# Statistical Models for Forest Ecology


Prof. Albert Y. Kim

Environmental Science & Policy Lunchbag

Wednesday, September 30, 2020

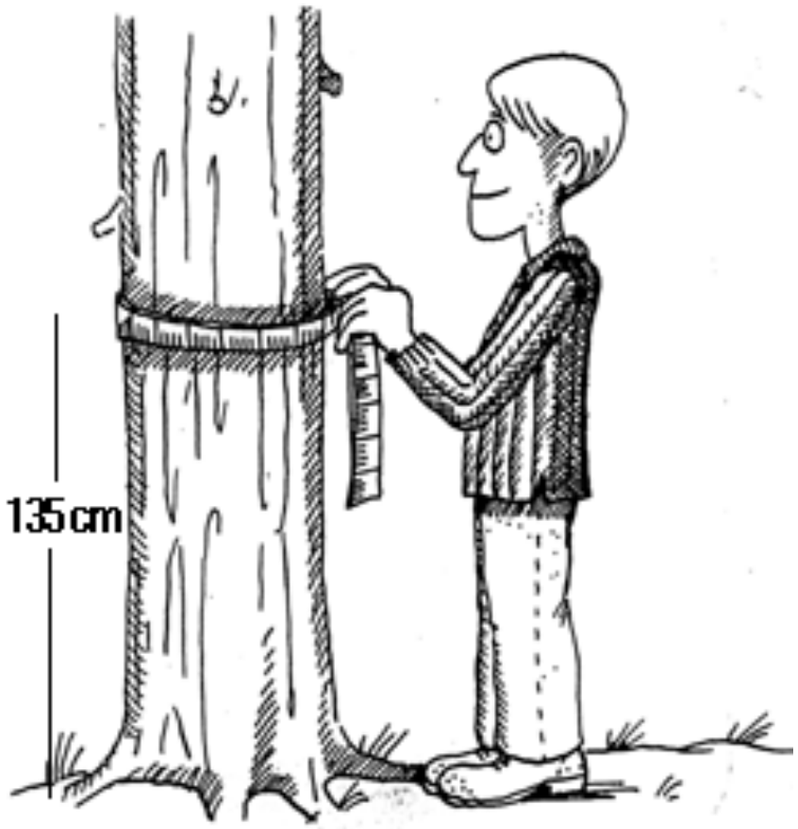
Smith College SDS Statistical & Data Sciences

# Diameter at Breast Height (dbh)

After species & location, one of the most informative variables about a tree is dbh

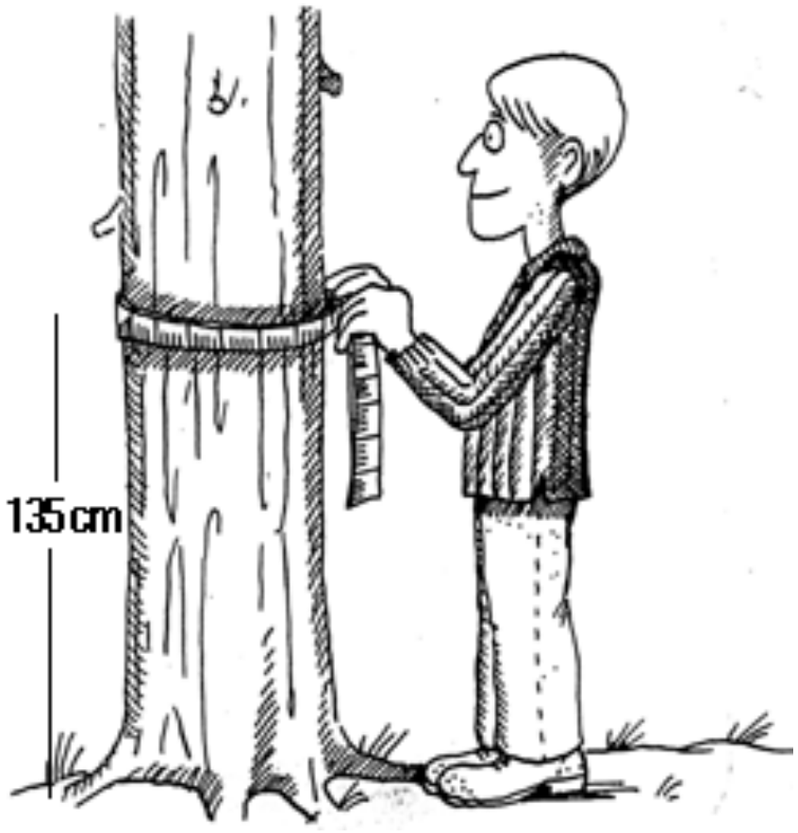
# Diameter at Breast Height (dbh)

After species & location, one of the most informative variables about a tree is dbh



# Diameter at Breast Height (dbh)

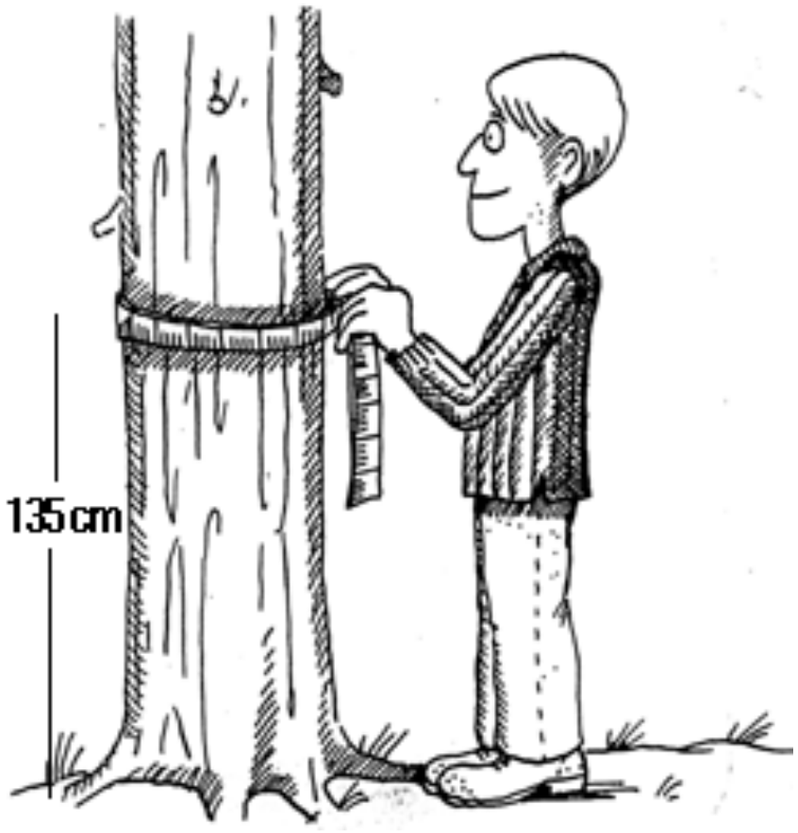
After species & location, one of the most informative variables about a tree is dbh




135cm off the ground

# Diameter at Breast Height (dbh)

After species & location, one of the most informative variables about a tree is dbh




135cm off the ground

🥥 for 🤔: Just whose breast height are we talking about?

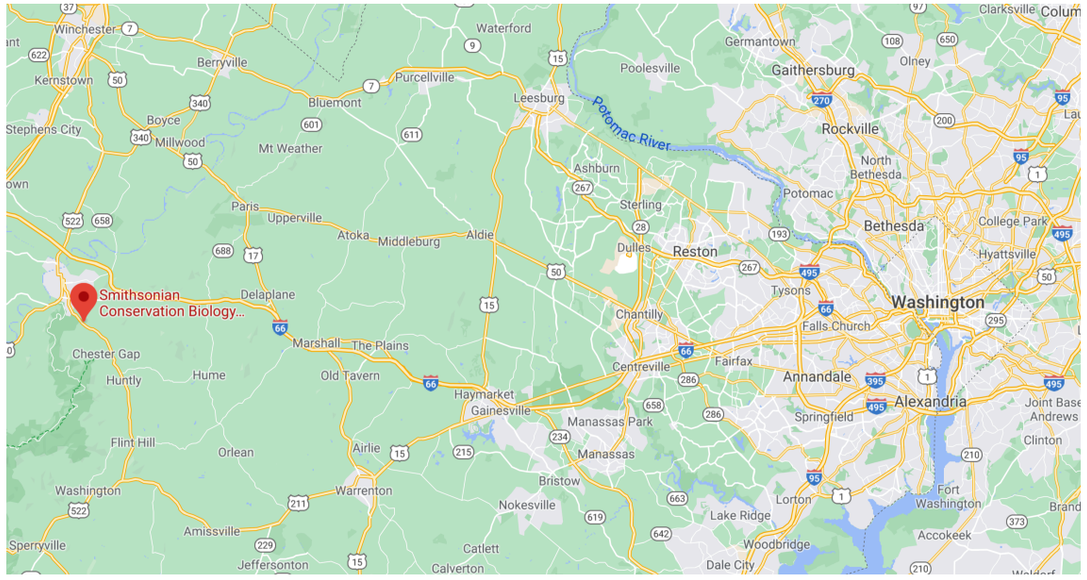
# Question 0: What data did we collect and how?

# Liriodendron Tulipifera i.e. Tulip Poplar

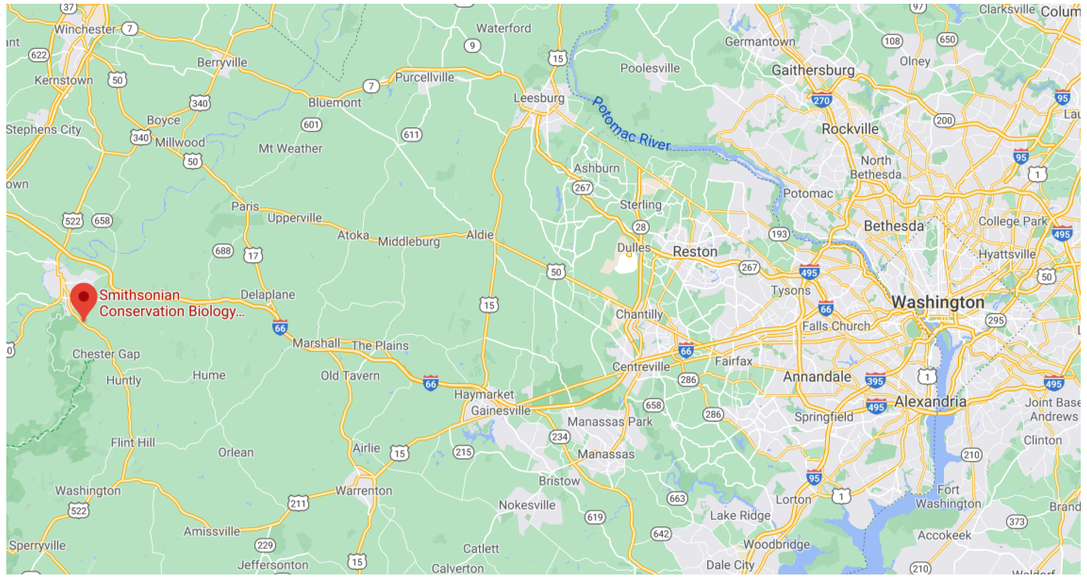
State tree of Indiana, Kentucky, & Tennessee.

