THESIS

ENVIRONMENTAL PREDICTORS OF ANNUAL INCREMENTAL *POPULUS DELTOIDES* GROWTH, AND RIPARIAN FOREST STRUCTURE OF THE SOUTH PLATTE RIVER IN NORTHEASTERN COLORADO

Submitted by

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In partial fulfillment of the requirements

For the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Summer 2020

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ABSTRACT

ENVIRONMENTAL PREDICTORS OF ANNUAL INCREMENTAL *POPULUS DELTOIDES* GROWTH, AND RIPARIAN FOREST STRUCTURE OF THE SOUTH PLATTE RIVER IN NORTHEASTERN COLORADO

Riparian forests are biologically diverse systems that provide essential ecological services, such as flood attenuation, bank stabilization, habitat, nutrient cycling, temperature regulation, etc., for the landscapes they occupy. The present-day South Platte River riparian forest is dominated by native phreatophytes (*Populus* and *Salix* species) which require hydrologic disturbance to reproduce. However, with changing water-use patterns and hydrology in the South Platte basin of Colorado, the future riparian forest status is unknown. This study describes the contemporary forest composition and age structure. Data was collected along transects from seven randomly selected sites within three randomly positioned 30-km river sections between Kersey and Julesburg, Colorado on the South Platte River. A ring width chronology was developed using cores from 237 *Populus deltoides* (plains cottonwood) trees and was used in linear mixed modeling to describe relationships between climate, hydrology, and site attributes that affect annual biomass production (Basal Area Increment). *Populus deltoides* dominates the riparian forest overstory, while later successional species (*Ulmus pumila* and *Fraxinus pennsylvanica*) are present at low densities. Though the timing of recruitment has varied among sites, overall recruitment of *P. deltoides* is abundant, reflecting the ongoing flow-related channel change occurring in this system. Summer mean flows, as well as November and March mean flows, and climate factors (Palmer Drought Severity Index) during the growing season were responsible for variations in *P. deltoides* annual tree growth, as were tree age, site, and attributes of the individual trees. Our findings contrast with previously hypothesized successional trajectories for this system, which predicted the replacement of the *Populus-Salix* overstory by later successional species (*Ulmus pumila* and *Fraxinus pennsylvanica)*. The linear mixed model results highlight the importance of not only summer season flows and climate, but also the potential effects of off-season flow variables in a changing system.

TABLE OF CONTENTS

ABSTRACT ii

LIST OF TABLES vi

LIST OF FIGURES vii

Introduction and Background 1

Biological system 2

Research questions 5

Methods 6

Study Sites 6

Dendrochronological methods 7

Monthly climatic and hydrological variables 9

Modeling tree growth – environmental relationships 11

Results 14

General recruitment status of the South Platte River riparian forest. 14

Environmental variables affecting annual tree growth. 20

Discussion 23

General recruitment status of the forest. 23

Identification of environmental variables affecting annual tree growth. 30

Conclusion 32

Literature Cited 34

Appendix A. Correlations – Hydrologic and Climatic variables 39

CLIMATE CORRELATIONS 39

All Sites 39

Site 1 44

Site 2 49

Site 3 53

Site 4 58

Site 5 63

Site 6 67

Site 7 72

HYDROLOGIC CORRELATIONS 77
Appendix B. Model descriptions 81
Appendix C. Model Variables – Correlation Matrix 83

LIST OF TABLES

Table 1: Basal area and trees per hectare for the forest are shown for the seven sampling sites and for all sites together (weighted average). Seedlings and saplings are shown as proportion per site (plots where seedlings or saplings were present/total plots per site), and the total proportion for all sites. 16

Table 2: Three species were sampled from seven sites on the South Platte River. The presence and density of each species varied among sites. The count of trees cored for age analysis are shown. 17

Table 3: Fourteen models were tested and ranked using Akaike Information Criteria. 21

Table 4: Parameter estimates for the model that best explained Basal Area Increment. 22

Table 5: Fourteen models were developed for this study to describe the effect of environmental response variables on Basal Area Index. Tree and Tree by Age were included in all models as fixed effects. 81

LIST OF FIGURES

Figure 1. Map of the study area and location of sites. Sites had from 1-2 transects. Transects were established perpendicular to the active channel. See text for details. 7

Figure 2: Spaghetti plot of raw ring widths for tree cores from Site 1 (MUN) show the variation in ring-widths for all *Populus deltoides* samples. 10

Figure 3: Boxplots for the three species sampled in this study show the variation in establishment patterns for each of the study areas, and the presence and absence of latter successional species in the system. 17

Figure 4: Establishment dates of the three species sampled from all seven sites in the study. These are *Populus deltoides, Fraxinus pennsylvanica, and Ulmus pumila.* 19

Figure 5: Histograms represent years of establishment of *P. deltoides*, for all sites combined, and for each of the seven study sites. 20

Figure 6: Instantaneous peak discharge (ft^3/sec) is shown from the Julesburg stream gauge in Sedgwick County, Colorado (Latitude 40°58'30", Longitude 102°15'05" NAD2) from 1902 to 2019. The drainage area is 22,824 square miles. Gage datum 3,449.80 feet above NAVD88 (https://nwis.waterdata.usgs.gov/co/nwis/peak?site_no=06764000&agency_cd=USGS&format=gif). 28

Figure 7: The correlation matrix shows the correlations between all variables that were considered in model development. These included November flows (Nov.flw), March flows (Mar.flw), June and July Palmer Drought Severity Index (JJ.PDSI), summer flows (smr.flw), November precipitataion (Nov.ppt), growing season precipitation (grw.ppt), June Vapor Pressure Deficit (jun.vpd), April Vapor Pressure Deficit (Apr.vpd), October Vapor Pressure Deficit (Oct.vpd), age, and year. 83

Introduction and Background

The ecological function of riparian ecosystems depends on the variability of streamflow. The natural flow regime, which includes the magnitude, frequency, duration, timing, and rate-of-change of water in the river system, has major implications for riparian ecology (Scott et al. 1996, Poff et al. 1997). Pioneer species, such as *Populus deltoides*, depend on the variability of streamflow for establishment, and modifications to the streamflow alter the regeneration dynamics of *Populus* forests. In the past several decades, widespread *Populus* decline has been observed on rivers throughout the western United States (Johnson et al. 1976, Bradley and Smith 1986, Rood and Mahoney 1990, Howe and Knopf 1991, Snyder and Miller 1991, Snyder and Miller 1992, Johnson 1992). This decline has occurred alongside widespread water development, such as the construction of dams, flow diversions, and groundwater pumping. Generally, water development reduces peak flows resulting in slower channel migration, leading to reduced regeneration of *Populus* forest (Johnson et al. 1976, Bradley and Smith 1986, Rood and Mahoney 1990, Snyder and Miller 1991, Johnson 1992, Scott et al. 1997). Water development can also reduce growing-season flows, causing reduced *Populus* growth and survival. However, in the South Platte River basin, alterations to water dynamics beginning in the late 1800s resulted in riparian forest expansion (Johnson 1994, Nadler & Schumm 1981). Today, a broad riparian forest, dominated by *P. deltoides* exists along much of the length of the river. The vegetation developed due to alterations in environmental conditions, but it is unknown to what degree this novel system is being maintained. This research assesses the status and regeneration of the South Platte River riparian forest, and the environmental factors driving forest growth.

Biological system

The relationship between streamflow and riparian forest regeneration can be complicated due to site-specific factors, and to dynamic environmental conditions. On Western U.S. rivers, primary successional species, generally *Populus* (cottonwood and poplar) and *Salix* (willows), are the first woody species to colonize newly exhumed, or freshly deposited sediments (Scott et al. 1996), and are functionally ecosystem engineers (Corenblit et al. 2009). Freshly deposited/exposed alluvium provides generally sunny, moist substrate free from competition (Scott et al. 1996, Auble and Scott 1998). Though the dominant driver of these conditions is the streamflow, actual establishment of riparian trees is site specific and varies depending on geomorphology and other factors controlling formation of open moist sediment. At one site, riparian species may establish following high flows on the floodplain, where at another, riparian trees will establish during low flow periods on the channel bed (Stromberg 1993, Scott et al. 1996, Friedman et al. 1997, Stromberg 1997, Galuska and Kolb 2002). These differences in establishment are likely due to local geomorphology, soils, disturbance history, and local impacts of tributaries or water diversions (Johnson et al. 1976). The site level heterogeneity can create specific variations in fluvial geomorphic processes that produce suitable surfaces and moisture conditions for *Populus* establishment (Corenblit et al. 2009, Scott et al. 1996). As ecosystem engineers, *Populus* and *Salix* stabilize banks, capture substrate, and change the frictional dynamics within the stream itself, further stabilizing the stream banks (Corenblit et al. 2009). This mechanism of bio-stabilization initiated and persisted by pioneer species can provide conditions suitable for post-pioneer forest structure (Corenblit et al. 2009).

The South Platte River basin is an important resource for providing usufructuary water to large populations on the Colorado Front Range, and to agricultural water users in Colorado and Nebraska, USA. As a result of this water demand, the hydrology of the South Platte River has been profoundly altered. In turn, the altered hydrology has resulted in a changed fluvial system, including novel geomorphic and vegetation conditions. The South Platte River historically experienced an annual hydrograph dominated by mountain snowmelt, where the highest flows occurred in the late spring/early summer (May to June) and low flows occurred in late summer (Strange et al. 1999, Waskom 2013). Low flows in summer and rapid shifting of the channel prevented widespread establishment of riparian forest (Johnson 1994). Beginning in the 1880's flow was progressively stabilized and augmented by dams, sub-surface irrigation return-flows and trans-basin diversions into the basin (Strange et al. 1999, Waskom 2013). In the 1960s, trans-basin diversions accounted for 65 percent of the average annual volume of water in the South Platte Basin (Nadler 1978). These changes in base flow raised riparian water tables in some areas, and the flows shifted to perennial discharge, or year-round water flows (Strange et al. 1999). The increase in soil moisture led to a surge in riparian vegetation, which in turn stabilized the surfaces they established on. Sand bars of the once braided streambed became islands, and the channel shifted to a single thalweg dominated stream (Nadler and Schumm 1981, Johnson 1994). It is theorized that a period of drought occurred around 1900 which allowed for vegetation to additionally establish below the mean high-water level of the channel (Nadler and Schumm 1981). Over time the islands joined the floodplain, and an overall sinuous stream developed with a narrow floodplain and a *Populus-Salix* dominated forest.

Today, the main pulse of forest expansion is theorized to have stopped as the area available for colonization has been reduced (Sedgwick and Knopf 1989, Johnson 1994). Several authors have predicted that forest succession on the South Platte will result in a shift in composition from *Populus-Salix* to non-pioneer species such as green ash, and/or the non-native and invasive Siberian elm and Russian olive (Sedgwick and Knopf 1989, Johnson 1994, Friedman et al. 1997, Strange et al. 1999). Recent studies show that non-native phreatophytes make up between 4% and 10% of the riparian forest (on a per-area basis) in the north-eastern portion of the watershed (Norton et al. 2016). The presence of these species could be attributed to successional progression of this system. However, some research has been more optimistic about *Populus* recruitment on the South Platte River, suggesting that the current hydrologic regime still allows *Populus* establishment to occur (Snyder and Miller 1991).

The use of tree rings to understand how annual tree growth relates to environmental variables has a long history. Tree ring-width sequences have been used to reconstruct records of past climatic changes (Douglass 1914,Schulman 1947, 1951, 1956, Fritts 1976, Hughes et al.1982) as well as to study past hydrologic history (Cook and Jacoby, 1983, Stockton et al., 1985), but before tree rings can be used to reconstruct climate and hydrology these variables need to be correlated to annual growth. Studies looking at the relationship of *Populus* annual growth to environmental factors have shown a relationship between annual growth and climate and hydrology (Reily and Johnson 1982, Edmonson et al. 2014, Friedman et al. 2018). Previous studies have shown that the relationship between *Populus* growth and climate and hydrologic factors is altered following periods of hydrologic modifications (Reily and Johnson 1982, Friedman 2018). Annual growth of riparian trees along the Missouri River showed correspondence to Actual Evapotranspiration (AE), relating the macroclimate and the growth of floodplain trees (Reily and Johnson 1982). For the riparian forest on the Missouri River in North Dakota, cottonwood growth has been shown to be correlated with April-August flows for unregulated streams, and conversely correlated with temperature and soil moisture metrics following flow regulation (e.g. dam construction) (Friedman 2018). Additionally, annual growth has been shown to be correlated to precipitation and other aspects of flow (Edmundson et al. 2014, Meko et al. 2015, Schook et al. 2016, Friedman 2018).

Though studied on other river systems in the western U.S., the environmental drivers affecting annual growth of *Populus* trees on the South Platte River in northeastern Colorado has not been documented.

Research questions

This research documents river scale and site level patterns of *Populus deltoides* population age structure on the South Platte River, and assesses the environmental drivers that affect annual tree growth. Understanding the current age structure and state of regeneration in this forest system helps us understand the potential longevity of the forest. The examination of the relationship between annual biomass production and hydrology, climate, and local site factors gives insights to what contributes to tree growth. This research addresses (1) the general composition and recruitment status of the riparian forest on the South Platte River, and (2) the identification of environmental variables affecting annual tree growth.

Methods

Study Sites

The headwaters of the South Platte River are in the Rocky Mountains in central Colorado, and from there the river flows across Colorado's northeastern plains into Nebraska. Local tributaries to the South Platte River between Kersey and Julesburg, Colorado include Kiowa Creek, Bijou Creek, Beaver Creek, and Pawnee Creek. Bijou creek is approximately 10 km upstream of McClary Site 3, and 16 km upstream of JKT, Site 4. HAR Site 5 is approximately 25 km downstream of Pawnee creek. Site 2, THR, is 1 km upstream of Kiowa creek. The South Platte basin drains an area of 62,900 km^2 (Kircher and Karlinger 1983). The South Platte River joins the North Platte River in Nebraska, forming the Platte River, which flows across Nebraska to the Missouri River (Colorado's Water Plan 2015). Seven sites were randomly selected for data collection within three randomly positioned 30-km river sections on the South Platte River between Kersey and Julesburg, Colorado. Sites from one side of the river were selected that showed no visible evidence of forest management based on aerial photograph observations – though one side of the stream fit the criteria for sampling, at some sites the other side of the stream may have shown forest management. Sites ranged from public lands to private lands used for hunting and recreation to unmanaged. Land was accessed from Colorado Parks and Wildlife (sites 4 and 6), Colorado Land Trust (site 7), and several private landowners (sites 1, 2, 3, and 5). Approximately 250 km of total river length is included in the study area (Kersey to Julesburg, CO).

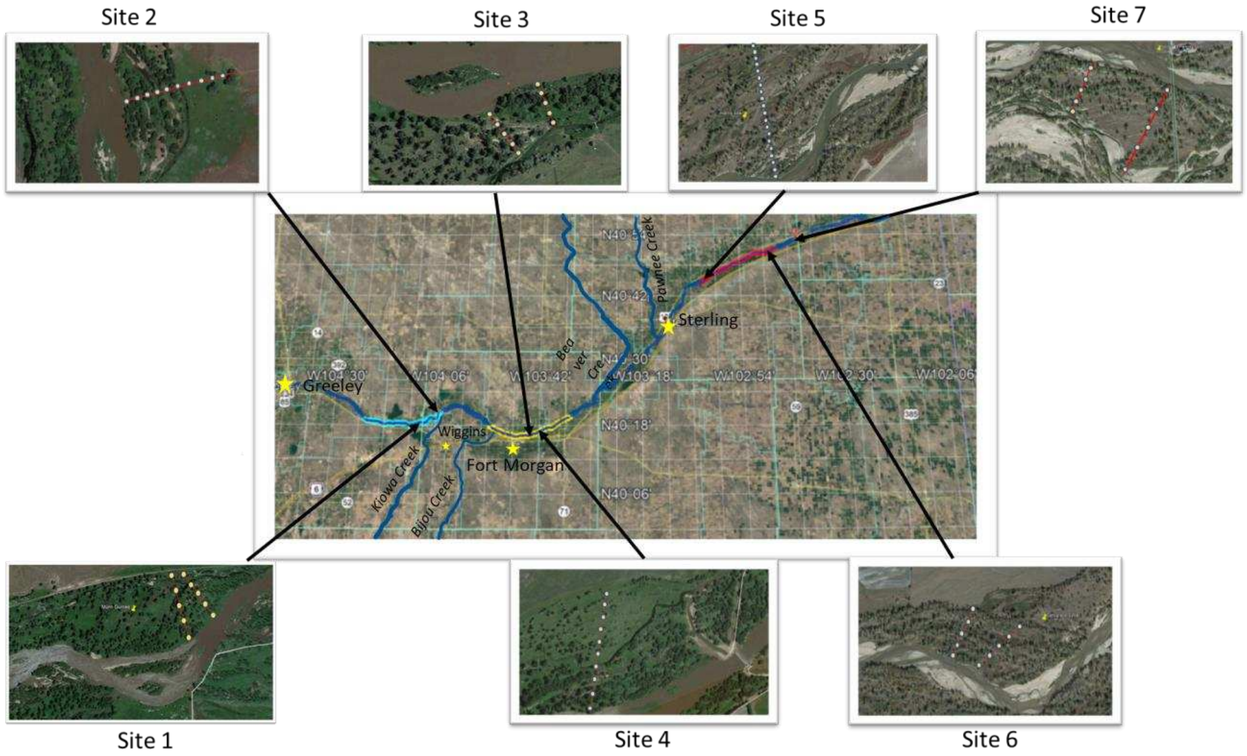

Figure 1. Map of the study area and location of sites. Sites had from 1-2 transects. Transects were established perpendicular to the active channel. See text for details.

Dendrochronological methods

I sampled riparian vegetation along transects oriented perpendicular to the active channel, with plots equally spaced along each transect (Figure 1). The width of the floodplain is variable, and the number of transects and spacing of sampling points varied accordingly in order to obtain at least ten plots per site. Based on the width of the flood plain, 5-10 plots were established on 1-2 transects. As a rule, floodplains >300m in width had one transect, and ten equidistant plot centers established along it. If the floodplain width was less than 300m, two transects were used, spaced 100 m apart, with five equidistant plot centers per transect. Each sampling plot was circular with a 7.98 m radius (.02 hectares). Data was collected from July to September in the years of 2018 and 2019.

Within each plot, I recorded the species, height and diameter at breast height (~1.37 meters height; dbh) of all trees, plot location on transect, canopy condition of each tree, seedling and sapling presence/absence, woody-understory presence/absence, and GPS location. Saplings were defined as trees >1 m tall and <2 cm dbh, and seedlings were anything smaller than the defined saplings (i.e. ≤ 1 m tall). In addition, the nearest five (if possible) *Populus deltoides, Fraxinus pennsylvanica*, and *Ulmus pumila* and *Ulmus americana* trees to the plot center were cored for age analysis. The species selected for inclusion in this study are the most prevalent in the forest and represent primary species and presumed later successional species. If fewer than five trees per species were present in a plot, additional trees were sampled at a distance up to 50 m perpendicular to the transect plot point. No duplicative sampling of trees was done between any two plots. In most instances, the density of trees was not high enough to collect five samples of each species for age analysis at each plot location. At some sites, there were not enough trees to collect cores of even 30 trees of a single species. In this instance additional sampling points along the transect were added to increase the number of trees sampled. The exact number of trees cored at the additional sampling points was determined by how many additional cores were needed for an adequate sample size at that site - 50 trees per species was the goal.

