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Long-Term (1900~2008) Climate Trends in the Mid-Atlantic Region, U.S.A.

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ABSTRACT

Long-term (1900-2008) daily climate data collected from the NOAA National Climatic Data Center's U.S. Historical Climate Network were analyzed to detect long-term air temperature and precipitation trends in the Mid-Atlantic Region (MAR). Trend tests found no homogeneous regional temperature trend, but an increasing trend in the coastal sub-region (+0.011 C°/yr in annual mean temperature) and a decreasing trend in the inland sub-region (-0.005 C°/yr in annual mean temperature) were observed. Total precipitation increased in the whole region, but more precipitation in the coastal sub-region (+0.084 cm/yr in total annual precipitation) than that in the inland sub-region (+0.025 cm/yr in total annual precipitation) were observed. The studied stations were further divided into three elevation groups (low elevation: < 280 m; medium elevation: 280-420 m; and high elevation: > 420 m). The Kruskal-Wallis tests show no significant elevation effects on most temperature-related trends. However, less cool days and higher minimum annual maximum temperature were observed as elevation decreased. And more annual total precipitation and higher precipitation intensity were found as elevation decreased. The observed climate trends may have resulted from the interactive influences of global climate change and possibly regional factors. The current study is one of the first explorations on long-term (i.e., over 100 years) station-based and most recent climate trends in the MAR, which provides useful information for regional climate impacts assessment, mitigation, and adaptation.

INTRODUCTION

Concerns for climate change and human development have attracted global attention towards their potential effects on the environment. The fourth Intergovernmental Panel on Climate Change report suggested a warming of 0.74 C° in global surface temperature over the years of 1906-2005 with an accelerating warming tendency during the latter half of the 21st century (IPCC 2007). Many research efforts have been directed to seeking evidence of climate changes, such as analyzing historical regional data for long-term trends in temperature and precipitation. Alexander *et al.* (2006) reported a significant warming throughout the 20th century with samples from over 70% of the global land area. The report showed a considerable decrease in the annual occurrence of cold nights as well as an increase in the annual occurrence of warm nights. They have also pointed out that the temperature records during the last 100 years showed obvious inconsistencies among different regions and seasons, and suggested that global warming was not uniform (Alexander *et al.* 2006). Most studies showed warming trends throughout the world (ex., Brunetti *et al.* 2004; Hundecha and Bárdossy 2005), nevertheless, cooling trends were also discovered (ex., Lu *et al.* 2005; El Kenawy *et al.* 2009). It was nevertheless hard to predict precipitation trends on a global scale due to large variability in both space and time (IPCC 2007). Increase of water vapor with the warming temperature may lead to an increase of precipitation at the global scale (IPCC 2007). However, analyses from surface stations in different regions showed that, locally or regionally, precipitation may either increase or decrease with the warming, depending on geographic location and season (ex., Gemmer *et al.* 2004).

Many efforts have also been devoted to climate changes in North America. For example, the U.S. Global Change Research Program (USGCRP) recently synthesized climate change and climate-related impacts in different regions of the United States (Karl *et al.* 2009). Portmann *et al.* (2009) stated that changes in climate differ from region to region across the United States. Intense warming trends were found in the lowest daily minimum air temperatures and daily maximum temperature over western and central North America in the months of January-March during the last half of the 20^{th} century (Robeson 2004). However, there was little change in either minimum or maximum air temperature in western and much of eastern North America in other months during the last half of the 20^{th} century (Robeson 2004). Other studies found similar positive trends in the western part of US: minimum temperature was warming at a highly significant rate in all seasons, being greatest in summer and fall ($> +0.25$ C° decade^{-1}) and annual mean temperature was $+0.07 \pm 0.07$ C° decade^{-1} (Christy *et al.* 2006). Precipitation had a more consistent pattern (mainly upwards) across the U.S. (Wang *et al.* 2009). Precipitation intensity in the United States had a statistically significant upward trend with a rate of 3% per decade for the period of 1931-1996, while the annual trend of precipitation in Canada was upward without significance for the period of 1951-1993. Approximately two-thirds of the rainfall amount trends of 2-, 5-, and 10-year return-periods were positive across the United States during 1950-2007 (DeGaetano 2009). Significant positive trends clustered in the Northeast, western Great Lakes, and Pacific Northwest, and slopes were more evident in the period of 1960-2007 than those in 1950-2007 (DeGaetano 2009).

The primary aim of this study was to examine overall long-term (1900-2008) regional trends of air temperature and precipitation in the Mid-Atlantic Region (MAR). The region covers a diverse landscape and landforms and is the home of many elevation-sensitive ecosystems. It is also the home of many head waters of major estuaries in U.S. including Chesapeake Bay, Delaware Bay, and Gulf of Mexico. Specific research questions of the current research include: (1) Are there any long-term homogeneous regional trends of air temperature or precipitation? and (2) Are there any effects of elevation and geographic location on the air temperature or precipitation trend?

2. MATERIALS AND METHODS

2.1 STUDY AREA

The Mid-Atlantic Region (MAR) crosses the states of West Virginia (WV), Virginia (VA), Maryland (MD), Pennsylvania (PA), New Jersey, Delaware, and part of North Carolina and New York which in total covers an area of approximately 200,000 km^2 (Herlihy *et al.* 1998). With diverse landscape and landforms such as Blue Ridge Mountains, Ridge and Valley, Coastal Plain as well as Appalachian Plateau, the MAR is one of the most multiform physical and ecological regions in U.S. The region mostly exhibits humid subtropical climate which covers the southwestern part of WV, VA and MD (McKnight and Darrel 2010). The other part of WV and most of PA falls into the category of humid continental climate (McKnight and Darrel 2000). The two most dominant land-cover types in the MAR are forest and agriculture which cover about 70% and 25% of the whole region, respectively (Rogers and McCarty 2000).

2.2 DATA COLLECTION AND CLASSIFICATION

Station-based climate data were obtained from NOAA National Climatic Data Center's

U.S. Historical Climate Network (HCN). Climate stations with over 100 years' data in the MAR were retrieved. As a result, a total of 25 and 24 stations were retained for detecting regional precipitation and temperature trends, respectively. Detailed information about these stations is summarized in Table 1.

In addition, four coastal and the remaining inland stations were tested as potential coastal and inland sub-regional trends, respectively (Polsky *et al.* 2000). To examine whether the climate trends were elevation-dependent (Giorgi *et al.* 1997), the studied stations were divided into three elevation groups (i.e., low, < 280 m; medium, 280-420 m, and high, > 420 m).

Data-screening steps were conducted before analysis (e.g., Zhai *et al.* 1999), and missing values were handled by following published approaches (e.g., Stooksbury *et al.* 1999; Klein *et al.* 2002). Specifically, (1) flagged values indicated by alphabetic letters or unique numbers such as 999.99 or 99999 were replaced as missing values; (2) percentage of missing values was calculated and only stations with less than 10% missing values were selected for the study; (3) a quick scan of the whole data set for each station was occupied to see if the missing data were randomly distributed; (4) data entirety was computed by counting the months in each year; and (5) an inventory informing which months were missing in a year was developed for decision making in the latter part of the study.

2.3 TEMPERATURE AND PRECIPITATION INDICIES

A total of 12 temperature and 4 precipitation indices were analyzed in this study (Appendix 1). Annual mean, minimum and maximum temperatures were calculated for each station using its daily records. In addition, other temperature indices were calculated by following Choi *et al.* (2009). Rainfall amount exceeding the 95th percentile value of each station was defined as extreme precipitation (Choi *et al.* 2009), and precipitation was calculated by adding up the total amount of rainfall (cm) that exceeded the 95th percentile. The total number of days for the extreme precipitation events per year, consecutive dry days (CDD), and precipitation intensity (cm/day) were also calculated (Choi *et al.* 2009).

2.4 STATISTICAL ANALYSIS

The current data did not follow a normal distribution, then the non-parametric test, Mann-Kendall, was used for trend analysis (Hirsch *et al.* 1982; Kunkel *et al.* 1999; Chen and Lin 2009). In the current trend analysis, time variable was set as year. The magnitude of a slope was estimated by a method described by Sen (1968). Regional trends were calculated using the trends at individual climate stations (Helsel and Frans 2006). The same estimate standard as Mann-Kendall test was used to compute the statistic and p value of the normal approximation for the overall regional Kendall test.

To test homogeneity of a regional trend, the statistic Z_g^2 was used instead of Z_g (Van Belle and Hughes, 1984). Applications of these methods for detecting and synthesizing long-term regional climate or environmental trends were reported elsewhere (Stoddard *et al.*, 1999; Chen and Lin 2009). The Kruskal-Wallis test was used to compare trend differences among groups of different elevations (low, medium, and high) and geographic locations (i.e., inland and coastal).

3. RESULTS

3.1 TEMPERATURE

3.1.1 ANNUAL MEAN, MAXIMUM, AND MINIMUM TEMPERATURE TRENDS

There were 14 of the 25 stations having decreasing annual mean temperature trends ranging from -0.001 to -0.016 C°/yr, and 13 of the 14 stations were located in WV and VA (Fig. 1; Appendix 2). Nine of the 14 station trends were significant and ranged from -0.005 to -0.016 C°/yr (Fig. 1; Appendix 2). There were 10 stations having increasing trends of annual mean temperature ranging from +0.002 to +0.016 C°/yr, and all the five MD stations had significant increasing trends ranging from +0.007 to +0.016 C°/yr (Fig. 1; Appendix 2).

