Lecture 6: Data Acquisition - Client-Side Websites and APIs

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*Parts of these slides related to APIs are adapted from **"Data Science for Economists"** by Grant McDermott.

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Prologue

Client-Side

Last time, we learned workflows for scraping **server-side** websites.

- Static sites with **rvest**
- Dynamic or interactive sites with **selenider** and **rvest**

Today, we'll turn our attention to **client-side** websites.

Packages for Today

First, a few packages for today:

```
pacman::p_load(lubridate, tidyverse, jsonlite, httr, usethis, fredr, XML,
```

Also recommended: **JSONView**, a browser extension for Firefox and Chrome that renders JSON output nicely.

APIs

Client-Side Web Sites

Recall that websites built using a **client-side** framework typically involve the following steps:

- Visit a URL containing an **empty template** of static content
- In the process of opening the URL, your browser sends a **request** to the host server
- If the request is valid, the server issues a **response** and populates the page dynamically with the requested data
- The final page you see is thus a mix of static and dynamic content

APIs

An **API (Application Programming Interface)** is a set of rules that carries out all this requesting, responding, and rendering. Some key concepts:

- **Server:** A powerful computer that runs an API.
- **Client:** A program that exchanges data with a server through an API.
- **Protocol:** The "etiquette" underlying how computers talk to each other (e.g. HTTP).
- **Methods:** The "verbs" that clients use to talk with a server.
  - The main one that we'll be using is GET (i.e. ask a server to retrieve information).
  - Other common methods are POST, PUT and DELETE.

APIs

An **API (Application Programming Interface)** is a set of rules that carries out all this requesting, responding, and rendering. Some key concepts:

- **Request:** What the client asks of the server (see Methods above).
- **Response:** The server's response. This includes:
  - Status Code (e.g. "404" if not found, or "200" if successful).
  - Header (i.e. meta-information about the response).
  - Body (i.e. the actual content that we're interested in).

API Endpoints

With web APIs, we can access information *directly* from the API database if we can specify the correct URL, known as an **API endpoint**.

- Similar to normal URLs, but the resulting page is… visually unappealing

API Endpoints

The reason the site looks like hot 🗑 is that its structured and formatted in a very particular way (that can be read directly into R!).

Usually these pages are formatted in one of two ways: XML or JSON

- We don't need too worry too much about the particular syntax of either

In general there are **three types** of API Endpoints:

1. **Explicit** API Endpoint, **no API Key**
2. **Explicit** API Endpoint, **API Key Required**
3. **Hidden** API Endpoints

Let's work through an example workflow for each. But first...

Some APIs that are free & legal

Some fun APIs:

- **TikTok (unofficial)**
- **Twitter**
- **Spotify**
- **YouTube**

This list of **Public APIs** has many more.

R API Packages

Many R packages have been built to make working with APIs easier. Some examples:

- **tidycensus** for American Community Survey microdata and other Census Bureau data
- **fredr** for more easily doing what we will do today
- **Quandl** for Nasdaq and other financial information
- **rtweet** for Twitter data
- **rnoaa** for NOAA weather data
- **prism** for PRISM gridded climate data (we'll work with this later on)
- **TADA** for Water Quality Portal Data (EPA, USGS)
- **rnassqs** for USDA's QuickStats API (agricultural data)
- **osmdata** for OpenStreetMap spatial data

Explicit API Endpoint, No Key

Explicit API Endpoint, No Key

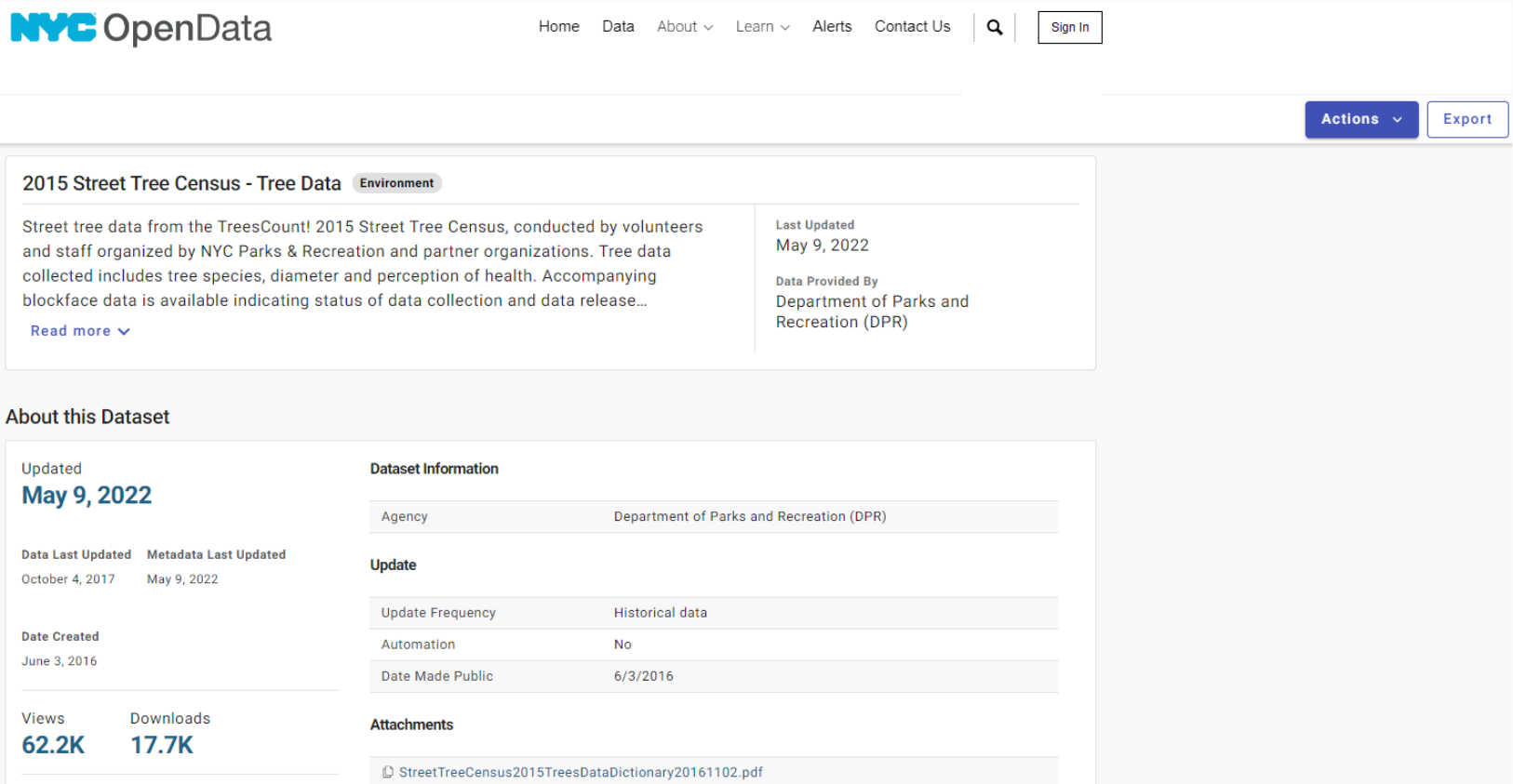
Let's work through an example of the first type of API: **explicit API without a key**.

