APPENDIX B

Additional Climate Analyses
American Burying Beetle Species Status Assessment
February 2019

Figure A. The mean (red line) and standard deviation (pink shading) of 20 statistically downscaled climate change models for two locations (East = Colome, SD; West =Merriman, NE) within the Niobrara Analysis Area. Each graph shows the change over time in the mean number of nights with minimum temperatures greater than or equal to 75°F. American Burying Beetles in captivity cannot reproduce when temperatures exceed 75°F.

Figure B. The mean (red line) and standard deviation (pink shading) of 20 statistically downscaled climate change models for two locations (East = Amelia, NE; West = Thedford, NE) within the Sand Hills Analysis Area. Each graph shows the change over time in the mean number of nights with minimum temperatures greater than or equal to 75°F. American Burying Beetles in captivity cannot reproduce when temperatures exceed 75°F.

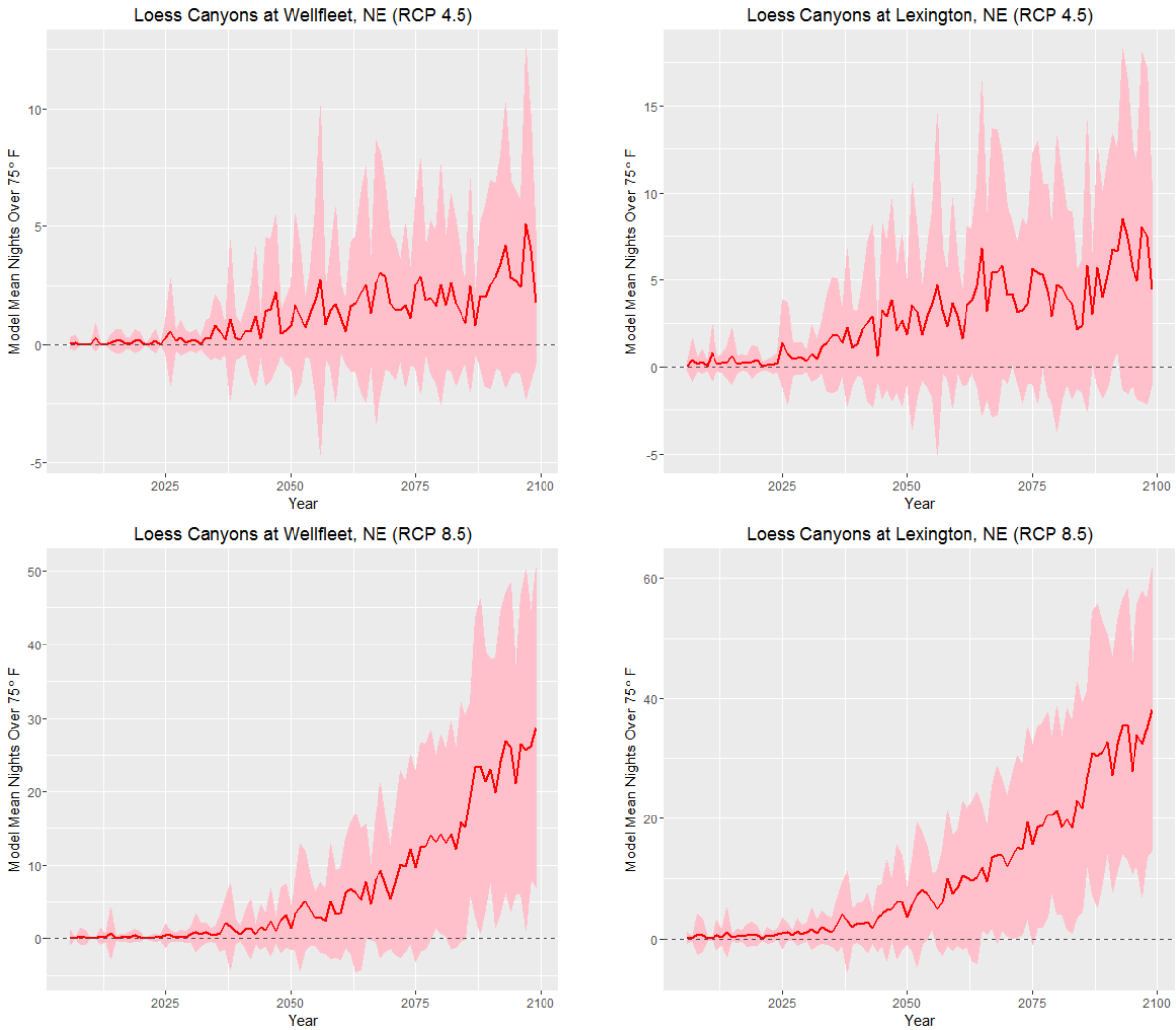

Figure C. The mean (red line) and standard deviation (pink shading) of 20 statistically downscaled climate change models for two locations (East = Lexington, NE; West = Wellfleet, NE) within the Loess Canyons Analysis Area. Each graph shows the change over time in the mean number of nights with minimum temperatures greater than or equal to 75°F. American Burying Beetles in captivity cannot reproduce when temperatures exceed 75°F.

Figure D. The mean (red line) and standard deviation (pink shading) of 20 statistically downscaled climate change models for two locations (East = Fredonia, KS; West = Webb City, OK) within the Flint Hills Analysis Area. Each graph shows the change over time in the mean number of nights with minimum temperatures greater than or equal to 75°F. American Burying Beetles in captivity cannot reproduce when temperatures exceed 75°F.

Figure E. The mean (red line) and standard deviation (pink shading) of 20 statistically downscaled climate change models for two locations (East = Van Buren, AR; West = Shawnee, OK) within the Arkansas River Analysis Area. Each graph shows the change over time in the mean number of nights with minimum temperatures greater than or equal to 75°F. American Burying Beetles in captivity cannot reproduce when temperatures exceed 75°F.