Annual maximum and minimum temperatures exhibited similar trend patterns as the annual mean temperature (Appendices 2-4). There were 16 stations with decreasing trends in annual maximum temperature and nine of them were significant (Appendices 2-3). Trends of annual maximum temperature ranged from -0.001 to -0.023 C°/yr for the 16 stations and from -0.007 to -0.023 C°/yr for the nine significant trend stations (Appendices 2-3). There were nine stations with increasing trends of annual maximum temperature ranging from +0.001 to +0.031 C°/yr, and four of them were in MD (Appendices 2-3). There were 13 stations with decreasing trends in annual minimum temperature, and eight of them were significant (Appendices 2, 4). There were 11 stations with increasing trends in annual minimum temperature, and seven of them were significant (Appendices 2, 4). The trends of T_{RANGE} (difference of annual maximum and minimum temperature) varied among stations (Appendix 2). A total of 13 stations had decreasing trends and 10 stations had increasing trends (Appendix 2). Significant trends were observed at nine of the 13 decreasing trend stations and six of the 10 increasing trend stations, respectively (Appendix 2).

3.1.2 EXTREME TEMPERATURE TRENDS

A total of 17 stations showed decreasing trends of TX90 (warm days), and 11 of them were statistically significant: five in WV ranging from -0.12 to -0.37 d/yr, four in VA ranging from -0.10 to -0.14 d/yr, and two in PA (-0.08 and -0.20 d/yr) (Appendix 5). There were six stations with increasing warm days, and two of them had significant increasing trends both in MD (+0.09 and +0.20 d/yr, respectively) (Appendix 5). There were 14 and seven stations having increasing and decreasing trends of TX10 (cool days), respectively. A total of seven stations had significant trends: four of them were increasing (two in WV: +0.11 and +0.13 d/yr, one in PA: +0.10 d/yr, and one in VA: +0.11 d/yr) and three of them were decreasing (one in PA: -0.10 d/yr and two in MD: -0.20 and -0.28 d/yr).

Trends of TN90 (warm nights) and TN10 (cool nights) also varied from station to station (Appendix 5). There were 13 and nine stations showing decreasing and increasing trends of warm nights, respectively. Five of the seven stations in WV showed decreasing trends, with one of them being statistically significant (-0.091 d/yr). Three stations in VA (-0.111, -0.165, and -0.067 d/yr) and one station in MD (-0.164 d/yr) had significant decreasing trends. Significant increasing trends include: one in WV (+0.098 d/yr) and VA (+0.172 d/yr), two in PA (+0.067 and +0.095 d/yr), and three in MD (+0.273, +0.138, and +0.160 d/yr). There were an equal number (n=11) of stations showing increasing and decreasing trends for cool nights (Appendix 5). Most stations in WV (six out of seven stations, ranging from +0.047 to +0.125 d/yr) and VA (four out of six stations, ranging from +0.012 to +0.130 d/yr) showed increasing trends, and most stations in PA (five out of six stations, ranging from -0.028 to -0.051 d/yr) and MD (all the five stations, ranging from -0.031 to -0.162 d/yr) showed decreasing trends in cool nights (Appendix 5).

A total of 15 stations showed no trend in maximum annual maximum temperature (TXX), six stations showed significant decreasing trends ranging from -0.009 to -0.024 C°/yr, and three stations in MD showed increasing trends ranging from +0.006 to +0.022 C°/yr (Appendix 6). A total of 10 stations showed no trend in maximum annual minimum temperature (TNX), and the remaining 14 stations showed decreasing trends where 11 of them were significant ranging from -0.007 to -0.028 C°/yr (Appendix 6). For minimum annual maximum temperature (TXN), 10 stations showed no trend and one station showed a non-significant decreasing trend. There were 13 stations showing increasing trends where six of them were significant and ranging from +0.021 to +0.044 C°/yr (Appendix 6). There were nine stations showing no trend in minimum annual minimum temperature (TNN). One of eight decreasing trends and one of six increasing trends were significant (Appendix 6).

3.1.3 REGIONAL TEMPERATURE TRENDS AND ELEVATION EFFECTS

The χ^2 homogeneous tests showed significant heterogeneous temperature trends in the studied region except the maximum annual maximum temperature (TXX) (Appendix 7). There were apparently different temperature trends between the inland and coastal sub-regions (Table 2). Most temperature parameters but two (T_{RANGE} and TXN) showed opposite trends between the two sub-regions. Median trend of annual mean temperature is -0.005 and +0.011 C°/yr in the inland and coastal sub-regions, respectively (Table 2). Median trends of annual maximum and minimum temperatures were -0.004 and -0.004 C°/yr in the inland sub-region, and +0.007 and +0.012 C°/yr in the coastal sub-region, respectively (Table 2). Median trends of warm days, cool days, warm nights, and cool nights were -0.100, +0.043, -0.027, and +0.029 d/yr in the inland sub-region, and +0.077, -0.130, +0.055, and -0.109 d/yr in the coastal sub-region, respectively (Table 2). Kruskal-Wallis tests found no significant differences among the three elevation groups in most temperature trends (Appendix 8). Only two temperature parameters had significant differences ($P<0.05$) among the three groups: TX10 (cool days, $K=12.644$, $P<0.01$; Appendix 8) and TXN (minimum annual maximum temperature, $K=7.67$, $P<0.05$; Appendix 8). Cool days (TX 10) increased with elevation (Fig. 2), and minimum annual maximum temperature (TXN) decreased with elevation (Fig. 2).

3.2 PRECIPITATION

3.2.1 PRECIPITATION TRENDS

There were 21 of the 25 stations showing increasing trends in annual wet day precipitation (P95) and nine of the 21 increasing trends were significant (Fig. 3; Appendix 9). Magnitudes of the significant wet day precipitation trends ranged from +0.061 to +0.107 cm/yr (Appendix 9). A total of 15 stations showed no trend in wet days (P95D; Appendix 9). Eight stations showed significant increases in wet days ranging from +0.009 to +0.049 d/yr (Appendix 9). Of 25 stations, 13 showed decreasing trends in consecutive dry days (CDD) ranging from -0.015 to -0.088 d/yr, and seven stations showed increasing trends in CDD ranging from +0.011 to +0.031 d/yr (Appendix 9). There were 15 stations showing decreasing trends in maximum precipitation intensity (PX) ranging from -0.003 to -0.030 cm/d/yr and nine of them were significant (Appendix 9). There were eight stations showing increasing trends in PX ranging from +0.003 to +0.013 cm/d/yr and three of them were significant (Appendix 9).

3.2.2 REGIONAL PRECIPIATION TRENDS AND ELEVATION EFFECTS

The χ^2 homogeneous tests showed significant heterogeneous precipitation trends in the studied region (Appendix 7). Median trends of total precipitation (P95) were consistent in the MAR and promote precipitation increase in the coastal (+0.084 cm/yr) than the inland (+0.025 cm/yr) sub-regions, respectively (Table 2). Median trends of CDD and PX were -0.027 d/yr and -0.005 cm/d/yr in the inland sub-region, and +0.018 d/yr and +0.007 cm/d/yr in the coastal sub-region, respectively (Table 2). Kruskal-Wallis tests indicated significant differences among the three elevation groups in

P95 (K=11.581, P<0.01; Appendix 8) and PX (K=12.956, P<0.01; Appendix 8). Both P95 and PX trends decreased with elevation (Fig. 4).

DISCUSSION

Long-term (1900-2008) temperature and precipitation data were analyzed to detect the MAR regional climate trends in this study. Due to our strict multi-layer data screening (e.g., over 100 years' data, missing values), only 25 stations were retained for final trend analysis, and only four stations were available to represent the coastal sub-region. The station-based trends provided an opportunity to detect climate trends from site to regional scale. Results obtained from the currently limited number of stations representing the whole MAR may need to be explained and applied with caution.

This study found no homogenous regional long-term climate trend in the MAR during 1900-2008. By using the VEMAP (Vegetation/Ecosystem Modeling and Analysis Project) data, Polsky *et al.* (2000) detected a mean increase of +0.5 C° over the period during 1895-1997 in this region. The data source (VEMAP data vs. HCN station data) and analysis period (1895-1997 vs. 1900-2008) may explain some of the differences in the trends between the two studies. In the current study, most stations in the region were experiencing decreased temperature and fewer warm days during the studied time period (Fig. 5). Mean annual temperature trends in the inland sub-region showed a decreasing trend (-0.005 C°/yr) while the coastal sub-region showed an increasing trend (+0.011 C°/yr). These results were consistent with the previous findings in intra-regional temperature variation where the eastern portion (coastal plain) of the study region had more of a warming while the western region (inland mountains) had much less of a warming or even a cooling trend (ex., Polsky *et al.* 2000). A similar discrepancy between the coastal and inland areas was also found in other study areas (ex., El Kenawy *et al.* 2009). During 1900-2008, about 64% of studied stations showed decreased annual maximum temperature trends (Fig. 5). To some extent, this was consistent with the results from Polsky *et al.* (2000) where average number of days per year with maximum temperatures above 32.2 °C decreased from 23 to 16 during 1931-1997 based on data from 13 HCN stations in the MAR.

Compared to the temperature trends, precipitation trends were relatively more consistent and most stations showed increasing total precipitation trends (Fig. 5). This was consistent with the total annual precipitation upward trends found in this region during 1931-1996 based on long-term monitoring climate stations (Kunkel *et al.* 1999). It was also consistent with results reported by Polsky *et al.* (2000) that the VEMAP-based data showed +10% increase of precipitation during 1895-1997 in the MAR. In the current study, the coastal sub-region was experiencing more precipitation and fewer dry days than the inland sub-region (Table 2), which was also consistent with previous studies in this region (ex., Polsky *et al.* 2000). We found 52% of the stations were experiencing less consecutive dry days and 60% of the stations were experiencing less maximum precipitation intensity but no overall regional extreme precipitation trends (Fig. 5). Polsky *et al.* (2000) reported similar results where a linear trend of extreme precipitation was not detected in the MAR based on data at 13 HCN stations during 1931-1997.

