frontiers

Supplementary Material

Table S1. Climatology across the *Chamaecyparis thyoides* study network from 1940-2000 by region. Seasons are: Winter (Win, prior-year Dec, current-year Jan & Feb), Spring (Spr, current-year Mar-Apr), Summer (Sum, current-year Jun-Aug), Fall (Fall, current-year Sept-Nov), and Warm Season (current-year May-October).

	Average Minimum Monthly Temperature (°C)					Average Maximum Monthly Temperature (°C)					Mean Total Precipitation (mm)			
Site Name	Win	Spr	Sum	Fall	Ann	Win	Spr	Sum	Fall	Ann	Win	Sum	May-Oct	Ann
Appleton Bog, ME	-11.1	0.3	13.1	3.8	1.5	-0.4	11.6	25.1	14.2	12.6	289.3	246.0	535.2	1152.0
Saco Heath, ME	-9.7	0.7	13.2	3.9	2.1	1.4	12.8	26.4	15.8	14.1	282.2	243.5	521.4	1129.6
Mount Agementicus, ME	-9.1	0.3	12.3	3.4	2.0	1.3	13.6	27.3	16.1	14.6	281.6	252.5	529.7	1131.5
Monson, MA	-8.6	1.3	13.6	4.2	2.6	1.2	13.0	25.6	15.4	13.8	266.3	305.7	597.4	1173.8
Westminster, MA	-9.9	0.2	13.3	3.2	1.4	0.4	12.4	25.0	14.8	13.2	270.6	287.7	570.1	1146.9

North	-9.7	0.56	13.1	3.7	1.92	0.78	12.7	25.9	15.3	13.7	278.0	267.1	550.7	1146.8
Ave. (STDEV)	(0.9)	(0.5)	(0.5)	(0.4)	(0.5)	(0.8)	(0.7)	(1.0)	(0.8)	(0.8)	(9.4)	(28.0)	(32.0)	(17.9)
Lake Tonetta Park, NY	-7.4	2.3	14.4	5.2	3.6	2.9	14.8	27.1	17.2	15.5	259.2	317.2	615.0	1179.6
North Madison, CT	-6.1	2.6	14.9	6.1	4.4	3.6	14.7	27.2	17.3	15.7	296.3	287.9	592.9	1236.8
High Point, NJ	-8.8	1.6	13.9	4.5	2.8	0.8	13.3	25.6	15.4	13.8	233.4	333.3	630.4	1170.3
Bellvale Mountain, NY	-7.7	2.2	14.2	5.0	3.4	1.9	14.0	26.4	16.5	14.7	276.0	335.7	653.8	1260.4
Sterling Forest, NY	-7.9	1.9	13.8	4.6	3.1	2.0	14.0	26.4	16.6	14.8	287.8	335.8	659.7	1282.3
Uttertown, NJ	-8.4	1.5	13.5	4.2	2.7	1.9	13.9	26.3	16.5	14.7	279.4	345.7	674.3	1292.4
Central	-7.7	2.0	14.1	4.9	3.3	2.2	14.1	26.5	16.6	14.9	272.0	325.9	637.7	1237.0
Ave. (STDEV)	(0.9)	(0.4)	(0.5)	(0.7)	(0.6)	(1.0)	(0.6)	(0.6)	(0.7)	(0.7)	(22.6)	(20.8)	(30.5)	(51.8)
Nixon Branch, NJ	-4.2	4.4	16.7	7.4	6.1	6.9	17.5	29.0	20.0	18.3	255.6	304.4	570.2	1113.0

Mardela Springs, MD	-1.9	6.6	18.2	8.8	8.0	8.5	19.2	30.3	21.2	19.8	254.4	315.0	573.6	1098.7
Dismal Swamp, VA	-0.8	8.1	19.0	9.9	9.1	11.3	21.2	30.7	22.6	21.5	282.2	383.6	683.2	1233.8
Alligator River, NC	1.3	9.3	19.9	12.0	10.7	12.6	21.3	30.3	23.0	21.8	282.5	420.2	735.2	1279.8
Dare Co. Bombing Range, NC	1.4	9.4	19.9	11.8	10.6	12.7	21.7	30.5	23.2	22.0	281.2	426.6	745.2	1289.0
Buckridge, NC	2.0	9.7	20.1	12.6	11.1	12.8	21.6	30.2	23.2	22.0	283.4	431.8	756.6	1303.2
Shealy's Pond, SC	1.5	10.4	20.5	11.2	10.9	14.5	24.3	32.5	24.6	24.0	291.9	366.8	623.6	1190.8
South	-0.1	8.3	19.2	10.5	9.5	11.3	21.0	30.5	22.5	21.3	275.9	378.3	669.7	1215.5
Ave. (STDEV)	(2.3)	(2.1)	(1.3)	(1.9)	(1.9)	(2.7)	(2.1)	(1.0)	(1.5)	(1.8)	(14.7)	(52.6)	(80.6)	(84.0)

