

Supplementary Material

Response of Northern Populations of Black Spruce and Jack Pine to Southward Seed Transfers: Implications for Climate Change

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Table S1. Northern seed sources used in black spruce rangewide provenance study.

Seed Source Identifier	Latitude (decimal degrees)	Longitude (decimal degrees)	Number of Test Sites	Average Height (m)	Average Survival (%)
2209	60.17	-130.52	2	5.60	45.5
4357	62.93	-155.58	1	6.33	25.0
4358	62.12	-145.75	2	4.32	38.5
4418	64.98	-147.00	1	5.00	50.0
4420	64.73	-148.32	2	5.78	27.5
4729	67.00	-151.52	1	6.40	25.0
6805	53.42	-60.38	13	7.54	73.3
6965	52.48	-101.43	7	7.62	73.3
6966	52.38	-101.12	9	7.52	67.8
6967	55.50	-98.07	7	6.99	71.1
6968	54.58	-101.00	5	7.85	72.8
6969	54.87	-102.80	8	7.18	71.3
6970	56.05	-108.70	6	7.67	68.7
6971	54.72	-107.82	5	7.80	81.8
6972	53.23	-105.77	5	8.13	61.2
6976	57.00	-97.87	3	7.30	69.7
6977	57.63	-96.75	4	6.19	60.3
6978	52.38	-115.03	3	7.16	83.7
6979	52.37	-115.25	8	7.11	67.0
6980	52.50	-115.88	2	6.72	83.0
6983	55.03	-115.27	5	7.57	65.2
6985	56.60	-121.38	2	6.52	79.5
6986	56.62	-121.47	5	7.20	63.8
6987	58.78	-123.60	2	6.97	76.0
6988	58.73	-123.63	2	7.42	75.0
6990	59.92	-131.67	1	4.57	70.0
6994	60.53	-134.45	2	6.45	36.0
6999	60.05	-112.77	2	6.93	71.0
7000	63.57	-135.92	7	5.55	50.3
7007	64.73	-148.30	3	5.75	59.0

Table S2. Northern seed sources used in jack pine rangewide provenance study.

Seed Source Identifier	Latitude (decimal degrees)	Longitude (decimal degrees)	Number of Test Sites	Average Height (m)	Average Survival (%)
3253	54.0333	-76.5167	7	14.81	9.7
3285	53.0500	-93.2500	8	13.94	41.0
3287	53.1167	-106.0667	13	14.20	37.4
3288	53.7500	-106.9667	12	13.28	30.9
3289	52.2000	-104.9167	15	13.21	30.4
3290	52.0500	-100.3833	14	13.56	36.2
3291	55.1167	-101.1500	15	12.80	24.8
3292	57.0833	-102.0250	9	13.71	13.5

Table S3. Parameters from quadratic regression models between climate transfer distance and height/survival of northern seed sources used in rangewide provenance trials for black spruce. Bold values indicate statistical significance at $p < 0.05$.

Species	Seed Source Origin	Climate Variable*	Response Variable	N	Intercept (β_0)	slope 1 (β_1)	slope 2 (β_2)	R-squared
Black Spruce	Northern	MAT	Height	125	7.230	0.14180	-0.032500	0.12
Black Spruce	Northern	MAT	Survival	125	74.777	-2.51790	-0.070200	0.21
Black Spruce	Northern	CMI	Height	125	7.075	-0.00610	0.000070	0.01
Black Spruce	Northern	CMI	Survival	125	70.618	0.06200	-0.003600	0.11
Black Spruce	Northern	ANNP	Height	125	7.138	-0.00071	0.000001	0.01
Black Spruce	Northern	ANNP	Survival	125	72.320	-0.01121	-0.000015	0.13
Black Spruce	Northern	GSL	Height	125	7.268	0.01213	-0.000550	0.09
Black Spruce	Northern	GSL	Survival	125	74.565	-0.42544	0.000194	0.19
Black Spruce	Central	MAT	Height	999	8.091	0.22390	-0.029600	0.13
Black Spruce	Central	MAT	Survival	999	66.688	0.20833	0.117680	0.00
Black Spruce	Central	CMI	Height	999	8.125	0.00030	-0.000088	0.00
Black Spruce	Central	CMI	Survival	999	69.084	-0.05567	-0.001115	0.02
Black Spruce	Central	ANNP	Height	999	8.081	0.00065	-0.000001	0.02
Black Spruce	Central	ANNP	Survival	999	69.090	-0.00531	-0.000014	0.02
Black Spruce	Central	GSL	Height	999	8.178	0.02404	-0.000464	0.11
Black Spruce	Central	GSL	Survival	999	67.533	0.12512	-0.000601	0.02
Black Spruce	Southern	MAT	Height	221	8.940	0.10240	-0.052800	0.26
Black Spruce	Southern	MAT	Survival	221	69.387	3.75430	0.137400	0.12
Black Spruce	Southern	CMI	Height	221	8.392	-0.00046	-0.000086	0.00
Black Spruce	Southern	CMI	Survival	221	66.464	-0.06715	-0.001954	0.05
Black Spruce	Southern	ANNP	Height	221	8.404	0.00049	-0.000002	0.02
Black Spruce	Southern	ANNP	Survival	221	64.990	-0.00524	-0.000019	0.02
Black Spruce	Southern	GSL	Height	221	8.907	0.00981	-0.000742	0.20
Black Spruce	Southern	GSL	Survival	221	68.717	0.25604	-0.002252	0.10

