

Abstract:

Rapid, extensive urbanization has caused a rise in minimum temperatures of upwards of 6°C within metropolitan Phoenix, Arizona during the past half century. Though much urban heat island (UHI) research within the region focuses on summer temperatures, this project examines the temporal and spatial change in frost and freeze patterns within the metropolitan area during the past decade. The study uses temperature records from 1995 through 2005 from 14 weather stations scattered across the metropolitan area, and situated in urban, suburban and rural settings. Station data are evaluated for changes in the number and duration of frost/freeze events – the number of hours and days at or below the 4°C threshold, the point at which plants become stressed by cold. Statistical analysis is used to determine similarities, differences, and change in stations' temperature patterns that may be linked to encroaching urbanization.

Background and Methods

Phoenix, Arizona, USA's explosive growth has doubled the population from 1980 to 2000 with 3.09 to 4.36 percent annual growth rates. In 2005, the population was >3.6 million within metropolitan area. The heterogeneous urban fabric with its differences in vegetation, land use and materials produces considerable air temperature variability across the metropolitan area (see center map). The climate is a hot, dry, desert climate, with summer temperatures frequently reaching over 40°C. Winter temperatures are warm, though frosts and freezes occur.

Landscape vegetation has changed considerably in the past 30 years within the metropolitan area – with many more frost sensitive plants being the landscape material of choice. This may not be such a smart idea for some areas as there is considerable variability in temperatures in the metropolitan area as can be seen by the maps (center). The average annual number of frost events (at or below 4°C) ranged from 12 to 67 and the average number of hours ranged from 21 to 410 hours.

Winter Temperatures °C	November	December	January	February	March
Mean Maximum	23.9	19.5	19.6	21.9	24.5
Mean Minimum	10.2	6.6	7.1	9.3	11.7
Monthly Mean	17.1	13.1	13.4	15.5	18.1

Several stations, particularly southeast of the city center, experienced land use/landcover change during the 10 year study period (LULCC stations). These LULCC weather stations were situated in rural settings in 1995 but were encroached upon by urbanization by 2005 (see maps on right).

Statistical analyses on temperature data show a trend with reductions in the number, duration and intensity of events at the 4°C threshold at these stations. Cluster analyses were done on data for the ten year period, five year increments, and individual seasons, producing considerably different results. Analyses on individual years' data show a change over the study period indicative of the impact of urbanization and the impacts of the accompanying urban heat island.

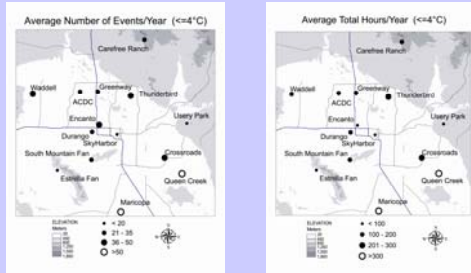


(Shown on the McDowell Mountains: Suburban Phoenix - Winter 2002)



Results:

Though metropolitan Phoenix experiences considerable variability in frost/freeze temperature events, the impact of expanding urbanization can be seen statistically in the data. Stations experiencing land use/landcover change during the 10 year study period show a drop in the number of freeze events (days per winter season) and duration (hours per event and hours per year) when compared to stations not impacted by much change during the same period. Cluster analyses show that these LULCC stations, which in 1995 either did not cluster with other stations or clustered with other rural stations, by 2005 clustered differently – generally with stations located within urbanized areas. While this change in frost and freeze patterns can have positive implications for energy consumption, increases in minimum temperatures could have long term impacts on native vegetation.



Temperature Trends 1995 to 2005			
Weather Station (Red indicates station changed in cluster analysis)	Average Number of Events Trend	Average Duration Trend	Minimum Temperature Trend
ACDC	2.78	0.36	-0.24
Carefree Ranch	0.98	0.03	0.12
Cross Roads	-2.59	-0.11	0.13
Durango	-0.34	0.06	-0.27
Encanto	-0.01	0.00	-0.03
Estrella Fan	0.08	0.07	0.06
Greenway	-0.19	0.07	-0.04
Maricopa	-1.41	-0.01	0.03
Queen Creek	-2.59	-0.16	0.10
S Mountain Fan	-1.4	0.19	0.08
Sky Harbor	-0.47	-0.06	0.06
Thunderbird	1.64	0.14	-0.09
Usery	0.24	0.08	0.09
Waddell	0.54	0.16	0.00

AS HOUSING STARTS ENCROACH UPON RURAL STATIONS...



Maricopa County's Housing Starts* – 1990 - 1994

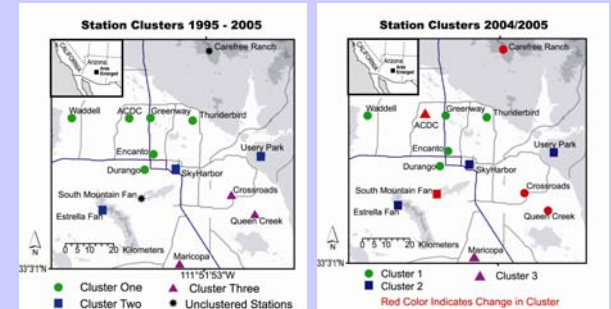


Maricopa County's Housing Starts – 1995 - 1999



Maricopa County's Housing Starts – 2000 - 2004

BY THE 2004 – 05 WINTER SEASON “RURAL” STATIONS STATISTICALLY CLUSTER WITH URBAN STATIONS



*The Maricopa Weather Station is located in Pinal County