Cores were stored in paper straws and returned to the lab for processing. Cores were mounted and sanded with progressively finer grits (initially with 250, 350, 400 and finally with 600 grit) to observe annual tree rings. The annual ring boundaries were marked, and verified with the second core sample per tree, and a skeleton plot for each site was developed to identify any anomalies or errors. Marker rings of 2008, 2006, 1968, 1953, and 1950, were used to align the ring-widths due to their consistent narrow width in all trees from the seven sites sampled. Of the two tree cores from each tree, the core with the earliest recorded date was used for ring width measurement.

Annual tree rings were measured to the nearest 0.001 mm using a sliding stage micrometer (Velmex Inc., Bloomfield, New York, USA). Cross-dating was confirmed using skeleton plots at the site level, and statistically for all *Populus deltoides* tree cores using the program COFECHA (Holmes 1983). Interseries correlations within sites ranged from 0.205 to 0.615. Following cross-dating, the number of tree rings to the pith of the tree were estimated to establish the age for each tree using a ring-curvature method and the missing-length method (Norton et al. 1987, Meko et al. 2015, Friedman et al. 2018). Data from the longest tree core record for each tree was used to generate descriptive statistics of age and dates of establishment, while the actual measured rings were used in the statistical modeling.

Monthly climatic and hydrological variables

To determine what factors are important for annual growth in *Populus deltoides* trees, tree ring chronologies were developed and correlated with seasonal climate and hydrologic data. I developed a chronology of ring widths in the dendrochronology program library in R (dplR) package (Bunn 2008) using a negative exponential curve specifically for the use in the response and correlation function analysis (see below). The negative exponential curve is considered a conservative method for detrending a series – which helps to maintain the long-term signals in the tree ring chronology while removing effects of tree age in the growth signal (Fritts, 1987, Speer 2010). The detrended dataset contained the ring width data, as well as estimated ring widths to the center of the tree, where needed (see above). The dataset was also reduced to 1901 to 2019 (from 1876 to 2019) to align with the climate and flow datasets (which are complete from 1901 to 2019). For analysis using linear mixed-effects models, the raw ring widths (rrw; Figure 2). BAI was used because it integrates ring width and tree diameter, and is a more consistent measurement of annual growth (Biondi & Qeadan 2008). This resulted in an estimation of the two-dimensional growth increment of the trees in this study and guarded against the detection of variations in ring width due to age

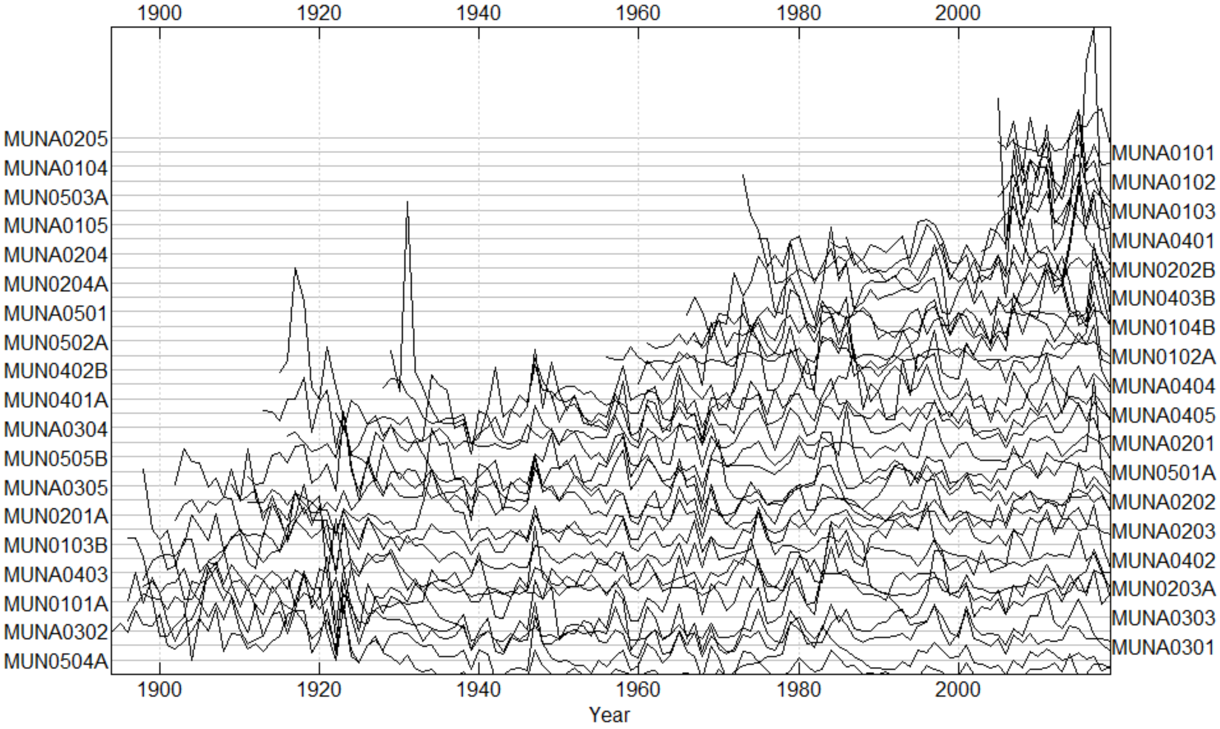

Figure 2: Spaghetti plot of raw ring widths for tree cores from Site 1 (MUN) show the variation in ring-widths for all *Populus deltoides* samples.

Two sources of climate data were used in this analysis. Palmer Drought Severity Index (PDSI) data was obtained from the National Climatic Data Center, National Oceanic Atmospheric Administration (NCDC NOAA; https://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#) database for Colorado's (region 05), Platte division/Platte Drainage Basin (division 04). This dataset is for the Platte River Basin which encompasses approximately 20,306 square miles and includes drainages for the North Platte River and the South Platte River covering the northeastern part of Colorado. Elevations in the Platte River Basin range from 14,000 feet in the headwater's region to approximately 3,400 feet in the high plains region (State Water Quality Management

Plan 2011). Additional data for precipitation, vapor pressure deficit (minimum and maximum), and temperature (minimum, mean, and maximum) were obtained from Parameter-elevation Regressions on Independent Slopes Model databank (PRISM; http://www.prism.oregonstate.edu/explorer/bulk.php) using GPS coordinates, at a resolution of 4km, for each of the seven sites on the South Platte River. PRISM uses point data, a Digital Elevation Model (DEM), other spatial datasets to generate regression-based estimates of climatic data. The PRISM model estimates are interpolated to a regular grid, making them compatible with GIS.

Two stream gauges exist on the South Platte River that were considered in this analysis, USGS 06764000 South Platte River at Julesburg, CO, available period 1902-04-01 to 2018-09-30, and USGS 06754000 South Platte River near Kersey, CO, available period 1901-05-01 to 2007-09-29 (https://nwis.waterdata.usgs.gov/co/nwis/). To address absent data from these two stream gauges, discharge was interpolated for highly correlated monthly records between the two gauges for a complete hydrologic dataset of monthly discharge values from 1896 to 1912, then 1914 to 2019. Parameters of interest from the hydrologic dataset included monthly mean flow, monthly maximum flow, and monthly low flow (ft^3/sec).

Modeling tree growth – environmental relationships

Response and correlation function analysis was performed to relate the de-trended *Populus deltoides* tree-ring chronology with the monthly regional NCDC climate data, the site PRISM climate data, and the hydrologic data parameters (Appendix A). The climate and hydrologic parameters were bootstrapped to calculate the significance and confidence intervals for these climatic factors influence on ring width variability. Results from the response and correlation function analysis informed the selection of variables to include in the linear mixed-effects model development. All analysis was performed using R statistical software version 3.6.3 (R Core Team 2020), and treeclim: an R package for the numerical calibration of proxy-climate relationships (Zang & Biondi 2015).

I developed models to describe the effect of individual climate variables on the natural log of BAI from the time period of 1901 to 2019. In each model, tree age and treeage^2 were included to accommodate the effects of tree age on the natural log of BAI. A categorical factor indicating each tree was included as a random effect in all models and allowed for a separate intercept and age slope for each tree. The unit of replication using this design is the individual tree, with annual rings as repeated measurements. Several flow and climate variables were chosen to include as fixed effects in model development due to their significant effect on BAI, as indicated by the response and correlation function analysis (Appendix A). Location (site) was additionally considered as a fixed effect in the model development to test for variation due to the site where trees were sampled. Fourteen linear mixed-effects models were evaluated using the R lme4 package (Bates et al. 2015).

These models were designed to evaluate the individual and combined effects of location (Site 1-7), flow, and climate. In all models, age and its interaction with all other dependent variables in the model accommodated the increasing effect of each variable as trees aged and BAI increased. Simple models included the individual effects of site, climate variables (June-July PDSI, April-July precipitation, previous October precipitation, minimum June and April VPD, and maximum October VPD), hydrologic variables (Average November, March, and June-August flows), or Palmer Drought Severity Index. More complicated models included two or more of these categories of independent variables, sometimes with interactions. Climate variables and PDSI were not included in the same model because PDSI is a composite of the climate variables, although integrated through time. Models included in this analysis are provided in Appendix B.

Because AIC comparisons were of interest, ML estimation was used for model fitting. The selected model had the smallest AIC values, and the Akaike weight showed the candidate model was the best for the observed data. Semi-partial R squared values were calculated for each fixed effect in the mixed model using the r2glmm package (Jaeger 2017).

Results

The riparian forest was dominated by *P. deltoides,* plains cottonwood. The composition of the sites sampled show that basal area of *P. deltoides* composed 11.6 m^2/ha (average) of the area sampled and the density of *P. deltoides* for all sites was 54 trees/ha (Table 1). Comparatively, *F. pennsylvanica* and *U. pumila* composed less than 10 percent of the basal area of the forest (approximately 6 percent of forest with 0.7 m^2/ha and approximately 3 percent of forest with 0.3 m^2/ha respectively, Table 1). The density and composition of each species varies among the seven sites, with the lowest density of *P. deltoides* occurring at Site 5 with only 3.3 m^2/ha of *P. deltoides*. Site 5 also had the highest density of *F. pennsylvanica* of the seven sites composing 4.3 m^2/ha and 70 *F. pennsylvanica* trees per hectare (Table 1). In comparison, the site with the highest density of *P. deltoides,* Site 3, did not have any *F. pennsylvanica* or *U. pumila* present along the sampling transects (Table 1).

Saplings and/or seedlings were present at some of the sites, but not aged, indicating regeneration at these sites up to when sampling was performed in 2019. *Populus deltoides* seedlings occurred in 3 percent of plots sampled (only occurring at two sites) and saplings occurred in 11 percent of the plots sampled, but only occurred at four of the seven sites (Table 1). *Fraxinus pennsylvanica* seedlings occurred in 36 percent of plots sampled, and were present in six of the study sites, and saplings occurred in 4 percent of the plots sampled and occurred at three of the study sites (Table 1). *Ulmus pumila* seedlings occurred in 10 percent of the plots sampled and at two of the study sites, but no saplings were present in any plots at any of the study sites (Table 1).

General recruitment status of the South Platte River riparian forest.

A total of 284 trees were sampled for age identification. Of these, 237 were *Populus deltoides*, 36 were *Fraxinus pennsylvanica*, and 11 were *Ulmus pumila* (Table 2). *Populus deltoides* tree ages ranged from 142 years of age (oldest tree established in 1876) to newly established seedlings (1 year-seedlings, established 2018) (Figure 3). The average tree age *P. deltoides* for all sites was 64 years. *Fraxinus pennsylvanica* trees ranged from 72 years of age (oldest tree established in 1947) to as young as 9 years (established in 2010) (Figure 3). This species was observed at six of the seven sites (only Site 3 did not have this species present), and newly established seedlings were observed in the same six study sites. The mean age for *F. pennsylvanica* trees sampled is 35 years of age. *Ulmus pumila* was documented in four of the seven study sites. The tree ages for *U. pumila* ranged from 73 years of age (oldest tree established in 1945) to 13 years of age (established in 2005) (Figure 3). The mean age for *U. pumila* trees sampled is 37 years of age.

Table 1: Basal area and trees per hectare for the forest are shown for the seven sampling sites and for all sites together (weighted average). Seedlings and saplings are shown as proportion per site (plots where seedlings or saplings were present/total plots per site), and the total proportion for all sites.

	mun	thr	mcc	jkt	har	tam	clc	
site	1	2	3	4	5	6	7	All sites
P. deltoides m^2/ha	14.1	3.8	25.8	11.3	3.3	10.9	11.9	11.6
F. pennsylvanica m^2/ha	0.0	0.2	0.0	0.0	4.3	0.0	0.3	0.7
U. pumila m^2/ha	0.0	2.1	0.0	0.3	0.0	0.0	0.0	0.3
P. deltoides trees/ha	45.0	10.0	95.0	60.0	35.0	20.0	115.0	54.3
F. pennsylvanica trees/ha	0.0	10.0	0.0	0.0	70.0	10.0	15.0	15.0
U. pumila trees/ha	0.0	20.0	0.0	5.0	0.0	0.0	0.0	3.6
P. deltoides saplings	2/10	0/10	3/10	0/10	2/10	0/10	1/10	8/70
F. pennsylvanica saplings	0/10	1/10	0/10	0/10	0/10	1/10	1/10	3/70
U. pumila saplings	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0//70
P. deltoides seedlings	0/10	0/10	0/10	1/10	0/10	0/10	1/10	2/70
F. pennsylvanica seedlings	0/10	3/10	4/10	1/10	5/10	7/10	5/10	25/70
U. pumila seedlings	0/10	6/10	0/10	0/10	0/10	0/10	1/10	7/70

Table 2: Three species were sampled from seven sites on the South Platte River. The presence and density of each species varied among sites. The count of trees cored for age analysis are shown.

Site code*	**Site**	***Populus deltoides* Trees**	***Fraxinus pennsylvanica* Trees**	***Ulmus pumila* Trees**	**Total Tree count**
1	mun	38	3	0	41
2	thr	21	1	5	27
3	mcc	28	0	0	28
4	jkt	37	4	2	43
5	har	41	11	0	52
6	tam	42	15	2	59
7	clc	30	2	2	34
Total trees cored=		237	36	11	284

* ordered from upstream to downstream

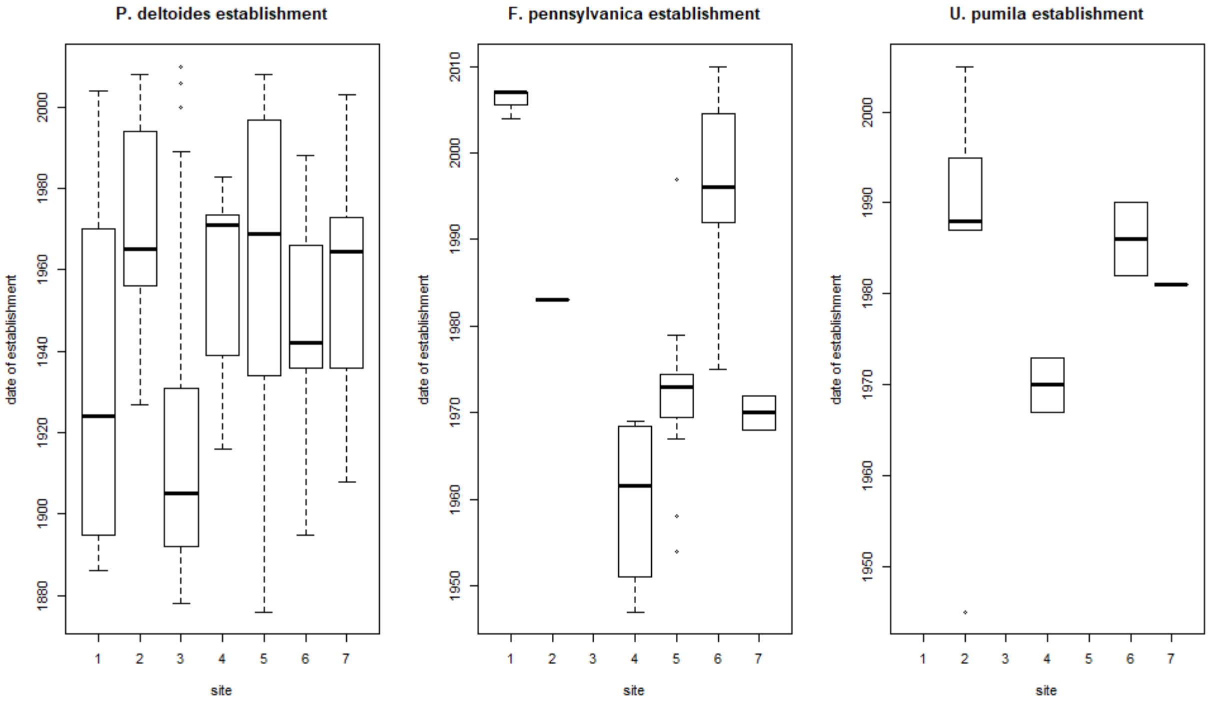

Figure 3: Boxplots for the three species sampled in this study show the variation in establishment patterns for each of the study areas, and the presence and absence of latter successional species in the system.

Overall, these results provide evidence for ongoing reproduction of *P. deltoides*, the dominant tree species in this system (Table 1, Figure 4). For the study reach overall, the establishment of *P. deltoides* showed a varied distribution of establishment through time. The earliest recruitment is seen in 1876. It cannot be said with certainty that there was no establishment before these dates, as trees may have died, or they were just not encountered in these sampling methods. The most recent dates of establishment indicated by the tree cores was 2010, though trees less than 2 cm dbh were too small to be selected for tree ring analysis per our sampling protocol (and thus were categorized as saplings). There are pulses of *P. deltoides* establishment seen from 1937 to 1950 and 1963 to 1980 – possibly corresponding to the 1935 and 1965 floods (Figures 4 and 6). *Fraxinus pennsylvanica* did not appear in the core records until 1945 and shows evidence of trees establishing as recently as 2010, based on tree core dates of establishment. *Ulmus pumila* does not appear in my samples until 1945 and shows evidence of minimal establishment to as recently as 2005 based on tree core dates of establishment.