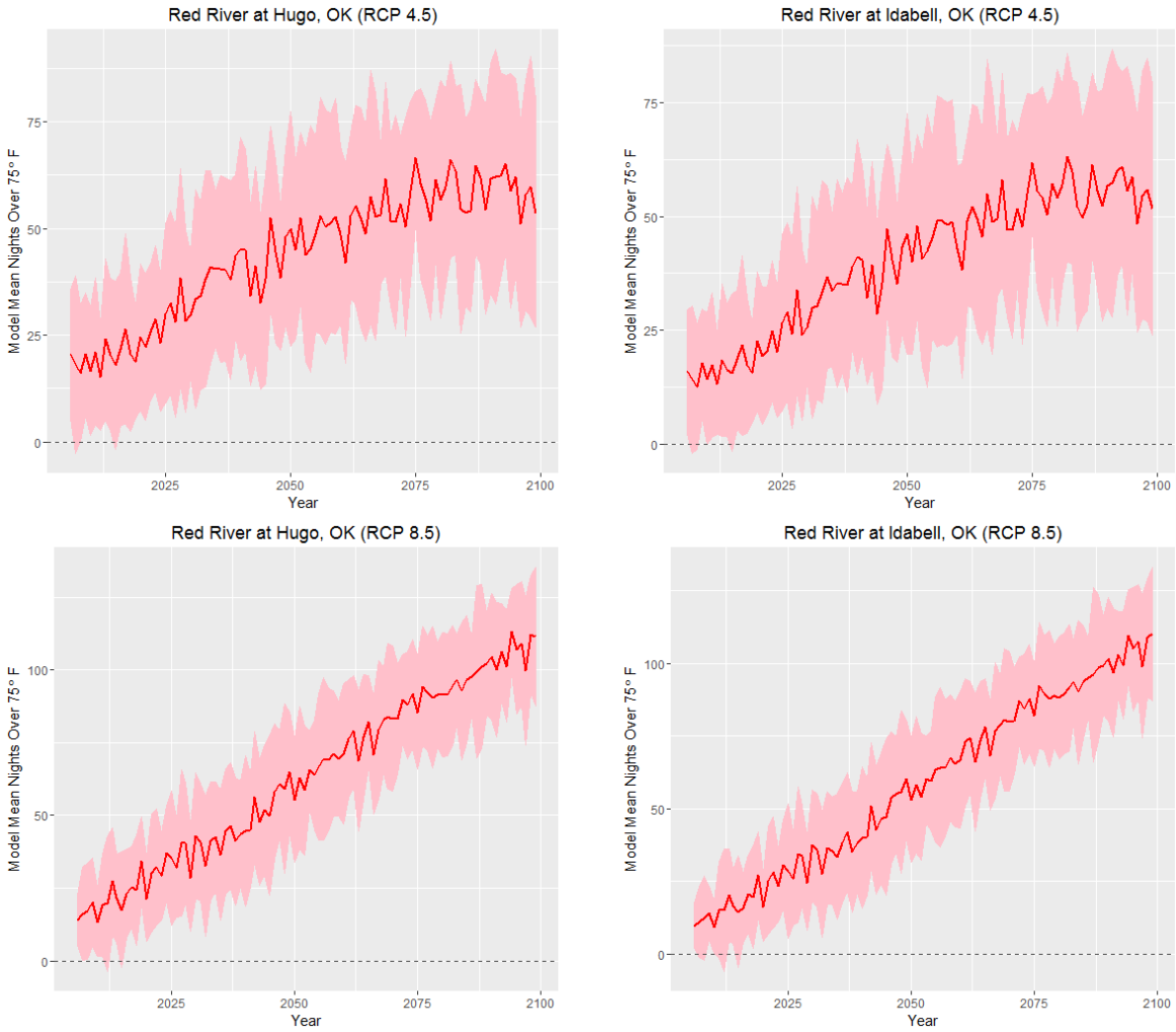

Figure F. The mean (red line) and standard deviation (pink shading) of 20 statistically downscaled climate change models for two locations (East = Idabell, OK; West = Hugo, OK) within the Red River Analysis Area. Each graph shows the change over time in the mean number of nights with minimum temperatures greater than or equal to 75°F. American Burying Beetles in captivity cannot reproduce when temperatures exceed 75°F.

Table A. Mean number nights above 75°F for each of the analysis areas during thirty year periods. RCP are Relative Concentration Pathways representing possible emission scenarios.

Analysis Area		Mean Number of Nights Above 75°F		
Nearest Town	RCP	2010 - 2039	2040 - 2069	2070 - 2099
Red River				
Idabell, OK	4.5	24.9	44.3	54.8
	8.5	26.9	61.3	94.6
Hugo, OK	4.5	28.8	47.9	58.3
	8.5	32.1	65.4	97.3
Arkansas River				
Van Buren, AR	4.5	22.1	38.8	48.5
	8.5	25.2	55.5	88.3
Shawnee, OK	4.5	30.1	46.9	56.0
	8.5	33.5	62.3	91.2
Flint Hills				
Freedonia, KS	4.5	14.5	27.4	34.6
	8.5	17.2	39.9	67.6
Webb City, OK	4.5	26.4	41.3	49.0
	8.5	29.5	54.7	82.1
Loess Canyons				
Lexington, NE	4.5	0.7	3.3	4.9
	8.5	1.0	7.3	24.8
Wellfleet, NE	4.5	0.2	1.4	2.3
	8.5	0.5	3.9	17.6
Sand Hills				
Amelia, NE	4.5	0.5	2.5	4.3
	8.5	0.8	6.1	21.7
Thedford, NE	4.5	0.1	0.6	1.2
	8.5	0.2	2.2	12.4
Niobrara				
Colome, SD	4.5	1.3	4.0	6.5
	8.5	1.7	8.4	24.7
Merriman, NE	4.5	0.1	0.5	0.9
	8.5	0.16	1.79	10.58

Table B. Results of linear regressions for predictions of change in nights above 75°F for each analysis area and emissions scenario.