# One particular tulip poplar

# One particular tulip poplar



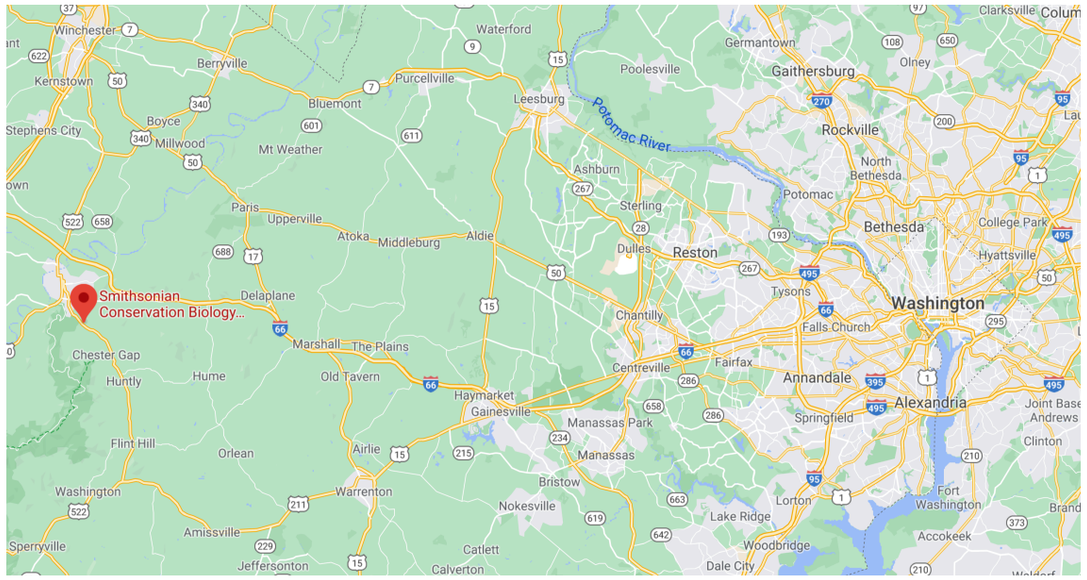
# One particular tulip poplar



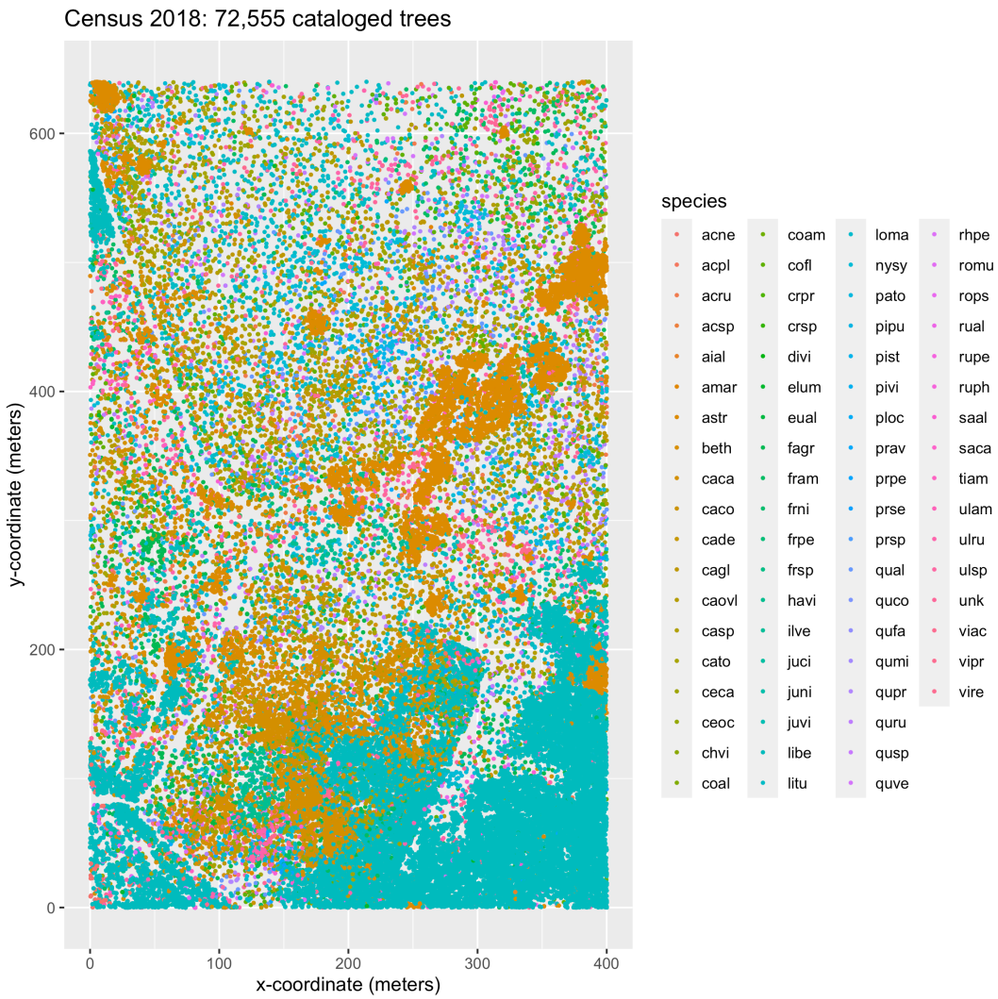


25.6 ha = 35.85 soccer fields

# One particular tulip poplar

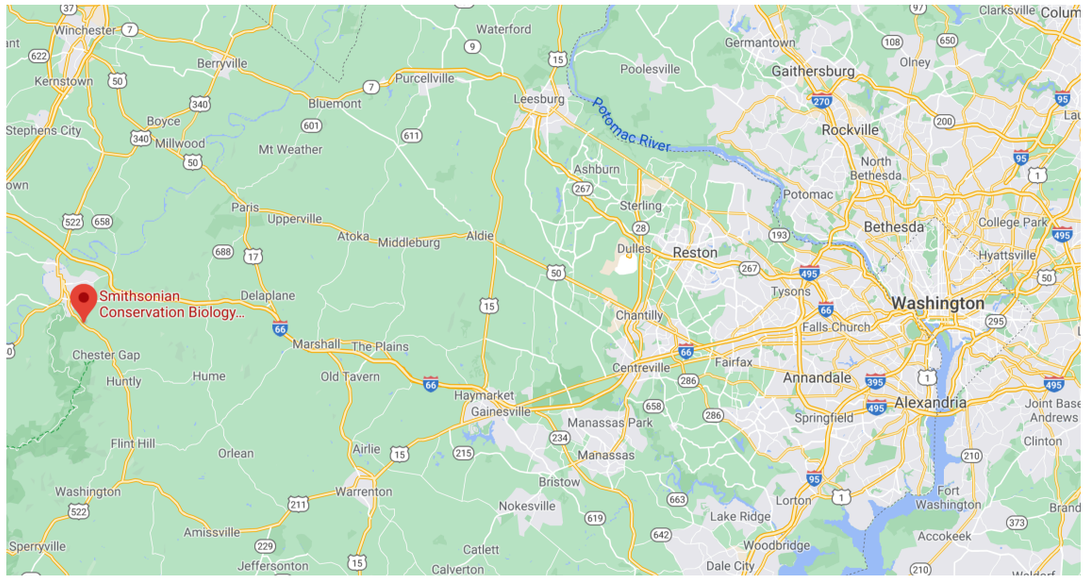


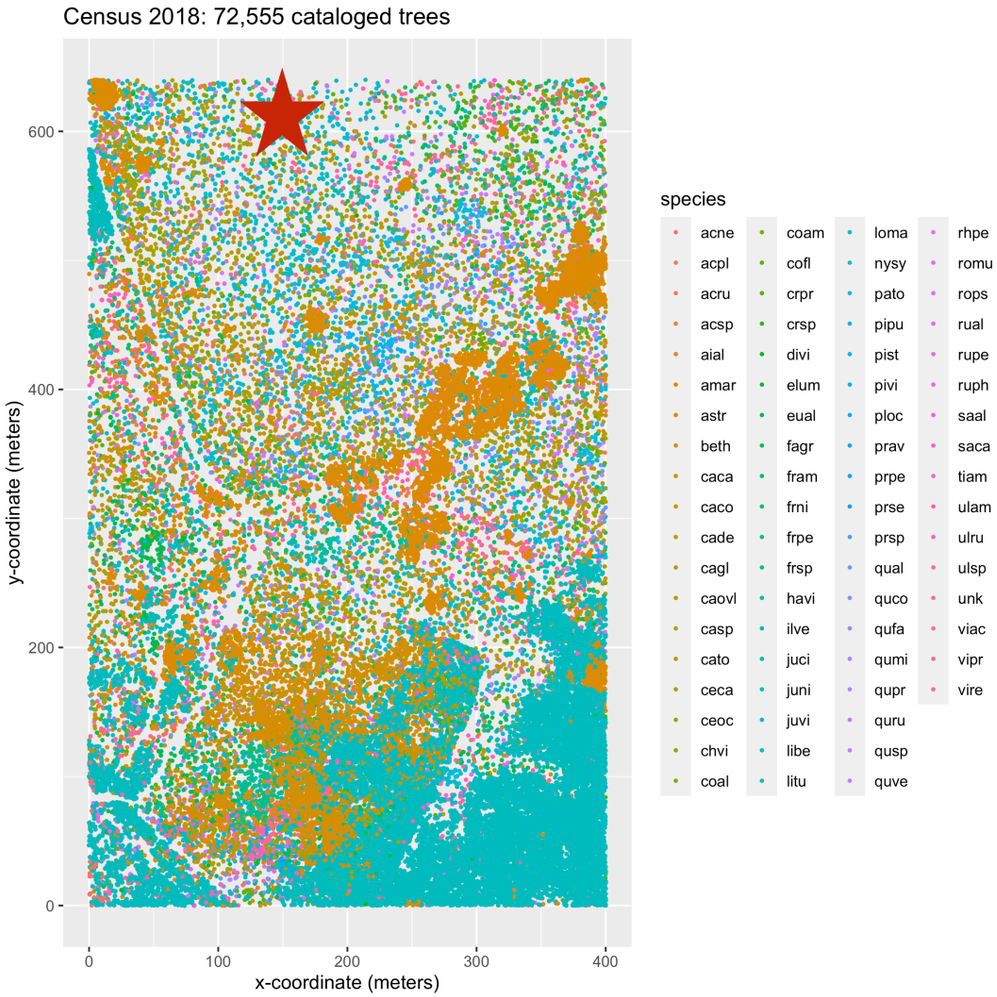





25.6 ha = 35.85 soccer fields

# One particular tulip poplar





25.6 ha = 35.85 soccer fields


Tag 082422

# 1. Measure diameter w/ dendroband + calipers

# 2. Share Data on GitHub

Search or jump to... / Pull requests Issues Codespaces Marketplace Explore

SCBI-ForestGEO / Dendrobands — Unwatch 5 | Star 0 | Fork 0

<> Code | Issues 3 | Pull requests | Actions | Projects | Wiki | Security | Insights

master — Dendrobands / data / scbi.dendroAll_2020.csv — Go to file

rudeboybert Replace text month coding with integer month coding for 2019 & 2020. F... — Latest commit aa41236 on Jul 3 — History

4 contributors

1280 lines (1280 sloc) | 190 KB — Raw | Blame

Search this file...

| | tag | stemtag | survey.ID | year | month | day | biannual | intraannual | sp | quadrat | lx | ly | measure | codes | notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 10469 | 1 | 2020.01 | 2020 | 3 | 11 | 1 | 0 | litu | 109 | 9.7 | 1 | NA | RE | window too large to measure |
| 3 | 10587 | 1 | 2020.01 | 2020 | 3 | 11 | 1 | 0 | litu | 113 | 2.6 | 13 | 61.41 | NA | NA |
| 4 | 10609 | 1 | 2020.01 | 2020 | 3 | 11 | 1 | 0 | cagl | 111 | 19.5 | 2.9 | 81.03 | NA | double-checked |

# 2. Share Data on GitHub

Search or jump to... / Pull requests Issues Codespaces Marketplace Explore

SCBI-ForestGEO / Dendrobands — Unwatch 5 | Star 0 | Fork 0

<> Code | Issues 3 | Pull requests | Actions | Projects | Wiki | Security | Insights

master — Dendrobands / data / scbi.dendroAll_2020.csv — Go to file

rudeboybert Replace text month coding with integer month coding for 2019 & 2020. F... — Latest commit aa41236 on Jul 3 — History

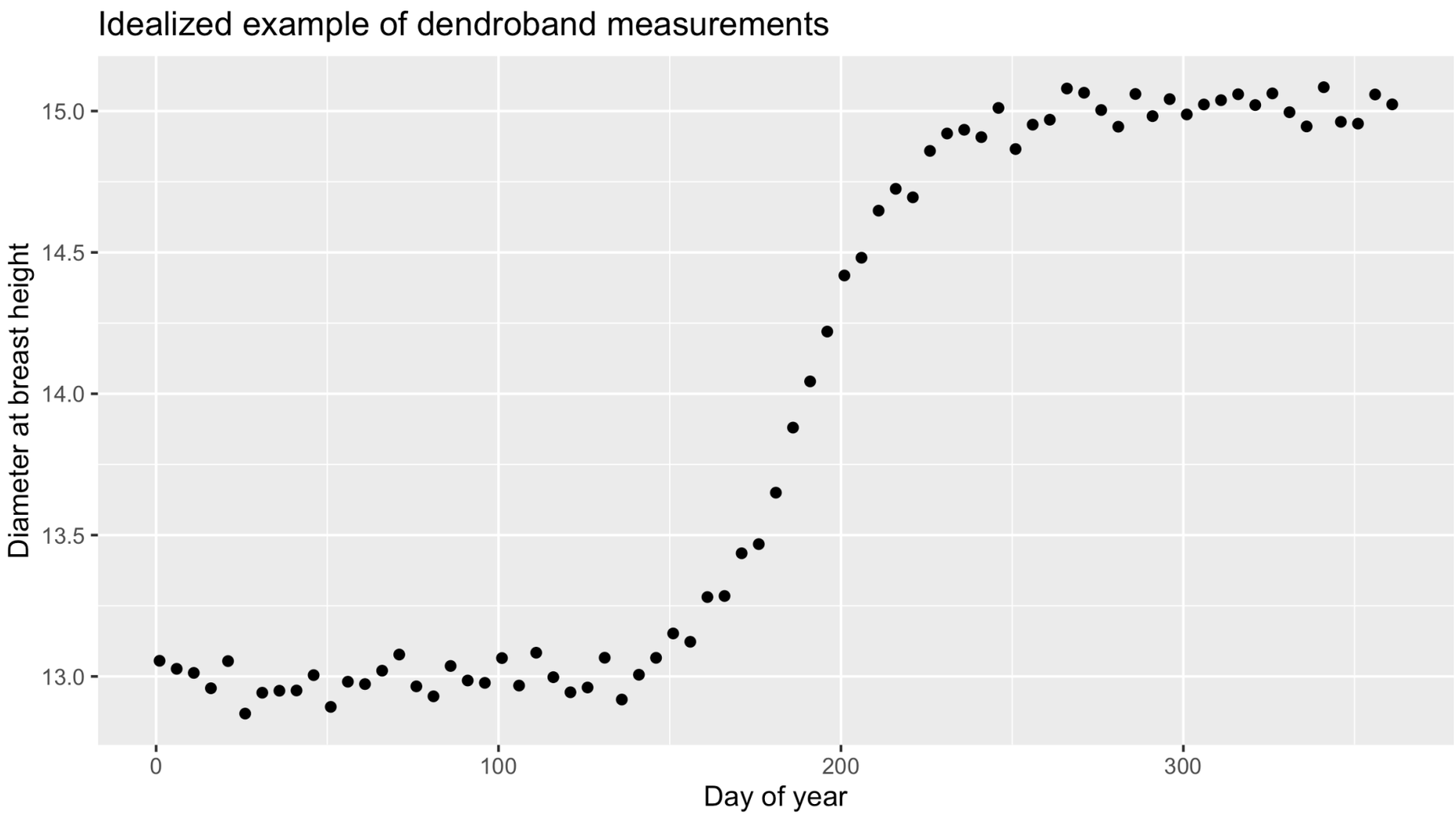
4 contributors

1280 lines (1280 sloc) | 190 KB — Raw | Blame

Search this file...