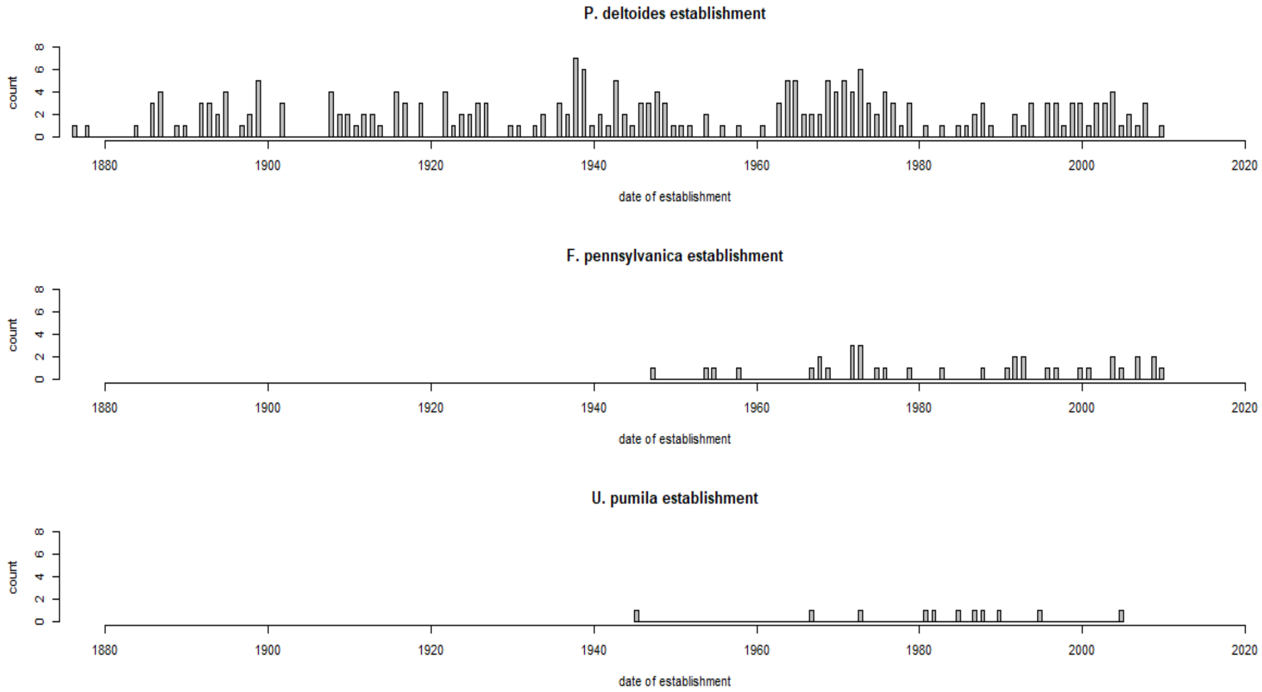

Figure 4: Establishment dates of the three species sampled from all seven sites in the study. These are *Populus deltoides, Fraxinus pennsylvanica, and Ulmus pumila.*

Populus deltoides establishment exhibited some site-to-site variability in age structure and establishment history (Figure 5). The results from the individual sites show that regeneration is intermittent, and not necessarily synchronous among sites, indicating that local effects contribute to the overall success of cohorts at a site. Site 1, Site 3 and Site 5 show generally continuous recruitment from the late 1800s to 2010, while Site 2 and Site 4 show distinct pulses of recruitment. Additionally, at Site 2, Site 4, and Site 7 no trees were sampled that showed establishment before 1900.

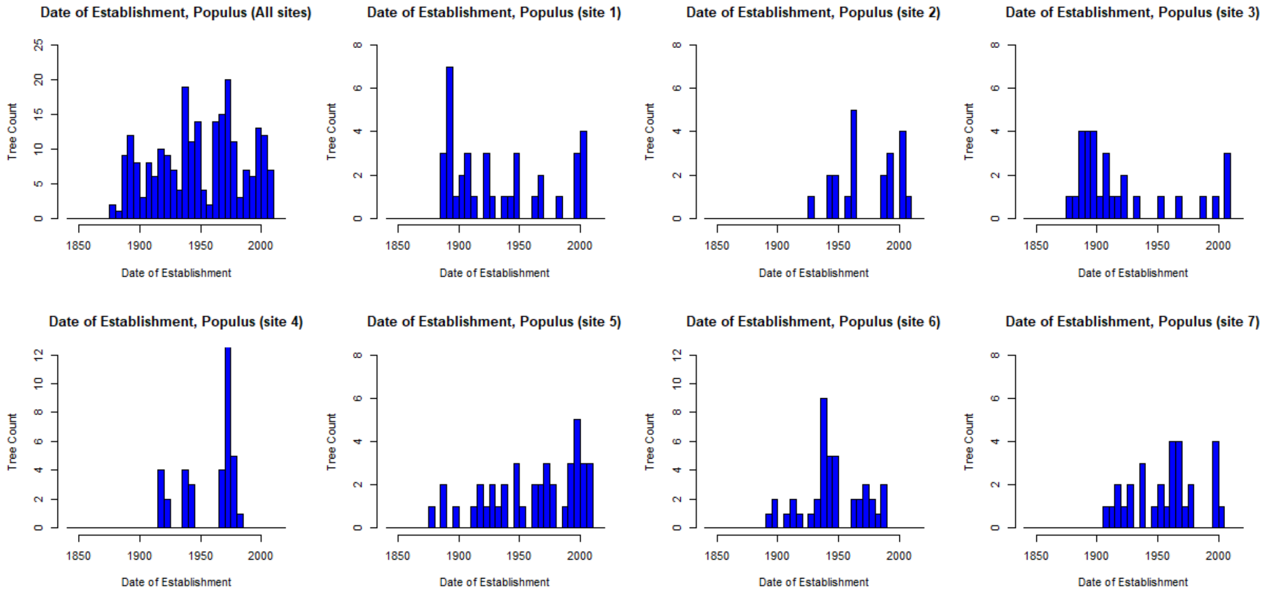

Figure 5: Histograms represent years of establishment of *P. deltoides*, for all sites combined, and for each of the seven study sites.

Environmental variables affecting annual tree growth.

A total of 237 live *P. deltoides* trees were used to develop a tree ring chronology for this section of the South Platte River. Over 16,700 annual ring widths were measured spanning 179 years (1840 to 2019). The mean series intercorrelation for all sites was 0.33 (the agreement for all the ring widths in the series), with a mean sensitivity of 0.54 (the trees ability to detect variation in the its local environment).

Akaike Information Criteria selection showed the most parsimonious model incorporated three flow variables, site, one climate variable, age, and age^2 (Table 3). The top model selected with AIC included thirteen parameters with all seven sampling sites, age, summer mean flows, march and november mean flows, June-July Palmer Drought Severity Index (PDSI), as well as interactions with June-July PDSI and summer mean flows, a polynomial age term, a random intercept for each tree, and a random slope for age (Table 4). Variance inflation factors for the independent variables were all less than 2.5 with the exception of summer mean flows (VIF =

4.41) and summer mean flows by June-July PDSI (VIF = 4.34). Removing this interaction term confirmed that it was the source of the higher VIF scores and it was retained in the model. Eleven parameters were significant ($p < 0.05$). This single best fit model explained 49.6 percent of the BAI variability. The random intercepts (i.e. the tree to tree variation) explained 42.5 percent of the variance, whereas the random slope (variation in the effect of age on BAI) explained 3 percent of the variance. These results indicate that most of the variation detected in this model is due to the differences associated with the individual trees. The climate and flow variables that were in this best-fit model for annual growth were off-season flows (previous November and March mean flows), average June and July PDSI, July – August (summer) mean flow, and the interactions of June and July PDSI with July- August mean flows. (Table 4).

Table 3: Fourteen models were tested and ranked using Akaike Information Criteria.

Model name	**dAICc**	**df**	**weight**
flow.pdsi.int.site1	0.0	18	1
flow.pdsi.int	21.1	12	<0.001
flow.clim.int.site2	30.0	24	<0.001
flow.clim.int.site1	33.6	23	<0.001
flow.pdsi.site	46.2	17	<0.001
flow.clim.int	50.2	18	<0.001
flow.pdsi.int.site2	66.7	17	<0.001
flow.pdsi	67.7	11	<0.001
flow.clim.site	74.0	21	<0.001
flow.clim	93.8	15	<0.001
flow.avg	162.3	10	<0.001
climate.model	535.2	12	<0.001
location.model	983.8	13	<0.001
pdsi.model	2351.8	6	<0.001

Table 4: Parameter estimates for the model that best explained Basal Area Increment.

Model Parameters	Coefficient (β)	R^2	P-value
Model		0.496	
Intercept - tree core	7.994		**< 2e-16**
Site 5	-0.3931	0.020	**0.033924**
Site 4	- 0.02908	0.000	0.874286
Site 3	-0.4305	0.026	**0.0282408**
Site 1	-0.6229	0.057	**0.000884**
Site 6	-0.4356	0.030	**0.015082**
Site 2	0.3892	0.013	0.075542
Mean November flow	0.1481	0.005	**< 2e-16**
Mean March flow	-0.05792	0.001	**0.003088**
June & July PDSI	0.01656	0.010	**< 2e-16**
Summer mean flows	0.2397	0.012	**< 2e-16**
poly(Age, 2)2	-1.997	0.001	0.055738
poly(Age, 2)1	70.102	0.425	**< 2e-16**
June & July PDSI: Summer mean flows	-0.01238	0.003	**3.77e-12**

The annual geometric growth of *P. deltoides* trees increased with age. This accounted for 1.9 percent of the variation in BAI. The sum of the R^2 for all sites accounts for 14.6 percent of the variation in BAI (Table 4). The sum of the R^2 for the flow variables explained 1.8 percent of the variation in BAI, and the R^2 June-July PDSI explained 1 percent of the variation in BAI. The relationship shown in this analysis, is that when PDSI is high (positive value is indicative of wet conditions), then BAI is greater. The interaction of summer flow parameters, and June-July PDSI explained 0.3 percent of the variation in BAI. Overall, there was an effect of site on annual tree growth (Table 4).

Discussion

General recruitment status of the forest.

Our findings contrast with previously hypothesized successional trajectories for this system, which predicted the replacement of the *Populus-Salix* overstory by later successional species (Sedgwick & Knopf 1989, Johnson 1994, Strange et al. 1999). Research on *Populus-Salix* recruitment and survivorship on the South Platte River shows that the pre-settlement active channel transitioned to woodland by the 1930s (generally from upstream to downstream) largely due to water management that decreased flood peaks and stored water in the floodplain and after periods of droughts in the 1900s that allowed for tree recruitment in the active channel (Nadler and Schumm 1981, Johnson 1994). Since the 1930s, woodland expansion was shown to be highly variable. Johnson (1994) showed that a study portion of the South Platte River increased in channel area over time, while portions of the North Platte and Platte Rivers showed a generally steady channel area or a stark decrease in channel area over time (Johnson 1994). This and other findings suggested that this system would transition to *Acer negundo*, *Ulmus pumila*, and *Fraxinus pennsylvanica* due to the system reaching a dynamic equilibrium or steady state, characterized by small increases and decreases in channel area with no net change (Sedgwick & Knopf 1989, Johnson 1994, Strange et al 1999). These previous understandings of the forest status were made with the qualification that variations in stream geomorphology, biota (namely exotic species), and the type, timing and magnitude of flow alterations present challenges to generalizing on the overall status of forest recruitment and primary species succession.

Our findings suggest that *P. deltoides* is regenerating in this system. This indicates that there is enough disturbance in the floodplain of the mainstem South Platte River for *Populus* regeneration. The South Platte River lacks large reservoirs for the lower portion of the stream. This lack of large impoundments seems to allow enough hydrologic fluctuations for disturbance dependent *Populus* to persist. The lack of impoundments, coupled with the water inputs into the watershed from trans-basin diversions, irrigation, and urban effluents, allowed for continued *Populus* regeneration. This finding is consistent with projections for the South Platte River (Friedman et al. 1997) but contrasts with findings for similar Western river systems with more highly regulated flows, such as the Platte River in Nebraska (Johnson 1994) and the Arkansas River in Eastern Colorado (Snyder and Miller 1991).

Our study additionally finds that later successional species are only present at low densities. Though the later successional species identified are younger (newer regeneration) they remain a minor component of the forest overstory (Table 1, Figure 2). The low densities may at least be partially explained by the occurrence of Dutch elm diseases, which appeared in Colorado in 1948 (Strobel and Lanier 1981) which affected *Ulmus americana* in this forest system. *Populus deltoides* remains the dominant species with younger age classes, indicating regeneration. This counters previous conclusions that this forest would follow the same path of senescence seen in other western plains streams, transitioning to later successional species, or that the stream is favorable to shade-tolerant exotics (Sedgwick & Knopf 1989, Johnson 1994, Strange et al. 1999). The *P. deltoides* forest appears to be regenerating which is not what these prior studies had predicted. *Populus deltoides* additionally remains the dominant species in terms of basal area and density where it composed 92 percent of the basal area (m^2/ha), *F. pennsylvanica* composed 5.6 percent of the basal area, and *U. pumila* composed 2.4 percent of the basal area of the forest sampled (Table 1). These results are consistent with Norton et al. (2016), showing a low density of later successional species in this forest, and that *P. deltoides* dominates the forest's composition.

This also reinforces earlier records of the forest composition being dominated by *P. deltoides* (Sedgwick & Knopf 1989, Johnson 1994).

Patterns in riparian vegetation for braided streams in the Great Plains region, and other semi-arid regions, is attributed to the availability of water, and the local fluxes in sediment erosion and deposition (Hupp & Osterkamp 1996). The variation in tree ages among sites may reflect the requirements needed for *P. deltoides* seedling establishment and causes of mortality in the floodplain. The requirement for moisture and light is generally met from high-flow events, which may either deposit fresh alluvium or remove vegetation from flood-plain surfaces (Auble & Scott 1998, Bendix & Hupp 2000, Lytle et al. 2017). Establishment of *Populus* follows a boom-bust cycle with large pulses of recruitment and subsequent high mortality following sequences of flooding and drought (Scott et al. 1996, Friedman et al. 1996, Auble and Scott 1998, Lytle et al. 2017). Braided streams often show recruitment during periods of low flows, when there's not enough power to rework the bed sediments (Johnson 1994, Scott et al. 1996).

Variation in the elevation of sites contributes to the overall success of established seedlings, due the ability to access groundwater in the riparian floodplain, and the scouring and upheaval of seedlings from flood events in lower elevation sites. The local landforms within the flood-plain have distinctive experiences in the frequency and severity of floods due to their position in the floodplain and the local hydrologic conditions, different landforms among the sampling sites may contribute to establishment variability and diversity of trees in that system (Hupp & Osterkamp 1996, Johnson 1994, Bendix & Hupp 2000). The local site elevation may also be associated with the presence of ephemeral streams during periods of high flows, indicated at a few sites in this study by high-water marks, debris, and deposition of sandy alluvium. The local site variation is an important consideration in the differences in age structure and species composition (Lytle &

Merritt 2004). Annual growth of the riparian forest sampled on the Missouri River showed increased annual growth with decreasing terrace elevation (Reily and Johnson 1982). Interestingly, though some trees in their study occupied high terraces, where access to ground water was reduced, trees still showed high annual growth (Reily and Johnson 1982). The sites on high terraces received concentrated upland runoff, allowing for trees to increase annual growth though having reduced access to groundwater (Reily and Johnson 1982).

In addition to elevation, a site's proximity to upstream tributaries, the presence of back channels, the local land-use legacies, and our sampling protocols (only one side of the stream sampled) may have contributed to the variability in *P. deltoides* age classes among the study sites. The forest structure varied on either side of the stream. For example, at Site 5 the northern side of the stream was selected for data collection and had only two plots with saplings. In contrast, the southern side of the stream had 1,000s of saplings established (visual estimation). Thus, our data collection protocol may have enhanced site level differences in cohort establishment dates by only looking at establishment on one side of the river. The land-use and land management goals for each of the study sites may have also contributed to variation in age structure among sites. The study sites ranged from unmanaged private property, to land managed by Colorado Parks and Wildlife for hunting and recreation. At site 5, the saplings did not meet the private landowner's management goals (the southern side was used for agriculture) and they indicated that the saplings would be mowed. At Site 4, there was a large amount of beaver activity, with several large trees felled (with dbh estimations from ~10 to 80 cm), effectively removing them from the forest stand.

The variation in location of sampling sites to tributaries may explain site to site variability in stand structure. Local tributaries on the South Platte, between Kersey and Julesburg, Colorado include Kiowa Creek, Bijou Creek, Beaver Creek, and Pawnee Creek. From Kiowa Creek and the South

Platte confluence, Site 2 was approximately 1 km upstream; from Bijou Creek and South Platte confluence, Site 3 was located approximately 10 km downstream, and Site 4 was located 16 km downstream; from Pawnee Creek and the South Platte confluence, Site 5 was approximately 25 km downstream. Site 4 seemed to experience low recruitment following the two major floods of 1935 and 1965 (Figure 4 and 6), while Site 2 seemed to experience a pulse of establishment following the 1965 flood, but no recruitment following the 1935 flood until 1940 (Figure 4). Other major floods that appear in the stream gauge records on the South Platte are for 1921, 1973, and 1997. For the seven sites, site 1, 4, and 5 show pulses of establishment that may be attributed to the 1921 flood. The 1973 flood may have contributed to establishment at all sites, except site 2 for this period. The 1997 flood may have contributed to pulses of establishment seen at sites 1, 2, 3, 5, and 7. These types of local variations at the study sites may have made a significant contribution to the varied age structure observed in this study, in this instance, while recruitment was overall continuous following these floods, site level responses of recruitment following these floods do not always show the same trends.

Studies on Bijou Creek and Kiowa Creek have shown the impact of the floods of 1935 and 1965, which resulted in substantial channel widening post-flood and then gradual channel narrowing accompanied by an increase in forest width (Friedman & Lee 2002). These two floods each resulted in a clear pulse of establishment of *P. deltoides* trees in the years following flooding (Friedman & Lee 2002). Most of the new forest was established in former channel beds during the process of channel narrowing following these two floods and the flood-related establishment exceeded the flood-related removal of trees resulting in a net increase in forest width (Friedman & Lee 2002). In the main stem South Platte River, the magnitude of these floods is recorded at the Julesburg gage, at the Colorado-Nebraska border (Figure 6). Regardless of the site to site variability, overall, we see similar trends in high recruitment during these two periods. We see the effect of the 1935 flood on recruitment, with high recruitment occurring in 1937 and 1938 in *P. deltoides* (Figure 2), and see that 1965 shows higher recruitment followed by a period of lower *P. deltoides* recruitment.

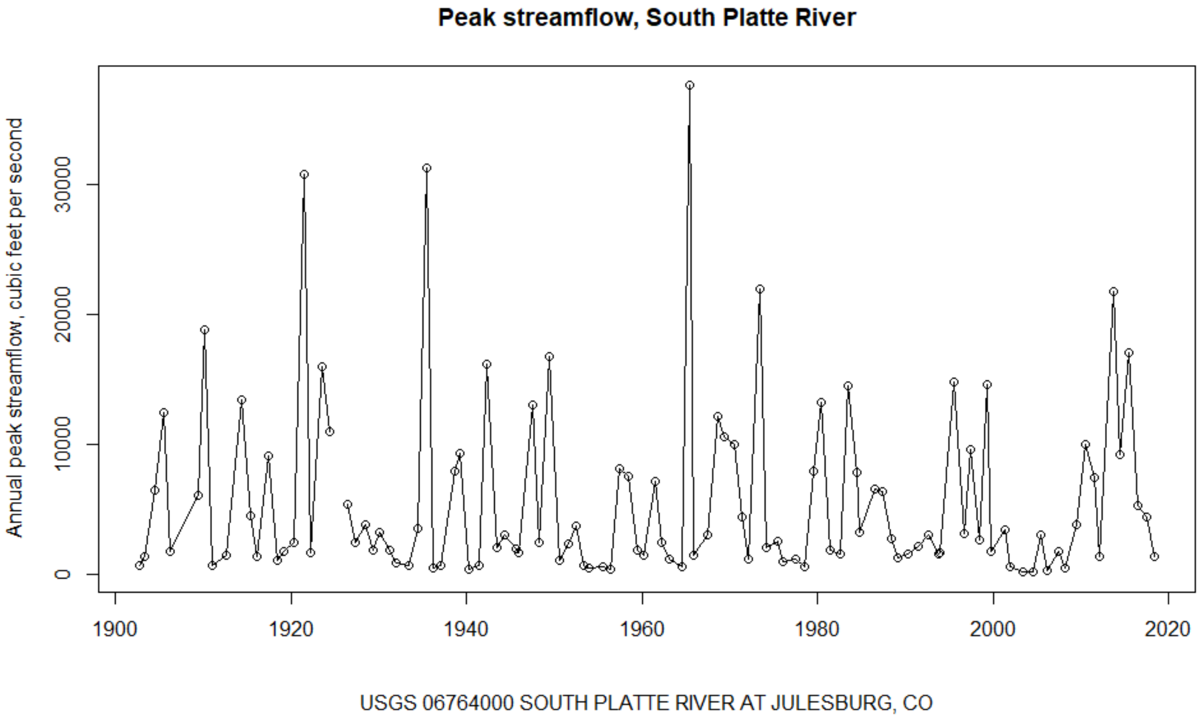

Figure 6: Instantaneous peak discharge (ft^3/sec) is shown from the Julesburg stream gauge in Sedgwick County, Colorado (Latitude 40°58'30", Longitude 102°15'05" NAD2) from 1902 to 2019. The drainage area is 22,824 square miles. Gage datum 3,449.80 feet above NAVD88 (https://nwis.waterdata.usgs.gov/co/nwis/peak?site_no=06764000&agency_cd=USGS&format=gif).

