TIA), Vic Lieffers (UofA), Darren Aitkin (ESRD), Amy Nixon (ABMI), Frazer Butt (DMI), Brett Purdy (AB Innovates), Larry Lafleur (SLFN), Tod Ramsfield (CFS), Pat Golec (WF), Angie Kuysters (Weyer), Amanda Schoonmaker (NAIT), Ian MacLachlan (UBC), Janice Cooke (UofA), Sima Mpofu (ESRD), Karalee Craig (SFP), Colleen Braconnier (Ainsworth), John MacLellan (Tolko), Susan Wood-Bohm (AI Bio/CCEMC), Kevin Jones (UofA), Alan Irwin (Copenhagen Business School), Kirk Andries (CCEMC), Yvette Thompson (ESRD), Tara Filliol (WBAC), and Daniel Chicoine (TIA).

Shane Sadoway (TIA) – Introductory comments and project highlights:

- Presentation attached

See Appendix 1_TIA_Workshop_Main.pdf for presentation.

Laura Gray (TIA/CCEMC) – Climate change risk management for commercial tree improvement programs in Alberta:

- Laura presented an update on her analysis and research about how climate change may impact the deployment of existing TI programs for pine, white spruce and black spruce; presentation attached
- Jean question: what about other climate data such as spring rains? Answer: Laura agreed that some of these were probably quite important and she would like to look at them.
- Jean question: how about lat's and long's as variables? Answer: Laura said that she hoped to be able to look at those too.
- Andy question: what about the out of province data? Answer: Laura mentioned that it is being looked at in a similar fashion.
- Someone asked about survival data: the analysis was based on height only and the assumption was that good growers were probably good survivors too. Deo mentioned that survival data is problematic since microsite and planting quality play a large part of the issue which is not genetically controlled.

See Appendix 2_Gray_CCRiskMgmt.pdf for presentation.

Barb Thomas (TIA) and Larry Lafleur (SLFN) – Mass propagation of trembling aspen:

- Barb introduced the mass propagation trial
- Larry presented some handouts on Smoky Lake Forest Nursery's experience with mass propagation of aspen using stacked styroblocks, presentation attached.
- Andy question: were any hormones used in the propagation? Answer was no.
- Deo question: trials will require material from all clones, are we going to be able to get enough from those that are poor rooters? Larry answered that if a clone was a great grower but a poor rooter there would likely not be as much material represented by that particular clone. Jean mentioned that the rootling through hydroponics method may be a better propagation tool for poor rooters.

See Appendix3_Lafleur_MassProp.pdf for presentation.

Ian MacLachlan (AdapTree, UBC) – The effects of selective breeding on climate related traits in spruce in western Canada:

- Ian described the AdapTree research on various seedlots grown in differing climatic conditions. Some of the materials tested were from Alberta seedlots (bulk wild and improved lots). Presentation attached.
- Sally question: early growth rate depends on seed weight? Answer: they looked at that and the correlation was poor so they are ignoring it.
- Barb question: were these bulk or individual collections? Answer: both so they cannot be separted.
- Jean question: latitude is an issue, so should we include day length and heat? Answer: it was all grown in one location so cannot look into that.
- Sally question: how did you achieve the -22C? Answer: in a freezer chamber.
- Larry observation: when measuring seedlings in the nursery they found that continuous measurements damaged the seedlings and they grew worse than unmeasured seedlings. Response: they were all measured on the same schedule so the damage should be consistent.
- Diane question: the cold treatment in Vancouver was different than cold in the real world? Answer: yes but the intent of the project was to test differences in response due to genetic differences not GxE (interactions of genetics and the environment in which they are grown).

See Appendix4_MacLachlan_AdapTree.pdf for presentation.

Kevin Jones (AdapTree, UofA) – Social acceptance of assisted migration:

- Kevin presented the study they are working on to assess the social acceptance of reforestation climate adaptation strategies. Presentation attached.

See Appendix5_Jones_AdapTree.pdf for presentation.

Cornelia Kreplin (AB Innovates, BioSolutions) – Overview of AB Innovates current funding initiatives:

- Presentation attached.

See Appendix6_Kreplin_AIBio.pdf for presentation.

Kirk Andries (CCEMC) – Overview of CCEMC climate change mitigation and adaptation initiatives:

- The presentation focused on the CCEMC goals, funds, and future direction. Presentation attached.
- Bob question: this round of funding is drawing to an end soon, what is the future? Answer: adaptation is very important to CCEMC, possibly adaptation may be more important than sequestration since climate is going to change in any case. Therefore funding may be available. The process of getting projects may be different than last time, it may be a call for proposals. The proposals will have to be aligned with CCEMC goals. The report on this project may help to show the importance of the results and the future work required.
- Deo comment: most of the last Grand Challenge funding went to US organizations, why not support local researchers and institutions? Response: They found that they were not getting any game changing ideas locally after the first few rounds and that they could go anywhere in the world to get transformative technology ideas but they must be able to be adopted/applied locally and there is a requirement for the project to be implemented in Alberta.
- Barb question: the first round of funding was not based on the usual level of matching funding requirements and in-kind, would this change in a second round? Answer: it may not be 1:1 in a next round but it would be more than the last one.

See Appendix7_Andries_CCEMC.pdf for presentation.

Janice Cooke (UofA) – MPB genetics and climate change:

- Janice presented a large amount of information on MPB and its interaction with both jack and lodgepole pine (and hybrids) and climate. Presentation attached.

See Appendix8_Cooke_MPB.pdf for presentation.

Tod Ramsfield (CFS) – Climate change and forest pathogens in Alberta:

- Todd discussed how climate change might impact both tree species and pest species distributions. Presentation attached.
- Jean question: was Phellinus found on older or younger trees? Answer: older mostly but not always.

See Appendix9_Ramsfield_Pathogens.pdf for presentation.

Darren Aitkin (ESRD) – Growth & yield and genetic gain – issues and challenges:

- Darren described the processes and issues with including genetic gain into forest management plans. Presentation attached.
- Sally question: will TI be singled out in G&Y? Answer: yes, the regenerated yield curves will include TI curves specifically.
- Sally question: with double digit gains coming, will this increase the priority in finding more robust methods on including TI in G&Y? Answer: uncertain, Darren is to be informed about an upcoming workshop on this topic.
- Jean question: North Carolina did a lot of this work 50 years ago, why are we still being so conservative? Answer: this was more of a statement than a question – no answer provided.

See Appendix10_Aitkin_G&Y.pdf for presentation.

Deogratias Rweyongeza (ESRD) – Updates on tree improvement initiatives, FGRMS review, and AFGRC:

- Deo provided updates to the three items mentioned. Presentation attached.
- Brett comment: There was a comment that we need to include gaps in scientific knowledge into FGRMS and the AFGRC report as that makes it easier to get funding from government.

See Appendix 1_TIA_Workshop_Main.pdf for presentation.

Shane Sadoway (TIA) and Kim Rymer (TIA) – FRIAA funding updates:

- Shane and Kim provided updates on the funding and projects under the FRIAA tree improvement program. Presentation attached.

See Appendix 1_TIA_MainPresentation.pdf for presentation.

Barb Thomas (UofA) – Update on the TI chair at the UofA:

- Presentation attached.

See Appendix 1_TIA_MainPresentation.pdf for presentation.

Dawn Griffin (TIA) – TIA next steps and summary of the business meeting:

- Dawn provided a summary of the business meeting of the Tree Improvement Alberta held the previous evening. Presentation attached.

See Appendix 1_TIA_MainPresentation.pdf for presentation.

TIA members at workshop

A select few pictures of Leonard Barnhardt (former TIA BOD member, ESRD – retired) in the good old days!

Appendix 1: TIA_Workshop_Main

Tree Improvement Alberta

January 14, 2015 8 AM – 4 PM

Workshop Agenda:

8:00-8:15am	Registration & refreshments
8:15-8:30am	Welcome and introductory comments - Shane Sadoway (TIA)
8:30-8:55am	Project highlights – Shane Sadoway (TIA)
8:55-9:55am	Updates on provincial and controlled parentage program-specific climate change modeling and analysis - Laura Gray(CCEMC/TIA)
9:55-10:10am	**Refreshment Break**
10:10-10:40am	Mass propagation of trembling aspen project – intro by Barb Thomas (TIA) followed by Larry Lafleur (SLFN)
10:40-11:10am	The effects of selective breeding on climate-related traits in spruce in Western Canada – Ian MacLachlan (AdapTree - UBC)
11:10-11:40am	Social acceptance of assisted migration – Kevin Jones (AdapTree - UofA)
11:40-11:50pm	Overview of current funding initiatives – Cornelia Kreplin (AB Innovates)
11:50-12:00pm	Overview of cc mitigation & adaptation initiatives - Kirk Andries (CCEMC)
12:00-12:45pm	**Lunch (group photo)**
12:45-1:15pm	MPB genetics and climate change – Janice Cooke (UofA)
1:15-1:45pm	Diseases and climate change – Todd Ramsfield (CFS)
1:45-2:15pm	G&Y and genetic gain – issues and challenges – Darren Aitken (ESRD)
2:15-2:45pm	Updates on TI Initiatives – Deogratias Rweyongeza (TIA/ESRD)
2:45-3:00pm	**Refreshment Break**
3:00-3:15pm	FRIAA project updates - Shane Sadoway and Kim Rymer (TIA)
3:15-3:25pm	TI Chair – Barb Thomas (UofA)
3:25-4:00pm	TIA Next Steps - Dawn Griffin (TIA)
4:00pm	Wrap-up

Welcome and Introductions:

- Ian MacLachlan – AdapTree (UBC)
- Kevin Jones – AdapTree (UofA)
- Janice Cooke – University of Alberta
- Todd Ramsfield – Canadian Forest Service
- Kirk Andries – Climate Change & Emissions Management (CCEMC) Corporation
- Cornelia Kreplin – AB Innovates, BioSolutions
- Darren Aitken - Alberta Environment and Sustainable Resources Development

Project Highlights
Shane Sadoway (TIA)

Project Background:

Project Title: Tree Species Adaptation Risk Management
- $3,000,000 approved project funding (April 2012 – July 2015)
- Grant agreement between foothills Research Institute (fRI) & CCEMC
- Project managed by Tree Improvement Alberta

Primary Project Objectives:
- Testing wild populations for climatic tolerance
- Assessing climate change adaptation needs for tree improvement programs

Project Highlights

- **Adaptation Test Sites (Coniferous and Deciduous)**
  - Historic Provenance Trials in Alberta were designed to determine how climate and other environmental conditions affect performance (survival, growth and reproduction) of trees when planted away from their site of origin.
  - Were designed to test variation in the most productive environments, assuming a static climate.

Development of provenance trial sites – developing new field experimental sites to:

a) Test wild and orchard populations of native species for climatic tolerance, especially drought.
b) Test wild populations of non-native species that have potential to be substitute for Alberta native commercial species if the latter were to fail due to climate change.

Project Highlights

- **Adaptation Test Sites (Coniferous and Deciduous)**

Four Coniferous – Northern Dry Mixedwood, Northern Sub-alpine, Southern Sub-alpine, and Central Parkland.
• Site access, preparation and fencing completed or underway on all except Southern Sub-alpine site.

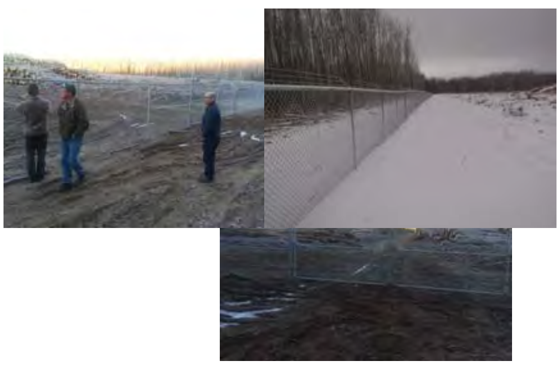
Four Deciduous – HRA (N of High Level), Grande Prairie area, Cowpar (NE of Lac La Biche), and Stevens Ck (W of Rocky Mountain House).
• Legal survey, site access, and application for disposition underway on all sites. No site preparation or fencing scheduled as of yet given the lack of current funding.

Map of Adaptation Test Sites

Coniferous
•Machesis (N. Dry Mxwd)
•Muskeg (N. Sub-alpine)
•Coleman (S. Sub-alpine)
•Brooks (Central Parkland)

Deciduous
•HRA (N. Dry Mxwd)
•Cowpar (Central Mxwd)
•Grande Prairie (Dry Mxwd)
•Stevens Ck (Lower Foothills)

Photos of Coniferous Test Site at Brooks Alberta (Central Parkland)



Photos of Coniferous Test Site at Machesis (Northern Dry Mixedwood)

Photos of Coniferous Test Site at Muskeg (Northern Sub-alpine)

CCEMC

TIA

Project Highlights

- **Review of Controlled Parentage Program (CPP) Plans**

Twenty-one Coniferous CPPs – Reviewed and template populated.

Three Deciduous – Reviewed and template populated.

- **Analysis of measurement data (update provided by Laura Gray)**

CPP Reviews - Table of CPP Ownership

CPP Program	Species	Seed Share Ownership	Research Partners
A	Pl	West Fraser (HWP)	West Fraser (HWP)
B1	Pl	HASOC (ANC 22.3%, Canfor 37.5%, Weyer 40.2%)	ANC, Canfor, ESRD, Weyer
B2	Pl	HASOC (HWP 46.7%, Weyer 53.3%)	ESRD, HWP, Weyer
C	Pl	West Fraser (BRL)	BRL, ESRD
K1	Pl	West Fraser (Sundre)	ESRD, Sundre
J	Pl	FGAA (MDFP, ESRD, Tolko)	ESRD, MDFP, Tolko
P1	Pj	FGAA (Northland, ESRD)	ESRD, Northland
M	Lw	ESRD	ESRD
D	Sw	West Fraser (BRL)	BRL, ESRD
D1	Sw	ESRD	ESRD
E	Sw	ESRD	ESRD
E1	Sw	FGAA (Northland)	ESRD, Northland
E2	Sw	ESRD	ESRD
G1	Sw	HASOC (Canfor 50%, Weyer 50%)	Canfor, ESRD, Weyer
G2	Sw	FGAA (MDFP, ESRD, Tolko)	ESRD, MDFP, Tolko
H	Sw	ESRD	ESRD
I	Sw	HASOC (ANC 6.6%, HWP 31%, MWFP 32.4%, Weyer 30%)	ANC, ESRD, HWP, MWFP, Weyer
F1	Fdi	ESRD	ESRD
L1	Sb	HASOC (ANC, HWP, MWFP)	ANC, ESRD, HWP, MWFP
L2	Sb	HASOC (Canfor 50%, Weyer 50%)	Canfor, ESRD, Weyer
L3	Sb	ESRD	ESRD
Pb1	Pb	Al-Pac	Al-Pac, ESRD
Aw1	Aw	WBAC (Ainsworth, DMI, Weyer)	Ainsworth, DMI, Weyer
Aw2	Aw	WBAC (Ainsworth, DMI, Weyer)	Ainsworth, DMI, Weyer

Project Highlights

- **Measurements Completed**

Coniferous – 29 trials (lodgepole pine, jack pine, white spruce, black spruce, and scots pine).

Deciduous – 16 trials (trembling aspen and balsam poplar – provenance and progeny).

Project Highlights

- **Clone/Family Orchard Seed Collections for Field Testing/Conservation Completed**

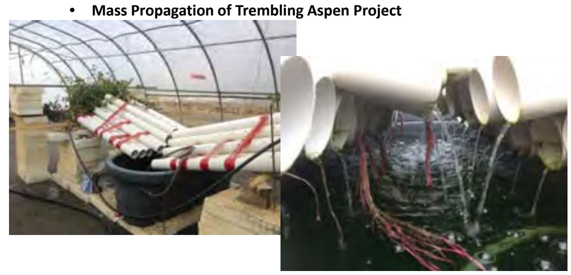
Over 732 individual clones/families collected (lodgepole pine, jack pine, white spruce, and black spruce).

Project Highlights

- **Mass Propagation of Trembling Aspen Project**

Project Highlights

- **Mass Propagation of Trembling Aspen Project**



Project Highlights

- Key Learnings, opportunities, challenges, & linkage to Public Policy
  - Massive searchable database of our trials, sites, and parents in tests.
  - Individual family/clone collections for all parents in seed orchards available for use in research, assisted migration, breeding, and conservation.
  - Provincial view of tree improvement programs and integration – degree of overlap of testing and breeding region exceeded expectation – in order to address climate change adaptation and transfers.

Update on Provincial and Controlled Parentage Program-Specific CC Modeling and Analysis

Laura Gray (CCEMC/TIA)

Morning Refreshment Break

Mass Propagation of Trembling Aspen Project
Barb Thomas (UofA) & Larry Lafleur (SLFN/TIA)

Mass Propagation of Trembling Aspen Project

Overview:

1. Project I: The development and production of ~ 4000 rooted cuttings from ~ 25 clones from each aspen CPP.
   - 30 clones/AW region provided over 2-years
   - 2 nurseries contracted to complete the work (Woodmere & Bonnyville+SLFN) developing/refining mass propagation methodology
   - Each nursery to provide an economic analysis of protocol with a target of producing an OWD plug @40-50 cents each
2. Project II: A detailed study by SLFN of the stacked styro-block technique using 11 preselected clones from AW2 (southern region).

