

Ecological impacts and associated management strategies for western larch in the face of climate change

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Research Branch



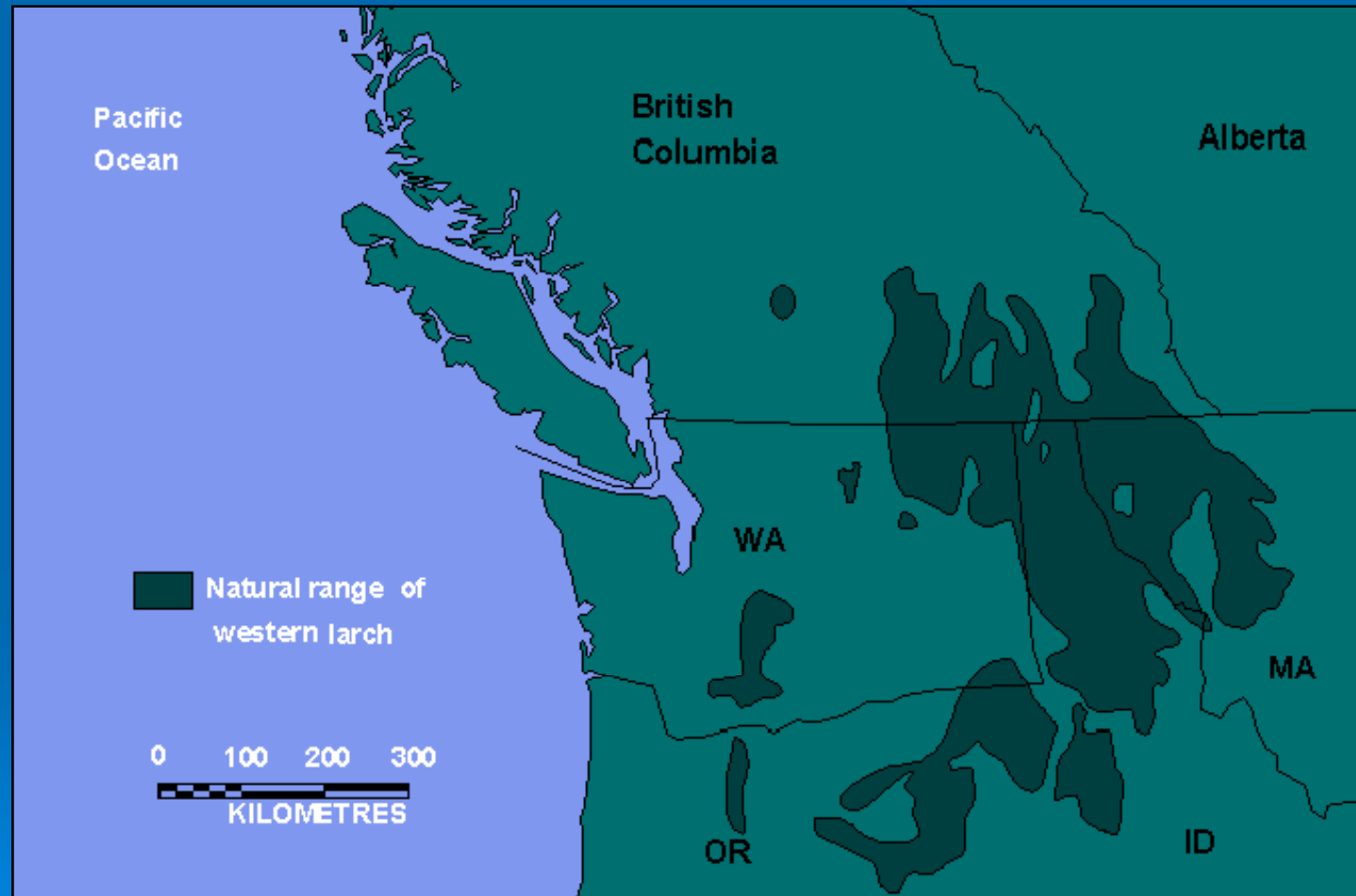
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U.S. Forest Service, retired
Moscow, Idaho







Natural distribution of western larch (*Larix occidentalis*)





North-west of Golden, near Rogers Pass

Prairie Ck, south-east
of Horsefly





Prairie Ck, south-east of Horsefly



South-west Burns Lake: SBS mc, 1020 m, blk E100

South-west Burns Lake,
SBS mc, 1020 m, blk E100
snow press



South-west of Burns Lake
SBS mc, 840 m, blk E098





West of Burns Lake
SBS dk 01, 640m, blk L046

South-east of Burns Lake
SBS dk 07, 740m, blk K003





West of Burns Lake: ESSF k 04, 1320 m, blk L029



Date Ck Demonstration Forest (north of Kispiox) - 20-years



Bell-Irving, north of Meziadin Junction – 12-years

Bell-Irving, north of
Meziadin Junction
12 - years



Background

- Mountain pine beetle infestation, climate change and assisted migration, and a desire increase ecosystem complexity to increase resilience prompted Chief Forester to request the establishment of seed transfer rules for planting western larch outside its natural distribution.
- Jaquish and Rehfeldt - range-wide study based on climate variables; biological and ecological considerations only

Introduction

- Over the last decade - dramatic increase in research focused on documenting and describing biotic responses to a rapidly warming climate ;
- Statistical and mechanistic models to describe bioclimatic relationships and model responses to climate change in: biomes and ecosystems, species, and populations;
- Results suggest a wholesale geographic redistribution of vegetation will be required to re-establish a semblance of equilibrium between climate and vegetation by the end of the century.

Introduction

- Unfortunately, one of the weaknesses of much of this work centres on their inability to account effectively for species' intrinsic abilities to respond to climate change
 - life history characteristics, adaptive strategies, population genetic structure, and patterns of genetic variation are commonly ignored

Introduction

- Climate is the primary factor controlling plant distributions, largely through edaphoclimatic interactions that function as selection agents to mould systems of genetic variation;
- Responses to selection determine adaptive strategies, genetic architecture, dispersal and establishment rates that interact to control adaptation to changing climate.