In addition to *P. deltoides* regeneration, our findings suggest that *Ulmus pumila* and *Fraxinus pennsylvanica* do not show a high competitive advantage as later successional species over the primary successional species of this forest. *Ulmus pumila* is an exotic invader in this forest system (Webb 1948, Leopold 1980), but the low population level indicates that the forest is not transitioning to maintain this species. In fact, our field assessments showed that trees rarely reached older ages. Older trees at our study sites generally showed canopy die-back and tree senescence. A possible cause of this die-back may be inhospitable site factors for too long of root inundation (Ball 2011), water availability in the airid climate (Smith et al. 1998), and ice storms (Perry et al. 2018). Because groundwater is so high in the South Platte River forest floodplain, as the trees age and roots extend laterally, the soil moisture conditions may prove inhospitable if roots are inundated too long. *Ulmus pumila* is considered a flood-tolerant species, but long-term inundation of roots, may have negative effects on the tree longevity (Ball 2011). Studies for seedlings of this genus have shown an intolerance to increased length of flooding during the growing season, and intolerance to increased flood depth during the dormant season (King & Grant 1996), though it may not be appropriate to extend this survivorship information to adult trees. Ice storms have also shown to be a source of dieback for this species (Perry et al. 2018), as well as susceptibility to frost (Klingaman 1999).

Fraxinus pennsylvanica is considered to have high tolerance to flooding and inundation (Ball 2011), though their presence was still sparse within the South Platte River forest. Walla et al. (2000) found significant dieback of *F. pennsylvanica* sampled in the Great Plains and Rocky Mountain regions for many hypothesized reasons such as disease and pathogens, drought, flooding, insects, and herbicides. Today, as the emerald ash borer spreads along the South Platte River, *F. pennsylvanica* in this forest can be expected to decline. A study of heart rot disease of ash caused by *Perenniporia fraxinophila* showed higher rates of die back for infected trees, but also indicated that *P. fraxinophila* is not the primary cause of canopy dieback (Lesica et al. 2003). These findings of dieback may be a cause of the low species densities in this study, though I did not directly test this.

Identification of environmental variables affecting annual tree growth.

Mean June and July PDSI had a negative relationship with BAI, which is consistent with other findings (Edmonson et al. 2014, Yu et al. 2018). Because PDSI is an estimate of relative dryness, and is based on temperature and precipitation patterns as well as Available Water Content (AWC) of the soil, PDSI captures the effects of potential evapotranspiration and the preceding month's moisture conditions (Dai et al. 2019). The June and July PDSI and summer flow interaction in the model indicate that the effects of droughts (negative value denote dry conditions) are offset by higher summer flows. Because our correlations were done with raw ring widths (shown in Appendix A), they appear relatively small compared to other findings (Schook et al. 2016).

There was a significant effect of site on BAI. Johnson and Abrams (2009) showed that trees growing on poor quality sites have inherently slower growth as reflected in small annual BAI (trees in this study were hemlock (*Tsuga canadensis*) and blackgum (*Nyssa sylvatica*)). Because of the high variability in site being able to predict annual incremental growth, the quality of the site may be contributing to this. Access to groundwater, nutrient loading, competition, and elevation may contribute to the ability of a site to support annual tree growth, but this was not directly measured in this study.

As with climate factors, hydrologic factors during the growing season had a positive relationship with annual BAI. Mean flows for the months of June, July and August positively impacted the tree for that year's growth. Additionally, mean flows from the previous November and March are significant to tree growth. This indicates that having higher late season flows (November) increases the annual growth of trees for the next year. Alternatively, high average March flows decreases the annual growth for the coming summer growing season. Why these coefficients are opposite is not exactly clear. Higher flows in March may be indicative of early snow melt. If this is true, this may result in lower flows later in the growing season, which may negatively impact annual incremental growth.

Variation in November and March flows have contrasting effects on annual growth. Higher November mean flows significantly increased annual growth of *P. deltoides* trees for the following growing season (Table 4). As water-use in the basin has changed, increased municipal inputs from the Colorado Front Range (the area with most of the the state's population) during traditionally lower flow periods (i.e. November), may be contributing to the overall growth of trees. The positional status and South Platte basin water use would suggest that the increase in November flows is due to increased urban flows (i.e. municipal water source inputs). But it is unclear how November flows relate to the increase of annual growth for the following growing season. It is possible, that November flows are contributing to available water storage for the following growing season, but more research is needed to understand this relationship. This relationship might explain landowner's perceptions (personal communication with Dr. Andrew Norton and landowners) that *P. deltoides* are growing at faster rates than they did previously. In contrast, higher March flows were shown to decrease the annual growth for the coming growing season, which may be attributed to early snowmelt and a reduction in flows during the growing season, but this relationship is unclear at this time.

Conclusion

The findings of this study suggest that regeneration of *P. deltoides* is occurring in this forest. This is indicated by the presence of younger age classes distributed throughout sites along the stream. In contrast, this data show that the predicted transition to later successional species is not occurring in this system. The data suggests that recruitment for trees is mediated by local site drivers, meaning that regeneration is not observed consistently among sites –instead recruitment is heterogenous. More broadly, this work shows that *P. deltoides* trees are sensitive to changes in the environment, and annual growth rates reflect variation in the local environment and may contribute to our understandings of environmental changes.

The *P. deltoides* trees sampled and measured for this study show that hydrology and climate factors during the growing season (approximately May-August) are responsible for variations in annual tree growth. Though trees growing at or near the water table have traditionally been expected to produce complacent annual rings that are not useful for detecting differences in moisture variability (Stokes and Smiley 1996; Fritts 2001), the relationship of hydrology and annual growth variation is a result supported by others (Reily and Johnson 1982; Dudek et al. 1998; Yu et al. 2011, Edmonson et al. 2014). These results suggest that off-season flows (November and March) contribute to annual tree growth, which has not been previously indicated for this species.

These hydrologic and climate findings are important to understanding dynamics of the current forest under the influence of novel hydrologic regimes and a changing climate. An important contribution of this research is the finding that November flows have continued to change from the 1890s to current day (Appendix C), and these changes have occurred alongside an increase in annual growth exhibited by the trees in this forest. As atmospheric carbon dioxide levels change, there may be additional attributes of the forest changed with these altered atmospheric conditions, including an increase in annual tree growth (Cole et al. 2010). Alternatively, alterations in hydrology and climate may affect the abundance of the native *Populus-Salix* forest and favor herbaceous species and late-successional and drought-tolerant woody species (Perry et al. 2011). The forest that exists today was established due to anthropogenic alterations in the hydrology of this system (i.e. trans-basin diversions, agricultural and municipal water inputs), and we find that alterations have persisted in this basin due to urban influences that have increased annual incremental growth of the *P. deltoides* trees in this forest. As the climate continues to change due to anthropogenic alterations there may continue to be alterations to growth dynamics of this forest.

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Appendix A. Correlations – Hydrologic and Climatic variables

CLIMATE CORRELATIONS

All Sites

	id	varname	month	coeff	significant	ci_lower	ci_upper
prev.jun	1	PDSI	Jun	-0.023	FALSE	-0.18	0.113
prev.jul	2	PDSI	Jul	-0.011	FALSE	-0.134	0.092
prev.aug	3	PDSI	Aug	0.022	FALSE	-0.048	0.104
prev.sep	4	PDSI	Sep	0.022	FALSE	-0.073	0.148
prev.oct	5	PDSI	Oct	0.02	FALSE	-0.098	0.141
prev.nov	6	PDSI	Nov	0.012	FALSE	-0.086	0.106
prev.dec	7	PDSI	Dec	-0.005	FALSE	-0.085	0.081
curr.jan	8	PDSI	JAN	-0.005	FALSE	-0.089	0.059
curr.feb	9	PDSI	FEB	-0.009	FALSE	-0.103	0.058
curr.mar	10	PDSI	MAR	-0.004	FALSE	-0.105	0.071
curr.apr	11	PDSI	APR	0.033	FALSE	-0.094	0.149
curr.may	12	PDSI	MAY	0.089	FALSE	-0.037	0.252
curr.jun	**13**	**PDSI**	**JUN**	**0.122**	**TRUE**	**0.063**	**0.271**
curr.jul	**14**	**PDSI**	**JUL**	**0.128**	**TRUE**	**0.063**	**0.246**
curr.aug	15	PDSI	AUG	0.1	FALSE	-0.013	0.198
curr.sep	16	PDSI	SEP	0.089	FALSE	-0.136	0.201
prev.jun	1	precip	Jun	-0.008	FALSE	-0.208	0.148
prev.jul	2	precip	Jul	0.025	FALSE	-0.169	0.213
prev.aug	3	precip	Aug	0.111	FALSE	-0.124	0.329
prev.sep	4	precip	Sep	-0.04	FALSE	-0.195	0.138
prev.oct	5	precip	Oct	0.123	FALSE	-0.011	0.286
prev.nov	6	precip	Nov	0.158	FALSE	-0.004	0.299
prev.dec	7	precip	Dec	0.08	FALSE	-0.063	0.241
curr.jan	8	precip	JAN	-0.002	FALSE	-0.202	0.17

curr.feb	9	precip	FEB	0.118	FALSE	-0.064	0.276
curr.mar	10	precip	MAR	-0.097	FALSE	-0.251	0.058
curr.apr	**11**	**precip**	**APR**	**0.153**	**TRUE**	**0.008**	**0.306**
curr.may	12	precip	MAY	0.177	FALSE	-0.028	0.361
curr.jun	13	precip	JUN	0.123	FALSE	-0.055	0.287
curr.jul	14	precip	JUL	0.128	FALSE	-0.028	0.307
curr.aug	15	precip	AUG	0.035	FALSE	-0.177	0.247
curr.sep	16	precip	SEP	-0.065	FALSE	-0.187	0.091
prev.jun	1	Maximum Temp (deg C)	Jun	0.01	FALSE	-0.122	0.14
prev.jul	2	Maximum Temp (deg C)	Jul	-0.031	FALSE	-0.182	0.139
prev.aug	3	Maximum Temp (deg C)	Aug	-0.116	FALSE	-0.283	0.048
prev.sep	4	Maximum Temp (deg C)	Sep	0.007	FALSE	-0.121	0.132
prev.oct	5	Maximum Temp (deg C)	Oct	-0.124	FALSE	-0.276	0.009
prev.nov	6	Maximum Temp (deg C)	Nov	-0.154	FALSE	-0.302	0.005
prev.dec	7	Maximum Temp (deg C)	Dec	-0.057	FALSE	-0.213	0.099
curr.jan	8	Maximum Temp (deg C)	JAN	-0.037	FALSE	-0.144	0.074
curr.feb	9	Maximum Temp (deg C)	FEB	0.067	FALSE	-0.079	0.207
curr.mar	10	Maximum Temp (deg C)	MAR	0.064	FALSE	-0.118	0.231
curr.apr	**11**	**Maximum Temp (deg C)**	**APR**	**-0.168**	**TRUE**	**-0.289**	**-0.045**
curr.may	12	Maximum Temp (deg C)	MAY	-0.139	FALSE	-0.343	0.064

curr.jun	13	Maximum Temp (deg C)	JUN	-0.128	FALSE	-0.266	0.011
curr.jul	14	Maximum Temp (deg C)	JUL	-0.075	FALSE	-0.176	0.03
curr.aug	15	Maximum Temp (deg C)	AUG	-0.022	FALSE	-0.137	0.093
curr.sep	16	Maximum Temp (deg C)	SEP	-0.027	FALSE	-0.218	0.131
prev.jun	1	Mean Temp (deg C)	Jun	-0.005	FALSE	-0.157	0.142
prev.jul	2	Mean Temp (deg C)	Jul	-0.04	FALSE	-0.205	0.169
prev.aug	3	Mean Temp (deg C)	Aug	-0.126	FALSE	-0.303	0.054
prev.sep	4	Mean Temp (deg C)	Sep	0.038	FALSE	-0.111	0.177
prev.oct	5	Mean Temp (deg C)	Oct	-0.106	FALSE	-0.256	0.039
prev.nov	6	Mean Temp (deg C)	Nov	-0.152	FALSE	-0.301	0.024
prev.dec	7	Mean Temp (deg C)	Dec	-0.096	FALSE	-0.243	0.066
curr.jan	8	Mean Temp (deg C)	JAN	-0.005	FALSE	-0.135	0.119
curr.feb	9	Mean Temp (deg C)	FEB	0.084	FALSE	-0.069	0.224
curr.mar	10	Mean Temp (deg C)	MAR	0.051	FALSE	-0.131	0.218
curr.apr	**11**	**Mean Temp (deg C)**	**APR**	**-0.147**	**TRUE**	**-0.268**	**-0.01**
curr.may	12	Mean Temp (deg C)	MAY	-0.11	FALSE	-0.299	0.085

curr.jun	13	Mean Temp (deg C)	JUN	-0.094	FALSE	-0.27	0.055
curr.jul	14	Mean Temp (deg C)	JUL	-0.034	FALSE	-0.146	0.075
curr.aug	15	Mean Temp (deg C)	AUG	-0.027	FALSE	-0.164	0.115
curr.sep	16	Mean Temp (deg C)	SEP	-0.01	FALSE	-0.196	0.157
prev.jun	1	Maximum VPD (hPa)	Jun	0.019	FALSE	-0.114	0.157
prev.jul	2	Maximum VPD (hPa)	Jul	-0.017	FALSE	-0.157	0.153
prev.aug	3	Maximum VPD (hPa)	Aug	-0.12	FALSE	-0.292	0.047
prev.sep	4	Maximum VPD (hPa)	Sep	0.02	FALSE	-0.118	0.155
prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.166**	**TRUE**	**-0.333**	**-0.024**
prev.nov	6	Maximum VPD (hPa)	Nov	-0.123	FALSE	-0.295	0.035
prev.dec	7	Maximum VPD (hPa)	Dec	-0.008	FALSE	-0.195	0.155
curr.jan	8	Maximum VPD (hPa)	JAN	-0.058	FALSE	-0.185	0.072
curr.feb	9	Maximum VPD (hPa)	FEB	0.044	FALSE	-0.091	0.179
curr.mar	10	Maximum VPD (hPa)	MAR	0.115	FALSE	-0.105	0.33
curr.apr	**11**	**Maximum VPD (hPa)**	**APR**	**-0.151**	**TRUE**	**-0.28**	**-0.026**
curr.may	12	Maximum VPD (hPa)	MAY	-0.146	FALSE	-0.333	0.074

curr.jun	**13**	**Maximum VPD (hPa)**	**JUN**	**-0.142**	**TRUE**	**-0.255**	**-0.001**
curr.jul	14	Maximum VPD (hPa)	JUL	-0.103	FALSE	-0.218	0.008
curr.aug	15	Maximum VPD (hPa)	AUG	-0.026	FALSE	-0.143	0.089
curr.sep	16	Maximum VPD (hPa)	SEP	-0.012	FALSE	-0.184	0.14
prev.jun	1	Minimum VPD (hPa)	Jun	0.064	FALSE	-0.091	0.233
prev.jul	2	Minimum VPD (hPa)	Jul	0.009	FALSE	-0.164	0.178
prev.aug	3	Minimum VPD (hPa)	Aug	-0.097	FALSE	-0.22	0.031
prev.sep	4	Minimum VPD (hPa)	Sep	0.029	FALSE	-0.12	0.204
prev.oct	5	Minimum VPD (hPa)	Oct	-0.083	FALSE	-0.228	0.051
prev.nov	**6**	**Minimum VPD (hPa)**	**Nov**	**-0.16**	**TRUE**	**-0.288**	**-0.003**
prev.dec	7	Minimum VPD (hPa)	Dec	-0.087	FALSE	-0.257	0.078
curr.jan	8	Minimum VPD (hPa)	JAN	0.014	FALSE	-0.12	0.148
curr.feb	9	Minimum VPD (hPa)	FEB	-0.011	FALSE	-0.193	0.172
curr.mar	10	Minimum VPD (hPa)	MAR	0.033	FALSE	-0.157	0.191
curr.apr	11	Minimum VPD (hPa)	APR	-0.105	FALSE	-0.24	0.064
curr.may	12	Minimum VPD (hPa)	MAY	-0.027	FALSE	-0.186	0.117

curr.jun	13	Minimum VPD (hPa)	JUN	-0.129	FALSE	-0.275	0.034
curr.jul	14	Minimum VPD (hPa)	JUL	-0.053	FALSE	-0.161	0.092
curr.aug	15	Minimum VPD (hPa)	AUG	-0.013	FALSE	-0.157	0.129
curr.sep	16	Minimum VPD (hPa)	SEP	0.015	FALSE	-0.128	0.175

Site 1

	id	varname	month	coeff	significant	ci_lower	ci_upper
precip.prev.jun	1	precip	Jun	-0.077	FALSE	-0.242	0.109
precip.prev.jul	2	precip	Jul	0.066	FALSE	-0.077	0.21
precip.prev.aug	3	precip	Aug	0.119	FALSE	-0.076	0.267
precip.prev.sep	4	precip	Sep	0.013	FALSE	-0.153	0.155
precip.prev.oct	5	precip	Oct	0.182	TRUE	0.047	0.324
precip.prev.nov	**6**	**precip**	**Nov**	**0.225**	**TRUE**	**0.095**	**0.359**
precip.prev.dec	7	precip	Dec	0.063	FALSE	-0.067	0.188
precip.curr.jan	8	precip	JAN	0.054	FALSE	-0.137	0.238
precip.curr.feb	9	precip	FEB	0.063	FALSE	-0.063	0.185
precip.curr.mar	10	precip	MAR	-0.049	FALSE	-0.17	0.092
precip.curr.apr	**11**	**precip**	**APR**	**0.168**	**TRUE**	**0.027**	**0.278**
precip.curr.may	**12**	**precip**	**MAY**	**0.269**	**TRUE**	**0.037**	**0.442**
precip.curr.jun	**13**	**precip**	**JUN**	**0.195**	**TRUE**	**0.044**	**0.338**
precip.curr.jul	**14**	**precip**	**JUL**	**0.259**	**TRUE**	**0.081**	**0.435**
precip.curr.aug	15	precip	AUG	0.076	FALSE	-0.142	0.261
precip.curr.sep	16	precip	SEP	-0.033	FALSE	-0.188	0.114

