Supplement of Biogeosciences, 13, 2945–2958, 2016
http://www.biogeosciences.net/13/2945/2016/
doi:10.5194/bg-13-2945-2016-supplement

Biogeosciences
Open Access

Supplement of

Contributions of dynamic environmental signals during life-cycle transitions to early life-history traits in lodgepole pine (*Pinus contorta* Dougl.)

Yang Liu et al.

Correspondence to: Yousry A. El-Kassaby (y.el-kassaby@ubc.ca)

Table S1 A list of important climatic variables

Table S2 Canonical correlation analysis (CCA) and MANOVA statistical test criteria

Table S3 Errors from ecosystem zones in life-history traits' models

Table S4 Parameter estimates and statistical tests for the geographic variables-based hierarchical models regarding life-history traits

Figure S1 Geographical distribution of the 83 populations (green triangles) on the map regarding AMT value (A) and ecosystem zones (B) of British Columbia, Canada.

Figure S2 The distribution of the samples based on mean annual temperature (MAT) against annual heat moisture index (AHM).

Figure S3 Schematic representation of the cumulative germination curve parameters used to characterize seed dormancy.

DI (dormancy index): the gray shaded area, the difference of area under germination curves (*AUC*) of control and any other treatment; *GS* (germination speed): the number of days to reach 50% of final germination; *GC* (germination capacity): the final germination percentage.

Figure S4 PLS biplot of 194 climatic variables (green), 83 populations (red), and 21 (above) 20 (below) categories for 83 population habitats (blue).

Figure S5 PCA for 194 climatic variables. The 15 most correlated climatic variables were marked in red.

Figure S6 Seed dormancy (*DI*, a) and weight (*SW*, b) distribution for the 83 populations labeled on the map of British Columbia, Canada.

Figure S7 Linear relationship between 1,000-seed weight and 'predicted' 1,000-seed weight using 83 populations.

Figure S8 The amount of changes for *DD_0_winter*, *DD5_spring*, and *DD5* in 2050s relative to present.

Note: The population was ranked as per its current *DI* in ascending order. Each data point is the average of predictions using three methods (RCP2.6, 4.5, and 8.5). Bars indicate the SEM. Ranges across populations under different scenarios are provided in a table format.

Table S1 A list of important climatic variables

Abbreviations	Full names
Eref06, *07*, *08*, *09*, *_summer*, and *_autumn*	June, July, August, September, summer, and autumn hargreaves reference evaporation (caculated by temperature and solar radiation)
DD_0_summer	summer degree-days below 0°C
PPT06, *07*, *09*, *10*, and *_autumn*	June, July, September, October, and autumn precipitation (mm)
Tmax07 and *_summer*	July and summer maximum mean temperatures (°C)
PAS04, *05*, and *_spring*	April, May, and spring precipitation as snow (mm)
DD18_04, *_06*, *_07*, *09*, *_10*, *_spring*, and *_autumn*	April, June, July, September, October, spring, and autumn degree-days above 18°C
DD18	annual degree-days above 18°C
DD5_07, *09*, and _autumn	July, September, and autumn degree-days above 5°C
Tmin 04, *10*, *11*, *_spring* and *_autumn*	April, October, November, spring and autumn minimum mean temperatures (°C)
CMD09 and *_autumn*	September and autumn hargreaves climatic moisture deficit (calculated by *Eref* and precipitation)
NFFD10	October number of frost-free days
MAT	mean aunnal temperature (°C)
MAP	mean annual precipitation (mm)
AHM	annual heat-moisture index (*MAT*+10)/(*MAP*/1000))
Tave09, *10*, *_spring*, and *_autumn*	September, October, spring and autumn mean temperature (°C)

Table S2 Canonical correlation analysis (CCA) and MANOVA test criteria

A)

Canonical function	Likelihood ratio	Approximate *F*-value	Num DF†	Den DF†	Pr > *F*††
1	0.1371	2.89	60	102	**<0.0001**
2	0.5776	1.31	29	52	0.1943

† Num DF and Den DF represent numerator and denominator degrees of freedom, respectively.
†† Hypothesis is, H_0: none of the canonical functions is significant; H_a: at least one of the canonical functions is significant ($P < 0.05$).

B)

MANOVA tests†	*F* Value	Num DF††	Den DF††	Pr > *F*
Wilks' Lambda	3.30	42	120	**<0.0001**
Pillai's Trace	3.27	42	122	**<0.0001**
Hotelling-Lawley Trace	3.34	42	105.24	**<0.0001**
Roy's Greatest Root	4.53	21	61	**<0.0001**

† null hypothesis for the statistic tests is the centroids of life-history traits are equal across the 22 ecosystem zones ($P < 0.05$).
†† Num DF and Den DF represent numerator and denominator degrees of freedom, respectively.

