



Urbanization may reduce the risk of frost damage to spring flowers in South Korea

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Regional warming, owing to urbanization, leads to earlier spring phenological events and may expose plants to hard freeze damage. This study examined the influence of urbanization on the risk of frost damage to spring flowers in South Korea from 1973 to 2015. For the analysis period, we categorized 25 cities into two groups: those showing rapid population growth (rPG) [$> 200,000$], including 13 cities, and those showing no or decreased population growth (nPG), including 12 cities. We then investigated the time from the last frost dates (LFDs) in spring to the first flowering dates (FFDs) for each group. The rPG group experienced significant spring warming of 0.47 C per decade, resulting in earlier LFDs and FFDs. For this group, the advancement of LFD was more rapid than that of FFD, and the days between these two dates increased from 0.42 to 0.47 days per decade, implying a reduced risk of frost damage. Spring warming and the advancement of FFDs and LFDs were relatively small for the nPG group, and the LFDs were rather delayed. Consequently, the days between LFDs and FFDs were reduced from -1.05 to -1.67 days per decade, indicating an increased risk of frost damage. The contrasting changes in the frost-damage risk between the two city groups can be attributed to distinct urban warming at night, which makes the LFDs substantially earlier in the rPG group. Therefore, this study suggests that the warming associated with urbanization may lessen the risk of spring frost damage to plants in rapidly growing urban areas.