The elevation dependence of climate trends in our study was not significant for most temperature parameters (Appendix 8). But significantly less cool days and higher minimum annual maximum temperature were observed as elevation decreased. The difference of temperature trends between the two sub-regions (i.e., warming trends in the coastal sub-region and cooling trends in the inland sub-region) did explain some elevation related effects as coastal stations generally have lower elevations (Table 1). This temperature response to elevation was different from previous studies in other regions. For example, Giorgi *et al.* (1997) suggested that the warming at high elevation sites would be more pronounced than those at low elevation sites. The amplified response at high elevations could be utilized as an early climate change detection tool (Giorgi *et al.* 1997). Similar elevation dependent climate signals were also reported in other regions (e.g., Shrestha *et al.* 1999; Liu *et al.* 2009). However, our study area differed from those in Europe and Asia where higher elevation levels (e.g., more than 1000 m) were examined and snow cover was a very important factor. Similar to our study, the largest warming trends occurred at lower elevations and smallest warming trends occurred in the Rockies in the Pacific Northwest US (Mote 2003). In the current study, elevation did affect precipitation trends which showed more precipitation and higher precipitation intensity as elevation decreased (Fig. 4). Similar to a previous study in this region, the closeness to the Atlantic Ocean may explain the higher precipitation totals in the lower elevations or coastal stations (Polsky *et al.* 2000).

The currently observed trends in temperature and precipitation in the Mid-Atlantic Region may have occurred as a consequence of both global climate change and possible regional factors. These sub-regional climate trends are useful for assessing the climate impacts on water resources and ecological health, and explore strategies to mitigate and adapt the global climate change, especially for the coastal sub-region (Najjar *et al.* 2010).

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Table 1. Climate stations in the Mid-Atlantic Region of the United States examined in this study.

Station ID	Station name	State	Latitude, longitude	Elevation (m)	Data range
460580	Beckley Hospital	WV	-81.20, 37.77	710.2	1896-2008
461220	Buckhannon	WV	-80.22, 38.98	443.5	1892-2008
463544	Glenville	WV	-80.83, 38.93	216.4	1892-2008
465224	Lewisburg	WV	-80.43, 37.80	686.1	1900-2008
466867	Parsons 1 NE	WV	-79.67, 39.10	556.6	1900-2008
467730	Romney	WV	-78.77, 39.33	284.1	1897-2008
468384	Spencer	WV	-81.37, 38.80	287.4	1893-2008
469436	Weston	WV	-80.47, 39.03	311.8	1897-2008
363028	Franklin	PA	-79.83, 41.40	309.4	1897-2008
366233	New Castle 1 N	PA	-80.37, 41.02	251.5	1904-2008
367477	Ridgway	PA	-78.75, 41.42	414.5	1900-2008
368449	State College	PA	-77.87, 40.80	356.6	1893-2008
368905	Towanda 1 S	PA	-76.45, 41.75	231.6	1895-2008
369298	Warren	PA	-79.15, 41.85	368.8	1897-2008
441209	Burkes Garden	VA	-81.33, 37.10	935.1	1897-2008
442208	Dale Enterprise	VA	-78.93, 38.45	426.7	1893-2008
442245	Danville	VA	-79.38, 36.58	125	1900-2008
447338	Rocky Mt	VA	-79.90, 36.98	400.8	1895-2008
448062	Staunton W.T. Plant	VA	-79.08, 38.18	499.9	1893-2008
449263	Woodstock	VA	-78.48, 38.90	271.0	1897-2008
185111	Laurel 3 W	MD	-76.90, 30.08	121.9	1896-2008
186620	Oakland 1 SE	MD	-79.40, 39.42	737.6	1894-2008
187330	Princess Anne	MD	-75.68, 38.22	6.1	1895-2008
188000	Salisbury	MD	-75.58, 38.37	3.0	1907-2008
188405	Solomons	MD	-76.45, 38.32	3.7	1893-1983*

Note: Data were collected from NOAA National Climatic Data Center's U.S. Historical Climate Network (HCN). *The Solomons station in MD has over 100 years' data, but only 91 years' data can meet our final data screening.

Table 2. Median climate trends in the inland and coastal sub-regions.

Parameter		Median slope	
		Inland sub-region	Coastal sub-region
Temperature	Tmean (°C/yr)	-0.005	+0.011
	Tmax (°C/yr)	-0.004	+0.007
	Tmin (°C/yr)	-0.004	+0.012
	T_{RANGE} (°C/yr)	-0.001	-0.006
	TX90 (d/yr)	-0.100	+0.077
	TX10 (d/yr)	+0.043	-0.130
	TN90 (d/yr)	-0.027	+0.055
	TN10 (d/yr)	+0.029	-0.109
	TXX (°C/yr)	No trend	+0.006
	TNX (°C/yr)	-0.007	No trend
	TXN (°C/yr)	+0.006	+0.013
	TNN (°C/yr)	No trend	+0.017
Precipitation	P95 (cm/yr)	+0.025	+0.084
	P95D (d/yr)	No trend	No trend
	CDD (d/yr)	-0.027	+0.018
	PX (cm/d/yr)	-0.005	+0.007

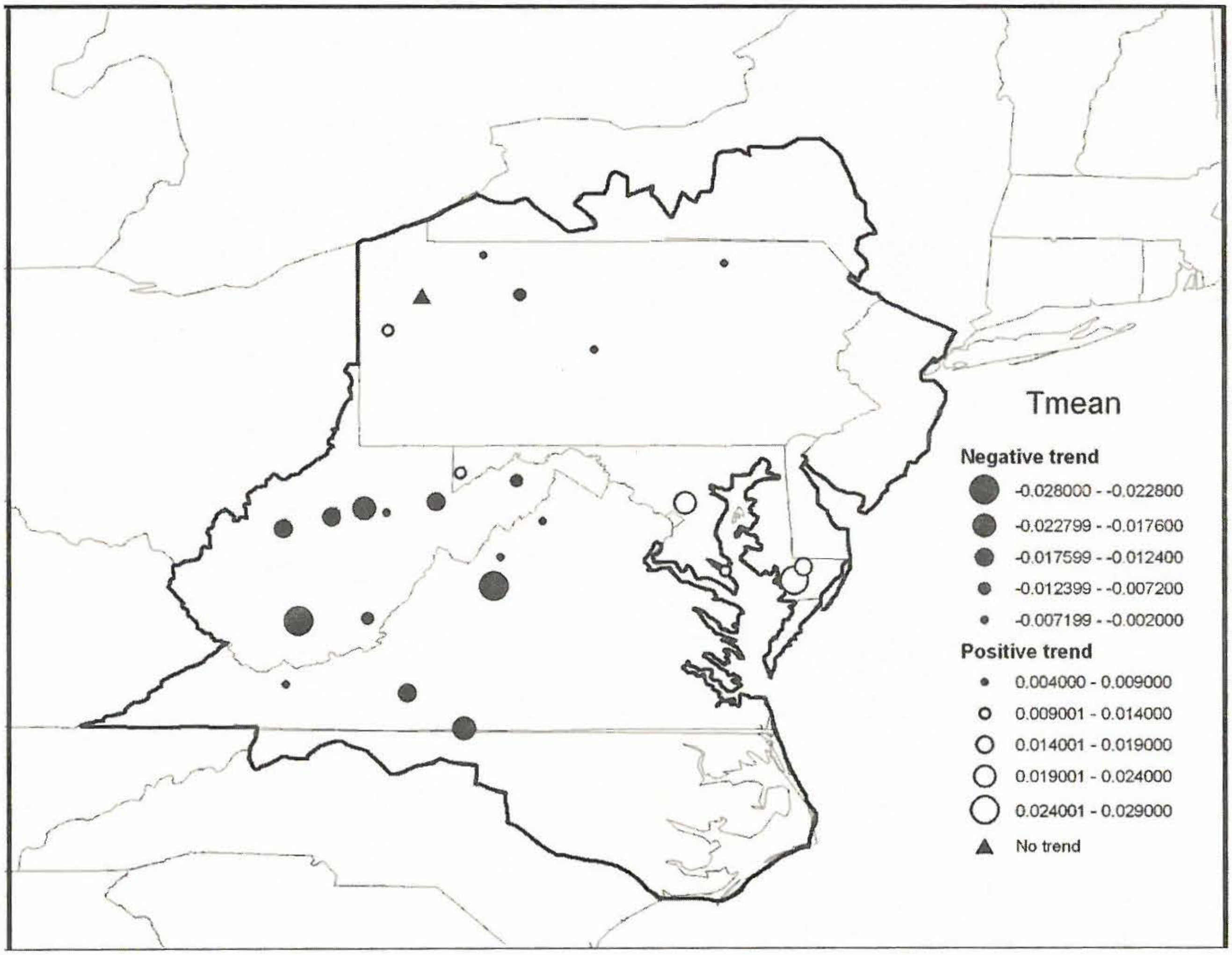


Figure 1. Spatial distributions of annual mean temperature trends (°C/yr; 1900-2008).