Mass Propagation of Trembling Aspen Project

Anticipated outcomes:

1. An analysis of the economic viability of this technology/protocol for mass propagation of selected best aspen clones.
2. Sufficient materials from both AW1 & AW2 to install two types of field trials in new test sites:
   1. Clonal block planting (0.5ha blocks of 18 clones)
   2. Mixed block planting (1.0 ha mixed blocks of 18 clones)

The Effects of Selective Breeding on Climate-Related Traits in Spruce in Western Canada
Ian MacLachlan (AdapTree, UBC)

<u>Social Acceptance of Assisted Migration</u>
Kevin Jones (AdapTree, U of A)

<u>Overview of AB Innovates Current Funding Initiatives</u>
Cornelia Kreplin (AB Innovates - BioSolutions)

<u>Overview of CCEMC CC Mitigation and Adaptation Initiatives</u>
Kirk Andries (CCEMC)

<u>Lunch</u>
Group photo

<u>MPB Genetics and Climate Change</u>
Janice Cooke (U of A)

<u>Diseases and Climate Change</u>
Todd Ramsfield (CFS)

Growth & Yield and Genetic Gain – Issues and Challenges
Darren Aitkin (ESRD)

Updates on Tree Improvement Initiatives & Reviews of Forest Genetic Resource Management & Conservation Standards
Deogratias Rweyongeza (ESRD)

UPDATES FROM ESRD, GENETIC COUNCIL AND FGRMS REVIEW

Deogratias Rweyongeza, ESRD

January 13 – 14, 2015

Environment and Sustainable Resource Development (ESRD) -Update

ATISC Manager –Leonard Barnhardt is retiring on January 16, 2015

1. New manager is not yet recruited –process underway.
2. To contact ATISC manager send emails to Pearl Gutknecht (Pearl.Gutknecht@gov.ab.ca) and copy Deogratias Rweyongeza (Deogratias.Rweyongeza@gov.ab.ca).
3. Forest Management Branch will appoint Leonard's replacement to TIA, genetic council, etc.

Staff changes

1. Erica Samis (Senior Manager) –Forest Health and Adaptation Section.
2. Jodie Krakowski (Geneticist) – takes conservation and species recovery tasks where Leonard was a lead.
3. Sima Mpofu (Program Service) –handle the business side of TI programs.
4. Arvind Cheniveerappan (Arvind) –new ATISC grower.
5. Tom Hutchinson (Senior Forest Health Officer) –with the Forest Health and Adaptation Section in Edmonton.

Alberta Forest Genetic Resources Council -Update

Alberta Forest Genetic Resources Council (RGFC) currently engaged in

1. Working on the council biennial report to be published in 2015
2. Updating the council website
3. Working to draft a long-term council strategic business plan with input/guidance from ESRD (FMB) – what will be the role of FGRC in tree improvement; growth and yield; adaptation to climate change; overall basic and applied research in forest genetics; reclamation, etc.?
4. Coordinating the review of Alberta Forest Genetic Resource Management and Conservation Standards (FGRMS) –to be republished in 2015.
5. There are vacant positions to be filled in FGRC –e.g., replacement for Leonard Barnhardt and Barb Thomas –council and FMB will work on this.

Alberta Forest Genetic Resource Management and Conservation Standards (FGRMS) -Update

FGRMS review is ongoing –major additions to the existing standards will be:

1. Standards for planting (deployment) of clonal species such as aspen on crown land.
2. Regulating collection and use of seed and/clones of shrubs for reclamation purposes.
3. An option for establishing seed zone-based Stream 1 seed orchards for easier procurement of reclamation seed –shrub users would benefit from this option.
4. An option for establishing a species-specific seed zone supported by provenance trial –shrub users would benefit from this option.
5. Genetic diversity (effective population) requirements that would enable deployment of Stream 2 (genetically improved) seed to more that 50% of the breeding region target strata.
6. Making FGRMS user-friendly by -will publish (a) a Stream 1 only manual and (b) a combined Stream 1 and Stream 2 manual.
7. Etc.

Afternoon Refreshment Break

FRIAA Project Updates
Kim Rymer and Shane Sadoway (TIA)

Updates

- **Deciduous FRIAA Funding**

Al-Pac: work on BP1 – CPP
- Trial installation, maintenance & measurements
- Material production

WBAC: work on Aspen CPPs
- Trial maintenance & measurement
- Arboretum & orchard care
- Selection & propagation of progeny

Updates

- **Deciduous FRIAA Funding**

Phase I - 2012-2014, Weyer managing (WBAC),
Total $500,000 (Completed)
Phase II - 2014-2015, Al-Pac managing (Kim Rymer),
Total $300,000 ($80,000 paid to date)
Funds split 50:50 between Al-Pac & WBAC
5% administration fee to managing company

In Phase II $10,000 set aside to support the TIA program manager in 2015.

Updates

- **Coniferous FRIAA Funding**

Support for Forest Industry Coniferous Tree Improvement Programs

Phase 1 – 2012-2014 (completed)

$500,000 project funding

Project Sponsors
- Alberta Newsprint Company
- Blue Ridge Lumber
- Canadian Forest Products
- Hinton Wood Products
- Manning Diversified Forest Products
- Millar Western Forest Products
- Sundre Forest Products
- Weyerhaeuser

Updates

- **Coniferous FRIAA Funding**

Support for Forest Industry Coniferous Tree Improvement Programs

Phase 2 – 2014-2015 (ongoing)

$300,000 project funding ($100,000 paid to date)

Request for data for 2014 annual report sent out, to be submitted to FRIAA early February

- **$10,000 to support TIA project manager activities to December, 2015**

Industrial Research Chair in Tree Improvement
Barb Thomas (U of A)

Update

- **NSERC Industrial Research Chair in Tree Improvement**

NSERC site visit held April 9th, 2014. Notice of success late June 2014.

Started at UofA – September 1st, 2014.

Partners include:
Al-Pac, ANC, Canfor, Millar Western
Forest Genetics Fund held at UofA
West Fraser (AB Plywood, BRL, HWP, Sundre)
Weyerhaeuser (Grande Prairie & Pembina)

ESRD (not matched with NSERC funds)

Project Updates

1.0 Deciduous Tree Improvement Programs – Basic Research:

1.1 Patterns and mechanisms driving clone size and gender performance in aspen in Alberta. (PhD) – **open**

1.2 Assessing the potential for hybrid vigour within a species: disparate population breeding of balsam poplar. (PhD) – **open, in discussions**

Project Updates

2.0 Coniferous Tree Improvement Programs – Applied Research:

2.1 **Assessing drought resistance and genetic variation in lodgepole and hybrid pine. (PDF)**
Dr. Raul de la Mata – May 2015 (starting early due to availability of candidate)

2.2 Trade-offs between wood density, drought resistance and growth for breeding programs based on comparisons of parent trees, progeny trials and adjacent wild stands. (MSc) – Sept. 2016

2.3a Enhancing flowering and seed production in lodgepole pine orchards. (PhD)
Mr. Yadvinder Bhardwaj – September 2015 (project to commence summer 2015)

2.3b Parental selection and assessing the impact of elite breeding in a white spruce program. (PhD) – Sept. 2016

Project Updates

3.0 Realize the Benefits of Tree Improvement Programs – Provincial Models:

3.1 Develop alternative models to incorporate genetic gain into growth and yield projections. (originally PhD)

Dr. Suborna Ahmed – August 2015 (converted to a PDF due to availability of candidate)

3.2 Determine the value (economic and social) of tree improvement in Alberta. (PDF) – **open & seeking a candidate**

TIA Next Steps (Summary of Business Meeting)
Dawn Griffin (TIA)

Summary of TIA Business Meeting

- CCEMC Work Plan Update provided to members
- Proposed Tree Improvement and Growth & Yield Merger update
- Tree Improvement Initiative update from ESRD
- FRIAA Tree Improvement Funding update
- Alignment of Climate Change Adaptation Activities with TIA Priorities

Wrap-up
Shane Sadoway (TIA)

Leonard in 1978
Picked up Shirley (wife) with his good looks

Leonard in 1985
It appears a razor and hair cut may have occurred

Appendix 2: Gray_CCRiskMgmt

Climate change risk management for commercial tree improvement programs in Alberta

Project Update

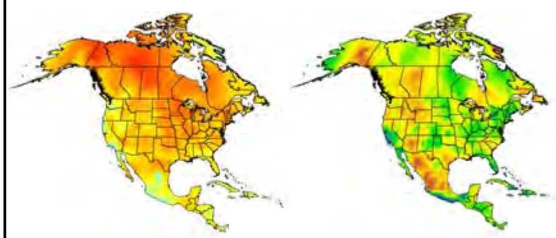
Laura Gray, Ph.D. P.Stat., A.Ag.
Andreas Hamann, Daniel Chicoine, Leonard Barnhardt, Kim Rymer, Deogratias Rweyongeza, Barb Thomas, Dawn Griffin, Shane Sadoway, Sally John

Tree Improvement Alberta Workshop
Wednesday January 14th, 2015
Edmonton, Alberta

CCEMC Climate Change and Emissions Management (CCEMC) Corporation

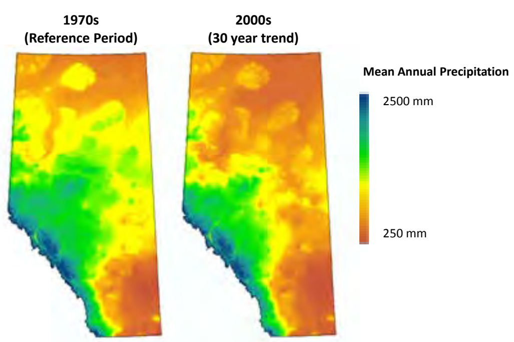
TIA

Shifts in temperature and precipitation over the last 30 years



Temperature: 0 to +5°C   Precipitation: -20 to +20%

Climate change already impacting annual precipitation



Hamann. (2009). The Role of Adaptation in Forest Management. AFGRC. www.abtreegene.com/toolkit/resources.html

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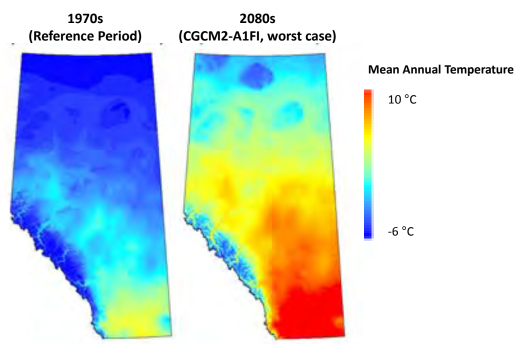
Significant temperature changes are projected for Alberta



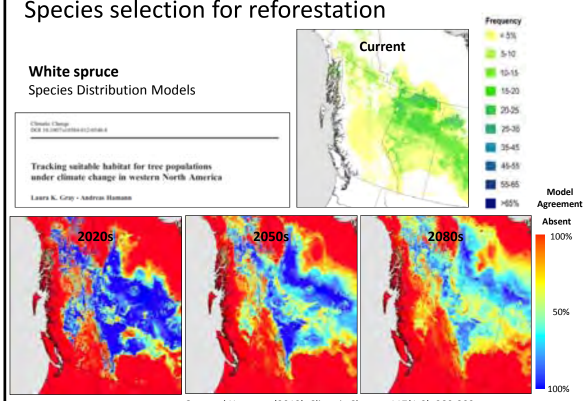
Hamann. (2009). The Role of Adaptation in Forest Management. AFGRC. www.abtreegene.com/toolkit/resources.html

---

Key questions for reforestation under climate change

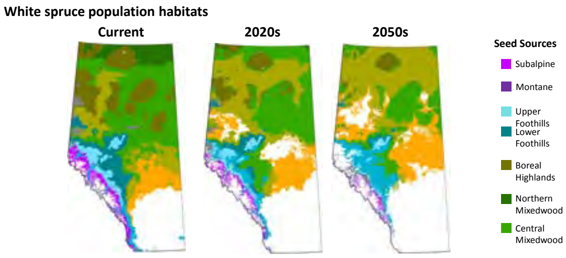
- What species should we plant?
  - What is the uncertainty in species occurrence under climate change?
- What populations will be best adapted?
  - Is there currently local mal-adaptation?
  - How will populations perform under temperature and precipitation changes?

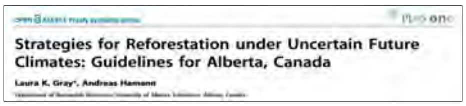
Species selection for reforestation



Gray and Hamann. (2013). Climatic Change. 117(1-2): 289-303.

Population selection for reforestation




Strategies for Reforestation under Uncertain Future Climates: Guidelines for Alberta, Canada

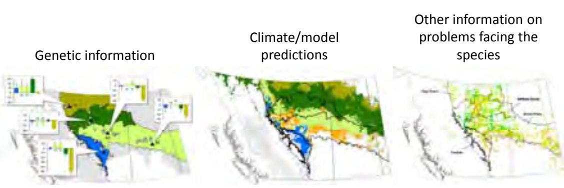
Laura K. Gray*, Andreas Hamann

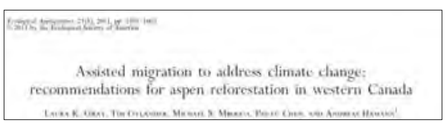
Gray and Hamann. (2011). PLoS One. 6(8): e22977.

Key questions for reforestation under climate change

- What species should we plant?
  - What is the uncertainty in species occurrence under climate change?
- What populations will be best adapted?
  - Is there currently local mal-adaptation?
  - How will populations perform under temperature and precipitation changes?

Synthesizing multiple sources of information for practical decision making




Assisted migration to address climate change: recommendations for aspen reforestation in western Canada

Gray *et al*. (2011). Ecological Applications. 21(5): 1590-1603.

Project tasks

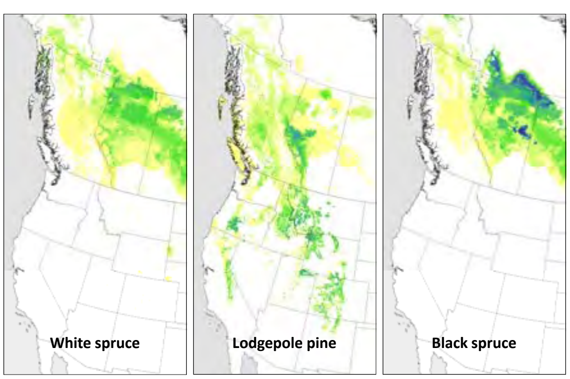
- **Task #1**: Genetic analysis of CPP trial data
  List of non-matching and non-stable parental material that can be used as information to rogue seed orchards and/or modify breeding populations

  Criterion:
  #1: Collection performs badly in origin region
  #2: Performance worsens under seed transfer
  #3: Comes from a colder pocket within the CPP region and performs badly under current or transfers into a warmer CPPs region

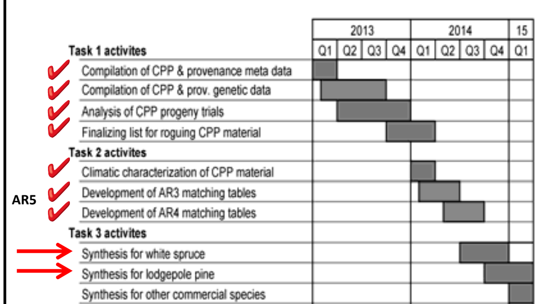
- **Task #2**: Multivariate matching of source and target climates
  Recommendation tables which outline:
  - Where available seed can be safely planted? (deployment)
  - Where seed should be collected for particular planting sites? (procurement)

- **Task #3**: Synthesis of information
  Tables/publications identify which climate change adaptation measures have a high probability of success

Commercially important tree species



Project timelines

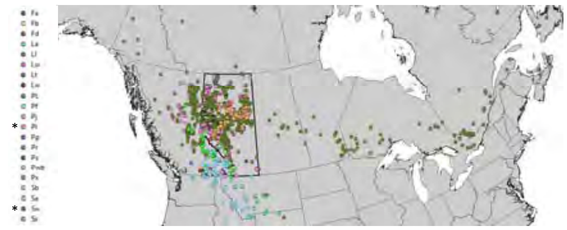


Provenance & progeny field sites – pine & spruce

Details

- 17 provenance sites
- 37 progeny sites
- 14 sites with both provenance and progeny sites present
- 33 additional sites (not displayed)

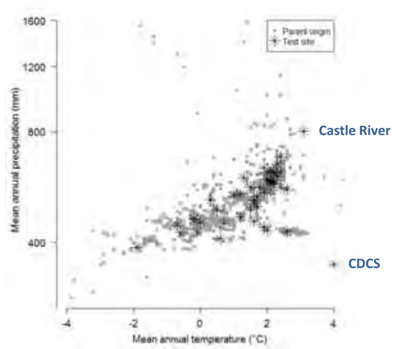
Species collections



Details

- Masterfile contains 5424 individual collections (all species)
- 1338 white spruce collections used in analysis
- 1904 Lodgepole pine collections used in analysis

Collection vs site climate – white spruce



Key findings - preliminary work

- DEM well correlated with recorded elevation, but some outliers
- ≤250m DEMs appeared to better represent the data & filled in the gaps
- Climate generation with 250m DEM values

- Test site climates are a good representation of collections
- The majority of test sites are “within the cloud” for collections

Measurement master files

White Spruce

- 135,485 individual trees in 48 Trials
- Measurement records for ages 4 to 32 years (not for all trials)

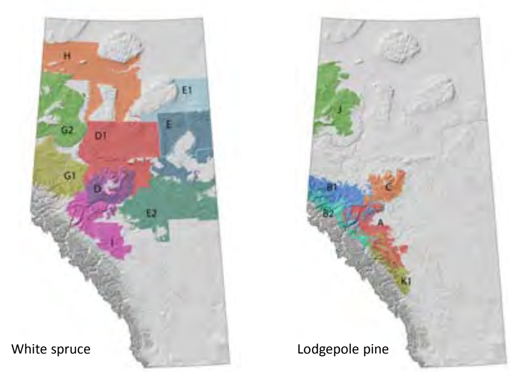
Lodgepole Pine

- 139,874 individual trees in 43 Trials
- Measurement records for ages 4 to 30 years (not for all trials)

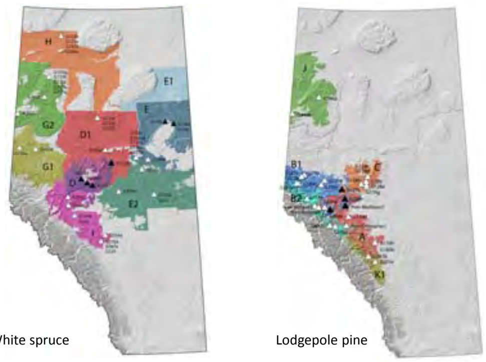
Black Spruce

- 3,816 individual trees in 2 Trials
- Measurement records for ages 10 to 25 years (not for all trials)

