# Urban forest expansion is predicted to reduce the air temperature impacts of urban heat islands

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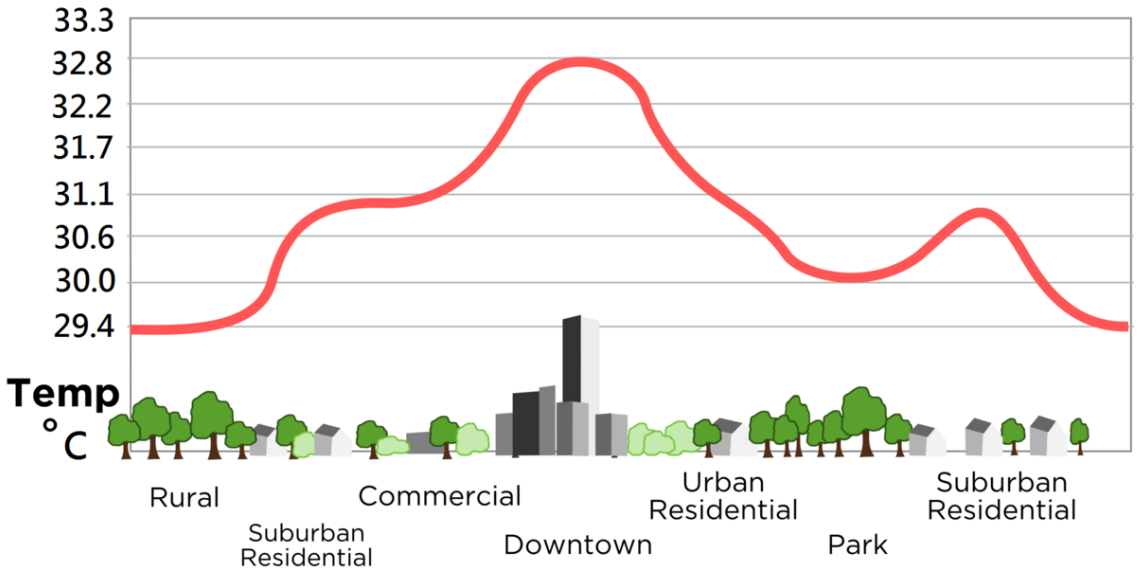
# Motivation & Science Question

- Sustainable Development Goals impeded by urban heat islands.
- How will **no** versus **more** urban forests affect air temperatures?



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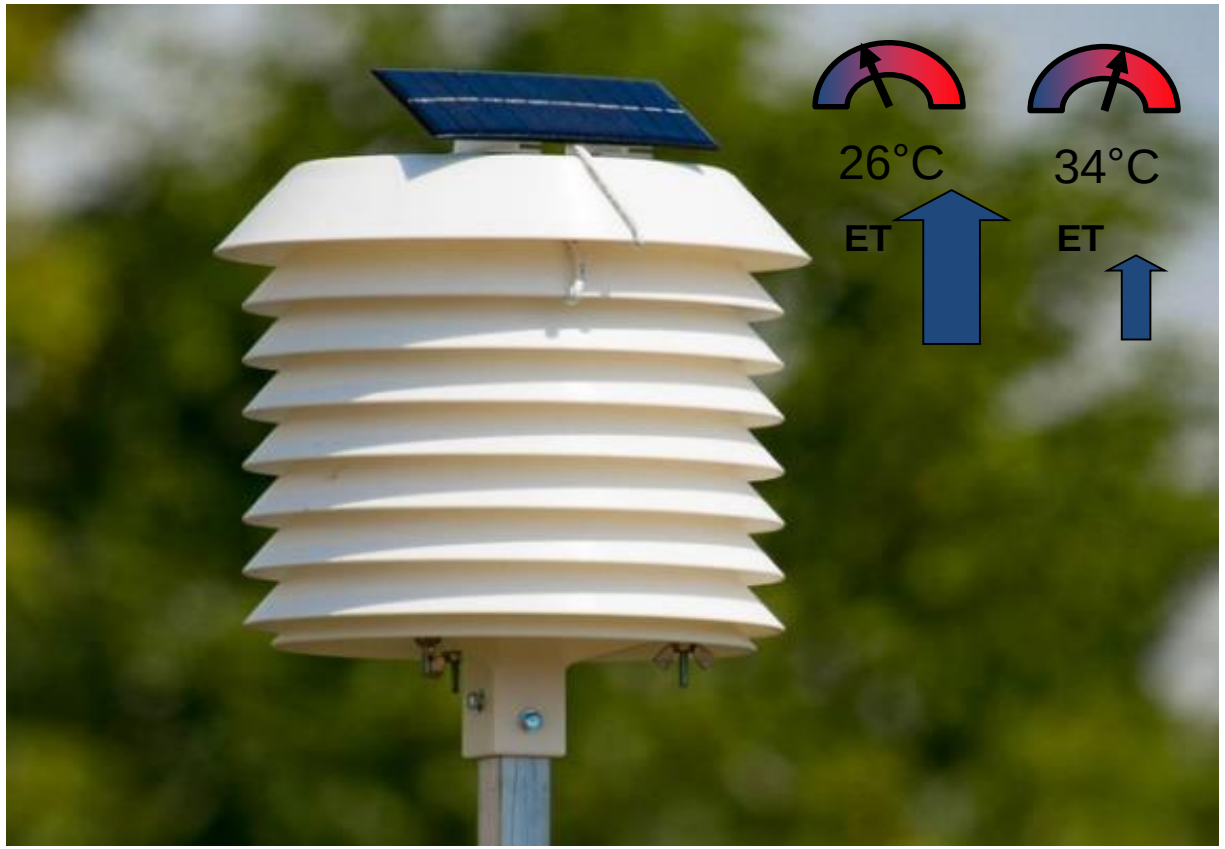
# Methods 1: Modeling Microclimate

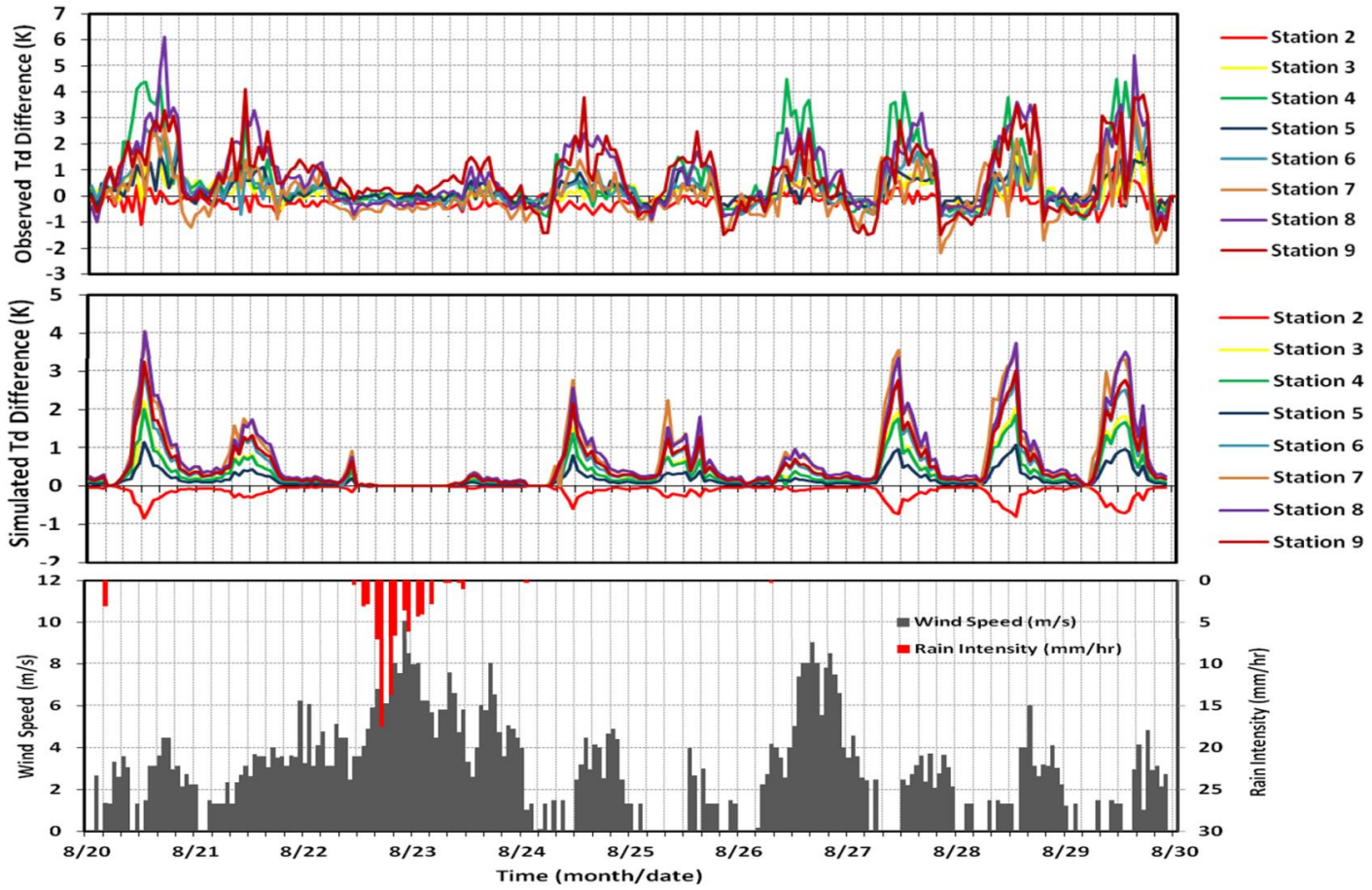
**i-Tree Cool Air Water balance*: PPT = RO + ET + $\Delta S_W$ & Energy balance*: NR = SE + LE + $\Delta S_E$**