Analysis Area Nearest Town	RCP	Regression Type	Intercept	Coefficient	R-Squared	*P*-value
Red River						
Idabell, OK	4.5	Ln-Linear	-25.92	0.0144	0.8323	< 0.000
	8.5	Simple Linear	-2216.87	1.1088	0.9860	< 0.000
Hugo, OK	4.5	Ln-Linear	-22.70	0.0129	0.8191	< 0.000
	8.5	Simple Linear	-2134.74	1.0707	0.9828	< 0.000
Arkansas River						
Van Buren, AR	4.5	Ln-Linear	-25.85	0.0143	0.8307	< 0.000
	8.5	Simple Linear	-2058.70	1.0296	0.9850	< 0.000
Shawnee, OK	4.5	Ln-Linear	-19.52	0.0113	0.8137	< 0.000
	8.5	Simple Linear	-1880.91	0.9459	0.9806	< 0.000
Flint Hills						
Freedonia, KS	4.5	Ln-Linear	-28.85	0.0156	0.8300	< 0.000
	8.5	Simple Linear	-1637.89	0.8176	0.9695	< 0.000
Webb City, OK	4.5	Ln-Linear	-19.44	0.0112	0.8182	< 0.000
	8.5	Simple Linear	-1711.35	0.8601	0.9764	< 0.000
Loess Canyons						
Lexington, NE	4.5	Simple Linear	-142.02	0.0706	0.7691	< 0.000
	8.5	Ln-Linear	-83.26	0.0415	0.9701	< 0.000
Wellfleet, NE	4.5	Simple Linear	-69.95	0.0347	0.6952	< 0.000
	8.5	Ln-Linear	-80.95	0.0402	0.9509	< 0.000
Sand Hills						
Amelia, NE	4.5	Simple Linear	-126.09	0.0626	0.8183	< 0.000
	8.5	Ln-Linear	-83.41	0.0415	0.9743	< 0.000
Thedford, NE	4.5	Simple Linear	-35.85	0.0178	0.6863	< 0.000
	8.5	Ln-Linear	-76.11	0.0377	0.9285	< 0.000
Niobrara						
Colome, SD	4.5	Simple Linear	-173.48	0.0864	0.8253	< 0.000
	8.5	Ln-Linear	-75.75	0.0379	0.9732	< 0.000
Merriman, NE	4.5	Simple Linear	-26.65	0.0132	0.5723	< 0.000
	8.5	Ln-Linear	-71.37	0.0353	0.9056	< 0.000

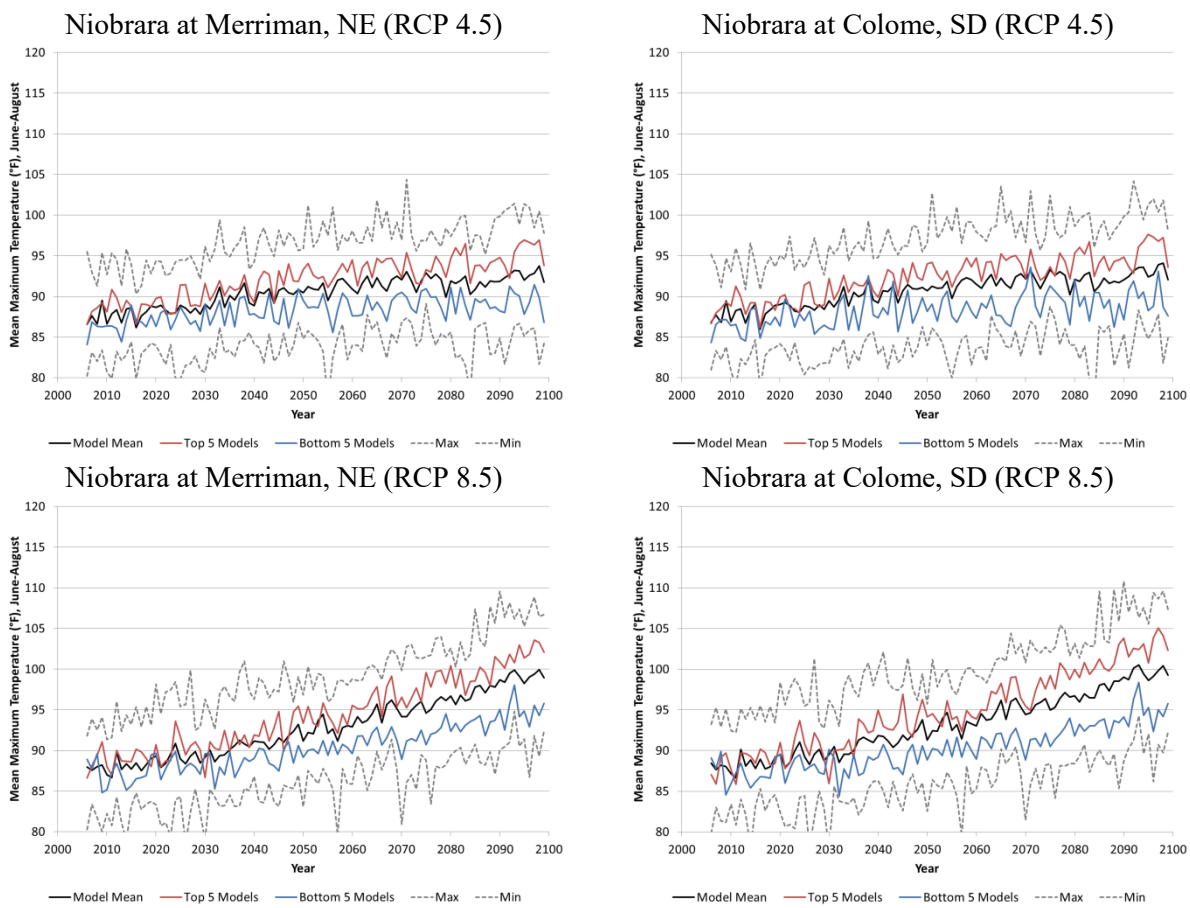

Figure G. The mean (black line), five mean warmest (red line), five mean coolest (blue line), and maximum and minimum values (grey dashed line) of 20 statistically downscaled climate change models for two locations (East = Colome, SD; West =Merriman, NE) within the Niobrara Analysis Area. Each graph shows the change over time in the mean maximum temperature for the months June, July, and August.