*MAT=Mean Annual Temperature; CMI = Climate Moisture Index; ANNP=Annual Precipitation; and GSL=Growing Season Length.

Table S4. Parameters from quadratic regression models between climate transfer distance and height/survival of northern seed sources used in rangewide provenance trials for jack pine. Bold values indicate statistical significance at $p < 0.05$.

Species	Seed Source Origin	Climate Variable	Response Variable	N	Intercept (β_0)	slope 1 (β_1)	slope 2 (β_2)	R-squared
Jack Pine	Northern	MAT	Height	86	13.327	0.55380	-0.077800	0.17
Jack Pine	Northern	MAT	Survival	93	40.413	-4.07980	0.147300	0.19
Jack Pine	Northern	CMI	Height	86	14.196	0.00460	-0.000500	0.06
Jack Pine	Northern	CMI	Survival	93	21.809	0.50380	-0.005100	0.11
Jack Pine	Northern	ANNP	Height	86	13.410	0.00836	-0.000018	0.15
Jack Pine	Northern	ANNP	Survival	93	20.520	0.04508	-0.000049	0.01
Jack Pine	Northern	GSL	Height	86	13.509	0.08187	-0.001730	0.23
Jack Pine	Northern	GSL	Survival	93	35.742	-0.48562	0.003183	0.11
Jack Pine	Central	MAT	Height	541	15.108	0.14866	-0.079611	0.12
Jack Pine	Central	MAT	Survival	548	47.940	0.59644	-0.039450	0.01
Jack Pine	Central	CMI	Height	541	14.900	-0.01827	-0.000575	0.09
Jack Pine	Central	CMI	Survival	548	52.301	-0.03323	-0.003969	0.14
Jack Pine	Central	ANNP	Height	541	14.960	-0.00281	-0.000010	0.11
Jack Pine	Central	ANNP	Survival	548	51.780	0.00019	-0.000053	0.10
Jack Pine	Central	GSL	Height	541	15.076	0.03251	-0.001412	0.14
Jack Pine	Central	GSL	Survival	548	47.836	0.12761	-0.000893	0.01
Jack Pine	Southern	MAT	Height	386	14.951	-0.15910	-0.067910	0.04
Jack Pine	Southern	MAT	Survival	394	50.057	3.75510	-0.247800	0.25
Jack Pine	Southern	CMI	Height	386	15.063	-0.02220	-0.000793	0.07
Jack Pine	Southern	CMI	Survival	394	41.247	-0.06841	-0.005467	0.05
Jack Pine	Southern	ANNP	Height	386	14.960	-0.00567	-0.000018	0.12
Jack Pine	Southern	ANNP	Survival	394	40.270	0.00551	-0.000056	0.05
Jack Pine	Southern	GSL	Height	386	15.037	-0.00879	-0.000836	0.04
Jack Pine	Southern	GSL	Survival	394	46.524	0.42419	-0.000967	0.17

*MAT=Mean Annual Temperature; CMI = Climate Moisture Index; ANNP=Annual Precipitation; and GSL=Growing Season Length.