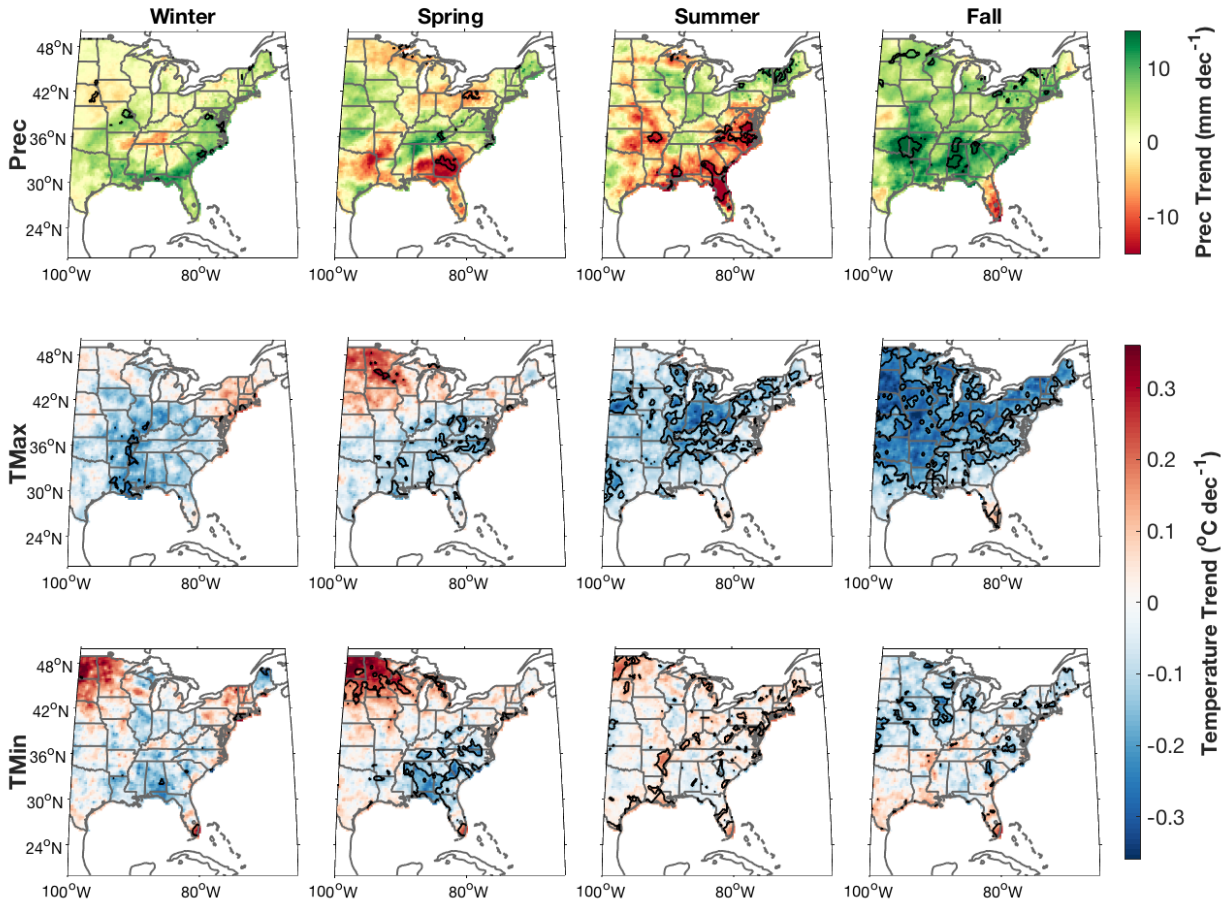

Figure S1 – Seasonal trends of climate over the eastern U.S. from 1940-2000. Areas outlined in black represent areas with significant trends.