Table S3 Errors from ecosystem zone for seed dormancy and weight models

		Seed dormancy model				Seed weight model			
Ecosystem zone	DF	Estimate	STD Pred	t Value	Pr > |t|	Estimate	STD Pred	t Value	Pr > |t|
BB	58	-0.8391	1.5939	-0.53	0.6006	0.09572	0.0974	0.98	0.3300
BLK	58	-1.1614	1.6123	-0.72	0.4742	-0.04007	0.1055	-0.38	0.7060
CHL	58	0.1542	1.7931	0.09	0.9318	-0.1539	0.1218	-1.26	0.2110
CP	58	1.8555	1.669	1.11	0.2708	-0.0866	0.1099	-0.79	0.4340
CT	58	-0.6866	1.8897	-0.36	0.7177	0.1130	0.1515	0.75	0.4590
DK	58	0.0068	1.7932	0.00	0.9970	-0.1033	0.1319	-0.78	0.4370
EK	58	1.8960	1.7285	1.10	0.2772	0.05822	0.0989	0.59	0.5590
FIN	58	0.2597	1.641	0.16	0.8748	-0.1450	0.1054	-1.38	0.1740
FN	58	0.2124	1.811	0.12	0.9070	0.1040	0.1377	0.76	0.4530
GL	58	0.6919	1.8805	0.37	0.7143	0.0824	0.1525	0.54	0.5910
HH	58	0.5785	1.5921	0.36	0.7177	0.1606	0.1103	1.46	0.1510
M	58	-1.0011	1.7276	-0.58	0.5645	0.1579	0.1440	1.10	0.2780
MGR	58	0.4678	1.8017	0.26	0.7961	-0.2729	0.1316	-2.07	**0.0430**
MRB	58	-1.2299	1.8959	-0.65	0.5191	-0.0010	0.1509	-0.01	0.9950
NCH	58	-0.3918	1.6630	-0.24	0.8146	-0.0329	0.1127	-0.29	0.7720
NST	58	-2.1080	1.6615	-1.27	0.2096	-0.2655	0.1111	-2.39	**0.0200**
QL	58	0.0288	1.8147	0.02	0.9874	-0.0751	0.1338	-0.56	0.5770
SA	58	-0.7419	1.6473	-0.45	0.6541	-0.0279	0.1064	-0.26	0.7940
SM	58	-0.4658	1.6725	-0.28	0.7816	-0.1020	0.1200	-0.85	0.3990
TOA	58	0.9769	1.6045	0.61	0.5450	0.2323	0.0996	2.33	**0.0230**
TOD	58	1.4143	1.6246	0.87	0.3876	0.2303	0.0984	2.34	**0.0230**
WK	58	0.0826	1.7959	0.05	0.9635	0.0716	0.1203	0.60	0.5540

The ecosystem zones in BC are abbreviated BB, BLK, CHL, CP, CT, DK, EK, FIN, FN, GL, HH, M, MGR, MRB, NCH, NST, QL, SA, SM, TOA, TOD and WK; these denote Big Bar, Bulkley, Chilcotin, Central Plateau, Cariboo Transition, Dease Klappan, East Kootenay, Finlay, Ft. Nelson, Georgia Lowlands, Hudson Hope, Maritime zones, McGregor, Mt. Robson, Nechako, Nass Skeena Transition, Quesnel Lakes, Shuswap Adams, Submaritime, Tompson Okanagan Arid, Tompson Okanagan Dry, and West Kootenay, respectively.

Table S4 Parameter estimates and statistical tests for the geographic variables-based hierarchical models regarding seed dormancy and seed weight

(A) Seed dormancy model

Effect	Estimate	Standard Error	DF	Statistic	*P*
Intercept[¶] (β_0)	146.32	32.3917	21	t = 4.52	**0.0002**
Longitude (β_1')	0.9794	0.3150	58	F = 9.66	**0.0029**
Elevation (β_2')	0.0029	0.0020	58	F = 1.98	0.1643
Latitude (β_3')	-0.1070	0.3808	58	F = 0.08	0.7797

Note: the same model as described in the text but using geographic variables as independent variables,

$(\text{life-history trait})_{ij} = (\beta_0' + \varepsilon_j) + \beta_1' \times \text{Long}_{ij} + \beta_2' \times \text{Elev}_{ij} + \beta_3' \times \text{Lat}_{ij} + \varepsilon_{ij}$

where i and j represent two levels, i.e., i^{th} population in j^{th} ecosystem zone; Long_{ij}, Elev_{ij} and Lat_{ij} represent the longitude, elevation, latitude for i^{th} population within j^{th} ecosystem zone; ε_j and ε_{ij} represent errors from ecosystem zone and population, respectively. Intercept (β_0'+ ε_j) and coefficients (β_1', β_2' and β_3') were estimated using our experiment data.

