Understanding leafout and growing season length along an urban-forest gradient

Exploring model accuracy using weather station vs hobo logger data:

1. By accounting for microclimates, we improve model accuracy in predicting leafout (Figure 1)
2. Individuals that leaf out later grow less over the course of a season (Figure 2). Earlier bursting species generally grow faster (think willow).
    (a) Additionally, individuals from more northern provenance latitudes grow less (Figure 2)
3. Thus, it is crucial to improve model accuracy for predicting leafout in order to better understand temperate forest growth in the face of climate change.
4. Additionally, accounting for microclimates improves model prediction for growing degree days (GDDs) from budburst to leafout, which is essential for understanding false spring risk (Figure 3)
5. Finally, using phenology observations for the Arnold Arboretum (2015-2019), Harvard Forest (2015-2018) and a common garden (2017-2019) we see that, overall, there is variation across sites in GDDs to leafout (Figure 4).
    (a) The common garden site – which was planted in 2016 – initiated leafout with fewer GDDs than the Arboretum and Harvard Forest required more GDDs for leafout to occur, but provenance latitude has little affect on GDDs to leafout.

Getting a grasp on growing season length:

1. Again, using phenology observations for the Arnold Arboretum (2015-2018), Harvard

Forest (2015-2018) and a common garden (2017-2018) we see that, overall, there is variation across sites in growing season length (Figure 5).

   (a) Overall, individuals from the common garden had longer growing seasons – with variation among species – and individuals from Harvard Forest had shorter growing seasons.

   (b) Across all three sites, individuals from more northern provenance latitudes had longer growing seasons.

2. And finally, individuals exposed to higher mean temperatures between leafout and leafdrop had shorter growing seasons but, again, individuals from more northern provenances had longer growing seasons (Figure 6).

3. Accumulated precipitation from leafout to leafdrop had little affect on growing season length.

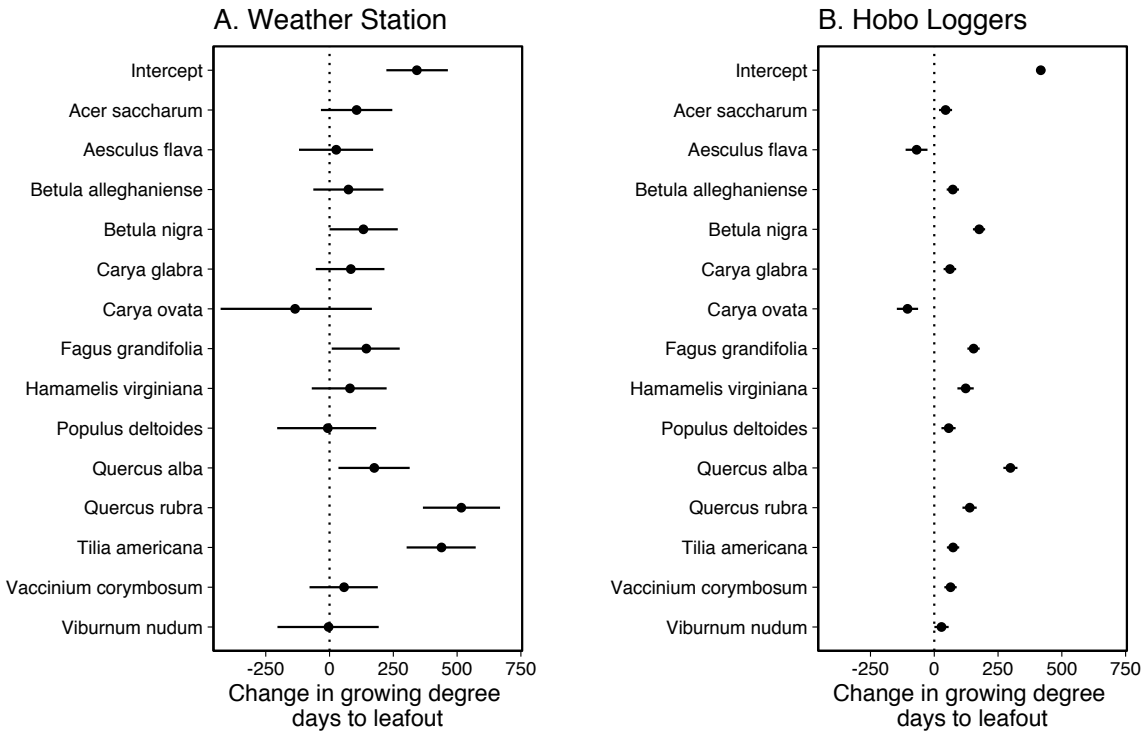

Figure 1: Model output for growing degree days to leafout using weather station data (A) and hobo logger data (B). Dots and lines show means and 50% uncertainty intervals.