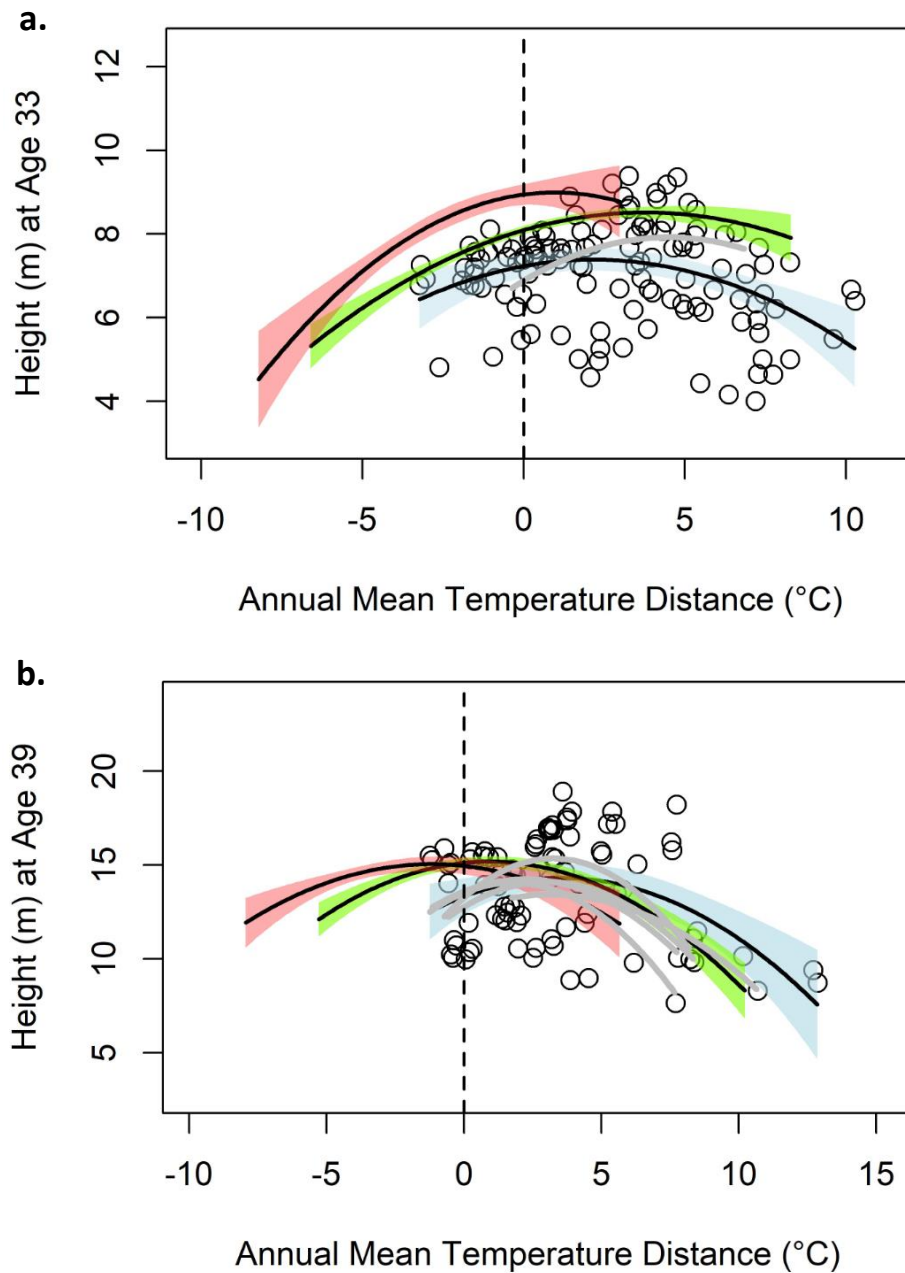


Figure S1. Relationship between mean annual temperature and height growth for a) black spruce and b) jack pine. Separate regression lines and 95 % confidence intervals are shown for southern (red), central (green), and northern (blue) seed sources. Gray regression lines are for individual northern seed sources that had more than 10 data points associated with them. Data points (black circles) are shown only for northern seed sources. The vertical dashed line indicates local deployment of seed sources (i.e., a transfer distance of zero); points to the right of this line indicate seed transfers to warmer planting sites and vice versa.