Mean Temp (deg C).prev.jun	1	Mean Temp (deg C)	Jun	0.038	FALSE	-0.115	0.188
Mean Temp (deg C).prev.jul	2	Mean Temp (deg C)	Jul	-0.022	FALSE	-0.173	0.163
Mean Temp (deg C).prev.aug	3	Mean Temp (deg C)	Aug	-0.061	FALSE	-0.254	0.144
Mean Temp (deg C).prev.sep	4	Mean Temp (deg C)	Sep	0.035	FALSE	-0.139	0.193
Mean Temp (deg C).prev.oct	5	Mean Temp (deg C)	Oct	-0.106	FALSE	-0.26	0.052
Mean Temp (deg C).prev.nov	6	Mean Temp (deg C)	Nov	-0.121	FALSE	-0.28	0.06
Mean Temp (deg C).prev.dec	7	Mean Temp (deg C)	Dec	-0.083	FALSE	-0.232	0.061
Mean Temp (deg C).curr.jan	8	Mean Temp (deg C)	JAN	-0.003	FALSE	-0.119	0.114
Mean Temp (deg C).curr.feb	9	Mean Temp (deg C)	FEB	0.106	FALSE	-0.048	0.238
Mean Temp (deg C).curr.mar	10	Mean Temp (deg C)	MAR	0.116	FALSE	-0.059	0.292
Mean Temp (deg C).curr.apr	11	Mean Temp (deg C)	APR	-0.133	FALSE	-0.303	0.036
Mean Temp (deg C).curr.may	12	Mean Temp (deg C)	MAY	-0.153	FALSE	-0.325	0.044
Mean Temp (deg C).curr.jun	13	Mean Temp (deg C)	JUN	-0.1	FALSE	-0.268	0.044
Mean Temp (deg C).curr.jul	14	Mean Temp (deg C)	JUL	-0.051	FALSE	-0.178	0.087
Mean Temp (deg C).curr.aug	15	Mean Temp (deg C)	AUG	-0.001	FALSE	-0.152	0.142
Mean Temp (deg C).curr.sep	16	Mean Temp (deg C)	SEP	0.056	FALSE	-0.146	0.236

Maximum Temp (deg C).prev.jun	1	Maximum Temp (deg C)	Jun	0.057	FALSE	-0.101	0.211
Maximum Temp (deg C).prev.jul	2	Maximum Temp (deg C)	Jul	-0.02	FALSE	-0.21	0.185
Maximum Temp (deg C).prev.aug	3	Maximum Temp (deg C)	Aug	-0.081	FALSE	-0.267	0.095
Maximum Temp (deg C).prev.sep	4	Maximum Temp (deg C)	Sep	-0.013	FALSE	-0.158	0.12
Maximum Temp (deg C).prev.oct	5	Maximum Temp (deg C)	Oct	-0.124	FALSE	-0.288	0.016
Maximum Temp (deg C).prev.nov	6	Maximum Temp (deg C)	Nov	-0.119	FALSE	-0.28	0.036
Maximum Temp (deg C).prev.dec	7	Maximum Temp (deg C)	Dec	-0.068	FALSE	-0.242	0.077
Maximum Temp (deg C).curr.jan	8	Maximum Temp (deg C)	JAN	-0.053	FALSE	-0.168	0.069
Maximum Temp (deg C).curr.feb	9	Maximum Temp (deg C)	FEB	0.08	FALSE	-0.054	0.201
Maximum Temp (deg C).curr.mar	10	Maximum Temp (deg C)	MAR	0.107	FALSE	-0.08	0.287
Maximum Temp (deg C).curr.apr	**11**	**Maximum Temp (deg C)**	**APR**	**-0.174**	**TRUE**	**-0.336**	**-0.012**
Maximum Temp (deg C).curr.may	12	Maximum Temp (deg C)	MAY	-0.196	FALSE	-0.366	0.03
Maximum Temp (deg C).curr.jun	13	Maximum Temp (deg C)	JUN	-0.12	FALSE	-0.284	0.037
Maximum Temp (deg C).curr.jul	14	Maximum Temp (deg C)	JUL	-0.101	FALSE	-0.224	0.017
Maximum Temp (deg C).curr.aug	15	Maximum Temp (deg C)	AUG	-0.027	FALSE	-0.189	0.108
Maximum Temp (deg C).curr.sep	16	Maximum Temp (deg C)	SEP	0.04	FALSE	-0.142	0.221

Maximum VPD (hPa).prev.jun	1	Maximum VPD (hPa)	Jun	0.072	FALSE	-0.097	0.234
Maximum VPD (hPa).prev.jul	2	Maximum VPD (hPa)	Jul	-0.004	FALSE	-0.201	0.217
Maximum VPD (hPa).prev.aug	3	Maximum VPD (hPa)	Aug	-0.08	FALSE	-0.284	0.089
Maximum VPD (hPa).prev.sep	4	Maximum VPD (hPa)	Sep	0.012	FALSE	-0.119	0.146
Maximum VPD (hPa).prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.161**	**TRUE**	**-0.331**	**-0.027**
Maximum VPD (hPa).prev.nov	6	Maximum VPD (hPa)	Nov	-0.075	FALSE	-0.245	0.094
Maximum VPD (hPa).prev.dec	7	Maximum VPD (hPa)	Dec	-0.049	FALSE	-0.212	0.122
Maximum VPD (hPa).curr.jan	8	Maximum VPD (hPa)	JAN	-0.111	FALSE	-0.237	0.006
Maximum VPD (hPa).curr.feb	9	Maximum VPD (hPa)	FEB	0.084	FALSE	-0.06	0.231
Maximum VPD (hPa).curr.mar	10	Maximum VPD (hPa)	MAR	0.153	FALSE	-0.052	0.356
Maximum VPD (hPa).curr.apr	11	Maximum VPD (hPa)	APR	-0.143	FALSE	-0.328	0.021
Maximum VPD (hPa).curr.may	12	Maximum VPD (hPa)	MAY	-0.209	FALSE	-0.374	0.031
Maximum VPD (hPa).curr.jun	13	Maximum VPD (hPa)	JUN	-0.134	FALSE	-0.267	0.021
Maximum VPD (hPa).curr.jul	14	Maximum VPD (hPa)	JUL	-0.114	FALSE	-0.248	0.025
Maximum VPD (hPa).curr.aug	15	Maximum VPD (hPa)	AUG	-0.047	FALSE	-0.224	0.107
Maximum VPD (hPa).curr.sep	16	Maximum VPD (hPa)	SEP	0.071	FALSE	-0.113	0.237

Minimum VPD (hPa).prev.jun	1	Minimum VPD (hPa)	Jun	0.079	FALSE	-0.06	0.231
Minimum VPD (hPa).prev.jul	2	Minimum VPD (hPa)	Jul	0.055	FALSE	-0.134	0.271
Minimum VPD (hPa).prev.aug	3	Minimum VPD (hPa)	Aug	-0.091	FALSE	-0.246	0.08
Minimum VPD (hPa).prev.sep	4	Minimum VPD (hPa)	Sep	0.006	FALSE	-0.125	0.151
Minimum VPD (hPa).prev.oct	5	Minimum VPD (hPa)	Oct	-0.069	FALSE	-0.256	0.126
Minimum VPD (hPa).prev.nov	6	Minimum VPD (hPa)	Nov	-0.011	FALSE	-0.17	0.149
Minimum VPD (hPa).prev.dec	7	Minimum VPD (hPa)	Dec	0.044	FALSE	-0.094	0.192
Minimum VPD (hPa).curr.jan	8	Minimum VPD (hPa)	JAN	-0.108	FALSE	-0.295	0.075
Minimum VPD (hPa).curr.feb	9	Minimum VPD (hPa)	FEB	-0.005	FALSE	-0.206	0.18
Minimum VPD (hPa).curr.mar	10	Minimum VPD (hPa)	MAR	0.047	FALSE	-0.157	0.214
Minimum VPD (hPa).curr.apr	**11**	**Minimum VPD (hPa)**	**APR**	**-0.147**	**TRUE**	**-0.291**	**-0.022**
Minimum VPD (hPa).curr.may	12	Minimum VPD (hPa)	MAY	-0.147	FALSE	-0.315	0.048
Minimum VPD (hPa).curr.jun	**13**	**Minimum VPD (hPa)**	**JUN**	**-0.143**	**TRUE**	**-0.275**	**-0.015**
Minimum VPD (hPa).curr.jul	14	Minimum VPD (hPa)	JUL	-0.12	FALSE	-0.255	0.018
Minimum VPD (hPa).curr.aug	15	Minimum VPD (hPa)	AUG	-0.031	FALSE	-0.177	0.11
Minimum VPD (hPa).curr.sep	16	Minimum VPD (hPa)	SEP	-0.016	FALSE	-0.203	0.176

Site 2

	id	varname	month	coeff	significant	ci_lower	ci_upper
precip.prev.jun	1	precip	Jun	-0.082	FALSE	-0.26	0.101
precip.prev.jul	2	precip	Jul	0.083	FALSE	-0.055	0.235
precip.prev.aug	3	precip	Aug	0.084	FALSE	-0.097	0.227
precip.prev.sep	4	precip	Sep	0.065	FALSE	-0.139	0.213
precip.prev.oct	**5**	**precip**	**Oct**	**0.181**	**TRUE**	**0.025**	**0.328**
precip.prev.nov	**6**	**precip**	**Nov**	**0.236**	**TRUE**	**0.107**	**0.345**
precip.prev.dec	7	precip	Dec	0.033	FALSE	-0.106	0.173
precip.curr.jan	8	precip	JAN	0.05	FALSE	-0.135	0.231
precip.curr.feb	9	precip	FEB	0.045	FALSE	-0.076	0.17
precip.curr.mar	10	precip	MAR	-0.068	FALSE	-0.214	0.091
precip.curr.apr	**11**	**precip**	**APR**	**0.152**	**TRUE**	**0.002**	**0.266**
precip.curr.may	**12**	**precip**	**MAY**	**0.294**	**TRUE**	**0.076**	**0.432**
precip.curr.jun	**13**	**precip**	**JUN**	**0.18**	**TRUE**	**0.03**	**0.33**
precip.curr.jul	**14**	**precip**	**JUL**	**0.255**	**TRUE**	**0.068**	**0.425**
precip.curr.aug	15	precip	AUG	0.097	FALSE	-0.094	0.265
precip.curr.sep	16	precip	SEP	-0.013	FALSE	-0.164	0.135
Mean Temp (deg C).prev.jun	1	Mean Temp (deg C)	Jun	0.031	FALSE	-0.123	0.191
Mean Temp (deg C).prev.jul	2	Mean Temp (deg C)	Jul	-0.02	FALSE	-0.182	0.175
Mean Temp (deg C).prev.aug	3	Mean Temp (deg C)	Aug	-0.05	FALSE	-0.253	0.14
Mean Temp (deg C).prev.sep	4	Mean Temp (deg C)	Sep	0.047	FALSE	-0.14	0.226
Mean Temp (deg C).prev.oct	5	Mean Temp (deg C)	Oct	-0.099	FALSE	-0.264	0.047

Mean Temp (deg C).prev.nov	6	Mean Temp (deg C)	Nov	-0.109	FALSE	-0.262	0.048
Mean Temp (deg C).prev.dec	7	Mean Temp (deg C)	Dec	-0.088	FALSE	-0.238	0.063
Mean Temp (deg C).curr.jan	8	Mean Temp (deg C)	JAN	0	FALSE	-0.113	0.114
Mean Temp (deg C).curr.feb	9	Mean Temp (deg C)	FEB	0.111	FALSE	-0.035	0.24
Mean Temp (deg C).curr.mar	10	Mean Temp (deg C)	MAR	0.122	FALSE	-0.063	0.291
Mean Temp (deg C).curr.apr	11	Mean Temp (deg C)	APR	-0.131	FALSE	-0.283	0.04
Mean Temp (deg C).curr.may	12	Mean Temp (deg C)	MAY	-0.146	FALSE	-0.317	0.046
Mean Temp (deg C).curr.jun	13	Mean Temp (deg C)	JUN	-0.106	FALSE	-0.298	0.044
Mean Temp (deg C).curr.jul	14	Mean Temp (deg C)	JUL	-0.039	FALSE	-0.167	0.101
Mean Temp (deg C).curr.aug	15	Mean Temp (deg C)	AUG	0.012	FALSE	-0.133	0.142
Mean Temp (deg C).curr.sep	16	Mean Temp (deg C)	SEP	0.071	FALSE	-0.156	0.259
Maximum Temp (deg C).prev.jun	1	Maximum Temp (deg C)	Jun	0.053	FALSE	-0.099	0.213
Maximum Temp (deg C).prev.jul	2	Maximum Temp (deg C)	Jul	-0.024	FALSE	-0.201	0.178
Maximum Temp (deg C).prev.aug	3	Maximum Temp (deg C)	Aug	-0.079	FALSE	-0.27	0.12
Maximum Temp (deg C).prev.sep	4	Maximum Temp (deg C)	Sep	0.007	FALSE	-0.139	0.149
Maximum Temp (deg C).prev.oct	5	Maximum Temp (deg C)	Oct	-0.129	FALSE	-0.292	0.018

Maximum Temp (deg C).prev.nov	6	Maximum Temp (deg C)	Nov	-0.115	FALSE	-0.286	0.046
Maximum Temp (deg C).prev.dec	7	Maximum Temp (deg C)	Dec	-0.074	FALSE	-0.24	0.08
Maximum Temp (deg C).curr.jan	8	Maximum Temp (deg C)	JAN	-0.048	FALSE	-0.155	0.077
Maximum Temp (deg C).curr.feb	9	Maximum Temp (deg C)	FEB	0.086	FALSE	-0.045	0.204
Maximum Temp (deg C).curr.mar	10	Maximum Temp (deg C)	MAR	0.11	FALSE	-0.07	0.308
Maximum Temp (deg C).curr.apr	11	Maximum Temp (deg C)	APR	-0.168	FALSE	-0.342	-0.002
Maximum Temp (deg C).curr.may	12	Maximum Temp (deg C)	MAY	-0.173	FALSE	-0.354	0.044
Maximum Temp (deg C).curr.jun	13	Maximum Temp (deg C)	JUN	-0.122	FALSE	-0.284	0.033
Maximum Temp (deg C).curr.jul	14	Maximum Temp (deg C)	JUL	-0.094	FALSE	-0.211	0.034
Maximum Temp (deg C).curr.aug	15	Maximum Temp (deg C)	AUG	-0.011	FALSE	-0.162	0.118
Maximum Temp (deg C).curr.sep	16	Maximum Temp (deg C)	SEP	0.048	FALSE	-0.134	0.22
Maximum VPD (hPa).prev.jun	1	Maximum VPD (hPa)	Jun	0.063	FALSE	-0.095	0.212
Maximum VPD (hPa).prev.jul	2	Maximum VPD (hPa)	Jul	0.002	FALSE	-0.183	0.215
Maximum VPD (hPa).prev.aug	3	Maximum VPD (hPa)	Aug	-0.061	FALSE	-0.255	0.092
Maximum VPD (hPa).prev.sep	4	Maximum VPD (hPa)	Sep	0.035	FALSE	-0.112	0.192
Maximum VPD (hPa).prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.151**	**TRUE**	**-0.319**	**-0.018**

Maximum VPD (hPa).prev.nov	6	Maximum VPD (hPa)	Nov	-0.068	FALSE	-0.25	0.102
Maximum VPD (hPa).prev.dec	7	Maximum VPD (hPa)	Dec	-0.039	FALSE	-0.215	0.132
Maximum VPD (hPa).curr.jan	8	Maximum VPD (hPa)	JAN	-0.106	FALSE	-0.231	0.035
Maximum VPD (hPa).curr.feb	9	Maximum VPD (hPa)	FEB	0.092	FALSE	-0.052	0.24
Maximum VPD (hPa).curr.mar	10	Maximum VPD (hPa)	MAR	0.153	FALSE	-0.051	0.368
Maximum VPD (hPa).curr.apr	11	Maximum VPD (hPa)	APR	-0.13	FALSE	-0.311	0.023
Maximum VPD (hPa).curr.may	12	Maximum VPD (hPa)	MAY	-0.201	FALSE	-0.37	0.02
Maximum VPD (hPa).curr.jun	13	Maximum VPD (hPa)	JUN	-0.139	FALSE	-0.291	0.008
Maximum VPD (hPa).curr.jul	14	Maximum VPD (hPa)	JUL	-0.104	FALSE	-0.219	0.028
Maximum VPD (hPa).curr.aug	15	Maximum VPD (hPa)	AUG	-0.018	FALSE	-0.2	0.144
Maximum VPD (hPa).curr.sep	16	Maximum VPD (hPa)	SEP	0.086	FALSE	-0.096	0.268
Minimum VPD (hPa).prev.jun	1	Minimum VPD (hPa)	Jun	0.098	FALSE	-0.065	0.256
Minimum VPD (hPa).prev.jul	2	Minimum VPD (hPa)	Jul	0.054	FALSE	-0.125	0.246
Minimum VPD (hPa).prev.aug	3	Minimum VPD (hPa)	Aug	-0.045	FALSE	-0.201	0.116
Minimum VPD (hPa).prev.sep	4	Minimum VPD (hPa)	Sep	-0.004	FALSE	-0.138	0.153
Minimum VPD (hPa).prev.oct	5	Minimum VPD (hPa)	Oct	-0.086	FALSE	-0.292	0.096

Minimum VPD (hPa).prev.nov	6	Minimum VPD (hPa)	Nov	-0.019	FALSE	-0.163	0.142
Minimum VPD (hPa).prev.dec	7	Minimum VPD (hPa)	Dec	0.004	FALSE	-0.139	0.178
Minimum VPD (hPa).curr.jan	8	Minimum VPD (hPa)	JAN	-0.093	FALSE	-0.271	0.1
Minimum VPD (hPa).curr.feb	9	Minimum VPD (hPa)	FEB	0.012	FALSE	-0.201	0.211
Minimum VPD (hPa).curr.mar	10	Minimum VPD (hPa)	MAR	0.081	FALSE	-0.109	0.259
Minimum VPD (hPa).curr.apr	11	Minimum VPD (hPa)	APR	-0.149	FALSE	-0.305	-0.006
Minimum VPD (hPa).curr.may	12	Minimum VPD (hPa)	MAY	-0.166	FALSE	-0.355	0.038
Minimum VPD (hPa).curr.jun	**13**	**Minimum VPD (hPa)**	**JUN**	**-0.157**	**TRUE**	**-0.298**	**-0.023**
Minimum VPD (hPa).curr.jul	14	Minimum VPD (hPa)	JUL	-0.1	FALSE	-0.237	0.053
Minimum VPD (hPa).curr.aug	15	Minimum VPD (hPa)	AUG	0.026	FALSE	-0.132	0.172
Minimum VPD (hPa).curr.sep	16	Minimum VPD (hPa)	SEP	0.005	FALSE	-0.183	0.178