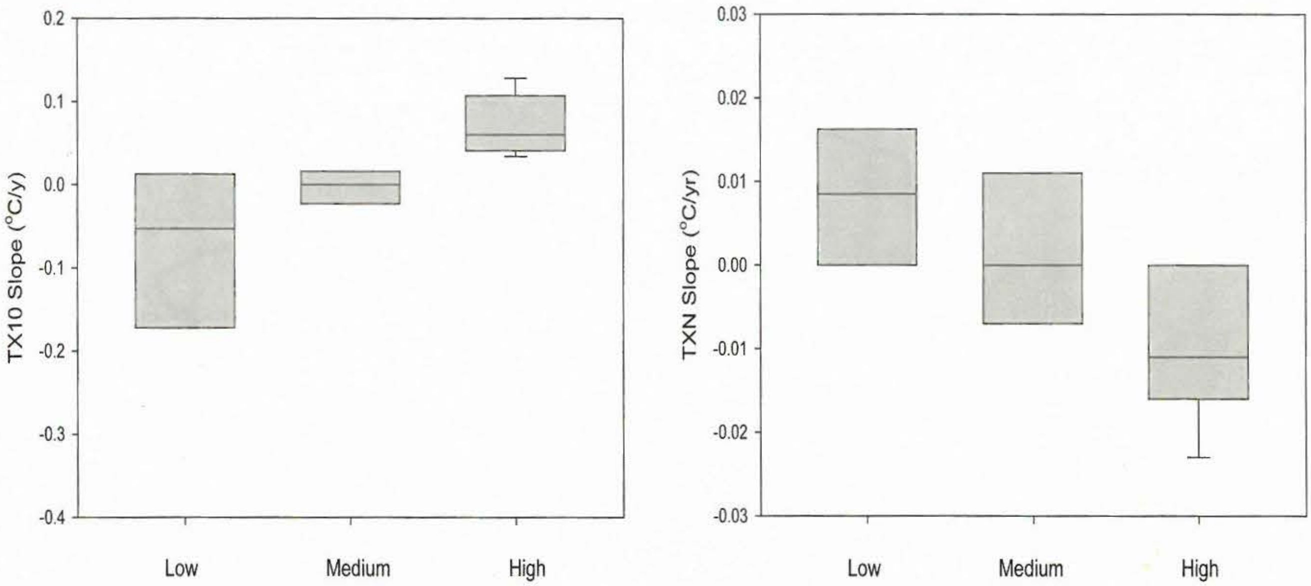


Figure 2. Slopes of cool days (TX10) and minimum annual maximum temperature (TXN) of different elevation groups.

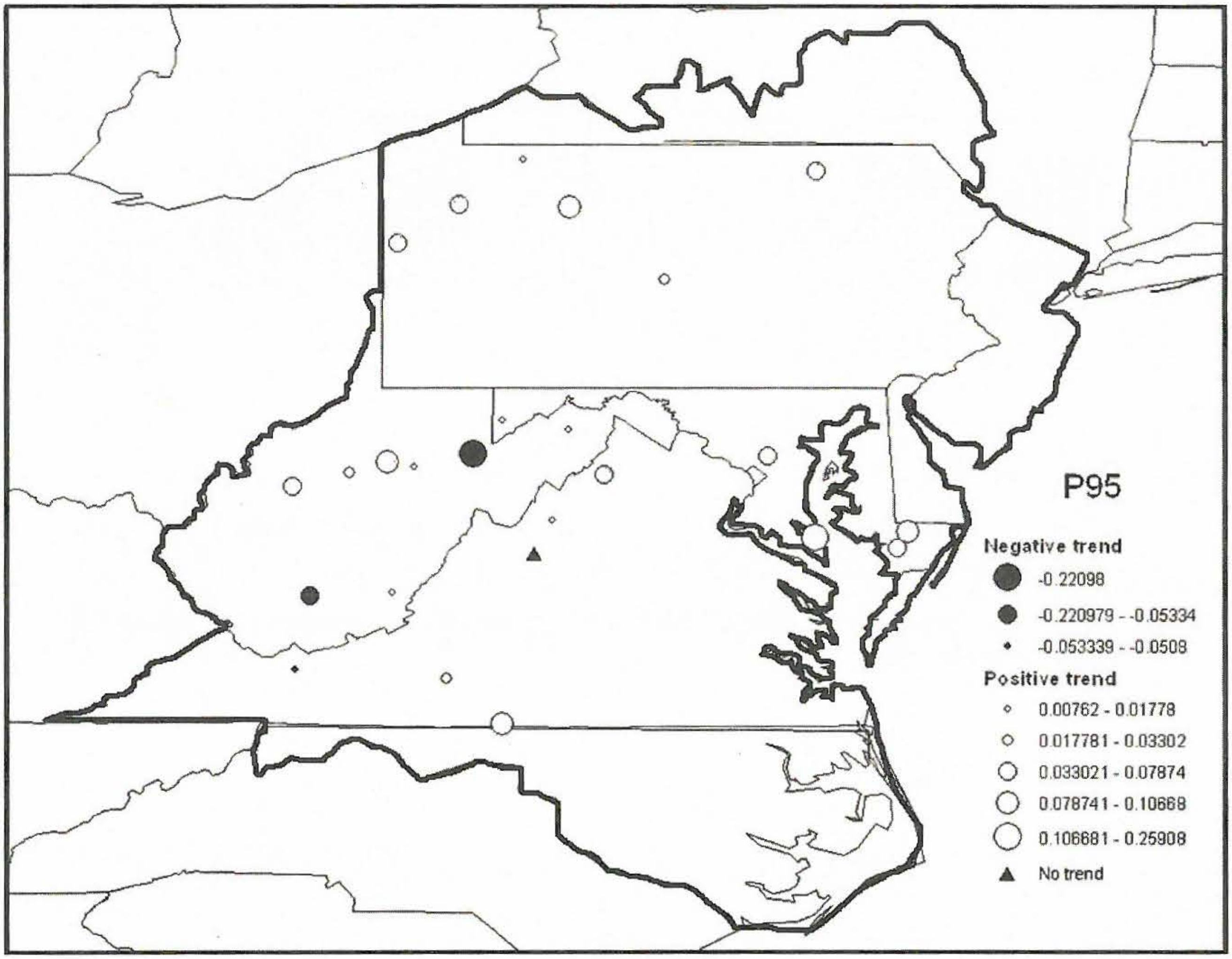


Figure 3. Spatial distributions of annual total precipitation exceeding 95th percentile trends (cm/yr; 1900-2008).

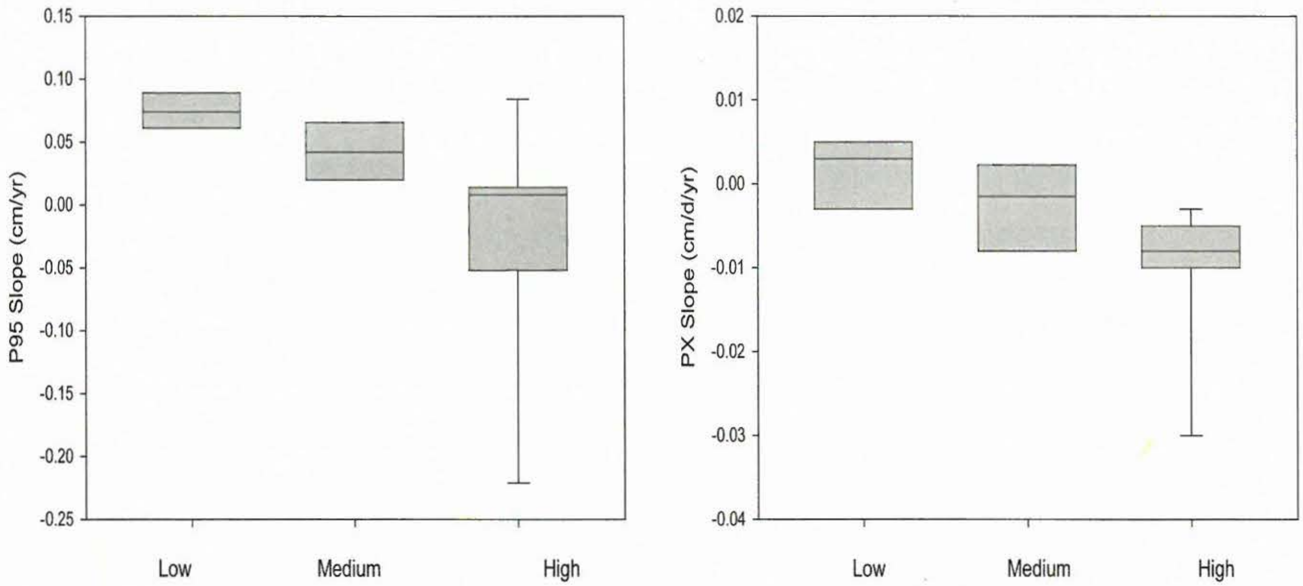


Figure 4. Slopes of wet day precipitation (P95) and maximum precipitation intensity (PX) of different elevation groups.

