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Planning of Urban Greenspace for Cooling Singapore: Modeling the Cooling Effects of Greenspace and Urban Morphology

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The intensified accumulation of greenhouse gasses has led to rapid changes in global temperature trends and climate. In urban areas, this issue may also be exacerbated by the Urban Heat Island (UHI) effect. There is an extensive body of studies investigating the effectiveness of nature-based solutions in addressing these concerns. The majority of investigations have been conducted in evaluating the performance of urban greenspaces on cooling the environment since greenspaces can provide significant urban cooling via shade provision, evapotranspiration, and increased albedo. However, there remain some technical constraints for currently widely used methods for quantifying the cooling effect of greenspace. For example, although remote sensing techniques can provide spatially representative temperature observations over large areas from regional to global scales, satellite thermal sensors possess relatively low-spatial resolution. Therefore, this study proposes an effective temperature downscaling method to assess the cooling effect of urban greenspaces based on the high-resolution temperature data. A total of five sites among typical urban communities in a highly-density city/country - Singapore were selected as study areas. The temperature downscaling algorithm proposed in this research combines predictions of both the geographically weighted regression (GWR) and the neural network. Results show that the hybrid temperature downscaling method outperforms the conventional downscaling method on whole territories of study regions. The cooling effect of greenspace improves with both increments in the area and the intensity of greenspace (indicated by the green plot ratio; GnPR) with R^2 of 0.12 and 0.24, respectively. The characteristics of the urban built environment can also affect the cooling effect of greenspace with the R^2 between the cooling effect and the sky view factor (SVF) ranging from 0.10 to 0.22 among the sites. Based on the high-resolution cooling performance of greenspace, our research offered some interesting findings: (1) small greenspace with low canopy density (e.g., small patches of grassland) may deliver higher temperature than the temperature of surroundings, thus becoming local heat islands. (2) In sites characterized by relatively high SVF, greenspace is less effective in urban cooling with an increase of openness. This suggests the effect of wind in dense high-rise urban built environments. These findings may assist in better planning of urban greenspaces to increase their cooling effects among different urban communities. The model developed in this study can also be used in other studies to study the influences of potential driving factors on the cooling performance of urban greenspace or other types of nature-

based solutions at the regional level.