Let's use the impressive **NYC Open Data** to look at... 🌲.

Seriously, trees.

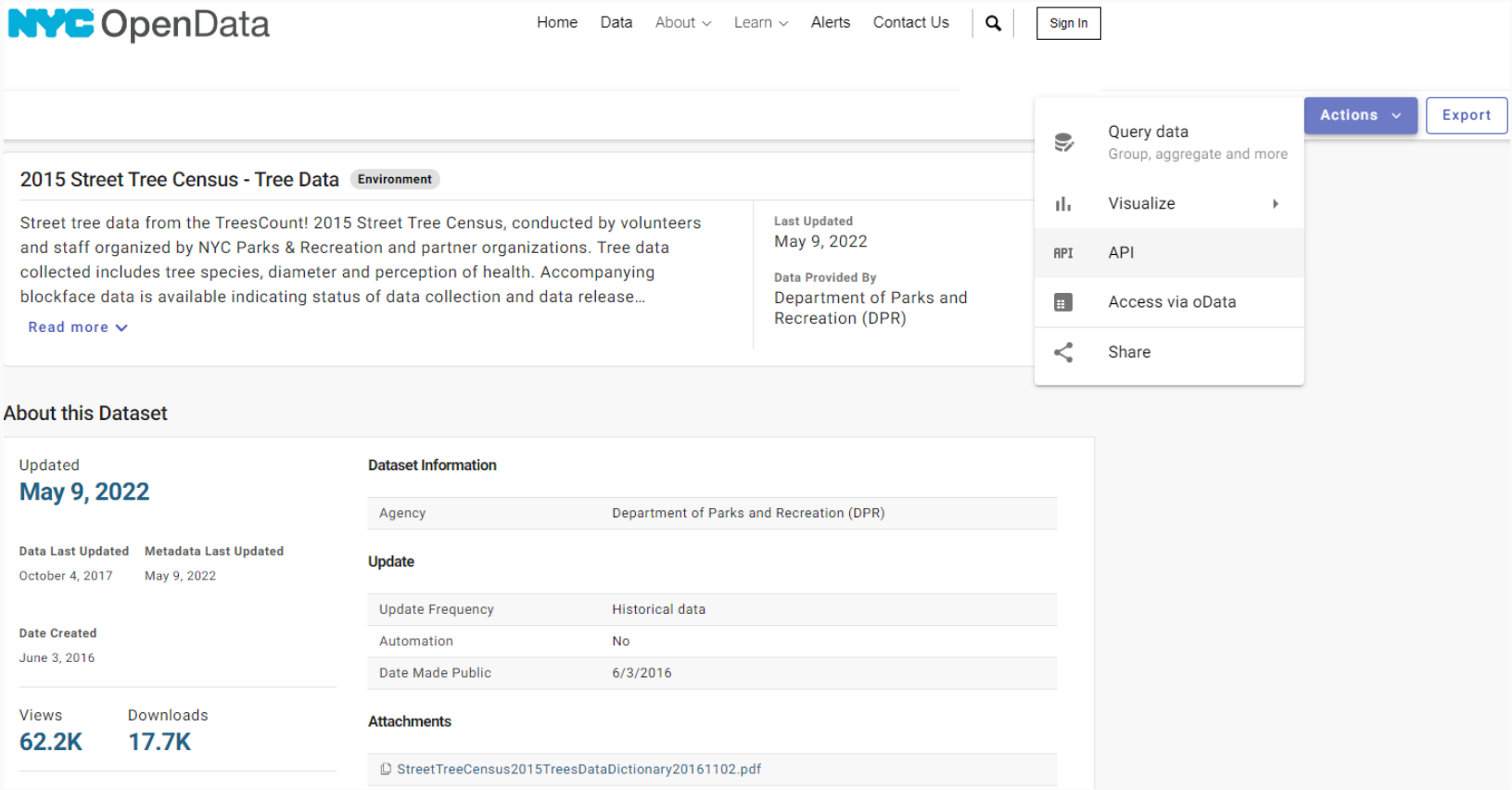
Application 1: NYC Tree Census

First, open the **Tree Census page** in your browser (if you haven't done so already)