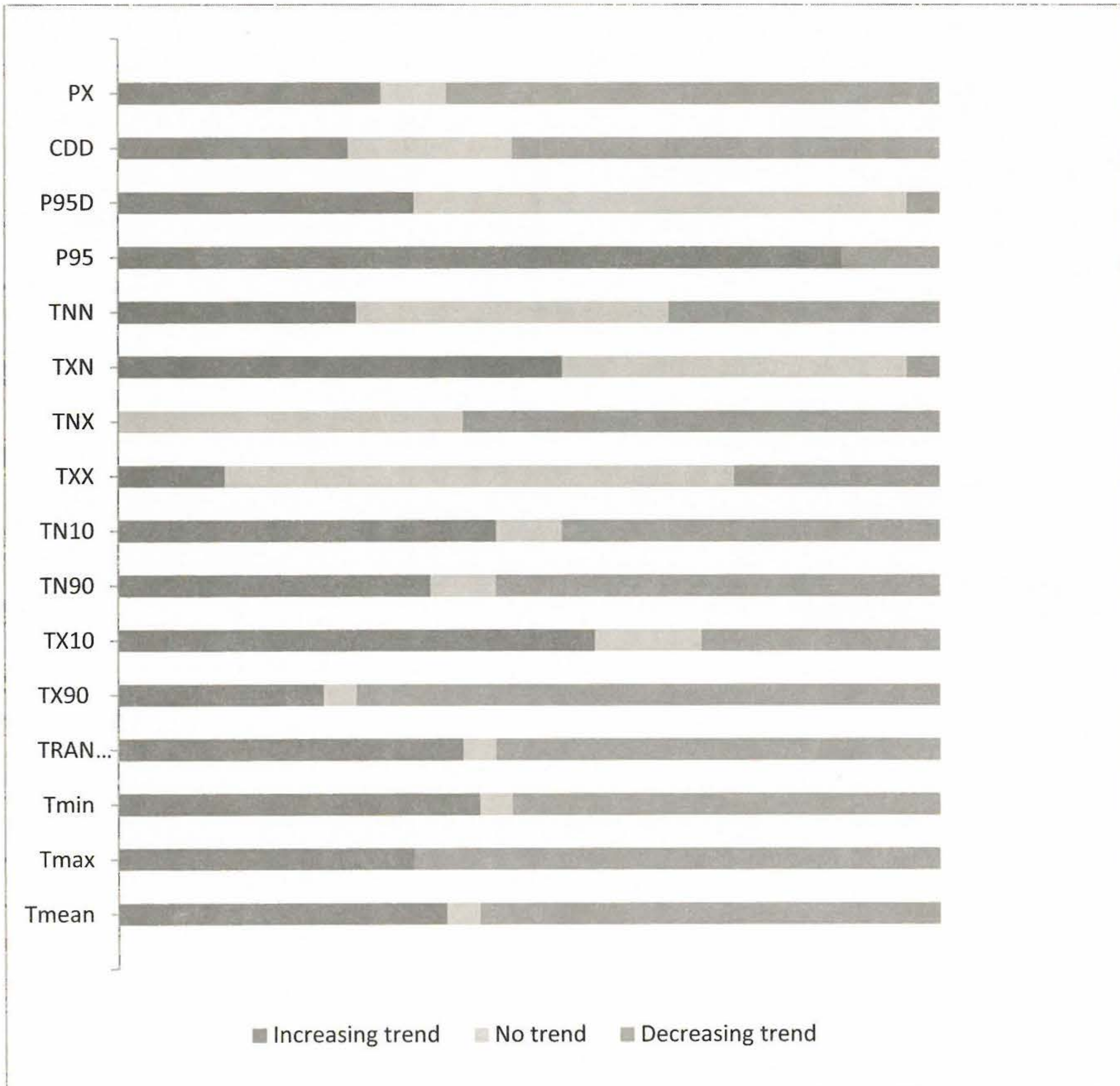


Figure 5. Percentages of stations with long-term (1900-2008) decreasing trends, no trend and increasing trends for different climate parameters.

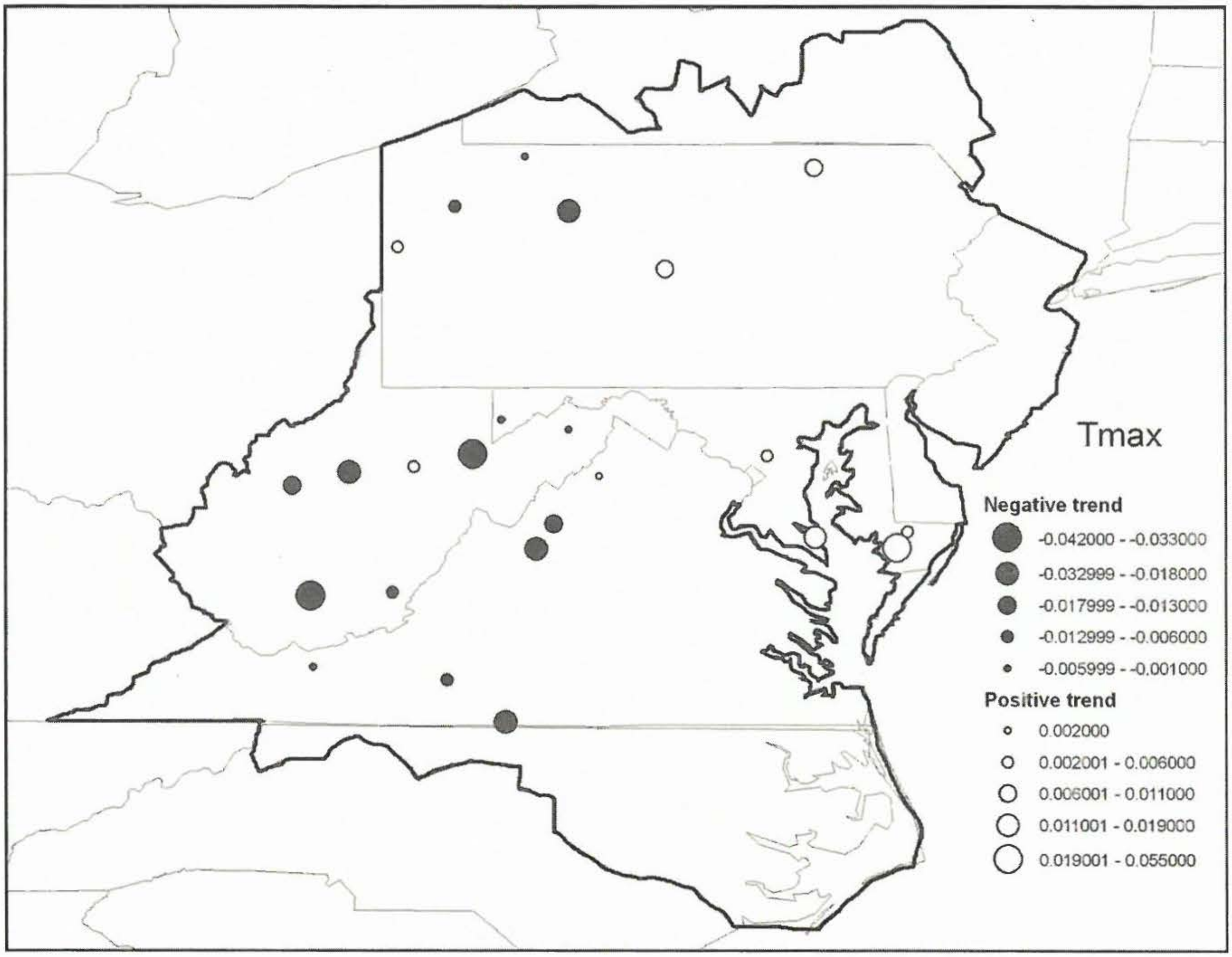
Appendix 1. Temperature and precipitation indices.

Abbreviation	Term	Definition
Tmean(TM)	Mean temperature	Annual average mean temperature in degree Celsius
Tmax(TX)	Maximum temperature	Annual average maximum temperature in degree Celsius
Tmin(TN)	Minimum temperature	Annual average minimum temperature in degree Celsius
T_{RANGE}	Difference of Tmax and Tmin	Difference of annual average maximum and minimum temperature
TX90(TX10)	Warm days (Cool days)	Annual counts of days when TX>90th (TX<10th) percentile
TN90(TN10)	Warm nights (Cool nights)	Annual counts of days when TN>90th (TN<10th) percentile
TXX(TNX)	Max annual max (min) temperature	Maximum annual maximum (minimum) temperature in degree Celsius
TXN(TNN)	Min annual max (min) temperature	Minimum annual maximum (minimum) temperature in degree Celsius
P95	Wet day precipitation	Annual total precipitation when precipitation >95th percentile
P95D	Wet days	Annual counts of days when precipitation >95th percentile
CDD	Consecutive dry days	Maximum number of consecutive days without precipitation
PX	Maximum precipitation intensity	Maximum annual precipitation intensity in cm/day

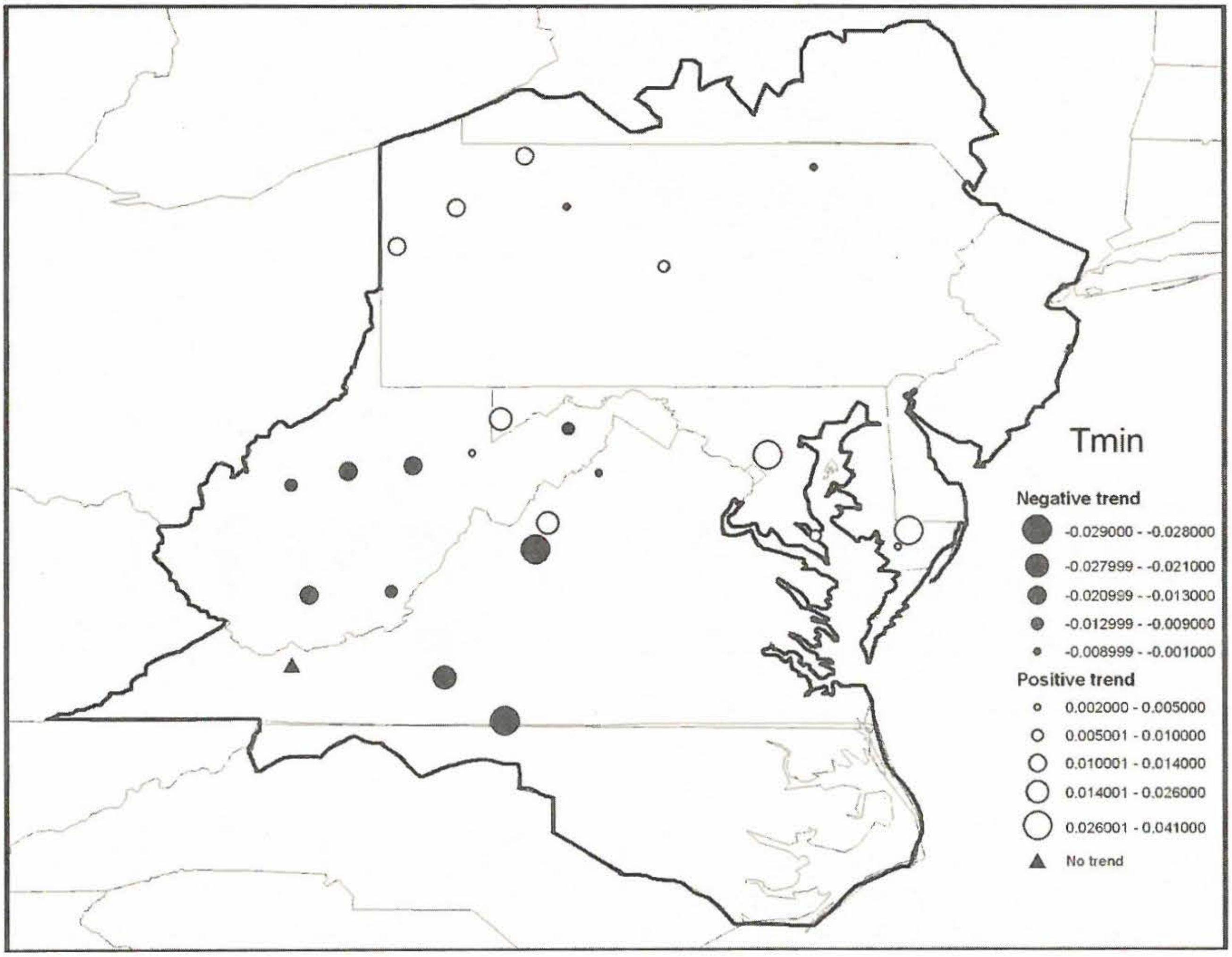
Appendix 2. Trends (1900-2008) of annual mean (Tmean), maximum (Tmax), minimum (Tmin) temperature and difference of annual maximum and minimum temperatures (T_{RANGE}) in the Mid-Atlantic Region of the United States.