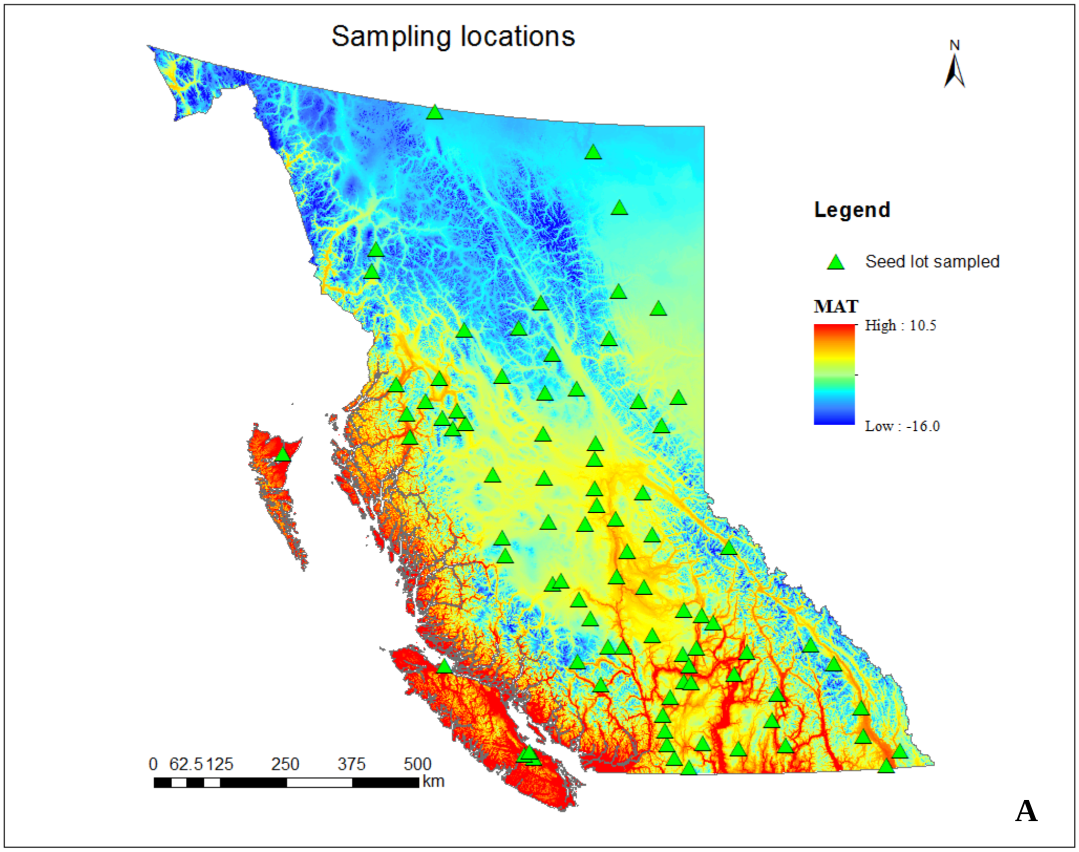
(B) Seed weight model

Effect	Estimate	Standard Error	DF	Statistic	*P*
Intercept[¶] (β_0)	10.8374	1.6076	21	t = 6.74	**<.0001**
Longitude (β_1')	0.0615	0.0127	59	F = 23.32	**<.0001**
Elevation (β_2')	-0.0003	0.0001	59	F = 11.43	**0.0013**

Note: assuming that β_3' is zero in the model.

[¶] residual from ecosystem zones (ε_j) is integrated into ‘intercept’ (data not shown).

Figure S1


Sampling locations
N
Legend
Seed lot sampled
MAT
High : 10.5
Low : -16.0
0 62.5 125 250 375 500
km
A

