Emerald Ash Borers in Ontario

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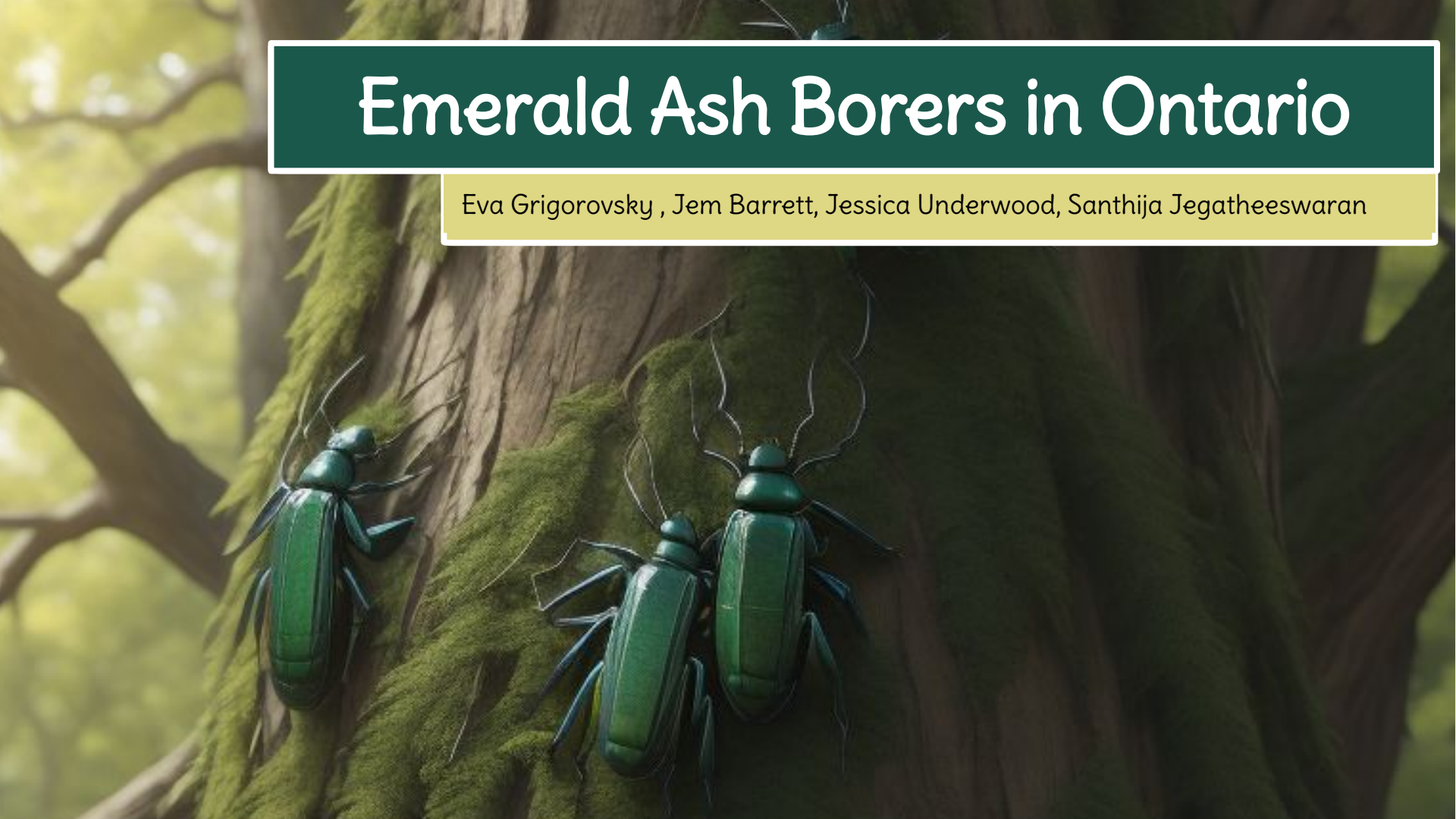
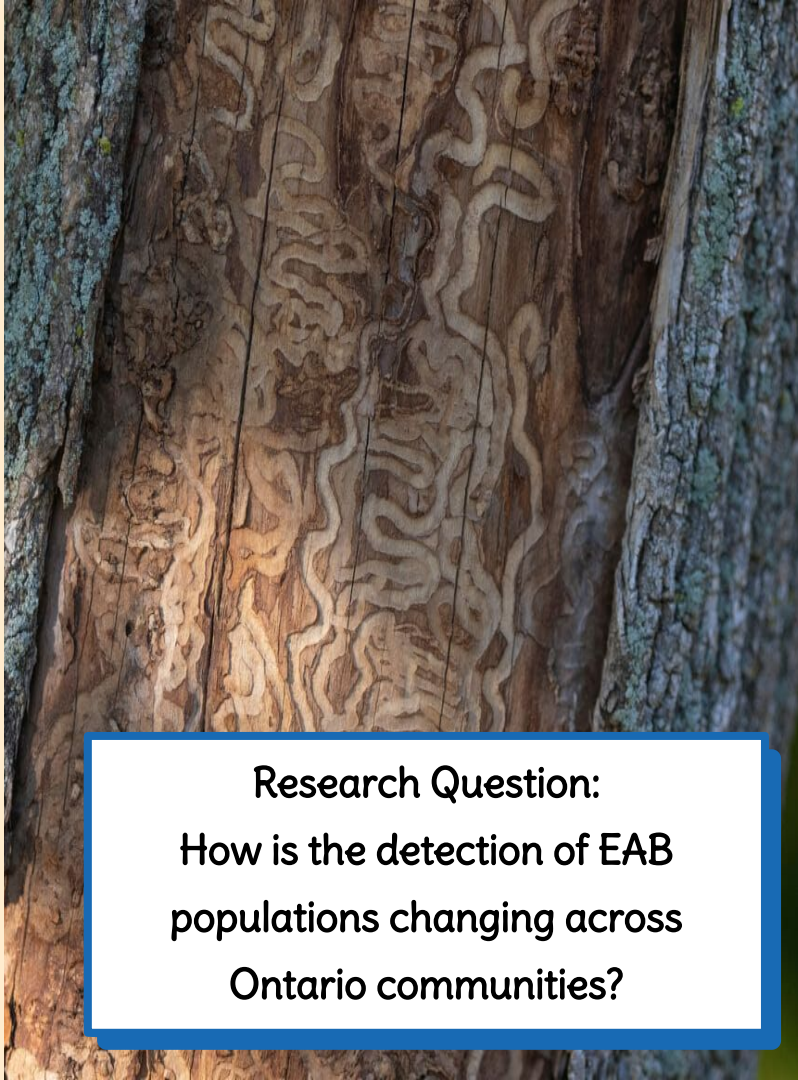


Background

Emerald Ash Borer (EAB)

- Invasive wood-boring beetle species[1]
- Accidentally introduced into North America 2002
  - Detected near Windsor, Ontario
- Tunnel in ash trees
  - 2-4 years of EAB larval presence leads to tree mortality[1]

- **WHY SHOULD WE CARE?**
  - All NA ash trees are susceptible to EAB
  - Widespread across southern Ontario and has killed 90% of ash trees since first appeared[2]



Research Question:

How is the detection of EAB populations changing across Ontario communities?

Hypotheses

#1: Time impacts the detection of EABs in various Ontario Communities.