Station	Tmean		Tmax		Tmin		T_{RANGE}	
	Slope (°C/yr)	*P*	Slope (°C/yr)	*P*	Slope (°C/yr)	*P*	Slope (°C/yr)	*P*
WV								
460580	**-0.016**	**<0.001**	**-0.023**	**<0.001**	**-0.007**	**<0.05**	**-0.017**	**<0.001**
461220	-0.003	0.249	*+0.003*	*0.363*	**-0.007**	**<0.01**	***+0.006***	***<0.01***
463544	**-0.009**	**<0.01**	**-0.013**	**<0.05**	**-0.008**	**<0.01**	-0.002	0.622
465224	-0.004	0.06	-0.004	0.228	-0.005	0.064	No trend	
466867	**-0.008**	**<0.01**	**-0.018**	**<0.001**	*+0.003*	*0.367*	**-0.021**	**<0.001**
467730	**-0.005**	**<0.05**	-0.002	0.442	**-0.005**	**<0.05**	***+0.006***	***<0.05***
468384	**-0.008**	**<0.01**	**-0.007**	**<0.05**	-0.006	0.131	-0.001	0.925
469436	**-0.012**	**<0.01**	**-0.009**	**<0.05**	**-0.019**	**<0.001**		
PA								
363028	No trend		-0.003	0.219	***+0.007***	***<0.01***	**-0.012**	**<0.001**
366233	*+0.006*	*0.064*	*+0.003*	*0.407*	***+0.007***	***<0.05***	-0.001	0.566
367477	-0.006	0.059	**-0.011**	**<0.01**	-0.003	0.429	**-0.010**	**<0.05**
368445	*+0.003*	*0.108*	*+0.005*	*0.057*	*+0.004*	*0.125*	*+0.001*	*0.515*
368905	*+0.003*	*0.177*	***+0.006***	***<0.05***	-0.001	0.806	***+0.007***	***<0.001***
369298	*+0.004*	*0.105*	-0.001	0.746	***+0.008***	***<0.01***	**-0.009**	**<0.01**
VA								
441209	-0.001	0.646	-0.002	0.364	No trend		-0.002	0.427
442208	*+0.002*	*0.253*	**-0.008**	**<0.01**	***+0.011***	***<0.001***	**-0.016**	**<0.001**
442245	**-0.012**	**<0.001**	**-0.011**	**<0.01**	**-0.016**	**<0.001**	*+0.004*	*0.153*
447338	**-0.009**	**<0.01**	-0.006	0.101	**-0.012**	**<0.001**	***+0.007***	***<0.05***
448062	**-0.013**	**<0.001**	**-0.010**	**<0.001**	**-0.016**	**<0.001**	***+0.009***	***<0.05***
449263	-0.001	0.65	*+0.001*	*0.668*	-0.001	0.601	*+0.003*	*0.362*
MD								
185111	***+0.013***	***<0.001***	*+0.003*	*0.168*	***+0.023***	***<0.001***	**-0.018**	**<0.001**
186620	***+0.007***	***<0.01***	-0.002	0.482	***+0.014***	***<0.001***	**-0.016**	**<0.001**
187330	***+0.016***	***<0.001***	***+0.031***	***<0.001***	*+0.001*	*0.617*	***+0.032***	***<0.001***
188000	***+0.009***	***<0.001***	*+0.002*	*0.523*	***+0.018***	***<0.001***	**-0.014**	**<0.001**
188405	***+0.008***	***<0.05***	***+0.011***	***<0.01***	*+0.006*	*0.092*	*+0.003*	*0.151*

Note: Significant trends (i.e., slopes with $P<0.05$) were indicated in bold. Increasing trends were in italic.



Appendix 3. Spatial distributions of annual max temperature trends (°C/yr; 1900-2008).



Appendix 4. Spatial distributions of annual minimum temperature trends (°C/yr; 1900-2008).

Appendix 5. Trends (1900-2008) of annual warm (TX90) and cool (TX10) days, and annual warm (TN90) and cool (TN10) nights in the Mid-Atlantic Region of the United States.

Station	TX90		TX10		TN90		TN10	
	Slope (d/yr)	*P*	Slope (d/yr)	*P*	Slope (d/yr)	*P*	Slope (d/yr)	*P*
WV								
460580	**-0.367**	**<0.001**	***+0.114***	***<0.05***	-0.074	0.056	***+0.125***	***<0.001***
461220	*+0.016*	*0.666*	*+0.034*	*0.265*	No trend		***+0.094***	***<0.01***
463544	**-0.253**	**<0.001**	*+0.017*	*0.593*	**-0.091**	**<0.01**	*+0.047*	*0.168*
465224	-0.031	0.427	*+0.060*	*0.106*	-0.039	0.295	*+0.059*	*0.079*
466867	**-0.250**	**<0.001**	***+0.128***	***<0.001***	***+0.098***	***<0.01***	No trend	
467730	**-0.124**	**<0.01**	*+0.016*	*0.652*	-0.014	0.645	*+0.053*	*0.15*
468384	**-0.348**	**<0.001**	*+0.016*	*0.572*	-0.044	0.243	*+0.061*	*0.075*
469436								
PA								
363028	**-0.077**	**<0.05**	No trend		*+0.022*	*0.396*	-0.051	0.157
366233	-0.057	0.275	No trend		*+0.063*	*0.061*	-0.038	0.328
367477	**-0.200**	**<0.01**	***+0.100***	***<0.05***	-0.048	0.194	***+0.084***	***<0.05***
368445	*+0.024*	*0.474*	-0.036	0.186	***+0.067***	***<0.05***	-0.031	0.332
368905	No trend		**-0.098**	**<0.01**	-0.012	0.551	-0.028	0.409
369298	*+0.014*	*0.697*	No trend		***+0.095***	***<0.05***	-0.030	0.37
VA								
441209	-0.028	0.484	*+0.061*	*0.052*	No trend		No trend	
442208	**-0.100**	**<0.05**	*+0.043*	*0.192*	***+0.172***	***<0.001***	**-0.083**	**<0.05**
442245	**-0.111**	**<0.05**	***+0.109***	***<0.05***	-0.054	0.285	***+0.108***	***<0.05***
447338	-0.074	0.143	*+0.059*	*0.112*	**-0.111**	**<0.01**	*+0.057*	*0.092*
448062	**-0.222**	**<0.001**	*+0.048*	*0.097*	**-0.165**	**<0.001**	***+0.130***	***<0.001***
449263	**-0.143**	**<0.01**	-0.023	0.55	**-0.067**	**<0.05**	*+0.012*	*0.671*
MD								
185111	*+0.067*	*0.08*	-0.042	0.201	***+0.273***	***<0.001***	**-0.162**	**<0.001**
186620	-0.089	0.058	*+0.039*	*0.187*	***+0.138***	***<0.001***	-0.031	0.235
187330	***+0.199***	***<0.001***	**-0.284**	**<0.001**	**-0.164**	**<0.001**	**-0.090**	**<0.05**
188000	-0.026	0.544	-0.064	0.124	***+0.160***	***<0.001***	**-0.128**	**<0.001**
188405	***+0.087***	***<0.01***	**-0.197**	**<0.001**	-0.050	0.079	**-0.080**	**<0.01**

Note: Significant trends (i.e., slopes with $P<0.05$) were indicated in bold. Increasing trends were in italic.

Appendix 6. Trends (1900-2008) of maximum annual maximum (TXX) and maximum annual minimum (TNX) temperatures, and minimum annual maximum (TXN) and minimum (TNN) temperatures in the Mid-Atlantic Region of the United States.