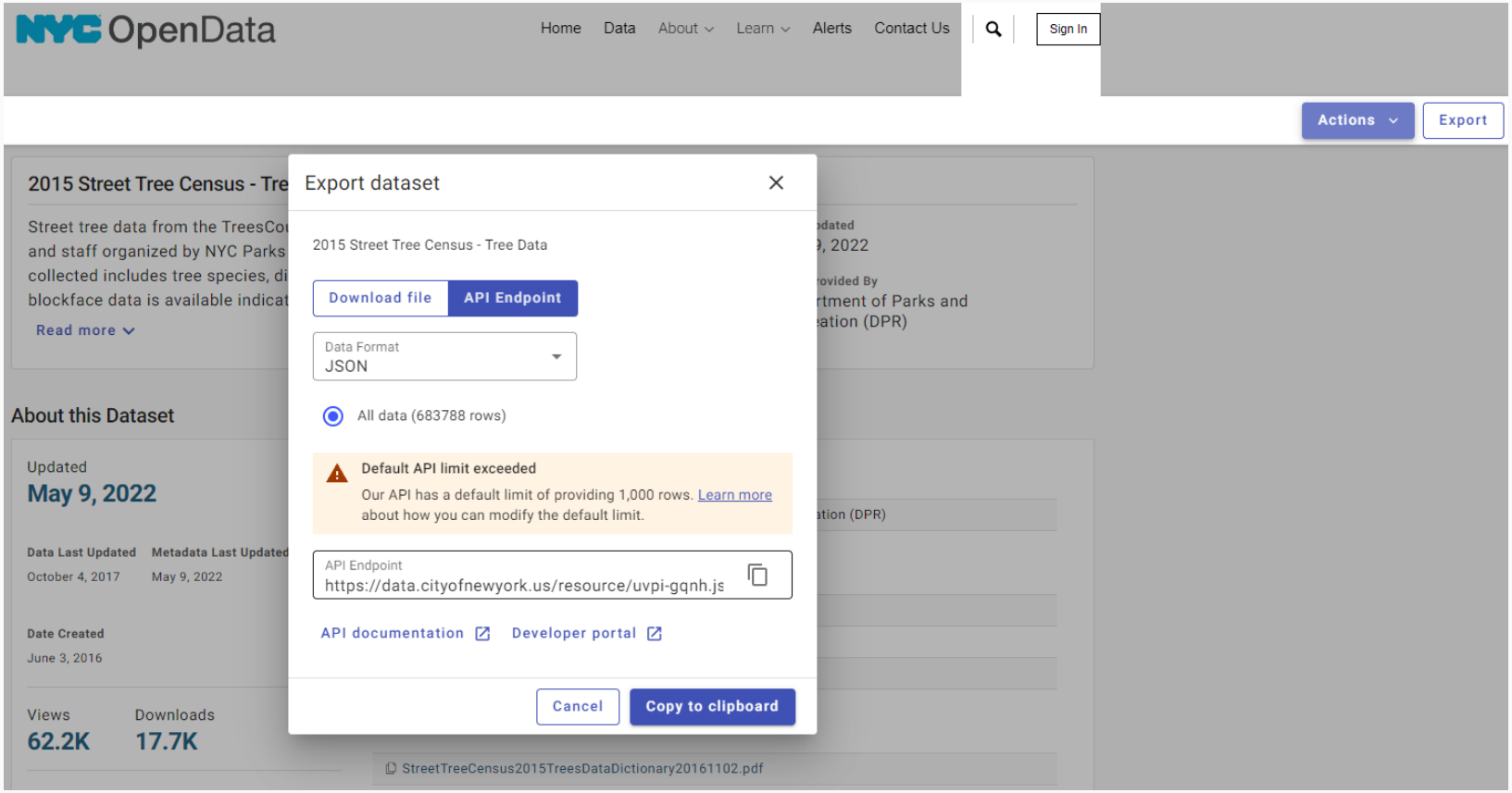
Application 1: NYC Tree Census

Click on **Actions > API** in upper-right to display the API Endpoint



Application 1: NYC Tree Census

Click on **Actions > API** in upper-right to display the API Endpoint



Application 1: NYC Tree Census

Copy/Paste or clickc "go to" to open the API endpoint link in another tab. You'll see a bunch of JSON text.