Controlled Parentage Program Regions

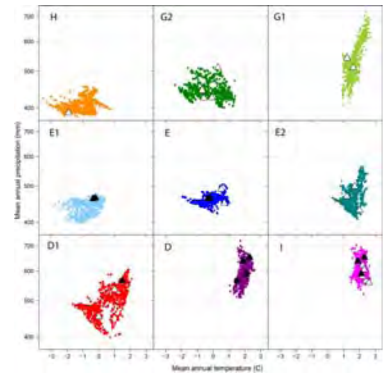


Test sites in the CPP regions

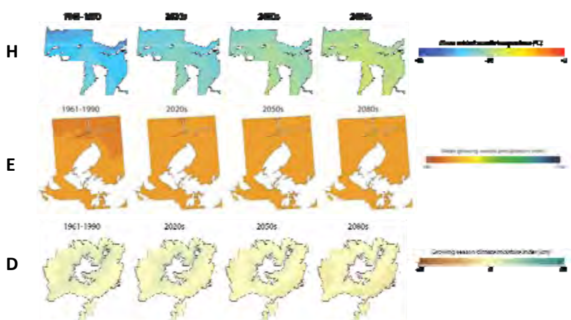


CPP region vs Site Climate – White spruce

- Test site climate are an okay-to-good representation of CPP regional climate
- But there are a few exceptions (e.g. H, E1, D1)

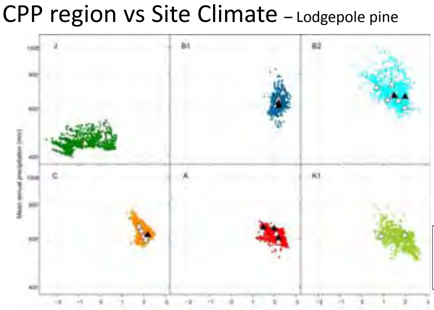


Future climate projections – white spruce



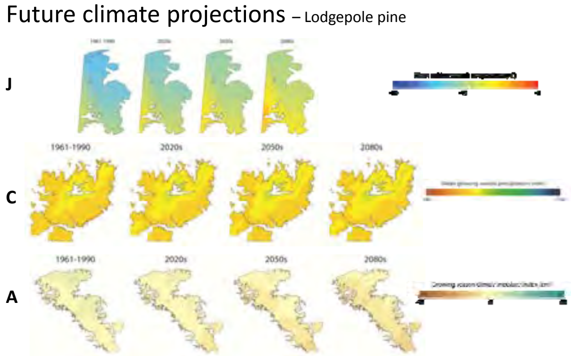
Climate projection summary report available upon request – All CPPs available
Contact Daniel Chicoine

CPP region vs Site Climate – Lodgepole pine



- Test site climate are an okay-to-good representation of CPP regional climate
- But there are a few exceptions (e.g. J, K1)

Future climate projections – Lodgepole pine

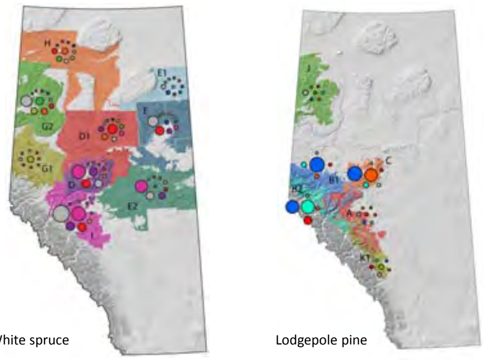


Climate projection summary report available upon request – All CPPs available
Contact Daniel Chicoine

Key findings - climate work

- Test site climates are a good representation of CPP regions – with a few exceptions
- The majority of test sites are "within the cloud" for CPPs
- For climate change in the CPP regions
  - Warming winter temperatures in the north
  - Drier conditions across the province, especially in the southern regions

Transfers among the CPP regions

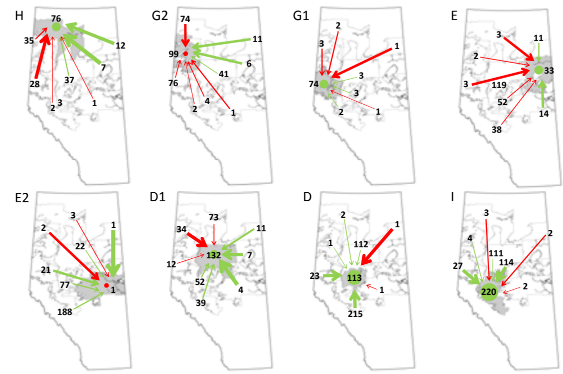


White spruce

Lodgepole pine

Transfers – White spruce

RED/GREEN = Poor/Good Performance
Thickness of arrow indicates magnitude
Number of collections transferred provided



Transfers – White spruce

RED/GREEN = Poor/Good Performance
Thickness of arrow indicates magnitude
Number of collections transferred provided

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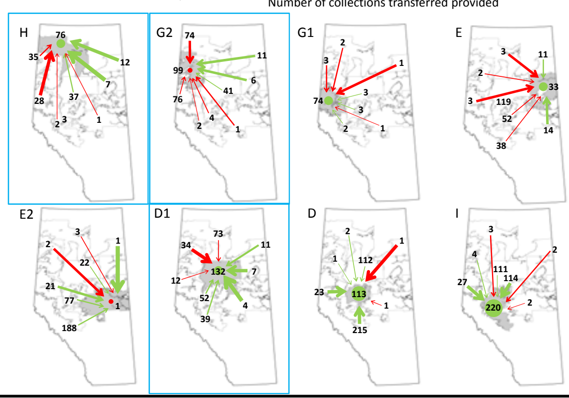
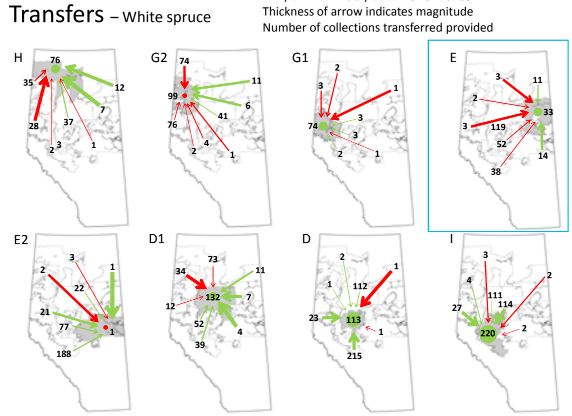
Number of collections transferred provided



Transfers – White spruce

RED/GREEN = Poor/Good Performance
Thickness of arrow indicates magnitude
Number of collections transferred provided



Transfers – White spruce

RED/GREEN = Poor/Good Performance
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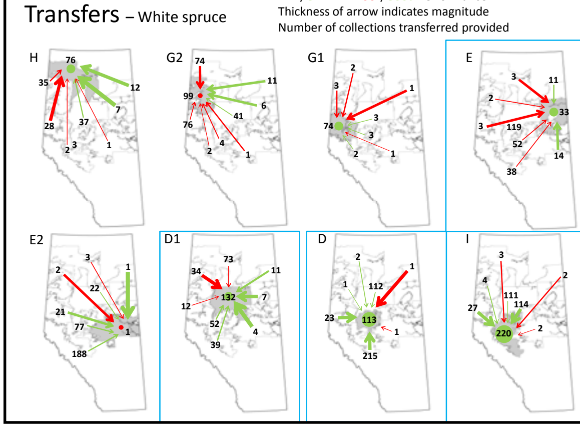
Number of collections transferred provided



Transfers – White spruce

RED/GREEN = Poor/Good Performance
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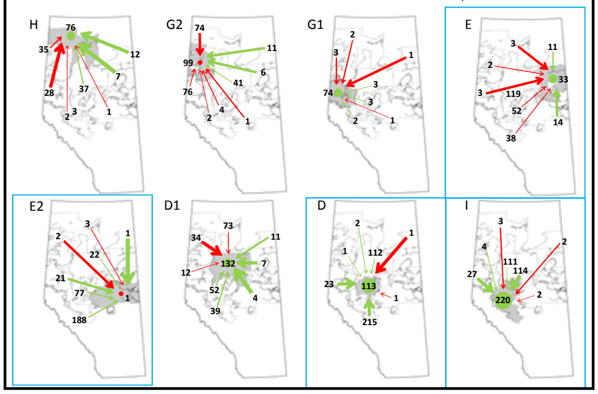
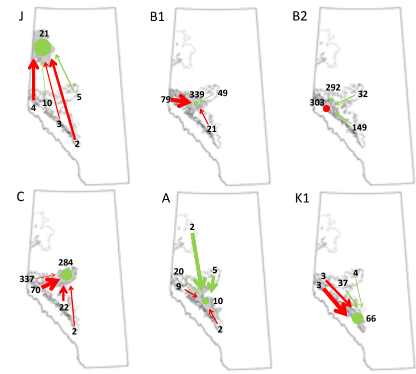
Number of collections transferred provided



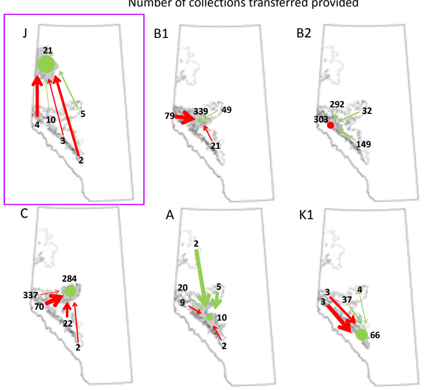
Transfers – Lodgepole pine

RED/GREEN = Poor/Good Performance
Thickness of arrow indicates magnitude
Number of collections transferred provided



Transfers – Lodgepole pine

RED/GREEN = Poor/Good Performance
Thickness of arrow indicates magnitude
Number of collections transferred provided



Transfers – Lodgepole pine

RED/GREEN = Poor/Good Performance
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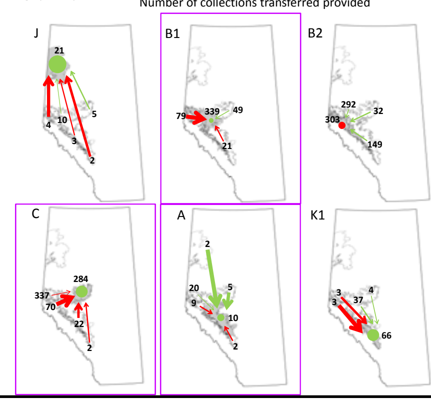
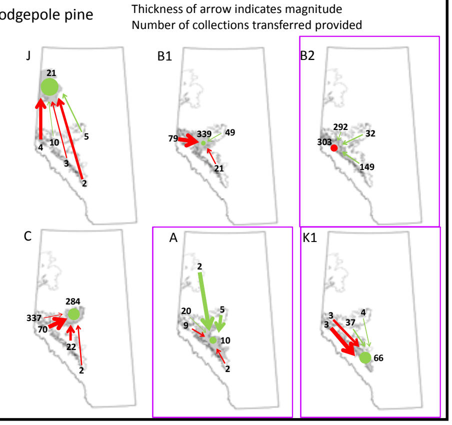
Number of collections transferred provided



Transfers – Lodgepole pine

RED/GREEN = Poor/Good Performance
Thickness of arrow indicates magnitude
Number of collections transferred provided



Key findings – seed transfers

- **Seed performance under transfer appears to be tightly linked to available precipitation**

1. Transfers from Foothills ecosystems to boreal ecosystems (wet → dry) result in poor performance (SPRUCE & PINE)
2. SPRUCE: Within the boreal, lateral transfers west are ok (→ wet)
3. SPRUCE: Within the boreal, lateral transfer east are bad (→ drier)
4. PINE: Local seed appears to be an appropriate seed choice in most regions

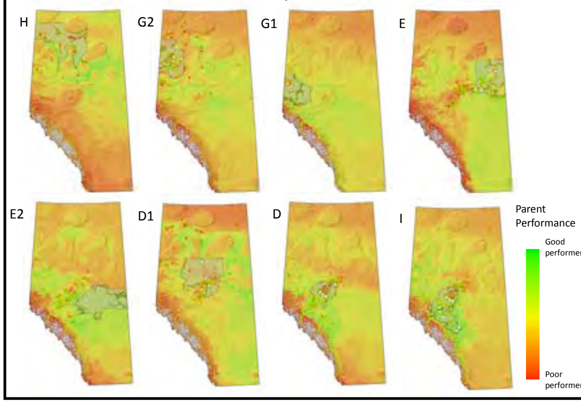
Key findings – seed transfers

- **Seed performance under transfer appears to be tightly linked to available precipitation**

5. If precipitation is approximately constant:
   a. SPRUCE: Seed transfers slightly north into colder environments result in good performance
      - "local" still appears appropriate
   b. SPRUCE: Moving seed into slightly warmer environments could be advantageous, while transfers over longer distances result in poor performance
   c. PINE: Seed transfers north into colder environments result in poor performance
   d. PINE: Moving seed south into warmer environments could be adventageous

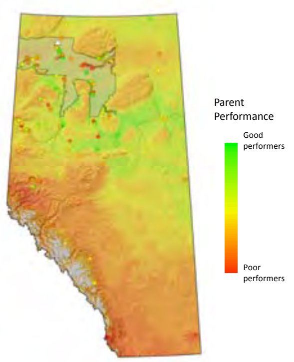
Transfer functions – White spruce

Random Forest
10 climate variables



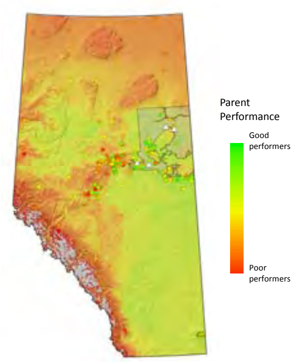
Transfer functions – White spruce CPP Region H

- Provides information as to where we can collect seed for deployment in CPP region H
- Optimal stock appears to originate in dry mixedwood ecosystems
- Optimal seed originating south of the region indicates possible mal-adaptation of local stock



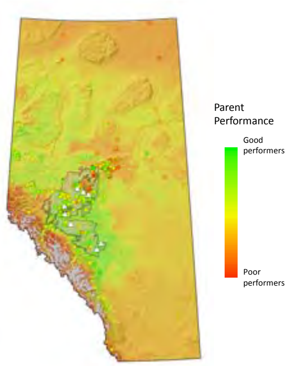
Transfer functions – White spruce CPP Region E

- Provides information as to where we can collect seed for deployment in CPP region E
- Optimal stock appears to originate in dry mixedwood ecosystems
- Seed originating from wet foothills ecosystems poorly performs



Transfer functions – White spruce CPP Region I

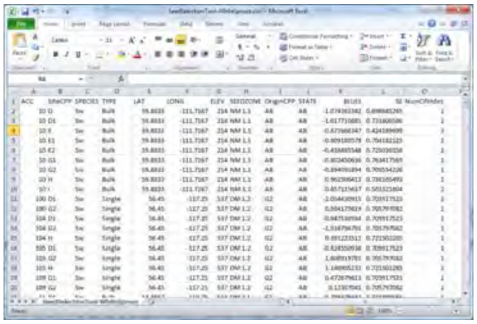
- Provides information as to where we can collect seed for deployment in CPP region I
- Local stock from wet foothills ecosystems appears optimal
- Seed originating in dry southern or northern boreal ecosystems poorly performs



Key findings – transfer functions

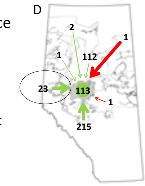
- Random forest models are visually a good fit to observed relative performance
  – We can have some confidence in these projections
- Provide information as to where we can collect seed for deployment within a CPP region
- BUT, The best strategy is to use this information together with the performance measurements for the individual collections within a CPP region (e.g. the rogueing lists)
  – This gives us the best information to make seed selection

Searchable Database for Seed – White spruce



Databases available (both Sw and Pl) – can be queried to develop rogueing list for SiteCPP, or look at the performance of a particular collection across multiple environments
Uncertainty measures also presented (SE)

Searchable Database for Seed – White spruce



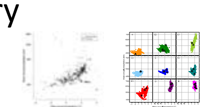
- We can select material for a planting site in CPP region D (characteristically warm and wet)
- G1 material on average performs well
- Accession 2054 would be a good selection (originates in a wet Lower Foothills ecosystem)
- BUT, Accession 2045 would be a poor selection (originates in the drier central mixedwood portion of the CPP region)

Searchable Database for Seed – White spruce

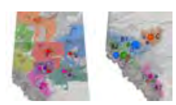
- Now let's say we have material from G1 – want to know where we can put it
- Look at how a particular Accession performs on all sites it was tested
- Accession 2054 is a GOOD one! Performs above average on all sites
- Good support for performance in G2 and I (low SE)

Summary

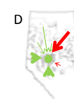
- Test site climates are a good representation of collections and CPPs
- Future climate projections for all CPPs are available



- There is a lot of transfer occurring in Alberta

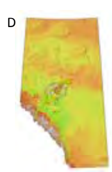


- Seed performance under transfer appears to be tightly linked to available precipitation
- General transfer guidelines for white spruce and lodgepole pine are available



Summary

- Transfer functions built with random forest and seed performance can be used to distinguish where better performing seed can be collected from



- For seed selection, the best strategy is to use the generalized transfer information with the performance of individual collections tested in CPP regions
- Rogueing lists available

Summary

- Publication for spruce in preparation intending to submit to Tree Genetics and Genomes Feb 2014

Climate change risk management for commercial tree improvement programs of white spruce (*Picea glauca*) in Alberta, Canada