Station	TXX		TNX		TXN		TNN	
	Slope (°C/yr)	*P*	Slope (°C/yr)	*P*	Slope (°C/yr)	*P*	Slope (°C/yr)	*P*
WV								
460580	**-0.0130**	**0.001**	**-0.014**	**0.01**	No trend		-0.016	0.179
461220	No trend		No trend		No trend		No trend	
463544	No trend		**-0.012**	**<0.05**	*+0.021*	*0.088*	*+0.007*	*0.348*
465224	No trend		**-0.007**	**<0.05**	No trend		**-0.023**	**<0.05**
466867	No trend		**-0.019**	**<0.001**	-0.018	0.08	-0.016	0.133
467730	**-0.0240**	**<0.001**	-0.007	0.078	No trend		-0.013	0.129
468384	No trend		No trend		*+0.012*	*0.289*	*+0.011*	*0.274*
469436								
PA								
363028	No trend		**-0.013**	**<0.01**	***+0.027***	***<0.05***	-0.007	0.288
366233	No trend		**-0.012**	**<0.05**	*+0.019*	*0.096*	No trend	
367477	**-0.0160**	**<0.001**	**-0.028**	**<0.001**	No trend		-0.011	0.289
368445	No trend		**-0.006**	**<0.05**	***+0.021***	***<0.01***	No trend	
368905	No trend		No trend		*+0.019*	*0.063*	*+0.014*	*0.121*
369298	No trend		No trend		***+0.035***	***<0.001***	No trend	
VA								
441209	No trend		**-0.011**	**<0.01**	No trend		-0.013	0.155
442208	No trend		No trend		***+0.03***	***<0.01***	No trend	
442245	**-0.009**	**<0.05**	**-0.016**	**<0.01**	No trend		-0.015	0.141
447338	**-0.016**	**<0.001**	-0.006	0.075	No trend		No trend	
448062	No trend		**-0.013**	**<0.01**	No trend		No trend	
449263	**-0.014**	**<0.001**	No trend		***+0.044***	***<0.001***	*+0.012*	*0.203*
MD								
185111	***+0.022***	***<0.001***	No trend		***+0.026***	***<0.05***	*+0.010*	*0.194*
186620	*+0.006*	*0.052*	No trend		*+0.022*	*0.107*	No trend	
187330	No trend		No trend		No trend		***+0.027***	***<0.001***
188000	***+0.011***	***<0.001***	-0.006	0.065	*+0.013*	*0.183*	No trend	
188405	No trend		No trend		*+0.012*	*0.104*	*+0.017*	*0.056*

Note: Significant trends (i.e., slopes with $P<0.05$) were indicated in bold. Increasing trends were in italic.

Appendix 7. Homogeneity tests of long-term (1900-2008) regional climate trends.

Parameter		χ^2 (df)	*P*
Temperature	Tmean	201 (24)	<0.001
	Tmax	189 (24)	<0.001
	Tmin	230 (24)	<0.001
	T_{RANGE}	363 (23)	<0.001
	TX90	151 (23)	<0.001
	TX10	144 (23)	<0.001
	TN90	124 (23)	<0.001
	TN10	225 (23)	<0.001
	TXX	33 (23)	0.08
	TNX	120 (23)	<0.001
	TXN	41 (23)	< 0.05
	TNN	42 (23)	<0.01
Precipitation	P95	76 (24)	<0.001
	P95D	112 (24)	<0.001
	CDD	141(24)	<0.001
	PX	113(24)	<0.001

Note: χ^2 is the Chi-square value; df is degree of freedom; significant heterogeneity is indicated by $P<0.05$.

Appendix 8. Kruskal-Wallis test results on climate trends (1900-2008) among three elevation groups (low elevation group: < 280 m, medium elevation group: 280-420 m, and high elevation group: > 420 m).

Parameter		K	*P*
Temperature	Tmean	4.625	0.099
	Tmax	5.362	0.068
	Tmin	1.088	0.58
	T_{RANGE}	2.962	0.227
	TX90	3.666	0.16
	TX10	**12.644**	**<0.01**
	TN90	0.091	0.956
	TN10	5.056	0.08
	TNX	3.929	0.14
	TXX	1.903	0.386
	TNN	4.254	0.119
	TXN	**7.67**	**<0.05**
Precipitation	**P95**	**11.581**	**<0.01**
	P95D	3.165	0.205
	CDD	5.992	0.05
	PX	**12.956**	**<0.01**

Note: Significant difference (i.e., slopes with $P<0.05$) was indicated in bold.

Appendix 9. Trends (1900-2008) of annual wet day precipitation (P95), wet days (P95D), annual maximum number of consecutive days without precipitation (CDD) and maximum precipitation intensity (PX) in the Mid-Atlantic Region of the United States.

Station	P95		P95D		CDD		PX	
	Slope (cm/yr)	*P*	Slope (d/yr)	*P*	Slope (d/yr)	*P*	Slope (cm/d/yr)	*P*
WV								
460580	-0.053	0.223	No trend		**-0.076**	**<0.001**	-0.005	0.092
461220	*+0.015*	*0.63*	No trend		**-0.029**	**<0.05**	-0.005	0.096
463544	*+0.033*	*0.32*	No trend		-0.019	0.055	-0.003	0.516
465224	*+0.008*	*0.8*	No trend		No trend		**-0.008**	**<0.05**
466867	**-0.221**	**<0.001**	**-0.041**	**<0.001**	**-0.088**	**<0.001**	**-0.030**	**<0.001**
467730	*+0.008*	*0.754*	No trend		**-0.058**	**<0.001**	-0.003	0.681
468384	*+0.056*	*0.145*	*+0.013*	*0.081*	**-0.060**	**<0.001**	-0.008	0.062
469436	***+0.099***	***<0.05***	***+0.025***	***<0.01***	No trend		***+0.013***	***<0.001***
PA								
363028	***+0.066***	***<0.05***	*+0.013*	*0.059*	**-0.054**	**<0.001**	No trend	
366233	***+0.074***	***<0.05***	***+0.018***	***<0.05***	-0.019	0.082	*+0.003*	*0.417*
367477	***+0.084***	***<0.05***	***+0.022***	***<0.01***	**-0.025**	**<0.05**	-0.008	0.066
368445	*+0.025*	*0.376*	No trend		No trend		*+0.003*	*0.3*
368905	***+0.061***	***<0.05***	***+0.015***	***<0.05***	No trend		-0.003	0.482
369298	*+0.018*	*0.557*	No trend		**-0.015**	**<0.05**	**-0.008**	**<0.05**
VA								
441209	-0.051	0.124	No trend		**-0.075**	**<0.001**	**-0.010**	**<0.05**
442208	*+0.013*	*0.633*	No trend		-0.011	0.262	**-0.010**	**<0.001**
442245	***+0.107***	***<0.05***	***+0.015***	***<0.05***	*+0.026*	*0.053*	*+0.005*	*0.215*
447338	*+0.028*	*0.43*	No trend		**-0.047**	**<0.001**	**-0.008**	**<0.05**
448062	No trend		No trend		*+0.017*	*0.131*	-0.010	**<0.05**
449263	***+0.064***	***<0.05***	***+0.009***	***<0.05***	*+0.018*	*0.207*	No trend	
MD								
185111	*+0.061*	*0.075*	No trend		*+0.012*	*0.297*	*+0.003*	*0.645*
186620	*+0.013*	*0.652*	No trend		No trend		-0.003	0.437
187330	***+0.079***	***<0.05***	No trend		*+0.025*	*0.063*	***+0.015***	***<0.001***
188000	***+0.089***	***<0.05***	No trend		***+0.031***	***<0.05***	*+0.003*	*0.525*
188405	***+0.102***	***<0.001***	***+0.049***	***<0.001***	*+0.011*	*0.319*	***+0.011***	***<0.001***

Note: Significant trends (i.e., slopes with $P<0.05$) were indicated in bold. Increasing trends were in italic.

INSTRUCTIONS TO AUTHORS

(http://www.marshall.edu/wvas/AUTHORS.HTML)

1. General Policy

The publications policy of the Academy is intended to implement the goal of publication of the *Proceedings* by the Academy, namely, stimulation of research on the part of West Virginia scientists and Academy members by providing an outlet for publication of their research results. Within the limits of available resources, the Academy will attempt to maximize the number of articles it can publish, while maintaining standards by the peer review process. Where selection must be made, the sole criterion for judgment shall be the quality of the research involved. Articles of a local or regional nature, as well as those of broader scope, are encouraged. Articles will not be discriminated against because of their subject matter, as long as they satisfy the requirement of the bylaws (http://www.marshall.edu/wvas/WELCOME.HTML; click on the Bylaws link) that they be "...of a scientific nature" (Section VII, Article 1).

The Academy will consider papers that report the results of original research or observation. The Academy will not publish papers that have been published elsewhere. Each manuscript will be reviewed by the Publications Committee and by referees. Manuscripts longer than 15 pages of double-spaced, typed copy normally will not be accepted. Membership in the Academy is a requirement for publishing in the Proceedings. In the case of joint authorship, at least one author must be a member of the Academy. No author, or co-author, may submit more than two papers for any volume of the Proceedings. Ordinarily, papers offered for publication must have been presented at the annual meeting of the Academy but presentation is not a requirement for publication. Publication is not automatic. The *Proceedings* editors also solicit outstanding expository papers.

2. Abstract for Annual Meeting

A 'call-for-abstracts' announcement is mailed to each member in the fall.

The abstract will be formatted in the following manner:

JOHN SMITH, Dept of Biological Mathematics, West Virginia University, Morgantown, WV, 26506, and JIM DOE, Dept of Chemical Sociology, Marshall University, Huntington, WV 25755. **Analysis of trigonometric cell structure in the chromosome.**

Skip one line and begin the first paragraph of text. Single-space the text. Start each new paragraph by indenting 0.25" (1/4") using a tab, not the space bar. Do not skip a line between paragraphs. Standard abbreviations may be used. The abstract should contain a brief statement of (a) the objectives of the study, (b) the method of study used, (c) the essential results including data and statistics, (d) the conclusions, and (e) the source of support (if applicable). Figures and tables cannot be accommodated. Please check the abstract for misspellings, poor hyphenation, and poor grammar. The text of the abstract should not exceed 250 words.