#2: Differences in population densities of rural and urban Ontario communities impact the detection of EAB over the years.

#3: Differences in temperature impact the detection of EABs in various communities of Ontario.

Predictions

HYPOTHESIS #1

If time has an effect on the detection of EABs, we would expect to see more detections of EABs in later years compared to earlier years.

- Growing stages occur beneath the bark[3]
- 2-3 years to see damage[3]

Predictions

HYPOTHESIS #2

If population density of Ontario communities impacts EAB detection, we would expect to see more detections in rural areas compared to urban communities

➢ Higher population density & less green space = less resources and space for EABs to invade

Predictions

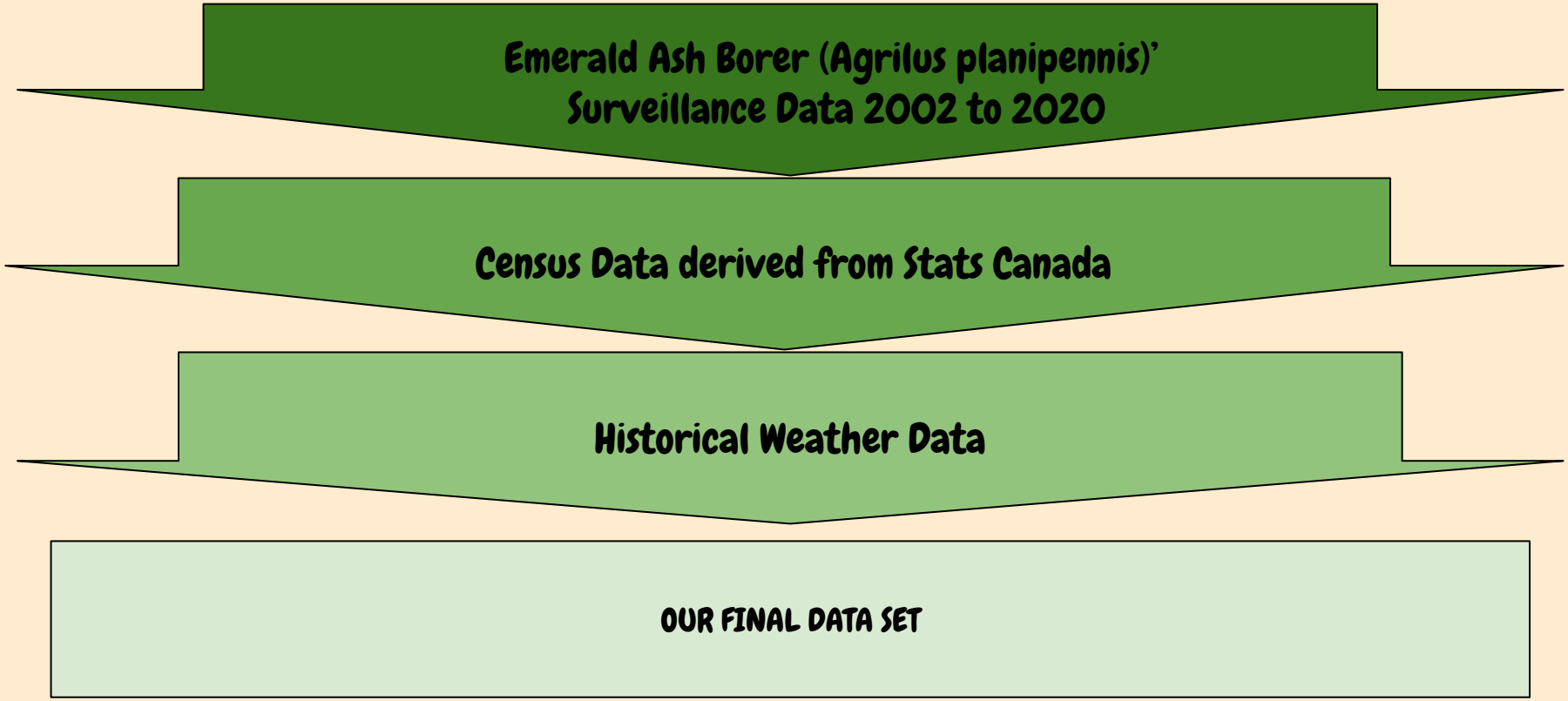
HYPOTHESIS #3

If temperature drives the detection of emerald ash borers in various communities of Ontario, we would expect to see more EAB detections in communities with higher annual temperatures.

➢ Warmer temperatures = more reproduction, development, and survival

METHODS

DATA MANIPULATION



OUR DATA SET

	latitude	longitude	year	community	result	community_2	community_type	avg_temp
1	42.274	-82.397	2002	CHATHAM-KENT DIVISION	NOT DETECTED	CHATHAM-KENT	rural	10.48154
2	42.412	-82.185	2002	CHATHAM-KENT DIVISION	NOT DETECTED	CHATHAM-KENT	rural	10.48154
3	42.098	-82.449	2002	CHATHAM-KENT DIVISION	NOT DETECTED	CHATHAM-KENT	rural	10.48154
4	42.275	-82.343	2002	CHATHAM-KENT DIVISION	NOT DETECTED	CHATHAM-KENT	rural	10.48154
5	42.391	-82.210	2002	CHATHAM-KENT DIVISION	NOT DETECTED	CHATHAM-KENT	rural	10.48154

Independent:

Years sampled: 2002 to 2020

(Ontario) Community: 154

Community Type: Rural or Urban

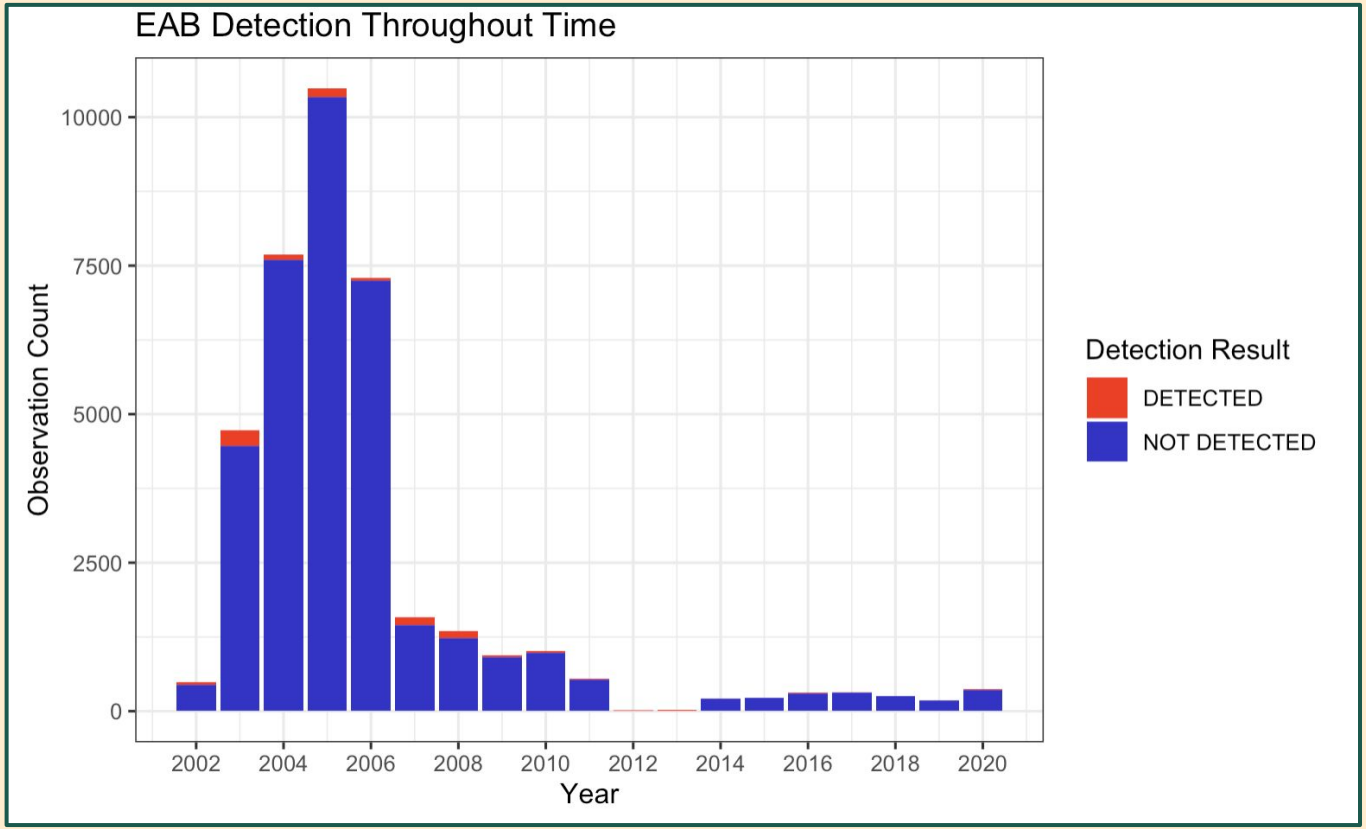
Average Annual Temperature: °C

Dependent:

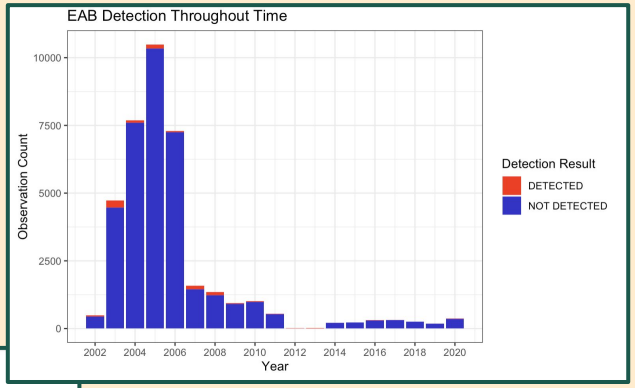
Result: Detected or Not Detected

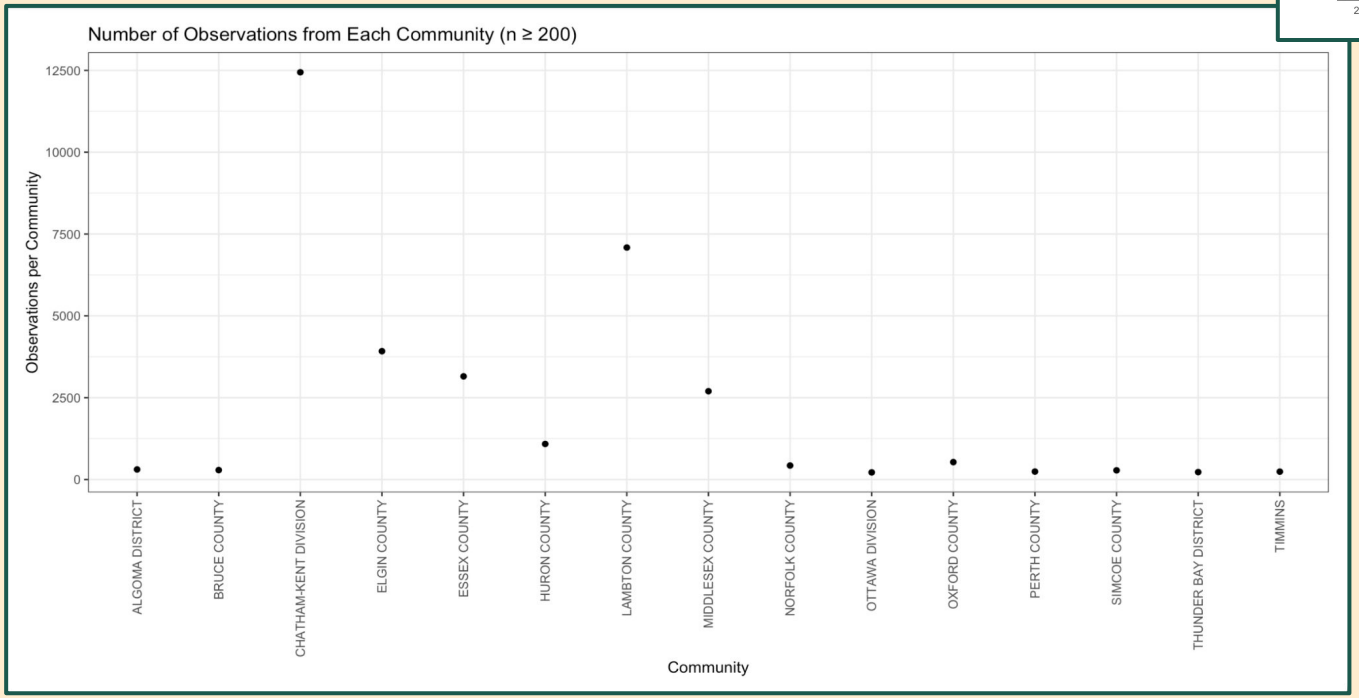
Hypothesis #1: Time impacts the detection of emerald ash borers in various Ontario communities.

Hypothesis #1:



An Aside: What communities are driving the number of observations??





- 15 communities had ≥200 observations
- Unequal observations led to skew
- Some communities were very underrepresented
- Chatham-Kent!!

Hypothesis #1:

Is there an effect of time on EAB detection by community?

- *glm(as.factor(result)~year*community, family = binomial, data = ont_eab_data)*

No Significant Coefficients

```
(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 8649.4  on 38000  degrees of freedom
Residual deviance: 6027.0  on 37740  degrees of freedom
AIC: 6549

Number of Fisher Scoring iterations: 20
```