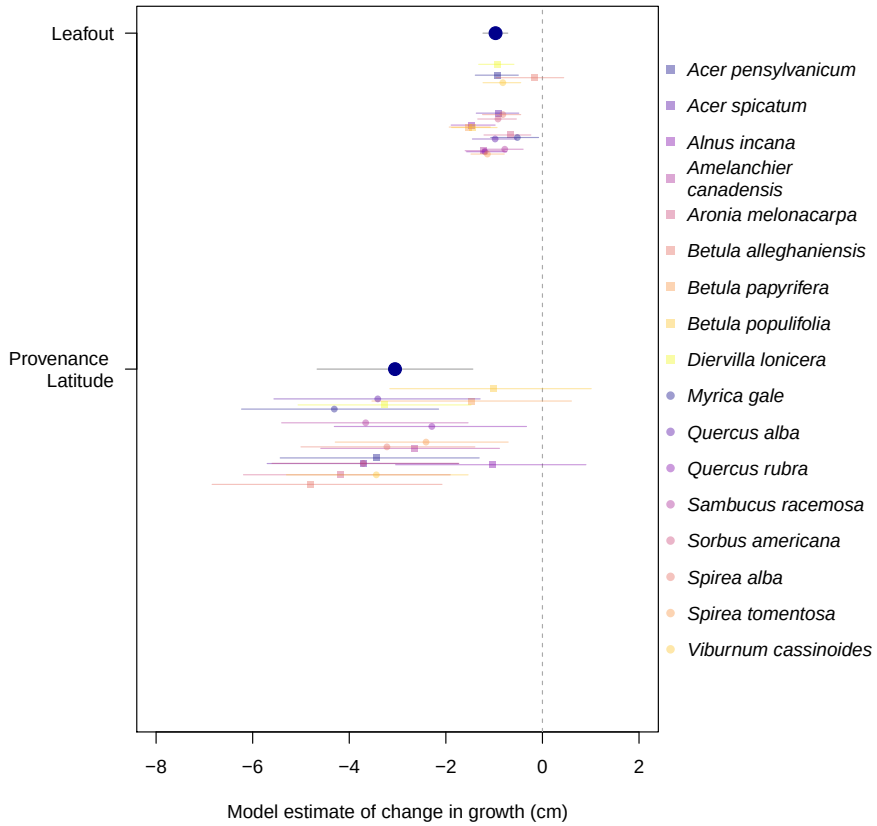

Figure 2: Model output for amount of growth over a season (cm). Dots and lines show means and 25% uncertainty intervals.