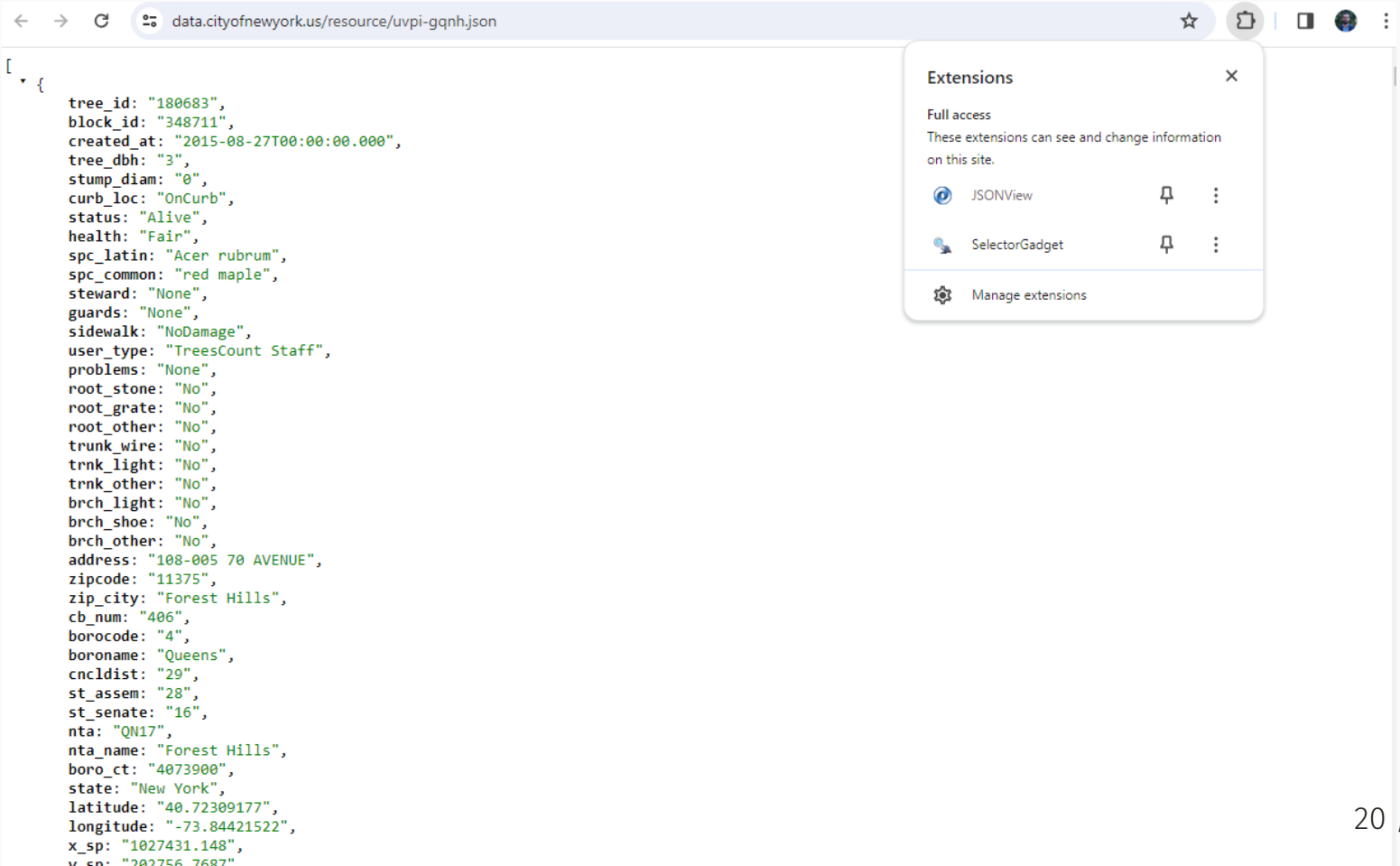
data.cityofnewyork.us/resource/uvpi-gqnh.json


```
[{"tree_id":"180683","block_id":"348711","created_at":"2015-08-
27T00:00:00.000","tree_dbh":"3","stump_diam":"0","curb_loc":"OnCurb","status":"Alive","health":"Fair","spc_latin":"Acer rubrum","spc_common":"red
maple","steward":"None","guards":"None","sidewalk":"NoDamage","user_type":"TreesCount
Staff","problems":"None","root_stone":"No","root_grate":"No","root_other":"No","trunk_wire":"No","trnk_light":"No","trnk_other":"No","brch_light":"No","brch_shoe":"No","brc
h_other":"No","address":"108-005 70 AVENUE","zipcode":"11375","zip_city":"Forest
Hills","cb_num":"406","borocode":"4","boroname":"Queens","cncldist":"29","st_assem":"28","st_senate":"16","nta":"QN17","nta_name":"Forest
Hills","boro_ct":"4073900","state":"New
York","latitude":"40.72309177","longitude":"-73.84421522","x_sp":"1027431.148","y_sp":"202756.7687","council_district":"29","census_tract":"739","bin":"4052307","bbl":"4022
210001"}
,{"tree_id":"200540","block_id":"315986","created_at":"2015-09-
03T00:00:00.000","tree_dbh":"21","stump_diam":"0","curb_loc":"OnCurb","status":"Alive","health":"Fair","spc_latin":"Quercus palustris","spc_common":"pin
oak","steward":"None","guards":"None","sidewalk":"Damage","user_type":"TreesCount
Staff","problems":"Stones","root_stone":"Yes","root_grate":"No","root_other":"No","trunk_wire":"No","trnk_light":"No","trnk_other":"No","brch_light":"No","brch_shoe":"No","
brch_other":"No","address":"147-074 7
AVENUE","zipcode":"11357","zip_city":"Whitestone","cb_num":"407","borocode":"4","boroname":"Queens","cncldist":"19","st_assem":"27","st_senate":"11","nta":"QN49","nta_name"
:"Whitestone","boro_ct":"4097300","state":"New
York","latitude":"40.79411067","longitude":"-73.81867946","x_sp":"1034455.701","y_sp":"228644.8374","council_district":"19","census_tract":"973","bin":"4101931","bbl":"4044
750045"}
,{"tree_id":"204026","block_id":"218365","created_at":"2015-09-
05T00:00:00.000","tree_dbh":"3","stump_diam":"0","curb_loc":"OnCurb","status":"Alive","health":"Good","spc_latin":"Gleditsia triacanthos var.
inermis","spc_common":"honeylocust","steward":"1or2","guards":"None","sidewalk":"Damage","user_type":"Volunteer","problems":"None","root_stone":"No","root_grate":"No","root
_other":"No","trunk_wire":"No","trnk_light":"No","trnk_other":"No","brch_light":"No","brch_shoe":"No","brch_other":"No","address":"390 MORGAN
AVENUE","zipcode":"11211","zip_city":"Brooklyn","cb_num":"301","borocode":"3","boroname":"Brooklyn","cncldist":"34","st_assem":"50","st_senate":"18","nta":"BK90","nta_name"
:"East Williamsburg","boro_ct":"3044900","state":"New
York","latitude":"40.71758074","longitude":"-73.9366077","x_sp":"1001822.831","y_sp":"200716.8913","council_district":"34","census_tract":"449","bin":"3338310","bbl":"30288
70001"}
,{"tree_id":"204337","block_id":"217969","created_at":"2015-09-
05T00:00:00.000","tree_dbh":"10","stump_diam":"0","curb_loc":"OnCurb","status":"Alive","health":"Good","spc_latin":"Gleditsia triacanthos var.
inermis","spc_common":"honeylocust","steward":"None","guards":"None","sidewalk":"Damage","user_type":"Volunteer","problems":"Stones","root_stone":"Yes","root_grate":"No","r
oot_other":"No","trunk_wire":"No","trnk_light":"No","trnk_other":"No","brch_light":"No","brch_shoe":"No","brch_other":"No","address":"1027 GRAND
STREET","zipcode":"11211","zip_city":"Brooklyn","cb_num":"301","borocode":"3","boroname":"Brooklyn","cncldist":"34","st_assem":"53","st_senate":"18","nta":"BK90","nta_name"
:"East Williamsburg","boro_ct":"3044900","state":"New
York","latitude":"40.71353749","longitude":"-73.93445616","x_sp":"1002420.358","y_sp":"199244.2531","council_district":"34","census_tract":"449","bin":"3338342","bbl":"3029
250001"}
```