Introduction

- Therefore, without basic genetic knowledge managers lack information fundamental necessary to making informed decisions

e.g. conservation, seed transfer & zones

- General objective: to assess the potential impacts of changing climate on western larch taking into consideration ecologic and genetic responses

Objectives

- Define climate profile with a bioclimate model that predicts presence or absence from climate variables;
- Develop models of genetic variation;
- Develop and map seed zones within predicted distributions for present and future climates;
- Identify threatened populations and develop conservation strategies; and,
- Develop strategies for transfer of seed sources to future locations of their optimal climate considering: future distributions, adaptation of populations, and variability of GCM models

Methods

- 185,000 observations from 4 data sources, 4,548 contained western larch;
- Climate surfaces of Rehfeldt 2006 (Hutchinson's anuspline) using 34 climate variables, 18 derived from monthly climate estimates ;
- Random Forest classification tree used to predict presence/absence of western larch from climate variables;
- Genetic variation assessed from two experiments:
 - 15-year-old range-wide provenance test at Lamb Ck, south of Cranbrook (128 populations), and,
 - re-analysis of 4-year data from farm-field tests in north Idaho (143 populations);



Lamb Creek western larch research installation,
South-east of Cranbrook, B.C.

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Lamb Creek western larch research installation,
South-east of Cranbrook, B.C.

Methods

- Multiple regression used to relate genetic variation to climate of the seed source;
- Climate grids (1 km²) for geographic area run through bioclimate and genetic models to construct maps;
- Three GCMs and two scenarios used to project climate profile and genetic attributes into future climate space:

CCCNA, UKMO and GFDL.

Results

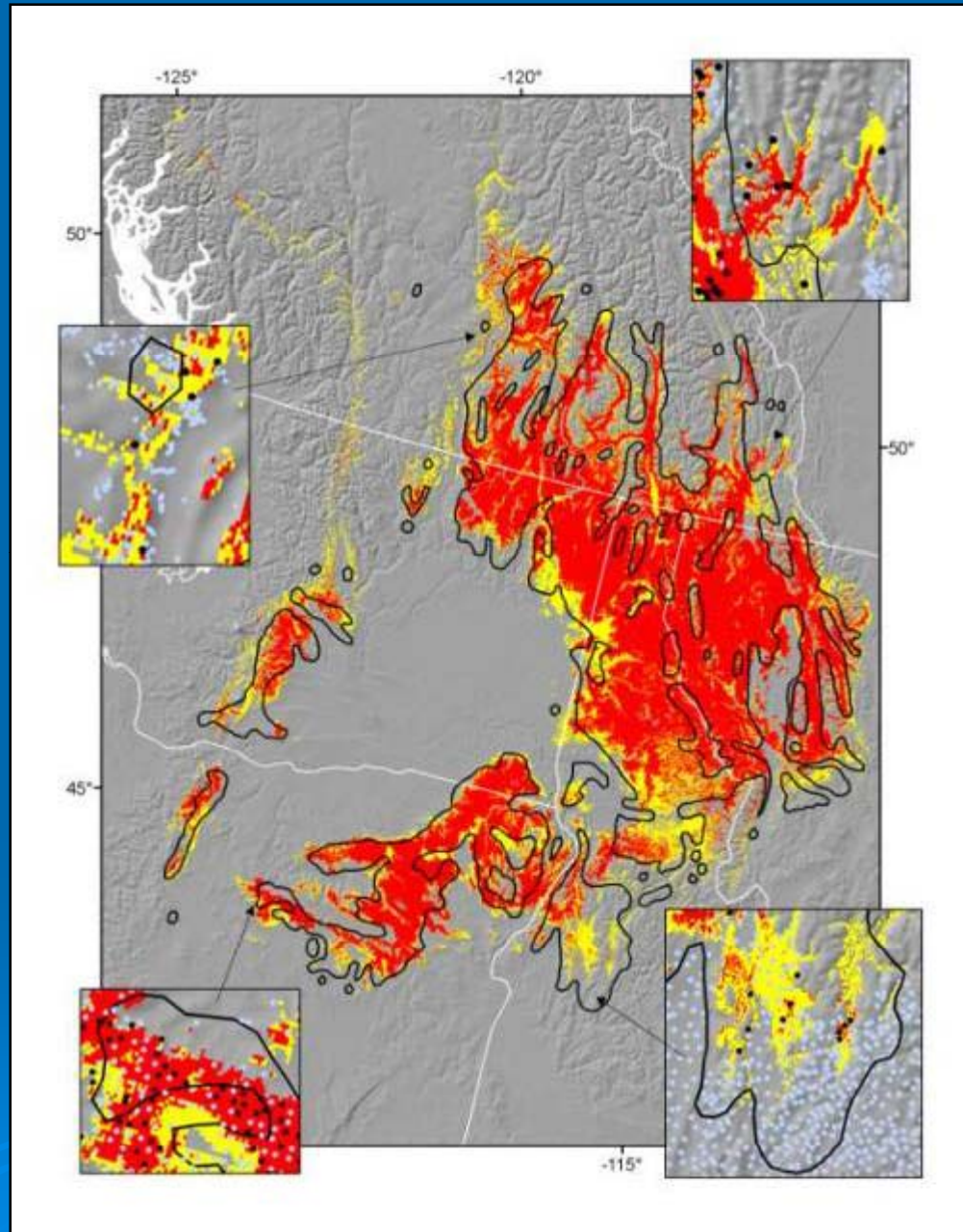
- 8-variable model used to describe climate profile (error of prediction = 2.9%);
- Most important climate variables for western larch occurrence:
 - **summer dryness x winter temperatures** (cool winters, cold temperatures weighted by summer precipitation);
 - **ratio summer to total precipitation** (moisture stresses generally minimized); and,
 - **DD>5 x MTCM** (winter and summer temperature not extreme).