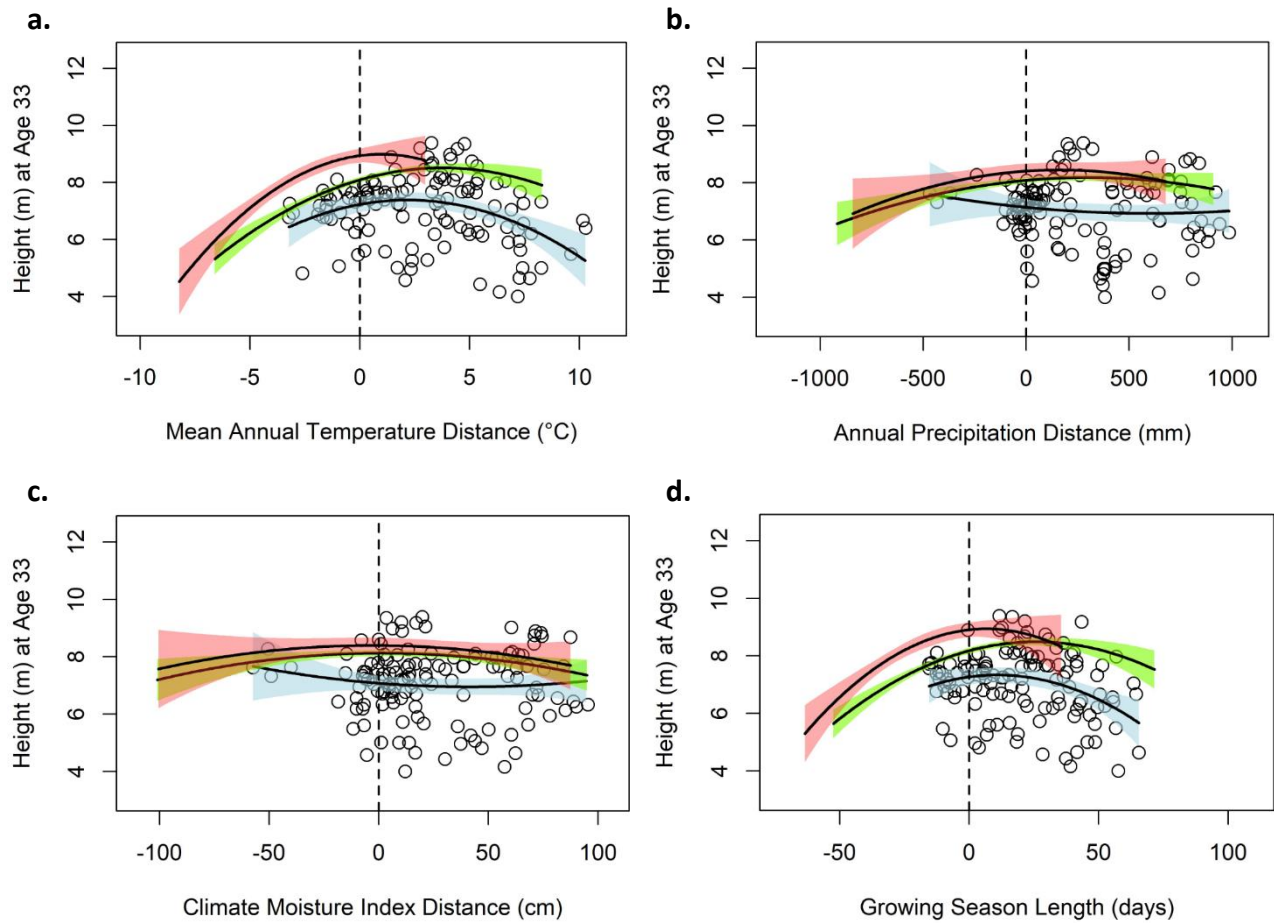


Figure S2. Relationship between black spruce height growth and climate transfer distance of a) mean annual temperature, b) annual precipitation c) climate moisture index, and d) growing season length. Separate regression lines and 95 % confidence intervals are shown for southern (red), central (green), and northern (blue) seed sources. Data points (black circles) are shown only for northern seed sources. The vertical dashed line indicates local deployment of seed sources (i.e., a transfer distance of zero); points to the right of this line indicate seed transfers to warmer planting sites and vice versa.