Application 1: NYC Tree Census

If you installed JSONView, it will look a lot nicer

- A lot like a transposed dataframe row...




```
[
  {
    tree_id: "180683",
    block_id: "348711",
    created_at: "2015-08-27T00:00:00.000",
    tree_dbh: "3",
    stump_diam: "0",
    curb_loc: "OnCurb",
    status: "Alive",
    health: "Fair",
    spc_latin: "Acer rubrum",
    spc_common: "red maple",
    steward: "None",
    guards: "None",
    sidewalk: "NoDamage",
    user_type: "TreesCount Staff",
    problems: "None",
    root_stone: "No",
    root_grate: "No",
    root_other: "No",
    trunk_wire: "No",
    trnk_light: "No",
    trnk_other: "No",
    brch_light: "No",
    brch_shoe: "No",
    brch_other: "No",
    address: "108-005 70 AVENUE",
    zipcode: "11375",
    zip_city: "Forest Hills",
    cb_num: "406",
    borocode: "4",
    boroname: "Queens",
    cncldist: "29",
    st_assem: "28",
    st_senate: "16",
    nta: "QN17",
    nta_name: "Forest Hills",
    boro_ct: "4073900",
    state: "New York",
    latitude: "40.72309177",
    longitude: "-73.84421522",
    x_sp: "1027431.148",
    y_sp: "202756.7687"
```

Load JSON into R

Next, use the `fromJSON()` function in the **excellent jsonlite package** to read JSON into R.

```
nyc_trees <- fromJSON("https://data.cityofnewyork.us/resource/uvpi-gqnh.js
  as.data.frame()
nyc_trees
```

```
##      tree_id block_id              created_at tree_dbh stump_diam
## 1     180683   348711 2015-08-27T00:00:00.000        3          0
## 2     200540   315986 2015-09-03T00:00:00.000       21          0
## 3     204026   218365 2015-09-05T00:00:00.000        3          0
## 4     204337   217969 2015-09-05T00:00:00.000       10          0
## 5     189565   223043 2015-08-30T00:00:00.000       21          0
## 6     190422   106099 2015-08-30T00:00:00.000       11          0
## 7     190426   106099 2015-08-30T00:00:00.000       11          0
## 8     208649   103940 2015-09-07T00:00:00.000        9          0
## 9     209610   407443 2015-09-08T00:00:00.000        6          0
## 10    192755   207508 2015-08-31T00:00:00.000       21          0
## 11    203719   302371 2015-09-05T00:00:00.000       11          0
## 12    203726   302371 2015-09-05T00:00:00.000        8          0
```

Aside: API Limits

Note that while the full census of NYC trees contains over 700,000 trees, we only downloaded a small portion.

By default, the API limits us to 1,000 rows.

For our use case (seeing an example of the workflow) this isn't an issue, but **reading the documentation** reveals a way to get around that (if so desired).

Punchline: always read the API documentation!

Work with the Data

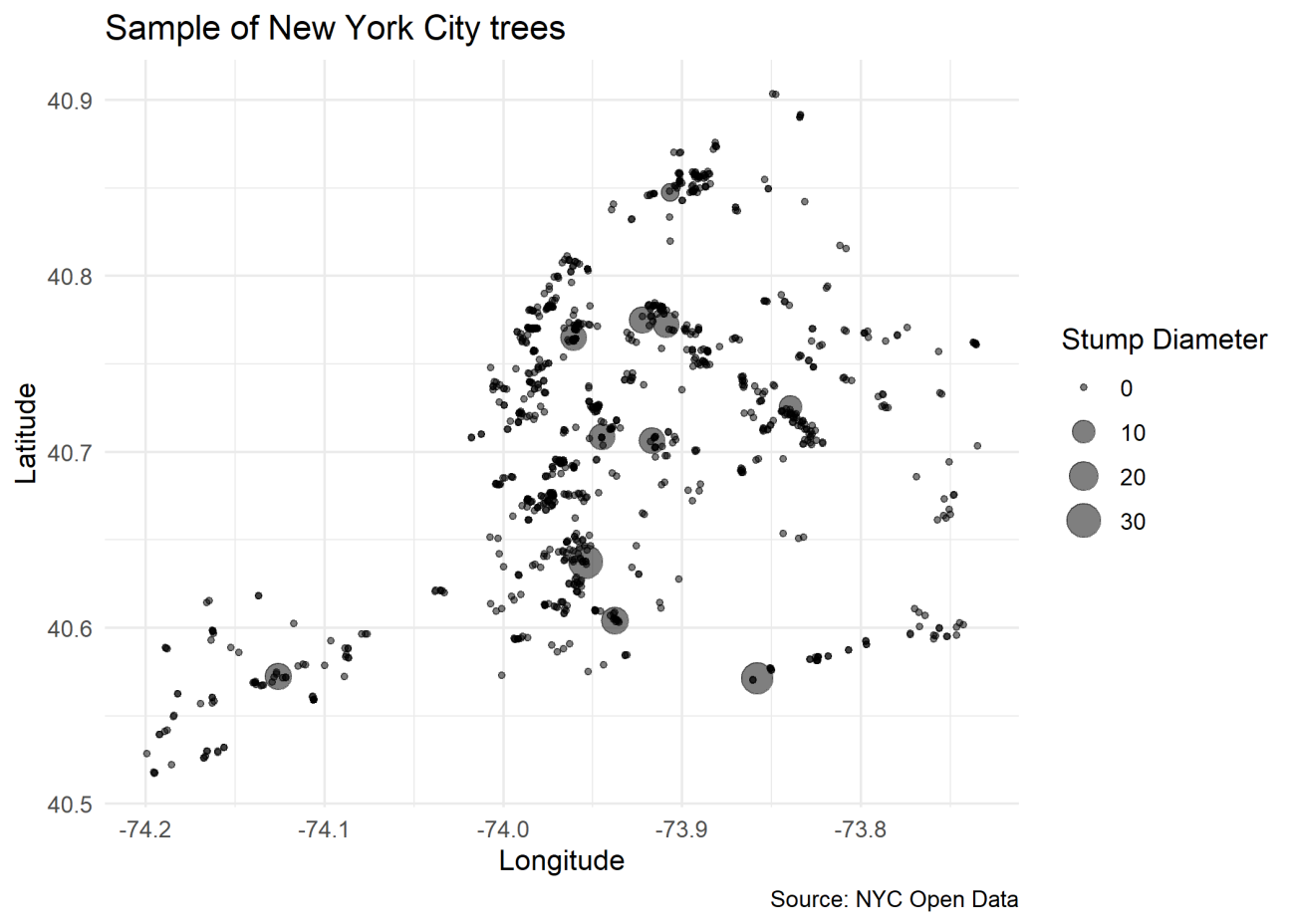
Now we have the data, accessed through an API Endpoint!