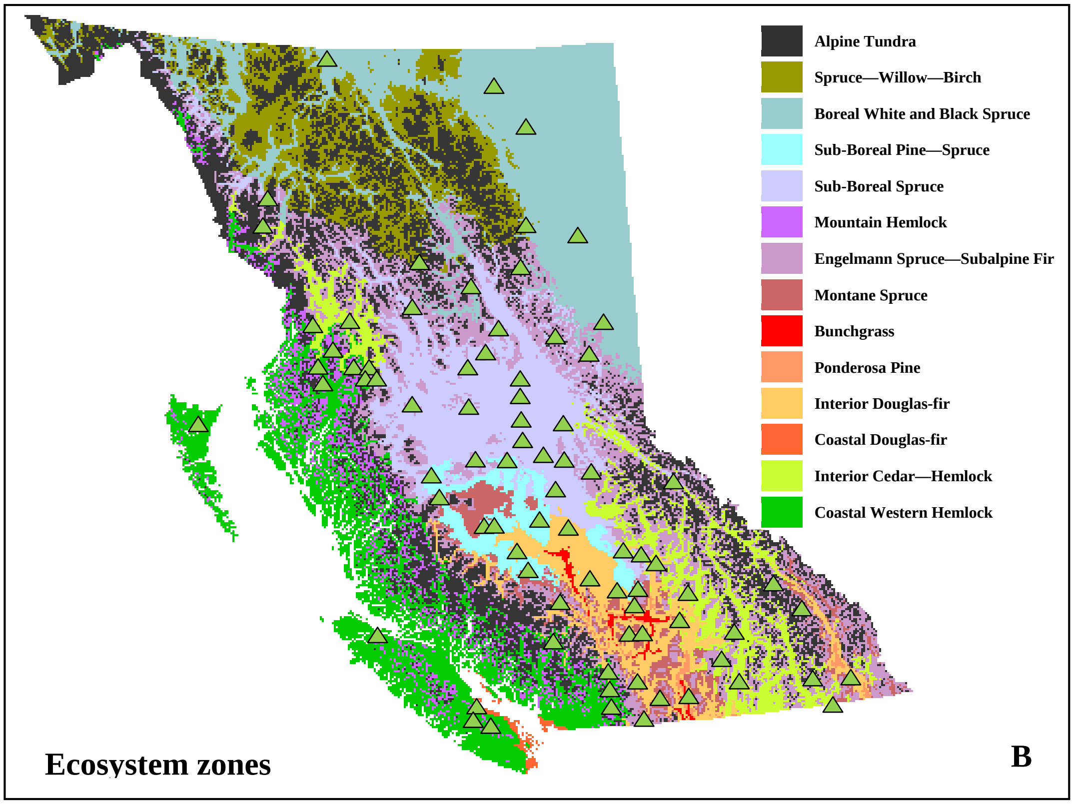

Alpine Tundra
Spruce—Willow—Birch
Boreal White and Black Spruce
Sub-Boreal Pine—Spruce
Sub-Boreal Spruce
Mountain Hemlock
Engelmann Spruce—Subalpine Fir
Montane Spruce
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Coastal Douglas-fir
Interior Cedar—Hemlock
Coastal Western Hemlock
Ecosystem zones
B