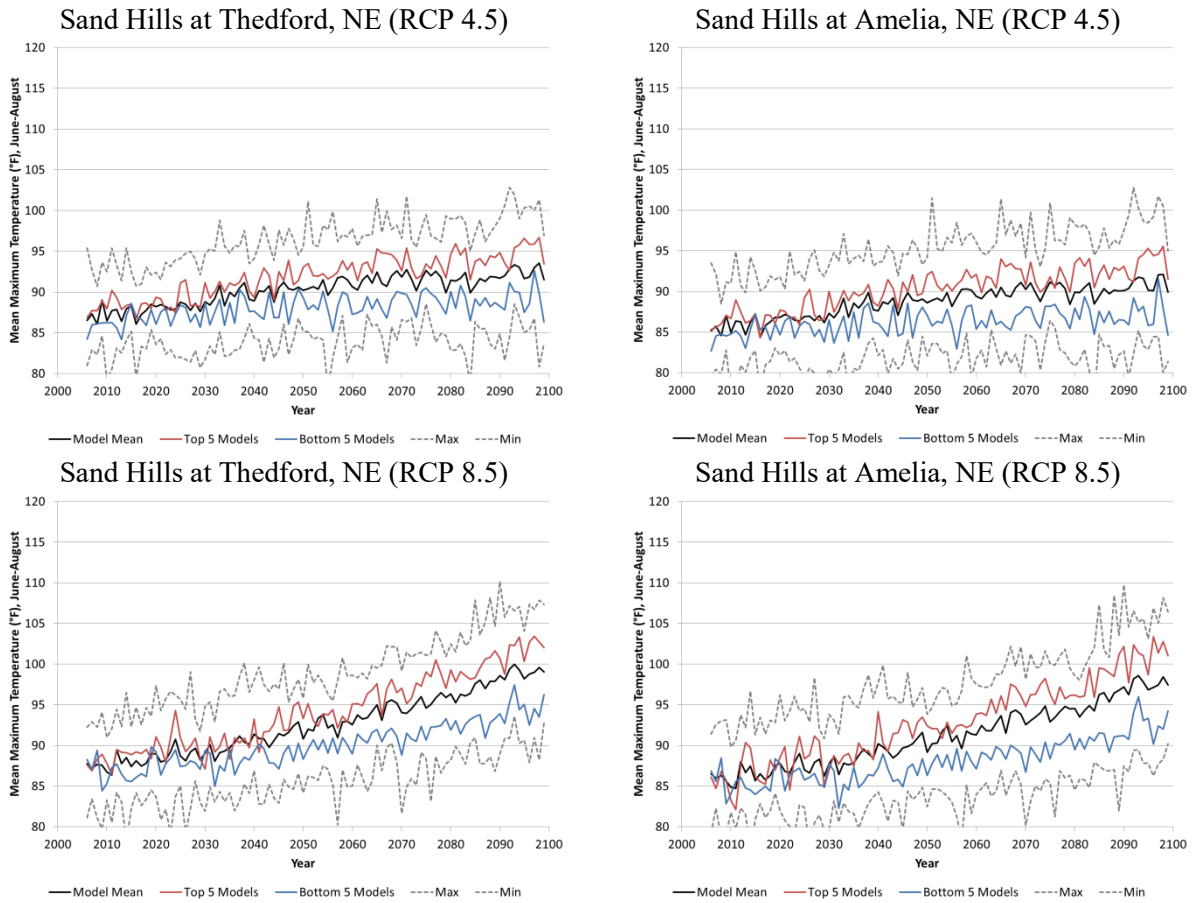

Figure H. The mean (black line), five mean warmest (red line), five mean coolest (blue line), and maximum and minimum values (grey dashed line) of 20 statistically downscaled climate change models for two locations (East = Amelia, NE; West =Thedford, NE) within the Sand Hills Analysis Area. Each graph shows the change over time in the mean maximum temperature for the months June, July, and August.