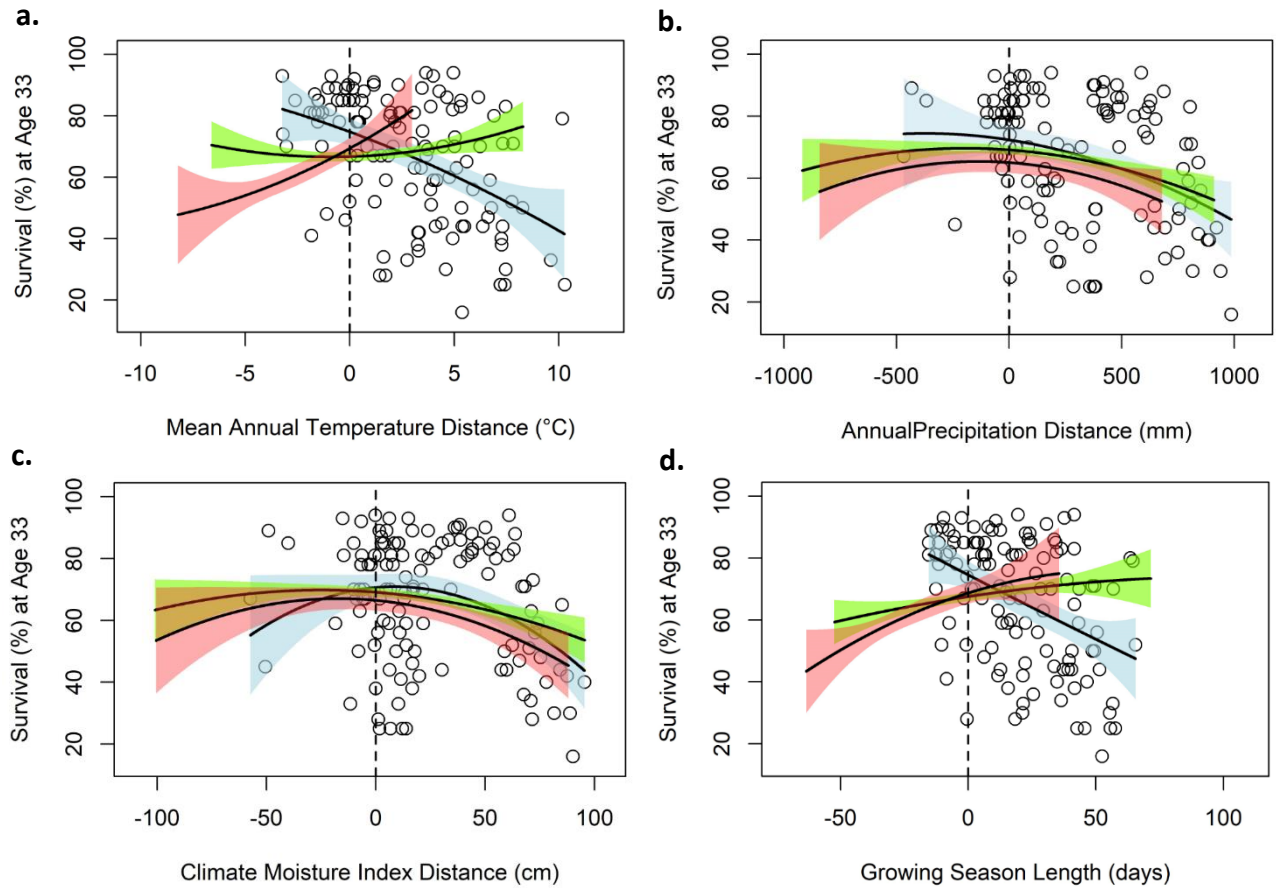


Figure S3. Relationship between black spruce survival and climate transfer distance of a) mean annual temperature, b) annual precipitation c) climate moisture index, and d) growing season length. Separate regression lines and 95 % confidence intervals are shown for southern (red), central (green), and northern (blue) seed sources. Data points (black circles) are shown only for northern seed sources. The vertical dashed line indicates local deployment of seed sources (i.e., a transfer distance of zero); points to the right of this line indicate seed transfers to warmer planting sites and vice versa.