**The 2 balances are connected: ET = LE / ($\lambda \rho_w$) & Air temperature determined: $T_{air}$ = (SE r) / ($C_p \rho_a$)**
**Less ET equals less LE and more SE, and hotter air**




*** PPT = precipitation, RO = runoff, ET = evapotranspiration, $\Delta S_W$ = change in storage of water**
*** NR = net radiation, SE = sensible energy, LE = latent energy, $\Delta S_E$ = change in storage of energy**
**$\lambda$ = latent heat of vaporization, $\rho_w$ = density of water, r = resistance, $C_p$ = specific heat, $\rho_a$ = density of air**

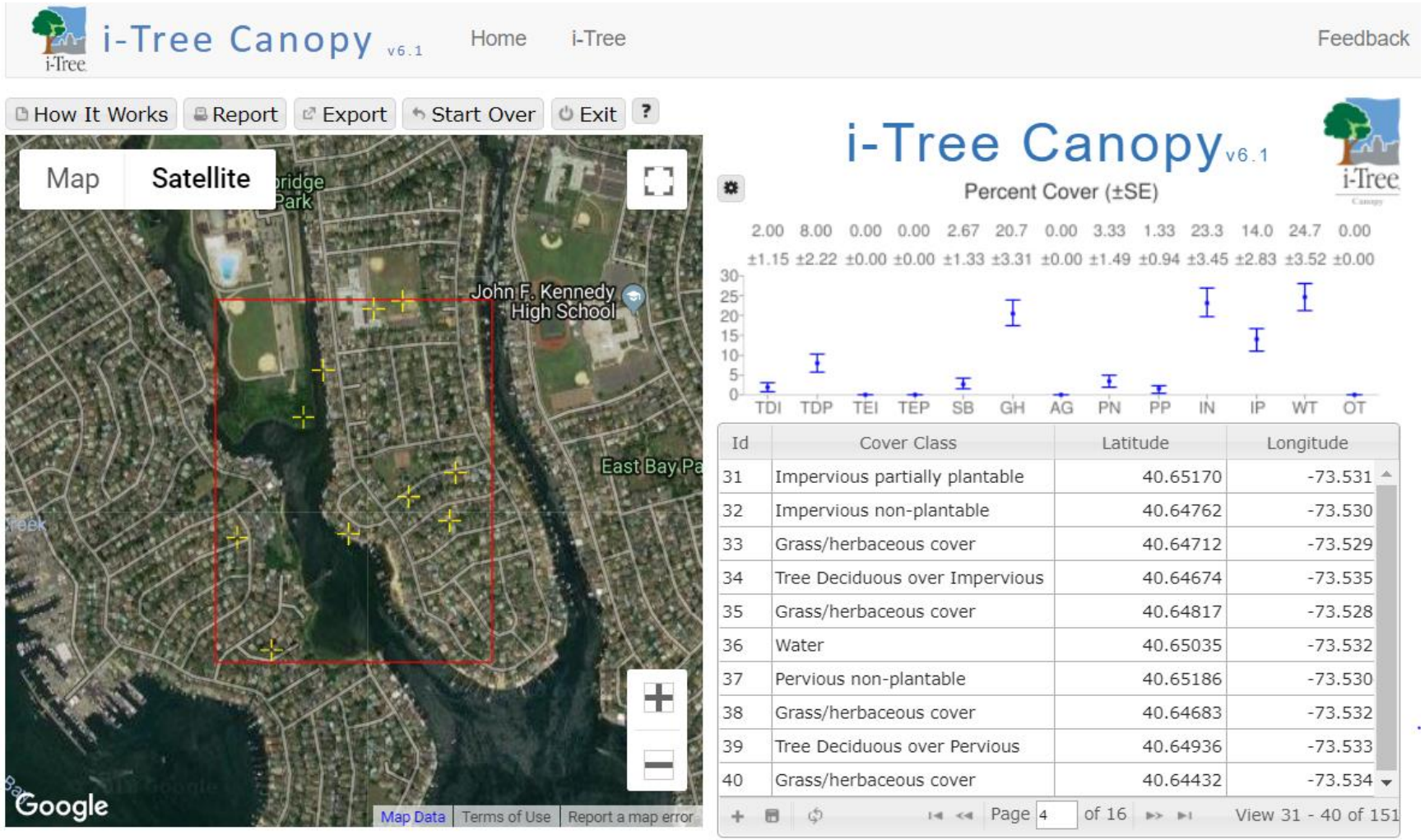
# Methods 1: Model Validation




Yang, Y., T.A. Endreny, and D.J. Nowak. "A Physically Based Analytical Spatial Air Temperature and Humidity Model", Journal of Geophysical Research: Atmospheres, 118(18): 10,449-10,463, DOI: 10.1002/jgrd.50803, 2013.

# Methods 2: Megacity Study Sites

# Methods 3: Land Cover Types




| Id | Cover Class | Latitude | Longitude |
|---|---|---|---|
| 31 | Impervious partially plantable | 40.65170 | -73.531 |
| 32 | Impervious non-plantable | 40.64762 | -73.530 |
| 33 | Grass/herbaceous cover | 40.64712 | -73.529 |
| 34 | Tree Deciduous over Impervious | 40.64674 | -73.535 |
| 35 | Grass/herbaceous cover | 40.64817 | -73.528 |
| 36 | Water | 40.65035 | -73.532 |
| 37 | Pervious non-plantable | 40.65186 | -73.530 |
| 38 | Grass/herbaceous cover | 40.64683 | -73.532 |
| 39 | Tree Deciduous over Pervious | 40.64936 | -73.533 |
| 40 | Grass/herbaceous cover | 40.64432 | -73.534 |