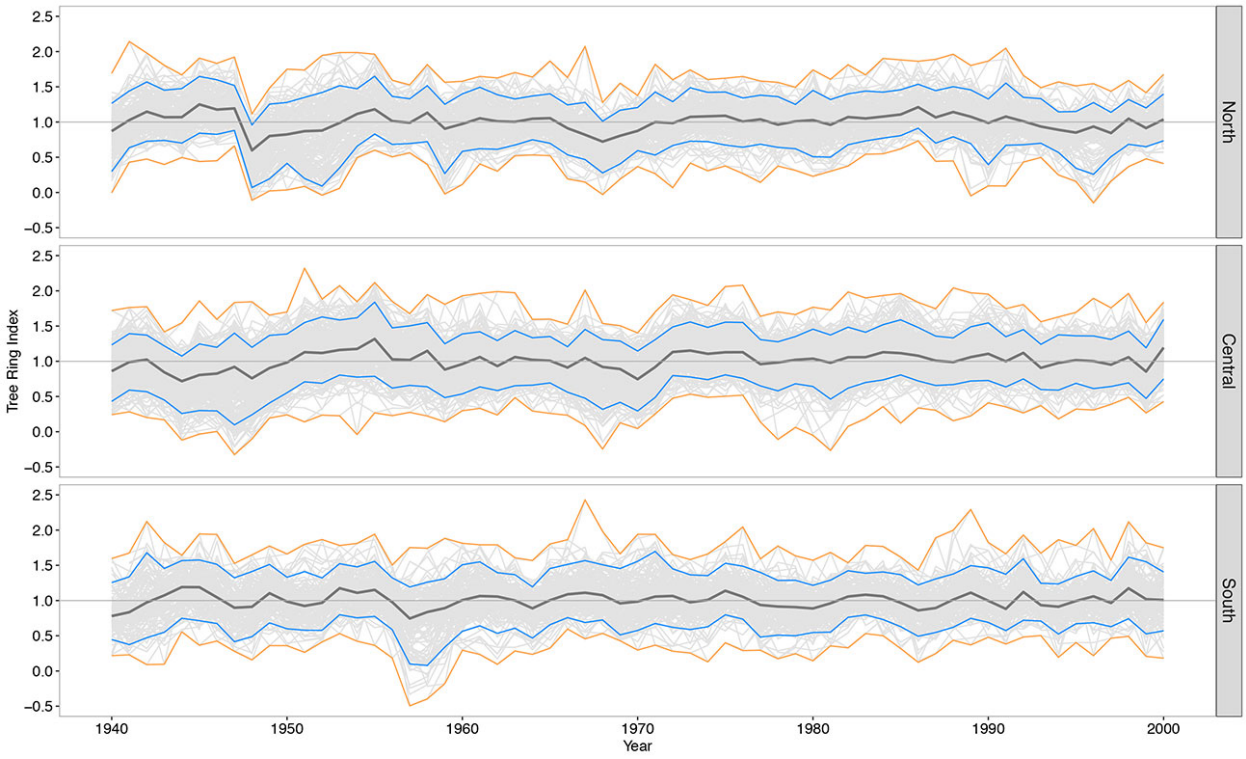

Figure S2 – Standardized tree-growth indices from 1940-2000 for all *Chamaecyparis thyoides* trees by region. From top to bottom: north, central, and south. Grey traces represent individual trees. The solid black line represents the regional mean. The darker grey fill represents the upper 95% and lower 5% distribution of tree-growth indices within each region. The solid orange lines represent the maximum and minimum value for each year.

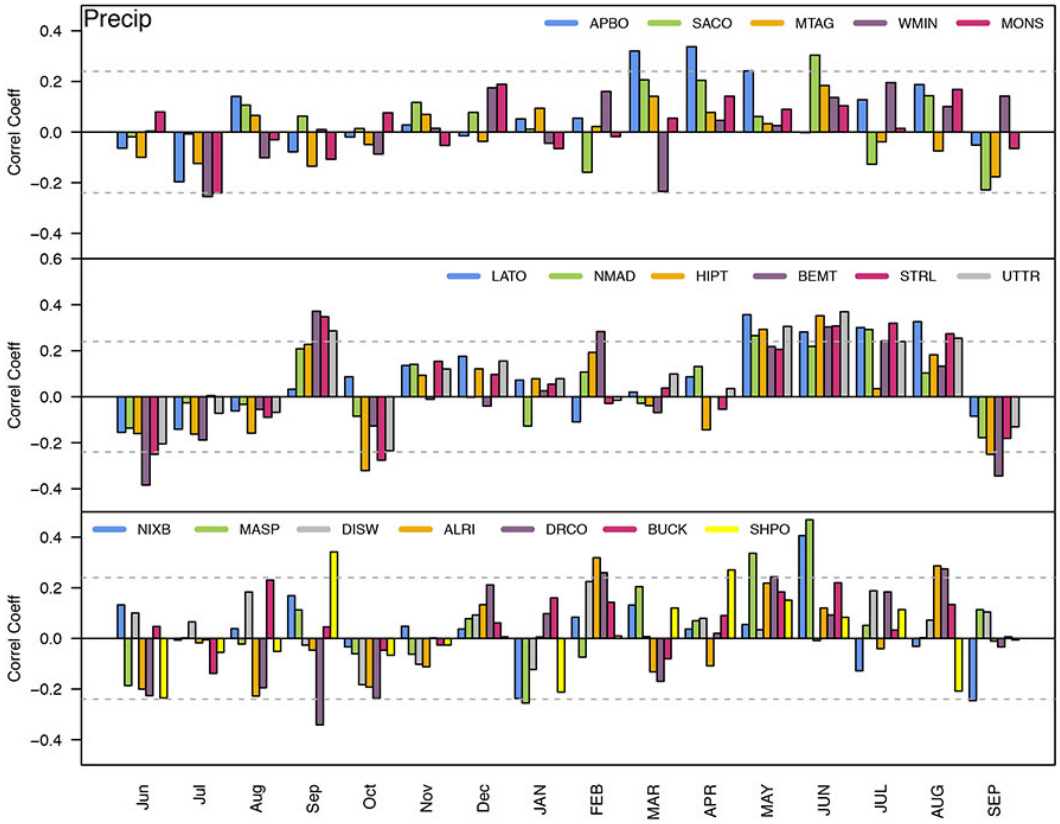

Figure S3 - Correlation statistics of population-level *Chamaecyparis thyoides* growth versus total monthly precipitation by region (from top to bottom): northern, central, and southern. Populations are arranged by latitude within each region, from the northern to southern ends of our network and within each region from left to right by latitude. Full names for each population can be found in Table 1. Dashed, horizontal lines represent significance level at $p \leq 0.05$.