Hypothesis #1 Results

Hypothesis 1: Detection of EAB through time

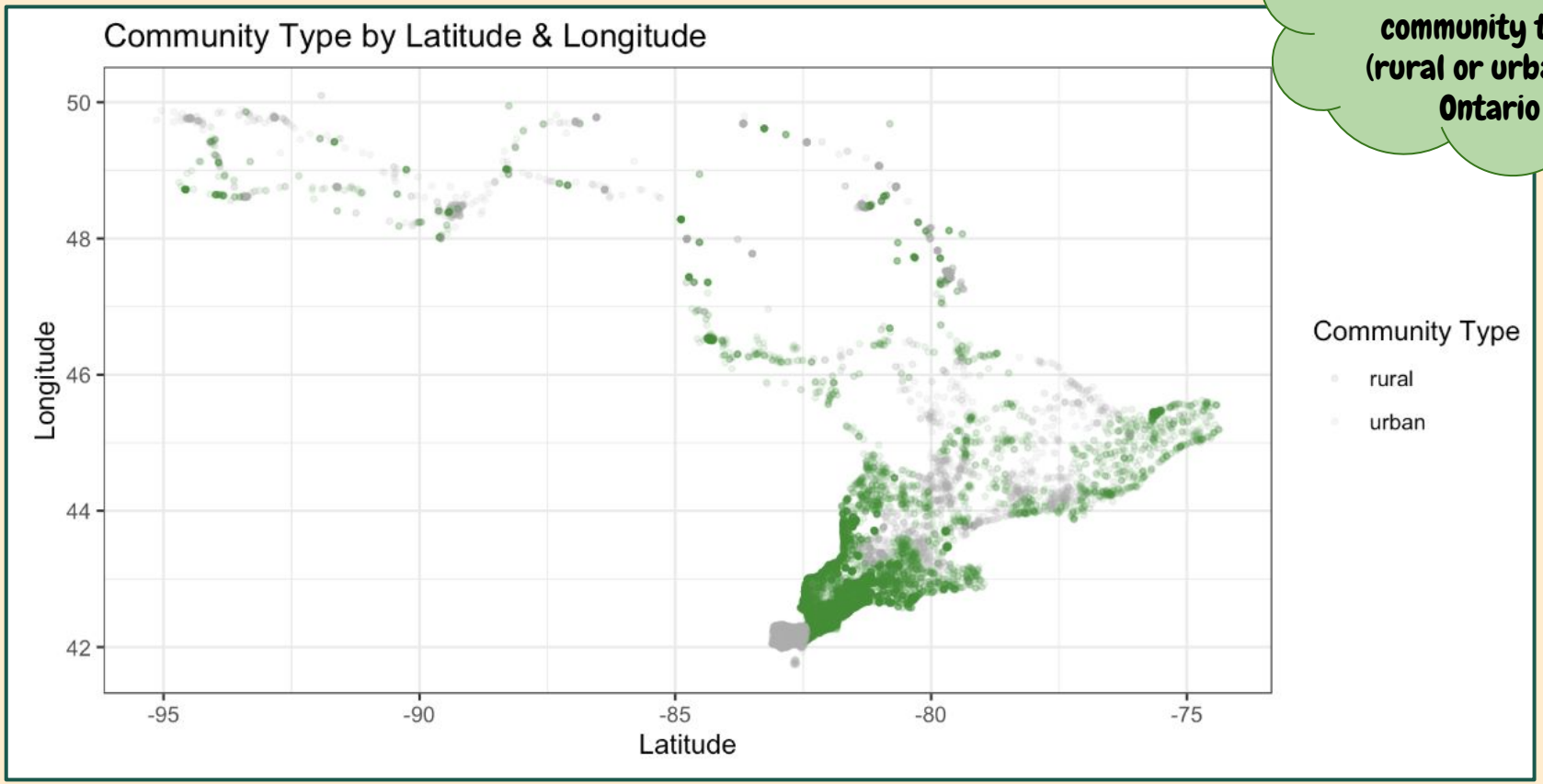
- *Recall Prediction:* ***If time has an effect on the detection of EABs, we would expect to see more detections of EABs in later years compared to earlier years***
- *Trend in data for earlier years*
- *Fail to reject the null*

Hypothesis #2:

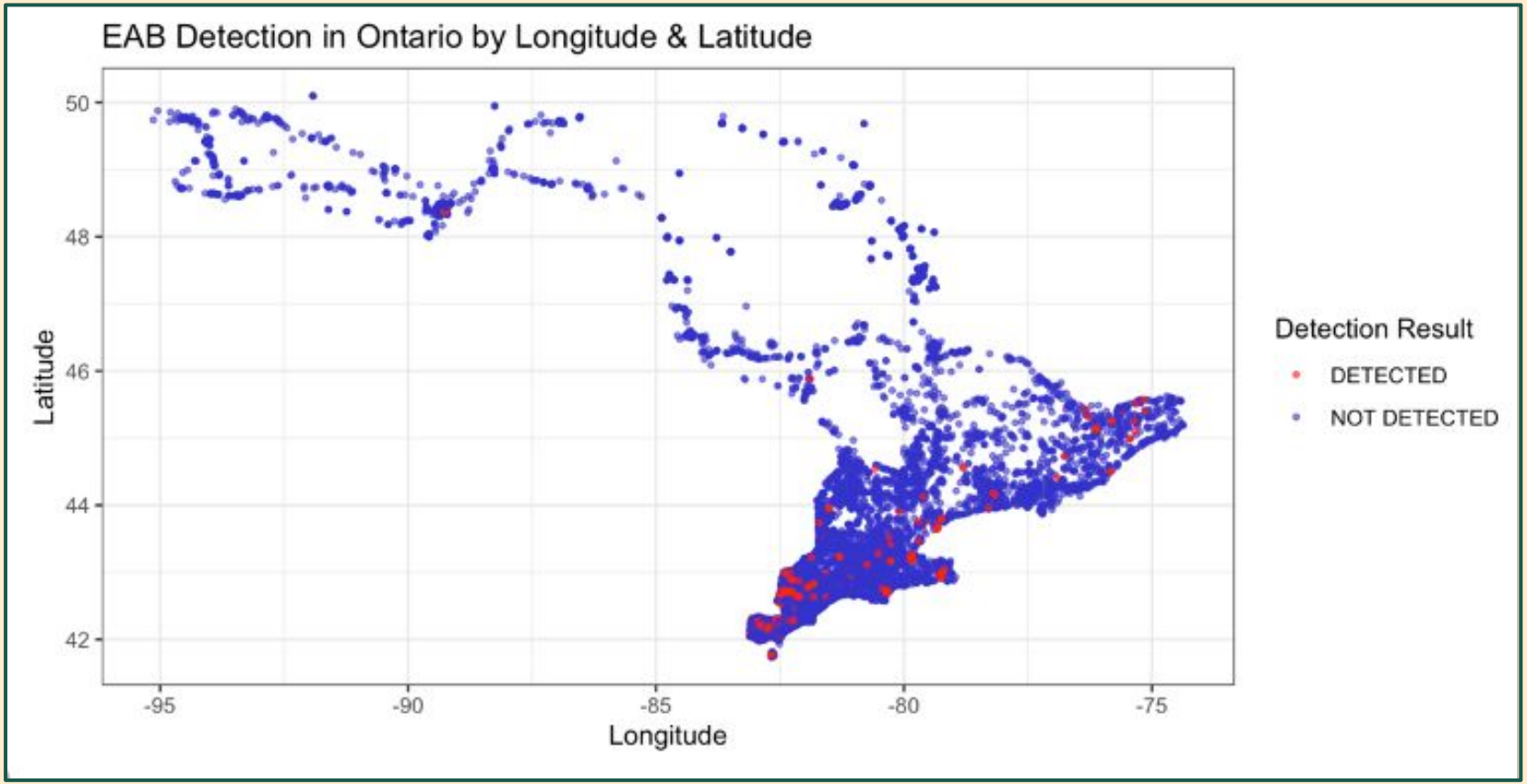
Population densities of Ontario communities impact EAB detection.