| | tag | stemtag | survey.ID | year | month | day | biannual | intraannual | sp | quadrat | lx | ly | measure | codes | notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 10469 | 1 | 2020.01 | 2020 | 3 | 11 | 1 | 0 | litu | 109 | 9.7 | 1 | NA | RE | window too large to measure |
| 3 | 10587 | 1 | 2020.01 | 2020 | 3 | 11 | 1 | 0 | litu | 113 | 2.6 | 13 | 61.41 | NA | NA |
| 4 | 10609 | 1 | 2020.01 | 2020 | 3 | 11 | 1 | 0 | cagl | 111 | 19.5 | 2.9 | 81.03 | NA | double-checked |

# 3. Load data into statistical software



# Lesson 1: Numbers are numbers, but data has ***context***.

# Question 1: How can we model *within-year* tree growth?

# Models

$$y = f(x) + \epsilon$$

# Models

$$y = f(x) + \epsilon$$

Models in general:

- y = outcome you want to explain
- x = input info
- f = function connecting y & x
- epsilon = error

# Models

$$y = f(x) + \epsilon$$

Models in general:

- y = outcome you want to explain
- x = input info
- f = function connecting y & x
- epsilon = error

$$dbh = f(doy) + \epsilon$$

# Models

$$y = f(x) + \epsilon$$

Models in general:

- y = outcome you want to explain
- x = input info
- f = function connecting y & x
- epsilon = error

$$dbh = f(doy) + \epsilon$$

Model for dbh from dendrobands

- y = dbh
- x = day of year where Jan 1st = 1
- f = function connecting y & x
- epsilon = measurement error, etc

# Models

$$y = f(x) + \epsilon$$

Models in general:

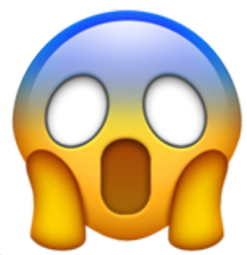
- y = outcome you want to explain
- x = input info
- f = function connecting y & x
- epsilon = error

$$dbh = f(doy) + \epsilon$$

Model for dbh from dendrobands

- y = dbh
- x = day of year where Jan 1st = 1
- f = function connecting y & x
- epsilon = measurement error, etc

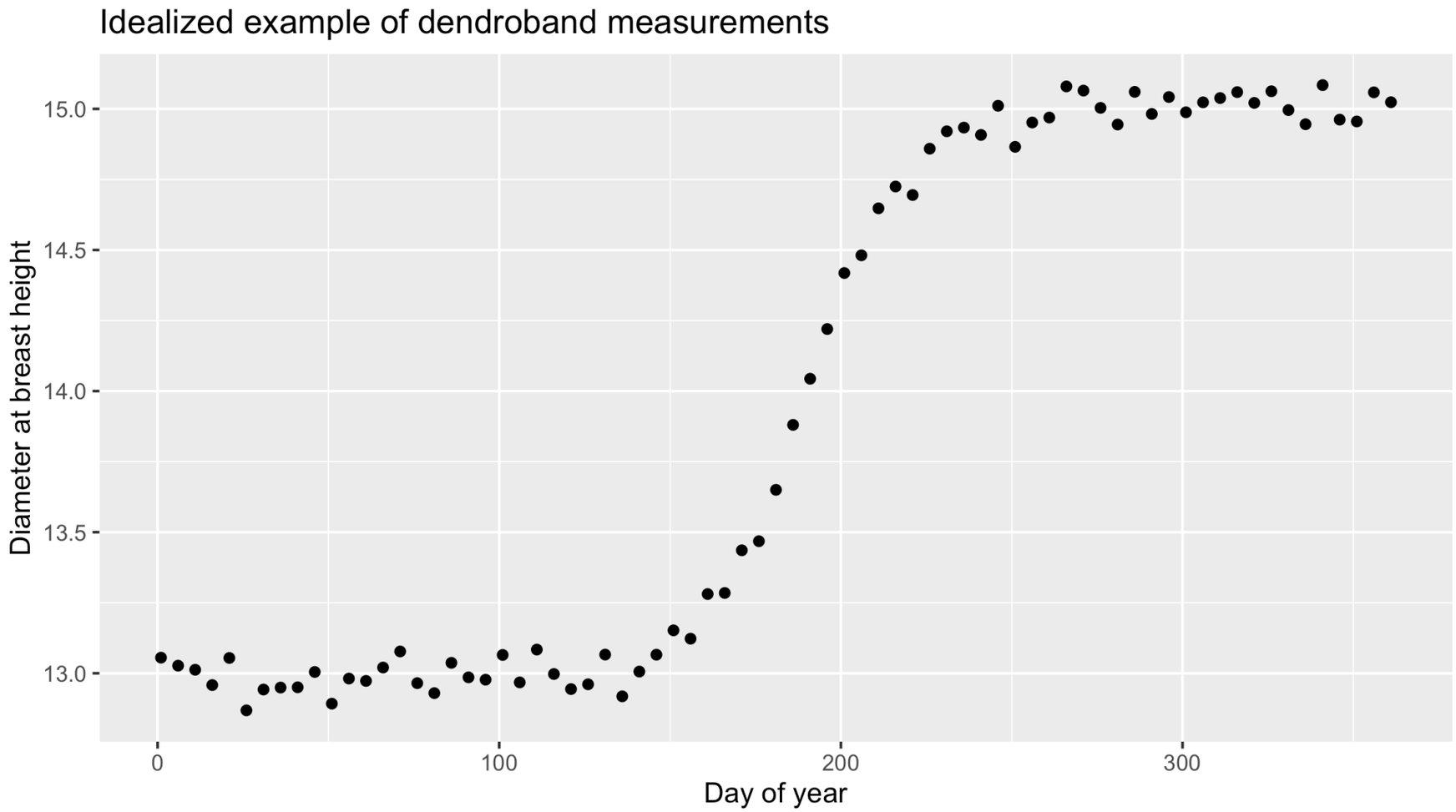
$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}} + \epsilon$$



McMahon (2014)