Growth response analysis of *Chamaecyparis thyoides* at the population-level to total monthly precipitation adds nuance to our regional-level analysis (Figure 4). Central populations have the most synchronous and strongest response to total monthly precipitation from May to August with all populations having a significant relation between May and July ($p \leq 0.05$). The only significant correlations to precipitation in the northern populations are observed in late winter at Appleton Bog, the most northern population, and in June at Saco Heath, where trees grow on an ombrotrophic bog. The most consistent positive relation between total monthly precipitation and growth in the southern region is in May and June. Growth at Shealy's Pond, the population at the southern end of our network, is significantly related to total April precipitation, suggesting that differences in seasonality might affect growth differently among the most southern populations.

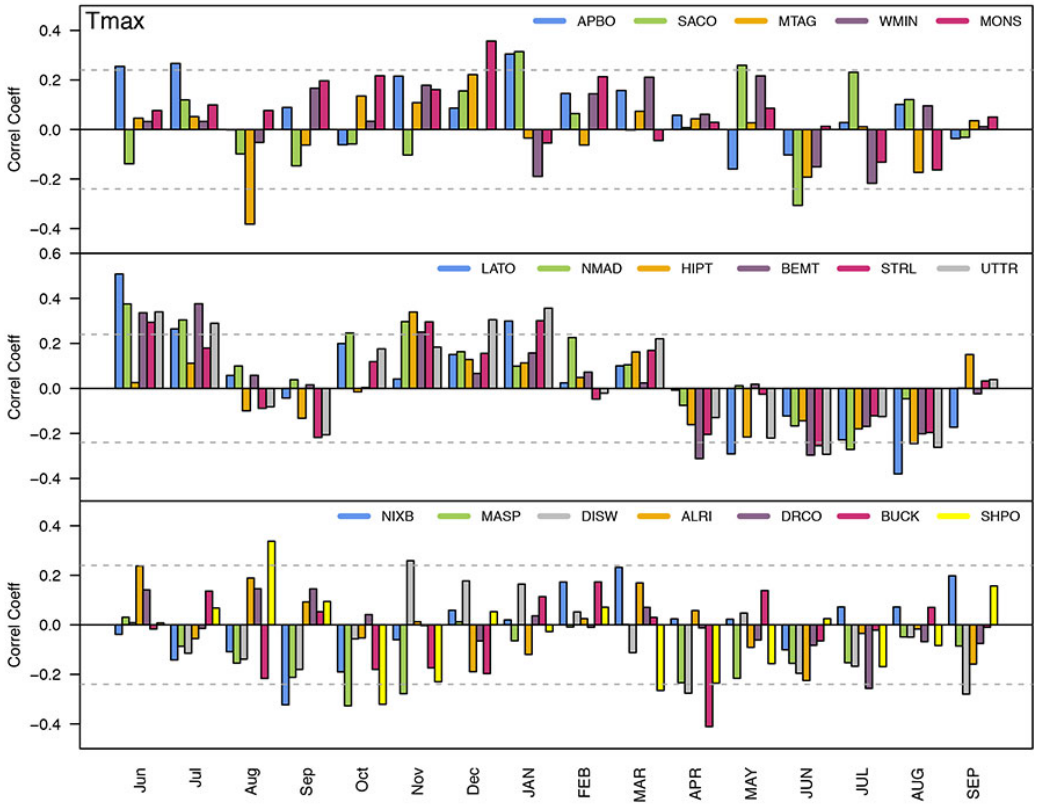

Figure S4 - Correlation statistics of *Chamaecyparis thyoides* versus average maximum monthly temperature by region (from top to bottom): northern, central, and southern. Populations are arranged by latitude within each region, from the northern to southern ends of our network and within each region from left to right by latitude. Full names for each population can be found in Table 1. Dashed, horizontal lines represent significance level at $p \leq 0.05$.

There are differences in the growth response of *Chamaecyparis thyoides* at the population-level to average monthly maximum temperatures, but these responses are fairly distinct within each region. Populations in the central region have the strongest and most consistent correlations, where negative correlations are calculated with maximum temperatures from April through August with the most frequent significant correlations in summer. Central populations also have consistently positive and significant correlations in prior-year June and July and current January. Populations in the northern and southern regions have fewer significant correlations to maximum temperatures and are broadly mirrors of each other: correlations are predominantly positive in the northern populations and negative in the southern populations. Appleton Bog, the most northern population, has the strongest positive correlations to maximum temperatures. The strongest negative correlations in the southern populations are in April and May of the current year. Notably, and unlike most other populations, the most common relations to maximum temperatures in the southern region are negative and occur during the prior fall and March-July.