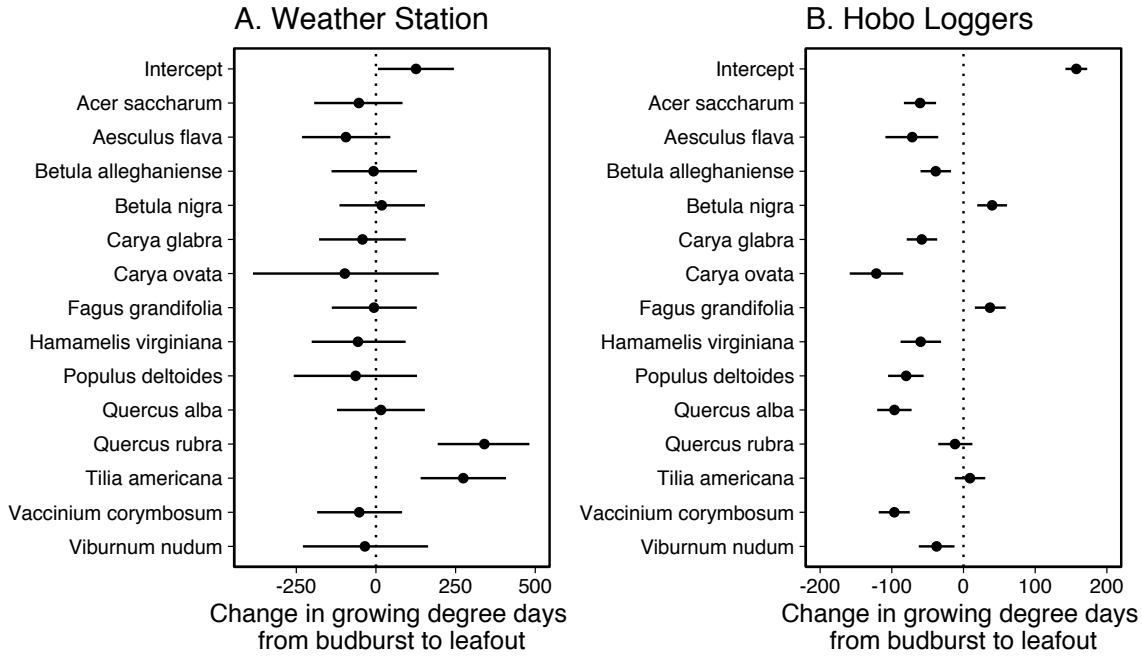

Figure 3: Model output for growing degree days from budburst to leafout using weather station data (A) and hobo logger data (B). Dots and lines show means and 25% uncertainty intervals. Note the x-axis scales are different to see the estimates more clearly.

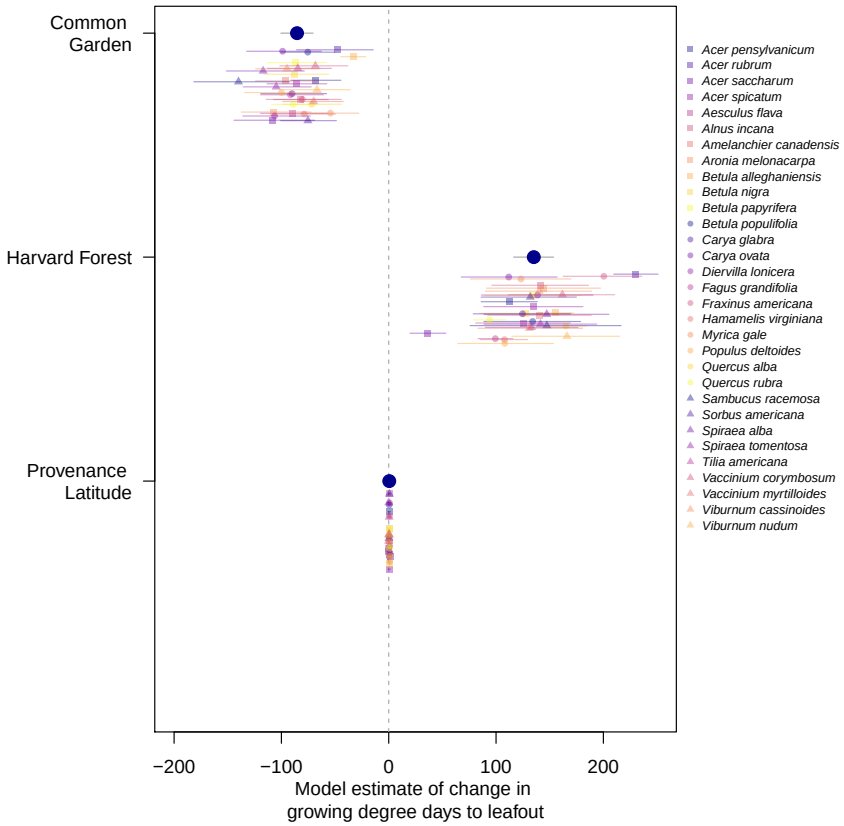

Figure 4: Model output for growing degree days to leafout using weather station data comparing three different sites. The Arnold Arboretum is the intercept. Dots and lines show means and 25% uncertainty intervals.