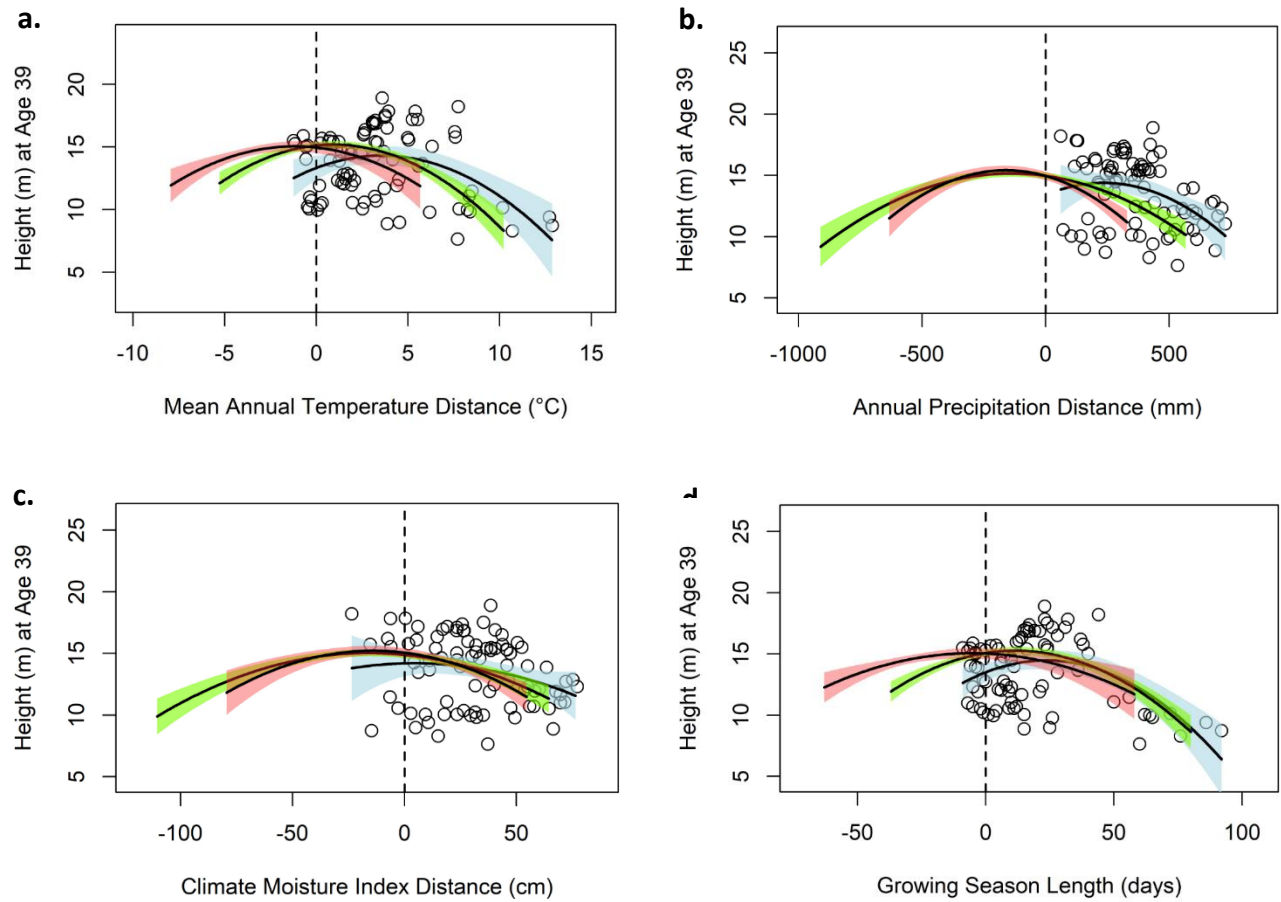


Figure S4. Relationship between jack pine height growth and climate transfer distance of a) mean annual temperature, b) annual precipitation c) climate moisture index, and d) growing season length. Separate regression lines and 95 % confidence intervals are shown for southern (red), central (green), and northern (blue) seed sources. Data points (black circles) are shown only for northern seed sources. The vertical dashed line indicates local deployment of seed sources (i.e., a transfer distance of zero); points to the right of this line indicate seed transfers to warmer planting sites and vice versa.