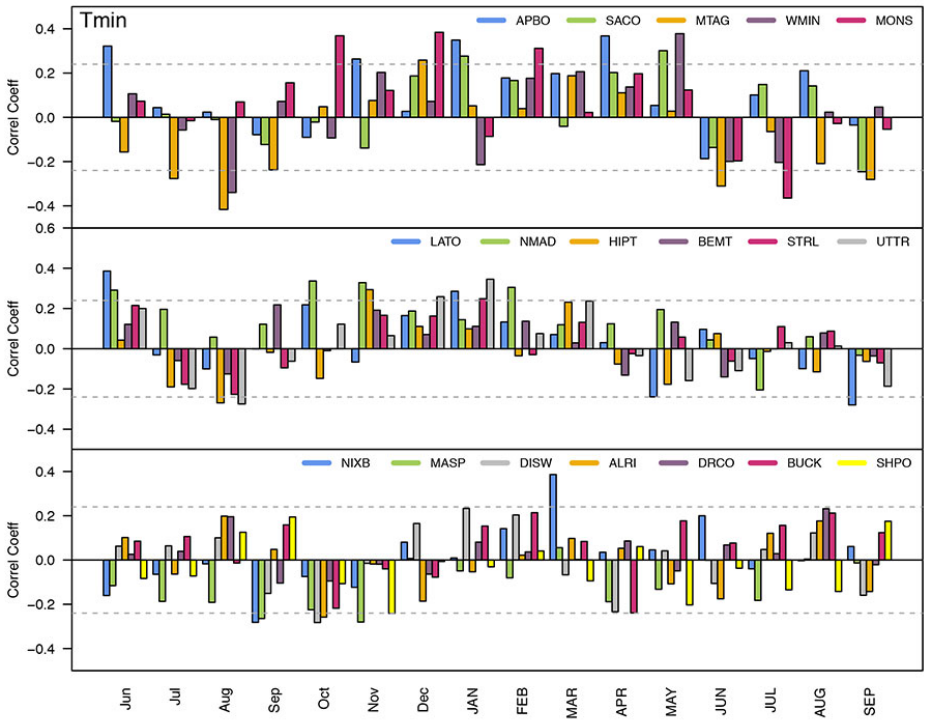

Figure S5 - Correlation statistics of population-level *Chamaecyparis thyoides* growth versus average minimum monthly temperature by region (from top to bottom): northern, central, and southern. Populations are arranged by latitude within each region, from the northern to southern ends of our network and within each region from left to right by latitude. Full names for each population can be found in Table 1. Dashed, horizontal lines represent significance level at $p \leq 0.05$.

Similar to the regional analysis, growth broadly correlates positively from prior fall through current May in the northern and central populations with the most northern populations likely having more growth over the broad season while in central populations, the positive influence of warming on growth occurs primarily between prior fall and the January before the growing season. The correlation of growth to minimum temperatures is weaker and less consistent in the southern populations and are observed between September and November of the prior fall.