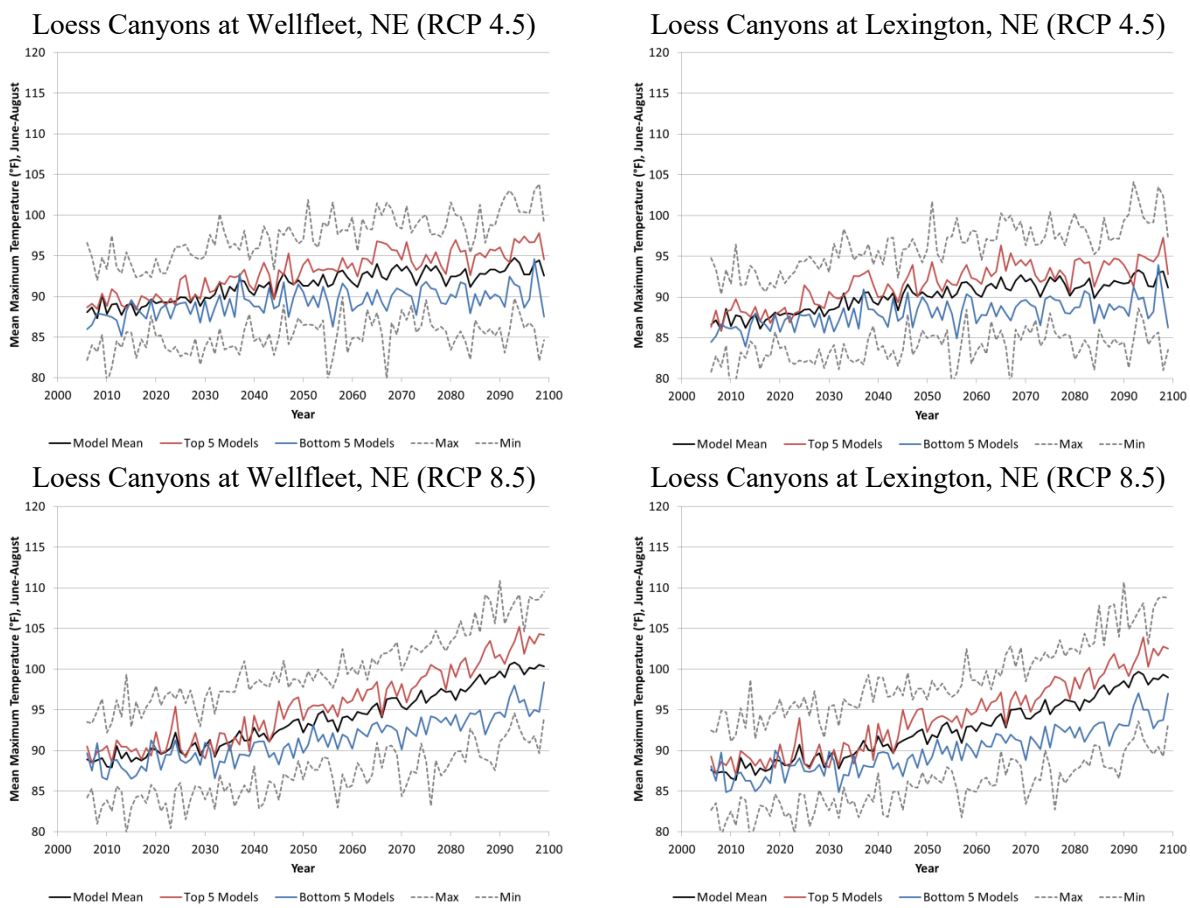

Figure I. The mean (black line), five mean warmest (red line), five mean coolest (blue line), and maximum and minimum values (grey dashed line) of 20 statistically downscaled climate change models for two locations (East = Lexington, NE; West =Wellfleet, NE) within the Loess Canyons Analysis Area. Each graph shows the change over time in the mean maximum temperature for the months June, July, and August.

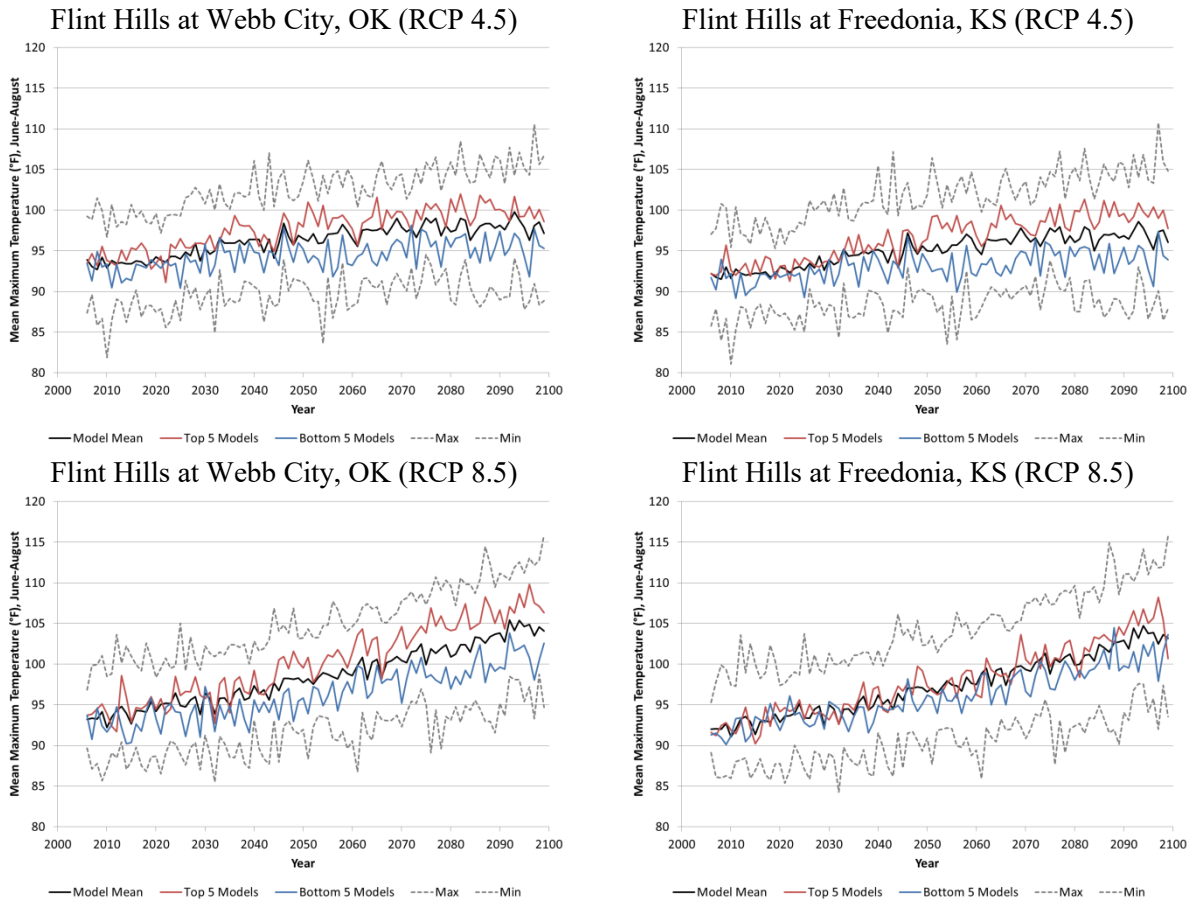

Figure J. The mean (black line), five mean warmest (red line), five mean coolest (blue line), and maximum and minimum values (grey dashed line) of 20 statistically downscaled climate change models for two locations (East = Freedonia, KS; West =Webb City, OK) within the Flint Hills Analysis Area. Each graph shows the change over time in the mean maximum temperature for the months June, July, and August.