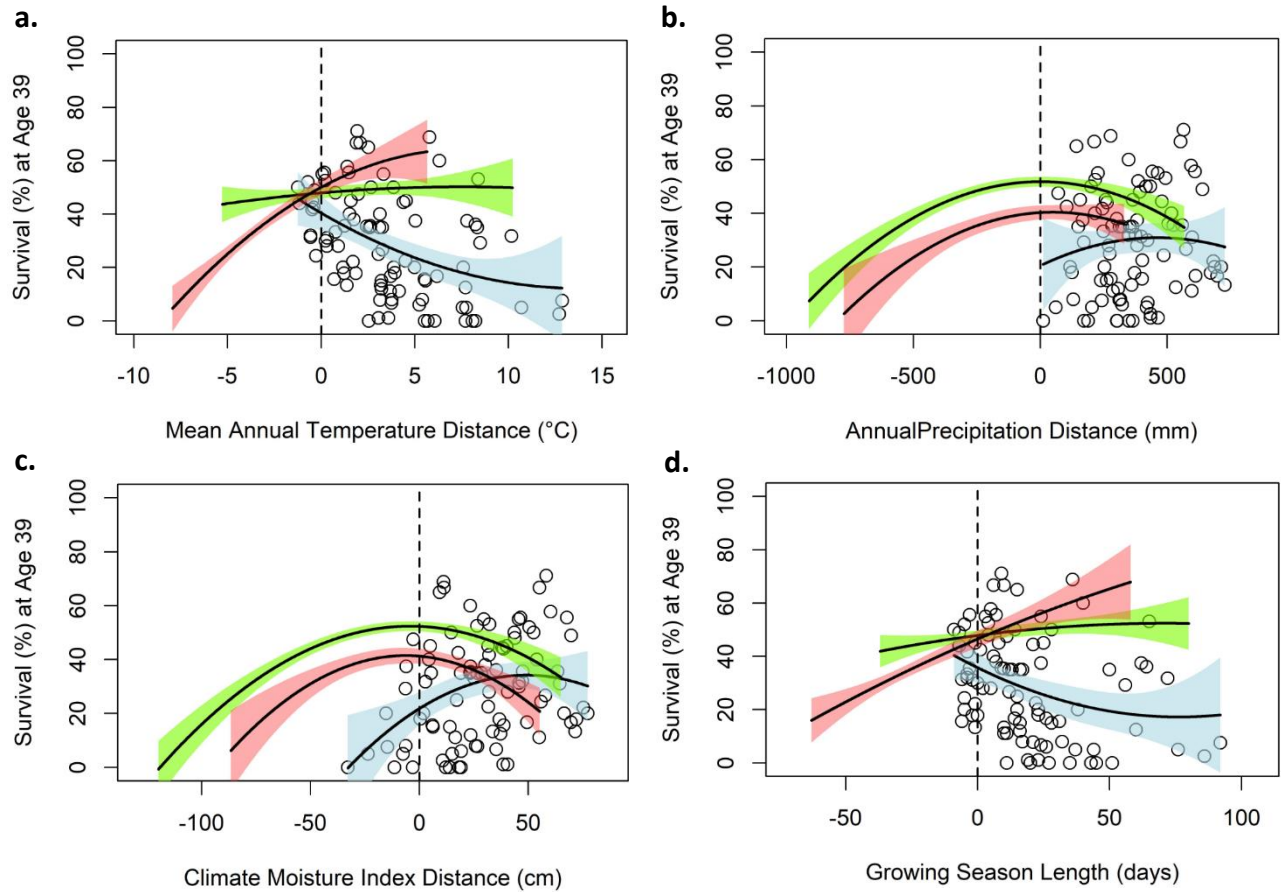


Figure S5. Relationship between Jack pine survival and climate transfer distance of a) mean annual temperature, b) annual precipitation c) climate moisture index, and d) growing season length. Separate regression lines and 95 % confidence intervals are shown for southern (red), central (green), and northern (blue) seed sources. Data points (black circles) are shown only for northern seed sources. The vertical dashed line indicates local deployment of seed sources (i.e., a transfer distance of zero); points to the right of this line indicate seed transfers to warmer planting sites and vice versa.