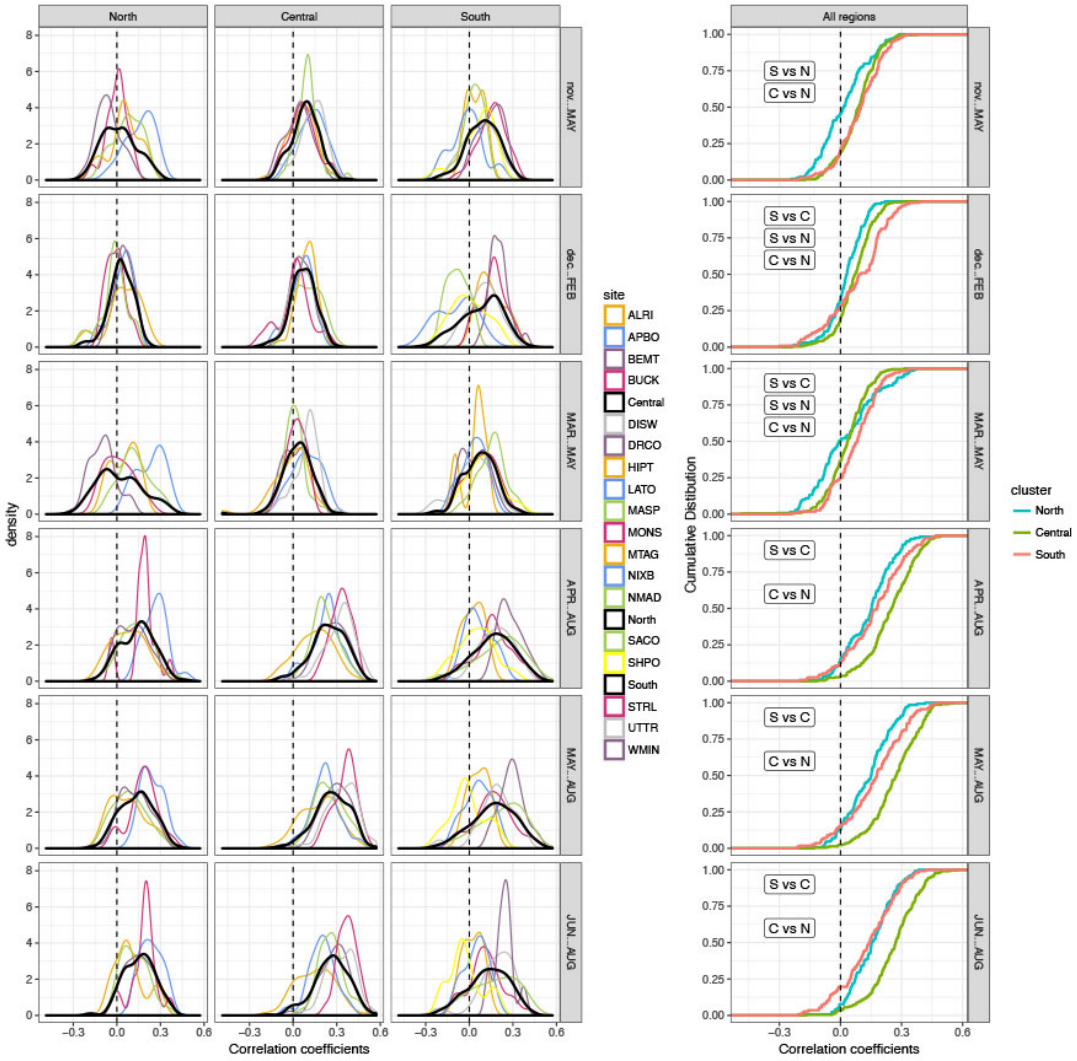

Figure S6 – Left panel: Probability distribution functions of tree-level correlations to total precipitation arranged by seasons (rows) and region (columns, North->South from left->right). The right panel represents the empirical cumulative distribution function of the seasonal probability distribution functions by region (right panel). Seasons from top to bottom are: prior November-current May, December-February, March-May, April-August, May-August, and June-August. Individual sites within a region are colored to distinguish sites with the northernmost sites in each region blue. In the left panels, Black lines represent the regional distributions. Text on the upper left of the Empirical cumulative distribution function plots indicate significant differences ($p<0.05$) between regions based on Kolmogorov-Smirnov test. For example, in the top Empirical cumulative distribution function plot, the distribution of tree-level correlations in the north is significantly different than the distribution of tree-level correlation in both the central and southern regions during the prior November-current May season.