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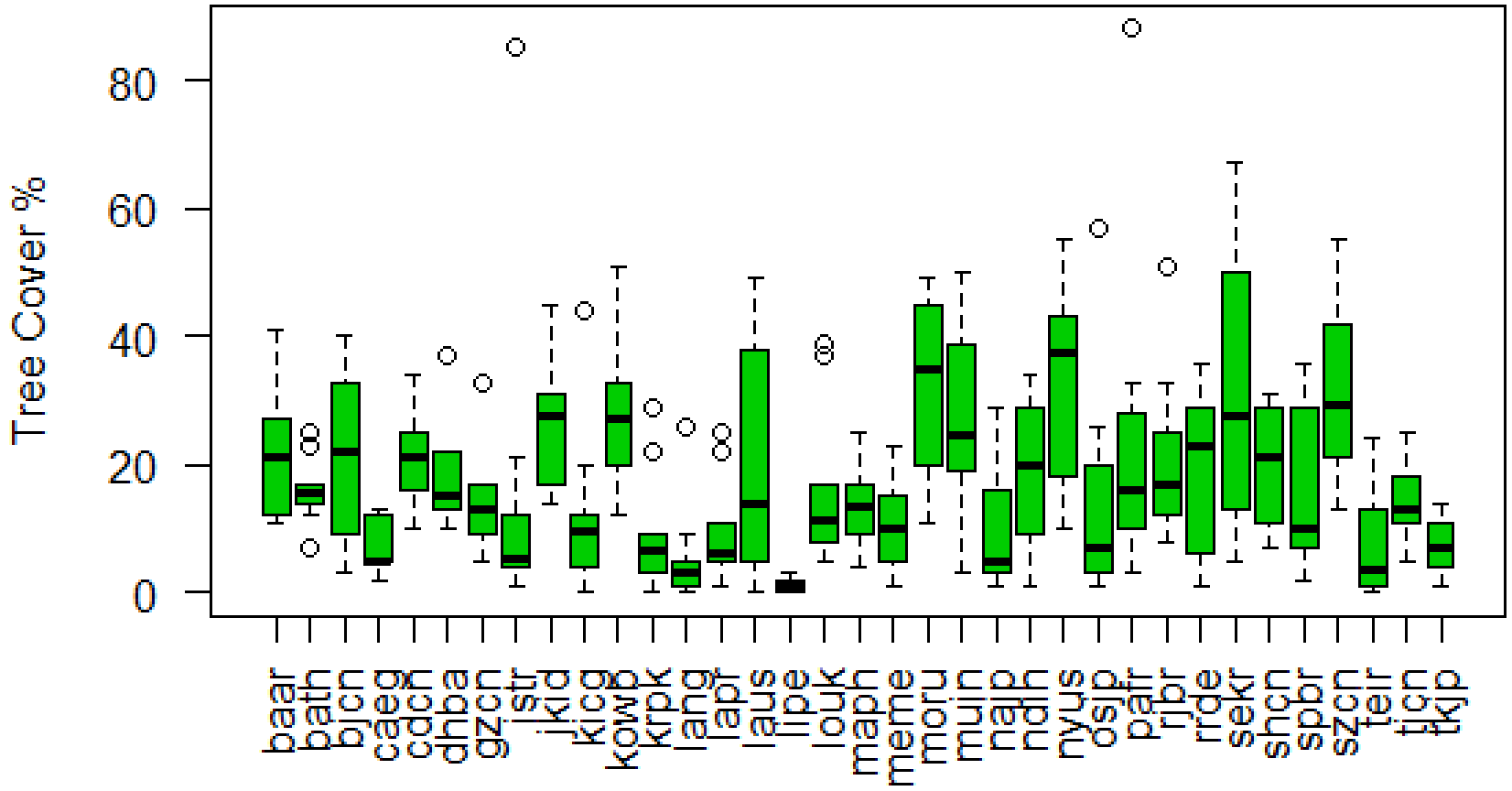
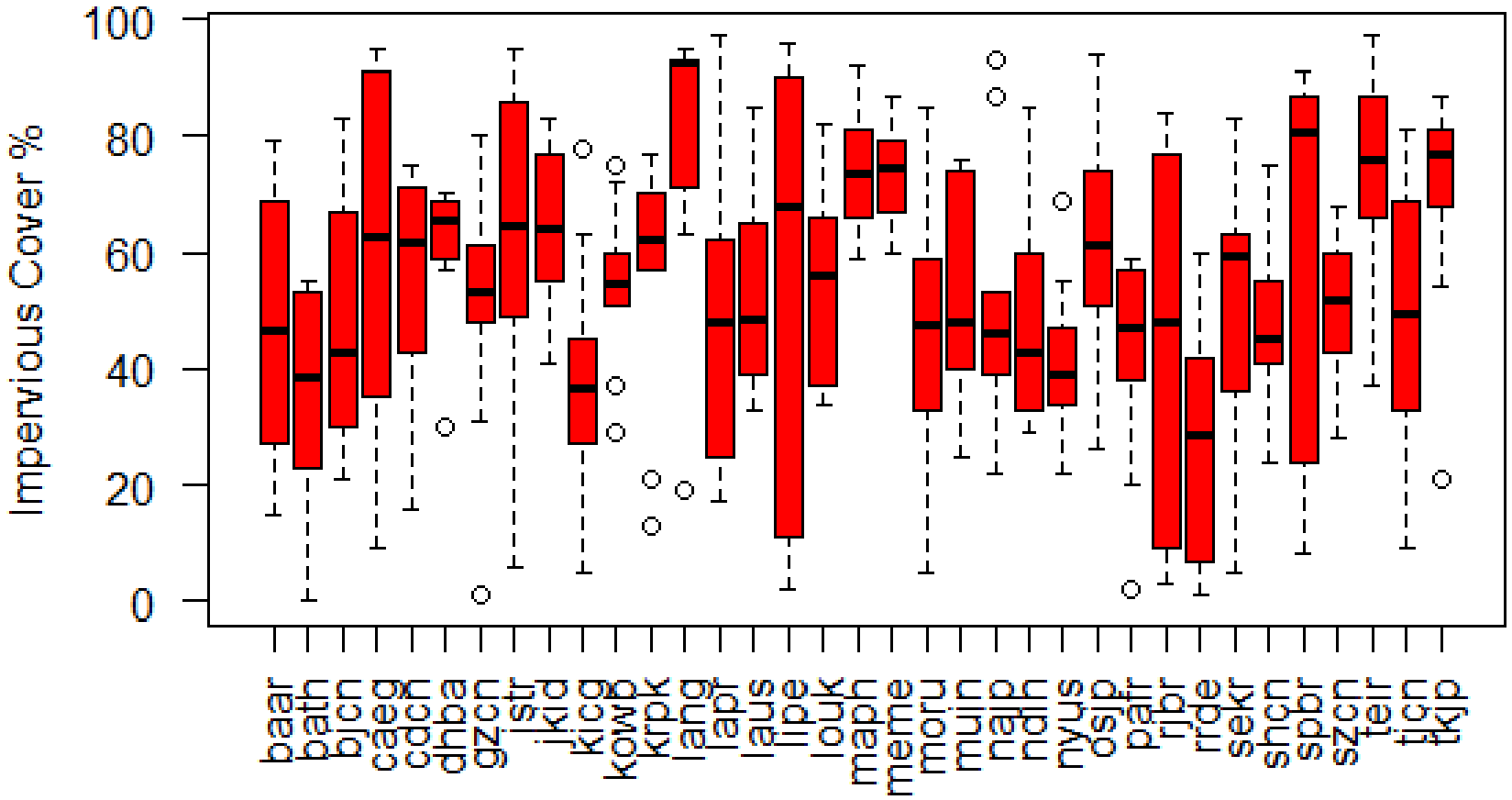
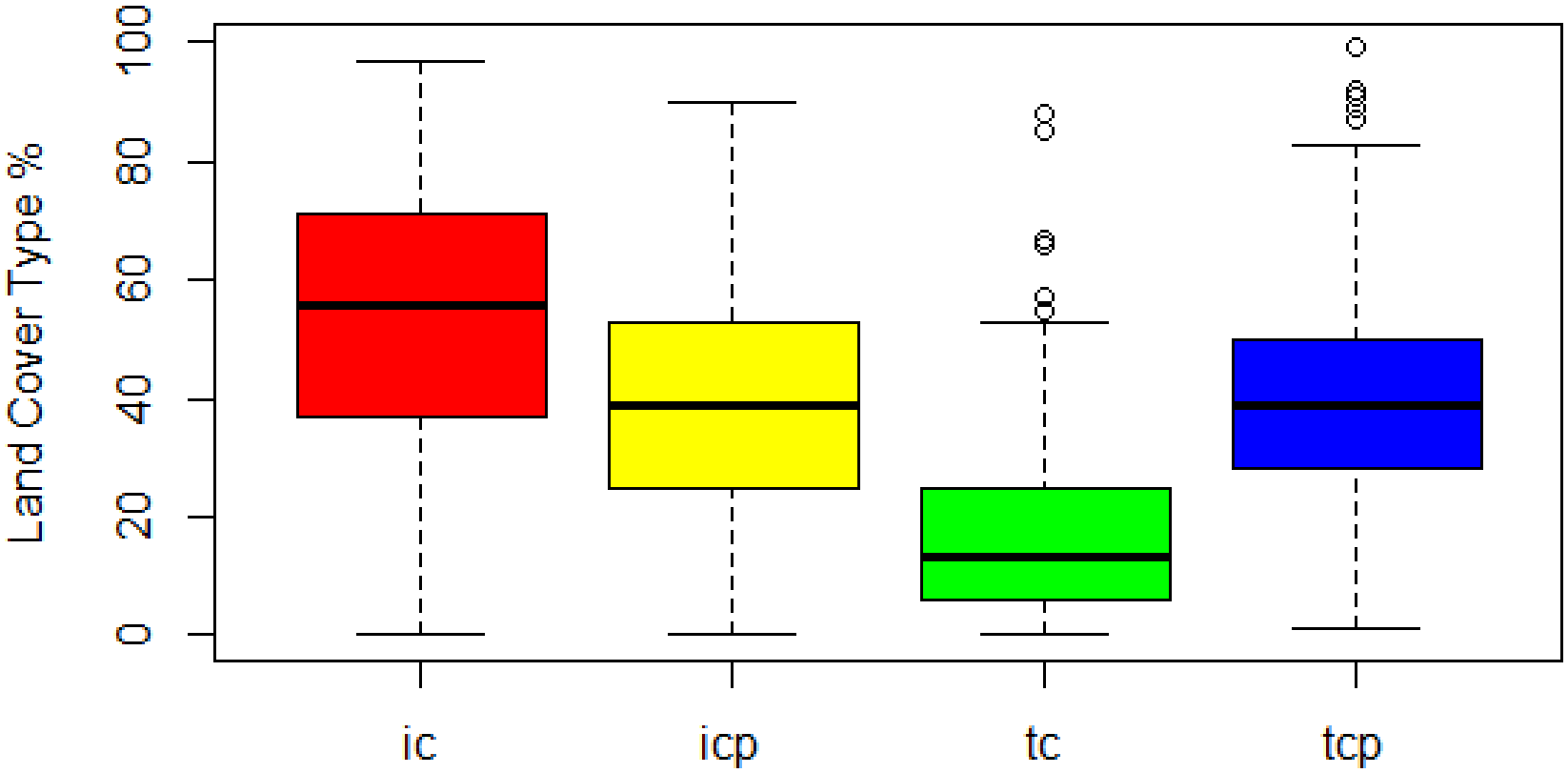
# Methods 3: Tree Cover