Figure S2

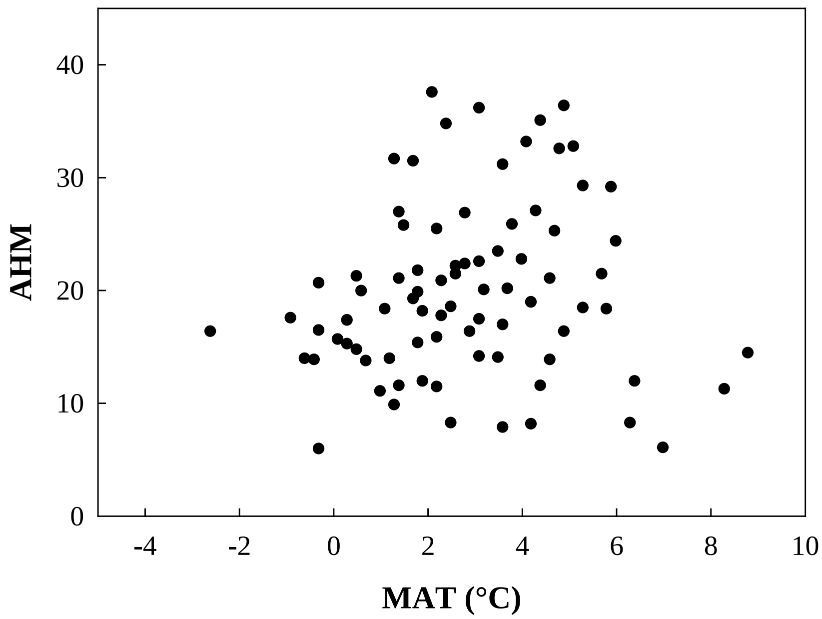


Figure S3

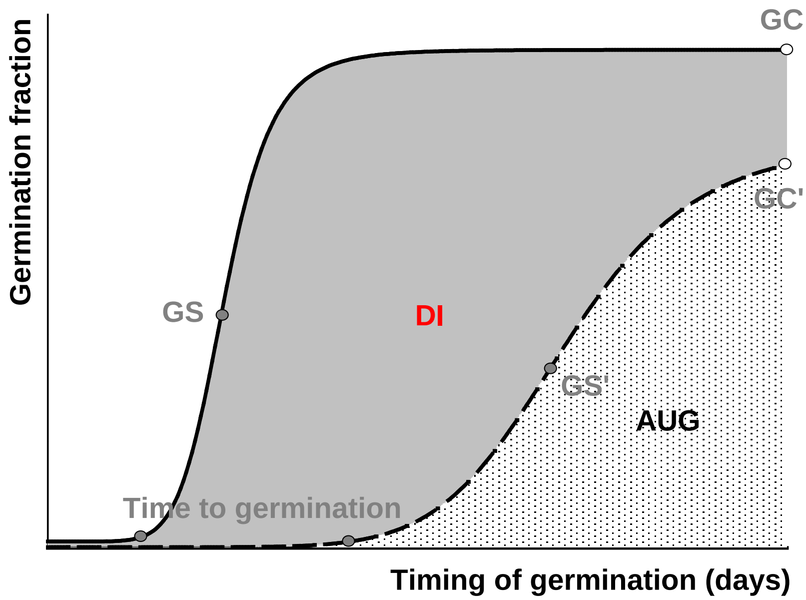
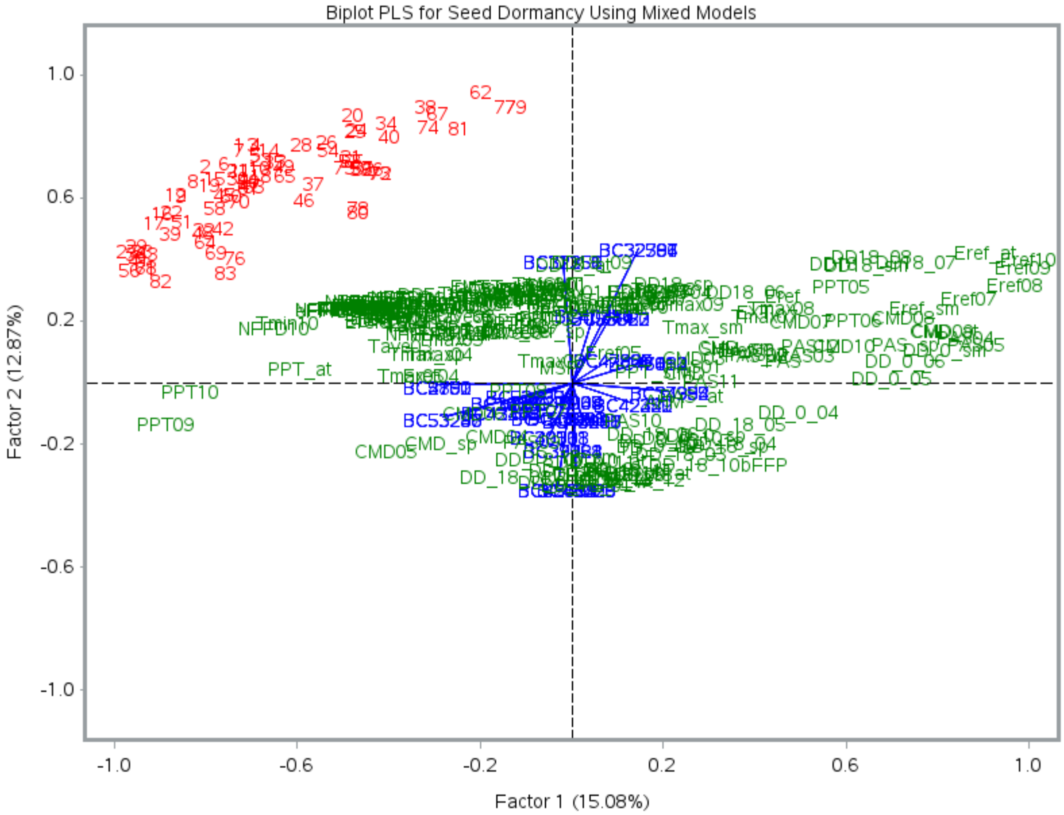

GC
GC'
GS
DI
GS'
AUG
Time to germination
Germination fraction
Timing of germination (days)

Figure S4


Biplot PLS for Seed Dormancy Using Mixed Models
Factor 1 (15.08%)
Factor 2 (12.87%)
-1.0
-0.6
-0.2
0.2
0.6
1.0