Thank You

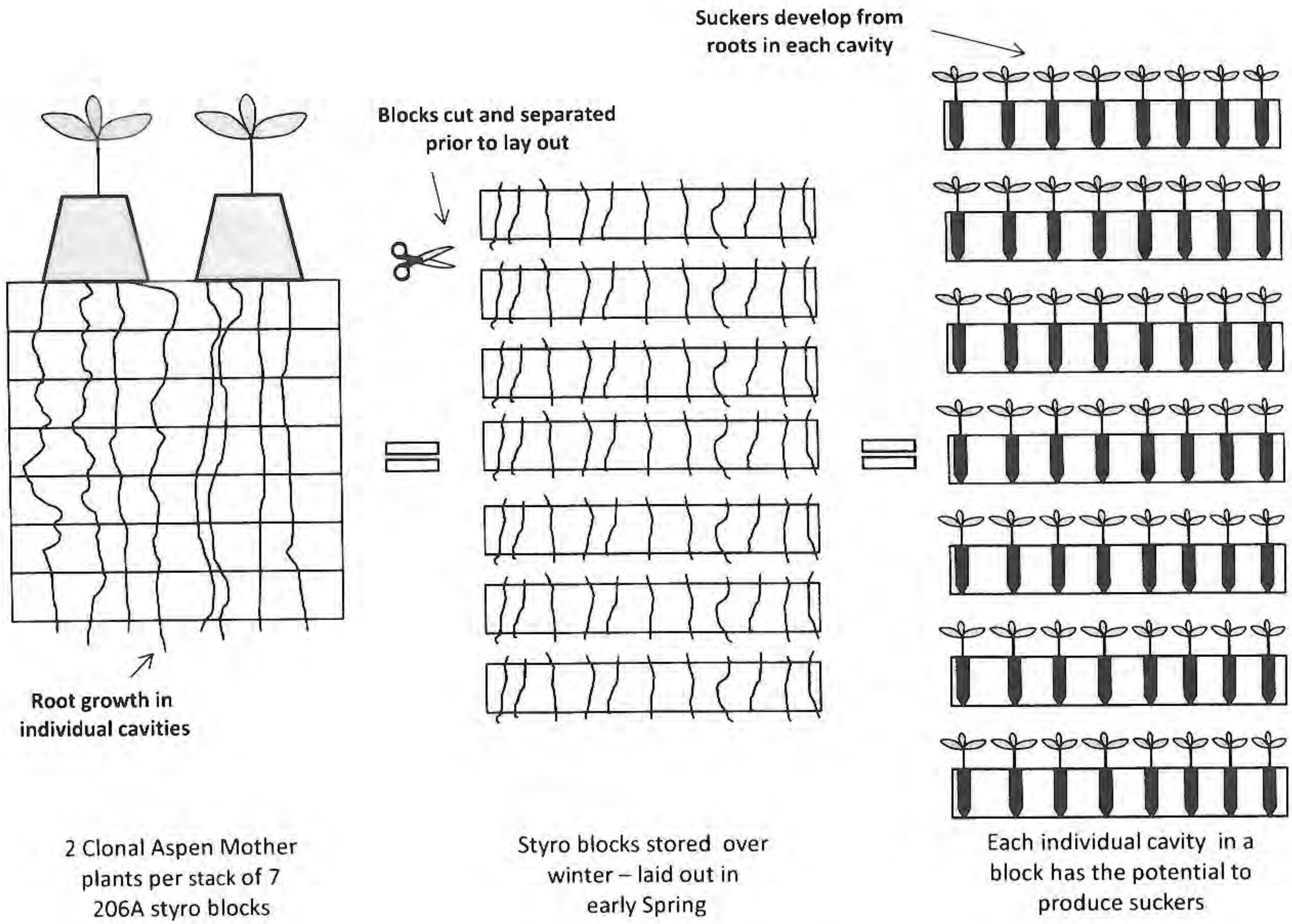
Questions or Comments?

Laura Gray
lkgray@ualberta.ca

CCEMC Climate Change and Emissions Management (CCEMC) Corporation

TIA

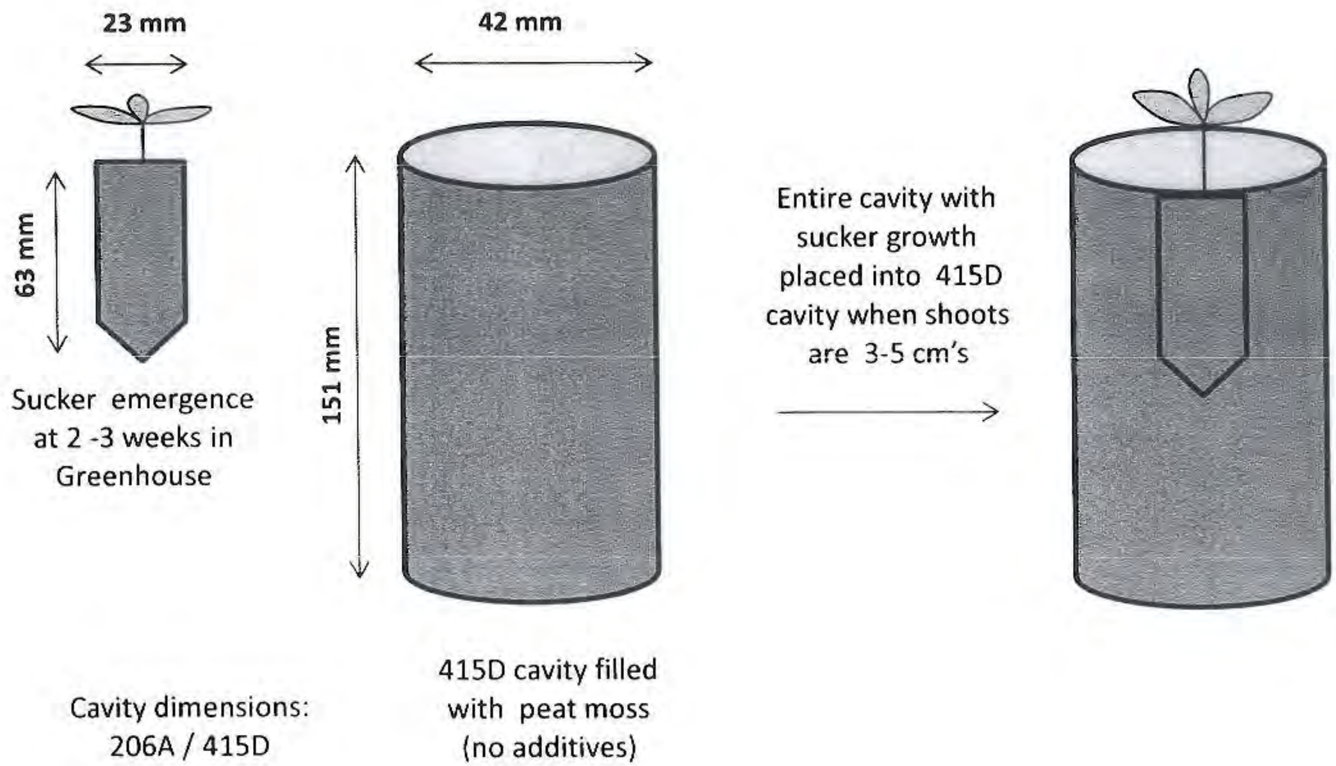
Appendix3: Lafleur_MassProp



CLONAL ASPEN PROPAGATION PROCESS

CLONAL ASPEN MOTHER PLANTS

CLONAL ASPEN ROOT GROWTH



CLONAL ASPEN TRANSPLANT PROCESS

Appendix4: MacLachlan_AdapTree

The effects of selective breeding on climate-related traits in spruce in western Canada

Ian MacLachlan*, Joanne Tuytel*, Pia Smets*, Tongli Wang*, Andreas Hamann† and Sally Aitken*

* Dept. of Forest and Conservation Sciences, University of British Columbia, Vancouver, BC, Canada
† Dept. of Renewable Resources, University of Alberta, Edmonton, AB, Canada,
ian.maclachlan@forestry.ubc.ca

Tree Improvement Alberta and CCEMC Tree Species Adaptation Risk Management Project Workshop, January 14th 2015

AdapTree — Centre for Forest Conservation Genetics -CFCG- — forestry university of british columbia

Tree Breeding

Practiced in Canada since 1958 (Morgenstern 1996)

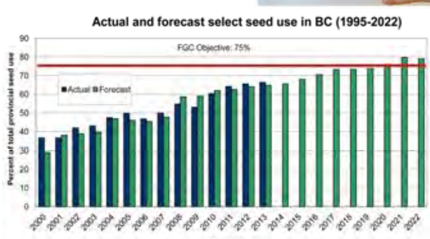
Photo: Nicholas Ukrainetz

Interior lodgepole pine selection and breeding demonstration plot

2

Provincial Tree Breeding Objectives

- Genetic gain
- Genetic diversity
- Adaptation
- Conservation



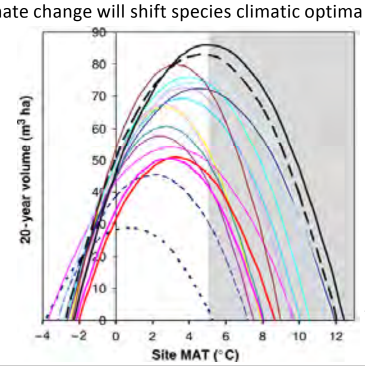
Increasing the use of selectively bred seed in BC to 75% of the provincial total.

(Forest Genetics Council of British Columbia 2013)

3

Climatic Adaptation

- Forests are genetically adapted to their natural environment
- Climate change will shift species climatic optima



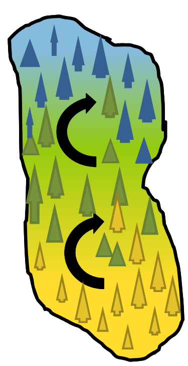
Wang *et al*. (2006)

4

Mitigation Strategies

1) Do Nothing/Chance?
2) Modify species mixtures?
3) Assisted gene flow?

How can we understand genetic adaptation in order to mitigate climate change?



Aitken & Whitlock (2013)

5

Team members

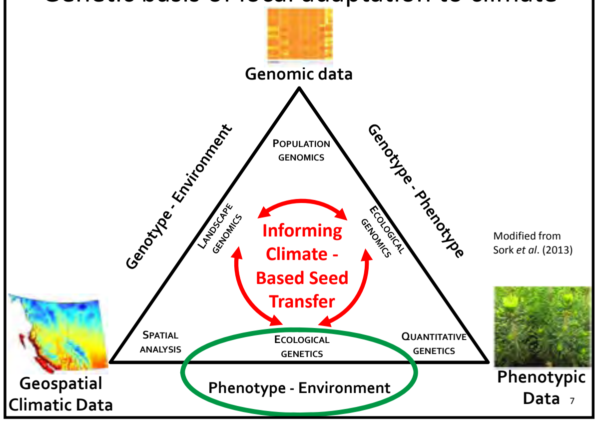
Sally Aitken (Project Leader)
Andreas Hamann (Co-PL) – Geospatial analysis (U of A)
Jason Holliday -- Re-sequencing (Virginia Tech)
Loren Rieseberg -- Bioinformatics (UBC)
Robert Kozak -- Socioeconomics (UBC)
Michael Whitlock -- Population structure (UBC)
Tongli Wang -- Climatology (UBC)
Debra Davidson -- Forest Policy (U of A)

Pia Smets – Project management (UBC)

Sam Yeaman – Bioinformatics (UBC)
Kay Hodgins – Bioinformatics (UBC/Monash)
Katie Lotterhos – Population structure (UBC/Wake Forest)
Simon Nadeau – Population genomics analysis (UBC)
Haktan Suren – Association genomics (Virginia Tech)
Kristin Nurkowski – Genomics (UBC/Monash)
Gina Conte – Bioinformatics (UBC)
Robin Mellway – Phenotyping and functional genetics (UBC)
Katharina Liepe – Geospatial phenotypic analysis
Laura Gray – Geospatial phenotypic analysis (U of A)
Ian MacLachlan – Effects of breeding (UBC)
Kim Gilbert – Field validation (UBC)
Susannah Tysor – Gene flow (UBC)

6

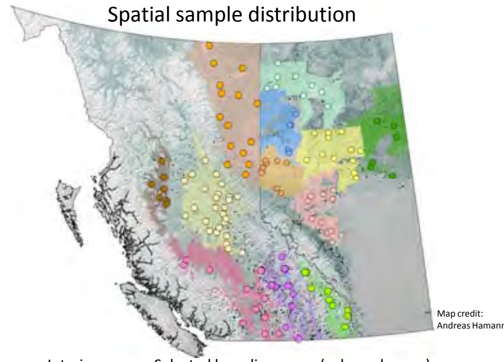
Genetic basis of local adaptation to climate



7

Methods

Spatial sample distribution



Interior spruce: Selected breeding zones (coloured zones) and respective natural seedlots (filled circles)

8

Experimental Establishment

- Raised bed common garden: established early May 2012 in Vancouver, Canada
- n = 2424 seedlings
  - 154 comparative natural seedlots (1236 seedlings)
  - 18 selectively bred seedlots (1188 seedlings) from 14 breeding programs

9

Data Sources

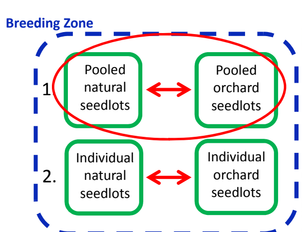
Climatic Variables:
- Provenance level estimates
  - 1961-1990 climate normal period
  - ClimateWNA v.4.84

Phenotypic Traits:
- Growth
- Phenology
- Cold Injury

http://climatewna.com/

10

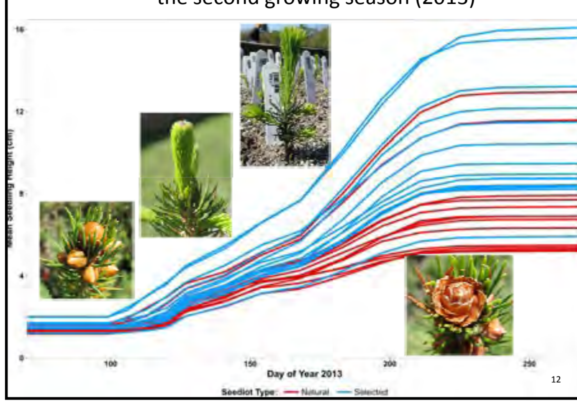
Phenotypic Analyses



- ANOVA of trait means
- Climate – trait clines
- Trait – trait correlations
- Variance component analysis

11

Breeding zone level growth responses during the second growing season (2013)



12

Results

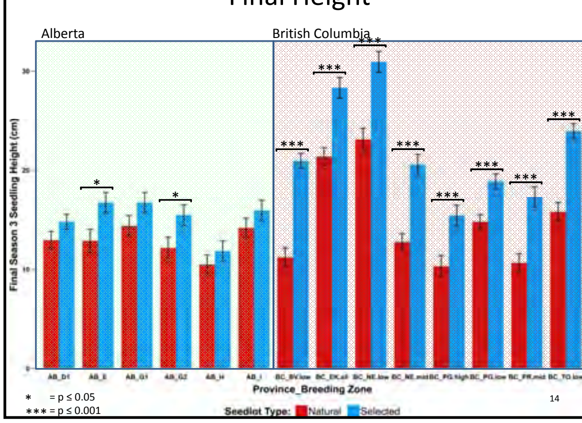
Coefficients of determination (r^2) for climatic clines in four phenotypic traits from natural and selected seedlots.

	Final Height 2014 (cm)		Max. Growth Rate 2013 (cm/day)		Growth Cessation 2013 (Day of Year)		Cold Injury 2014 (-22°C)	
	Natural	Selected	Natural	Selected	Natural	Selected	Natural	Selected
Latitude (°N)	* 0.43	*** 0.75	* 0.43	*** 0.76	0.18	** 0.45	*** 0.88	*** 0.86
Elevation m.ASL	0.00	0.07	0.06	0.15	0.07	0.00	* 0.39	* 0.31
Mean Annual Temperature (°C)	** 0.58	*** 0.70	** 0.60	** 0.58	0.22	** 0.54	*** 0.87	*** 0.89
Mean Annual Precipitation (mm)	0.25	0.35	0.25	* 0.41	0.09	0.14	*** 0.76	*** 0.64

* = p ≤ α = 0.05 (df = 12)
** = p ≤ α = 0.01 (df = 12)
*** = p ≤ α = 0.001 (df = 12)

13

Final Height



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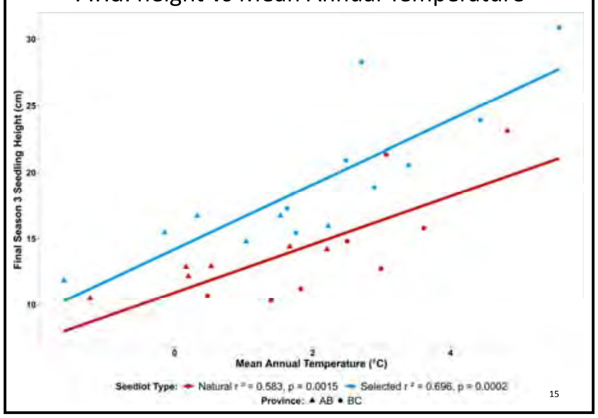
Final height vs Mean Annual Temperature



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Maximum Growth Rate:

	Final Height 2014 (cm)		Max. Growth Rate 2013 (cm/day)		Growth Cessation 2013 (Day of Year)		Cold Injury 2014 (-22°C)	
	Natural	Selected	Natural	Selected	Natural	Selected	Natural	Selected
Latitude (°N)	* 0.43	*** 0.75	* 0.43	*** 0.76	0.18	** 0.45	*** 0.88	*** 0.86
Elevation m.ASL	0.00	0.07	0.06	0.15	0.07	0.00	* 0.39	* 0.31
Mean Annual Temperature (°C)	** 0.58	*** 0.70	** 0.60	** 0.58	0.22	** 0.54	*** 0.87	*** 0.89
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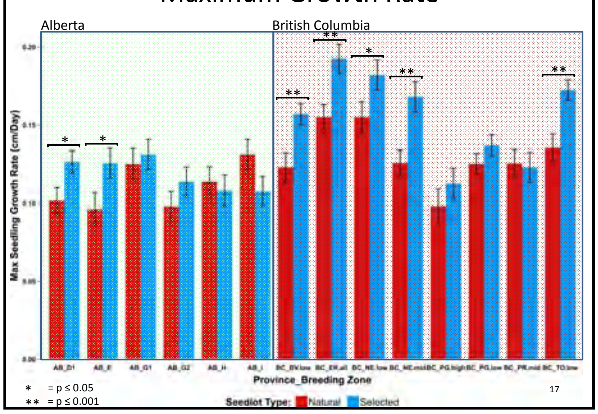
*** = p ≤ α = 0.001 (df = 12)