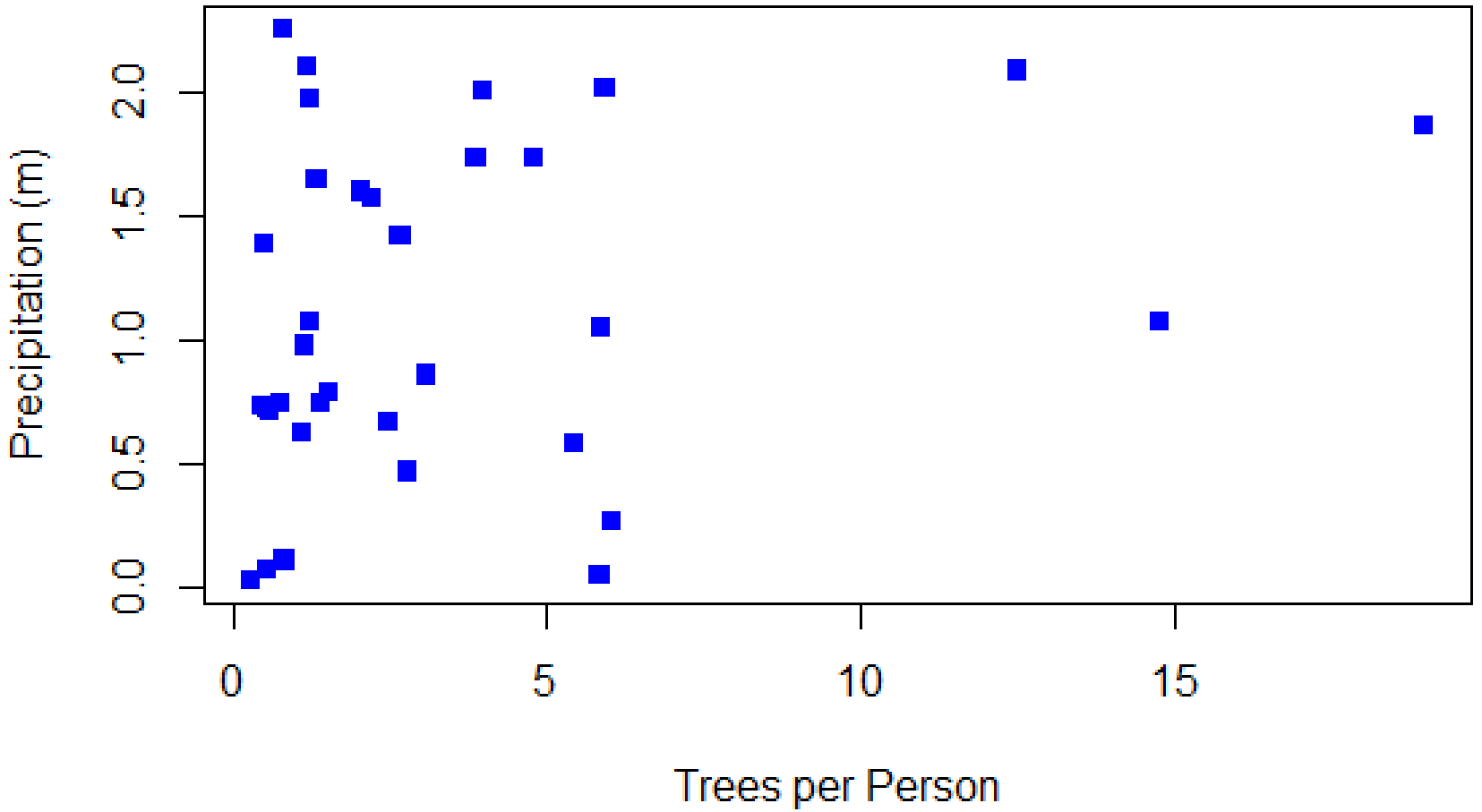
# Methods 3: Impervious Cover



# Methods 3: Land Cover Summary



# Methods 4: Tree Density & Climate

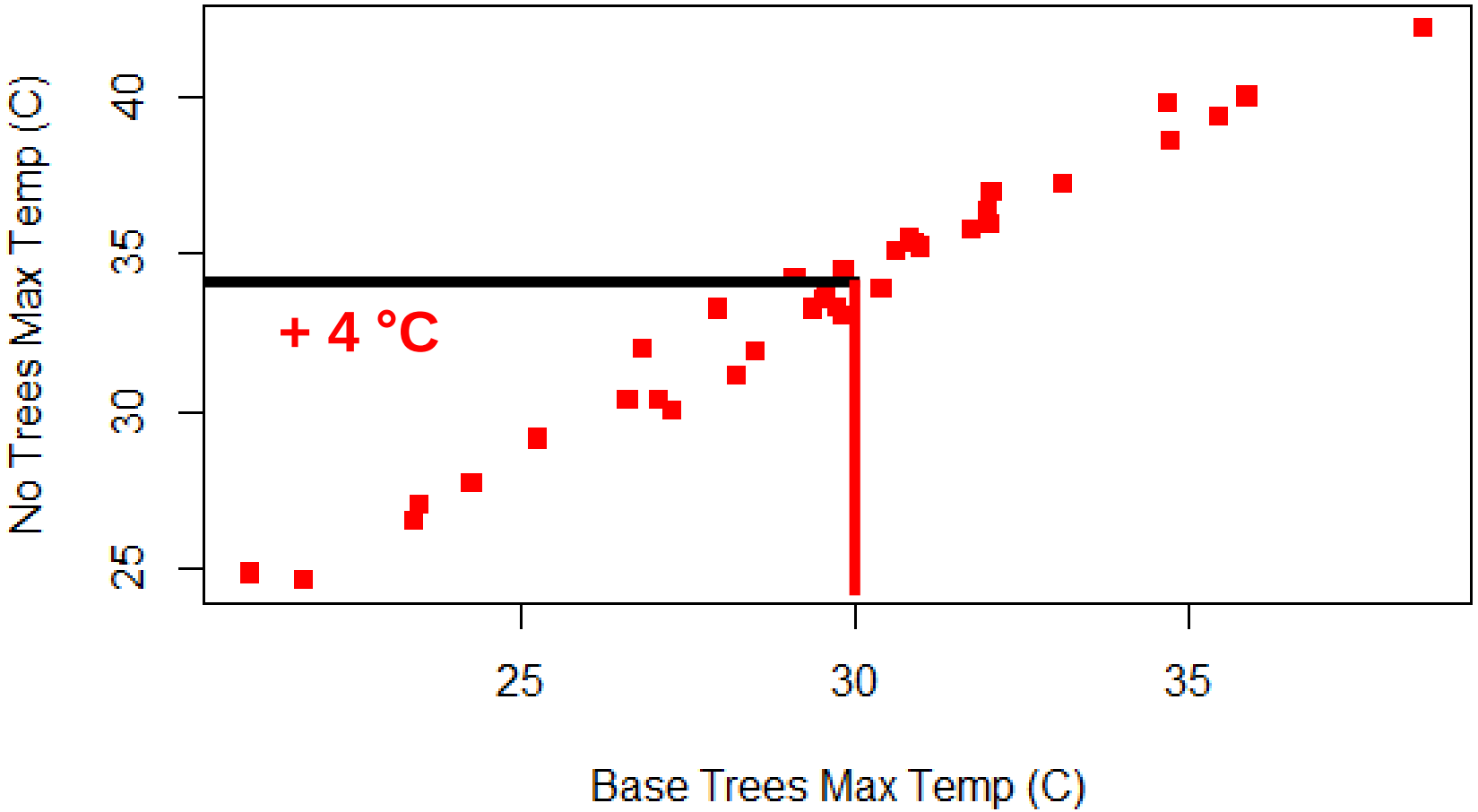


# Methods 5: Temperature Metrics

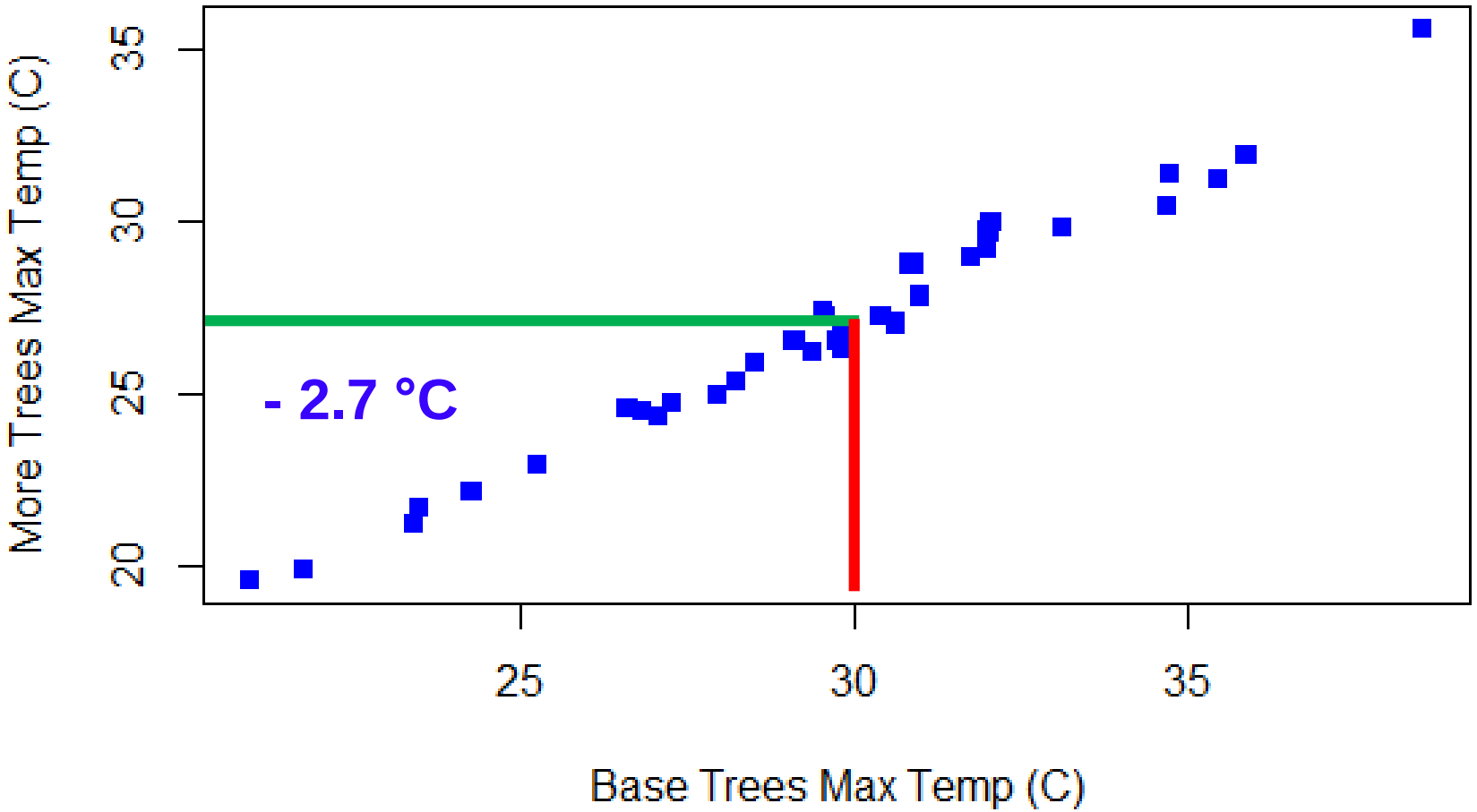
- Input:
  - Summer season, hourly weather 2015
  - Land cover for Base case, No tree case, More tree case
- Output:
  - Thermometer maximum & minimum temperature
  - Apparent maximum temperature (w/ relative humidity)
  - Cooling degree days (> 21°C)
  - Heat waves (2 consecutive days ≥ 35°C)