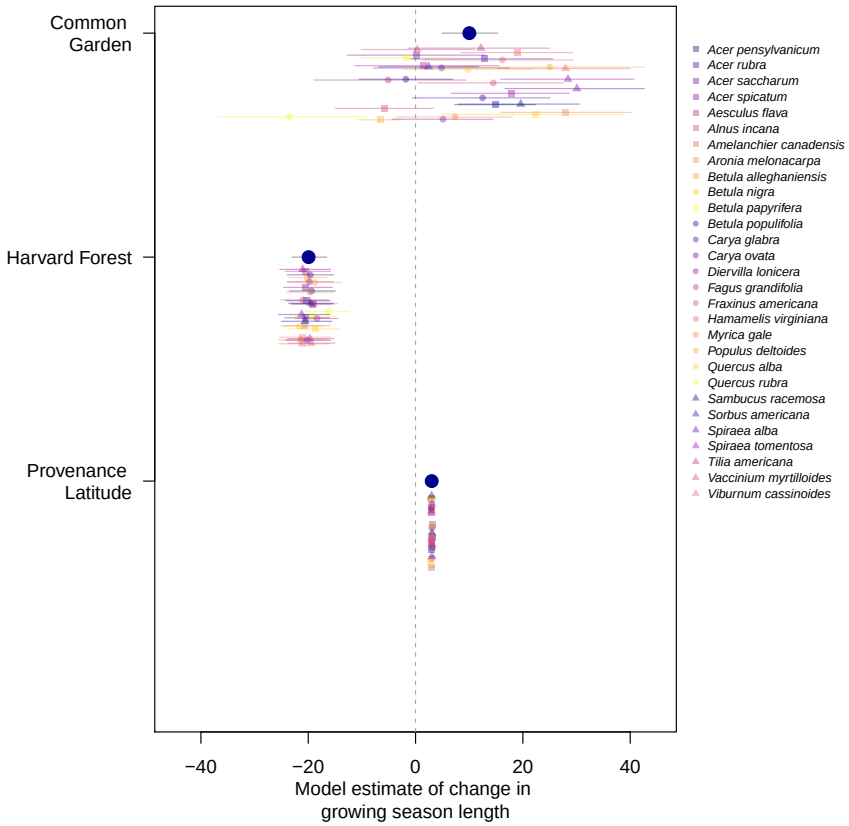

Figure 5: Model output for growing season length (from leafout to last observation) comparing three different sites. The Arnold Arboretum is the intercept. Dots and lines show means and 25% uncertainty intervals.

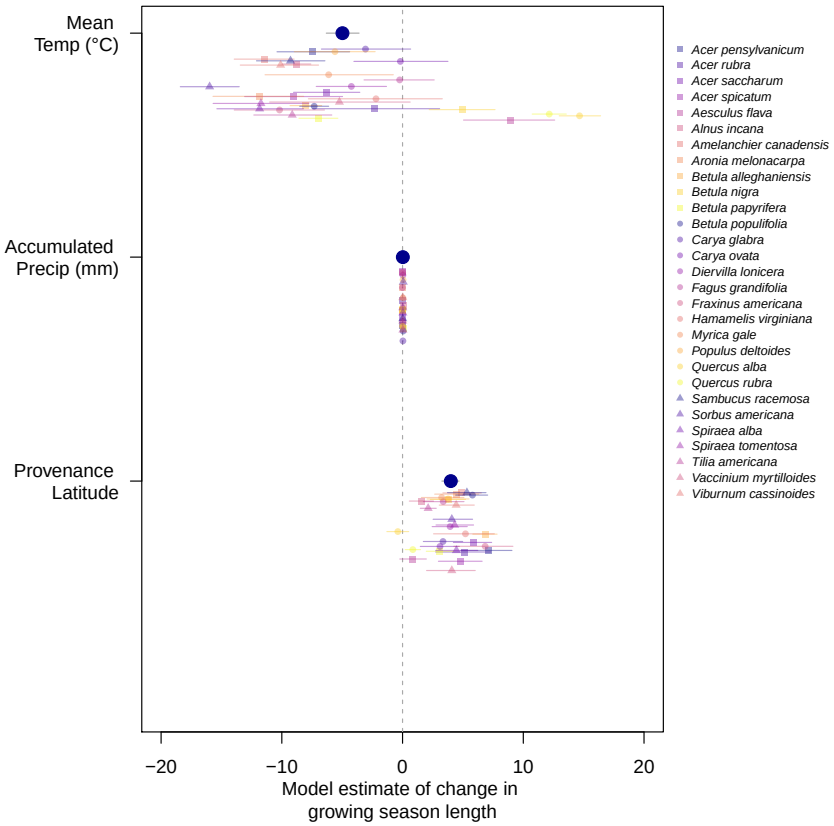

Figure 6: Model output for growing season length using weather station data comparing mean temperatures and precipitation among the different sites. The Arnold Arboretum is the intercept. Dots and lines show means and 25% uncertainty intervals.