Mapped western larch climate profile

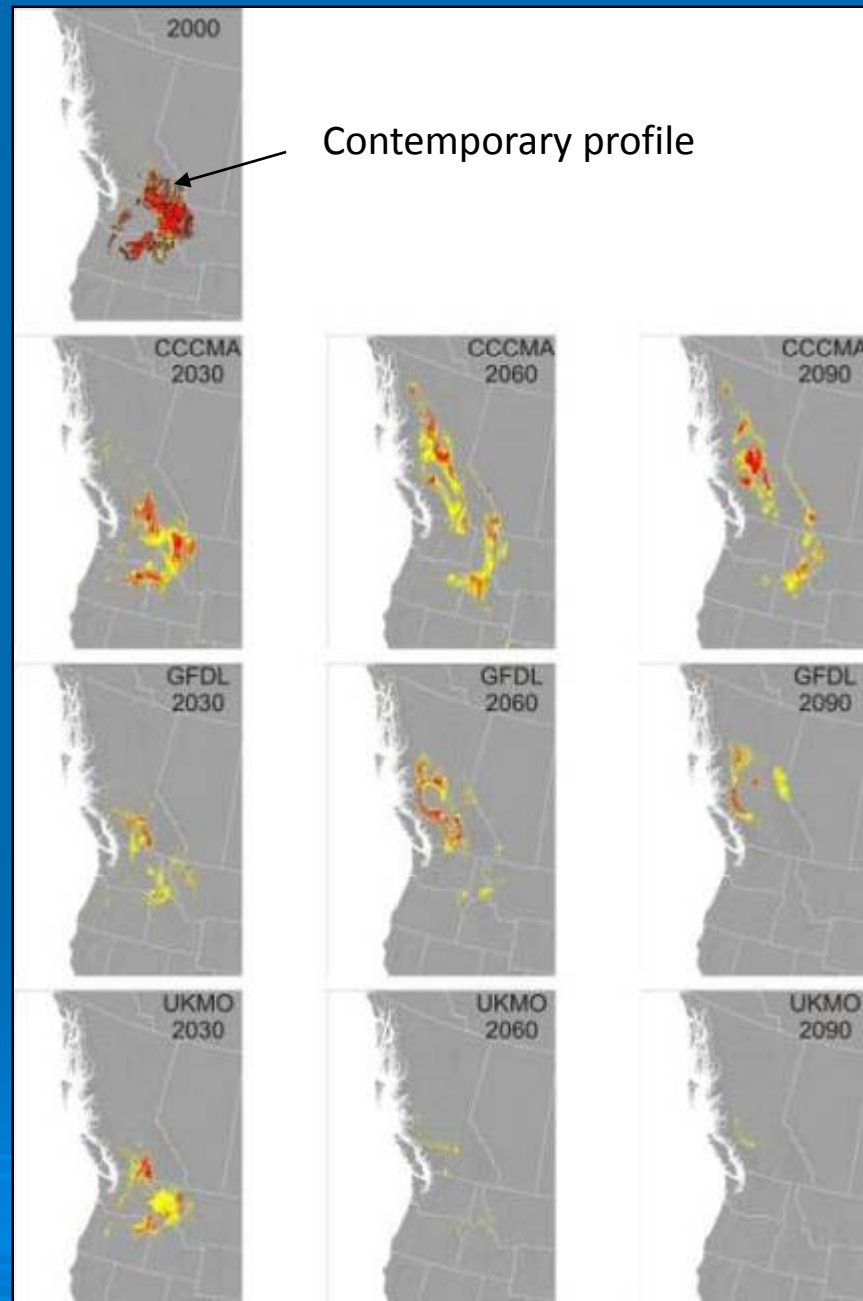
Yellow = 50 – 75% votes
Red = 75 – 100% votes

Insets present
location of data points
black = Lw
light = no Lw

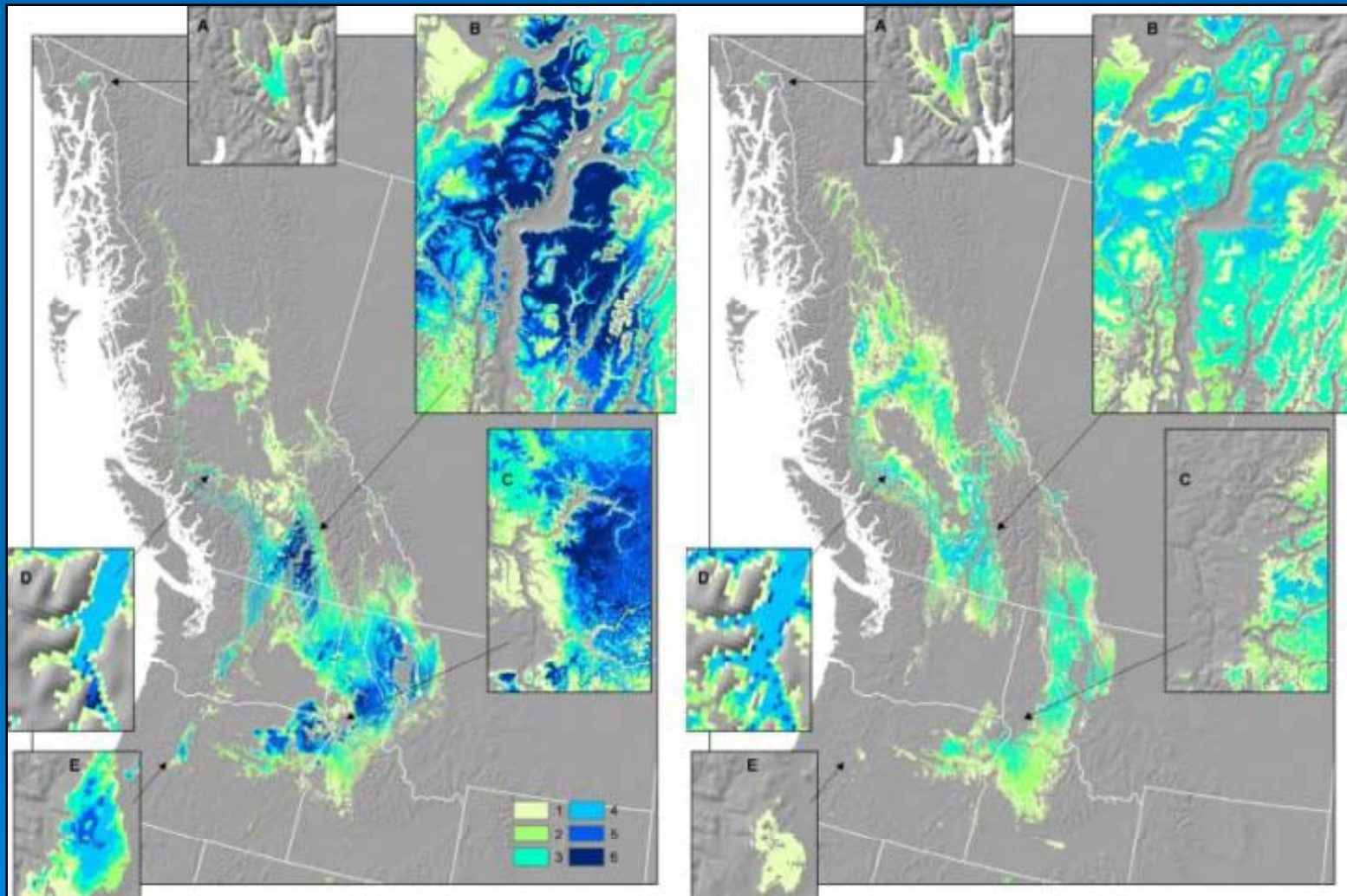
Black line = Little's range
map



Mapped climate profile for contemporary and future climates for three GCMs and scenario A2 (unrestrained carbon emissions)