# Results 1: Maximum Temperature

## No Trees

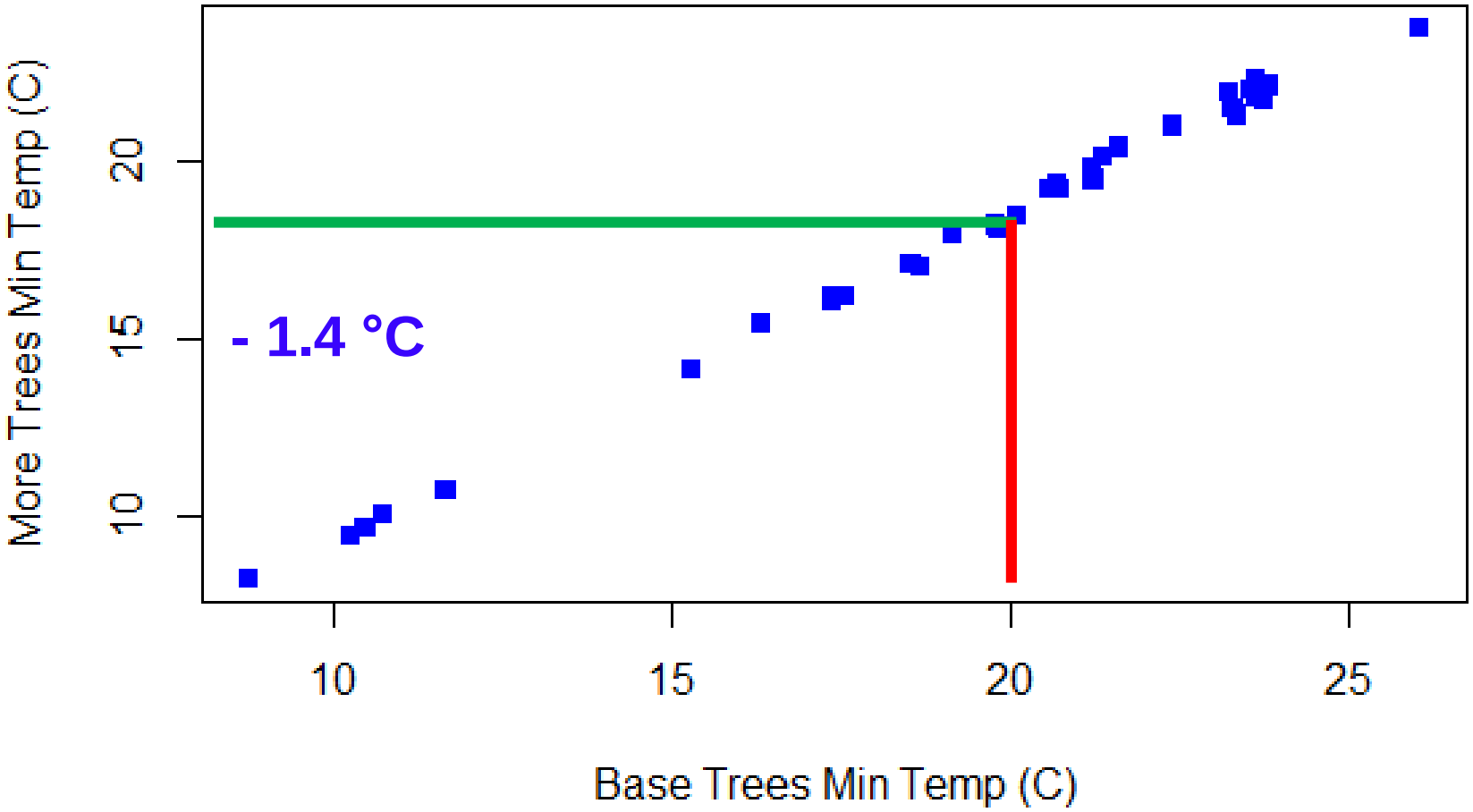


# Results 2: Maximum Temperature More Trees



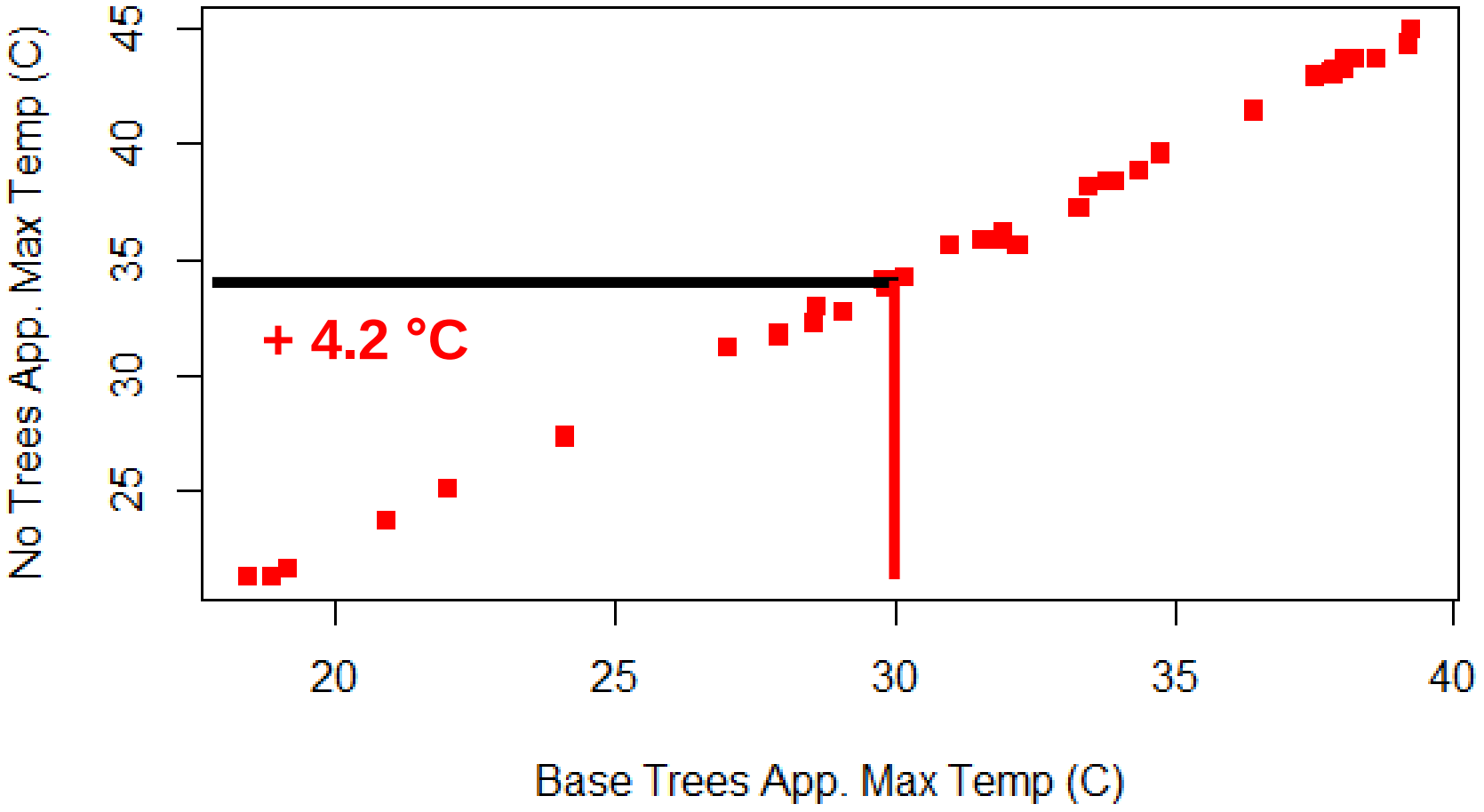
# Results 3: Minimum Temperature

## More Trees