Seriously, that's it. Now we can do whatever we want with the data - how about plotting it?

```
nyc_trees %>%
  select(longitude, latitude, stump_diam, spc_common, spc_latin, tree_id) %>%
  mutate_at(vars(longitude:stump_diam), as.numeric) %>%
  ggplot(aes(x=longitude, y=latitude, size=stump_diam)) +
  geom_point(alpha=0.5) +
  scale_size_continuous(name = "Stump Diameter") +
  labs(
    x = "Longitude", y = "Latitude",
    title = "Sample of New York City trees",
    caption = "Source: NYC Open Data"
    ) +
  theme_minimal()
```

Plotting Some Trees

.small[



Explicit API Endpoint with Key

Explicit API Endpoint with Key

For the second application, we're going to focus on the more common circumstance: an API endpoint that **requires an API key**.

An **API key** is a way to add a unique ID signature to every API call you make

- Required for all APIs linked to gov't agencies or institutions (e.g. Census, BEA).

Let's do an application working with the **Federal Reserve Bank of St. Louis (FRED) API**

Application 2: FRED API

FRED makes available a **ton of U.S. economic data** that can easily be accessed via API.

The only real difference from the last example: we first have to **register for an API key**

Application 2: FRED API

First, navigate to the **FRED API page**

fred.stlouisfed.org/docs/api/fred/#

ECONOMIC RESEARCH

Economic Research Resources | Switch Products | My Account

FRED® ECONOMIC DATA | ST. LOUIS FED

Your trusted data source since 1991.

Search FRED ...

Release Calendar | FRED Tools | FRED News | FRED Blog | About FRED

API Keys | Terms of Use

FRED® API

General Documentation | API | Maps API | Toolkits

The FRED® API is a web service that allows developers to write programs and build applications that retrieve economic data from the FRED® and ALFRED® websites hosted by the Economic Research Division of the Federal Reserve Bank of St. Louis. Requests can be customized according to data source, release, category, series, and other preferences.

General Documentation

- Overview
- What is FRED®?
- What is ALFRED®?
- FRED® versus ALFRED®
- Real-Time Periods
- Errors