Site 3

	id	varname	month	coeff	significant	ci_lower	ci_upper
precip.prev.jun	1	precip	Jun	-0.062	FALSE	-0.248	0.117
precip.prev.jul	2	precip	Jul	0.04	FALSE	-0.155	0.219
precip.prev.aug	3	precip	Aug	0.131	FALSE	-0.089	0.295
precip.prev.sep	4	precip	Sep	0.016	FALSE	-0.167	0.19
precip.prev.oct	5	precip	Oct	0.124	FALSE	-0.037	0.284
precip.prev.nov	**6**	**precip**	**Nov**	**0.156**	**TRUE**	**0.028**	**0.288**

precip.prev.dec	7	precip	Dec	0.104	FALSE	-0.037	0.234
precip.curr.jan	8	precip	JAN	0.047	FALSE	-0.157	0.213
precip.curr.feb	9	precip	FEB	0.106	FALSE	-0.03	0.258
precip.curr.mar	10	precip	MAR	-0.061	FALSE	-0.2	0.093
precip.curr.apr	**11**	**precip**	**APR**	**0.189**	**TRUE**	**0.028**	**0.305**
precip.curr.may	**12**	**precip**	**MAY**	**0.288**	**TRUE**	**0.051**	**0.441**
precip.curr.jun	**13**	**precip**	**JUN**	**0.247**	**TRUE**	**0.072**	**0.389**
precip.curr.jul	14	precip	JUL	0.165	FALSE	0.01	0.344
precip.curr.aug	15	precip	AUG	0.037	FALSE	-0.126	0.214
precip.curr.sep	16	precip	SEP	-0.011	FALSE	-0.138	0.119
Mean Temp (deg C).prev.jun	1	Mean Temp (deg C)	Jun	0.025	FALSE	-0.142	0.184
Mean Temp (deg C).prev.jul	2	Mean Temp (deg C)	Jul	-0.033	FALSE	-0.206	0.156
Mean Temp (deg C).prev.aug	3	Mean Temp (deg C)	Aug	-0.077	FALSE	-0.278	0.12
Mean Temp (deg C).prev.sep	4	Mean Temp (deg C)	Sep	0.046	FALSE	-0.129	0.228
Mean Temp (deg C).prev.oct	5	Mean Temp (deg C)	Oct	-0.107	FALSE	-0.258	0.049
Mean Temp (deg C).prev.nov	6	Mean Temp (deg C)	Nov	-0.112	FALSE	-0.272	0.038
Mean Temp (deg C).prev.dec	7	Mean Temp (deg C)	Dec	-0.089	FALSE	-0.238	0.054
Mean Temp (deg C).curr.jan	8	Mean Temp (deg C)	JAN	0.01	FALSE	-0.103	0.14
Mean Temp (deg C).curr.feb	9	Mean Temp (deg C)	FEB	0.113	FALSE	-0.029	0.24
Mean Temp (deg C).curr.mar	10	Mean Temp (deg C)	MAR	0.111	FALSE	-0.084	0.292

Mean Temp (deg C).curr.apr	11	Mean Temp (deg C)	APR	-0.143	FALSE	-0.306	0.025
Mean Temp (deg C).curr.may	12	Mean Temp (deg C)	MAY	-0.124	FALSE	-0.295	0.083
Mean Temp (deg C).curr.jun	13	Mean Temp (deg C)	JUN	-0.115	FALSE	-0.3	0.036
Mean Temp (deg C).curr.jul	14	Mean Temp (deg C)	JUL	-0.043	FALSE	-0.161	0.07
Mean Temp (deg C).curr.aug	15	Mean Temp (deg C)	AUG	0.005	FALSE	-0.135	0.15
Mean Temp (deg C).curr.sep	16	Mean Temp (deg C)	SEP	0.052	FALSE	-0.158	0.243
Maximum Temp (deg C).prev.jun	1	Maximum Temp (deg C)	Jun	0.057	FALSE	-0.097	0.213
Maximum Temp (deg C).prev.jul	2	Maximum Temp (deg C)	Jul	-0.032	FALSE	-0.224	0.178
Maximum Temp (deg C).prev.aug	3	Maximum Temp (deg C)	Aug	-0.095	FALSE	-0.277	0.094
Maximum Temp (deg C).prev.sep	4	Maximum Temp (deg C)	Sep	0.011	FALSE	-0.133	0.151
Maximum Temp (deg C).prev.oct	5	Maximum Temp (deg C)	Oct	-0.134	FALSE	-0.276	-0.001
Maximum Temp (deg C).prev.nov	6	Maximum Temp (deg C)	Nov	-0.113	FALSE	-0.273	0.053
Maximum Temp (deg C).prev.dec	7	Maximum Temp (deg C)	Dec	-0.062	FALSE	-0.222	0.09
Maximum Temp (deg C).curr.jan	8	Maximum Temp (deg C)	JAN	-0.035	FALSE	-0.149	0.092
Maximum Temp (deg C).curr.feb	9	Maximum Temp (deg C)	FEB	0.085	FALSE	-0.053	0.222
Maximum Temp (deg C).curr.mar	10	Maximum Temp (deg C)	MAR	0.127	FALSE	-0.091	0.315

Maximum Temp (deg C).curr.apr	**11**	**Maximum Temp (deg C)**	**APR**	**-0.166**	**TRUE**	**-0.322**	**-0.007**
Maximum Temp (deg C).curr.may	12	Maximum Temp (deg C)	MAY	-0.163	FALSE	-0.339	0.066
Maximum Temp (deg C).curr.jun	13	Maximum Temp (deg C)	JUN	-0.12	FALSE	-0.286	0.03
Maximum Temp (deg C).curr.jul	14	Maximum Temp (deg C)	JUL	-0.091	FALSE	-0.195	0.041
Maximum Temp (deg C).curr.aug	15	Maximum Temp (deg C)	AUG	-0.009	FALSE	-0.158	0.119
Maximum Temp (deg C).curr.sep	16	Maximum Temp (deg C)	SEP	0.034	FALSE	-0.163	0.217
Maximum VPD (hPa).prev.jun	1	Maximum VPD (hPa)	Jun	0.058	FALSE	-0.091	0.208
Maximum VPD (hPa).prev.jul	2	Maximum VPD (hPa)	Jul	-0.017	FALSE	-0.212	0.195
Maximum VPD (hPa).prev.aug	3	Maximum VPD (hPa)	Aug	-0.098	FALSE	-0.266	0.059
Maximum VPD (hPa).prev.sep	4	Maximum VPD (hPa)	Sep	0.047	FALSE	-0.085	0.175
Maximum VPD (hPa).prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.177**	**TRUE**	**-0.335**	**-0.025**
Maximum VPD (hPa).prev.nov	6	Maximum VPD (hPa)	Nov	-0.071	FALSE	-0.251	0.104
Maximum VPD (hPa).prev.dec	7	Maximum VPD (hPa)	Dec	-0.02	FALSE	-0.212	0.155
Maximum VPD (hPa).curr.jan	8	Maximum VPD (hPa)	JAN	-0.076	FALSE	-0.218	0.067
Maximum VPD (hPa).curr.feb	9	Maximum VPD (hPa)	FEB	0.078	FALSE	-0.074	0.236
Maximum VPD (hPa).curr.mar	10	Maximum VPD (hPa)	MAR	0.173	FALSE	-0.055	0.391

Maximum VPD (hPa).curr.apr	11	Maximum VPD (hPa)	APR	-0.15	FALSE	-0.31	0.02
Maximum VPD (hPa).curr.may	12	Maximum VPD (hPa)	MAY	-0.186	FALSE	-0.365	0.061
Maximum VPD (hPa).curr.jun	13	Maximum VPD (hPa)	JUN	-0.142	FALSE	-0.282	0.019
Maximum VPD (hPa).curr.jul	14	Maximum VPD (hPa)	JUL	-0.105	FALSE	-0.231	0.02
Maximum VPD (hPa).curr.aug	15	Maximum VPD (hPa)	AUG	-0.023	FALSE	-0.189	0.126
Maximum VPD (hPa).curr.sep	16	Maximum VPD (hPa)	SEP	0.062	FALSE	-0.118	0.261
Minimum VPD (hPa).prev.jun	1	Minimum VPD (hPa)	Jun	0.06	FALSE	-0.086	0.206
Minimum VPD (hPa).prev.jul	2	Minimum VPD (hPa)	Jul	0.011	FALSE	-0.175	0.199
Minimum VPD (hPa).prev.aug	3	Minimum VPD (hPa)	Aug	-0.102	FALSE	-0.238	0.042
Minimum VPD (hPa).prev.sep	4	Minimum VPD (hPa)	Sep	0.026	FALSE	-0.103	0.175
Minimum VPD (hPa).prev.oct	5	Minimum VPD (hPa)	Oct	-0.122	FALSE	-0.29	0.019
Minimum VPD (hPa).prev.nov	6	Minimum VPD (hPa)	Nov	-0.104	FALSE	-0.244	0.048
Minimum VPD (hPa).prev.dec	7	Minimum VPD (hPa)	Dec	-0.073	FALSE	-0.232	0.091
Minimum VPD (hPa).curr.jan	8	Minimum VPD (hPa)	JAN	-0.065	FALSE	-0.195	0.088
Minimum VPD (hPa).curr.feb	9	Minimum VPD (hPa)	FEB	-0.01	FALSE	-0.194	0.163
Minimum VPD (hPa).curr.mar	10	Minimum VPD (hPa)	MAR	0.1	FALSE	-0.086	0.266

Minimum VPD (hPa).curr.apr	**11**	**Minimum VPD (hPa)**	**APR**	**-0.18**	**TRUE**	**-0.312**	**-0.056**
Minimum VPD (hPa).curr.may	12	Minimum VPD (hPa)	MAY	-0.107	FALSE	-0.265	0.078
Minimum VPD (hPa).curr.jun	**13**	**Minimum VPD (hPa)**	**JUN**	**-0.184**	**TRUE**	**-0.297**	**-0.043**
Minimum VPD (hPa).curr.jul	14	Minimum VPD (hPa)	JUL	-0.116	FALSE	-0.247	0.029
Minimum VPD (hPa).curr.aug	15	Minimum VPD (hPa)	AUG	0.003	FALSE	-0.147	0.138
Minimum VPD (hPa).curr.sep	16	Minimum VPD (hPa)	SEP	-0.024	FALSE	-0.168	0.124

Site 4

	id	varname	month	coeff	significant	ci_lower	ci_upper
precip.prev.jun	1	precip	Jun	-0.04	FALSE	-0.231	0.143
precip.prev.jul	2	precip	Jul	0.059	FALSE	-0.131	0.231
precip.prev.aug	3	precip	Aug	0.118	FALSE	-0.105	0.29
precip.prev.sep	4	precip	Sep	0.022	FALSE	-0.16	0.184
precip.prev.oct	5	precip	Oct	0.111	FALSE	-0.052	0.281
precip.prev.nov	**6**	**precip**	**Nov**	**0.15**	**TRUE**	**0.023**	**0.281**
precip.prev.dec	7	precip	Dec	0.109	FALSE	-0.034	0.236
precip.curr.jan	8	precip	JAN	0.045	FALSE	-0.142	0.201
precip.curr.feb	9	precip	FEB	0.097	FALSE	-0.035	0.27
precip.curr.mar	10	precip	MAR	-0.055	FALSE	-0.2	0.086
precip.curr.apr	**11**	**precip**	**APR**	**0.18**	**TRUE**	**0.019**	**0.289**
precip.curr.may	**12**	**precip**	**MAY**	**0.288**	**TRUE**	**0.066**	**0.436**
precip.curr.jun	**13**	**precip**	**JUN**	**0.245**	**TRUE**	**0.065**	**0.375**
precip.curr.jul	14	precip	JUL	0.156	FALSE	0.002	0.327
precip.curr.aug	15	precip	AUG	0.025	FALSE	-0.154	0.211

precip.curr.sep	16	precip	SEP	-0.015	FALSE	-0.151	0.11
Mean Temp (deg C).prev.jun	1	Mean Temp (deg C)	Jun	0.022	FALSE	-0.131	0.179
Mean Temp (deg C).prev.jul	2	Mean Temp (deg C)	Jul	-0.032	FALSE	-0.21	0.177
Mean Temp (deg C).prev.aug	3	Mean Temp (deg C)	Aug	-0.077	FALSE	-0.278	0.105
Mean Temp (deg C).prev.sep	4	Mean Temp (deg C)	Sep	0.051	FALSE	-0.126	0.223
Mean Temp (deg C).prev.oct	5	Mean Temp (deg C)	Oct	-0.107	FALSE	-0.255	0.039
Mean Temp (deg C).prev.nov	6	Mean Temp (deg C)	Nov	-0.118	FALSE	-0.27	0.04
Mean Temp (deg C).prev.dec	7	Mean Temp (deg C)	Dec	-0.087	FALSE	-0.235	0.066
Mean Temp (deg C).curr.jan	8	Mean Temp (deg C)	JAN	0.016	FALSE	-0.11	0.132
Mean Temp (deg C).curr.feb	9	Mean Temp (deg C)	FEB	0.113	FALSE	-0.044	0.253
Mean Temp (deg C).curr.mar	10	Mean Temp (deg C)	MAR	0.108	FALSE	-0.082	0.291
Mean Temp (deg C).curr.apr	11	Mean Temp (deg C)	APR	-0.149	FALSE	-0.303	0.032
Mean Temp (deg C).curr.may	12	Mean Temp (deg C)	MAY	-0.124	FALSE	-0.305	0.082
Mean Temp (deg C).curr.jun	13	Mean Temp (deg C)	JUN	-0.105	FALSE	-0.308	0.048
Mean Temp (deg C).curr.jul	14	Mean Temp (deg C)	JUL	-0.049	FALSE	-0.159	0.072
Mean Temp (deg C).curr.aug	15	Mean Temp (deg C)	AUG	0.007	FALSE	-0.12	0.151

Mean Temp (deg C).curr.sep	16	Mean Temp (deg C)	SEP	0.053	FALSE	-0.156	0.234
Maximum Temp (deg C).prev.jun	1	Maximum Temp (deg C)	Jun	0.058	FALSE	-0.108	0.211
Maximum Temp (deg C).prev.jul	2	Maximum Temp (deg C)	Jul	-0.022	FALSE	-0.227	0.167
Maximum Temp (deg C).prev.aug	3	Maximum Temp (deg C)	Aug	-0.102	FALSE	-0.304	0.072
Maximum Temp (deg C).prev.sep	4	Maximum Temp (deg C)	Sep	0.008	FALSE	-0.137	0.151
Maximum Temp (deg C).prev.oct	5	Maximum Temp (deg C)	Oct	-0.136	FALSE	-0.281	-0.002
Maximum Temp (deg C).prev.nov	6	Maximum Temp (deg C)	Nov	-0.109	FALSE	-0.277	0.042
Maximum Temp (deg C).prev.dec	7	Maximum Temp (deg C)	Dec	-0.064	FALSE	-0.238	0.084
Maximum Temp (deg C).curr.jan	8	Maximum Temp (deg C)	JAN	-0.031	FALSE	-0.152	0.08
Maximum Temp (deg C).curr.feb	9	Maximum Temp (deg C)	FEB	0.082	FALSE	-0.069	0.216
Maximum Temp (deg C).curr.mar	10	Maximum Temp (deg C)	MAR	0.109	FALSE	-0.084	0.323
Maximum Temp (deg C).curr.apr	11	Maximum Temp (deg C)	APR	-0.171	FALSE	-0.322	0.001
Maximum Temp (deg C).curr.may	12	Maximum Temp (deg C)	MAY	-0.156	FALSE	-0.338	0.064
Maximum Temp (deg C).curr.jun	13	Maximum Temp (deg C)	JUN	-0.111	FALSE	-0.28	0.028
Maximum Temp (deg C).curr.jul	14	Maximum Temp (deg C)	JUL	-0.09	FALSE	-0.201	0.031
Maximum Temp (deg C).curr.aug	15	Maximum Temp (deg C)	AUG	-0.016	FALSE	-0.154	0.101

Maximum Temp (deg C).curr.sep	16	Maximum Temp (deg C)	SEP	0.029	FALSE	-0.173	0.204
Maximum VPD (hPa).prev.jun	1	Maximum VPD (hPa)	Jun	0.048	FALSE	-0.106	0.209
Maximum VPD (hPa).prev.jul	2	Maximum VPD (hPa)	Jul	-0.016	FALSE	-0.199	0.203
Maximum VPD (hPa).prev.aug	3	Maximum VPD (hPa)	Aug	-0.105	FALSE	-0.277	0.058
Maximum VPD (hPa).prev.sep	4	Maximum VPD (hPa)	Sep	0.044	FALSE	-0.097	0.18
Maximum VPD (hPa).prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.176**	**TRUE**	**-0.336**	**-0.03**
Maximum VPD (hPa).prev.nov	6	Maximum VPD (hPa)	Nov	-0.073	FALSE	-0.23	0.106
Maximum VPD (hPa).prev.dec	7	Maximum VPD (hPa)	Dec	-0.016	FALSE	-0.192	0.145
Maximum VPD (hPa).curr.jan	8	Maximum VPD (hPa)	JAN	-0.08	FALSE	-0.218	0.049
Maximum VPD (hPa).curr.feb	9	Maximum VPD (hPa)	FEB	0.072	FALSE	-0.083	0.239
Maximum VPD (hPa).curr.mar	10	Maximum VPD (hPa)	MAR	0.176	FALSE	-0.061	0.395
Maximum VPD (hPa).curr.apr	11	Maximum VPD (hPa)	APR	-0.157	FALSE	-0.327	0.033
Maximum VPD (hPa).curr.may	12	Maximum VPD (hPa)	MAY	-0.18	FALSE	-0.353	0.046
Maximum VPD (hPa).curr.jun	13	Maximum VPD (hPa)	JUN	-0.136	FALSE	-0.275	0.011
Maximum VPD (hPa).curr.jul	14	Maximum VPD (hPa)	JUL	-0.101	FALSE	-0.235	0.031
Maximum VPD (hPa).curr.aug	15	Maximum VPD (hPa)	AUG	-0.035	FALSE	-0.193	0.13

Maximum VPD (hPa).curr.sep	16	Maximum VPD (hPa)	SEP	0.06	FALSE	-0.135	0.239
Minimum VPD (hPa).prev.jun	1	Minimum VPD (hPa)	Jun	0.057	FALSE	-0.086	0.211
Minimum VPD (hPa).prev.jul	2	Minimum VPD (hPa)	Jul	0.009	FALSE	-0.191	0.207
Minimum VPD (hPa).prev.aug	3	Minimum VPD (hPa)	Aug	-0.099	FALSE	-0.245	0.038
Minimum VPD (hPa).prev.sep	4	Minimum VPD (hPa)	Sep	0.027	FALSE	-0.104	0.182
Minimum VPD (hPa).prev.oct	5	Minimum VPD (hPa)	Oct	-0.129	FALSE	-0.28	0.008
Minimum VPD (hPa).prev.nov	6	Minimum VPD (hPa)	Nov	-0.104	FALSE	-0.232	0.046
Minimum VPD (hPa).prev.dec	7	Minimum VPD (hPa)	Dec	-0.08	FALSE	-0.237	0.077
Minimum VPD (hPa).curr.jan	8	Minimum VPD (hPa)	JAN	-0.055	FALSE	-0.185	0.075
Minimum VPD (hPa).curr.feb	9	Minimum VPD (hPa)	FEB	0.001	FALSE	-0.182	0.174
Minimum VPD (hPa).curr.mar	10	Minimum VPD (hPa)	MAR	0.107	FALSE	-0.085	0.278
Minimum VPD (hPa).curr.apr	**11**	**Minimum VPD (hPa)**	**APR**	**-0.174**	**TRUE**	**-0.306**	**-0.049**
Minimum VPD (hPa).curr.may	12	Minimum VPD (hPa)	MAY	-0.105	FALSE	-0.271	0.073
Minimum VPD (hPa).curr.jun	**13**	**Minimum VPD (hPa)**	**JUN**	**-0.186**	**TRUE**	**-0.302**	**-0.05**
Minimum VPD (hPa).curr.jul	14	Minimum VPD (hPa)	JUL	-0.116	FALSE	-0.248	0.033
Minimum VPD (hPa).curr.aug	15	Minimum VPD (hPa)	AUG	0.006	FALSE	-0.15	0.147