Hypothesis #2:

Latitude and longitude coordinates correlate with community type (rural or urban) in Ontario



Hypothesis #2:



Hypothesis #2:

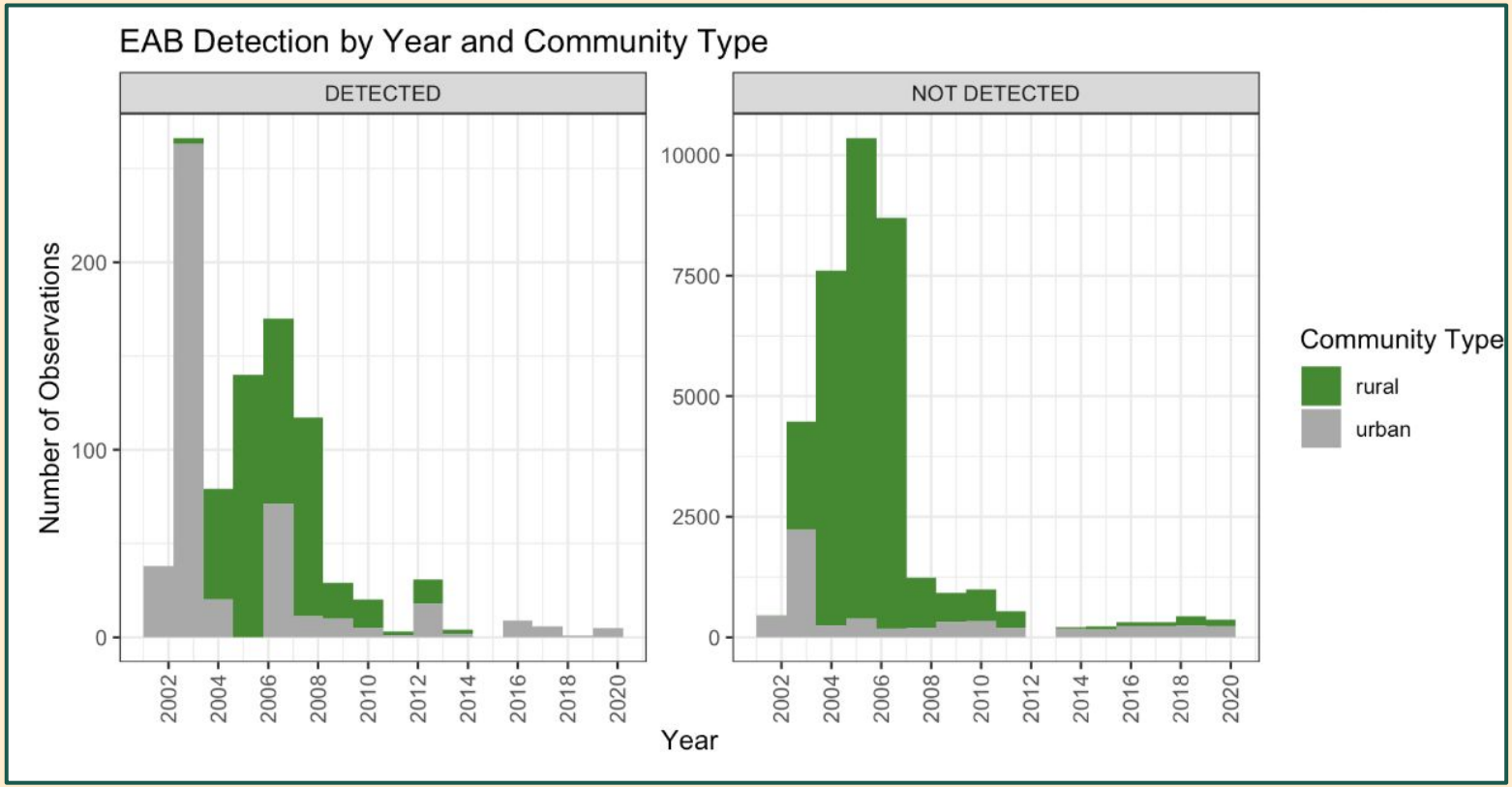
Model: community type on EAB detection

Out of 38,001 observations, 31,765 were from rural communities while only 6,236 were from urban communities

	DETECTED	NOT DETECTED
rural	458	31307
urban	460	5776

```
        Pearson's Chi-squared test

data:  ont_eab_data$community_type and ont_eab_data$result
X-squared = 778.8, df = 1, p-value < 2.2e-16


Call:
glm(formula = as.factor(result) ~ year * community_type, family = binomial,
    data = ont_eab_data)

Coefficients:
                            Estimate Std. Error z value Pr(>|z|)
(Intercept)               240.25054   26.60605   9.030   <2e-16 ***
year                       -0.11766    0.01326  -8.873   <2e-16 ***
community_typeurban      -444.33419   35.84048 -12.398   <2e-16 ***
year:community_typeurban    0.22066    0.01787  12.349   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 8649.4  on 38000  degrees of freedom
Residual deviance: 7920.9  on 37997  degrees of freedom
AIC: 7928.9

Number of Fisher Scoring iterations: 7
```

Hypothesis #2:



Hypothesis #2 Results

Hypothesis 2: Detection of EAB based on Community Type

- *Recall Prediction:* ***If population density of Ontario communities impacts EAB detection, we would expect to see more detections in rural areas compared to urban communities***
- *We found that rural and urban communities had a similar amount of detections despite rural communities having more observations*
- *Fail to reject the null*