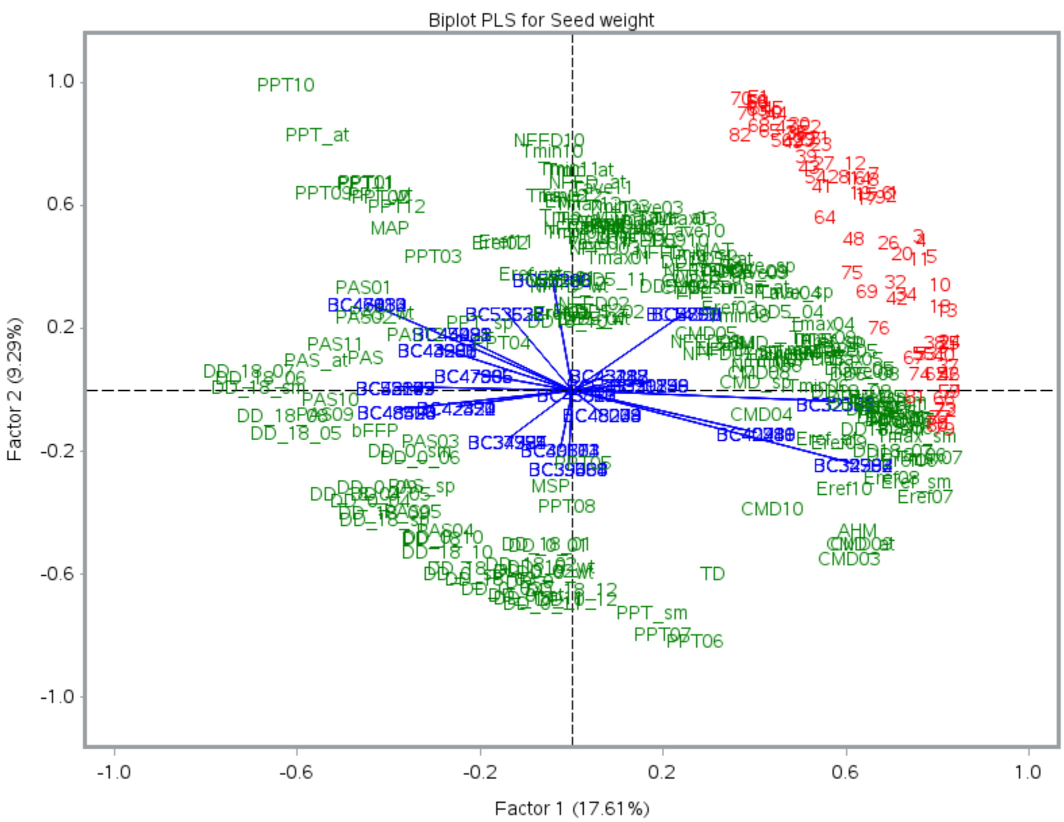

Biplot PLS for Seed weight
Factor 1 (17.61%)
Factor 2 (9.29%)
-1.0
-0.6
-0.2
0.2
0.6
1.0

Figure S5

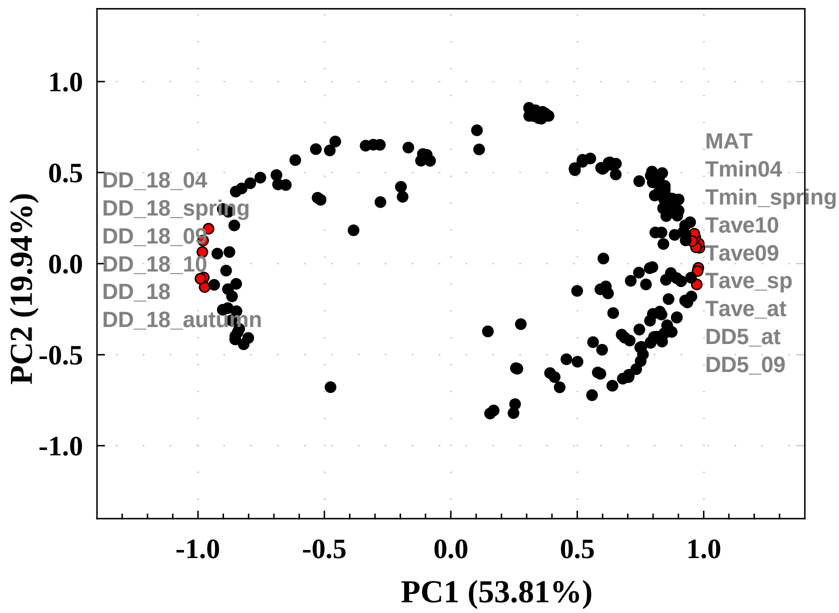
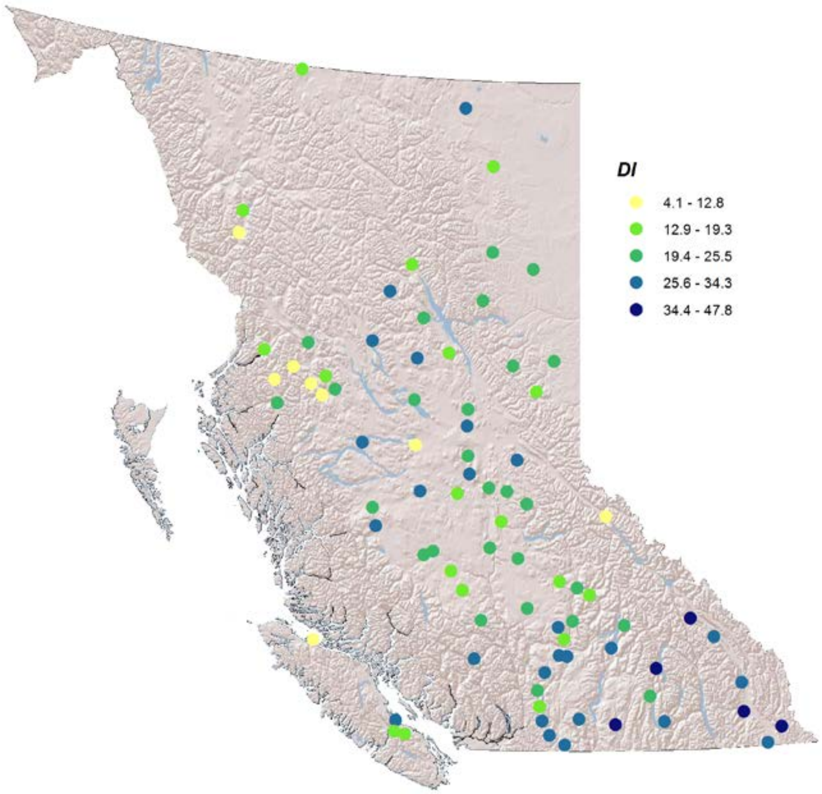

