Urban heat island effects account for a third of warming that drives plant phenology trends in a northern city

Elisabeth G. Beaubien[1]*, Mariah Casmey, Andreas Hamann [1], Annette Menzel [2]

[1] Department of Renewable Resources, University of Alberta
751 General Services Building, Edmonton, AB, Canada, T6G 2H1

[2] TUM School of Life Sciences, Ecoclimatology
Hans-Carl-von-Carlowitz Platz 2, 85354 Freising, Germany

Abstract: Plant phenology research has provided compelling evidence for biological responses to global climate change. However, warming trends are potentially exacerbated by urban heat island effects that increase due to population and economic growth. Here, we quantify heat island effects over a period of 85 years from 1936 to 2021, based on phenology data from urban and rural areas around Edmonton, a Canadian city at 53°N latitude that has experienced a 12-fold population increase and an expansion of built-up area from approximately 30 to 600 km² over the study period. We found statistically significant earlier bloom dates for five of seven plant species in urban versus rural locations, and due to the high density of the observer network, we could spatially map an urban heat island approximately 500 km² in size. Across all seven plant species in this study, the advance in phenology observed in urban areas was 5.8 days compared to 3.7 days in surrounding rural areas. The heat island effect, causing the 2.1 day difference, accounts for approximately one third of the 85-year phenology trend towards earlier flowering of plants in a northern city.

(*Manuscript under peer review. Key figures are included below.*
For more information, please contact *ebeaubie@ualberta.ca*)

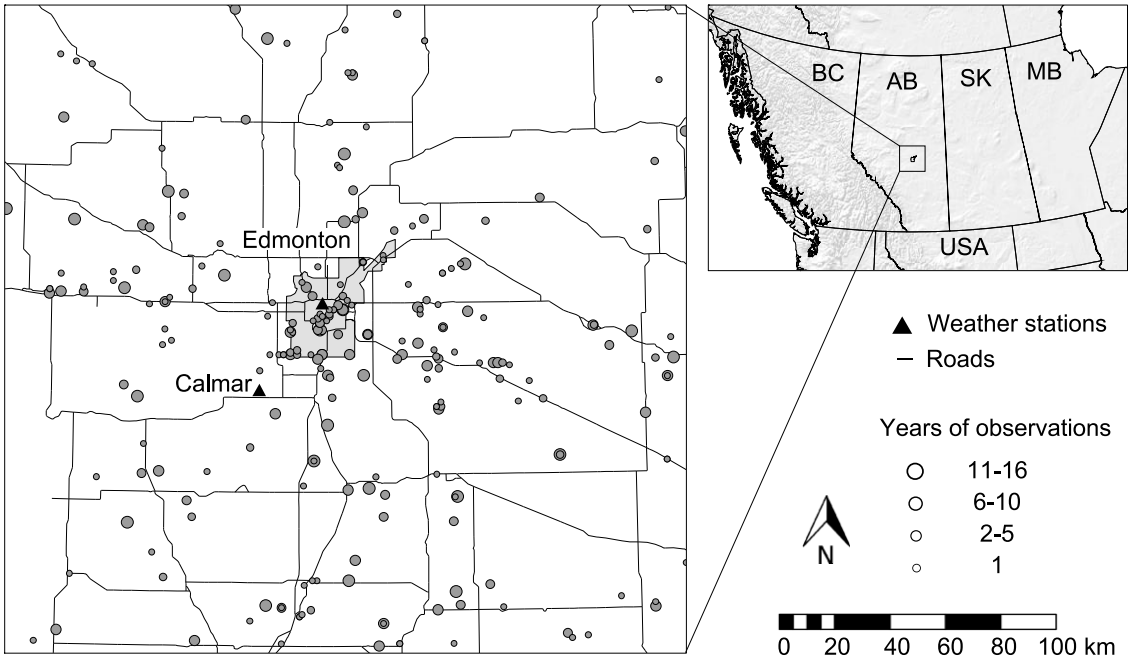

Fig. 1. Study area, 225×225 km in size, centered around Edmonton, Alberta. The gray area represents approximately 700 km^2 demarcated as land of the city of Edmonton, of which 500 km^2 are classified as urban. Plant phenology observation locations are shown by circles on map. Provinces of Canada indicated in the overview map are British Columbia (BC), Alberta (AB), Saskatchewan (SK) and Manitoba (MB).