16

Maximum Growth Rate



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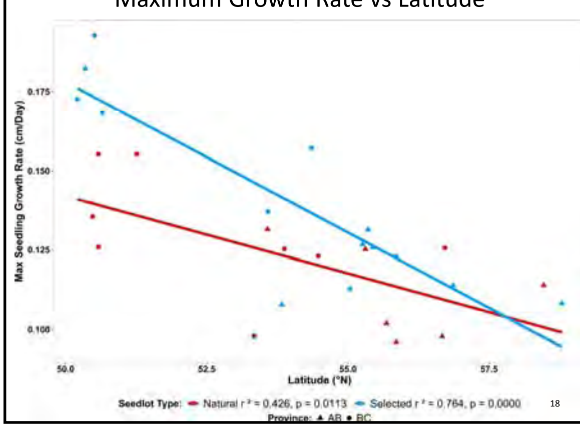
Maximum Growth Rate vs Latitude



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Growth Cessation Day:

	Final Height 2014 (cm)		Max. Growth Rate 2013 (cm/day)		Growth Cessation 2013 (Day of Year)		Cold Injury 2014 (-22°C)	
	Natural	Selected	Natural	Selected	Natural	Selected	Natural	Selected
Latitude (°N)	* 0.43	*** 0.75	* 0.43	*** 0.76	0.18	** 0.45	*** 0.88	*** 0.86
Elevation m.ASL	0.00	0.07	0.06	0.15	0.07	0.00	* 0.39	* 0.31
Mean Annual Temperature (°C)	** 0.58	*** 0.70	** 0.60	** 0.58	0.22	** 0.54	*** 0.87	*** 0.89
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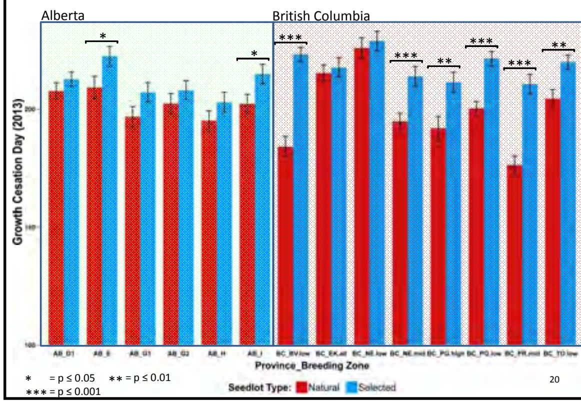
*** = p ≤ α = 0.001 (df = 12)

19

Growth Cessation Day



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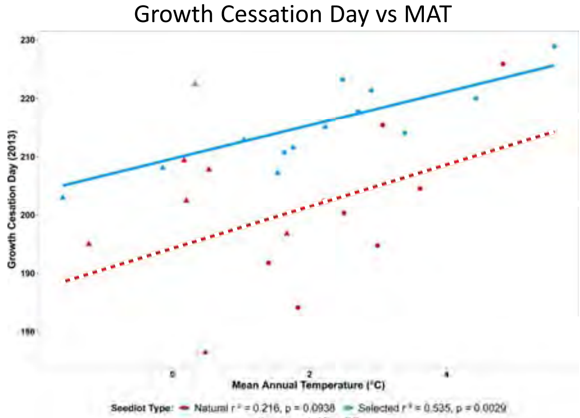
Growth Cessation Day vs MAT



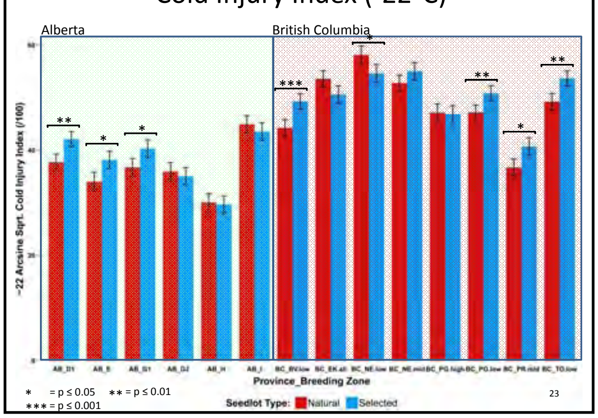
Cold Injury Index: latitude and mean annual temperature explain large amounts of variation

	Final Height 2014 (cm)		Max. Growth Rate 2013 (cm/day)		Growth Cessation 2013 (Day of Year)		Cold Injury 2014 (-22°C)	
	Natural	Selected	Natural	Selected	Natural	Selected	Natural	Selected
Latitude (°N)	* 0.43	*** 0.75	* 0.43	*** 0.76	0.18	** 0.45	*** 0.88	*** 0.86
Elevation m.ASL	0.00	0.07	0.06	0.15	0.07	0.00	* 0.39	* 0.31
Mean Annual Temperature (°C)	** 0.58	*** 0.70	** 0.60	** 0.58	0.22	** 0.54	*** 0.87	*** 0.89
Mean Annual Precipitation (mm)	0.25	* 0.35	0.25	* 0.41	0.09	0.14	*** 0.76	*** 0.64

* = p ≤ α = 0.05 (df = 12)
** = p ≤ α = 0.01 (df = 12)
*** = p ≤ α = 0.001 (df = 12)

22

Cold Injury Index (-22°C)



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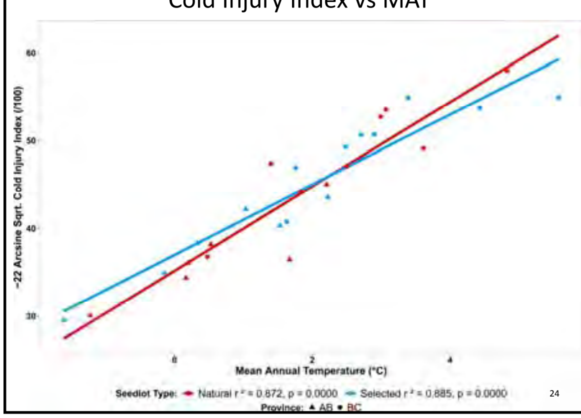
Cold Injury Index vs MAT



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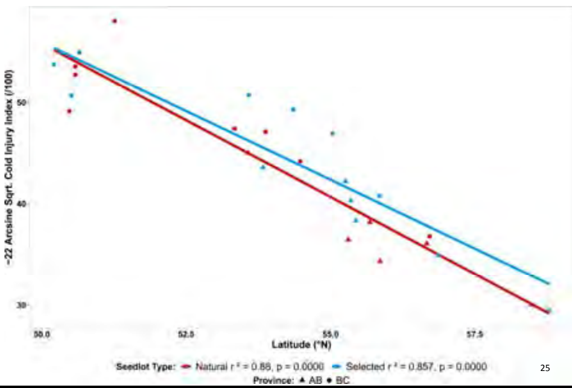
Cold Injury Index vs Latitude



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Spruce	Final Height 2014 (cm)		Max. Growth Rate 2013 (cm/day)		Growth Cessation 2013 (Day of Year)		Cold Injury 2014 (-22°C)	
	Natural	Selected	Natural	Selected	Natural	Selected	Natural	Selected
Latitude (°N)	*0.43	***0.75	*0.43	***0.76	0.18	**0.45	***0.88	***0.86
Elevation m.ASL	0.00	0.07	0.06	0.15	0.07	0.00	*0.39	*0.31
Mean Annual Temperature (°C)	**0.58	***0.70	**0.60	**0.58	0.22	**0.54	***0.87	***0.89
Mean Annual Precipitation (mm)	0.25	*0.35	0.25	*0.41	0.09	0.14	***0.76	***0.64

* = p ≤ α = 0.05 (df = 12) ** = p ≤ α = 0.01 (df = 12) *** = p ≤ α = 0.001 (df = 12)

Pine	Final Height 2014 (cm)		Max. Growth Rate 2013 (cm/day)		Growth Cessation 2013 (Day of Year)		Cold Injury 2014 (-22°C)	
	Natural	Selected	Natural	Selected	Natural	Selected	Natural	Selected
Latitude (°N)	*0.46	*0.39	0.22	0.29	*0.38	*0.35	***0.82	***0.80
Elevation m.ASL	0.01	0.32	0.03	*0.36	0.07	*0.37	0.01	0.03
Mean Annual Temperature (°C)	**0.60	***0.81	*0.43	***0.73	**0.58	***0.75	***0.87	***0.97
Mean Annual Precipitation (mm)	*0.47	0.25	0.31	*0.36	*0.36	0.21	**0.53	*0.43

* = p ≤ α = 0.05 (df = 10) ** = p ≤ α = 0.01 (df = 10) *** = p ≤ α = 0.001 (df = 10)

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Spruce: summary to date

- Climate change threatens forest productivity in Western Canada
- Assisted gene flow is one possible mitigation strategy
- Artificial vs Natural selection. The effects are mixed:
    - Cline strength increases for growth traits
    - MAT, Latitude and MAP are important
    - Trait – elevation relationships are weak
    - Height gains derived from increased maximum growth rate
    - Phenological effects are moderate
    - Growth – cold injury trade-offs not apparent

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Acknowledgements

University of British Columbia
Sally Aitken, Pia Smets, Tongli Wang, Joanne Tuytel, Sarah Markert, Connor Fitzpatrick, Kay Hodgins, Sam Yeaman, Katie Lotterhos, Kristen Nurkowski, Robin Mellway, Jon Degner, Sean King, Tyler Dergousoff, Joane Elleouet, Margarete Detlaff, Simon Nadeau, Elissa Sweeny-Bergen, Seane Trehane, Cathy Koot, Mircea Rau

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Dave Kolotelo

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Deogratias Rweyongeza
Andy Benowicz
Tammy Decosta

Forest Genetics Council of British Columbia
Jack Woods

Isabella Point Forestry
Sally John

Seed Contributors:
BC Ministry of Forests, Lands and Natural Resource Operations, Tree Seed Centre
Alberta Sustainable Resource Development Tree Improvement and Seed Centre
Forest Genetics Council of British Columbia
The many private contributors of tree seed

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Funding:

Genome Canada
FGC Forest Genetics Council of British Columbia
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Forest Service British Columbia
University of California
Genome Alberta
NSERC CRSNG
University of Alberta

References:

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Wang, T., A. Hamann, A. Yanchuk, G. A. O'Neill, and S. N. Aitken (2006). Use of response functions in selecting lodgepole pine populations for future climate. *Global Change Biology*. 12:2404 - 2416.

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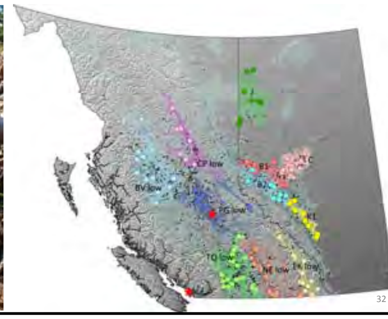
Validation Trial

- Interior BC medium-term validation study: Alex Fraser Research Forest
- Established from 2nd year seedlings in May 2013
- Pine n = 2300 seedlings; Spruce n = 3100 seedlings
- 6 randomised incomplete blocks with single-tree plots per species.



Trial Site: gentle east-facing slope with low levels of slash.

Appendix5: Jones_AdapTree

UNIVERSITY OF ALBERTA
DEPARTMENT OF RESOURCE ECONOMICS AND ENVIRONMENTAL SOCIOLOGY

GE3LS:

G = Genomics & its
E³ = Ethical, Environmental, Economic
L = Legal and
S = Social Aspects

Implications for assisted migration and tree improvement ?

AdapTree Assessing the adaptive portfolio of reforestation stocks for future climates

Overview:

1. Perceptions of forest adaptation strategies (Survey);
   Reem Hajjar, UBC.
2. Perceptions of forest adaptation strategies (Focus Group and Q Sort);
   Molly Moshofsky and Rob Kozak, UBC
3. Institutional adaptation and policy regime analysis.
   Debra Davidson and Kevin Jones, UofA

1. Survey

Reem Hajjar, UBC

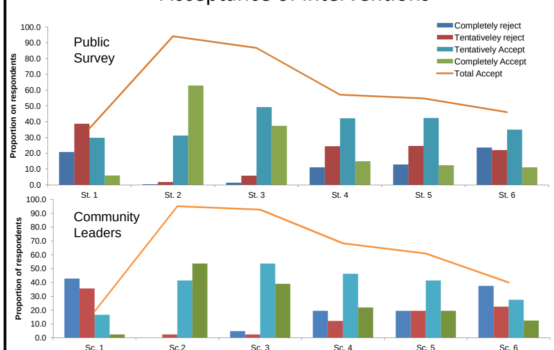
Aims:

1. Assess levels of acceptability of various reforestation strategies used to adapt our forests to climate change, including assisted migration.
2. Explore what factors seem to be associated with acceptance of interventions

Methods – Online Surveys 2012-13

- Public survey (BC and Alberta)
  - N=1544
  - 23% response rate; 86% completion rate
- Forest-dependent Community Leaders Survey (BC):
  - N= 37; 71% completion rate
  - 54% of 48 forest-dependent communities
- RPFs and RPBios (BC)
  - N= 76 RPFs; 1.4% of membership
  - N= 100 RPBios; 10% of membership

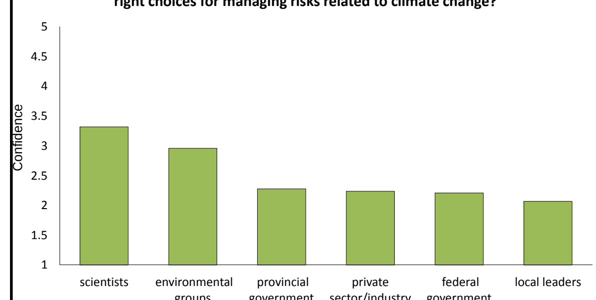
Acceptance of interventions



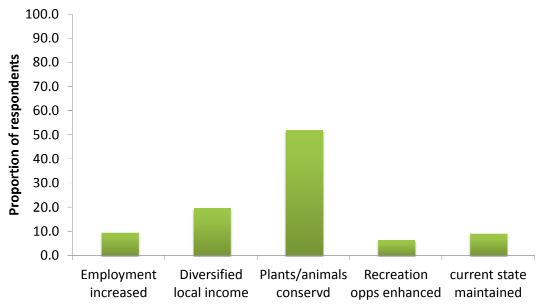
St. 1	St. 2	St. 3	St. 4	St. 5	St. 6
Do nothing, natural regen.	Local seeds, no breeding	Local seeds, with breeding	AM (pop'n range)	AM (species range)	GMOs

Confidence in decision-makers

How much confidence do you have in the following to make the right choices for managing risks related to climate change?



What is your priority future outcome for forests and forest-dependent communities?



The model – logistic regression

	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5	Strategy 6
	do nothing	local seeds	loc+ breeding	non-local + br	different sp	GMOs
Manipulating nature ethically wrong	++		- -	- -	-	- -
Aggregated threat of natural disasters	-		+	+	+	
Aggregated threat of reforestation technologies	+		-	-	-	-
Cluster 3 (baseline)						
Cluster 1	- -			- -		
Cluster 2	- -			-*		
No.1 priority (status quo)						
No.1 priority(employment)		- -*		+++	+++	
No.1_priority(diversification)		+++*		++*	+*	
No.1_priority(biodiversity)		+++*		++	+*	
No.1_priority(recreation)		+++*		+++	+++	
Age		+		+	+	+
Trust decision-makers to make right choice			++	++	++	
Skeptical intervention will work				-	- -	-
Confidence in local leaders				++	+	++
Risky to manipulate nature						-
Gender (male)						++
Nagelkerke R square	**0.078**	**0.102**	**0.233**	**0.35**	**0.295**	**0.363**
Classification table: percentage correct	67.1	97.8	91.9	73.1	71.6	72.2

2. Focus Groups, Q Sort

Molly Moshofsky and Rob Kozak UBC

Quesnel, BC
Fall, 2012

3 focus groups:
- Professional foresters
- Environmentalists
- Business owners/managers

High Level, AB
Spring, 2013

3 focus groups
- Professional foresters
- Environmentalists
- Business owners/managers

Golden, BC
Fall, 2012

3 focus groups:
- Professional foresters
- Environmentalists
- Business owners/managers

Athabasca, AB
Spring, 2013

3 focus groups
- Professional foresters
- Environmentalists
- Community volunteers

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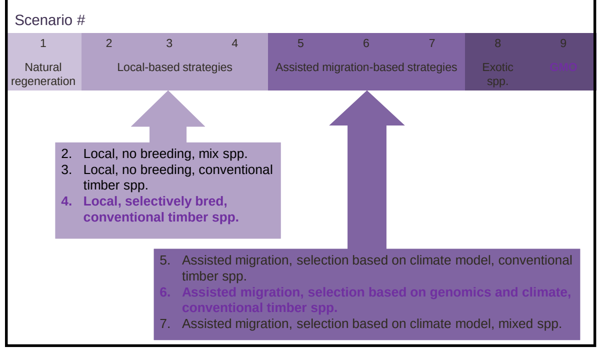
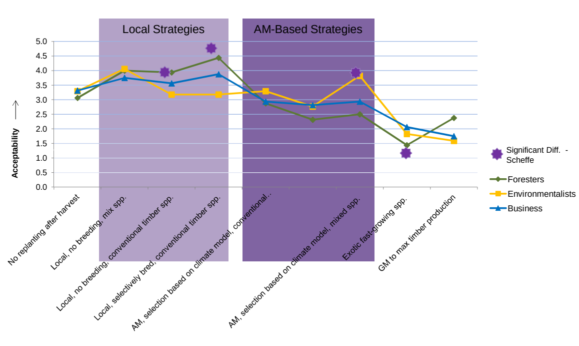
Research Design: Scenarios



Perceived Acceptability by Social Group



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3. Institutional Adaptation – Policy Regime Study

Debra Davidson and Kevin Jones (UofA)

General Aims:

1. What adaptations are being made in response to climate risks in the forest?
2. How can assisted migration support climate adaptation?
3. What factors promote adaptation and conversely where can we identify barriers?

What does institutional adaptation mean?

Analysis at the scale of the organizational field

a. An aggregate approach - "organizations that, in aggregate, constitute a recognized area of institutional life." (DiMaggio and Powel, 1983; 148).

b. Field dynamics - "[a]ttention shifted from the organization in an environment to the organization of the environment." (Scott, 2008; 216).

Themes - following the academic literature

a. Need to attend to uncertainty as a consequence of complex socio-environmental systems.

b. Need to engage the values, legitimacies and associations which perpetuate institutional approaches to risk.

c. Need to address democratic gaps and deficit approaches.

d. Socially robust approaches to expertise and scientific tools.