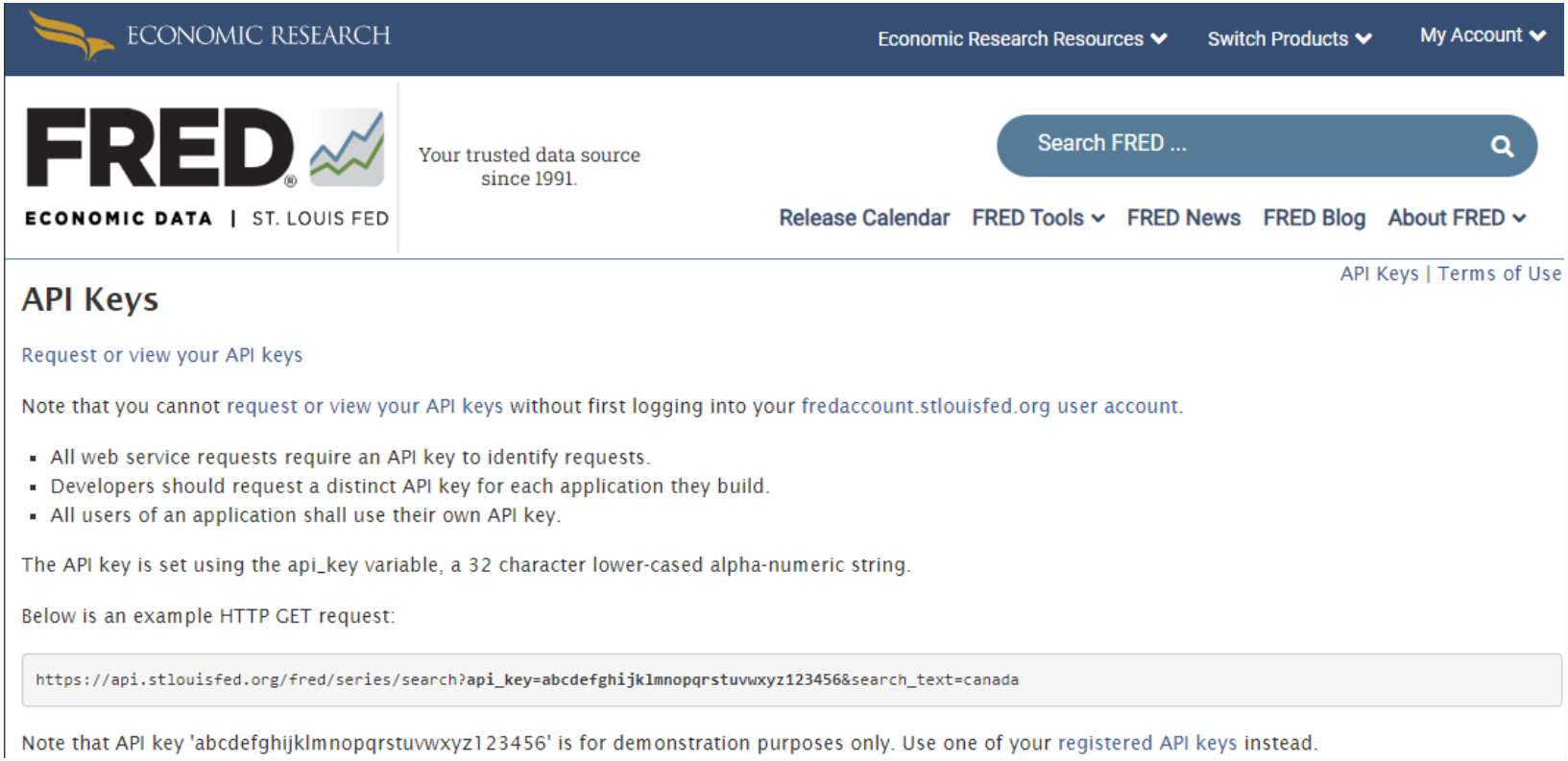
API

Categories

- fred/category - Get a category.
- fred/category/children - Get the child categories for a specified parent category.
- fred/category/related - Get the related categories for a category.
- fred/category/series - Get the series in a category.
- fred/category/tags - Get the tags for a category.

Application 2: FRED API

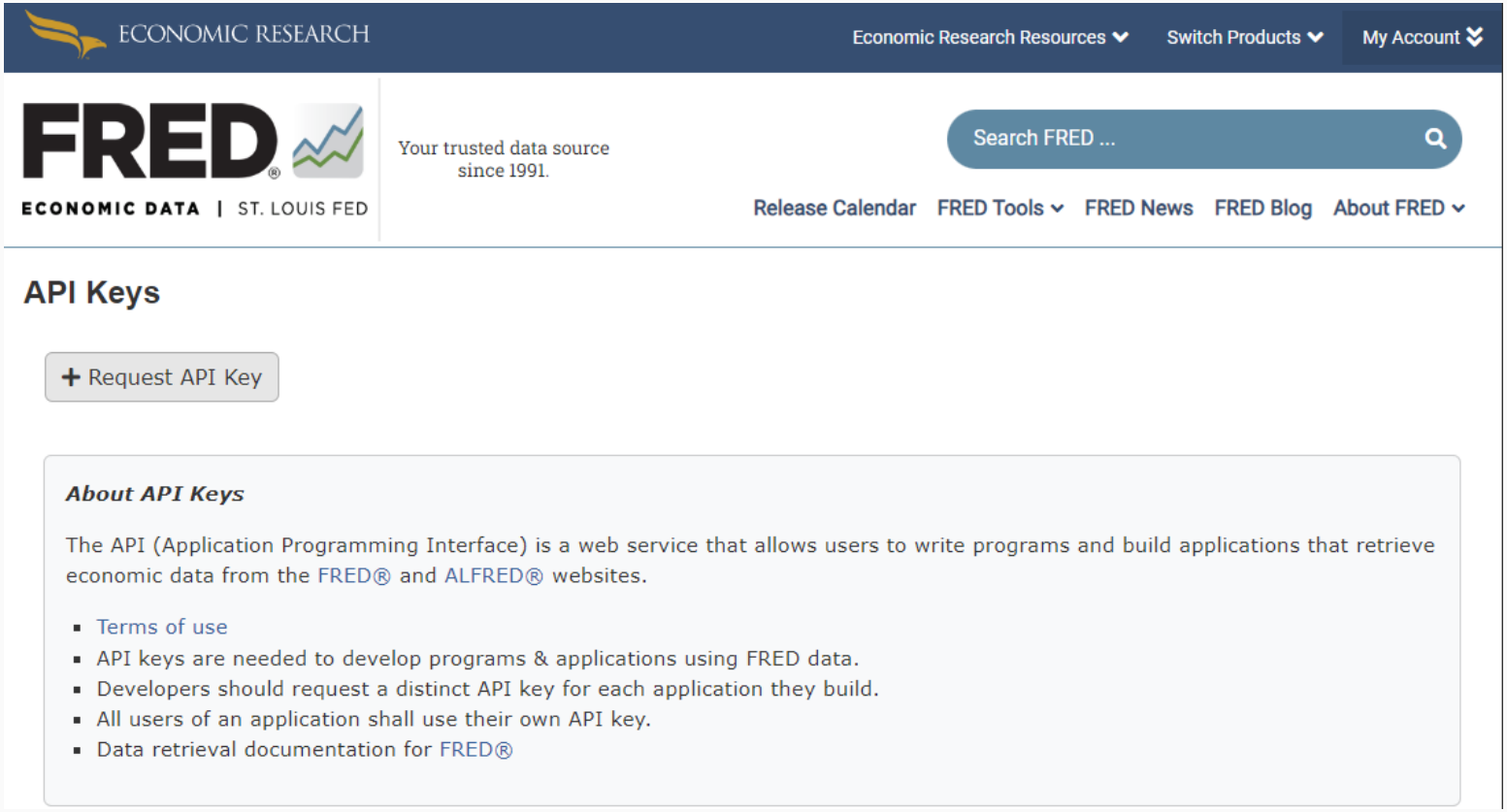
Click on "API Keys" in the upper-right then "Request or view your API keys"



Application 2: FRED API

Make an account, then request an API Key

- My Account > API Keys > Request API Key



Setting API Keys in R

Treat your API keys **like passwords**

- You're responsible for following API terms & conditions, and you can't control that if someone else is using your key

This means we shouldn't ever **harcode API keys into R scripts**.

Instead, we can define them as **environment variables**, either

1. For the current R session only
2. Globally across all R sessions

Environment Variables: Current Session

To define an environment variable for **your current session only**, run the following **in your console:**[1]

```
Sys.setenv(FRED_API_KEY = "abcdefghijklmnopqrstuvwxyz0123456789")
```

Replacing the fake API with your actual API.