1.0
0.5
0.0
-0.5
-1.0
PC2 (19.94%)
-1.0
-0.5
0.0
0.5
1.0
PC1 (53.81%)
DD_18_04
DD_18_spring
DD_18_09
DD_18_10
DD_18
DD_18_autumn
MAT
Tmin04
Tmin_spring
Tave10
Tave09
Tave_sp
Tave_at
DD5_at
DD5_09

Figure S6

a)


DI
4.1 - 12.8
12.9 - 19.3
19.4 - 25.5
25.6 - 34.3
34.4 - 47.8

b)

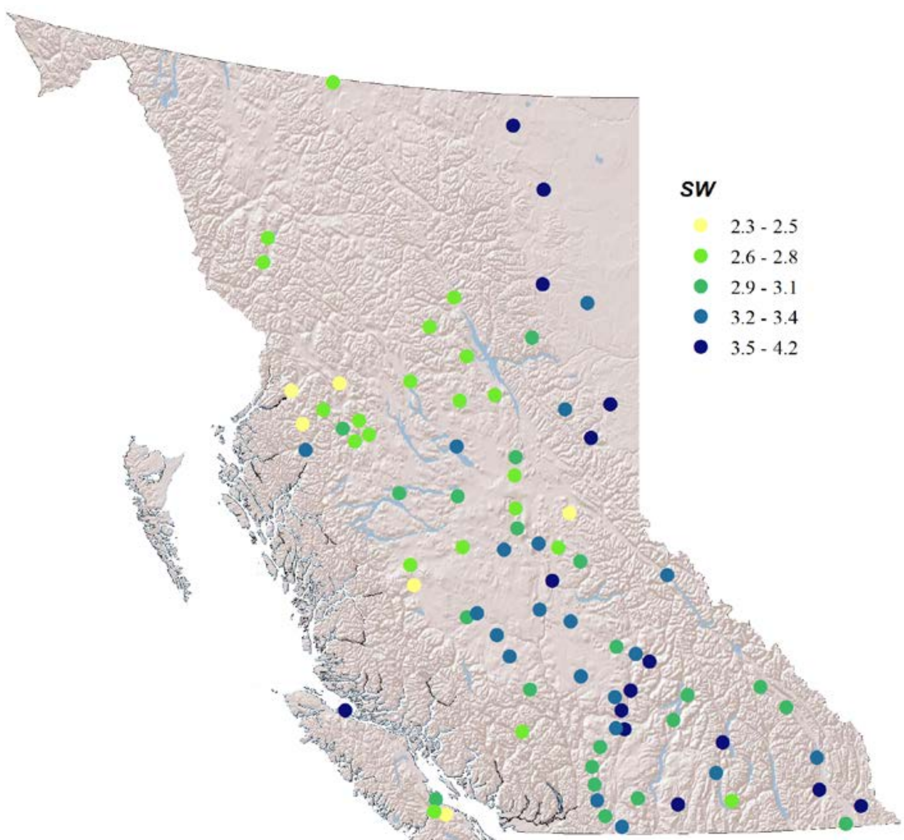
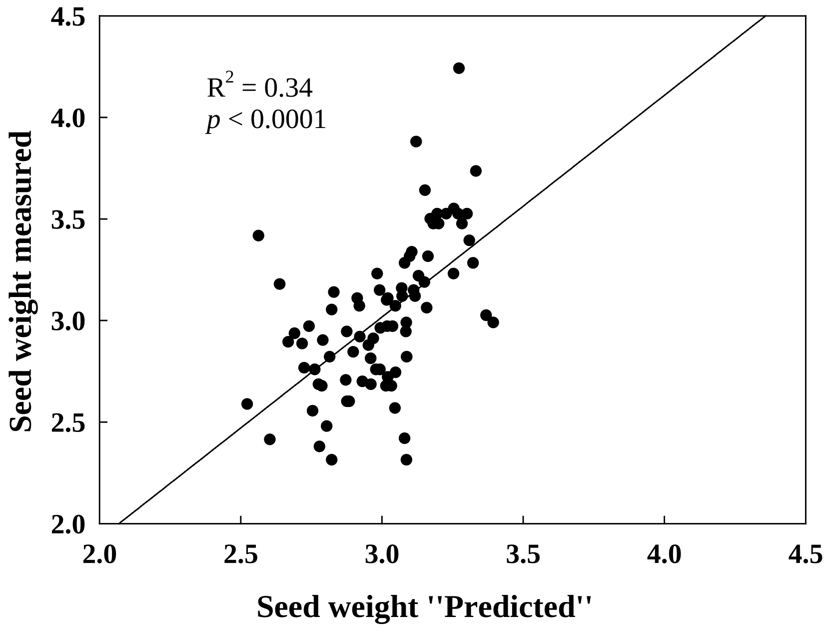