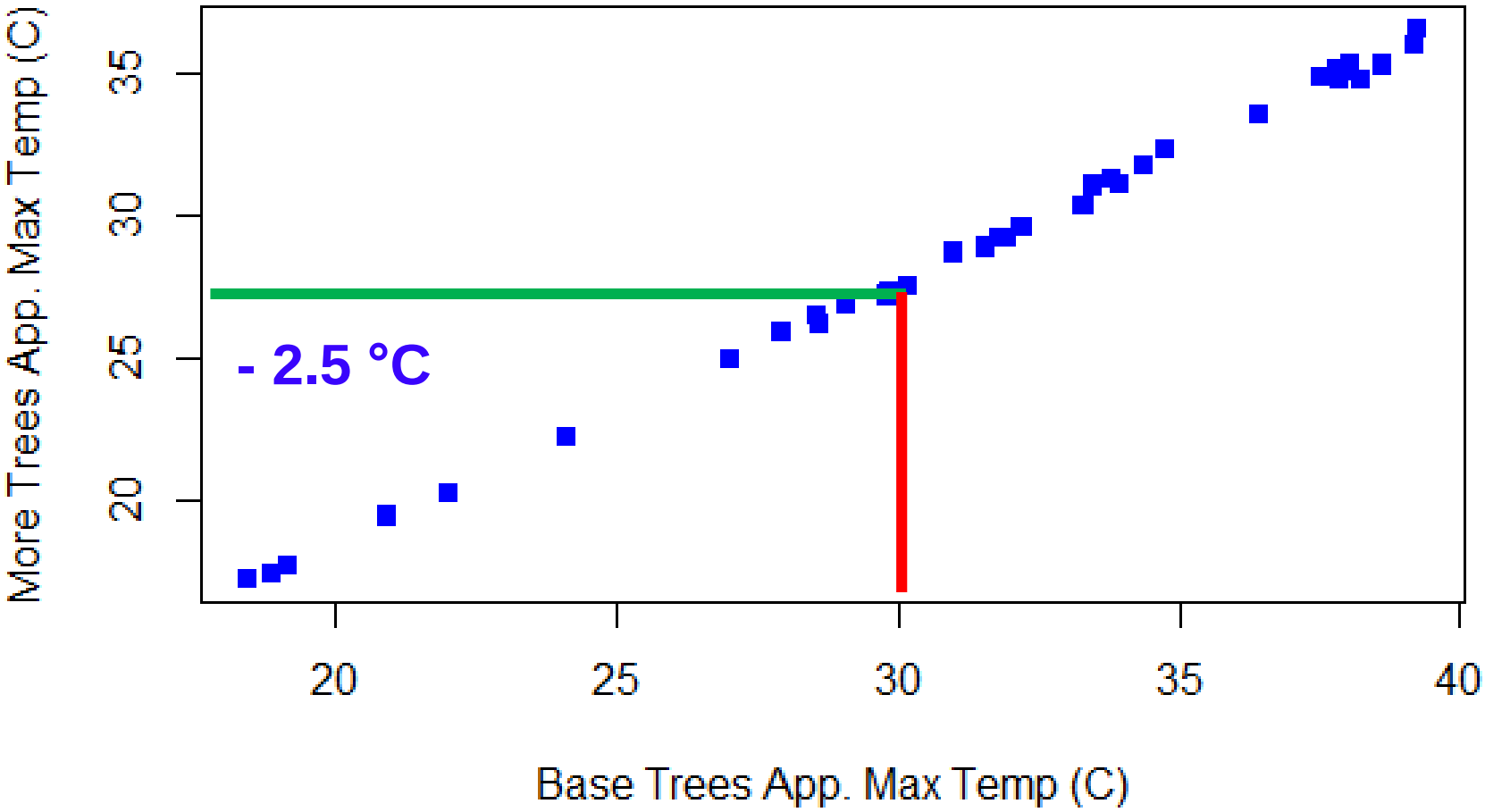


# Results 4: Apparent Max Temp

## No Trees

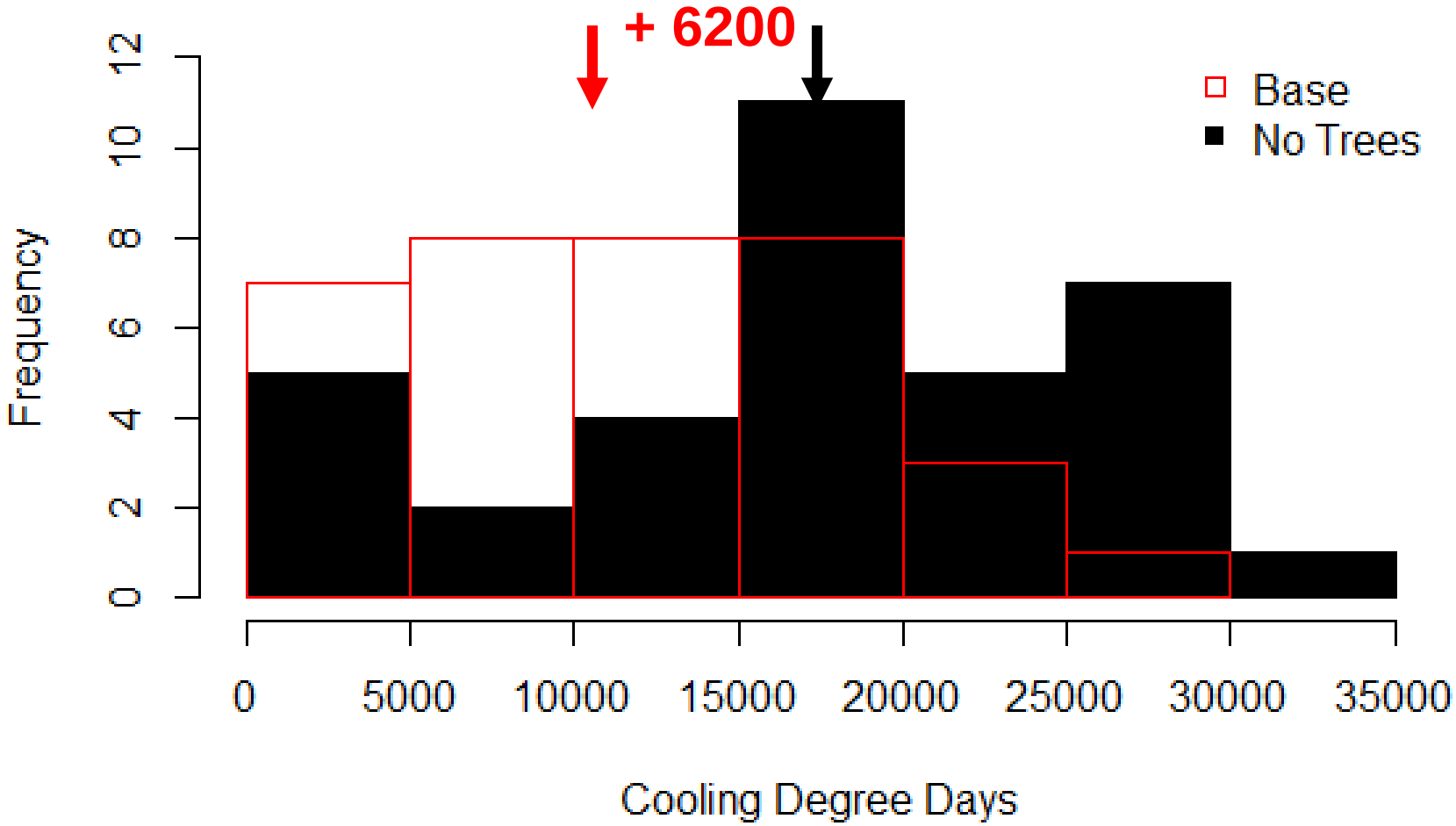


# Results 5: Apparent Max Temp More Trees

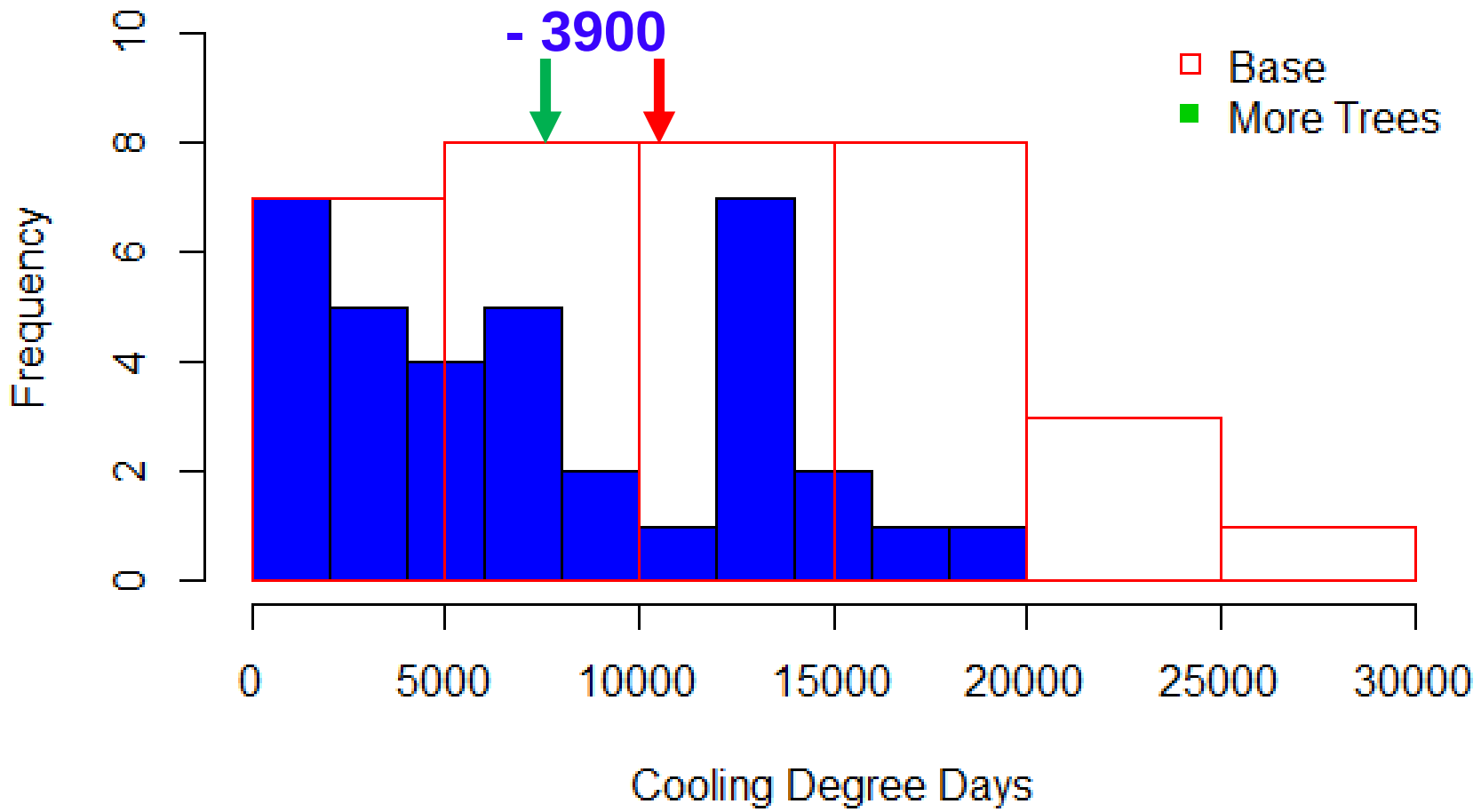