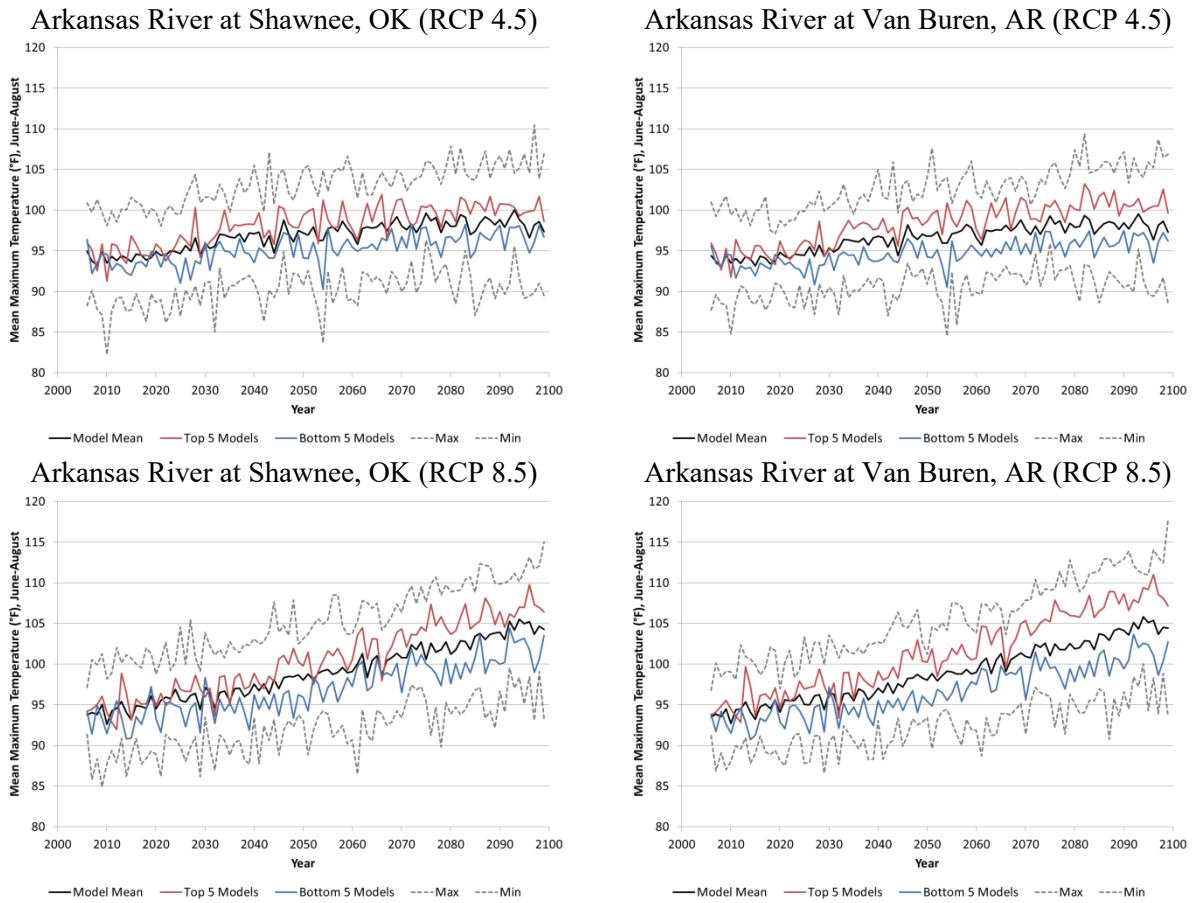

Figure K. The mean (black line), five mean warmest (red line), five mean coolest (blue line), and maximum and minimum values (grey dashed line) of 20 statistically downscaled climate change models for two locations (East = Van Buren, AR; West = Shawnee, OK) within the Arkansas River Analysis Area. Each graph shows the change over time in the mean maximum temperature for the months June, July, and August.

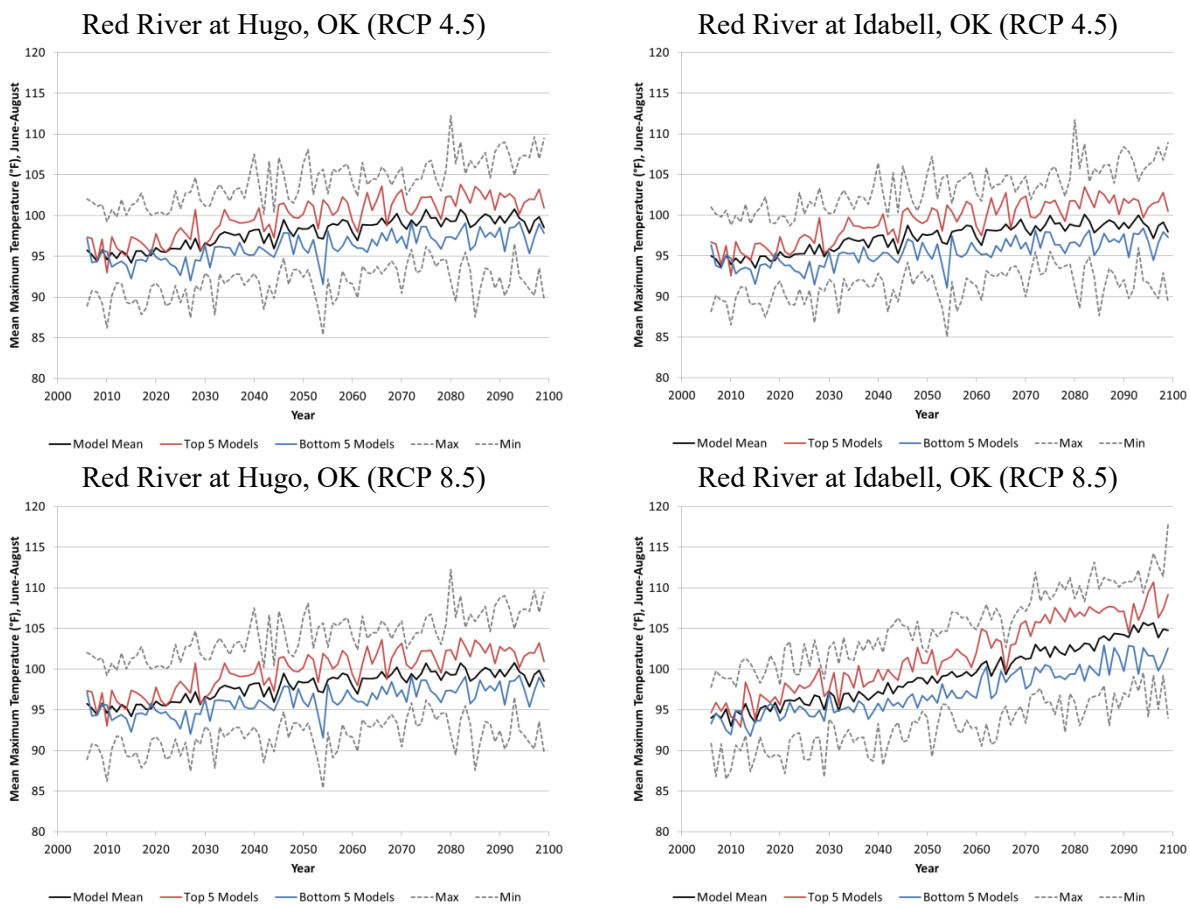

Figure L. The mean (black line), five mean warmest (red line), five mean coolest (blue line), and maximum and minimum values (grey dashed line) of 20 statistically downscaled climate change models for two locations (East = Idabell, OK; West = Hugo, OK) within the Red River Analysis Area. Each graph shows the change over time in the mean maximum temperature for the months June, July, and August.