Primary Research Activities (BC & AB)

1. LEAD ACTOR POLICY INTERVIEWS • Research on the background to climate adaptation policies, perceptions, and policy developments. • E.g. Strategic managers, policy makers and Prov. research staff.	**2. STAKEHOLDER INTERVIEWS** • Research on stakeholder perceptions and opportunities/barriers to adaptation. • E.g. Industry, Industry bodies, civic organizations, and other forest stakeholders.
3. FOCUS GROUPS • Investigating factors related to uptake amongst practitioner communities and key local stakeholders.	**4. Analysis** • Qualitative discourse analysis. • Comparative (BC / AB)

Context – a sense of malaise or even crises;

e.g.:

Contracting industry	Shrinking Government
Overlapping forest values	Increasing costs (and thus lowering profitability) in some regions.
Underinvestment in industry and R&D	Increasing competition
Challenges to market access	Impacts of climate change

"We're in a race to the bottom"

Consequences for Adaptation

Path Dependency

Narratives (descriptions, ideas, values)	Possible implications for the institutional field
1. "Who takes the risk?" Economic costs of failure.	a. Risk averse b. Static c. Homogenous d. Adaptation as externally driven e. Powerlessness
2. "Who moves first?" Inter-industry competition	
3. "It's a race to the bottom." Economic time frames.	
4. "Lack of incentive" e.g. Responsibility for sustainability.	

Professional Culture

Narratives (descriptions, ideas, values)	Possible implications for the institutional field
Difficulty of transitioning away from command & control approaches to forest hazards.	a. Response-based policy approaches. b. Focus on discrete hazards, as opposed to wider ecological and socio-economic risks. c. Deficits in trust and accountability restricting innovation. d. Professional challenges in capacity. c. Decreasing professional voice and value set.
Ongoing challenges in the relationship between industry and government.	
Maintaining professional roles in practice?	
Sustaining forestry as a profession.	

Findings and Implications

1. Public perceptions

Results reflect multi-faceted and complex ways in which publics engage issues of climate change and forest management

Ongoing need to provide publics with information about climate impacts and forest management.

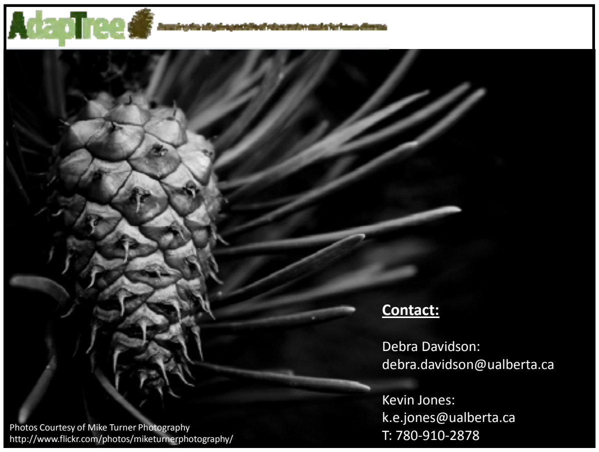
Development of policy and decision-making models which are expert informed but which are also publically engaged.

2. Adaptation

Integrating scientific and technical innovation with economic and social innovation

Finding space for innovating practice

Supporting professional development and flexible forms of forest management


AdapTree
Contact:
Debra Davidson:
debra.davidson@ualberta.ca
Kevin Jones:
k.e.jones@ualberta.ca
T: 780-910-2878
Photos Courtesy of Mike Turner Photography
http://www.flickr.com/photos/miketurnerphotography/

Appendix6: Kreplin_AIBio

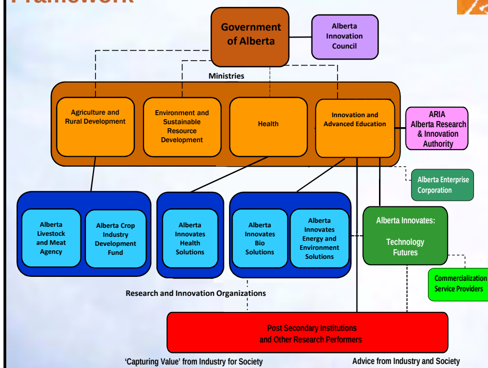
Alberta Innovates Bio Solutions

Dr. Cornelia Kreplin

January 2015

Funded by the Government of Alberta

Alberta Research & Innovation Framework



Alberta Innovates System

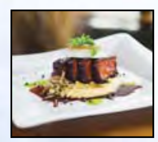
- Focus on areas where Alberta has a competitive advantage.
- A provincially-funded cohesive, accessible research and innovation system.
- World-class research to support Government of Alberta priorities.
- Coordinates and supports investments required to solve major industry challenges.

Alberta Innovates Bio Solutions
Alberta Innovates Energy and Environment Solutions
Alberta Innovates Health Solutions
Alberta Innovates Technology Futures
Alberta Innovates Alberta Research and Innovation Authority

Alberta Innovates Bio Solutions (AI Bio)

Vision:

"Inspiring smart solutions in agriculture, food and forestry for Albertans and the world"


AI Bio Goals and Priorities

- **Sustainable Production**
  - Sustainable agriculture and forest production
- **Bioindustrial Innovation**
  - New chemicals, materials and energy from biomass
- **Food Innovation**
  - Growth and diversification of Alberta's food industry
- **Ecosystem Services**
  - Integrated land and environmental management
- **Prion and Prion-like Neurological Disease**
  - Effective management of prion and prion–like neurological diseases

Sustainable Production

- Goal of sustainable agriculture and forest production through
  - Market-driven traits and product
  - Sustainable production systems

Sustainable Production

Specific Research and Innovation Initiatives:

- Advance the adaptation of forest species to a changing climate
- Inform forest management practices for species at risk, pest control and restoring disturbed boreal forest lands
- Optimize environmentally sustainable forest management practices

Consultations with Forestry Companies

- In 2012, AI Bio consulted with various forest industry companies to enquire about meaningful applied research needs of this sector
- The outcomes of these visits provided information that AI Bio can use to direct research investments and to design a meaningful research program in the area of Sustainable Production

Consultations with Forestry Companies

Topics heard during the visits included:

- Application of technologies
  - GIS tools are needed to integrate GIS mapping decision support systems with newer technologies such as LiDAR and multi-spectral technologies. Also, growth and yield models reflecting pine growth requires attention
- Issues regarding regeneration policies and seed zone movement of seed
  - To adapt and mitigate changes in climate
- Species at risk
  - Caribou, grizzly bear and biodiversity management plans

Consultations with Forestry Companies

- Social license to operate
  - Issues specific to roads, riparian access to fiber, public attitudes toward resource management, and need to investigate extension and public communication models
- Pests
  - Mountain Pine Beetle issues and supportive research
- Reclamation
  - Issues stemming from oil and gas exploration, well site construction and oil sands reclamation

2012 Value Chain Sustainability Program

Project Title	Researcher
Research to Support Recovery and Long Term Conservation of Grizzly Bears in Alberta	Gordon Stenhouse – Sustainable Resource Development
Multi-species Ecogenomics of Spruce Budworm Outbreaks in Alberta Forests	Felix Sperling-University of Alberta
Translating Mountain Pine Beetle Genomics Outputs into Genomics-Enhanced Environmental and Economic Risk Models	Janice Cooke-University of Alberta

2012 Value Chain Sustainability Program

Project Title	Researcher
Forest Vegetation Green-up and Fire Occurrence Prediction in Support of Wildland Fire Management in Alberta	Mike Flannigan-University of Alberta
Predicting the Impact of Management Activities on Forest Carbon Pools and Biodiversity	Fangliang He-University of Alberta
Soil Carbon Dynamics and Nutrient Retention in Reconstructed Sandy Soils	Sylvie Quideau-University of Alberta

2014 Forestry Sustainable Production Projects

Project Title	Researcher
Development of Seed Transfer Guidelines and Breeding Populations for Alberta to Address Climate Change	Andreas Hamann- University of Alberta
Co-funding for Purchase of an Illumina NextSeq 500 Desktop Sequencer for the Environmental Genomics Core Lab	Janice Cooke- University of Alberta
Genomics of Western Gall Rust Resistance in Lodgepole Pine for Tree Improvement	Janice Cooke- University of Alberta
Beyond Beetle: Natural and Facilitated Lodgepole Pine Regeneration after Mountain Pine Beetle Outbreak in Alberta	Ellen Macdonald- University of Alberta

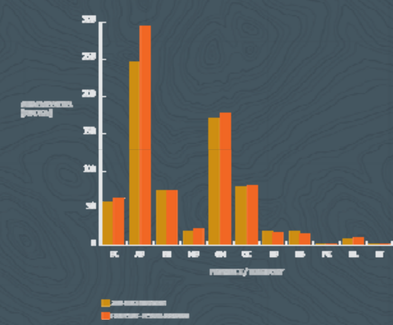
Going Forward

- AI-Bio is committed to continuing to support sustainable production in the forestry sector
- Our objectives are to continue to invest in meaningful research that
  - a) will contribute to addressing the challenges outlined by forestry companies
  - b) generate science needed to inform policy

Thank you!

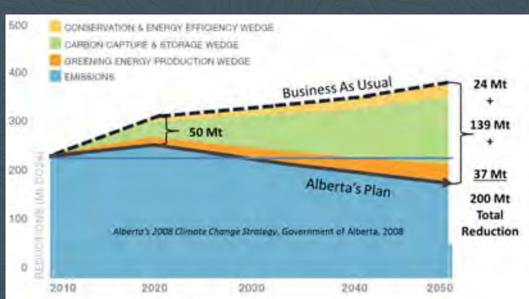
Appendix7: Andries_CCEMC

A climate for change



CCEMC

Alberta's 2008 Climate Change Strategy*



* Currently under review

CCEMC- Platform

Policy obligations

- Mandatory requirements to hit performance target
- Flexibility options
  - Continuous Improvement
  - Credits or Offsets
  - Pay into fund @ $15/tonne
- Annual compliance

Mandate

- Reduce GHG emissions and help Alberta adapt
- Focus is discovery development and deployment of technology

Delegated Administrative Organization

- Arms length - Board led
- Business and technical acumen
- Virtual – suite of service providers
- Governance best practices

CCEMC

Operational Strategy

- Align with Climate Change Strategy
- Pursue technology (transformative) development
- Seek technologies from around the world
- Run competitions to find/select the best projects
- Invest in all stages of technology development
- Manage a diverse portfolio
- Partner to assist in achieving outcomes
- Be patient
- Tell our story

CCEMC

Funding Process

$425.5M received to date, new funds received annually

Competitive process

1. Request for proposal – 2 stages
   a. Expression of interest
   b. Full project proposal
2. Due diligence – technical, financial, GHG reduction
3. Decision – portfolio considerations
4. Contracting and performance management
5. Commercialization – Innovation ecosystem

CCEMC

Our Performance

Operating for 5 years – 100 total active projects

- Committed $249M
- ~ $1.65 billion in total project value (leverage ~ 6:1)
- Emissions reduction estimated at 10.7 MT/2020
  - Market potential 9.7 MT/2020
- 24 Grand Challenge projects (1 MT)
- Adapting to climate change – $7M, 3 projects
- Biological program – $8.4M, 14 projects (1MT)
- Active RFP's - Open, Grand Challenge

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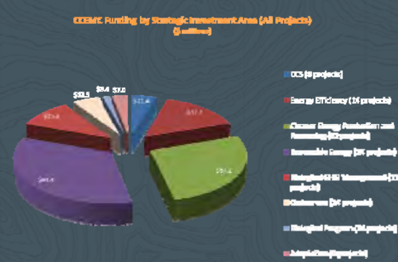
Funding by SIA



January 2015

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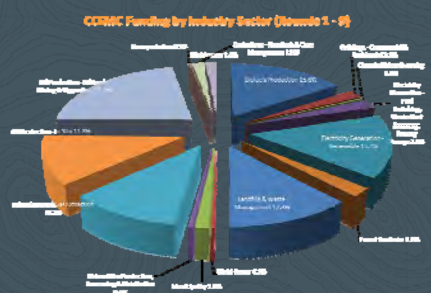
Investment by Sector



January 2015

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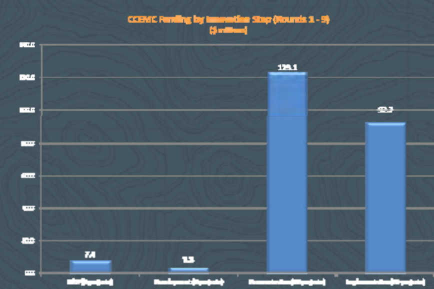
Innovation Step ($M)



Jan 2015

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Additional Value

New Conference Board report

- CCEMC portfolio from 2011-14
- Total economic impact - $2.4 B
- 13, 600 person years of employment

Alberta
- GDP impact approx. $2B
- 11,000 person years employment

Ontario
- GDP $219M
- 1100 person years employment

CCEMC

Closing message

- New Climate Change Strategy in development
- CCEMC business planning underway
- Open for business
  - Anticipate new calls

To learn more: CCEMC.CA
- Projects we support
- Funding opportunities

Climate Change and Emissions Management Corporation

CCEMC

Appendix8: Cooke_MPB

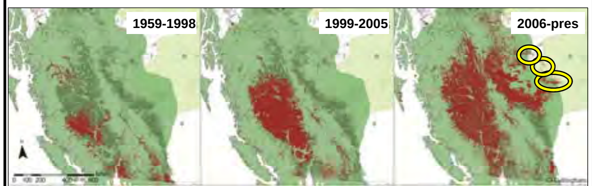
Effect of genetics and environment on host responses to mountain pine beetle and their fungi

Janice Cooke
Cathy Cullingham, David Coltman, Adriana Arango-Velez, Miranda Meents, Barry Cooke, Devin Goodsman, Mark Lewis, Allan Carroll, Patrick James, and the TRIA-Net Consortium

UNIVERSITY OF ALBERTA

1

Mountain pine beetle range expansion into novel habitats with new conditions

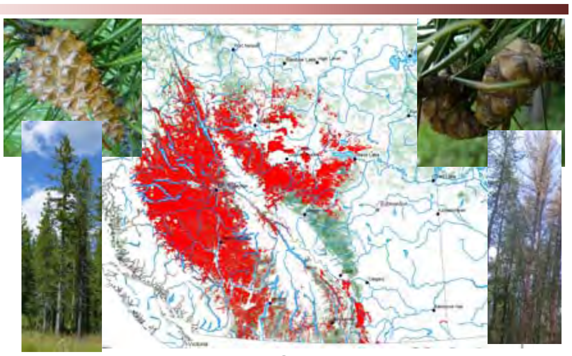


Data: Little (1971); S. Taylor, G. Thandi, D. Yemshinov

- Mountain pine beetle attacks
- Lodgepole pine range
- Jack pine range

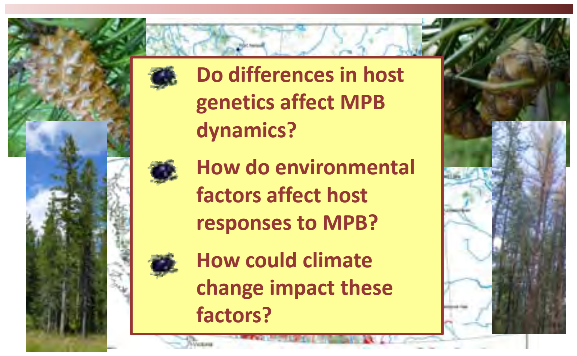
2

Resilient forests in the face of mountain pine beetle



3

Resilient forests in the face of mountain pine beetle



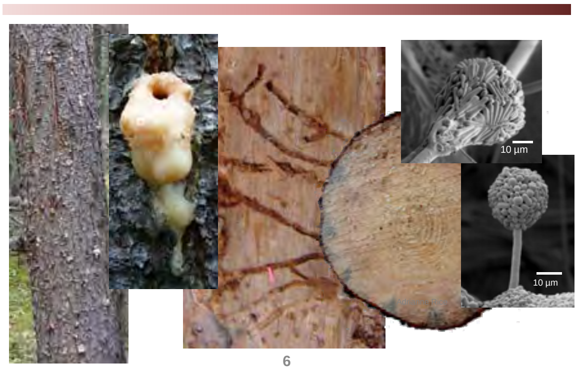
- Do differences in host genetics affect MPB dynamics?
- How do environmental factors affect host responses to MPB?
- How could climate change impact these factors?

4

Mountain pine beetles overcome pine defenses through density dependent mass-attack

5

Mountain pine beetles overcome pine defenses through density dependent mass-attack



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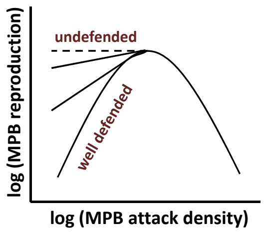
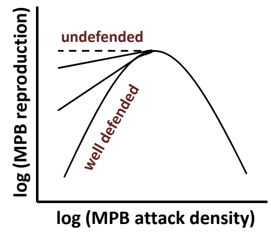
Mountain pine beetles overcome pine defenses through density dependent mass-attack



7

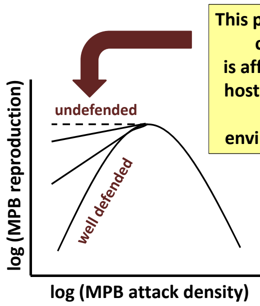
Mountain pine beetles overcome pine defenses through density dependent mass-attack



8

Mountain pine beetles overcome pine defenses through density dependent mass-attack

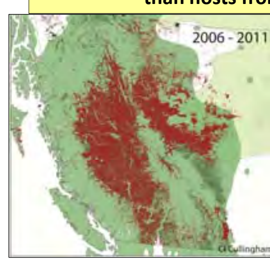
This part of the curve is affected by host genetics and environment

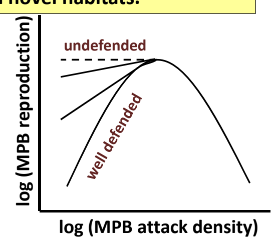


9

Mountain pine beetles overcome pine defenses through density dependent mass-attack

Hosts from MPB's native range may have acquired defenses & other traits that render greater protection than hosts from novel habitats.