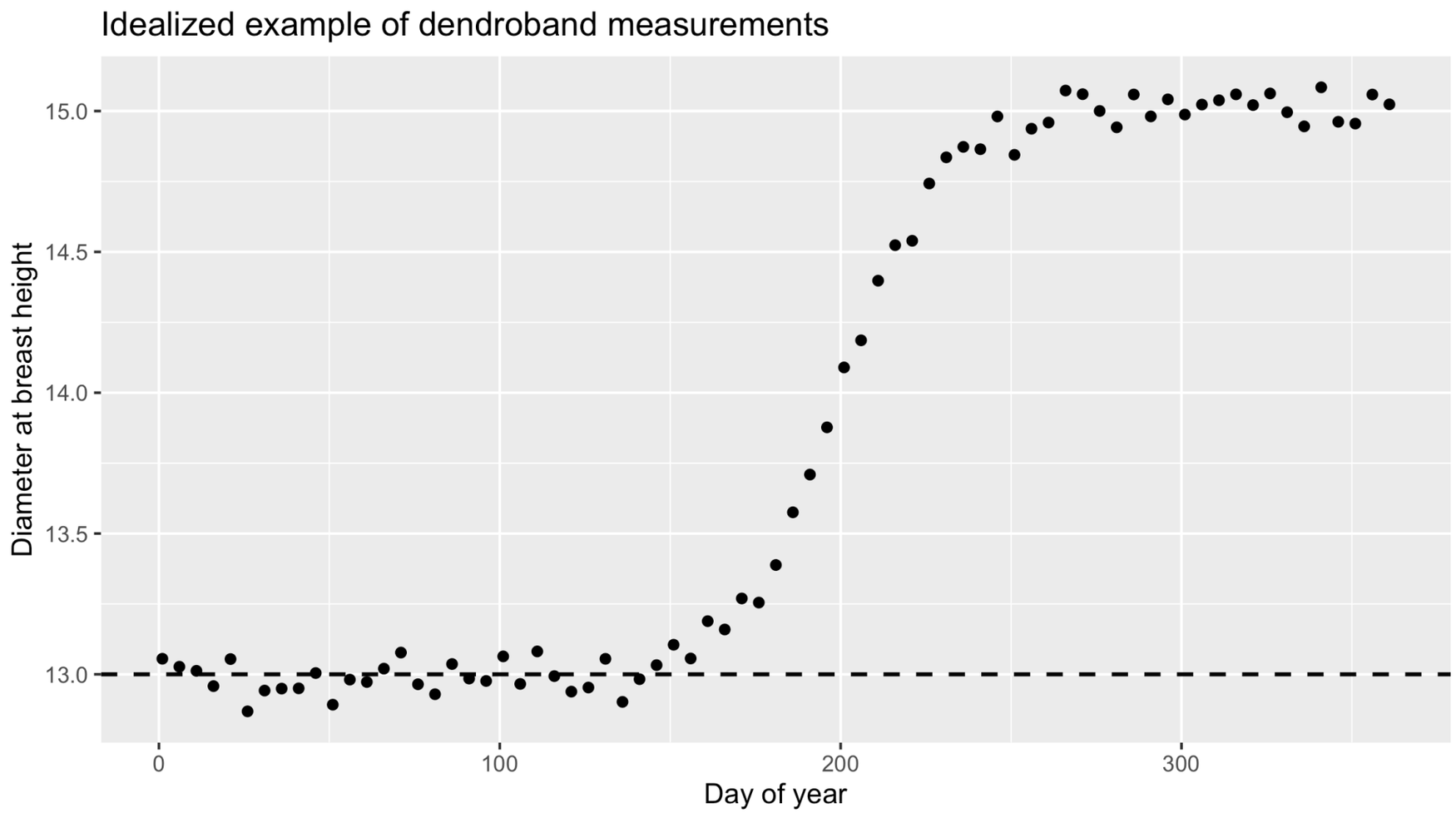
# Model for dbh

$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$



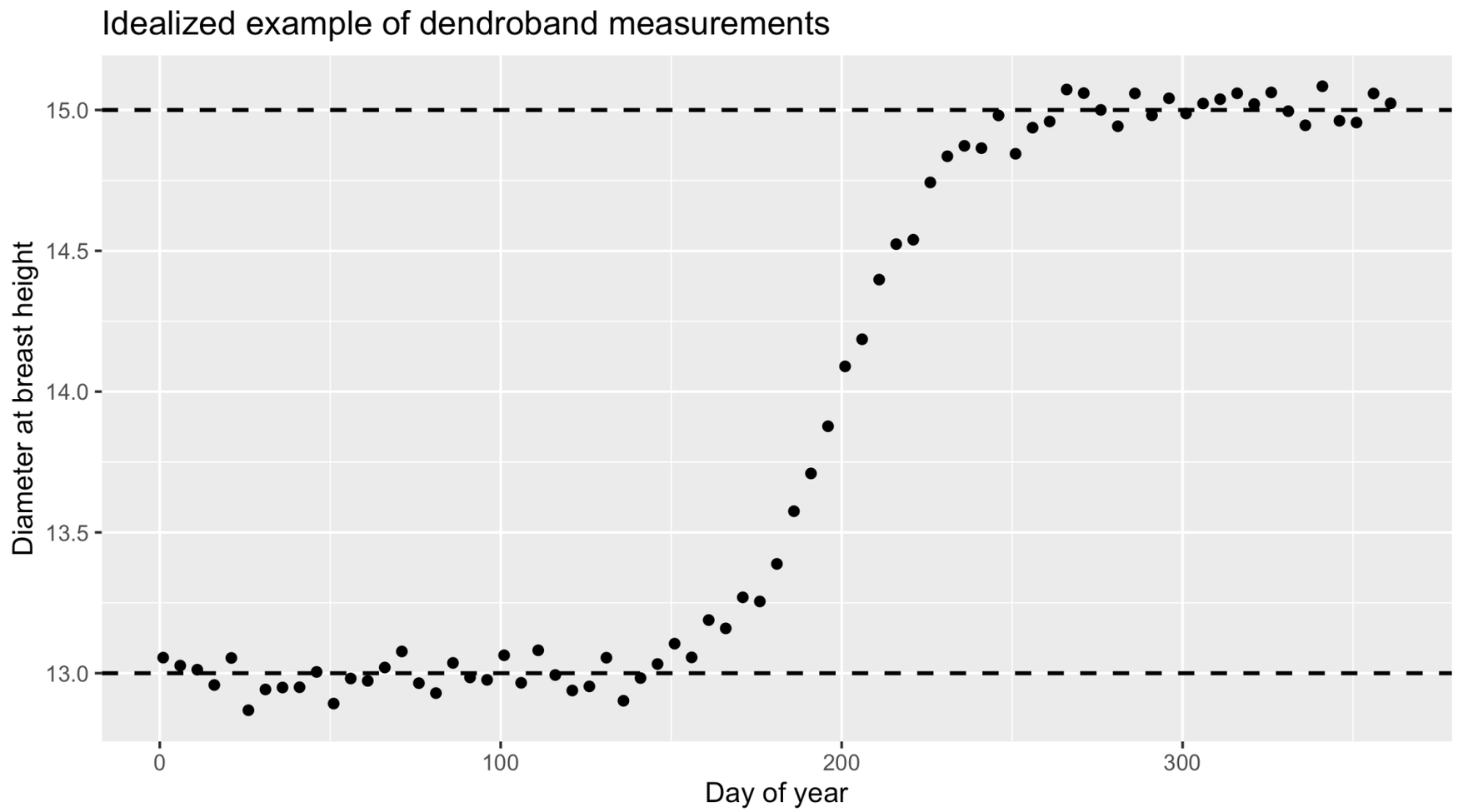
# Model for dbh

$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$



# Model for dbh

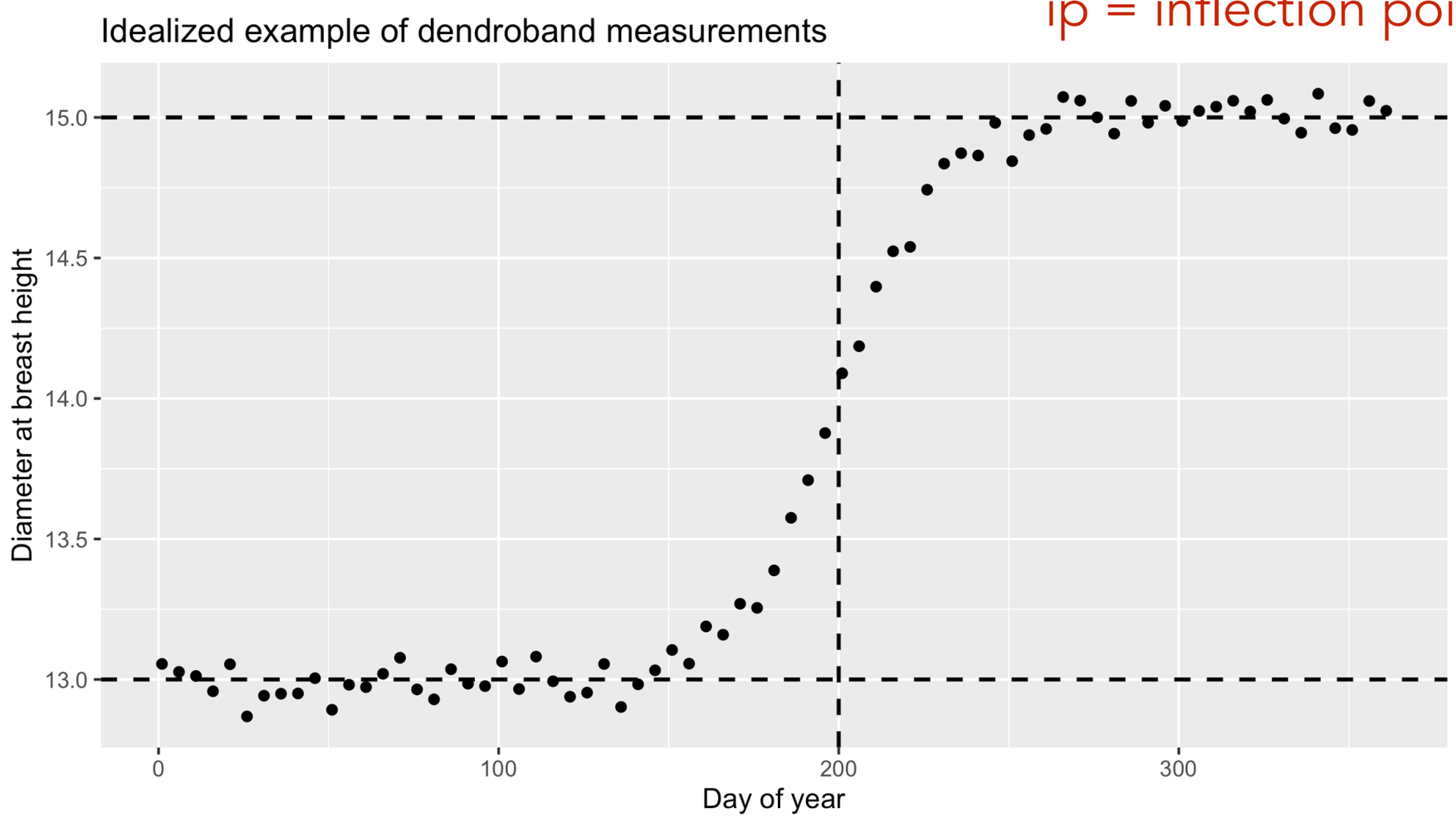
$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$



# Model for dbh

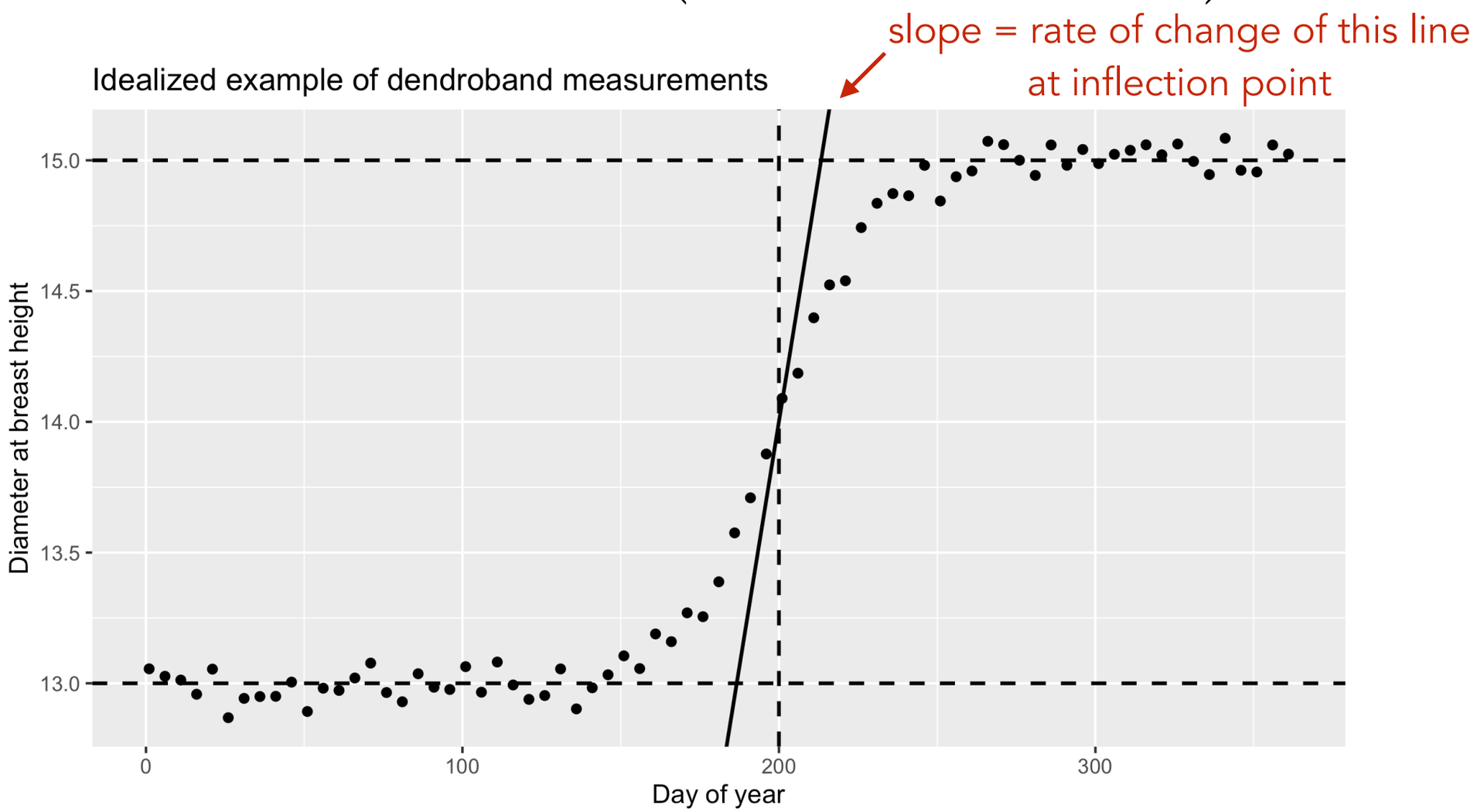
$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$