Table 3. The climate models used to calculate the five warmest (W) and five coolest (C) means for each scenario at each location by analysis area.

Location	Scenario	bcc-csm1-1	bcc-csm1-1-m	BNU-ESM	CanESM2	CCSM4	CNRM-CM5	CSIRO-Mk3-6-0	GFDL-ESM2M	GFDL-ESM2G	HadGEM2-CC365	HadGEM2-ES365	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	IPSL-CM5B-LR	MIROC5	MIROC-ESM	MIROC-ESM-CHEM	MRI-CGCM3	NorESM1-M
Niobrara																					
Merriman, NE	RCP 4.5						C	W	C	C		W				C	W	W	W	C	
	RCP 8.5					W	C	W	C	C	W	W				C		W		C	
Colome, SD	RCP 4.5							W	C	C		W	C			C	W	W	W	C	
	RCP 8.5						C	W	C	C	W	W				C		W		C	W
Sand Hills																					
Wellfleet, NE	RCP 4.5						C	W	C	C		W				C	W	W	W	C	
	RCP 8.5						C	W	C	C		W			W	C		W	W	C	
Amelia, NE	RCP 4.5						C	W	C	C		W				C	W	W	W	C	
	RCP 8.5						C		C	C	W	W				C		W	W	C	W
Loess Canyons																					
Thedford, NE	RCP 4.5						C	W	C	C		W				C	W	W	W	C	
	RCP 8.5						C	W	C	C	W	W				C		W	W	C	
Lexington, NE	RCP 4.5					W	C	W	C	C		W				C	W		W	C	
	RCP 8.5						C	W	C	C		W			W	C		W	W	C	
Flint Hills																					
Webb City, OK	RCP 4.5			W		W	C		C			W	C			C	W		W	C	
	RCP 8.5						C		C		W	W	C		W	C		W	W	C	
Freedonia, KS	RCP 4.5			W			C		C			W	C			C	W	W	W	C	
	RCP 8.5						C		C		W	W	C		W	C		W	W	C	
Arkansas River																					
Shawnee, OK	RCP 4.5						C		C	W	W	W	C			C	W		W	C	
	RCP 8.5						C		C		W	W	C		W	C		W	W	C	
Van Buren, AR	RCP 4.5						C			W	W	W	C			C	W	C	W	C	
	RCP 8.5						C		C		W	W	C		W	C		W	W	C	
Red River																					
Hugo, OK	RCP 4.5						C			W	W	W	C			C	W	C	W	C	
	RCP 8.5			C			C				W		C	W		W	C	W		C	W
Idabell, OK	RCP 4.5						C			W	W	W	C			C	W	C	W	C	
	RCP 8.5			C			C				W	W	C		W	C	W		W	C	

Table 4. The 20 model mean temperature predicted for each decade indicated by scenario, location, and analysis area for the northern beetle range. The difference between the five warmest model mean and five coolest model mean for each decade is also given.

Location	Scenario	Models	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069	2070-2079	2080-2089	2090-2099
Niobrara											
Merriman, NE	RCP 4.5	Mean	87.7	88.4	89.8	90.3	91.1	91.5	91.9	91.6	92.6
		Warmest	1.1	0.9	1.2	1.5	1.7	2.2	1.3	2.7	2.7
		Coolest	-1.0	-1.2	-1.6	-2.2	-2.3	-2.9	-2.5	-2.4	-3.3
	RCP 8.5	Mean	88.0	89.1	90.0	91.4	92.5	94.5	95.3	97.0	99.1
		Warmest	0.7	1.2	0.6	1.4	1.3	1.8	2.4	2.1	2.8
		Coolest	-1.2	-1.0	-1.9	-2.0	-2.4	-3.0	-3.6	-3.8	-4.2
Colome, SD	RCP 4.5	Mean	87.9	88.7	90.0	90.6	91.3	91.8	92.2	91.9	93.0
		Warmest	1.1	0.9	1.3	1.5	1.8	2.3	1.2	2.8	2.7
		Coolest	-1.4	-1.5	-1.9	-2.1	-2.9	-3.6	-2.4	-2.7	-3.3
	RCP 8.5	Mean	88.3	89.3	90.3	91.8	92.9	94.8	95.8	97.3	99.5
		Warmest	0.5	1.2	0.6	2.1	1.2	1.9	2.3	3.1	3.4
		Coolest	-1.3	-1.3	-2.3	-2.6	-2.8	-3.6	-4.2	-4.4	-4.6
Sand Hills											
Wellfleet, NE	RCP 4.5	Mean	88.7	89.5	90.8	91.4	92.0	92.7	92.8	92.6	93.6
		Warmest	0.8	0.7	1.1	1.1	1.6	2.4	1.5	2.7	2.6
		Coolest	-0.8	-1.1	-1.6	-1.9	-2.3	-3.2	-2.7	-2.5	-3.0
	RCP 8.5	Mean	89.1	90.2	91.0	92.6	93.6	95.2	96.4	98.0	100.1
		Warmest	0.9	0.9	0.0	1.7	1.7	1.9	2.2	2.9	3.0
		Coolest	-1.2	-1.0	-1.8	-2.3	-2.3	-2.8	-3.5	-4.3	-4.3
Amelia, NE	RCP 4.5	Mean	85.9	86.7	88.0	88.7	89.3	89.9	90.2	90.0	91.0
		Warmest	0.9	0.7	1.3	1.3	1.9	2.3	1.1	2.8	2.6
		Coolest	-0.8	-1.3	-2.0	-2.5	-2.9	-3.6	-3.0	-2.9	-3.6
	RCP 8.5	Mean	86.4	87.4	88.2	89.9	90.8	92.8	93.8	95.3	97.5
		Warmest	0.2	1.2	0.4	2.1	1.3	2.5	2.6	2.8	3.7
		Coolest	-1.2	-1.3	-2.5	-3.0	-2.9	-3.8	-4.3	-4.7	-4.8
Loess Canyons											
Thedford, NE	RCP 4.5	Mean	87.4	88.2	89.6	90.2	90.8	91.4	91.7	91.4	92.5
		Warmest	1.0	0.8	1.2	1.3	1.7	2.3	1.3	2.8	2.6
		Coolest	-0.9	-1.1	-1.6	-2.1	-2.4	-3.2	-2.7	-2.6	-3.2
	RCP 8.5	Mean	87.9	88.9	89.8	91.3	92.3	94.1	95.2	96.9	99.0
		Warmest	0.8	1.4	0.2	1.4	1.1	2.0	2.5	2.5	2.9
		Coolest	-1.2	-1.0	-1.9	-2.4	-2.5	-3.1	-3.7	-4.2	-4.4
Lexington, NE	RCP 4.5	Mean	87.2	88.1	89.4	90.1	90.7	91.3	91.6	91.3	92.2
		Warmest	0.9	0.8	2.0	1.0	1.6	2.3	1.2	2.6	2.0
		Coolest	-0.8	-1.1	-1.6	-1.9	-2.4	-3.2	-2.6	-2.5	-2.9
	RCP 8.5	Mean	87.7	88.8	89.6	91.3	92.2	93.8	95.1	96.8	98.9
		Warmest	0.9	0.8	0.2	1.7	1.6	1.9	2.1	2.7	2.7
		Coolest	-1.2	-1.0	-1.8	-2.4	-2.4	-2.8	-3.5	-4.4	-4.3