Mapped climate profiles of western larch for decade 2030 and 2060 superimposed for three GCMs and two scenarios (degree of concurrence coded to key in bottom right corner of 2030 figure)

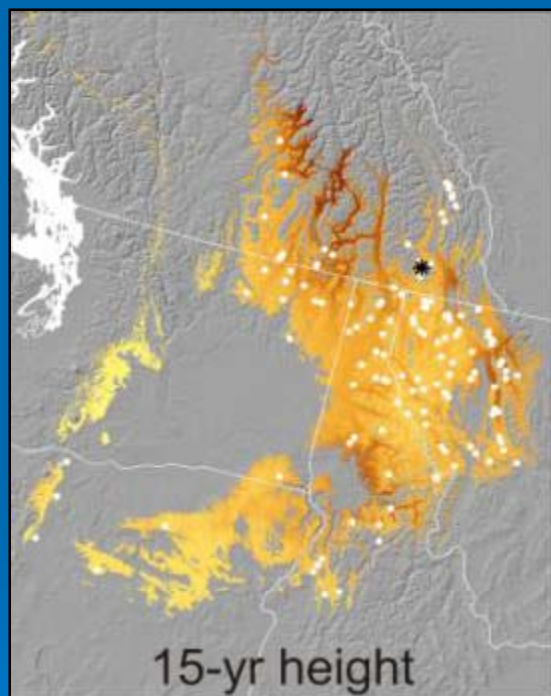
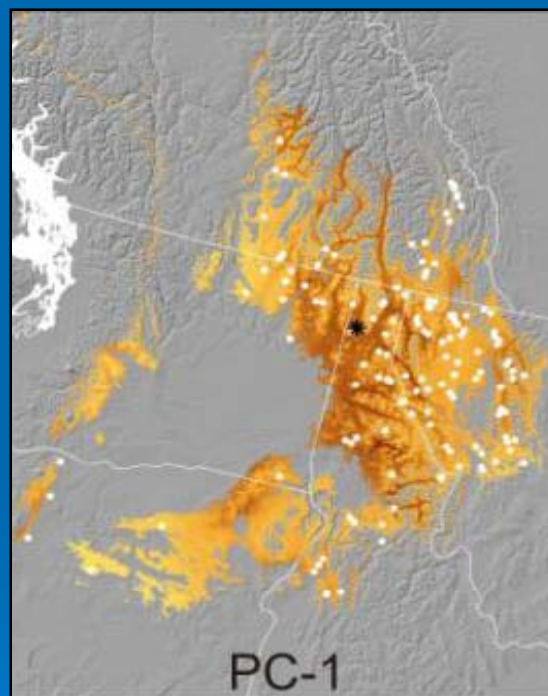
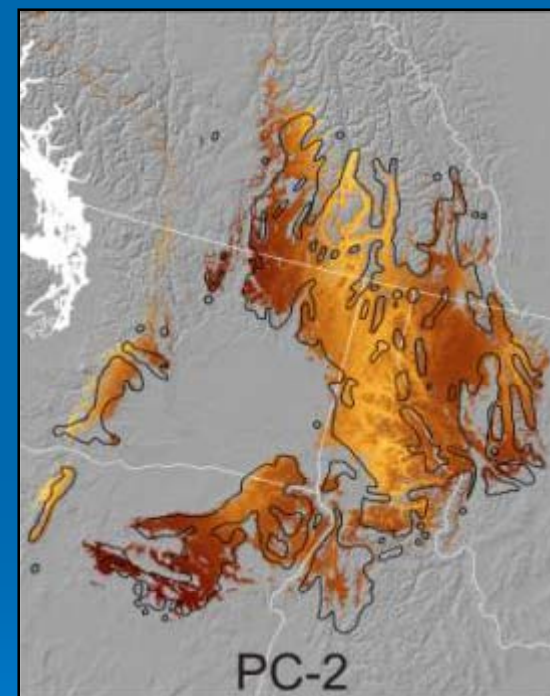


2030

2060

Mapped genetic variation in three characters predicted from regression models.

Dark and light shading indicates high and low values, respectively.
White and black dots indicate populations sampled and test locations.



4-yr ht and Meria resistance

mortality

Results

Seed transfer and seed zones

Seed transfer (climate based)

Location specific seed transfer guidelines can be constructed by searching for all pixels with predicted values for our three genetic attributes (Ht15, PC-1 and PC2)

Western larch seed
source procurement
within current range
for current and 2030
climate

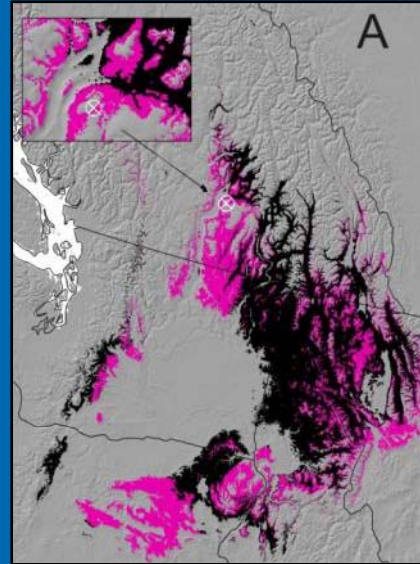
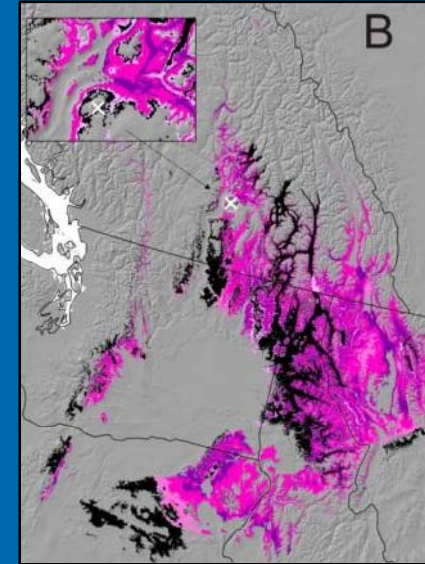
⊗ = planting site