ip = inflection point



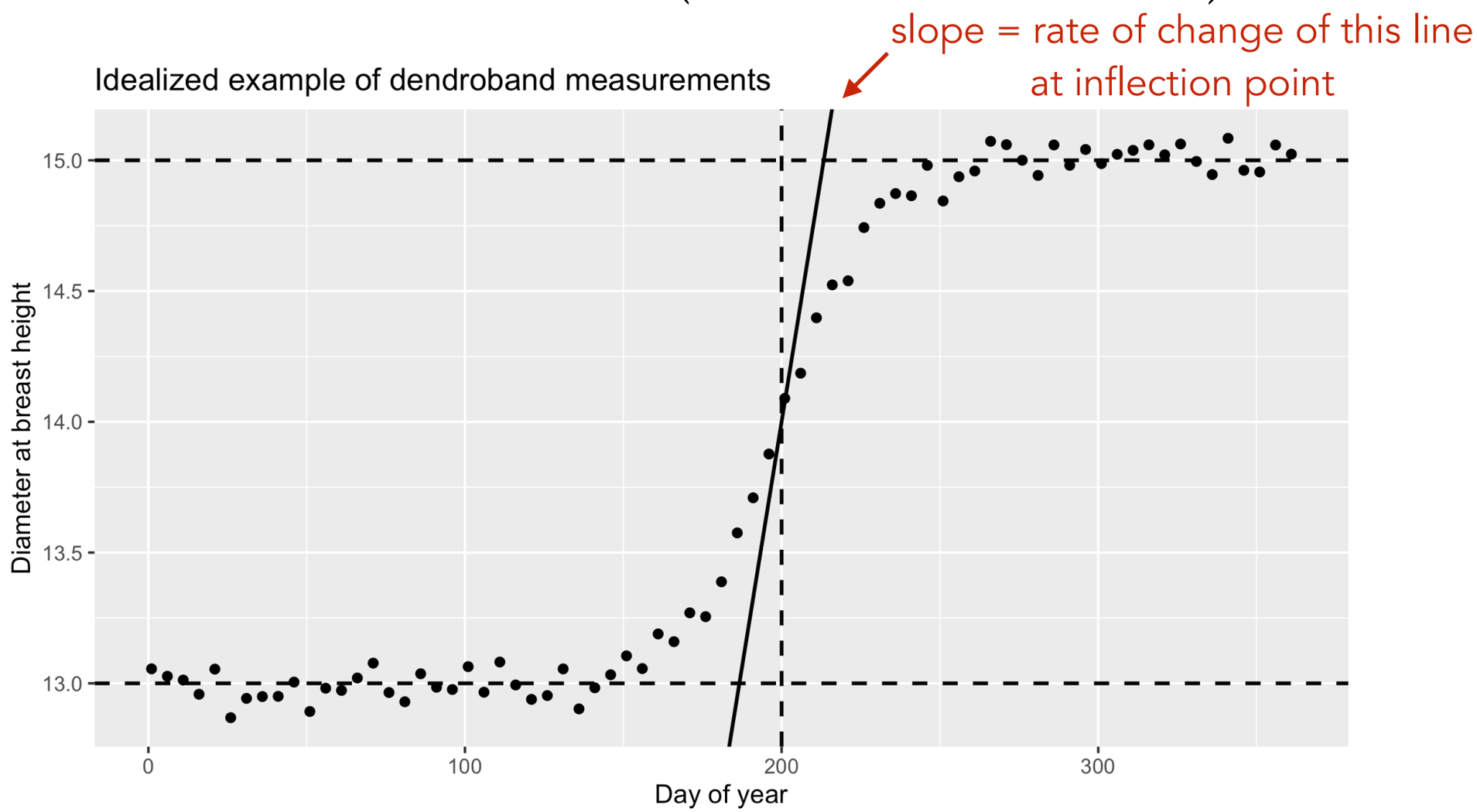
# Model for dbh

$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$



# Model for dbh

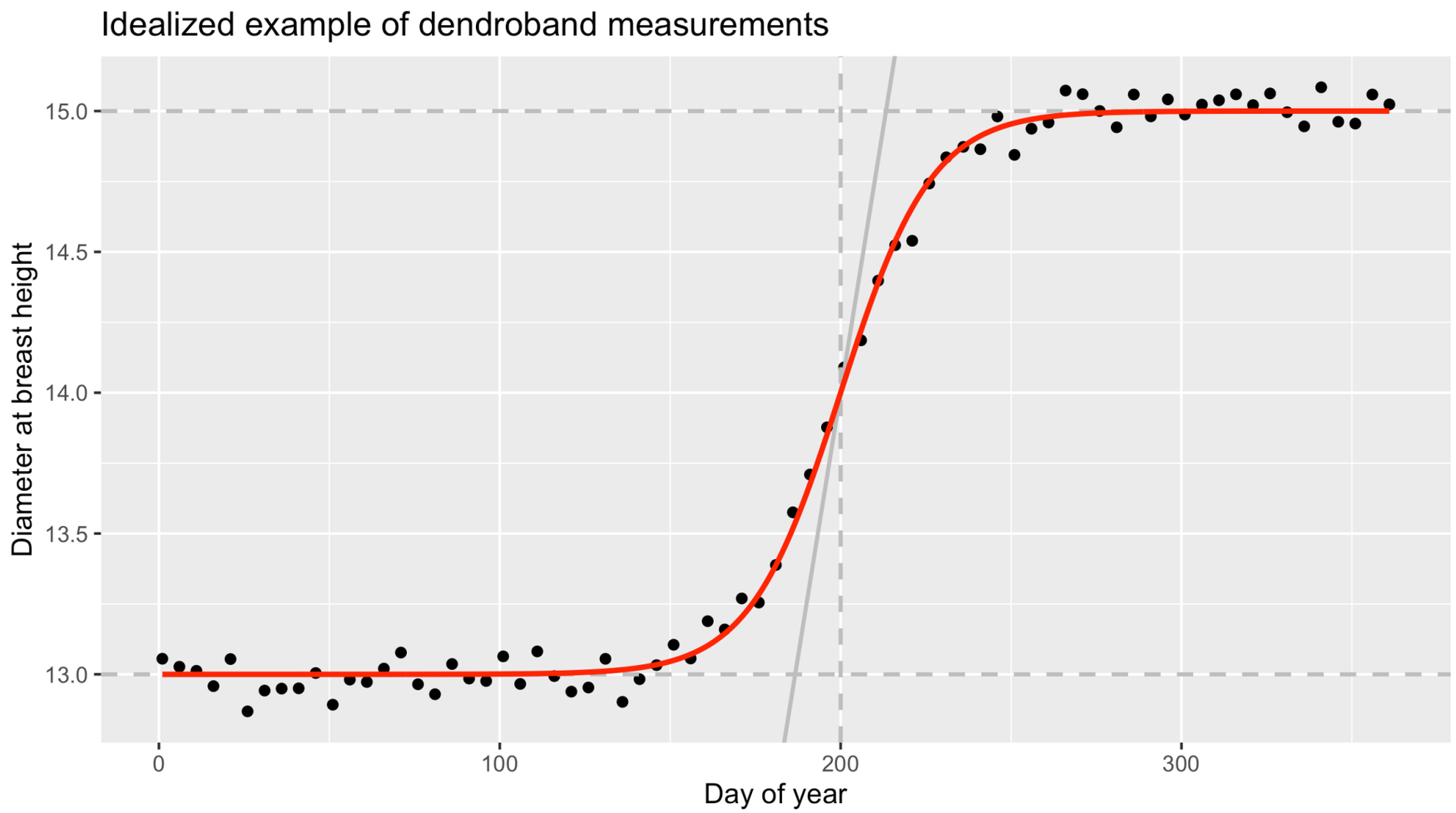
$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$




Ignoring θ, let's put it all together…

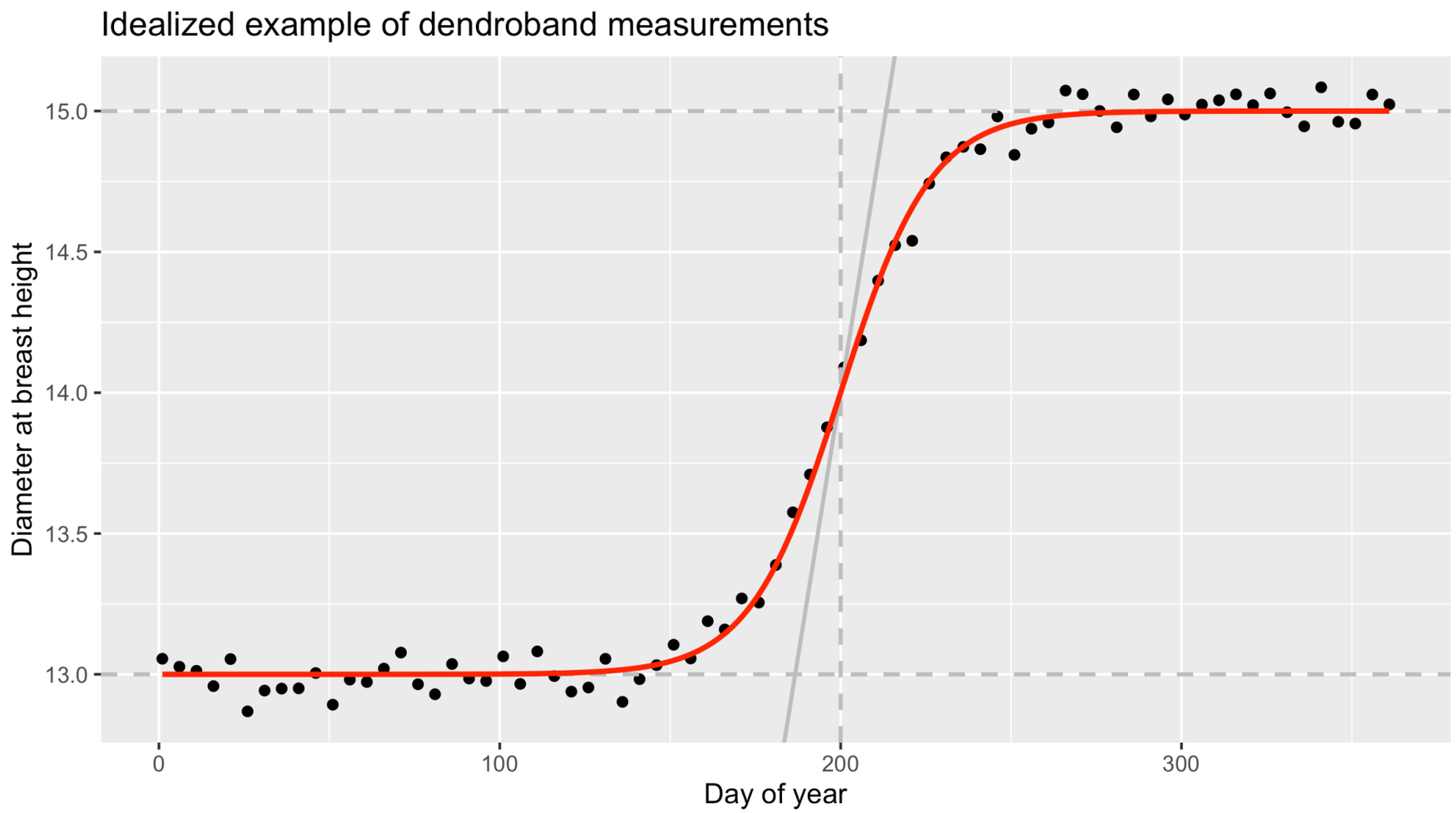
# Model for dbh

$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$



# Model for dbh

$$dbh = \frac{L + (K - L)}{1 + 1/\theta \cdot \exp\left(-r(doy - doy_{ip})/\theta\right)^{\theta}}$$

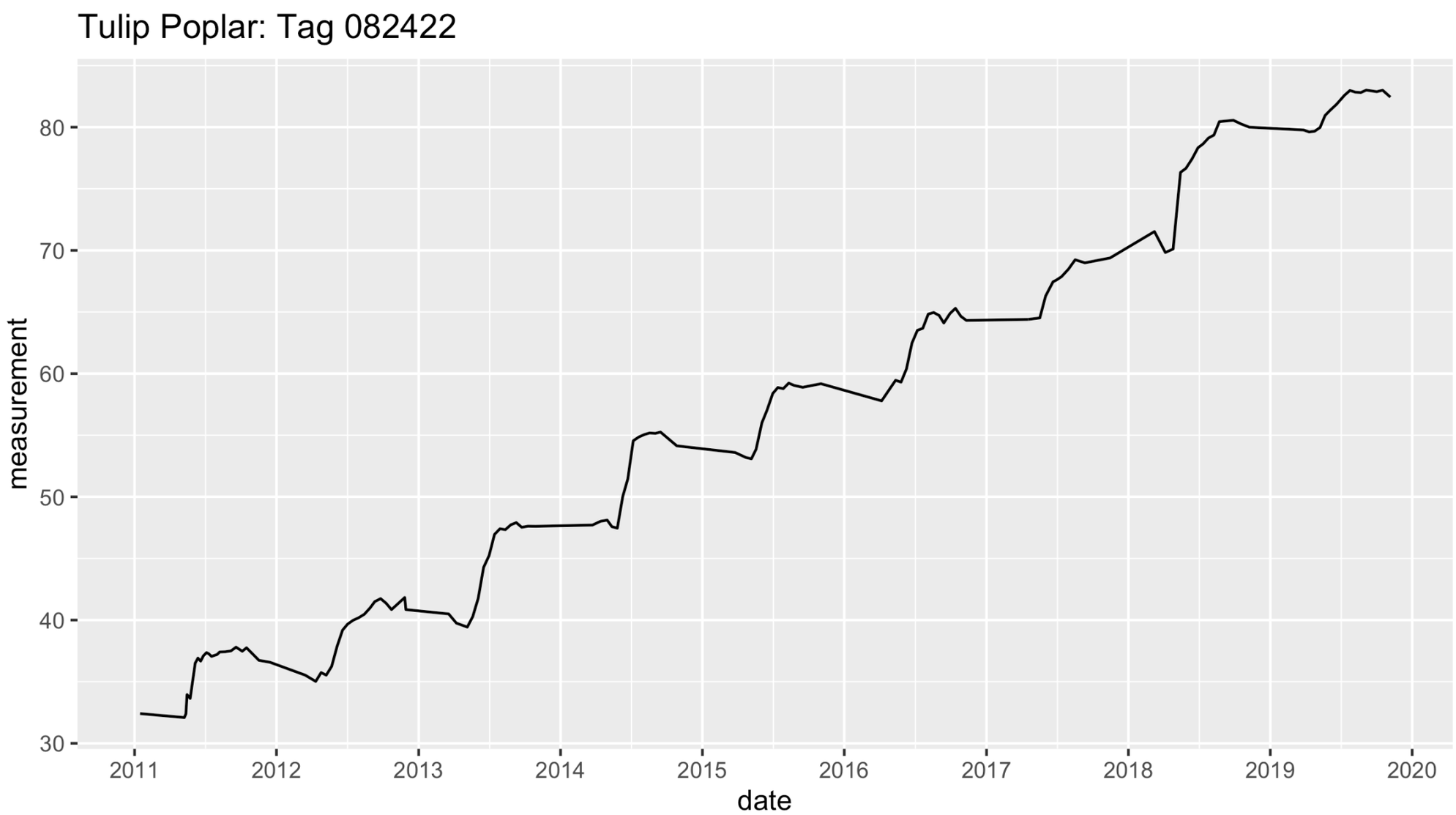



But remember, you need a model that works for ALL 🌲🌳🌴

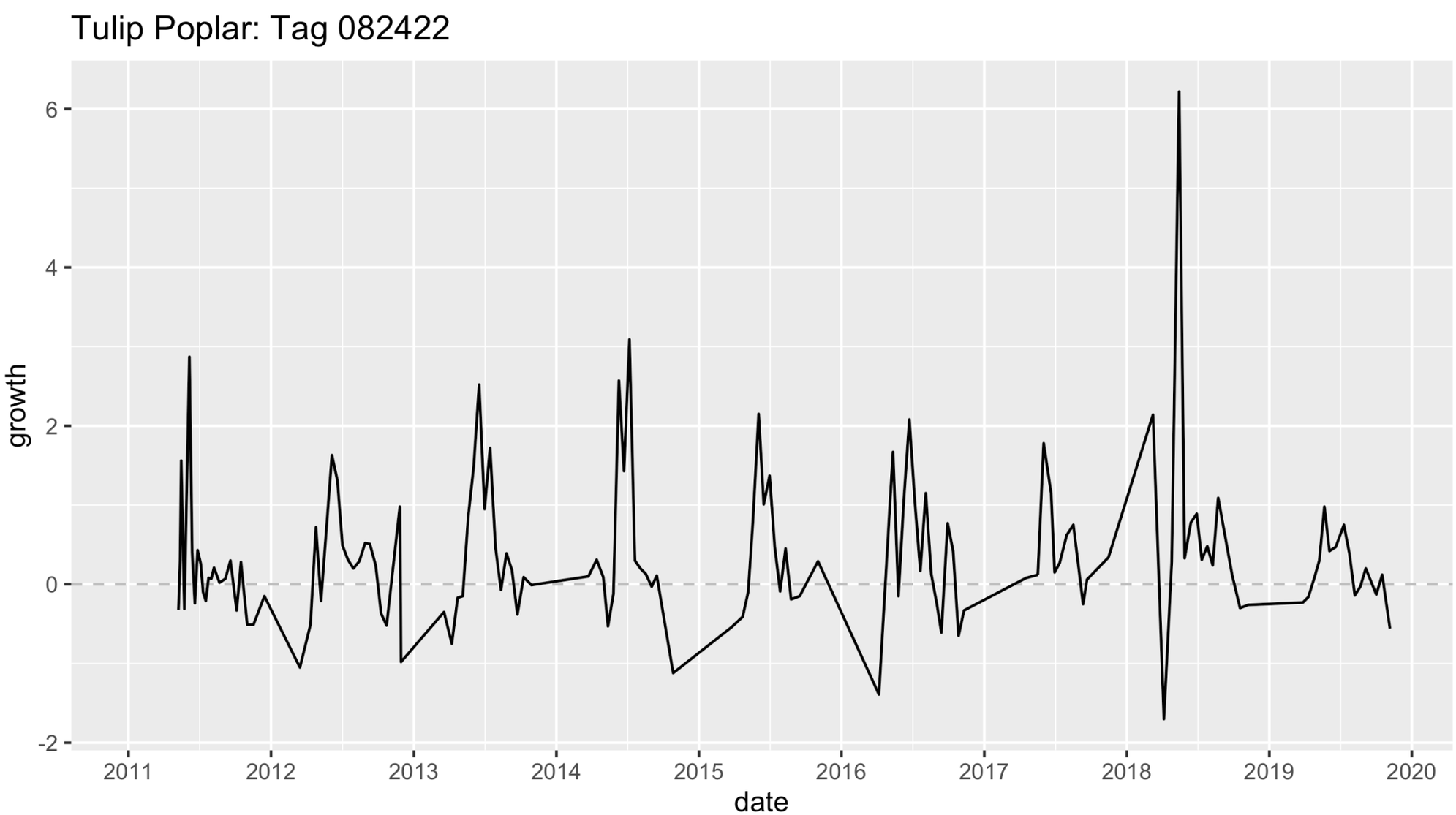
# Lesson 2: Statistics is *not* math, rather statistics *uses* math