3. Manuscripts

Manuscripts for publication should be sent to the editor, Dr. Richard Ford, Biology Department, West Virginia State University, 101D Hamblin Hall, Route 25 and Barron Drive, Box 1000, Institute, WV 25112-1000. Manuscripts must be sent electronically (email or compact disk) in Microsoft WORD to fordri@wvstate u.edu One hardcopy should also be sent to the address above. Proofs, edited manuscripts, and all correspondence regarding papers for publication should be directed to the editor. For additional information, call (304) 766-5742.

a. Cover-sheet (Title and by-line)

The cover sheet for each manuscript should include the title (bold, 12-pt. New Times Roman font) of the paper followed by the names and business addresses of all authors. The corresponding author should be indicated by an asterisk and include a business phone number, fax number (if available), and e-mail address (if available)

b. Organization of Manuscripts

Each manuscript shall start with an abstract (no more than 250 words) that should summarize the primary results. In general, the introductory abstract will replace a summary. This abstract should be suitable for sending to international abstracting services for immediate publication in the event that the paper is accepted for publication in the *Proceedings*.

The following sequence is suggested for organizing a paper: Introduction, Materials and Methods, Results, Discussion, Acknowledgments, and Literature Cited.

The text should be double-spaced (New Times Roman 12 pt. font size), and pages should be numbered consecutively in the top right-hand corner of each page preceded by the author's last name.

Major section headings (**INTRODUCTION**, **METHODS**, etc.) are to be bold and all caps and subsection headings should presented in 10-pt font size, in all caps but not bolded.

Using a tab, not the space bar, indent each paragraph 0.25" (1/4").

c. Grammatical Considerations

Place two spaces between the period at the end of one sentence and the first letter of the next sentence.

Hyphenate compound modifiers and compound words. A modifier made up of an adverb (other than adverbs ending in *-ly*) + adjective, adjective + noun, or two nouns is a compound or unit modifier. E.g., *plum-pox-resistant, transgenic plum*, where *plum-pox-resistant* is the compound modifier (hyphens are boldface for emphasis). Note: chemical names used as modifiers are not hyphenated except when misinterpretation is likely. Examples: 1. Iron sulfide containing bacteria is commonly found ... ; 2. Iron sulfide-containing bacteria are … (In example 1., a sample of iron sulfide that contains bacteria within it is the subject; in example 2., the bacteria contain iron sulfide and *bacteria* is the subject.

Include a comma after each member in a series of words that form a list in a sentence, form a series of modifiers modifying the same item, or for a series of phrases, as this sentence itself exemplifies. E.g., *...dogs, horses, antelope, and trout...* A different example exemplifies an important exception: When an adjective or noun acting as an adjective is conceptually very closely related to the immediately following noun, as *big* in *big apple*, it is not considered part of the series of modifiers modifying the noun. Thus in ...*moldy, green, foul-tasting big apple* ... commas follow all of the modifiers prior to *foul-tasting*, but because *big* is closely associated with apple, it is not in the series; hence *foul-tasting* is the last modifier in the series (it could have been preceded by *and*).

Latin epithets used in scientific names for animals and plants follow a different set of rules than English names, even "official" English names. The guideline for English names is based on the rule "only proper nouns are capitalized in sentences". E.g., *coastal plain oak, raspberry horntail sawfly* would not be capitalized in a sentence. Capitalize the first letter of the first word in a sentence and capitalize the first letter for each major term in titles, figure captions, and table headings. Note: the symbol *pH* always has a lowercase *p* and uppercase *H*; it should not be the first "word" in a sentence, caption, or title if things can be conveniently rearranged.

Spell out numbers "one" through "nine"; use numerals for numbers higher than nine. As with *pH*, avoid beginning sentences, captions, and titles with a numeral.

There exist hyphens, en-dashes, and em-dashes, and each has a use. One should distinguish especially between the hyphen (the shortest of these marks) and the en-dash (the intermediate in length of the three). The en-dash should be used in two-word concepts (e.g., *nickel–metal hydride battery*) and spans of time (e.g., *for the period January–June*), among other situations. In "Word" for PCs, the en- and em-dashes are available in the "Special Characters" tab of the "Symbol" sub-menu, which is under the "Insert" menu. In Macintosh computers, the en-dash is also available directly when the "alt/option" key is held down while striking the hyphen key.

For other grammatical considerations please consult a good scientific writing reference, such as the *Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers* by Council of Science Educators Style Manual Committee.

4. Figure, Illustrations, and Table Preparation

Each table or figure should be supplied with a legend sufficiently complete to make the table or figure intelligible without reference to the text. Footnotes may be used in connection with tables and figures where necessary. Footnotes should be avoided whenever possible in the text itself. Complicated formulas should be prepared with care in a form suitable for camera copy reproduction. Avoid such formulas in the text. Acceptable fonts include Times, New Times Roman, Arial, Courier, Helvetica, and Symbol. Table and figure format should follow those in issue **79***(2)* or later.

Example Table:

Table 1. Synthesis of PIT tag retention rates from American eel studies.

Study	Location of Study	Duration	Eel Length (mm)	Tag Location	Tag Retention
Thomas (2006)	Laboratory	6 months	≥ 500	Dorsal musculature	100%
Morrison and Secor (2003)	Hudson River, NY	2 months	Mean = 457	Visceral cavity	89%
Verdon and Desrochers (2003)	St. Lawrence River, NY	1998-1999	Mean = 471.7 (1998) Mean = 468.7 (1999)	Behind the head	98%
Verdon *et al.* (2003)	Richelieu River, Quebec	1997-1999	Mean = 379.7	Dorsal Musculature	93.9%

Prepare figures and illustrations to be close to the expected size within the publications, with a width of no less than 3 inches (column width) or 6.5 inches for full-page width.

All illustrations and photographs will be published in black and white or grayscale. Use shaded fills for shapes and graphs. For figures with bars, shading, diagonal, and horizontal lines are allowable. Each bar fill-type should be clearly distinct. All drawn lines must be greater than 0.25 pts (0.1 mm) thick. All figures should have a white chart area. See WVAS *Proceedings* **79*(2)*** or later for example formatting.

The recommended file format and resolution for various types of line drawing and photos are:

- Black and white line art, use 1000 dpi minimum resolution
- Half tone and grayscale – use minimum resolution of 600 dpi
- Images and photos need to be in grayscale with a minimum resolution of 600 dpi

All illustrations should be submitted electronically as a separate file for each figure. Acceptable file format are TIF, PDF, Microsoft PPT, DOC, or XLS. No other formats are accepted at this time.

Please note: Illustrations, graphs, and photos that do not comply with the recommended format will be returned to the author for correction. The manuscript will not be considered for review until it is resubmitted with the required corrections. Figures and tables covering more than one page should have the figure or table number repeated at the top of each of the other pages followed by the word "continued" within parentheses. Data, legends, and other identifiers that appear within a figure or table need to be large enough in the published version to be easily read.

5. Literature Cited

References shall be collected at the end of the manuscript as "Literature Cited" and must be cited in the text.

- Citations within text:

References should be cited by author and date within the text. Separate multiple citations with a semicolon.

- Example citations within text:

Single author: (Dare 2003)
Two authors: (Buzby and Deegan 1999)
Multiple authors: (Feldheim *et al.* 2002)
Multiple citations: (Buzby and Deegan 1999; Feldheim *et al.* 2002)

- Citations at the end of paper:

The title of the papers cited and the inclusive page numbers must be given.
The article title should be italicized and the journal name should be in normal font.
Bold the volume number, italicize the issue, and present page numbers in normal font.
End each citation with a period.
Citations should be formatted with hanging indentation of 0.5".
Do not skip a line between citations.

- Example journal citations:

Buzby, K. and L. Deegan. 1999. *Retention of anchor and passive integrated transponder tags by arctic grayling.* N. Am. J. Fish. Manage. **19**(*4*): 1147-1150.

Dare, M.R. 2003. *Mortality and long-term retention of passive integrated transponder tags by spring Chinook salmon.* N. Am. J. Fish. Manage. **23**: 1015-1019.

Feldheim, K.A., S.H. Gruber, J.R.C. de Marignac, and M.V. Ashley. 2002. *Genetic tagging to determine passive integrated transponder tag loss in lemon sharks.* J. Fish Biol. **61**: 1309-1313.

Example book citation:

Stacey, M. and S. A. Barker. 1960. *Polysaccharides of microorganisms*. Oxford Univ. Press. London. 228 pp.

Freemark, K. and B. Collins. 1992. *Landscape ecology of birds in temperate forest fragments* in J. M. Hagan, III and D. W. Johnston (eds.), Ecology and Conservation of Neotropical Migrant Landbirds, pp. 443-454. Smithsonian Institution. Washington, D.C.

6. Submission of Revised Manuscripts

All manuscripts accepted by the peer reviewers that need to be revised must be done according to instructions and submitted to the editor either by e-mail or on a compact disk.

7. Proof

If galley proofs are sent to authors for corrections they should be made on margins of the proof. Proofreader's marks may be found in dictionaries and in style manuals (e.g., "Style Manual for Biological Journals"). Changes in text after the manuscript is in galley proof are quite expensive and in general are not permitted. Galley proofs must be corrected and returned promptly (within ten days).

8. Reprints

A reprint order blank will be sent with the galley proofs. This should be returned with the corrected proof.

9. Cost of Publication

Authors will be billed by the Academy for pages in excess of the maximum allowed (see item 1). The cost of figures that require half-tone screens, such as photographs, will also be billed to the authors. Currently, a page charge of $15.00 per page is in effect, and the author will be sent a pro forma invoice to see if payment can be secured from the author's institution, company, research grant, etc. Failure to honor page charges will not prevent publication of a paper, but will greatly assist the publication program of the Academy.

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