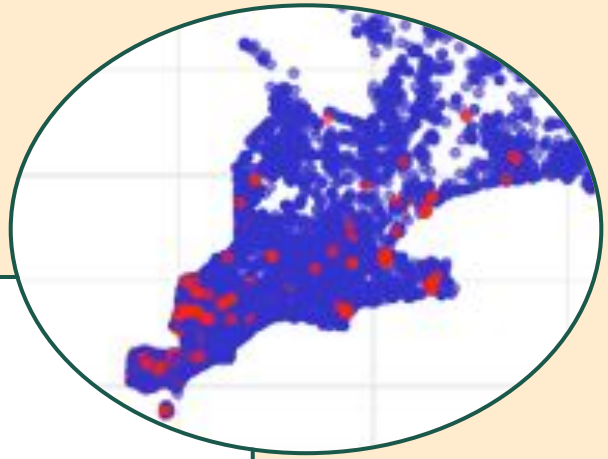
EAB Detection Rate

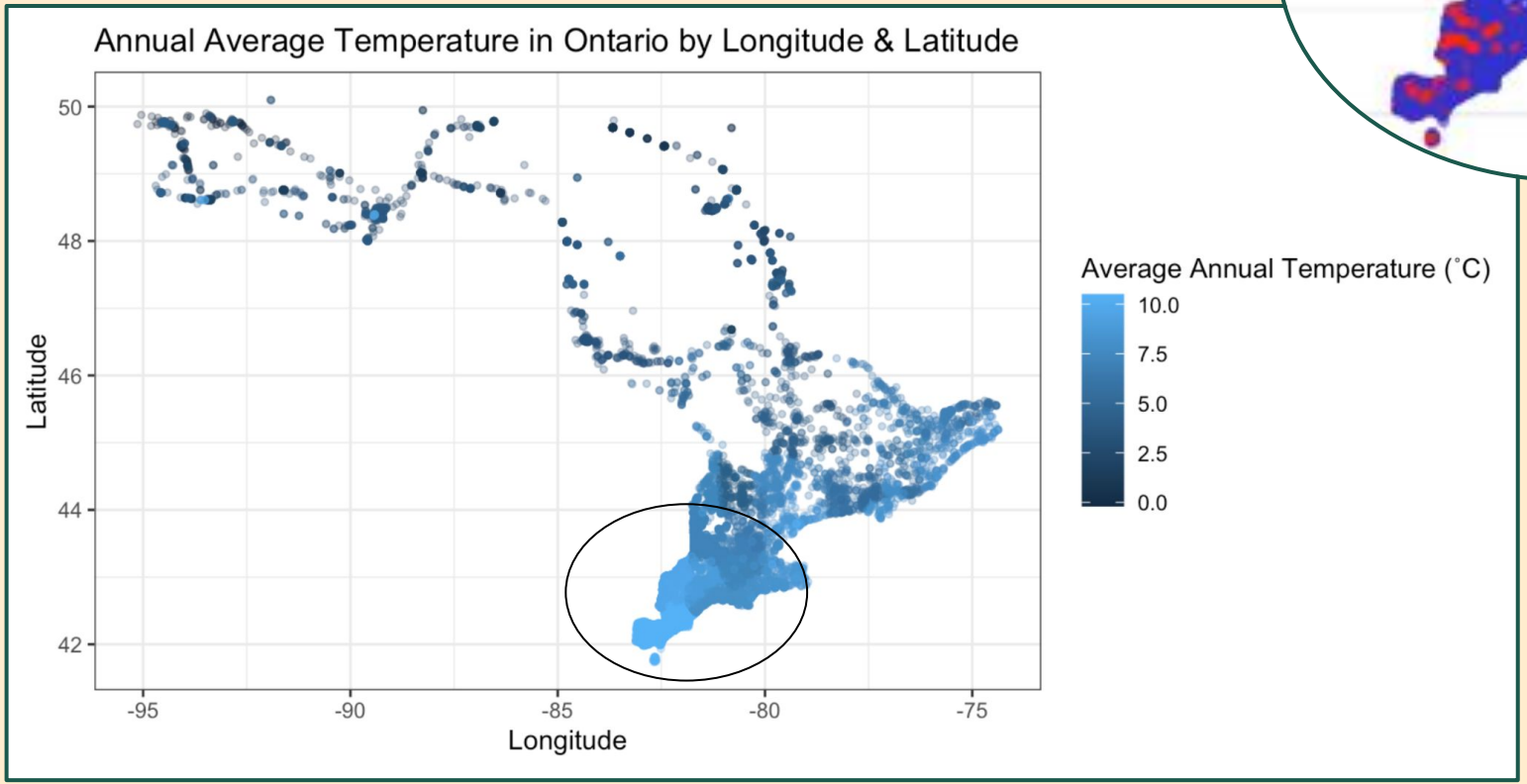
Rural Communities: 1.44%

Urban Communities: 7.38%

Hypothesis #3:
Temperature is a driver of EAB detection in various communities of Ontario.

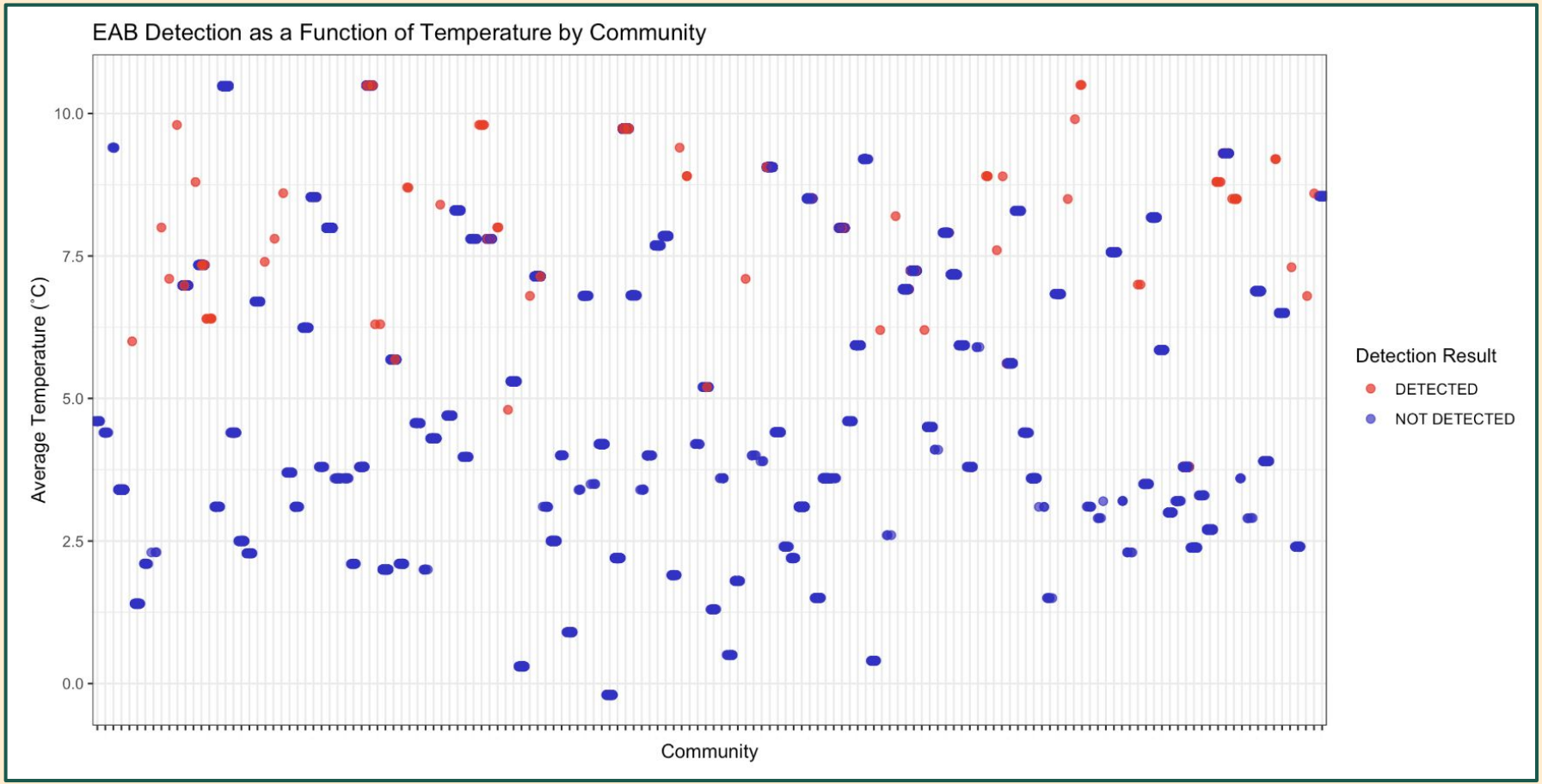
Hypothesis #3:





Red is Detected
Blue is Not Detected

Hypothesis #3:



Hypothesis #3:

temp_model <- glm(as.factor(result) ~avg_temp, family = binomial, data = ont_eab_data)

```
Call:
glm(formula = as.factor(result) ~ avg_temp, family = "binomial",
    data = ont_eab_data)

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  5.55926    0.21630  25.702   <2e-16 ***
avg_temp    -0.20102    0.02241  -8.969   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 8649.4  on 38000  degrees of freedom
Residual deviance: 8545.3  on 37999  degrees of freedom
AIC: 8549.3

Number of Fisher Scoring iterations: 7
```

temp_model <- glm(as.factor(result) ~avg_temp+community, family = binomial, data = ont_eab_data)

communityCOCHRANE DISTRICT	-2.204e+01	1.422e+05	0.000e+00	1.000
communityCONNAUGHT	4.504e+15	1.501e+07	3.001e+08	<2e-16 ***
communityCORNWALL	-4.504e+15	6.711e+07	-6.711e+07	<2e-16 ***
communityCUMBERLAND	-3.380e+01	2.059e+05	0.000e+00	1.000
communityDRUMBO	-4.504e+15	6.711e+07	-6.711e+07	<2e-16 ***
communityDRYDEN	-1.126e+01	1.101e+05	0.000e+00	1.000
communityDUBREUILVILLE	4.504e+15	1.861e+07	2.420e+08	<2e-16 ***
communityDUFFERIN COUNTY	4.504e+15	8.593e+06	5.241e+08	<2e-16 ***
communityDURHAM REGIONAL MUNICIPALITY	-3.508e-01	3.857e+02	-1.000e-03	0.999
communityEARLTON AIRPORT	4.504e+15	1.937e+07	2.325e+08	<2e-16 ***
communityELGIN COUNTY	-1.540e+00	1.267e+04	0.000e+00	1.000
communityELK LAKE	4.504e+15	1.540e+07	2.925e+08	<2e-16 ***
communityELK LAKE AIRPORT	7.380e+05	1.937e+07	3.800e-02	0.970
communityEMO	-2.787e+01	1.463e+05	0.000e+00	1.000
communityENGLEHART	4.504e+15	1.268e+07	3.551e+08	<2e-16 ***

Hypothesis #3 Results

Hypothesis 3: Effect of Temperature on EAB Detection

- *Recall Prediction:* ***If temperature drives the detection of emerald ash borers in various communities of Ontario, we would expect to see more EAB detections in communities with higher annual temperatures.***
- *We found that EABs were more prevalent in communities with higher average annual temperatures*
- *We reject the null hypothesis*
  - *BUT not all communities are significant*

Conclusions

The effectiveness of current management and removal strategies

The impact of climate change on EAB populations

Overall human impact and assistance in spread

Indirectly affecting human health: Respiratory Issues[5]

References

1. Johny S, Kyei-Poku G, Gauthier D, van Frankenhuyzen K, Krell PJ. 2012. Characterization and virulence of *Beauveria* spp. recovered from emerald ash borer in southwestern Ontario, Canada. *J Invertebr Pathol* 111(1): 41-49.
2. Eckenwalder JE, Metsger DA, Dickinson TA, Hodges SH. 2023. A Field Guide to Trees of Ontario. Royal Ontario Museum.
3. Ryall, K. L., Fidgen, J. G., & Turgeon, J. J. (2011). Detectability of the emerald ash borer (Coleoptera: Buprestidae) in asymptomatic urban trees by using branch samples. Environmental Entomology, 40(3), 679–688.
4. Donovan, G. H., Butry, D. T., Michael, Y. L., Prestemon, J. P., Liebhold, A. M., Gatziolis, D., & Mao, M. Y. (2013). The relationship between trees and human health. American Journal of Preventive Medicine, 44(2), 139–145.
5. Government of Canada. 2017b. CFIA Observations of EAB: Government of Canada, Emerald Ash Borer Surveillance Data 2002-2020, Canadian Food Inspection Agency. [online] https://open.canada.ca/data/en/dataset/69f4ecd8-9761-4d40-b0f9-e186f2fcce5b. [accessed 1 October 2023].