# Question 2: How can we model the effect of climate change on growth?

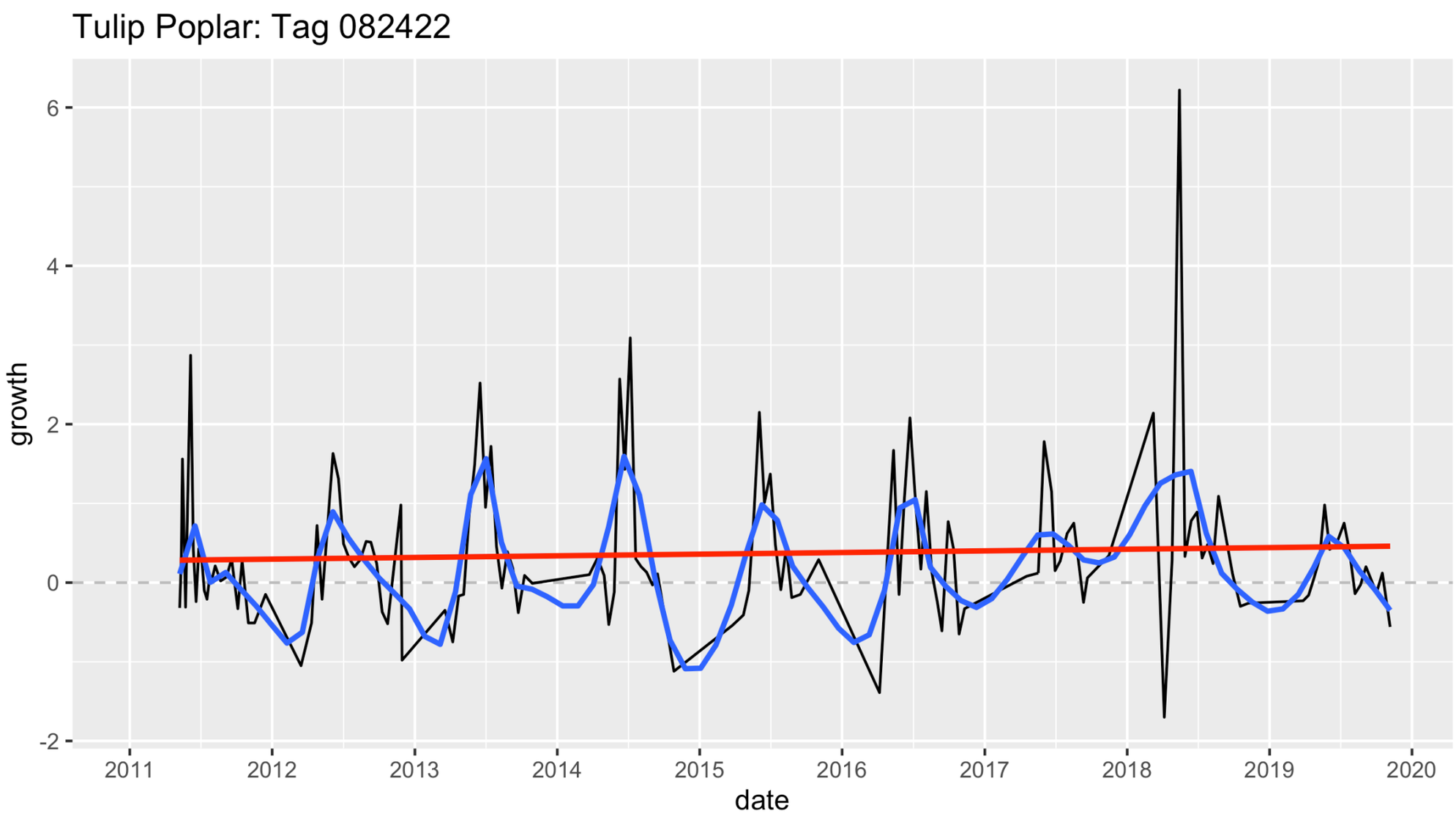
# Observed Dendroband Measurements



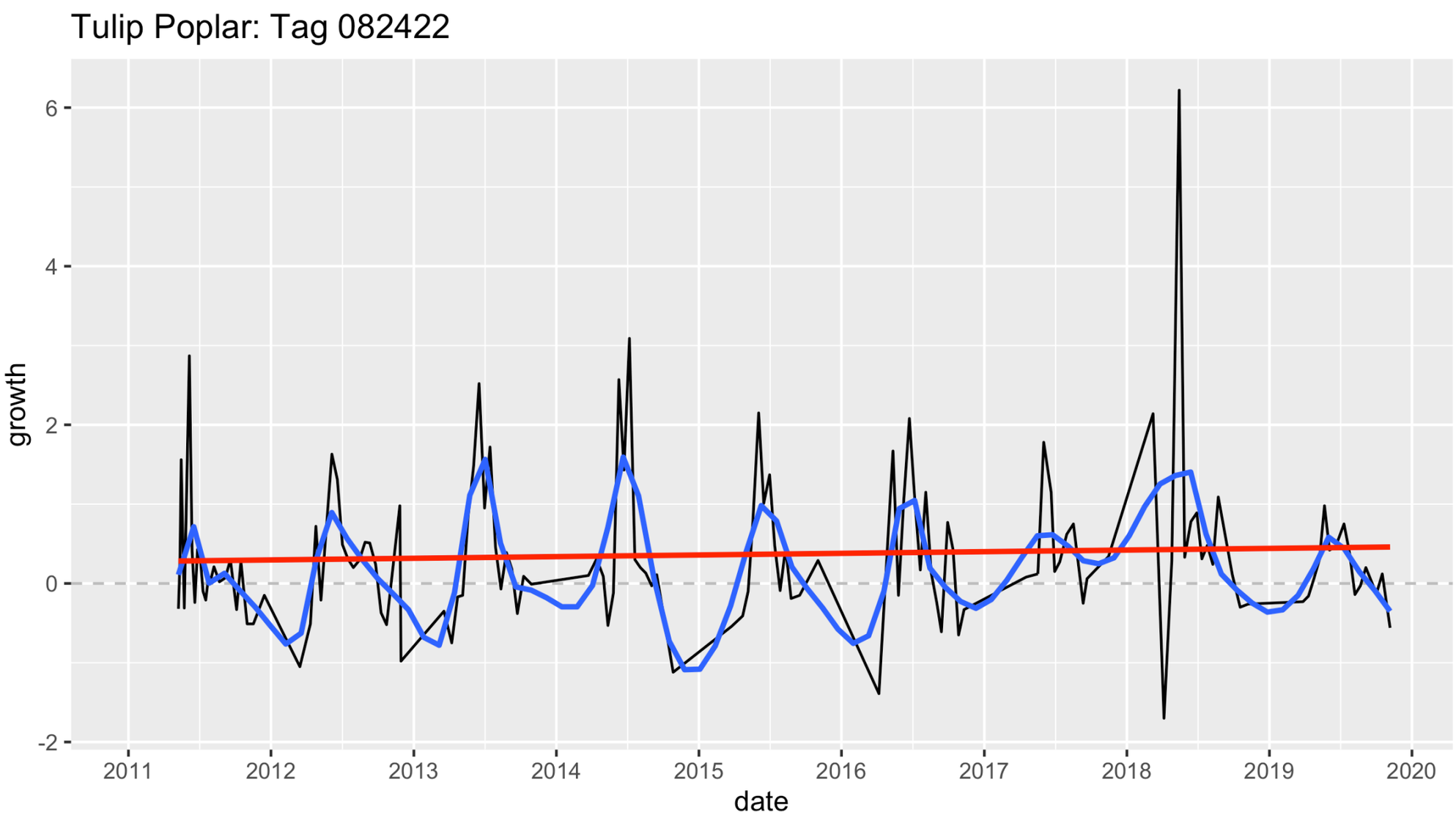
# Growth = difference in diameter



# Patterns

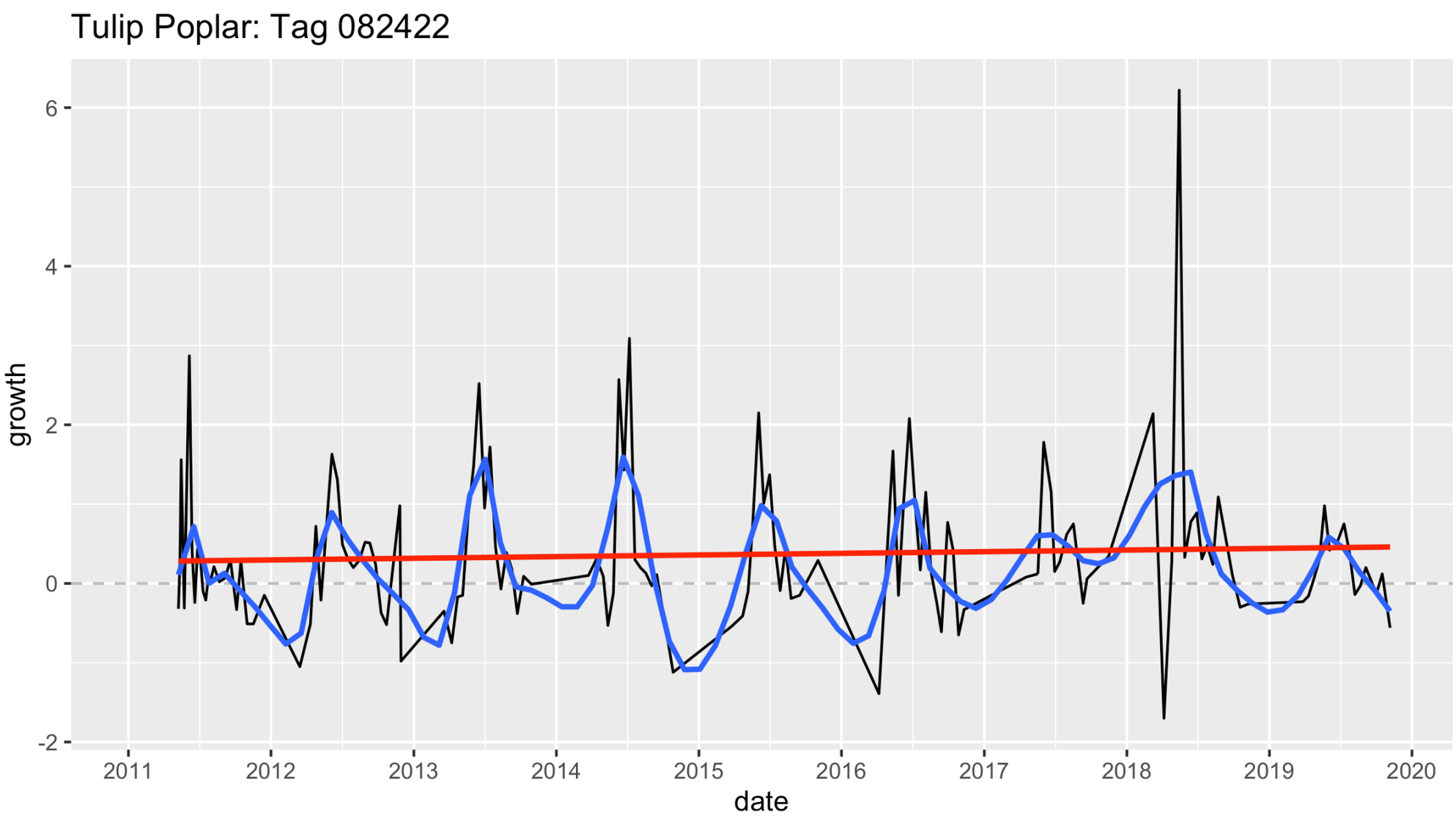

Tulip Poplar: Tag 082422
growth
6
4
2
0
-2
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
date