Black shading = climate profile

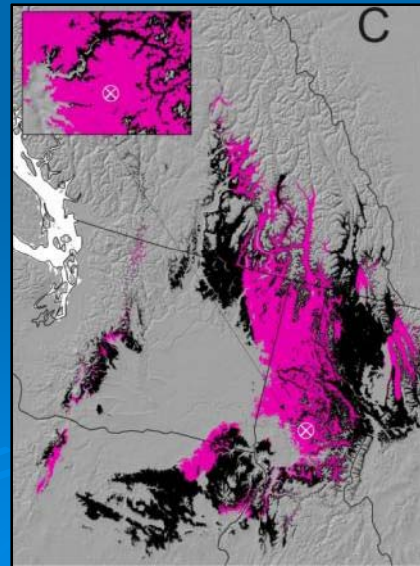
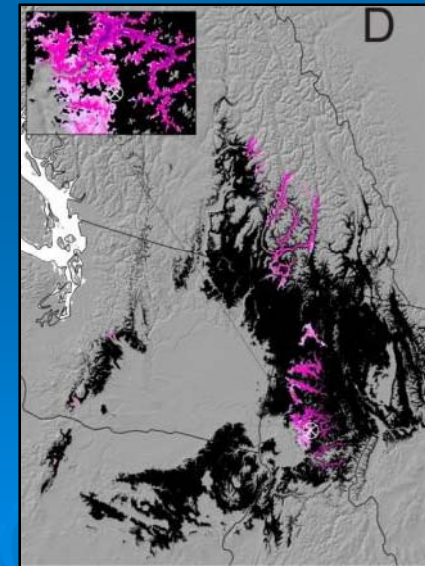
Pink shading = locations to
procure seeds genetically
compatible with test site