Table 5. The 20 model mean temperature predicted for each decade indicated by scenario, location, and analysis area for the southern beetle range. The difference between the five warmest model mean and five coolest model mean for each decade is also given.

Location	Scenario	Models	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069	2070-2079	2080-2089	2090-2099
Flint Hills											
Webb City, OK	RCP 4.5	Mean	93.5	94.3	95.8	96.2	96.9	97.4	97.9	97.9	98.1
		Warmest	0.9	0.6	1.5	0.9	2.2	1.4	1.5	2.6	1.6
		Coolest	-1.0	-1.2	-1.3	-1.4	-2.8	-2.8	-2.1	-2.4	-2.5
	RCP 8.5	Mean	93.9	95.1	95.8	97.3	98.4	99.8	101.4	102.5	104.3
		Warmest	0.6	1.0	0.7	1.6	1.7	2.3	3.0	3.1	2.8
		Coolest	-1.3	-1.7	-1.7	-2.4	-2.3	-1.7	-2.8	-3.4	-3.2
Freedonia, KS	RCP 4.5	Mean	92.1	93.0	94.4	94.9	95.7	96.2	96.8	96.7	97.0
		Warmest	0.7	0.3	0.7	1.1	2.5	1.8	1.6	3.0	2.4
		Coolest	-0.9	-1.2	-1.3	-1.5	-2.9	-3.1	-2.3	-2.5	-2.7
	RCP 8.5	Mean	92.7	93.8	94.5	96.2	97.3	98.8	100.2	101.4	103.4
		Warmest	0.0	0.5	0.4	0.7	0.3	0.1	0.8	0.9	1.8
		Coolest	0.1	-0.5	-0.8	-1.1	-1.7	-1.3	-1.9	-1.5	-2.5
Arkansas River											
Shawnee, OK	RCP 4.5	Mean	94.1	95.0	96.4	96.8	97.4	97.8	98.3	98.4	98.4
		Warmest	0.6	0.8	1.1	1.5	1.7	1.3	1.4	2.0	1.8
		Coolest	-0.8	-1.8	-1.4	-1.4	-2.6	-2.0	-1.9	-1.9	-1.4
	RCP 8.5	Mean	94.4	95.6	96.3	97.7	98.9	100.1	101.8	102.8	104.5
		Warmest	0.6	0.9	0.7	1.7	1.4	1.9	2.7	2.7	2.3
		Coolest	-1.1	-1.8	-1.6	-2.3	-2.2	-1.3	-2.2	-2.9	-2.6
Van Buren, AR	RCP 4.5	Mean	93.8	94.7	95.9	96.5	97.1	97.5	98.0	98.2	98.1
		Warmest	0.6	0.9	1.4	1.9	2.3	1.8	1.9	3.0	2.5
		Coolest	-0.7	-1.7	-1.7	-1.7	-2.9	-2.3	-2.1	-2.3	-1.8
	RCP 8.5	Mean	94.4	95.4	96.1	97.6	98.7	100.3	101.8	103.0	104.6
		Warmest	1.3	1.5	1.2	2.5	2.1	2.8	3.7	4.1	3.8
		Coolest	-1.4	-1.9	-1.7	-2.4	-2.4	-1.7	-2.8	-3.3	-3.3
Red River											
Hugo, OK	RCP 4.5	Mean	95.1	96.1	97.3	97.8	98.5	98.9	99.3	99.6	99.4
		Warmest	0.8	1.3	1.4	1.9	2.4	2.1	2.1	2.8	2.6
		Coolest	-0.8	-2.0	-1.6	-1.6	-2.7	-2.1	-2.0	-2.1	-1.7
	RCP 8.5	Mean	95.2	96.4	97.1	98.5	99.5	100.9	102.6	103.7	105.2
		Warmest	0.7	1.7	1.6	2.0	1.9	2.3	3.7	3.4	2.4
		Coolest	-0.7	-1.2	-1.3	-2.0	-2.2	-1.6	-2.8	-2.7	-3.3
Idabell, OK	RCP 4.5	Mean	94.4	95.4	96.5	97.1	97.8	98.1	98.6	98.9	98.7
		Warmest	0.9	1.3	1.5	2.0	2.5	2.2	2.2	3.0	2.7
		Coolest	-0.9	-2.0	-1.7	-1.6	-2.7	-2.2	-2.0	-2.1	-1.8
	RCP 8.5	Mean	94.7	95.9	96.6	98.0	99.1	100.5	102.2	103.3	104.8
		Warmest	0.8	1.9	1.8	2.2	2.2	2.8	4.0	3.8	2.8
		Coolest	-0.7	-1.3	-1.4	-2.1	-2.3	-1.8	-2.9	-2.9	-3.4