# Patterns




**Seasonal trend that repeats every year**

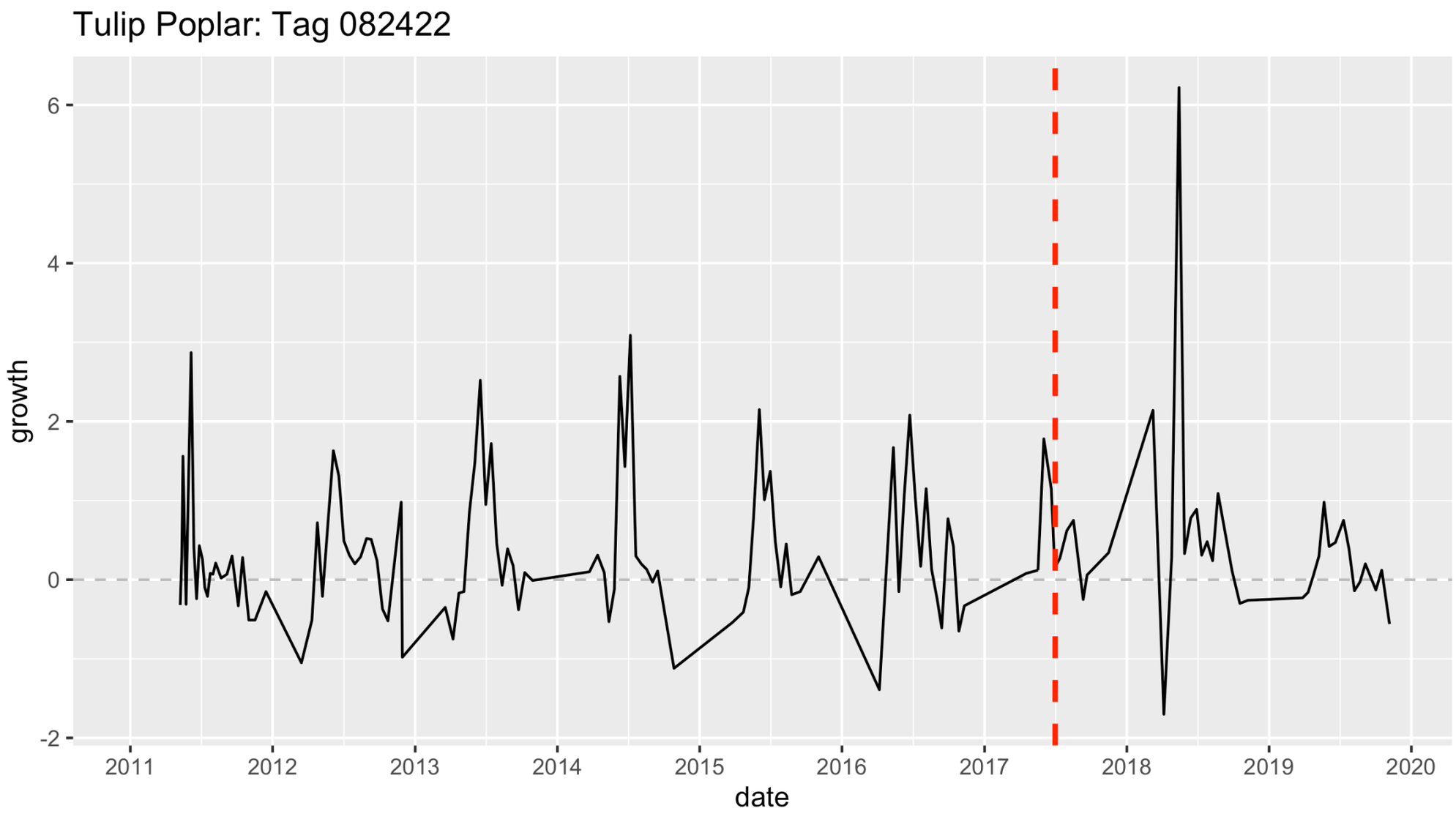
# Patterns



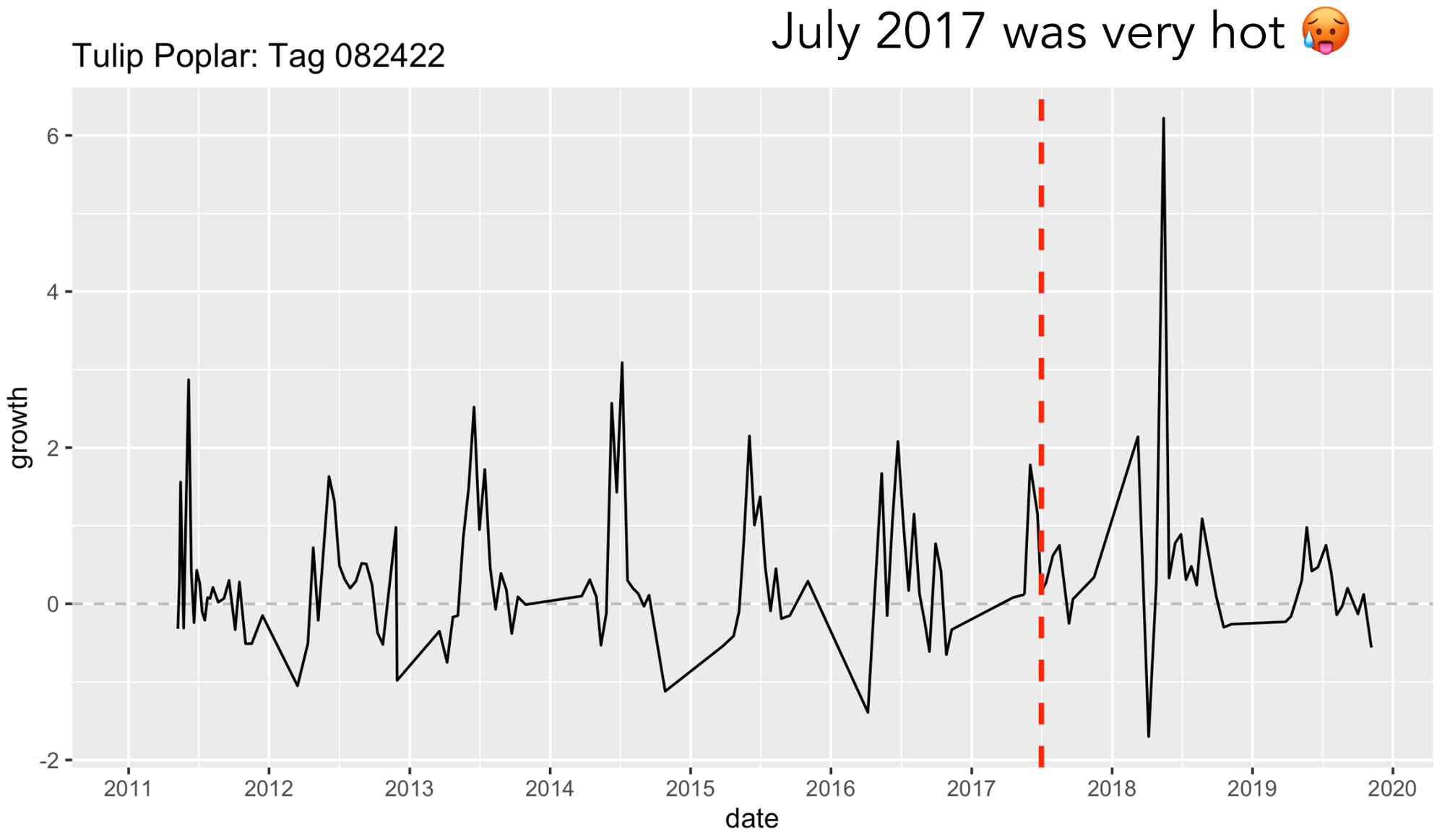

**Seasonal trend that repeats every year**

**Overall (slightly increasing) trend**

# Effect of Climate Change

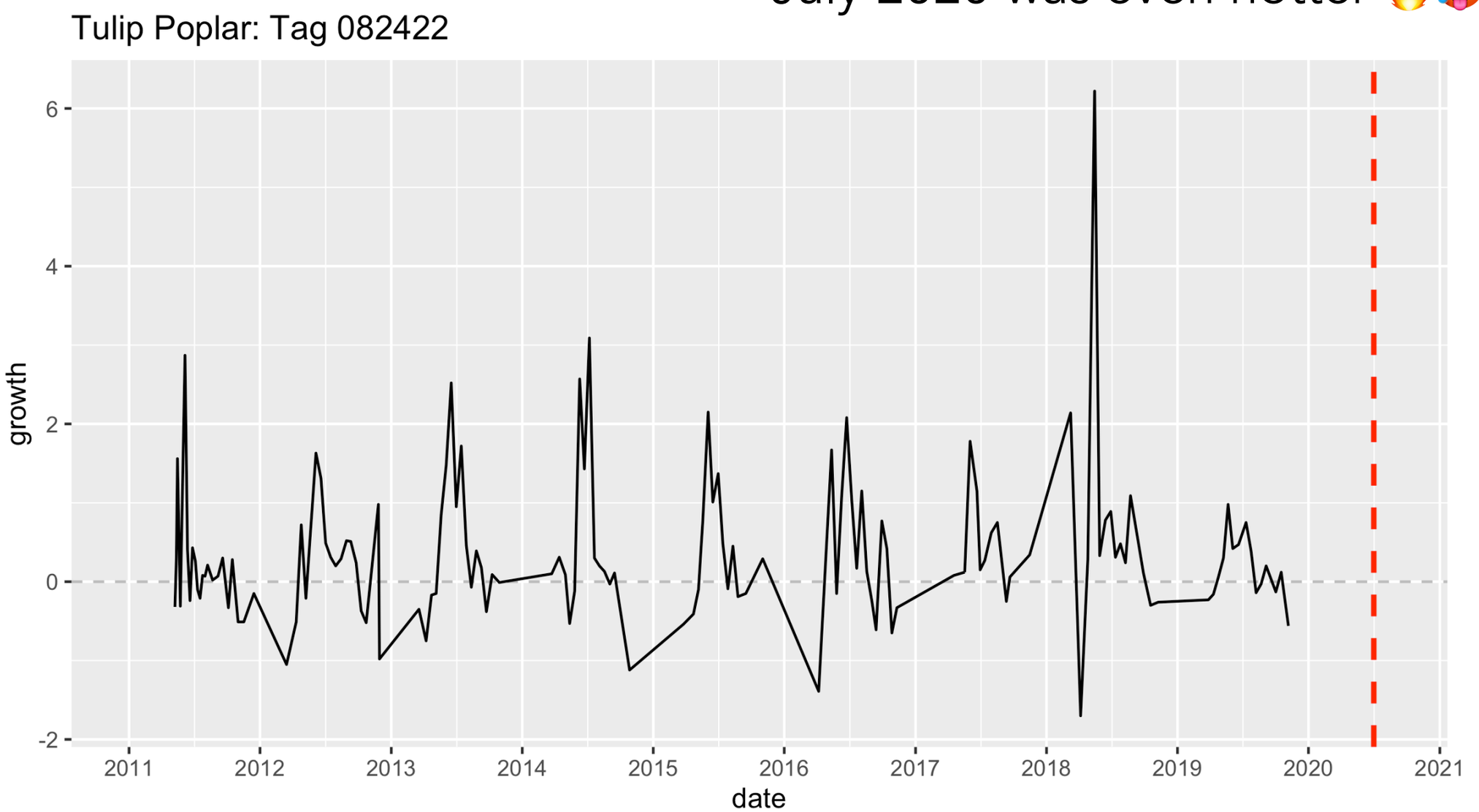


# Effect of Climate Change



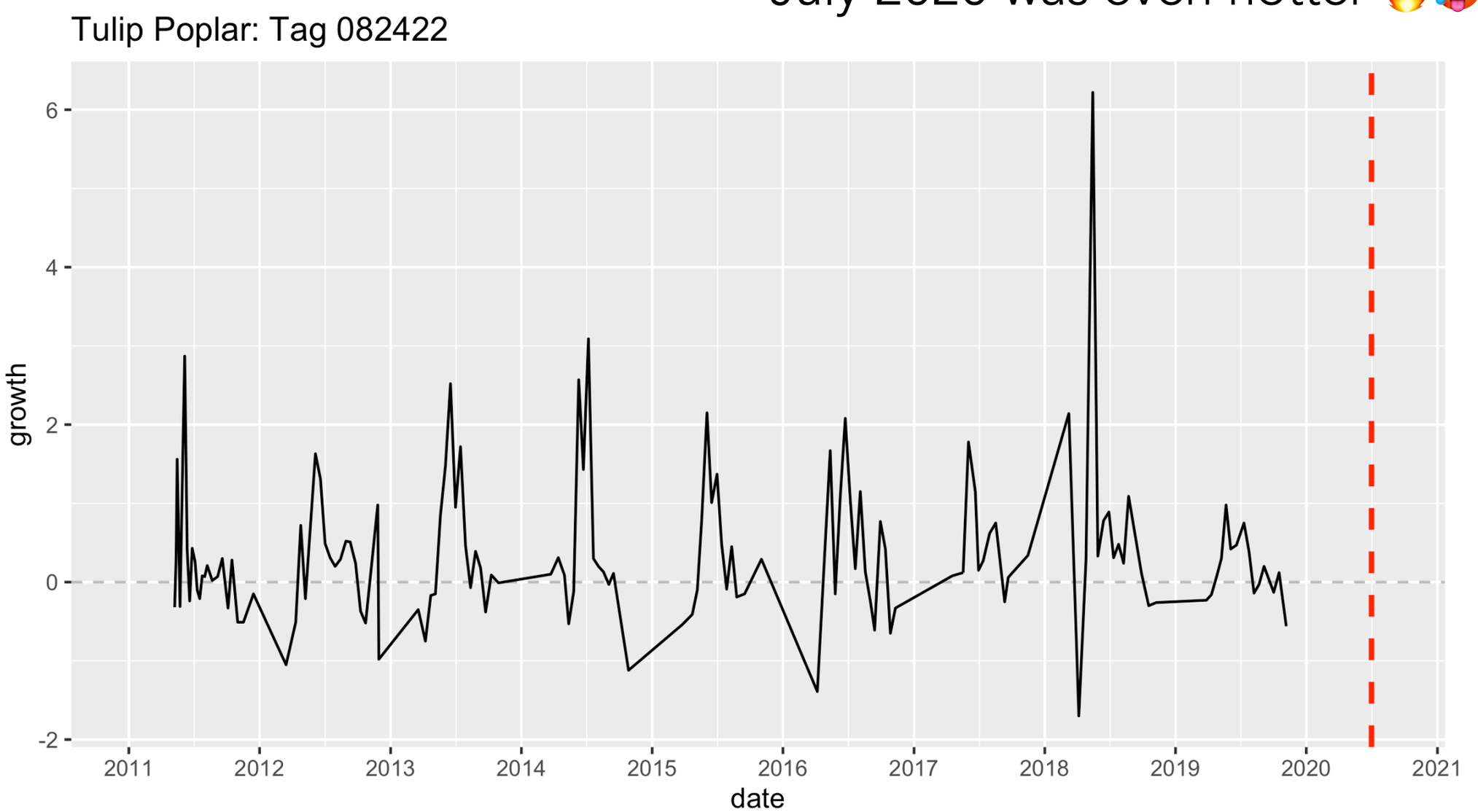
# Effect of Climate Change

July 2020 was even hotter 🔥🥵🔥



# Effect of Climate Change

July 2020 was even hotter 🔥🥵🔥

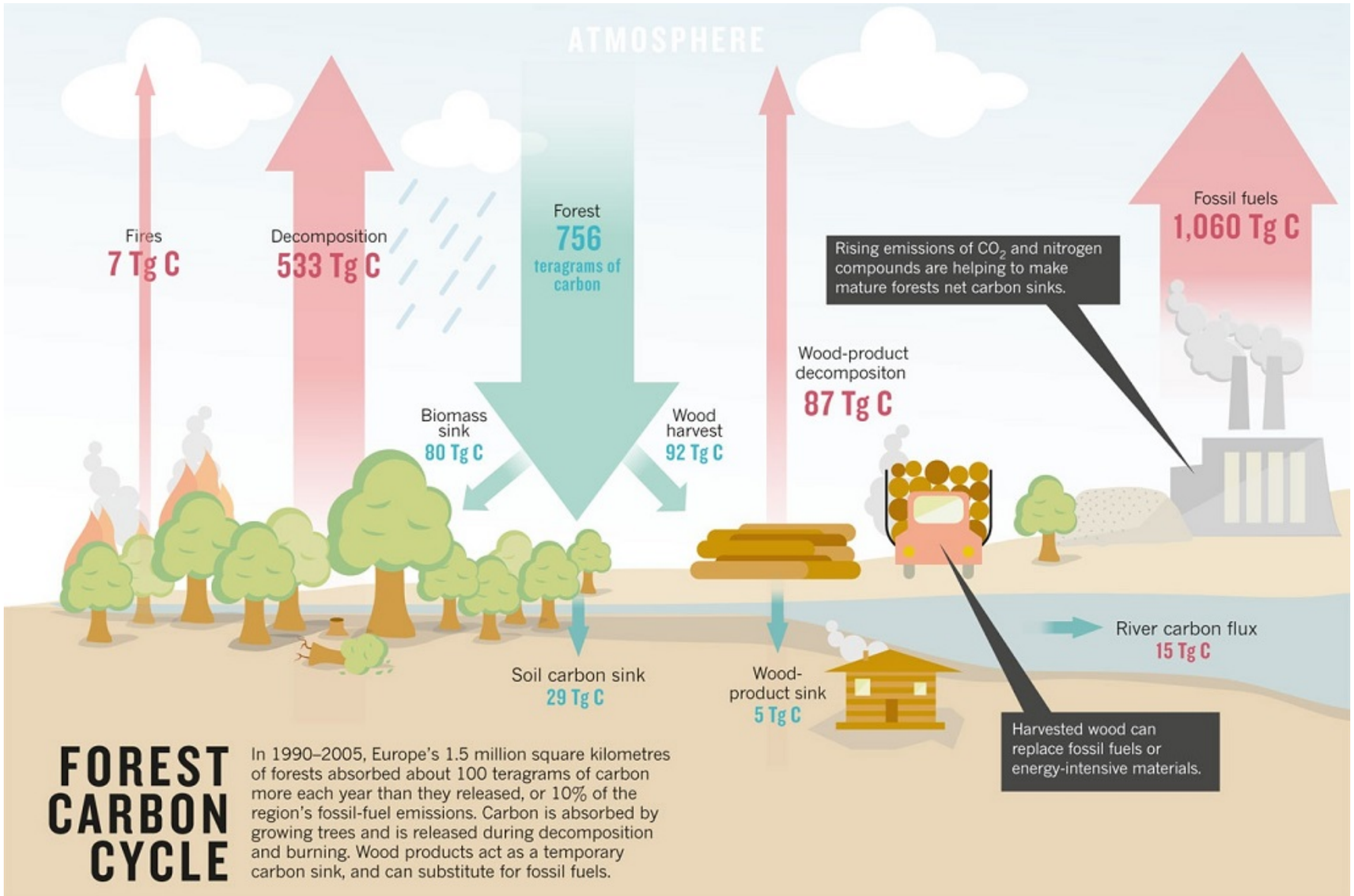



What other variables should we account for?
Drought? Humidity? Earlier springs?
Smoke from CA, WA, OR forest fires? etc…

# Lesson 3: “All models are wrong, but some are useful”
George Box

# Where is this headed?

# Forests as Carbon Sinks




Source: American Forests

# From yesterday's presidential "debate"

# From yesterday's presidential "debate"

## On the topic of climate change…

**Is the U.S. Really Planting a Billion Trees, as Trump Said?**

*Or maybe a trillion? Either way, it won't do much.*

By Alissa Walker | @awalkerinLA | Sep 30, 2020, 12:20am EDT

SHARE

Proof that Donald Trump has in fact planted one tree, with French president Emmanuel Macron in 2018. (It died.) | AFP via Getty Images

MOST READ

Is the U.S. Really Planting a Billion Trees, as Trump Said?

# To plant or not to plant?

Regrowing trees soak up carbon in Brazil's Atlantic Forest northeast of Rio de Janeiro. ROBIN CHAZDON

## Plant trees or let forests regrow? New studies probe two ways to fight climate change

By **Gabriel Popkin** | Sep. 23, 2020 , 12:25 PM

[Link to Science Article]

# Model for Natural Regrowth

nature

Explore our content  Journal information