Supplemental figures

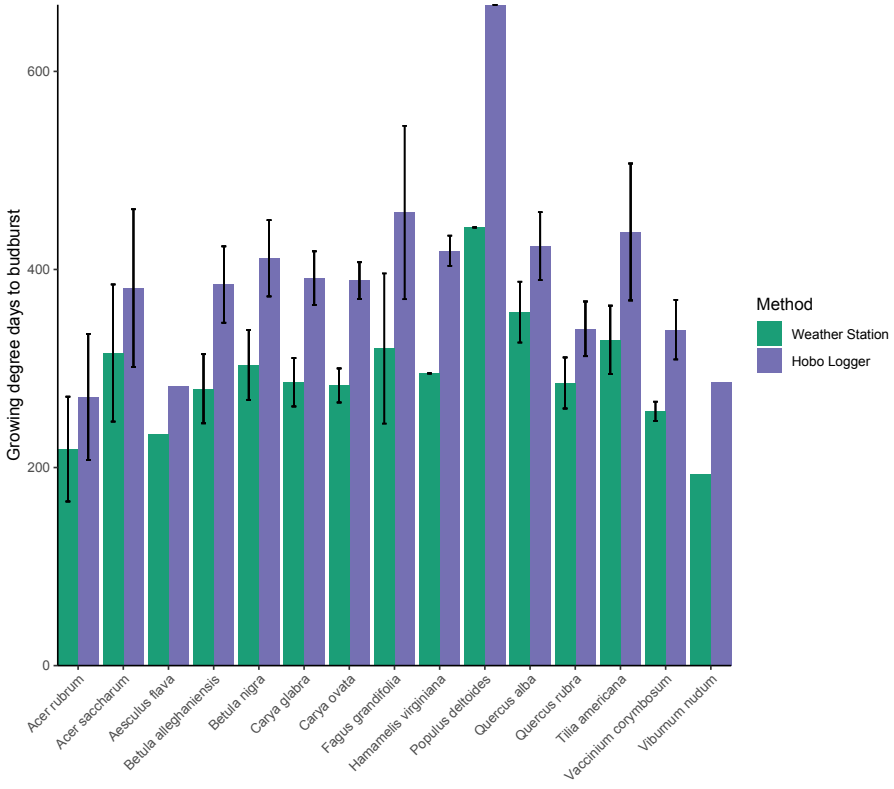

Figure 7

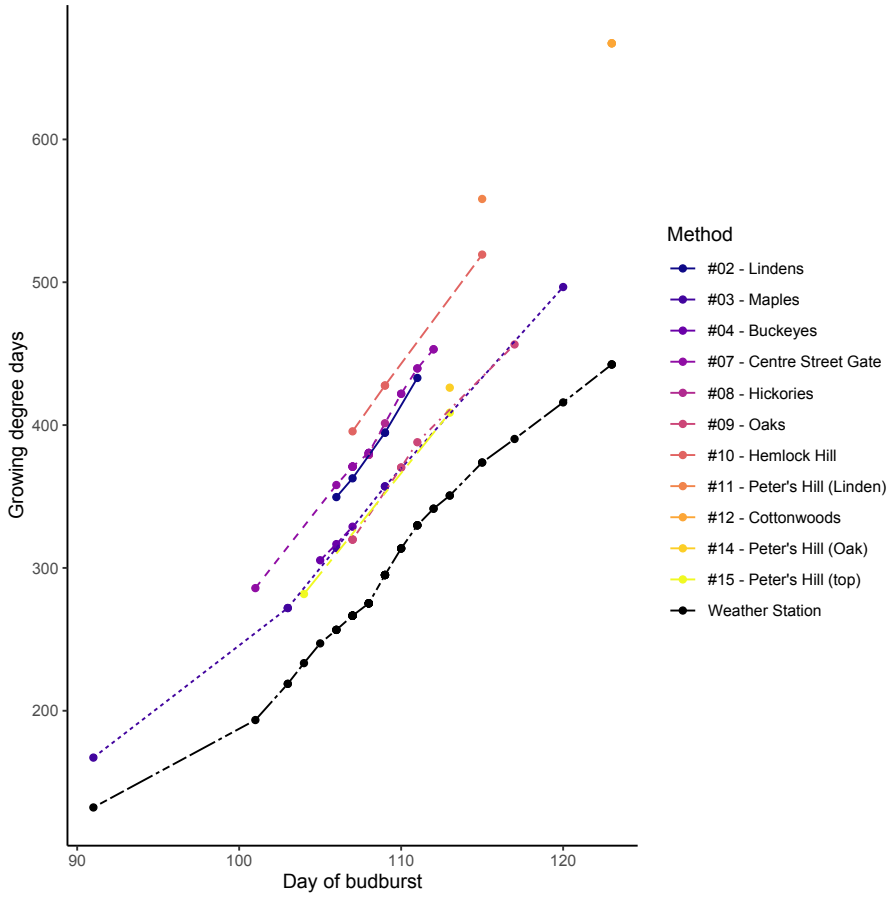
Growing degree days
600
500
400
300
200
90
100
110
120
Day of budburst
Method
#02 - Lindens
#03 - Maples
#04 - Buckeyes
#07 - Centre Street Gate
#08 - Hickories
#09 - Oaks
#10 - Hemlock Hill
#11 - Peter's Hill (Linden)
#12 - Cottonwoods
#14 - Peter's Hill (Oak)
#15 - Peter's Hill (top)
Weather Station

Figure 8