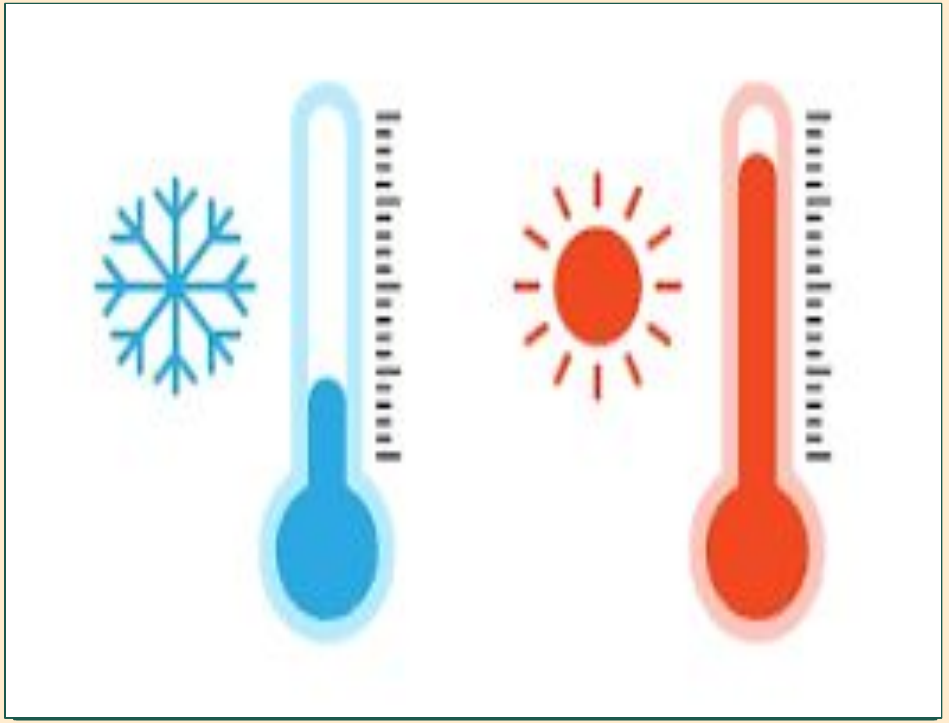
DATA MANIPULATION

Emerald Ash Borer Surveillance Data 2002 to 2020

Census Data derived from Stats Canada

Historical Weather Data

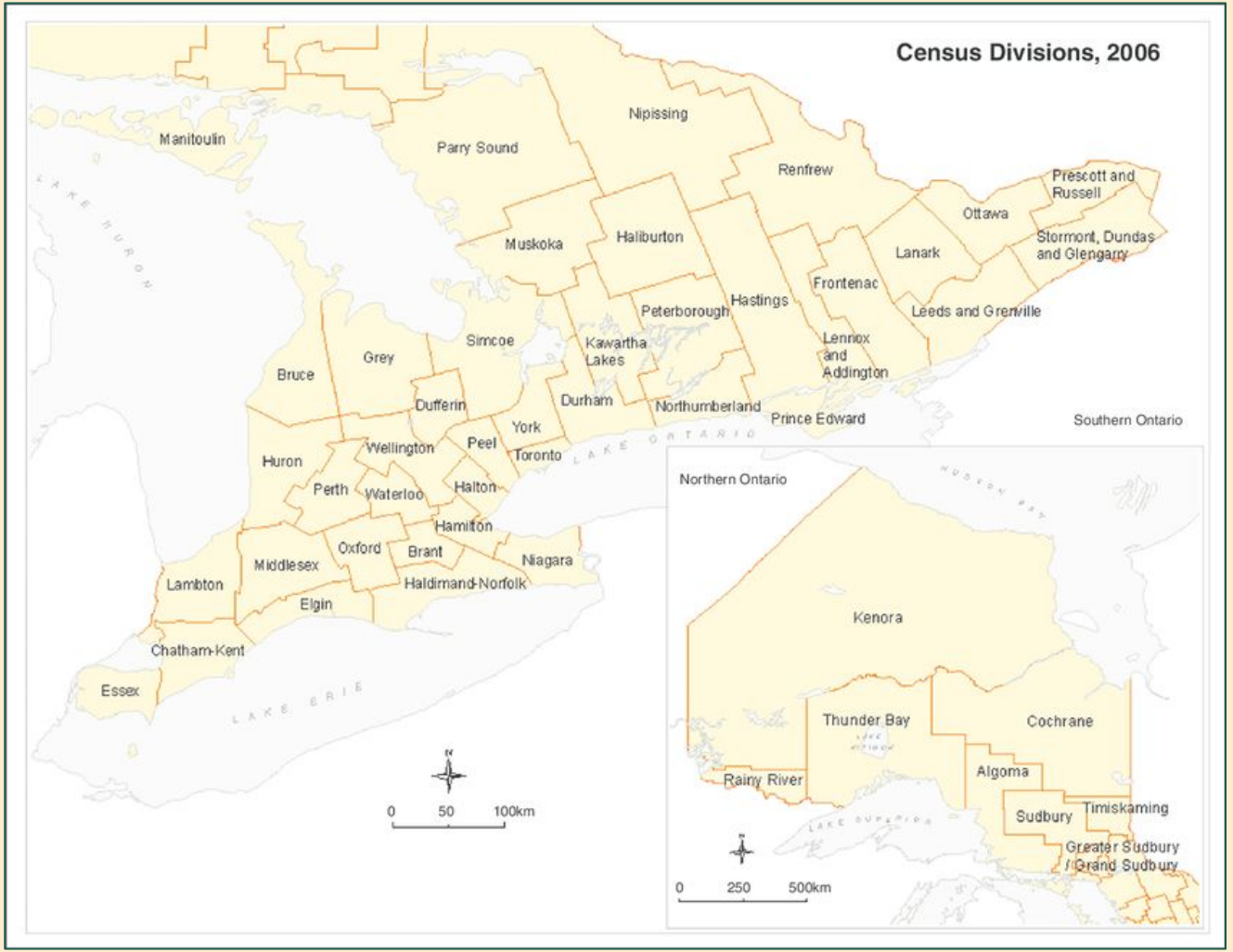
OUR FINAL DATA SET



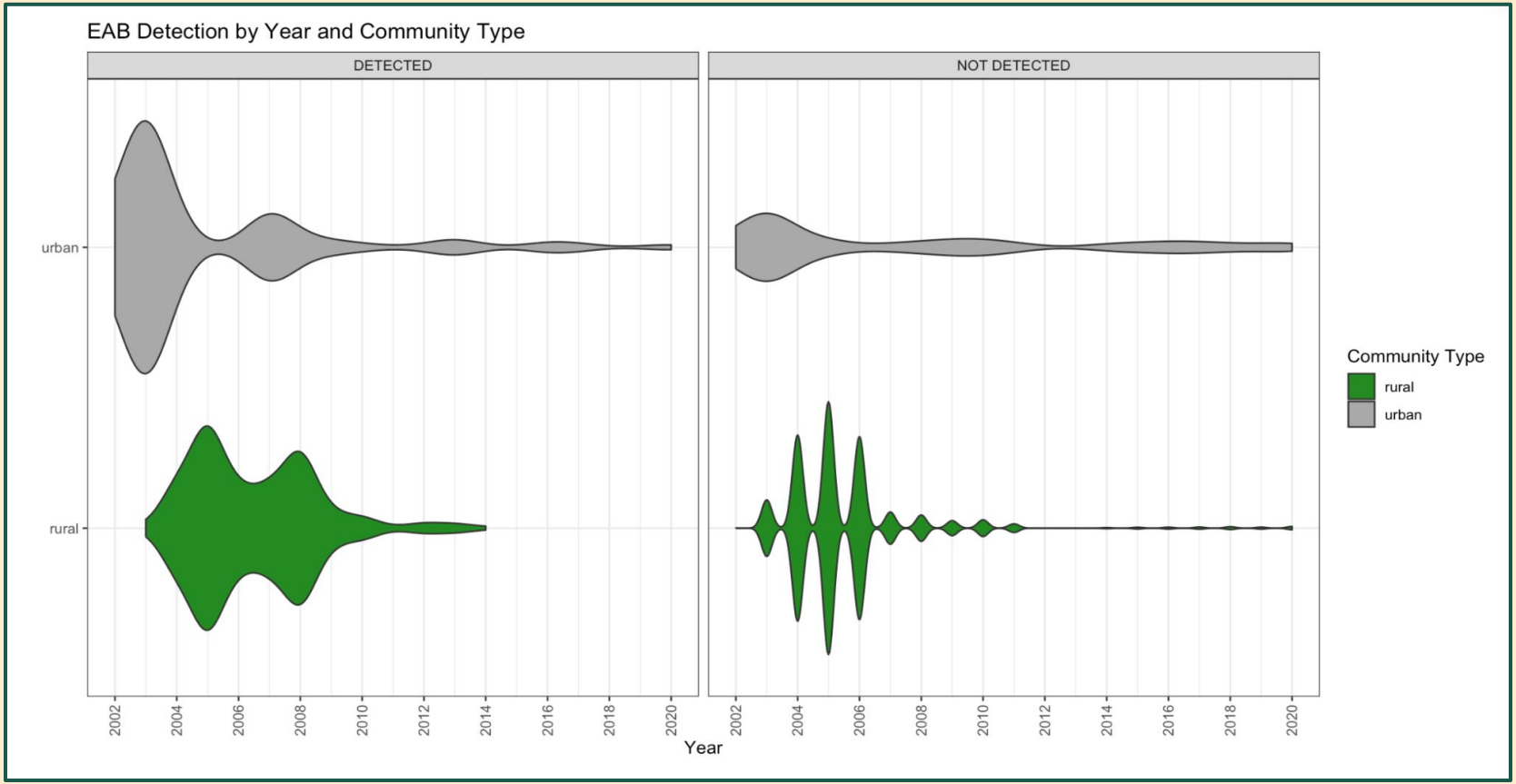
Government of Canada

Statistics Canada

Breakdown of some of the communities from our dataset!



Hypothesis #2:



```
Call:
glm(formula = as.factor(result) ~ year * latitude * longitude,
    family = binomial, data = ont_eab_data)

Coefficients:
                          Estimate Std. Error z value Pr(>|z|)
(Intercept)               4.469e+05  2.656e+04   16.82   <2e-16 ***
year                     -2.221e+02  1.319e+01  -16.84   <2e-16 ***
latitude                 -9.534e+03  5.867e+02  -16.25   <2e-16 ***
longitude                 5.387e+03  3.146e+02   17.12   <2e-16 ***
year:latitude             4.738e+00  2.911e-01   16.27   <2e-16 ***
year:longitude           -2.677e+00  1.562e-01  -17.14   <2e-16 ***
latitude:longitude       -1.150e+02  6.954e+00  -16.54   <2e-16 ***
year:latitude:longitude   5.716e-02  3.450e-03   16.57   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 8649.4  on 38000  degrees of freedom
Residual deviance: 8014.2  on 37993  degrees of freedom
AIC: 8030.2

Number of Fisher Scoring iterations: 9
```

Hypothesis #2:

Differences in population densities of rural and urban Ontario communities impact the detection of EAB over the years.

Latitude and longitude coordinates correlate with community type (rural or urban) in Ontario