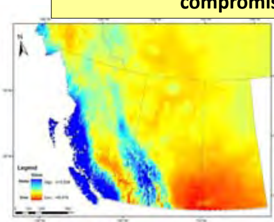




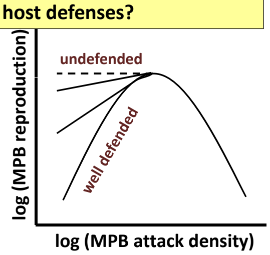
10

Mountain pine beetles overcome pine defenses through density dependent mass-attack

Stressed trees are favoured in endemic phase. Healthy trees are favoured in epidemic phase. Does drought compromise host defenses?

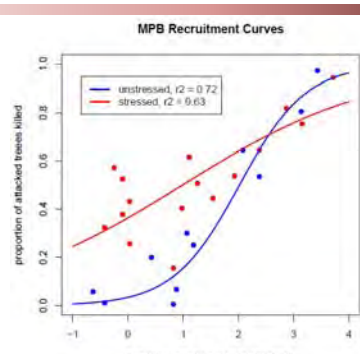


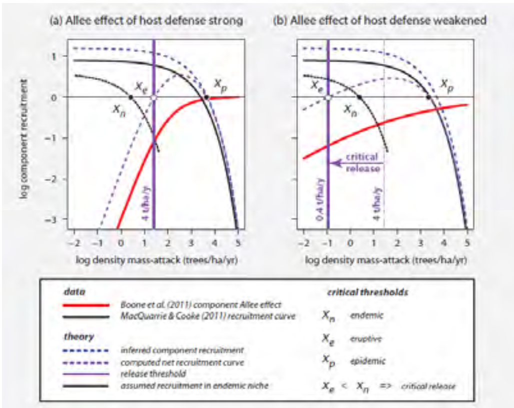
Hogg's climate moisture index

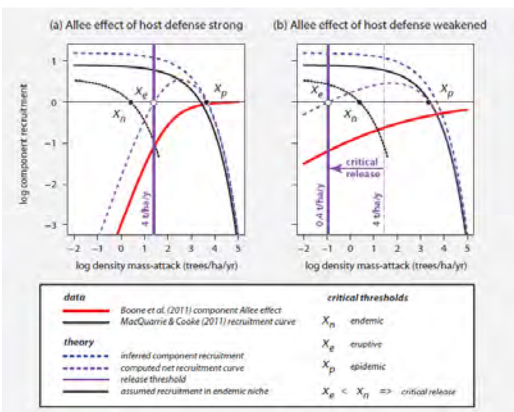


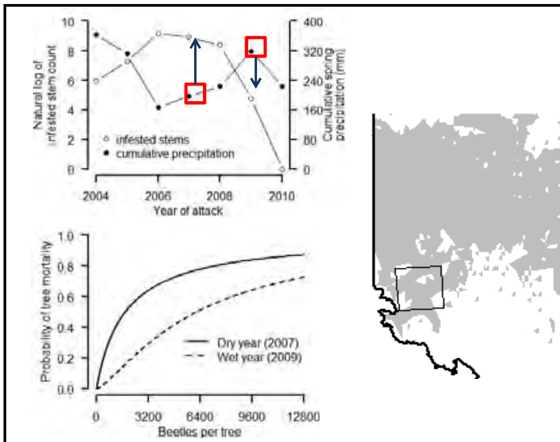
11

Stressed trees have a greater chance of being killed at relatively low attack densities









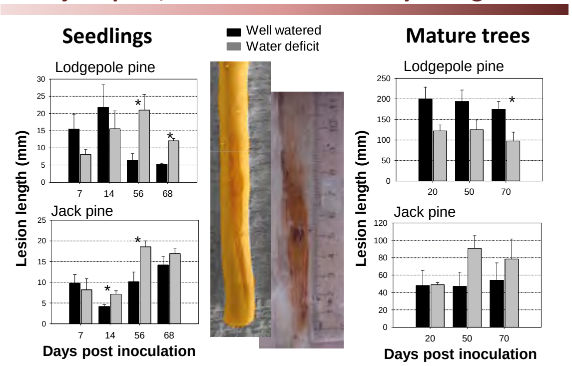
Examining effects of species and water limitation on tree responses to *G. clavigera* inoculation

Species	Water availability	Inoculation treatment
• Lodgepole pine • Jack pine • Hybrid *(field only)*	• Well watered • Water deficit	• Control unwounded/uninoculated • Wound only *(seedlings only)* • Wound + *G. clavigera* inoculation

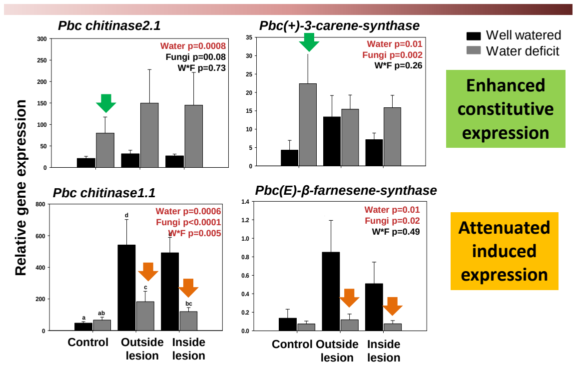
Growth Room Studies
Seedlings

Field Studies
Mature Trees

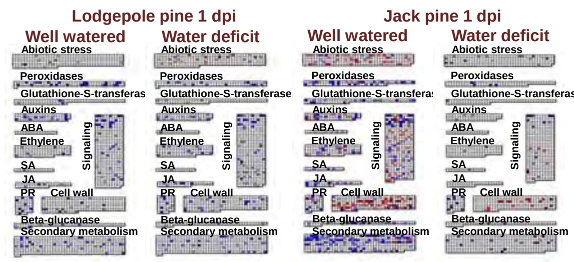
Lesion development differs in lodgepole and jack pine, and is also affected by drought



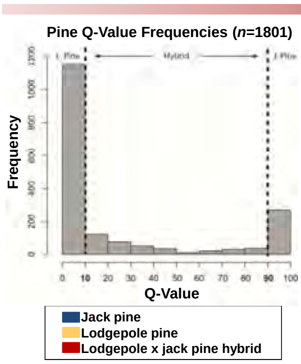
Drought affects gene expression associated with both constitutive and induced defenses

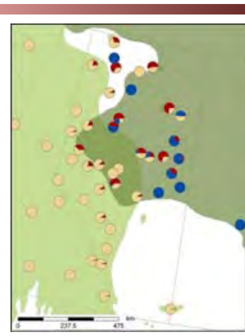


A lot more defense genes are turned up in jack pine than lodgepole pine in the early response

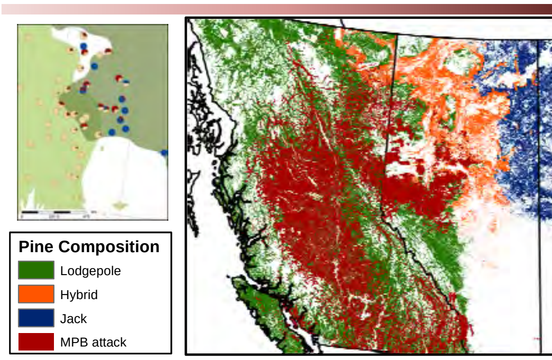


Redrawing the lodgepole x jack pine hybrid zone using genetic markers

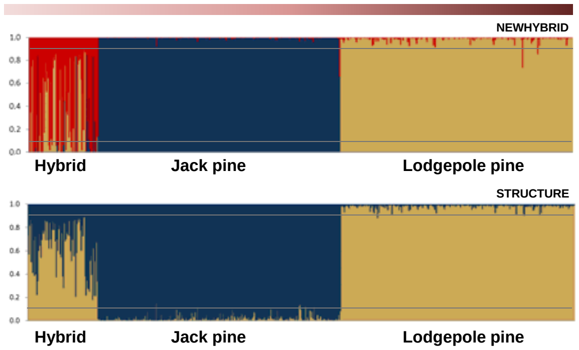




Redrawing the lodgepole x jack pine hybrid zone using molecular marker data



Genetic analyses infer greater lodgepole pine than jack pine ancestry in hybrids

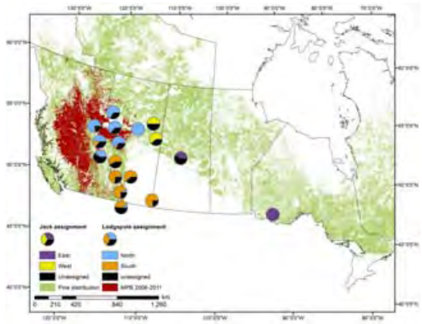


The probability of genetic ancestry for lodgepole and jack pine in the hybrid zone is well predicted by geography and habitat

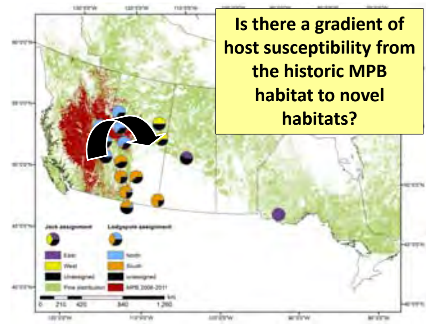
Species distribution modelling using logistic regression of environmental variables to predict genetic ancestry (Q-values) of individuals

Predictor	AIC	Marginal AIC	VIF	Coefficients	LRT*	Effect on *p*(jack)
(Intercept)	**43498**			**49.999**		
Elevation (m)	50513	7015	6.040	-0.007	7016.8	-
Drought index (CMI)*	46690	3192	2.400	0.058	3193.5	+
Mean Annual Precipitation (MAP)*	43615	117	3.730	-0.001	118.8	-
Summer heat:moisture index (SHM)*	43509	11	3.610	-0.007	12.6	-
Extreme min. temp. (EXT_Cold)*	44524	1026	3.790	-0.307	1027.7	+
Northing - Latitude*	46671	3173	5.490	-0.580	3174.5	-
Easting - Longitude*	46804	3306	2.210	0.233	3307.2	+

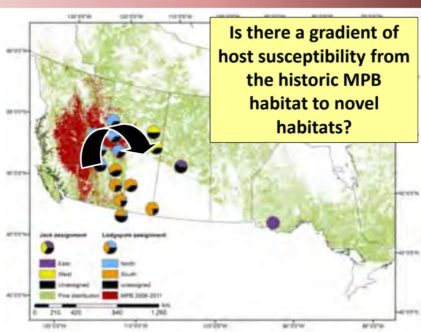
Molecular marker analyses show that the zone of introgression between lodgepole pine and jack pine is larger than we thought



Molecular marker analyses show that the zone of introgression between lodgepole pine and jack pine is larger than we thought



Is there merit in using lodgepole pine from historic beetle habitats in breeding programmes for novel habitats?



Summary

- Lodgepole pine and jack pine responses to mountain pine beetle and their fungal associates differ
- Maybe there is a gradient of host susceptibility through Alberta
- Drought compromises this response by attenuating induced defenses
- Can TI with pine from MPB historic habitats, or TI for drought resistance result in trees more resilient to MPB?

Acknowledgements

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Yisu Li
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Linette Lim
Jean Linsky
Rosalyn Loerke
Fang Yuan Luo
Inka Lusebrink
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Rhiannon Montgomery

Marcelo Mora
Boyd Mori
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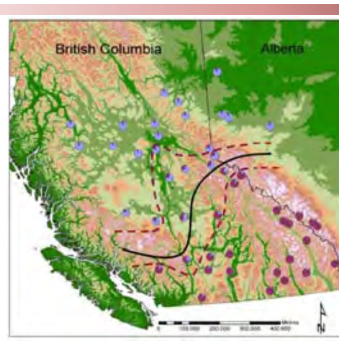
Adrianne Rice
Jeanne Robert
Amanda Roe
Dominik Royko
Kishan Sambaraju
Harpreet Sandhu
Bin Shan
Andrew Sharp
Andrea Singh
Bill Sperling
Euwing Teen
Amy Thommasen
Talya Truant
Clement Tsui
Ye Wang
Gayathri Weerasuriya
Patrick Welsh
Caroline Whitehouse
Christina Wong
Mack Yuen

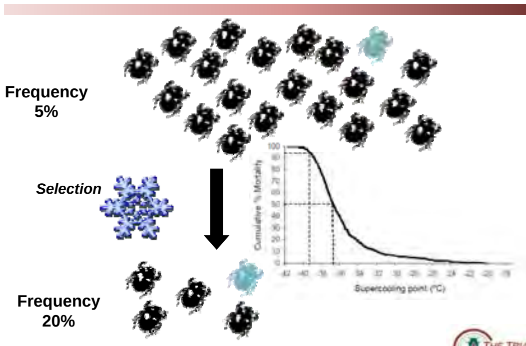
Genome Alberta
Genome Canada
Genome British Columbia
Invasive Species Centre
Alberta Innovates Bio Solutions

Evidence for genetic selection in MPB populations: possible adaptation to novel environments



THE TRIA PROJECT

Beetles in novel habitats: are they becoming more cold tolerant?



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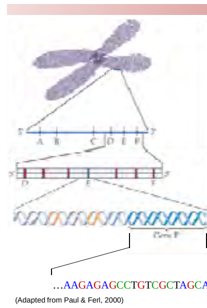
Genomics is based on gene sequence information



Genomes are parcelled into chromosomes

Genes are arranged along chromosomes

Genome sequences
Can be used to measure genetic variation

Expressed gene sequences
Can be used to measure gene activity

...AAGAGAGCCTGTCGCTAGCAAGCGATCC...

(Adapted from Paul & Ferl, 2000)

THE TRIA PROJECT

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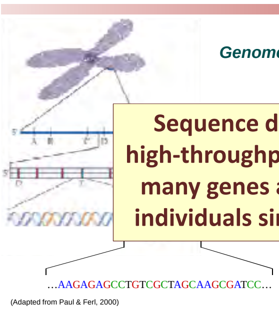
Genomics is based on gene sequence information



Genomes are parcelled into chromosomes

...romosomes

Sequence data enables high-throughput analyses of many genes and/or many individuals simultaneously

...ic variation

Expressed gene sequences
Can be used to measure gene activity

...AAGAGAGCCTGTCGCTAGCAAGCGATCC...

(Adapted from Paul & Ferl, 2000)

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Appendix9: Ramsfield_Pathogens

Climate change and forest pathogens in Alberta

Tod Ramsfield

Northern Forestry Centre, Edmonton

14 January 2015

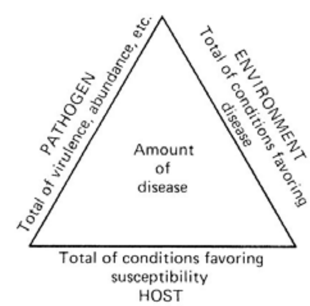
Outline

- Basic plant pathology
- Future climate predictions
- Disease examples from Alberta
- Conclusions

Plant disease definition

- Plant disease: "Any malfunctioning of host cells and tissues that results from **continuous irritation** by a pathogenic agent or environmental factor and leads to **development of symptoms**" Agrios (1988).

The disease triangle

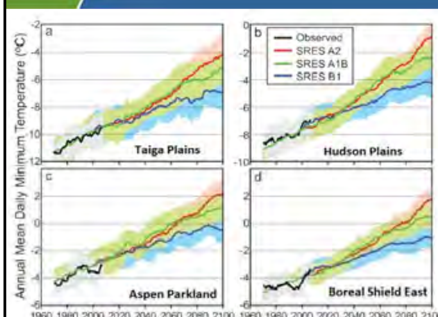


Agrios 1988

Future climate predictions

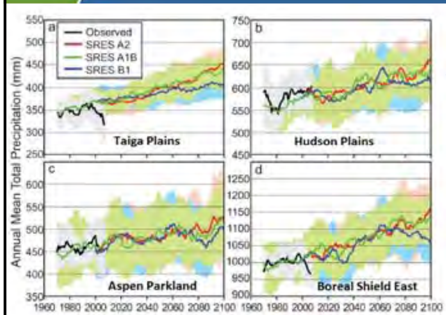
- According to Price et al. (2013; Environ. Rev.), boreal forest predicted to be warmer with increased precipitation (but overall drier).
- Moisture is important for forest pathogens.
- Problem: Models work on long timescales (i.e. seasonal), but many pathogens operate on shorter time scales (wave years).

Temperature predictions



From Price et al., 2013.

Predicted precipitation



From Price et al., 2013.

Foliar disease issues

- Signs and symptoms appear quickly as diseases are driven by conditions in the previous year.
- Climate directly influences pathogen behaviour.
- Dothistroma is an emerging problem in BC (Woods et al.) and has been found in Alberta (Expanding range of pathogens).

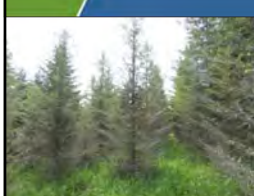
Fig. 2. Mature (60-year-old) lodgepole pine trees (left) and a young pine plantation (right), both examples of Dothistroma needle blight-caused mortality in NW BC.

Woods et al. 2010. The Forestry Chronicle 86(4).

Dothistroma septosporum

Dothistroma needle blight discovered at Alberta Tree Improvement and Seed Centre, Smokey Lake. Nursery thinned and spray program initiated. Causing serious problems in many parts of the world, including Northern BC.

Rhabdocline pseudotsugae

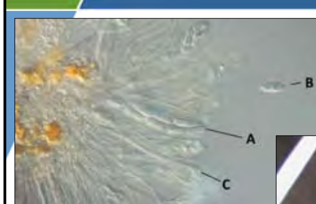


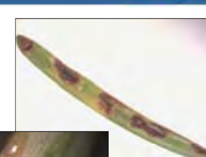
Moderate to severe defoliation

Douglas fir infected by *R. pseudotsugae* at Diamond Hills Forest Genetic Experimental site. July 2013.

Note: no *Phaeocryptopus gaeumannii* observed.