# Results 6: Cooling Degree Days

## No Trees

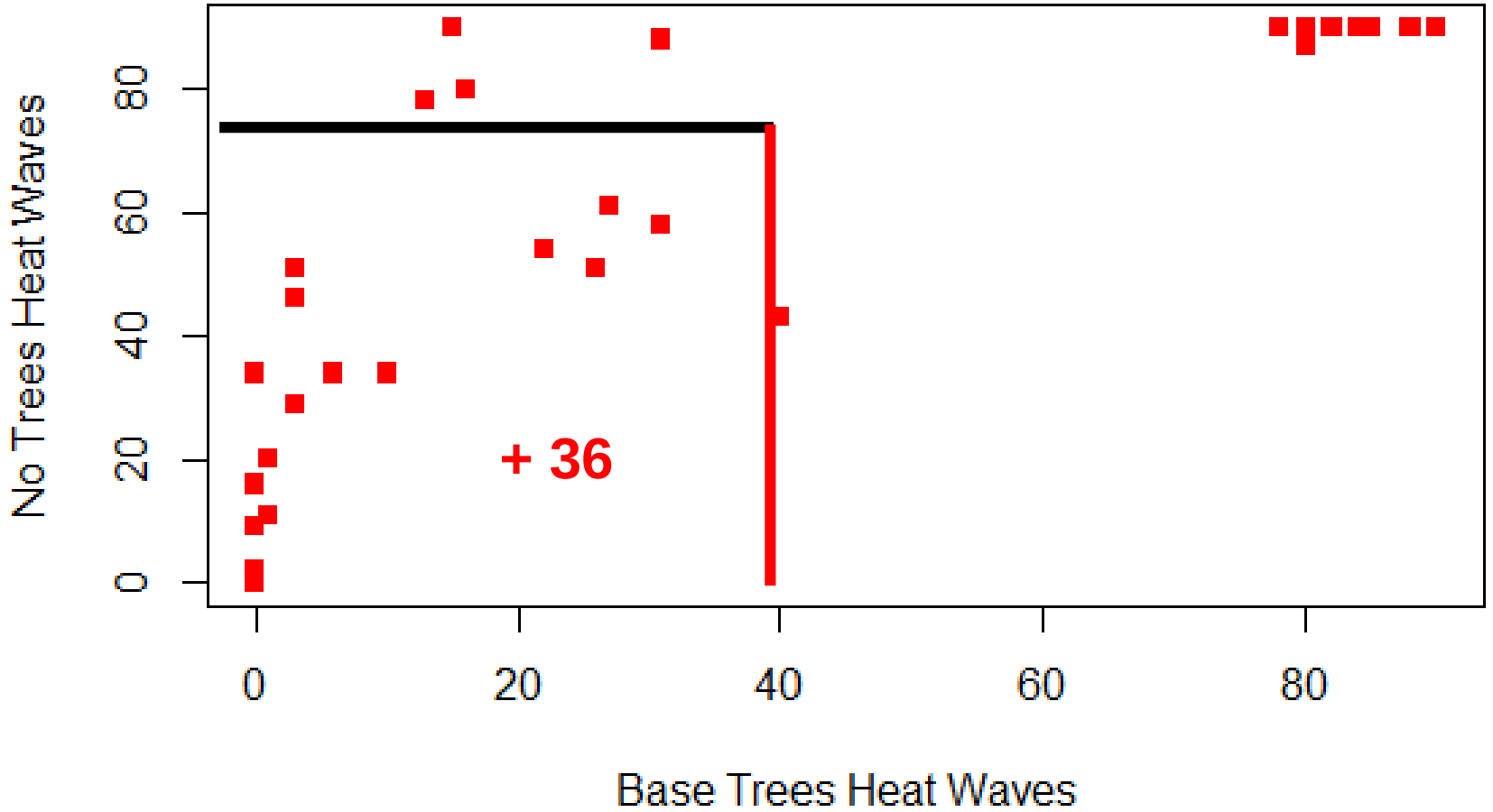


# Results 7: Cooling Degree Days
## More Trees

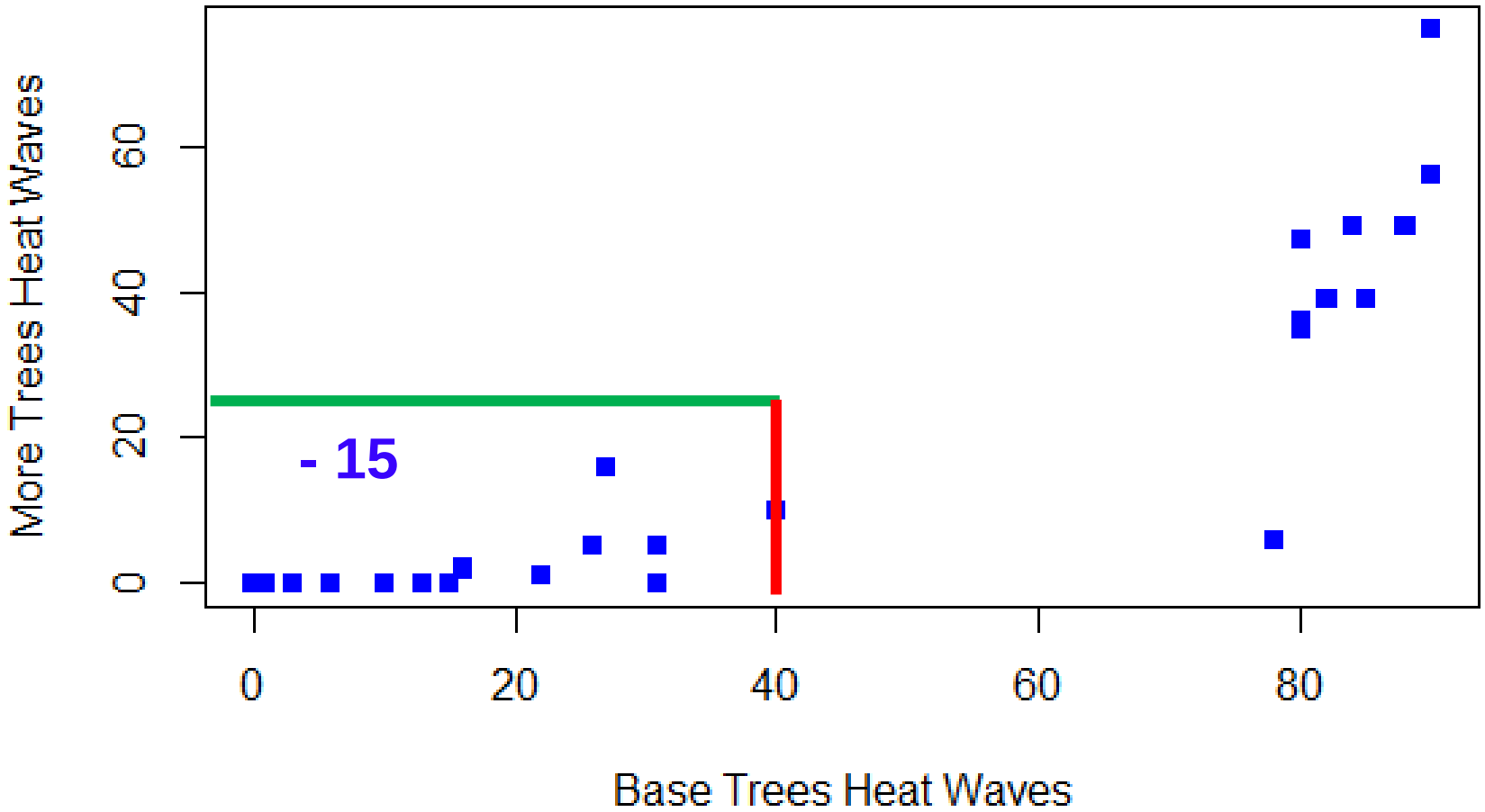


# Results 8: Heat Waves Apparent

## No Trees

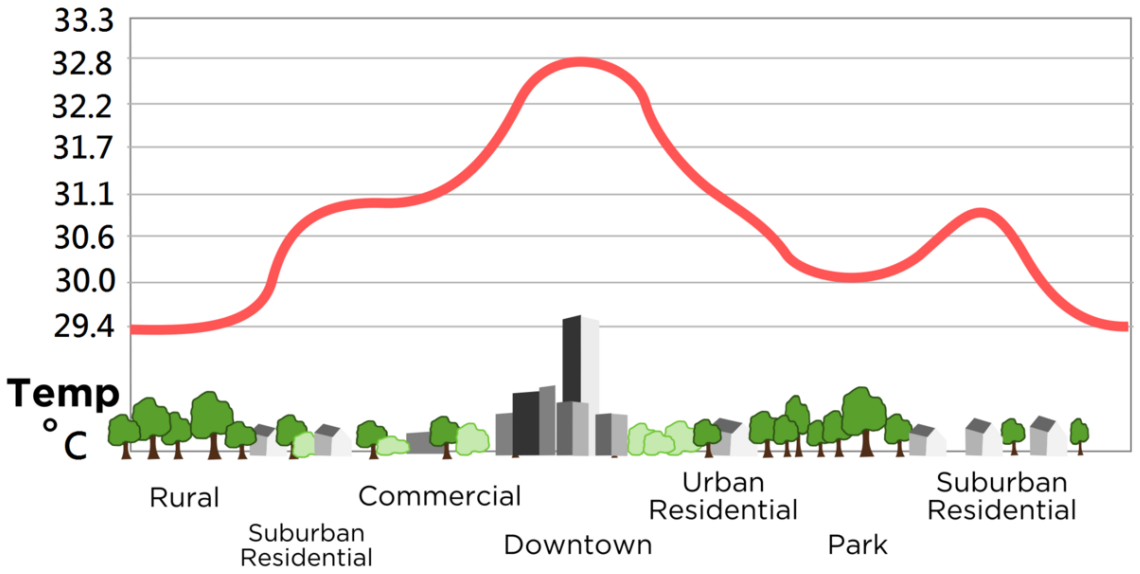


# Results 9: Heat Waves Apparent More Trees



# Conclusions

- Urban forests restore water & energy balance
- Urban forest expansion cools cities, saves lives



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