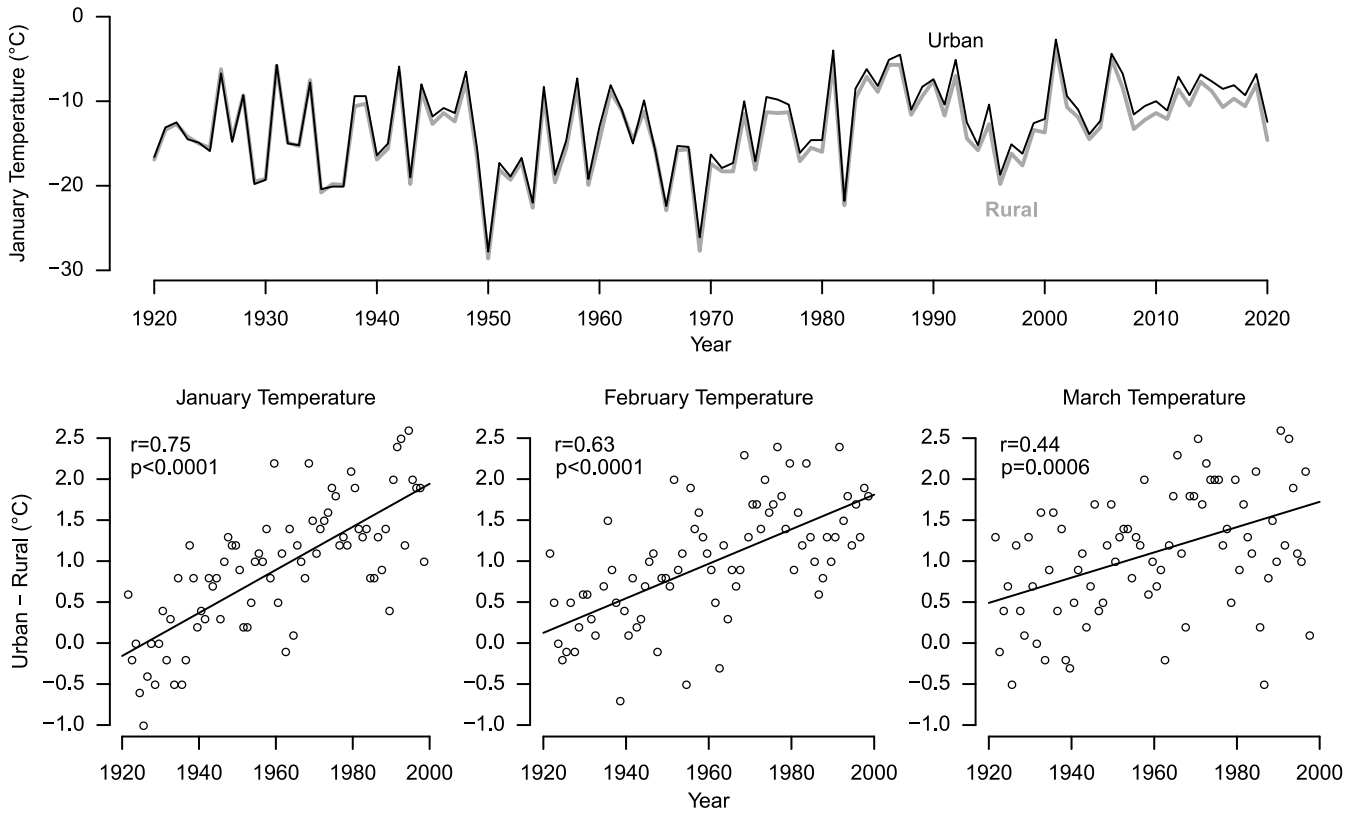

Fig. 2. Temperature records for the urban (Edmonton) versus rural (Calmar) weather stations. A heat island effect becomes visually apparent in the late 1960s for mean January temperature (a), and the difference between rural and urban temperature records significantly increase over time for January to March mean temperatures (b). There is no significant heat island effect for temperature in April and May (Table 1).