Rhabdocline pseudotsugae





A. Ascus
B. Ascospore
C. Paraphyses

Apothecia

R. pseudotsugae microscopic characteristics; infected Douglas-fir needles.

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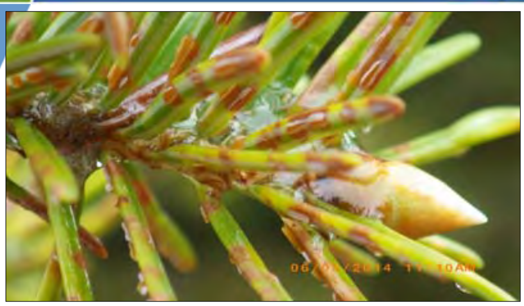
Rhabdocline pseudotsugae



Note moisture, ruptured epidermis. Photo: Ashley Romano, AESRD

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Climate change predictions

- If drought increases foliar pathogens may decrease (disease triangle).

But

- If minimum temperature increases and precipitation increases, conditions may support foliar pathogen survival.

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Long term disease issues

- Diseases related to host response to climate change.
  - Armillaria root disease
  - Heart rot caused by *Phellinus tremulae*
  - Rusts

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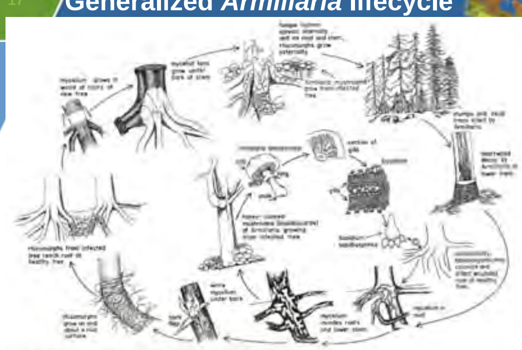
Armillaria root disease

- A long term disease issue that has been termed "a disease of the site" because it can persist over multiple rotations.
- Drought stress to host tree can make tree more susceptible to disease.

17

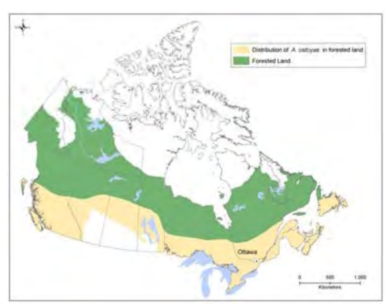
Generalized *Armillaria* lifecycle



From Agrios, 1988

18

Distribution of *A. ostoyae* in Canada



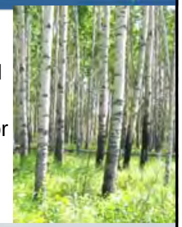
From Sturrock & Pellow

Root disease issues

- Increased drought stress on host may lead to increased disease.
- *A. sinapina* is not as aggressive as *A. ostoyae*, but may cause more damage in the future due to increased host stress.
- Northward movement of the pathogen.
- Cerezke et al. ranked Armillaria root disease as #2 candidate for resistance breeding with "medium" urgency.

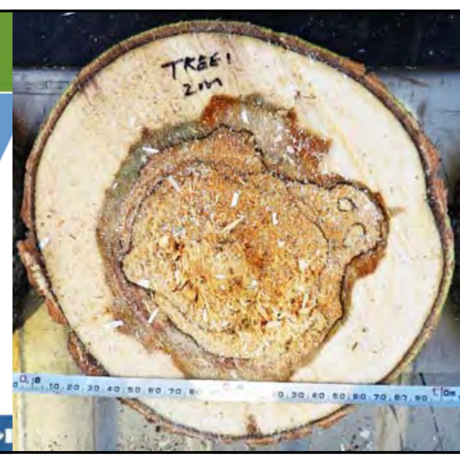
Trembling Aspen: *Populus tremuloides*

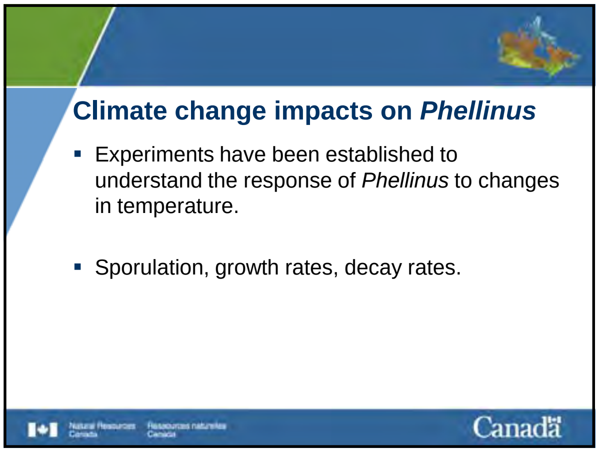
- Distribution: throughout the boreal forest. Est 2484 M m^3; 65% in boreal forest, 3% in Aspen parkland.
- Utilisation: pulp & paper, OSB, minor plywood and specialty
- "Pathological rotation".
- Clonal

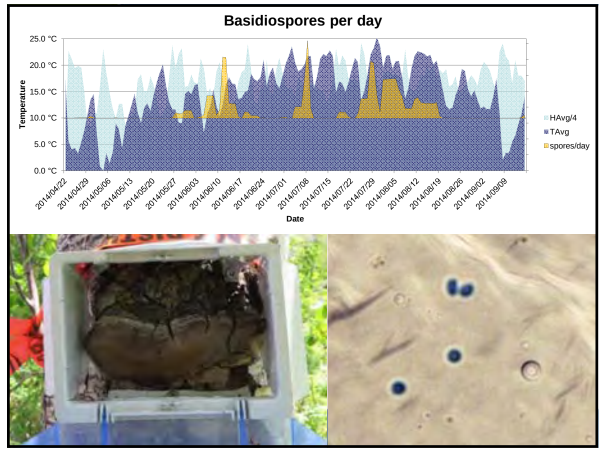


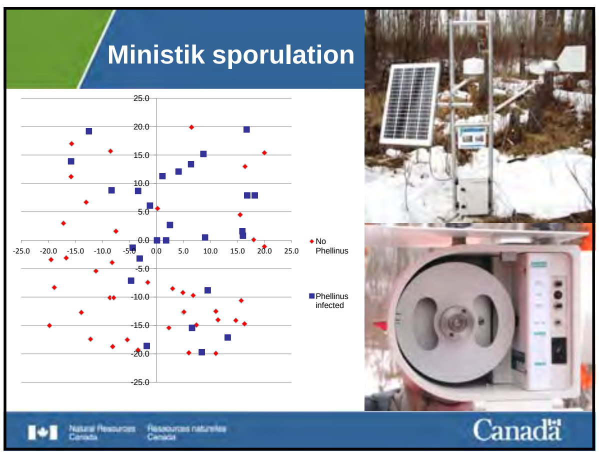
- Aspen utilisation greatest in Ontario and Alberta.
- *Populus* volume in AB est 183.29 M m^3 (12%)
- *Populus* area in AB est 1.045 M HA. (13%)

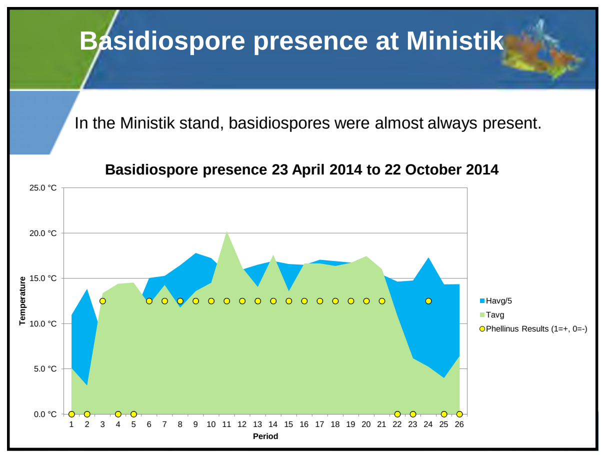
Source: Peterson and Peterson, 1992

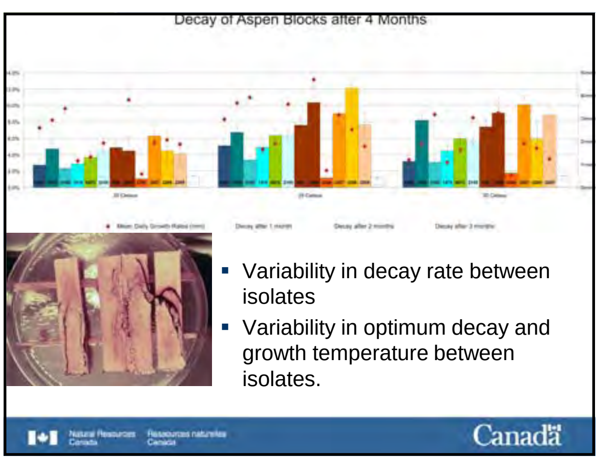


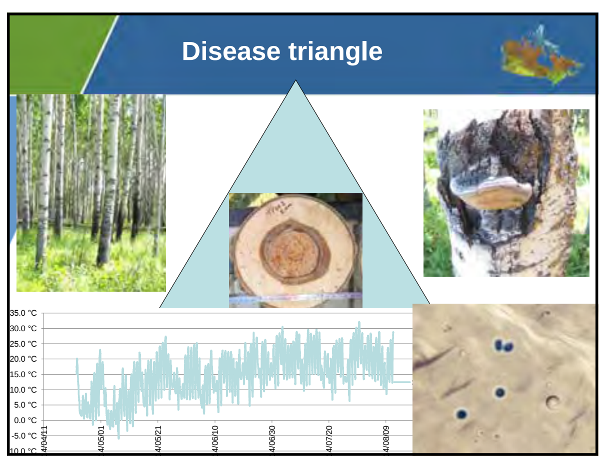

Climate change impacts on Phellinus
Experiments have been established to understand the response of Phellinus to changes in temperature.
Sporulation, growth rates, decay rates.
Canada


Basidiospores per day
Temperature
Date
HAvg/4
TAvg
spores/day


Ministik sporulation
No Phellinus
Phellinus infected
Canada


Basidiospore presence at Ministik
In the Ministik stand, basidiospores were almost always present.
Basidiospore presence 23 April 2014 to 22 October 2014
Temperature
Period
Havg/5
Tavg
Phellinus Results (1=+, 0=-)


Decay of Aspen Blocks after 4 Months
Variability in decay rate between isolates
Variability in optimum decay and growth temperature between isolates.
Canada


Disease triangle

Climate change impacts

- Expanding range of *P. tremulae* within aspen range
- Within range of *P. tremulae* increased number of days favourable for spore production.
- Within range of *P. tremulae* more days where aspen is susceptible to infection.
- The relationship between temperature and decay rate suggests that decay impacts will be greater.
- Increased CO_2 evolution to atmosphere.
- Increased fall down rate of aspen.
- Accurate estimates are difficult due to variation between Aspen clones and *Phellinus* populations.

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Western gall rust

Rusts are influenced by temperature and humidity and persist for multiple years. Wave year frequency.

Ranked as 3rd priority by Cerezke et al.

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Other considerations

- Invasive species
- Drought
- Assisted migration

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Invasive species

- With increased globalization, travel, trade, and climate change, we must keep our eyes open for new forestry pathology problems.
- Quote: "Each imported pathogen is therefore an uncontrolled, potentially dangerous, open-ended experiment in evolution". Brasier, Plant Pathology 57: 792-808.

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White pine blister rust

http://www.cosewic.gc.ca/

Cerezke et al. 2013 ranked WPBR as the #1 candidate for breeding for resistance, with "high" urgency.

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Aspen Decline, Drought

Drought during 2001-2002 resulted in severe aspen dieback in 2005-2006.

Estimated that 29 Mt of drought killed biomass, corresponding to 14 Mt of carbon; approx. 7% of Canada's annual carbon emissions.

Fig. 4 Aerial view showing an area of severe aspen mortality in the aspen parkland of Saskatchewan, Canada (photograph taken by M. Michaelian, 19 August 2004).

Michaelian et al. 2011

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Assisted migration

- The movement of genotypes by humans into areas to ensure persistence of the species.
- Issues:
  - Accidental movement of pathogens.
  - Disease impacts from established pathogens on new genotypes.
  - Upset balance within co-evolved systems.

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Conclusions

- Climate change will affect the pathogen, the host and their interaction.
- Host and pathogen distribution likely to change.
- It is difficult to predict exactly what will happen; drought may reduce foliar pathogen activity but increase the impact of root disease.
- Maintain genetic diversity of planting stock as pathogens can adapt more quickly than hosts.

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Literature

- Cerezke et al. 2013. Review of insect and disease challenges to Alberta coniferous forests in relation to resistance breeding and climate change. Alberta Environment and Sustainable Resource Development. Forest Management Branch. Edmonton. 122p.
- Michaelian et al. 2011. Massive mortality of aspen following severe drought along the southern edge of the Canadian boreal forest. Global Change Biology 17: 2084 – 2094.
- Price et al. 2013. Anticipating the consequences of climate change for Canada’s boreal forest ecosystems. Environmental Reviews 21: 322 – 365.
- Sturrock et al. 2011. Climate change and forest diseases. Plant Pathology 60: 133 – 149.
- Woods et al. 2010. Forest health and climate change: A British Columbia perspective. Forestry Chronicle 86 (4): 412 – 422.

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Appendix10: Aitkin_G&Y

Alberta Government

Tree Improvement in Yield Estimation

Darren Aitkin

TIA workshop
January 14, 2015

Overview

- Current practice – getting TI into your FMP
  - Policy paper
  - Some examples of yield adjustment
  - General requirements
- Future Developments

Current Practice
Getting TI into Yield Estimation

"Volume based genetic gain estimate" April 3, 2006

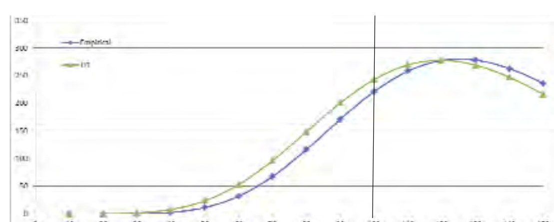
- Policy paper outlining how we consider incorporating Tree Improvement in yield estimation.
  - its dated… but still relevant
- First – need an approved height gain for a breeding program.
  - details regarding how to get an approved height gain are not covered in this policy paper
- Second – volume gain is considered to be 2x the height gain.
  - this paper provides some supporting analysis and discussion why 2x was selected
- Finally – some other general requirements are listed.
  - other things you need to take care of to include TI in your FMP

For Example
how to apply the volume gain

A height gain is approved for a specific breeding program by Forest Health and Adaptation Section of the Forest Management Branch to be <u>5% at 100 years</u> of age.

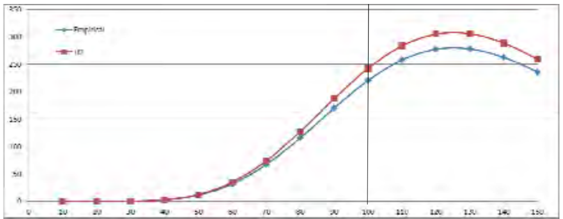
- By the 2x rule we would be looking for 10% volume gain at 100 years of age.
- Depending on the yield estimation methodology used in the FMP this can take various forms.

For Example
in the case of empirical yield estimates



- Assumes same magnitude of yield, but accelerated.
- With a 10% increase at 100yrs.

For Example
in the case of empirical yield estimates



- Assumes 10% yield increase throughout the forecast.
- With a 10% increase at 100yrs.

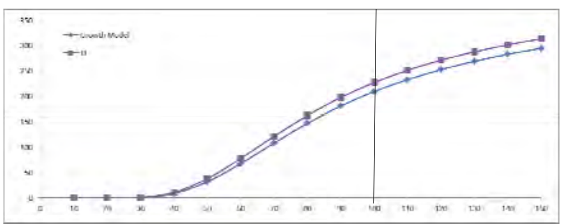
For Example
in the case of empirical yield estimates

Where:

Vol = f(age, SI)

- Adjust SI in an approximation of the approved height gain.
- Dependent on the relationship between SI and volume.
- Evaluate if yield increase at 100yrs approximates 10%.

For Example
in the case of growth modelled yield estimates



- Any of the above three options could be applied here.
- We are looking for 10% at 100 yrs.

General Requirements

1) Meet the terms and conditions of Alberta Forest Genetics Resource Management and Conservation Standards (<u>FGRMS</u>) Manual.

2) Calculate a <u>height gain</u> based on accepted procedures and get approval from Forest Health and Adaptation of Forest Management Branch.

3) Future program development plans, which have yet to be initiated, will not be considered for inclusion as an assumption of enhanced yield in the TSA.

General Requirements

4) There must be genetically improved post-harvest strata definitions that are incorporated into the company's Reforestation Standard of Alberta (RSA). There must also be a clearly stated commitment to monitoring, at an increased level of intensity, for each of the genetically improved post-harvest strata implemented in the TSA.
   - Declaration codes and associated MAI Standards are needed specific to these TI managed strata.
   - A companies growth and yield program must present an explicit strategy on how these TI managed strata are being monitored operationally (i.e. PSP's, realized gain trials).

General Requirements

5) To demonstrate feasibility of deployment plans, a table outlining planned deployment of improved stock is required. This must show cumulative hectares of deployment by stratum and period for the entire planning horizon. Area of improved versus regular stratum must be reported so that the proportion of each can be evaluated at any point in the forecast.
   - In the short-term this information will be used to evaluate the feasibility of the deployment plan.
   - For the long-term this information will be used to evaluate proportions of deployed stock in accordance with FGRMS.

Future Developments

How can we do this better?

The Flewelling Report (2008)

- Review of existing procedures and provides recommendations on how genetic gain could be incorporated into yield estimates in Alberta.
  - Note that component of this Report were hotly debated.
- Implementation Work Plan established in 2009.
  - However, this was promptly put aside as TI programs were being critically re-evaluated. Redesign of the programs was being explored to better ensure their own sustainability.

Growth Modelling in Alberta

- Currently available growth models do not explicitly model tree improvement.
- Both the GYPSY AC and the MGM SDT have identified TI as a desired functionality in these models.
- However, these tend to be lower down the list, with core functionality taking priority.

Potential Opportunity

- Collaboration between the Forest Growth Organization of Western Canada (FGrOW) and TIA to:
  - prioritize, find & assign resources, and advance our modeling capability for yield estimation with regard to Tree Improvement.

Maybe now is the time to reinitiate discussions on how to advance available tools and methods for incorporating TI into yield estimation?

Questions?

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