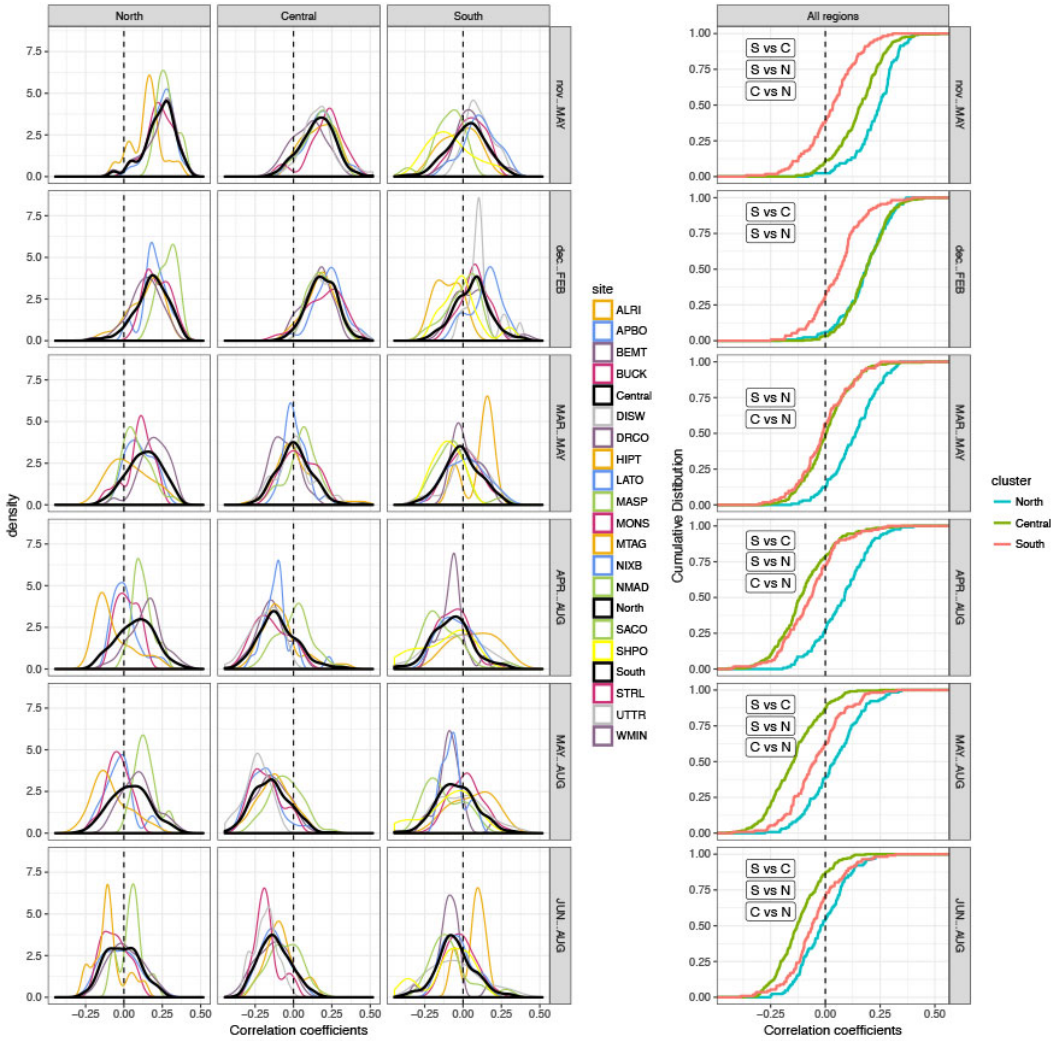

Figure S7 – Left panel: Probability distribution functions of tree-level correlations to average maximum temperature arranged by seasons (rows) and region (columns, North->South from left->right). The right panel represents the empirical cumulative distribution function of the seasonal probability distribution functions by region (right panel). Seasons from top to bottom are: prior November-current May, December-February, March-May, April-August, May-August, and June-August. Individual sites are within a region colored to distinguish sites with the northernmost sites in each region blue. Black lines represent the regional mean. Text on the upper left of the empirical cumulative distribution function plots indicate significant differences ($p<0.05$) between regions based on Kolmogorov-Smirnov test. For example, in the empirical cumulative distribution function plot second from the top, the distribution of tree-level correlations in the south is significantly different than the distribution of tree-level correlation in both the central and northern regions during the winter.

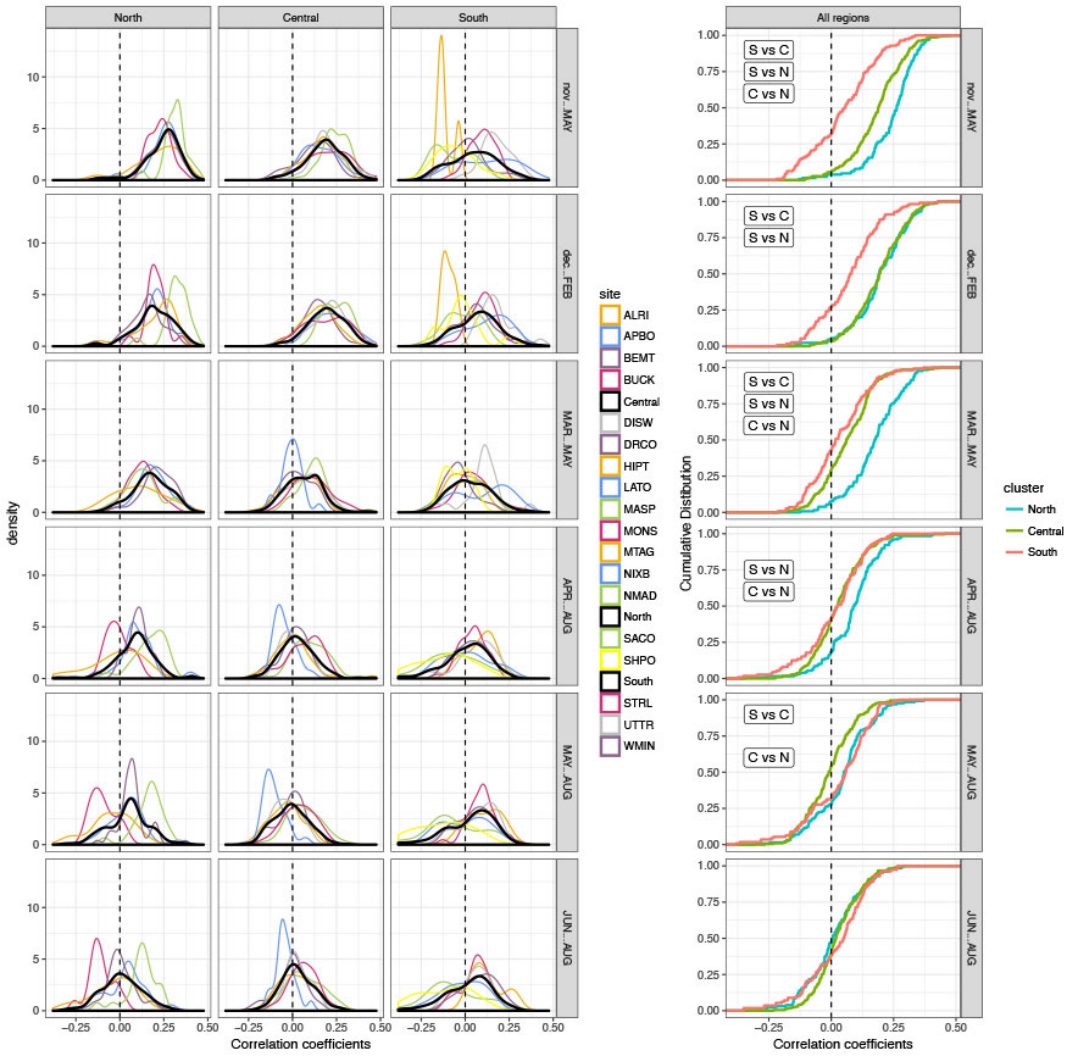

Figure S8 – Left panel: Probability distribution functions of tree-level correlations to average minimum temperature arranged by seasons (rows) and region (columns, North->South from left->right). The right panel represents the empirical cumulative distribution function of the seasonal probability distribution functions by region (right panel). Seasons from top to bottom are: prior November-current May, December-February, March-May, April-August, May-August, and June-August. Individual sites are within a region colored to distinguish sites with the northernmost sites in each region blue. Black lines represent the regional mean. Text on the upper left of the empirical cumulative distribution function plots indicate significant differences ($p<0.05$) between regions based on Kolmogorov-Smirnov test. For example, in the bottom empirical cumulative distribution function plot, the distribution of tree-level correlations in the south is significantly different than the distribution of tree-level correlation in the central region during the summer.