SW
2.3 - 2.5
2.6 - 2.8
2.9 - 3.1
3.2 - 3.4
3.5 - 4.2

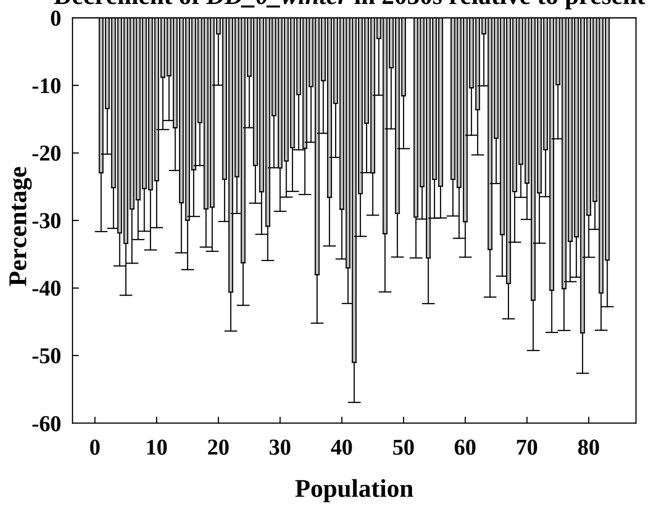
Figure S7



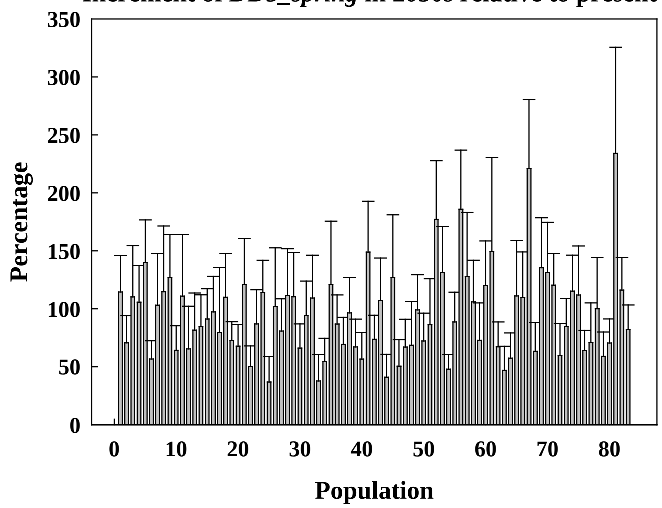
R^2 = 0.34
p < 0.0001
Seed weight measured
Seed weight "Predicted"
4.5
4.0
3.5
3.0
2.5
2.0
2.0
2.5
3.0
3.5
4.0
4.5

Figure S8

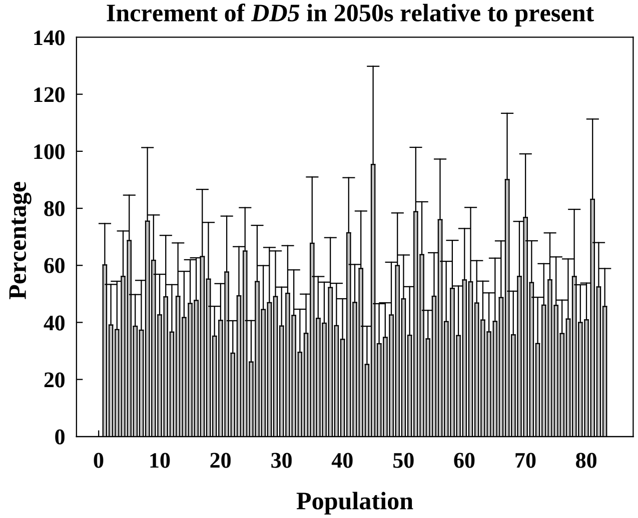
Decrement of *DD_0_winter* in 2050s relative to present



Increment of *DD5_spring* in 2050s relative to present



Increment of *DD5* in 2050s relative to present



Ranges across populations under different scenarios

	RCP2.6	RCP4.5	RCP8.5
Δ*DD_0_winter*	-479 ~ -46	-526 ~ -51	-689 ~ -57
Δ*DD5_spring*	70 ~ 396	88 ~ 428	112 ~ 546
Δ*DD5*	357 ~ 1099	425 ~ 1234	634 ~ 1557