Current climate

2030

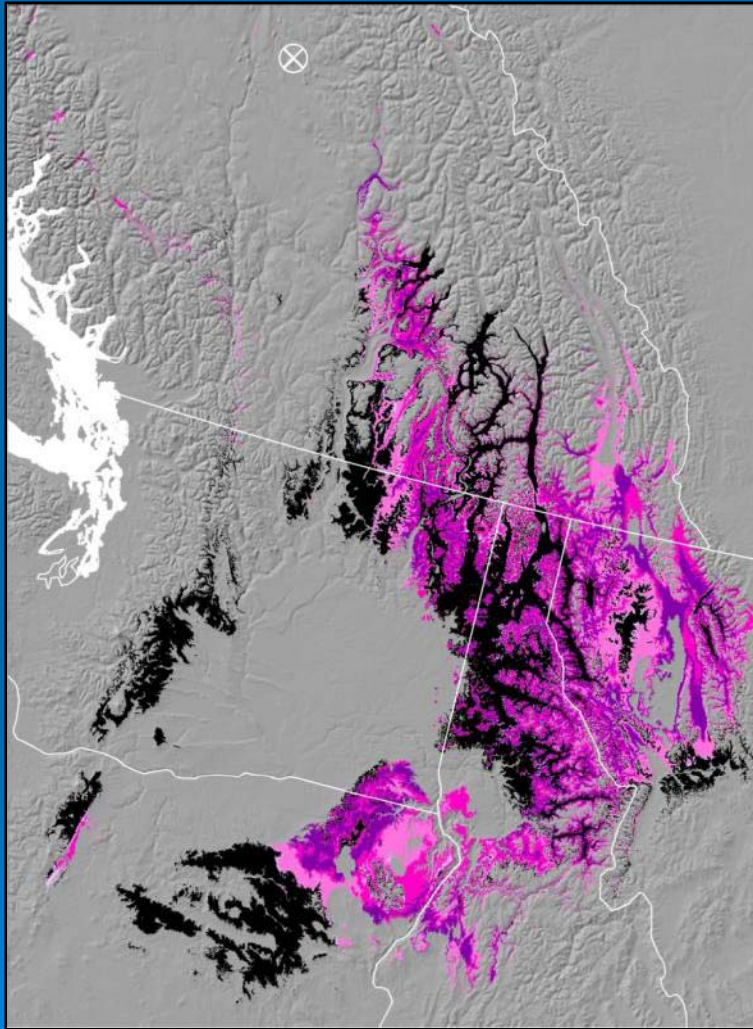


Vernon

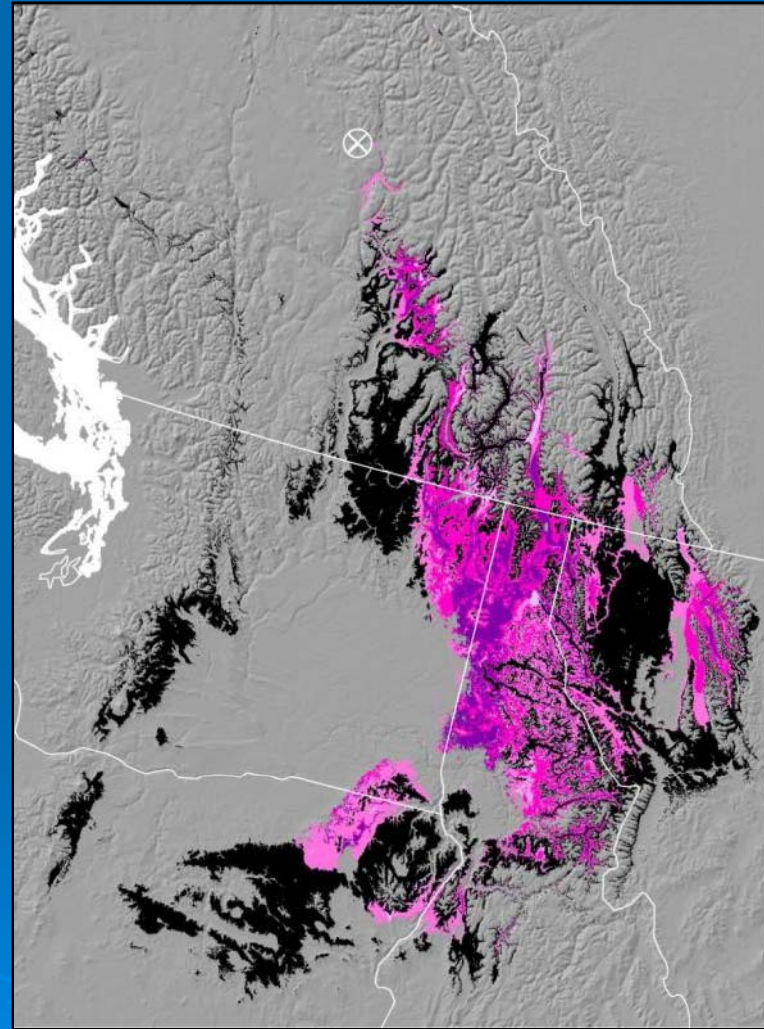


North
Idaho

Western larch seed procurement for
sites **outside** current range for 2030 climate



Gavin Lake



Mahood Lake

Results

Seed transfer and seed zones

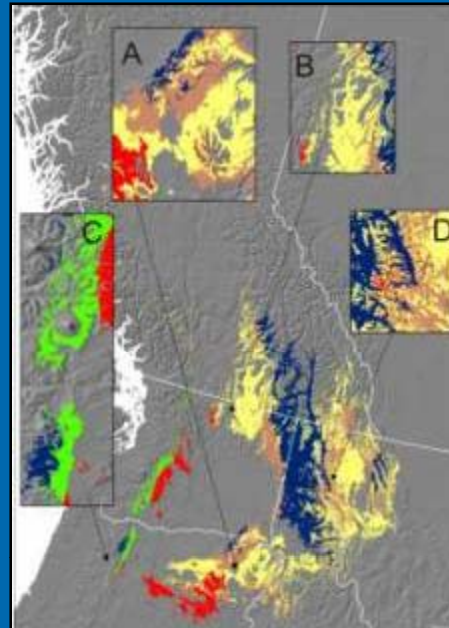
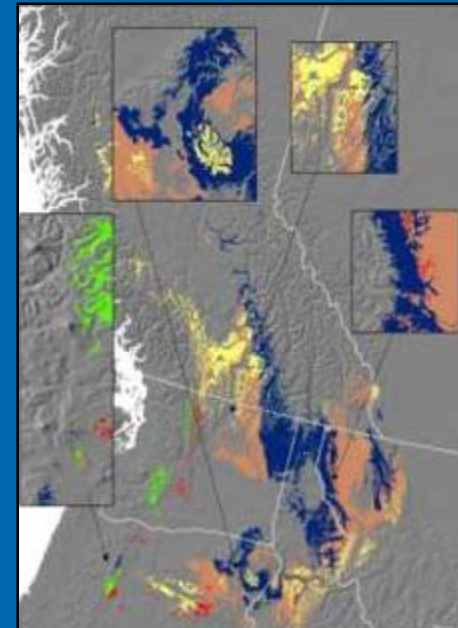
Seed zones

Climate ecotypes (seed zones) can be delineated by the qualitative subdivision of the continuous genetic variation

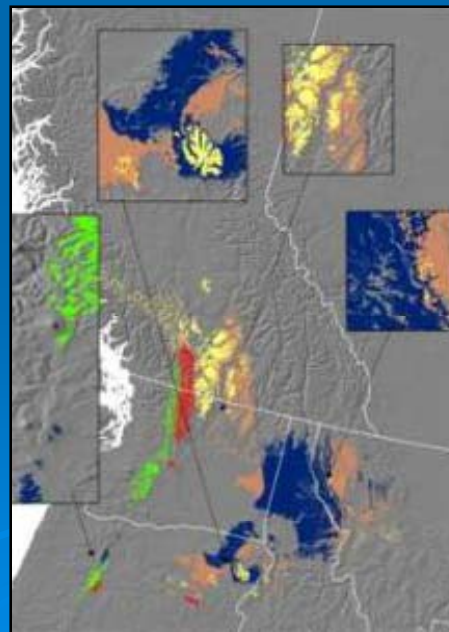
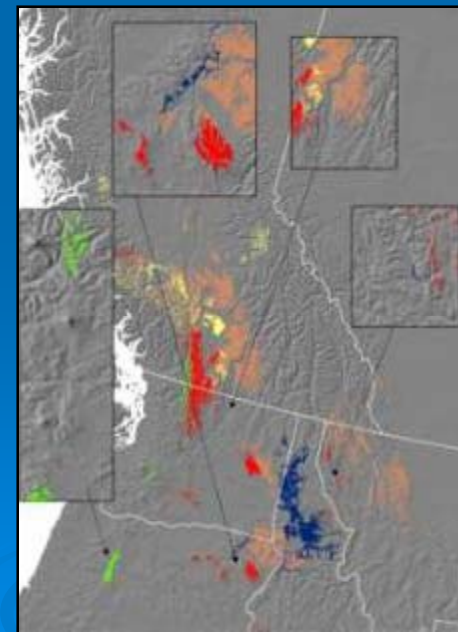
Map of five western larch seed zones (upper left) and their 2030 projections to A2 scenarios of three GCMs