Minimum VPD (hPa).curr.sep	16	Minimum VPD (hPa)	SEP	-0.021	FALSE	-0.177	0.122

Site 5

	id	varname	month	coeff	significant	ci_lower	ci_upper
precip.prev.jun	1	precip	Jun	0.02	FALSE	-0.173	0.167
precip.prev.jul	2	precip	Jul	0.063	FALSE	-0.111	0.219
precip.prev.aug	3	precip	Aug	0.056	FALSE	-0.121	0.218
precip.prev.sep	4	precip	Sep	0.064	FALSE	-0.142	0.225
precip.prev.oct	5	precip	Oct	0.113	FALSE	-0.023	0.261
precip.prev.nov	**6**	**precip**	**Nov**	**0.131**	**TRUE**	**0.019**	**0.252**
precip.prev.dec	7	precip	Dec	0.109	FALSE	-0.03	0.235
precip.curr.jan	8	precip	JAN	-0.081	FALSE	-0.26	0.097
precip.curr.feb	9	precip	FEB	0.079	FALSE	-0.074	0.228
precip.curr.mar	10	precip	MAR	-0.085	FALSE	-0.206	0.066
precip.curr.apr	**11**	**precip**	**APR**	**0.204**	**TRUE**	**0.038**	**0.335**
precip.curr.may	**12**	**precip**	**MAY**	**0.248**	**TRUE**	**0.013**	**0.439**
precip.curr.jun	**13**	**precip**	**JUN**	**0.214**	**TRUE**	**0.039**	**0.365**
precip.curr.jul	**14**	**precip**	**JUL**	**0.171**	**TRUE**	**0.025**	**0.31**
precip.curr.aug	15	precip	AUG	0.017	FALSE	-0.172	0.196
precip.curr.sep	16	precip	SEP	-0.007	FALSE	-0.133	0.138
Mean Temp (deg C).prev.jun	1	Mean Temp (deg C)	Jun	0.013	FALSE	-0.16	0.164
Mean Temp (deg C).prev.jul	2	Mean Temp (deg C)	Jul	-0.05	FALSE	-0.205	0.153
Mean Temp (deg C).prev.aug	3	Mean Temp (deg C)	Aug	-0.129	FALSE	-0.32	0.055

Mean Temp (deg C).prev.sep	4	Mean Temp (deg C)	Sep	0.028	FALSE	-0.138	0.185
Mean Temp (deg C).prev.oct	5	Mean Temp (deg C)	Oct	-0.119	FALSE	-0.265	0.027
Mean Temp (deg C).prev.nov	6	Mean Temp (deg C)	Nov	-0.145	FALSE	-0.3	0.019
Mean Temp (deg C).prev.dec	7	Mean Temp (deg C)	Dec	-0.093	FALSE	-0.251	0.045
Mean Temp (deg C).curr.jan	8	Mean Temp (deg C)	JAN	0	FALSE	-0.119	0.128
Mean Temp (deg C).curr.feb	9	Mean Temp (deg C)	FEB	0.079	FALSE	-0.074	0.231
Mean Temp (deg C).curr.mar	10	Mean Temp (deg C)	MAR	0.078	FALSE	-0.103	0.279
Mean Temp (deg C).curr.apr	11	Mean Temp (deg C)	APR	-0.152	FALSE	-0.292	0.004
Mean Temp (deg C).curr.may	12	Mean Temp (deg C)	MAY	-0.107	FALSE	-0.283	0.091
Mean Temp (deg C).curr.jun	13	Mean Temp (deg C)	JUN	-0.099	FALSE	-0.299	0.063
Mean Temp (deg C).curr.jul	14	Mean Temp (deg C)	JUL	-0.048	FALSE	-0.15	0.082
Mean Temp (deg C).curr.aug	15	Mean Temp (deg C)	AUG	-0.012	FALSE	-0.157	0.134
Mean Temp (deg C).curr.sep	16	Mean Temp (deg C)	SEP	0.027	FALSE	-0.18	0.204
Maximum Temp (deg C).prev.jun	1	Maximum Temp (deg C)	Jun	0.03	FALSE	-0.108	0.195
Maximum Temp (deg C).prev.jul	2	Maximum Temp (deg C)	Jul	-0.04	FALSE	-0.217	0.137
Maximum Temp (deg C).prev.aug	3	Maximum Temp (deg C)	Aug	-0.139	FALSE	-0.299	0.033

Maximum Temp (deg C).prev.sep	4	Maximum Temp (deg C)	Sep	-0.013	FALSE	-0.142	0.121
Maximum Temp (deg C).prev.oct	**5**	**Maximum Temp (deg C)**	**Oct**	**-0.14**	**TRUE**	**-0.275**	**-0.001**
Maximum Temp (deg C).prev.nov	6	Maximum Temp (deg C)	Nov	-0.146	FALSE	-0.296	0.006
Maximum Temp (deg C).prev.dec	7	Maximum Temp (deg C)	Dec	-0.058	FALSE	-0.2	0.098
Maximum Temp (deg C).curr.jan	8	Maximum Temp (deg C)	JAN	-0.038	FALSE	-0.141	0.071
Maximum Temp (deg C).curr.feb	9	Maximum Temp (deg C)	FEB	0.077	FALSE	-0.079	0.203
Maximum Temp (deg C).curr.mar	10	Maximum Temp (deg C)	MAR	0.088	FALSE	-0.088	0.273
Maximum Temp (deg C).curr.apr	**11**	**Maximum Temp (deg C)**	**APR**	**-0.17**	**TRUE**	**-0.305**	**-0.024**
Maximum Temp (deg C).curr.may	12	Maximum Temp (deg C)	MAY	-0.139	FALSE	-0.321	0.057
Maximum Temp (deg C).curr.jun	13	Maximum Temp (deg C)	JUN	-0.103	FALSE	-0.272	0.04
Maximum Temp (deg C).curr.jul	14	Maximum Temp (deg C)	JUL	-0.094	FALSE	-0.202	0.015
Maximum Temp (deg C).curr.aug	15	Maximum Temp (deg C)	AUG	-0.032	FALSE	-0.156	0.081
Maximum Temp (deg C).curr.sep	16	Maximum Temp (deg C)	SEP	-0.002	FALSE	-0.191	0.176
Maximum VPD (hPa).prev.jun	1	Maximum VPD (hPa)	Jun	0.042	FALSE	-0.096	0.19
Maximum VPD (hPa).prev.jul	2	Maximum VPD (hPa)	Jul	-0.036	FALSE	-0.195	0.161
Maximum VPD (hPa).prev.aug	3	Maximum VPD (hPa)	Aug	-0.171	FALSE	-0.336	0.007

Maximum VPD (hPa).prev.sep	4	Maximum VPD (hPa)	Sep	0.013	FALSE	-0.11	0.136
Maximum VPD (hPa).prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.181**	**TRUE**	**-0.341**	**-0.046**
Maximum VPD (hPa).prev.nov	6	Maximum VPD (hPa)	Nov	-0.113	FALSE	-0.256	0.031
Maximum VPD (hPa).prev.dec	7	Maximum VPD (hPa)	Dec	-0.021	FALSE	-0.191	0.154
Maximum VPD (hPa).curr.jan	8	Maximum VPD (hPa)	JAN	-0.084	FALSE	-0.216	0.049
Maximum VPD (hPa).curr.feb	9	Maximum VPD (hPa)	FEB	0.048	FALSE	-0.105	0.198
Maximum VPD (hPa).curr.mar	10	Maximum VPD (hPa)	MAR	0.143	FALSE	-0.09	0.346
Maximum VPD (hPa).curr.apr	11	Maximum VPD (hPa)	APR	-0.155	FALSE	-0.297	0.002
Maximum VPD (hPa).curr.may	12	Maximum VPD (hPa)	MAY	-0.136	FALSE	-0.311	0.066
Maximum VPD (hPa).curr.jun	**13**	**Maximum VPD (hPa)**	**JUN**	**-0.138**	**TRUE**	**-0.264**	**-0.01**
Maximum VPD (hPa).curr.jul	14	Maximum VPD (hPa)	JUL	-0.109	FALSE	-0.237	0
Maximum VPD (hPa).curr.aug	15	Maximum VPD (hPa)	AUG	-0.065	FALSE	-0.229	0.068
Maximum VPD (hPa).curr.sep	16	Maximum VPD (hPa)	SEP	0.012	FALSE	-0.154	0.156
Minimum VPD (hPa).prev.jun	1	Minimum VPD (hPa)	Jun	0.035	FALSE	-0.12	0.195
Minimum VPD (hPa).prev.jul	2	Minimum VPD (hPa)	Jul	-0.012	FALSE	-0.205	0.164
Minimum VPD (hPa).prev.aug	3	Minimum VPD (hPa)	Aug	-0.071	FALSE	-0.215	0.063

Minimum VPD (hPa).prev.sep	4	Minimum VPD (hPa)	Sep	0.052	FALSE	-0.084	0.196
Minimum VPD (hPa).prev.oct	**5**	**Minimum VPD (hPa)**	**Oct**	**-0.145**	**TRUE**	**-0.299**	**-0.012**
Minimum VPD (hPa).prev.nov	6	Minimum VPD (hPa)	Nov	-0.115	FALSE	-0.236	0.027
Minimum VPD (hPa).prev.dec	7	Minimum VPD (hPa)	Dec	-0.07	FALSE	-0.23	0.102
Minimum VPD (hPa).curr.jan	8	Minimum VPD (hPa)	JAN	-0.031	FALSE	-0.169	0.108
Minimum VPD (hPa).curr.feb	9	Minimum VPD (hPa)	FEB	0.008	FALSE	-0.175	0.183
Minimum VPD (hPa).curr.mar	10	Minimum VPD (hPa)	MAR	0.096	FALSE	-0.137	0.252
Minimum VPD (hPa).curr.apr	**11**	**Minimum VPD (hPa)**	**APR**	**-0.157**	**TRUE**	**-0.304**	**-0.027**
Minimum VPD (hPa).curr.may	12	Minimum VPD (hPa)	MAY	-0.088	FALSE	-0.29	0.069
Minimum VPD (hPa).curr.jun	**13**	**Minimum VPD (hPa)**	**JUN**	**-0.188**	**TRUE**	**-0.317**	**-0.035**
Minimum VPD (hPa).curr.jul	14	Minimum VPD (hPa)	JUL	-0.097	FALSE	-0.222	0.041
Minimum VPD (hPa).curr.aug	15	Minimum VPD (hPa)	AUG	0.033	FALSE	-0.1	0.196
Minimum VPD (hPa).curr.sep	16	Minimum VPD (hPa)	SEP	0.007	FALSE	-0.151	0.17

Site 6

	id	varname	month	coeff	significant	ci_lower	ci_upper
precip.prev.jun	1	precip	Jun	-0.031	FALSE	-0.229	0.137

precip.prev.jul	2	precip	Jul	-0.032	FALSE	-0.191	0.129
precip.prev.aug	3	precip	Aug	0.063	FALSE	-0.086	0.235
precip.prev.sep	4	precip	Sep	0.078	FALSE	-0.144	0.271
precip.prev.oct	5	precip	Oct	0.119	FALSE	-0.021	0.289
precip.prev.nov	**6**	**precip**	**Nov**	**0.196**	**TRUE**	**0.013**	**0.335**
precip.prev.dec	7	precip	Dec	0.068	FALSE	-0.096	0.232
precip.curr.jan	8	precip	JAN	-0.086	FALSE	-0.233	0.082
precip.curr.feb	9	precip	FEB	0.124	FALSE	-0.037	0.263
precip.curr.mar	10	precip	MAR	-0.07	FALSE	-0.223	0.087
precip.curr.apr	**11**	**precip**	**APR**	**0.185**	**TRUE**	**0.012**	**0.322**
precip.curr.may	**12**	**precip**	**MAY**	**0.238**	**TRUE**	**0.039**	**0.409**
precip.curr.jun	13	precip	JUN	0.173	FALSE	-0.002	0.343
precip.curr.jul	14	precip	JUL	0.117	FALSE	-0.029	0.274
precip.curr.aug	15	precip	AUG	0.019	FALSE	-0.181	0.211
precip.curr.sep	16	precip	SEP	0.056	FALSE	-0.087	0.214
Mean Temp (deg C).prev.jun	1	Mean Temp (deg C)	Jun	0.022	FALSE	-0.152	0.18
Mean Temp (deg C).prev.jul	2	Mean Temp (deg C)	Jul	-0.039	FALSE	-0.204	0.162
Mean Temp (deg C).prev.aug	3	Mean Temp (deg C)	Aug	-0.098	FALSE	-0.296	0.094
Mean Temp (deg C).prev.sep	4	Mean Temp (deg C)	Sep	0.061	FALSE	-0.094	0.223
Mean Temp (deg C).prev.oct	5	Mean Temp (deg C)	Oct	-0.099	FALSE	-0.244	0.049
Mean Temp (deg C).prev.nov	6	Mean Temp (deg C)	Nov	-0.131	FALSE	-0.292	0.051
Mean Temp (deg C).prev.dec	7	Mean Temp (deg C)	Dec	-0.087	FALSE	-0.224	0.064

Mean Temp (deg C).curr.jan	8	Mean Temp (deg C)	JAN	0.006	FALSE	-0.125	0.131
Mean Temp (deg C).curr.feb	9	Mean Temp (deg C)	FEB	0.095	FALSE	-0.061	0.243
Mean Temp (deg C).curr.mar	10	Mean Temp (deg C)	MAR	0.093	FALSE	-0.099	0.279
Mean Temp (deg C).curr.apr	**11**	**Mean Temp (deg C)**	**APR**	**-0.145**	**TRUE**	**-0.284**	**-0.003**
Mean Temp (deg C).curr.may	12	Mean Temp (deg C)	MAY	-0.107	FALSE	-0.276	0.09
Mean Temp (deg C).curr.jun	13	Mean Temp (deg C)	JUN	-0.091	FALSE	-0.267	0.058
Mean Temp (deg C).curr.jul	14	Mean Temp (deg C)	JUL	-0.047	FALSE	-0.153	0.077
Mean Temp (deg C).curr.aug	15	Mean Temp (deg C)	AUG	-0.016	FALSE	-0.159	0.127
Mean Temp (deg C).curr.sep	16	Mean Temp (deg C)	SEP	0.014	FALSE	-0.179	0.189
Maximum Temp (deg C).prev.jun	1	Maximum Temp (deg C)	Jun	0.066	FALSE	-0.103	0.221
Maximum Temp (deg C).prev.jul	2	Maximum Temp (deg C)	Jul	-0.018	FALSE	-0.196	0.185
Maximum Temp (deg C).prev.aug	3	Maximum Temp (deg C)	Aug	-0.127	FALSE	-0.294	0.042
Maximum Temp (deg C).prev.sep	4	Maximum Temp (deg C)	Sep	0.024	FALSE	-0.117	0.155
Maximum Temp (deg C).prev.oct	**5**	**Maximum Temp (deg C)**	**Oct**	**-0.152**	**TRUE**	**-0.293**	**-0.003**
Maximum Temp (deg C).prev.nov	6	Maximum Temp (deg C)	Nov	-0.122	FALSE	-0.284	0.039
Maximum Temp (deg C).prev.dec	7	Maximum Temp (deg C)	Dec	-0.057	FALSE	-0.212	0.092

Maximum Temp (deg C).curr.jan	8	Maximum Temp (deg C)	JAN	-0.038	FALSE	-0.156	0.082
Maximum Temp (deg C).curr.feb	9	Maximum Temp (deg C)	FEB	0.081	FALSE	-0.082	0.221
Maximum Temp (deg C).curr.mar	10	Maximum Temp (deg C)	MAR	0.127	FALSE	-0.072	0.334
Maximum Temp (deg C).curr.apr	**11**	**Maximum Temp (deg C)**	**APR**	**-0.167**	**TRUE**	**-0.308**	**-0.002**
Maximum Temp (deg C).curr.may	12	Maximum Temp (deg C)	MAY	-0.139	FALSE	-0.333	0.065
Maximum Temp (deg C).curr.jun	13	Maximum Temp (deg C)	JUN	-0.098	FALSE	-0.247	0.059
Maximum Temp (deg C).curr.jul	14	Maximum Temp (deg C)	JUL	-0.095	FALSE	-0.218	0.026
Maximum Temp (deg C).curr.aug	15	Maximum Temp (deg C)	AUG	-0.03	FALSE	-0.161	0.099
Maximum Temp (deg C).curr.sep	16	Maximum Temp (deg C)	SEP	-0.009	FALSE	-0.176	0.187
Maximum VPD (hPa).prev.jun	1	Maximum VPD (hPa)	Jun	0.061	FALSE	-0.086	0.217
Maximum VPD (hPa).prev.jul	2	Maximum VPD (hPa)	Jul	0.015	FALSE	-0.162	0.192
Maximum VPD (hPa).prev.aug	3	Maximum VPD (hPa)	Aug	-0.141	FALSE	-0.299	0.028
Maximum VPD (hPa).prev.sep	4	Maximum VPD (hPa)	Sep	0.05	FALSE	-0.081	0.181
Maximum VPD (hPa).prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.195**	**TRUE**	**-0.352**	**-0.04**
Maximum VPD (hPa).prev.nov	6	Maximum VPD (hPa)	Nov	-0.085	FALSE	-0.251	0.095
Maximum VPD (hPa).prev.dec	7	Maximum VPD (hPa)	Dec	-0.013	FALSE	-0.202	0.148

Maximum VPD (hPa).curr.jan	8	Maximum VPD (hPa)	JAN	-0.081	FALSE	-0.215	0.063
Maximum VPD (hPa).curr.feb	9	Maximum VPD (hPa)	FEB	0.1	FALSE	-0.063	0.246
Maximum VPD (hPa).curr.mar	10	Maximum VPD (hPa)	MAR	0.206	FALSE	-0.035	0.464
Maximum VPD (hPa).curr.apr	11	Maximum VPD (hPa)	APR	-0.13	FALSE	-0.303	0.034
Maximum VPD (hPa).curr.may	12	Maximum VPD (hPa)	MAY	-0.137	FALSE	-0.336	0.054
Maximum VPD (hPa).curr.jun	13	Maximum VPD (hPa)	JUN	-0.116	FALSE	-0.246	0.043
Maximum VPD (hPa).curr.jul	**14**	**Maximum VPD (hPa)**	**JUL**	**-0.139**	**TRUE**	**-0.264**	**-0.01**
Maximum VPD (hPa).curr.aug	15	Maximum VPD (hPa)	AUG	-0.034	FALSE	-0.195	0.101
Maximum VPD (hPa).curr.sep	16	Maximum VPD (hPa)	SEP	0.03	FALSE	-0.137	0.219

Minimum VPD (hPa).prev.jun	1	Minimum VPD (hPa)	Jun	0.076	FALSE	-0.068	0.214
Minimum VPD (hPa).prev.jul	2	Minimum VPD (hPa)	Jul	-0.009	FALSE	-0.196	0.16
Minimum VPD (hPa).prev.aug	3	Minimum VPD (hPa)	Aug	-0.089	FALSE	-0.242	0.055
Minimum VPD (hPa).prev.sep	4	Minimum VPD (hPa)	Sep	0.093	FALSE	-0.078	0.239
Minimum VPD (hPa).prev.oct	5	Minimum VPD (hPa)	Oct	-0.05	FALSE	-0.202	0.092
Minimum VPD (hPa).prev.nov	6	Minimum VPD (hPa)	Nov	-0.115	FALSE	-0.241	0.022
Minimum VPD (hPa).prev.dec	7	Minimum VPD (hPa)	Dec	-0.089	FALSE	-0.258	0.106