Full Linear Mixed Effects Model

The final linear effect model fitted was (in lme R notation):

```
final_tree_site_model<-lme(treeRWI ~  sc_tmax_JUN_AUG+sc_ppt_JUN_AUG+
sc_tmin_novMAY+
                  I(sc_ppt_JUN_AUG*stand.density)+I(sc_tmin_novMAY*lat),
                random= ~1+ sc_tmax_JUN_AUG+sc_ppt_JUN_AUG+sc_tmin_novMAY|site/tree,
                method = "REML",
                data =trw_data_use,
                control = lmeControl(opt='optim'),
                correlation = corAR1())
```

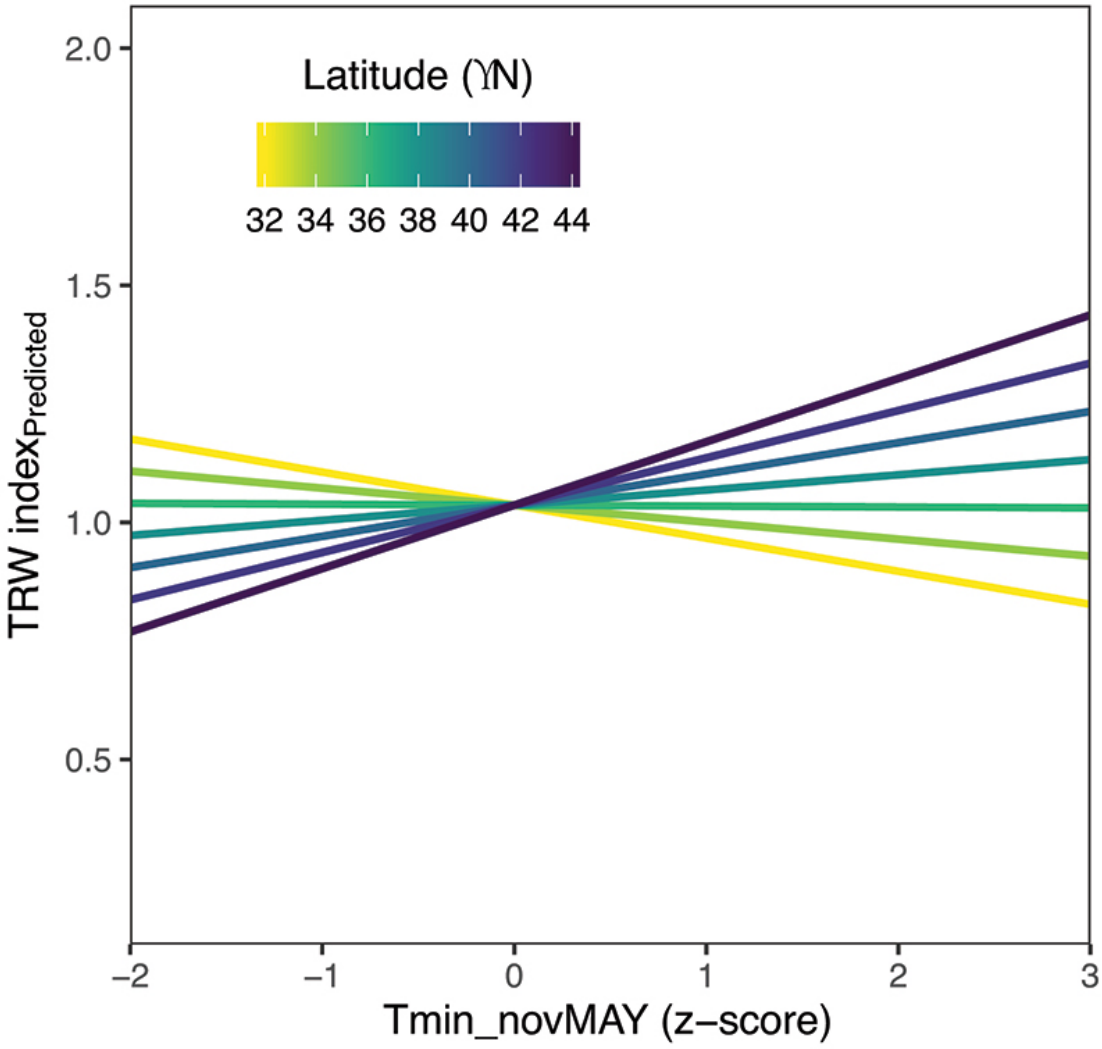

Figure S9 – A test of the final linear effect model, but over the full study region, like Figure 7 in the manuscript, but using all 18 sites, whether we had population-level structure and compositional data. In this test, the negative trend in the southern populations is still there, but at a reduced slope.