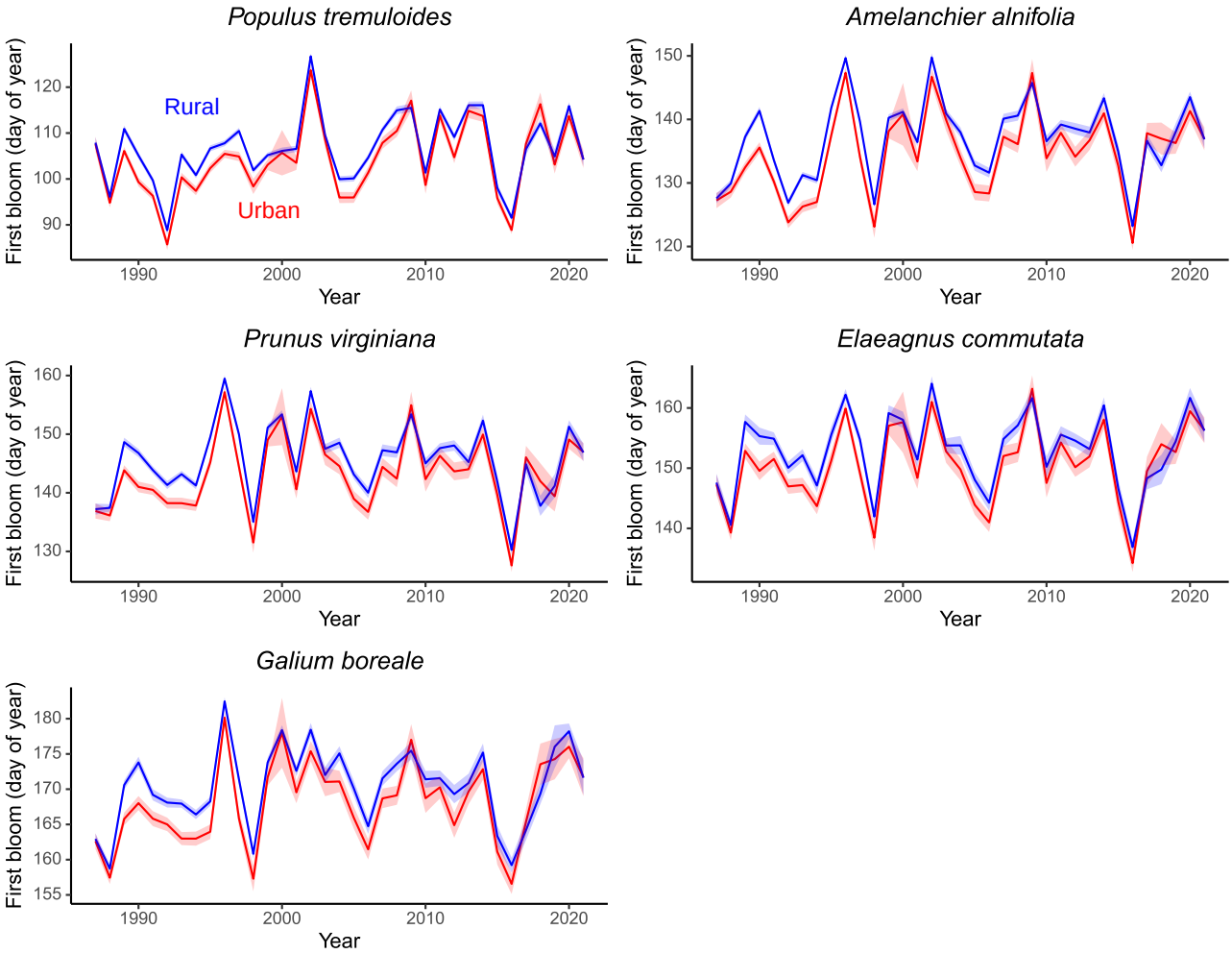

Fig. 3. First bloom time series, for five out of seven species that showed a significant difference between urban (red) and rural (blue) observations (Table 2). Standard errors for individual years of urban and rural least squares means are indicated by transparent ribbons.

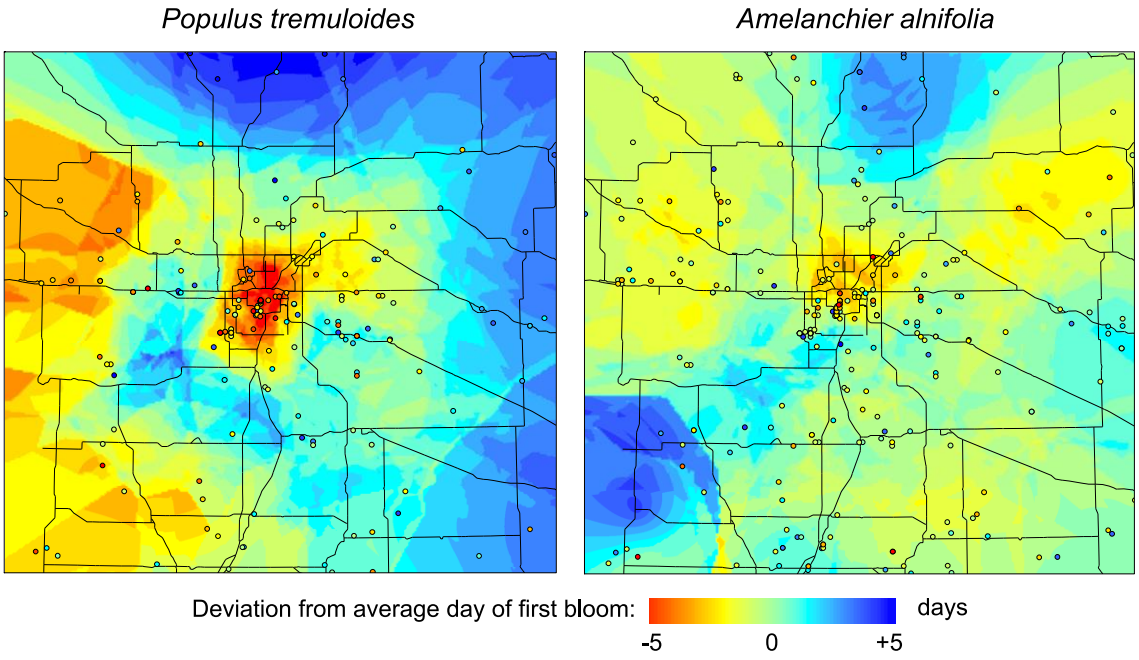

Fig. 4. Interpolated deviation from the average day of first bloom for a 225×225 km area centered around Edmonton, Alberta. Heat islands indicated by earlier bloom times are visible for the two species with the best spatial data coverage and the most accurate reporting of bloom times, aspen poplar (*Populus tremuloides* Michx.) and saskatoon (*Amelanchier alnifolia* Nutt.). Colours of dots (data points) and background represent deviations from mean first bloom date.