Minimum VPD (hPa).curr.jan	8	Minimum VPD (hPa)	JAN	0.019	FALSE	-0.133	0.163
Minimum VPD (hPa).curr.feb	9	Minimum VPD (hPa)	FEB	0.015	FALSE	-0.179	0.201
Minimum VPD (hPa).curr.mar	10	Minimum VPD (hPa)	MAR	0.091	FALSE	-0.11	0.273
Minimum VPD (hPa).curr.apr	11	Minimum VPD (hPa)	APR	-0.1	FALSE	-0.248	0.044
Minimum VPD (hPa).curr.may	12	Minimum VPD (hPa)	MAY	-0.039	FALSE	-0.199	0.114
Minimum VPD (hPa).curr.jun	13	Minimum VPD (hPa)	JUN	-0.137	FALSE	-0.275	0.005
Minimum VPD (hPa).curr.jul	14	Minimum VPD (hPa)	JUL	-0.066	FALSE	-0.183	0.074
Minimum VPD (hPa).curr.aug	15	Minimum VPD (hPa)	AUG	-0.009	FALSE	-0.15	0.154
Minimum VPD (hPa).curr.sep	16	Minimum VPD (hPa)	SEP	0.037	FALSE	-0.114	0.201

Site 7

	id	varname	month	coeff	significant	ci_lower	ci_upper
precip.prev.jun	1	precip	Jun	-0.006	FALSE	-0.206	0.162
precip.prev.jul	2	precip	Jul	0.017	FALSE	-0.165	0.196
precip.prev.aug	3	precip	Aug	0.109	FALSE	-0.144	0.305
precip.prev.sep	4	precip	Sep	-0.022	FALSE	-0.194	0.139
precip.prev.oct	5	precip	Oct	0.12	FALSE	-0.013	0.274
precip.prev.nov	**6**	**precip**	**Nov**	**0.165**	**TRUE**	**0.004**	**0.303**
precip.prev.dec	7	precip	Dec	0.085	FALSE	-0.069	0.235
precip.curr.jan	8	precip	JAN	-0.005	FALSE	-0.185	0.172

precip.curr.feb	9	precip	FEB	0.119	FALSE	-0.05	0.291
precip.curr.mar	10	precip	MAR	-0.1	FALSE	-0.24	0.063
precip.curr.apr	11	precip	APR	0.16	FALSE	-0.004	0.303
precip.curr.may	12	precip	MAY	0.187	FALSE	-0.019	0.351
precip.curr.jun	13	precip	JUN	0.135	FALSE	-0.06	0.286
precip.curr.jul	14	precip	JUL	0.127	FALSE	-0.023	0.319
precip.curr.aug	15	precip	AUG	0.035	FALSE	-0.204	0.251
precip.curr.sep	16	precip	SEP	-0.065	FALSE	-0.188	0.074
Mean Temp (deg C).prev.jun	1	Mean Temp (deg C)	Jun	-0.003	FALSE	-0.146	0.138
Mean Temp (deg C).prev.jul	2	Mean Temp (deg C)	Jul	-0.041	FALSE	-0.216	0.162
Mean Temp (deg C).prev.aug	3	Mean Temp (deg C)	Aug	-0.12	FALSE	-0.292	0.059
Mean Temp (deg C).prev.sep	4	Mean Temp (deg C)	Sep	0.035	FALSE	-0.105	0.171
Mean Temp (deg C).prev.oct	5	Mean Temp (deg C)	Oct	-0.11	FALSE	-0.265	0.045
Mean Temp (deg C).prev.nov	6	Mean Temp (deg C)	Nov	-0.148	FALSE	-0.329	0.008
Mean Temp (deg C).prev.dec	7	Mean Temp (deg C)	Dec	-0.093	FALSE	-0.235	0.057
Mean Temp (deg C).curr.jan	8	Mean Temp (deg C)	JAN	-0.004	FALSE	-0.119	0.114
Mean Temp (deg C).curr.feb	9	Mean Temp (deg C)	FEB	0.079	FALSE	-0.063	0.227
Mean Temp (deg C).curr.mar	10	Mean Temp (deg C)	MAR	0.054	FALSE	-0.138	0.224
Mean Temp (deg C).curr.apr	**11**	**Mean Temp (deg C)**	**APR**	**-0.143**	**TRUE**	**-0.28**	**-0.012**

Mean Temp (deg C).curr.may	12	Mean Temp (deg C)	MAY	-0.109	FALSE	-0.298	0.103
Mean Temp (deg C).curr.jun	13	Mean Temp (deg C)	JUN	-0.1	FALSE	-0.265	0.043
Mean Temp (deg C).curr.jul	14	Mean Temp (deg C)	JUL	-0.036	FALSE	-0.157	0.082
Mean Temp (deg C).curr.aug	15	Mean Temp (deg C)	AUG	-0.022	FALSE	-0.151	0.123
Mean Temp (deg C).curr.sep	16	Mean Temp (deg C)	SEP	-0.014	FALSE	-0.199	0.164
Maximum Temp (deg C).prev.jun	1	Maximum Temp (deg C)	Jun	0.006	FALSE	-0.124	0.142
Maximum Temp (deg C).prev.jul	2	Maximum Temp (deg C)	Jul	-0.031	FALSE	-0.193	0.162
Maximum Temp (deg C).prev.aug	3	Maximum Temp (deg C)	Aug	-0.116	FALSE	-0.288	0.05
Maximum Temp (deg C).prev.sep	4	Maximum Temp (deg C)	Sep	0.008	FALSE	-0.134	0.133
Maximum Temp (deg C).prev.oct	5	Maximum Temp (deg C)	Oct	-0.126	FALSE	-0.283	0.009
Maximum Temp (deg C).prev.nov	6	Maximum Temp (deg C)	Nov	-0.15	FALSE	-0.325	0.001
Maximum Temp (deg C).prev.dec	7	Maximum Temp (deg C)	Dec	-0.059	FALSE	-0.204	0.091
Maximum Temp (deg C).curr.jan	8	Maximum Temp (deg C)	JAN	-0.041	FALSE	-0.148	0.076
Maximum Temp (deg C).curr.feb	9	Maximum Temp (deg C)	FEB	0.069	FALSE	-0.08	0.205
Maximum Temp (deg C).curr.mar	10	Maximum Temp (deg C)	MAR	0.061	FALSE	-0.108	0.217
Maximum Temp (deg C).curr.apr	**11**	**Maximum Temp (deg C)**	**APR**	**-0.168**	**TRUE**	**-0.288**	**-0.042**

Maximum Temp (deg C).curr.may	12	Maximum Temp (deg C)	MAY	-0.146	FALSE	-0.336	0.083
Maximum Temp (deg C).curr.jun	13	Maximum Temp (deg C)	JUN	-0.127	FALSE	-0.269	0.023
Maximum Temp (deg C).curr.jul	14	Maximum Temp (deg C)	JUL	-0.074	FALSE	-0.172	0.024
Maximum Temp (deg C).curr.aug	15	Maximum Temp (deg C)	AUG	-0.021	FALSE	-0.141	0.093
Maximum Temp (deg C).curr.sep	16	Maximum Temp (deg C)	SEP	-0.024	FALSE	-0.2	0.128
Maximum VPD (hPa).prev.jun	1	Maximum VPD (hPa)	Jun	0.01	FALSE	-0.115	0.153
Maximum VPD (hPa).prev.jul	2	Maximum VPD (hPa)	Jul	-0.018	FALSE	-0.151	0.141
Maximum VPD (hPa).prev.aug	3	Maximum VPD (hPa)	Aug	-0.124	FALSE	-0.306	0.058
Maximum VPD (hPa).prev.sep	4	Maximum VPD (hPa)	Sep	-0.023	FALSE	-0.101	0.145
Maximum VPD (hPa).prev.oct	**5**	**Maximum VPD (hPa)**	**Oct**	**-0.164**	**TRUE**	**-0.328**	**-0.024**
Maximum VPD (hPa).prev.nov	6	Maximum VPD (hPa)	Nov	-0.122	FALSE	-0.282	0.024
Maximum VPD (hPa).prev.dec	7	Maximum VPD (hPa)	Dec	-0.014	FALSE	-0.198	0.161
Maximum VPD (hPa).curr.jan	8	Maximum VPD (hPa)	JAN	-0.06	FALSE	-0.18	0.064
Maximum VPD (hPa).curr.feb	9	Maximum VPD (hPa)	FEB	0.047	FALSE	-0.104	0.182
Maximum VPD (hPa).curr.mar	10	Maximum VPD (hPa)	MAR	0.113	FALSE	-0.097	0.325
Maximum VPD (hPa).curr.apr	**11**	**Maximum VPD (hPa)**	**APR**	**-0.156**	**TRUE**	**-0.289**	**-0.021**

Maximum VPD (hPa).curr.may	12	Maximum VPD (hPa)	MAY	-0.142	FALSE	-0.324	0.084
Maximum VPD (hPa).curr.jun	**13**	**Maximum VPD (hPa)**	**JUN**	**-0.134**	**TRUE**	**-0.262**	**-0.001**
Maximum VPD (hPa).curr.jul	14	Maximum VPD (hPa)	JUL	-0.103	FALSE	-0.215	0
Maximum VPD (hPa).curr.aug	15	Maximum VPD (hPa)	AUG	-0.03	FALSE	-0.145	0.086
Maximum VPD (hPa).curr.sep	16	Maximum VPD (hPa)	SEP	-0.017	FALSE	-0.191	0.142

Minimum VPD (hPa).prev.jun	1	Minimum VPD (hPa)	Jun	0.061	FALSE	-0.104	0.227
Minimum VPD (hPa).prev.jul	2	Minimum VPD (hPa)	Jul	0.007	FALSE	-0.164	0.169
Minimum VPD (hPa).prev.aug	3	Minimum VPD (hPa)	Aug	-0.097	FALSE	-0.22	0.032
Minimum VPD (hPa).prev.sep	4	Minimum VPD (hPa)	Sep	0.033	FALSE	-0.117	0.215
Minimum VPD (hPa).prev.oct	5	Minimum VPD (hPa)	Oct	-0.082	FALSE	-0.236	0.044
Minimum VPD (hPa).prev.nov	**6**	**Minimum VPD (hPa)**	**Nov**	**-0.16**	**TRUE**	**-0.283**	**-0.015**
Minimum VPD (hPa).prev.dec	7	Minimum VPD (hPa)	Dec	-0.092	FALSE	-0.261	0.084
Minimum VPD (hPa).curr.jan	8	Minimum VPD (hPa)	JAN	0.012	FALSE	-0.127	0.161
Minimum VPD (hPa).curr.feb	9	Minimum VPD (hPa)	FEB	-0.012	FALSE	-0.189	0.165
Minimum VPD (hPa).curr.mar	10	Minimum VPD (hPa)	MAR	0.037	FALSE	-0.164	0.204
Minimum VPD (hPa).curr.apr	11	Minimum VPD (hPa)	APR	-0.1	FALSE	-0.24	0.063

Minimum VPD (hPa).curr.may	12	Minimum VPD (hPa)	MAY	-0.026	FALSE	-0.197	0.108
Minimum VPD (hPa).curr.jun	13	Minimum VPD (hPa)	JUN	-0.127	FALSE	-0.273	0.024
Minimum VPD (hPa).curr.jul	14	Minimum VPD (hPa)	JUL	-0.051	FALSE	-0.166	0.088
Minimum VPD (hPa).curr.aug	15	Minimum VPD (hPa)	AUG	-0.015	FALSE	-0.156	0.135
Minimum VPD (hPa).curr.sep	16	Minimum VPD (hPa)	SEP	0.016	FALSE	-0.124	0.164

HYDROLOGIC CORRELATIONS

monthly avg flow.prev.jun	1	monthly avg flow	Jun	0.045	FALSE	-0.056	0.178
monthly avg flow.prev.jul	2	monthly avg flow	Jul	0.032	FALSE	-0.107	0.136
monthly avg flow.prev.aug	3	monthly avg flow	Aug	0.098	FALSE	-0.03	0.225
monthly avg flow.prev.sep	4	monthly avg flow	Sep	-0.103	FALSE	-0.26	0.072
monthly avg flow.prev.oct	5	monthly avg flow	Oct	0.083	FALSE	-0.023	0.162
monthly avg flow.prev.nov	6	monthly avg flow	Nov	0.091	FALSE	-0.002	0.172
monthly avg flow.prev.dec	7	monthly avg flow	Dec	0.072	FALSE	-0.005	0.158
monthly avg flow.curr.jan	8	monthly avg flow	JAN	0.013	FALSE	-0.059	0.088
monthly avg flow.curr.feb	9	monthly avg flow	FEB	-0.005	FALSE	-0.12	0.1
monthly avg flow.curr.mar	**10**	**monthly avg flow**	**MAR**	**-0.137**	**TRUE**	**-0.252**	**-0.015**

monthly avg flow.curr.apr	11	monthly avg flow	APR	0.017	FALSE	-0.071	0.105
monthly avg flow.curr.may	12	monthly avg flow	MAY	0.092	FALSE	-0.011	0.234
monthly avg flow.curr.jun	**13**	**monthly avg flow**	**JUN**	**0.245**	**TRUE**	**0.1**	**0.338**
monthly avg flow.curr.jul	**14**	**monthly avg flow**	**JUL**	**0.225**	**TRUE**	**0.109**	**0.377**
monthly avg flow.curr.aug	**15**	**monthly avg flow**	**AUG**	**0.232**	**TRUE**	**0.066**	**0.361**
monthly avg flow.curr.sep	16	monthly avg flow	SEP	0.001	FALSE	-0.11	0.141
monthly max flow.prev.jun	1	monthly max flow	Jun	0.049	FALSE	-0.062	0.175
monthly max flow.prev.jul	2	monthly max flow	Jul	0.082	FALSE	-0.044	0.2
monthly max flow.prev.aug	3	monthly max flow	Aug	0.015	FALSE	-0.114	0.149
monthly max flow.prev.sep	4	monthly max flow	Sep	0.027	FALSE	-0.206	0.139
monthly max flow.prev.oct	5	monthly max flow	Oct	0.068	FALSE	-0.138	0.196
monthly max flow.prev.nov	6	monthly max flow	Nov	0.039	FALSE	-0.065	0.127
monthly max flow.prev.dec	7	monthly max flow	Dec	0.068	FALSE	-0.022	0.154
monthly max flow.curr.jan	8	monthly max flow	JAN	0.155	FALSE	-0.059	0.327
monthly max flow.curr.feb	9	monthly max flow	FEB	-0.007	FALSE	-0.152	0.096
monthly max flow.curr.mar	10	monthly max flow	MAR	-0.082	FALSE	-0.21	0.043

monthly max flow.curr.apr	11	monthly max flow	APR	0.005	FALSE	-0.086	0.121
monthly max flow.curr.may	12	monthly max flow	MAY	0.174	TRUE	0.037	0.287
monthly max flow.curr.jun	13	monthly max flow	JUN	0.24	TRUE	0.114	0.322
monthly max flow.curr.jul	14	monthly max flow	JUL	0.235	TRUE	0.134	0.366
monthly max flow.curr.aug	15	monthly max flow	AUG	0.142	TRUE	0.004	0.284
monthly max flow.curr.sep	16	monthly max flow	SEP	-0.072	FALSE	-0.142	0.039
monthly min flow.prev.jun	1	monthly min flow	Jun	0.06	FALSE	-0.06	0.251
monthly min flow.prev.jul	2	monthly min flow	Jul	0.042	FALSE	-0.044	0.19
monthly min flow.prev.aug	3	monthly min flow	Aug	0.031	FALSE	-0.058	0.112
monthly min flow.prev.sep	4	monthly min flow	Sep	0.003	FALSE	-0.142	0.124
monthly min flow.prev.oct	5	monthly min flow	Oct	0.005	FALSE	-0.129	0.141
monthly min flow.prev.nov	6	monthly min flow	Nov	0.007	FALSE	-0.098	0.094
monthly min flow.prev.dec	7	monthly min flow	Dec	0.05	FALSE	-0.048	0.176
monthly min flow.curr.jan	8	monthly min flow	JAN	0.04	FALSE	-0.082	0.163
monthly min flow.curr.feb	9	monthly min flow	FEB	0.012	FALSE	-0.067	0.112
monthly min flow.curr.mar	10	monthly min flow	MAR	-0.032	FALSE	-0.156	0.089

monthly min flow.curr.apr	11	monthly min flow	APR	-0.009	FALSE	-0.177	0.128
monthly min flow.curr.may	12	monthly min flow	MAY	0.07	FALSE	-0.045	0.203
monthly min flow.curr.jun	13	monthly min flow	JUN	0.186	TRUE	0.059	0.394
monthly min flow.curr.jul	14	monthly min flow	JUL	0.165	TRUE	0.063	0.325
monthly min flow.curr.aug	15	monthly min flow	AUG	0.115	TRUE	0.039	0.205
monthly min flow.curr.sep	16	monthly min flow	SEP	0.089	FALSE	-0.055	0.239

Appendix B. Model descriptions

Table 5: Fourteen models were developed for this study to describe the effect of environmental response variables on Basal Area Index. Tree and Tree by Age were included in all models as fixed effects.

Variables	flow.avg	climate.model	pdsi.model	location.model	flow.clim	flow.pdsi	flow.clim.int	flow.pdsi.int	flow.clim.site	flow.pdsi.site	flow.pdsi.int.site1	flow.pdsi.int.site2	flow.clim.int.site1	flow.clim.int.site2
Random														
tree	x	x	x	x	x	x	x	x	x	x	x	x	x	x
tree*Age	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fixed														
Age	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Age^2	x	x	x	x	x	x	x	x	x	x	x	x	x	x
site		x		x					x	x	x	x	x	x
March flow	x				x	x	x	x	x	x	x	x	x	x
November flow	x				x	x	x	x	x	x	x		x	x
Avg. summer flow	x				x	x	x	x	x	x	x	x	x	x
PDSI in June and July			x			x		x		x	x	x		
November precipitation		x			x				x				x	x
April - July precipitation		x			x		x		x				x	
min. April VPD		x			x		x		x				x	x
min. June VPD		x			x				x				x	x
max. October VPD		x			x		x		x				x	x
PDSI in June and July * Avg. summer flow								x			x	x		

April - July precipitation * Avg. summer flow	x					x	x
Min. Jun VPD * Avg. summer flow	x					x	x
November precipitation * November flow							x

Appendix C. Model Variables – Correlation Matrix

Nov.flw										
0.51	Mar.flw									
0.29	0.31	JJ.PDSI								
0.23	0.38	0.69	smr.flw							
-0.02	0.17	0.22	0.24	Nov.ppt						
0.06	0	0.44	0.41	-0.01	grw.ppt					
0.05	0.04	-0.23	-0.3	-0.02	-0.54	jun.vpd				
0	0	-0.25	-0.33	-0.14	-0.25	0.43	Apr.vpd			
-0.36	-0.14	-0.22	-0.22	0.02	-0.01	0.07	-0.04	Oct.vpd		
0.13	0.08	-0.05	0.05	0	0.01	-0.08	-0.16	-0.06	age	
0.32	0.23	-0.08	0.14	-0.02	0.13	-0.22	-0.38	0	0.41	year

Figure 7: The correlation matrix shows the correlations between all variables that were considered in model development. These included November flows (Nov.flw), March flows (Mar.flw), June and July Palmer Drought Severity Index (JJ.PDSI), summer flows (smr.flw), November precipitataion (Nov.ppt), growing season precipitation (grw.ppt), June Vapor Pressure Deficit (jun.vpd), April Vapor Pressure Deficit (Apr.vpd), October Vapor Pressure Deficit (Oct.vpd), age, and year.