Four insets are repeated in all four panels

GFDL



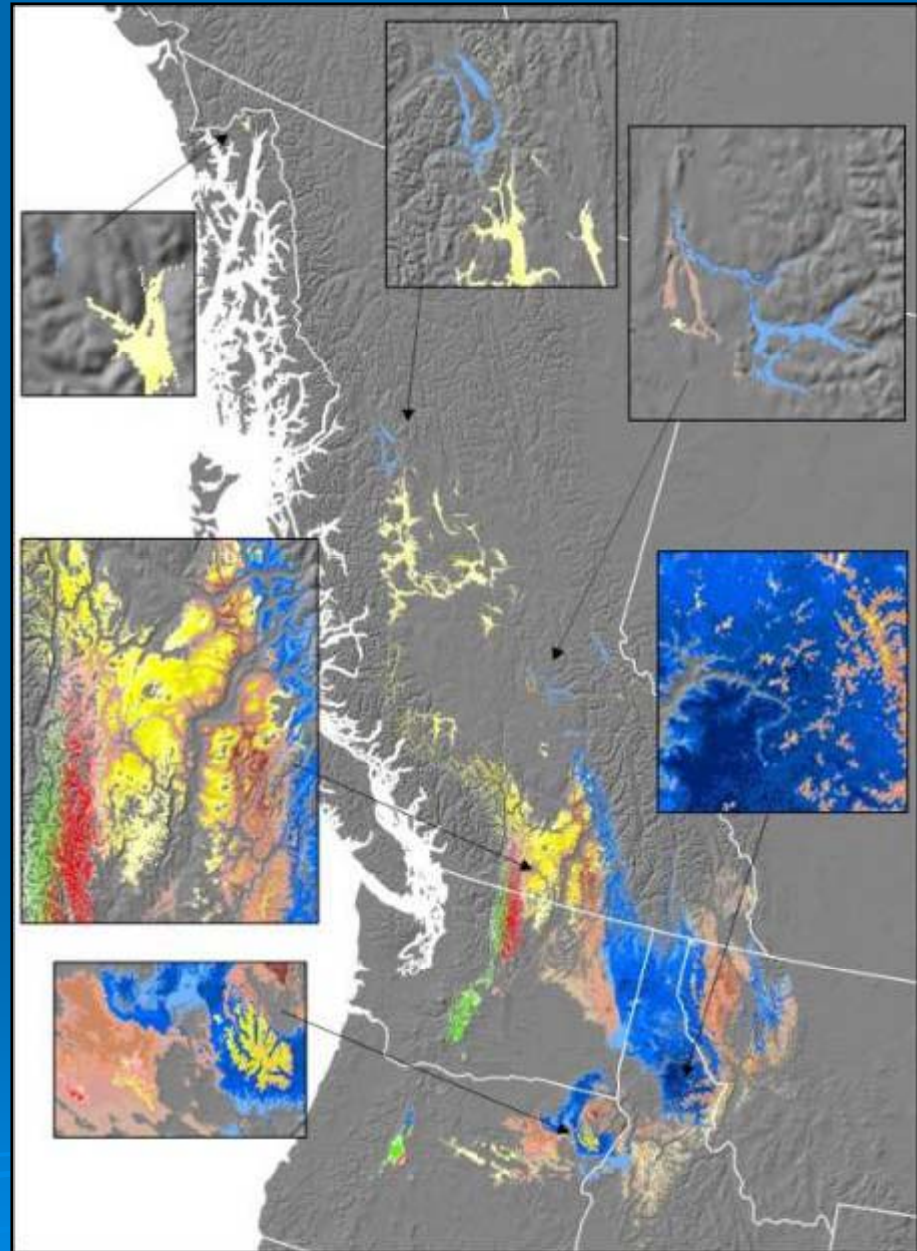
CCCMA



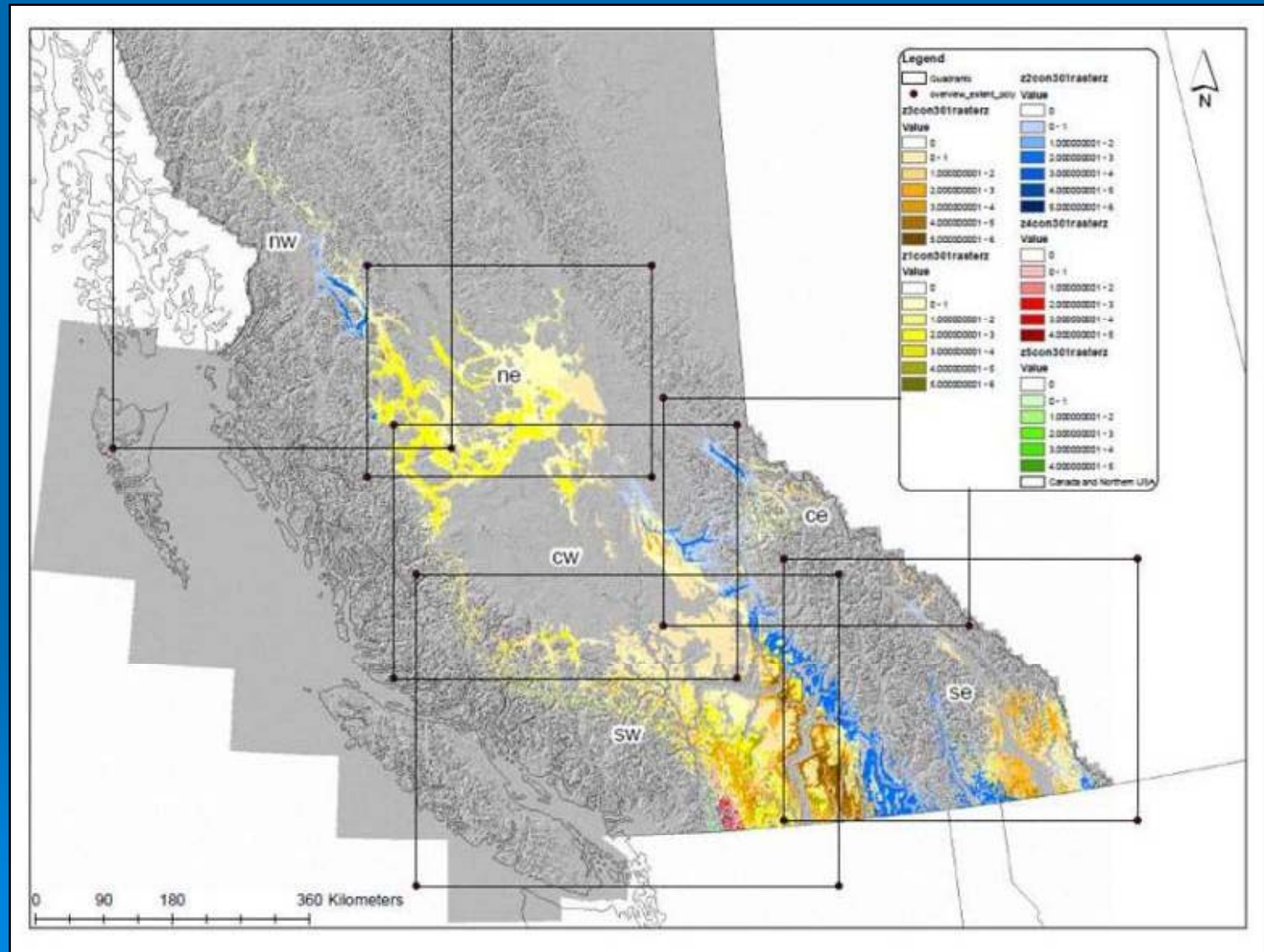
UKMO

Range-wide concurrence
among three GCM and
two scenarios for the 2030
location of the five seed zones

lightest = agreement among 3
darkest = agreement among 6



2030 location of the five western larch seed zones
lightest=1 scenario; darkest=6 scenarios