nature › articles › article

Article | Published: 23 September 2020

## Mapping carbon accumulation potential from global natural forest regrowth

Susan C. Cook-Patton ✉, Sara M. Leavitt, [...] Bronson W. Griscom

*Nature* **585**, 545–550(2020) | Cite this article

**4647** Accesses | **564** Altmetric | Metrics

## Abstract

To constrain global warming, we must strongly curtail greenhouse gas emissions and capture excess atmospheric carbon dioxide[1,2]. Regrowing natural forests is a prominent strategy for capturing additional carbon[3], but accurate assessments of its potential are limited by uncertainty and variability in carbon accumulation rates[2,3]. To assess why and

Link to Nature Article

# Model for Natural Regrowth

nature

Explore our content  Journal information

nature > articles > article

Article | Published: 23 September 2020

## Mapping carbon accumulation potential from global natural forest regrowth

Susan C. Cook-Patton ✉, Sara M. Leavitt, [...] Bronson W. Griscom

*Nature* **585**, 545–550(2020) | Cite this article

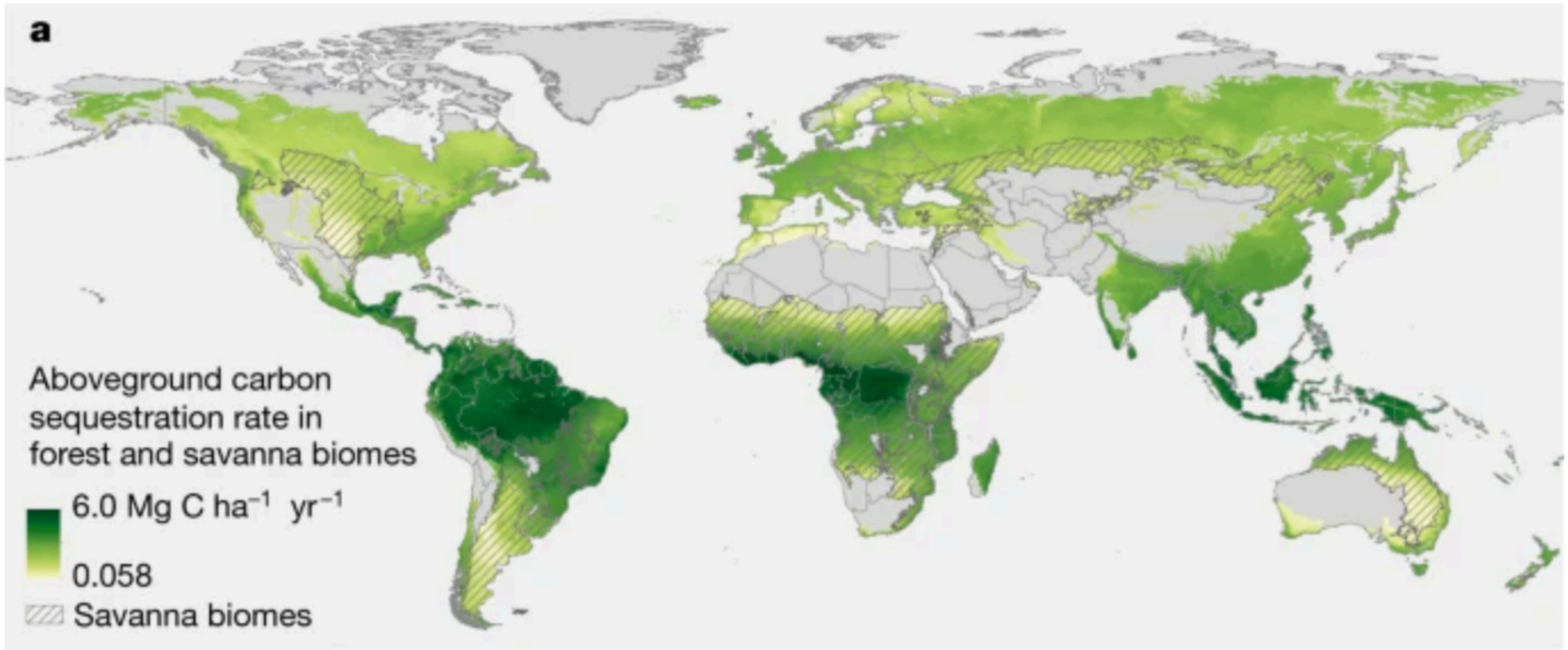
**4647** Accesses | **564** Altmetric | Metrics

### Abstract

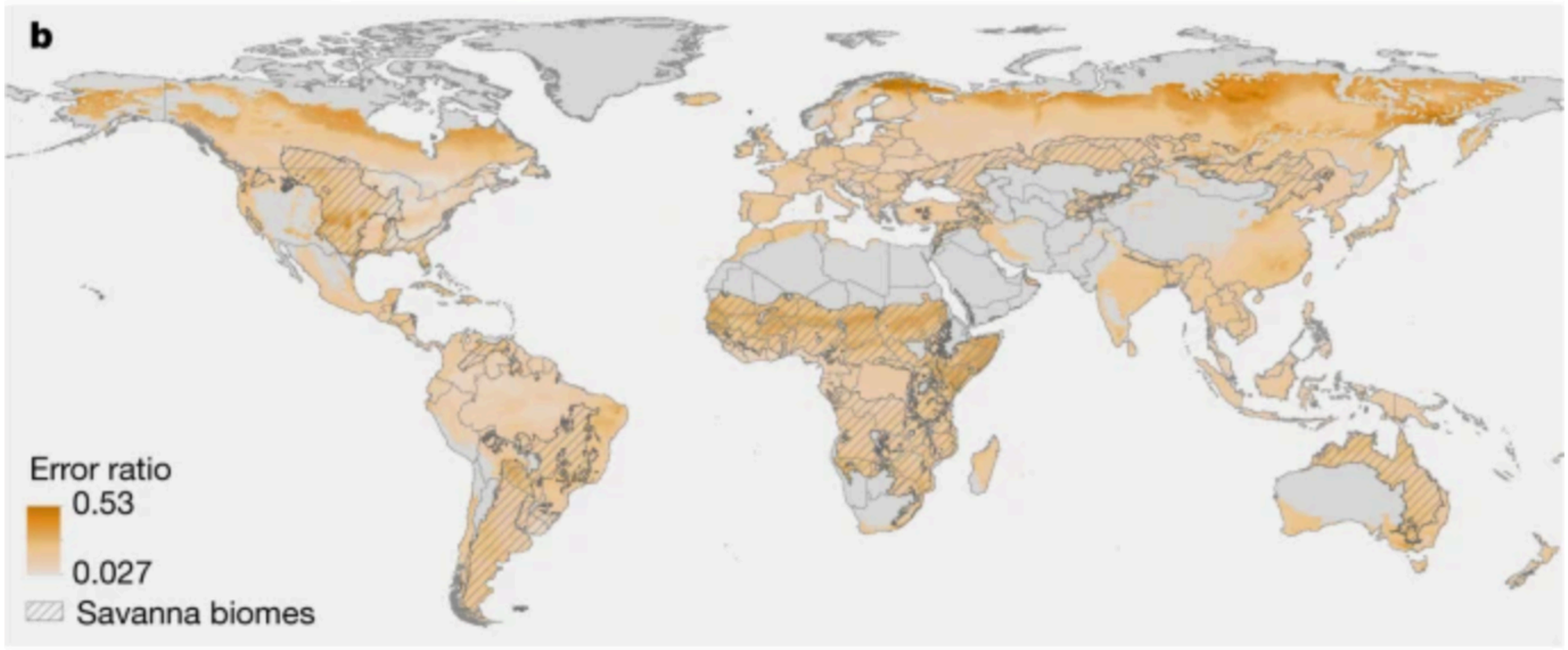
To constrain global warming, we must strongly curtail greenhouse gas emissions and capture excess atmospheric carbon dioxide[1,2]. Regrowing natural forests is a prominent strategy for capturing additional carbon[3], but accurate assessments of its potential are limited by uncertainty and variability in carbon accumulation rates[2,3]. To assess why and

Link to Nature Article

# Predicted/forecasted carbon accumulation



# All predictions/forecasts have errors too…



# Thanks!

# Slides on Twitter
# @rudeboybert