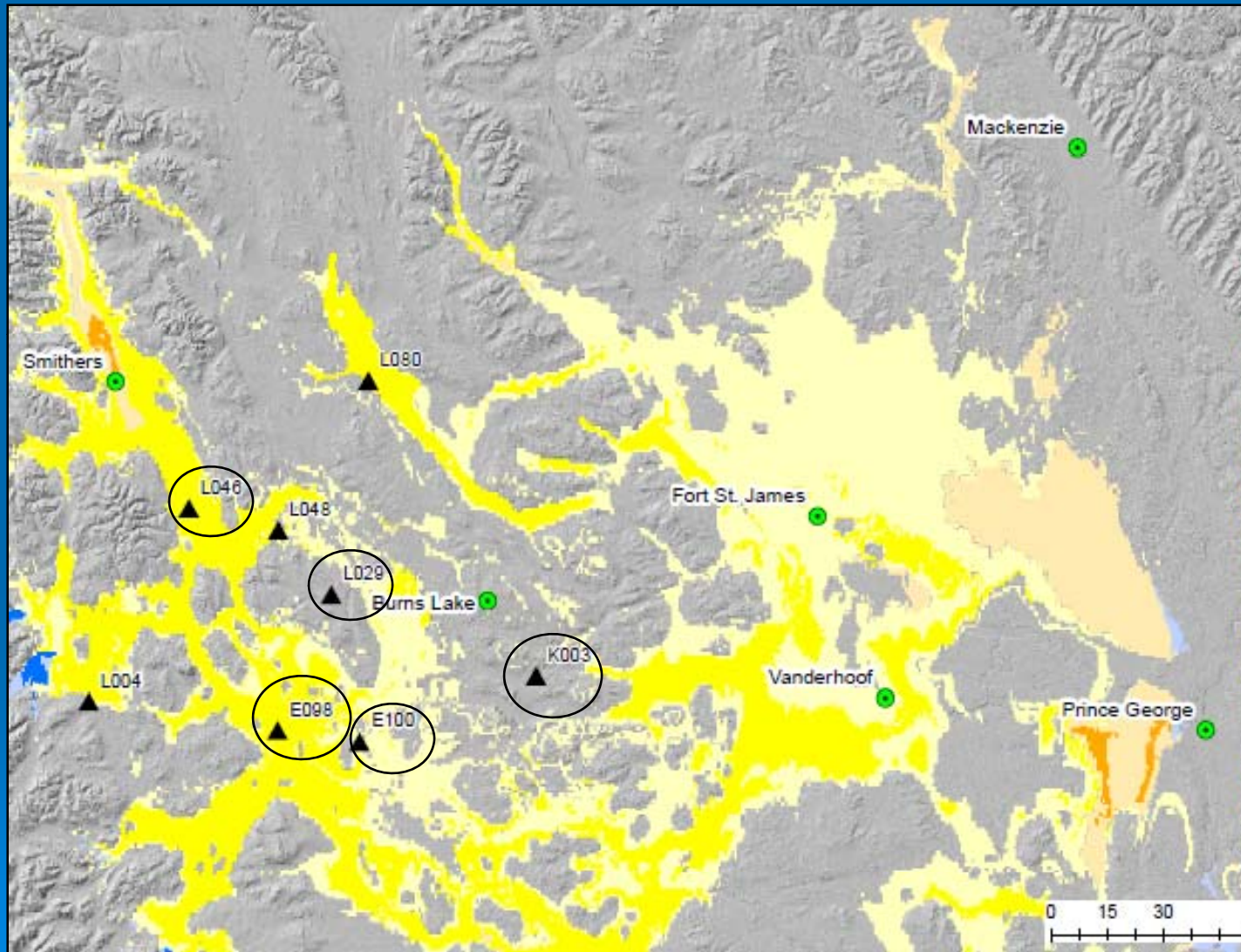


Elevation bands (m) for western larch seed sources for six B.C. quadrants

Geographic region	Seed Zone (zone colour in maps)				
	EK high (yellow)	NE low (blue)	EK low ^a (brown)	SSM high ^a (red)	SSM low ^a (green)
North-west	600 - 1000	200 - 600	-	-	-
North-east	600 - 1000	-	600 - 800	-	-
Central-west Interior	700 - 1100	700 - 1100	700 - 900	-	-
Central-west coast	700 - 1500	-	-	-	-
Central-east	900 - 1500	600 - 1100	900 - 1300	-	-
South-west	900 - 1600	600 - 1200	900 - 1300	1100 - 1600	700 - 1300
South-east	1000 - 1700	600 - 1400	1000 - 1400	-	-

^a no seed orchard presently in place

Predicted seed source validation: Sites within black circles are keyed to block numbers on slides 10 – 15



Conclusions

- Predicted climate profile closely related to present distribution of western larch;
- Considerable variation in GCM predictions of future climate space; however, agreement of northwest migration far outside its contemporary range;
- Contemporary climate space can be subdivided into five ecotypes (seed zones) largely differentiated by region and elevation; close agreement with current B.C. western larch class A seed zones;

Conclusions

- Maps of climate model concurrence for seed zones provide land managers with basic information for making informed decisions;
- presently in B.C. 3 western larch seed orchards
NE low = blue EK & NE high=yellow
consider establishing EK low (brown);
- Cascade populations (including Tyner Lake) merit conservation effort; and,
- New zones fail to align consistently with contemporary BEC zones or variants.

Options for western larch climate based seed transfer

- Systems based seed transfer
- Seed zone maps
 - determine if planting site is within the projected climate space;
 - identify appropriate seed source for the site and note the level of risk from the respective colour shade; and,
 - confirm elevation suitability from table.
- Ecotype (seed zone) polygons suitable for GIS mapping and analyses