You can then use an environment variable in your script with

```
# assign to R object and print out
my_key ← Sys.getenv("FRED_API_KEY")
my_key
```

[1] setting `Sys.setenv()` in scripts defeats the entire purpose!

Environment Variables: Globally

To set an environment variable **globally across all sessions**, we'll need to add a special `~/.Renviron` file.

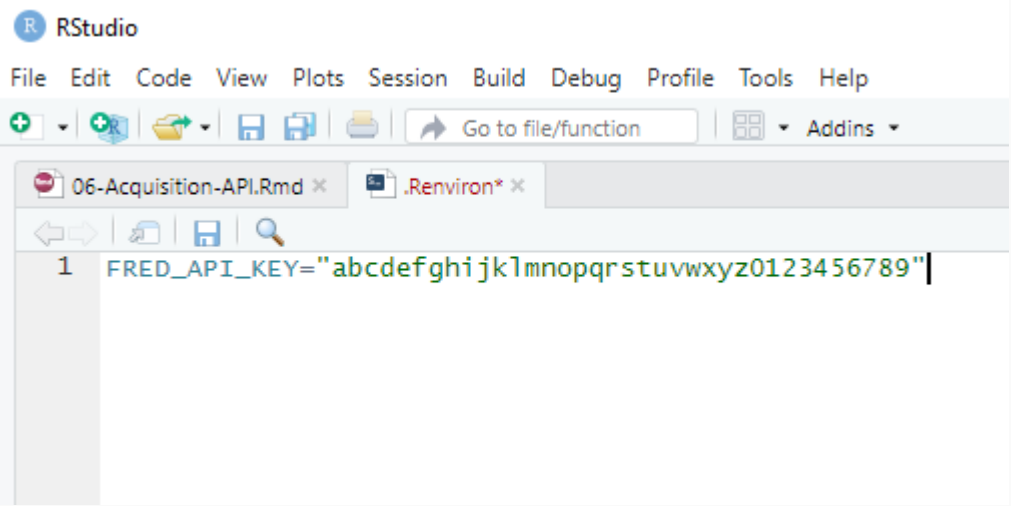
- Text file that lives in your home directory (hence the `~/` path)

To edit, we can use the `` `usethis::edit_r_environ() `` function:

```
usethis::edit_r_environ()
```

Environment Variables: Globally

This opens your `~/.Renviron` file in a new tab, where you can easily add a line defining your API key.



Hit save, then restart R or refresh your environment session to use it:

```
## Only necessary when reading in a new Renviron variable
readRenviron("~/Renviron")
```

Using the FRED API

With your API key set, let's figure out how to use the FRED API.

Looking at the **FRED API documentation** you'll see

- There are many types of requests you can make of FRED using the API
- If we want the underlying data for a data series, we want the **fred/series/observations** path.

Using the FRED API

Clicking the link takes us to [specific documentation for that path] (**https://fred.stlouisfed.org/docs/api/fred/series_observations.html**)

Here we can learn

1. In which **file formats** the API will return data
    - XML, JSON, zipped tab delimited, zipped Excel
2. The exact **syntax** for making a request
    - Potentially specific to each format
3. The **parameters** that you can provide
    - e.g. function arguments

Using the FRED API

One required parameter is `series_id`.

- Let's look at the median home listing price in East Lansing.
- By searching the FRED website, I found that the **ID** for this series is `MELIPRMSA29620`.

For the `file_type`, you can use either XML or JSON.

- Both can easily be read into R.
- Since we already saw JSON, let's try using XML.

Try out the API right in your browser. Paste this into your location bar, replacing the fake API key with your own:

```
https://api.stlouisfed.org/fred/series/observations?
series_id=MELIPRMSA29620&api_key=abcdefghijklmnopqrstuvwxyz123456&file_type
```

Using the FRED API

To use the API in R, we'll use the tidyverse package **httr**. First we need to define some variables with the information we need:

```
url = "https://api.stlouisfed.org/" # base URL
endpoint = "fred/series/observations" # endpoint path
params = list(api_key = Sys.getenv("FRED_API_KEY"), # API key
              file_type = "json", # format
              series_id = "MELIPRMSA29620") # series we want
```

Now we can use the `GET` method to request data from the server:

```
response = httr::GET(url = url, path = endpoint, query = params)
response
```

```
Response [https://api.stlouisfed.org/fred/series/observations?api_key=[YOUR_API
  Date: 2024-02-19 20:23
  Status: 200
  Content-Type: application/json; charset=UTF-8
  Size: 9.11 kB
```

Using the FRED API

The response is a complex list object. Extracting the XML content:

```
json <- response %>%
  httr::content(type = "text") %>% # from httr package
 jsonlite::fromJSON() # Parse the JSON file
```

Viewing this object reveals that what we really want is the `json$observations` data frame.

```
el_house_prices <- json$observations
el_house_prices
```

```
##    realtime_start realtime_end       date       value
## 1      2024-02-19   2024-02-19 2016-07-01           .
## 2      2024-02-19   2024-02-19 2016-08-01           .
## 3      2024-02-19   2024-02-19 2016-09-01           .
## 4      2024-02-19   2024-02-19 2016-10-01           .
## 5      2024-02-19   2024-02-19 2016-11-01           .
## 6      2024-02-19   2024-02-19 2016-12-01           .
```

Using the FRED API

Cleaning up a little bit:

```
el_house_prices <- mutate(el_house_prices,
    date = ymd(date),
    median_price = as.numeric(value)
  ) %>%
  select(date, median_price)
el_house_prices
```

```
##          date median_price
## 1  2016-07-01           NA
## 2  2016-08-01           NA
## 3  2016-09-01           NA
## 4  2016-10-01           NA
## 5  2016-11-01           NA
## 6  2016-12-01           NA
## 7  2017-01-01           NA
## 8  2017-02-01           NA
## 9  2017-03-01           NA
## 10 2017-04-01           NA
```

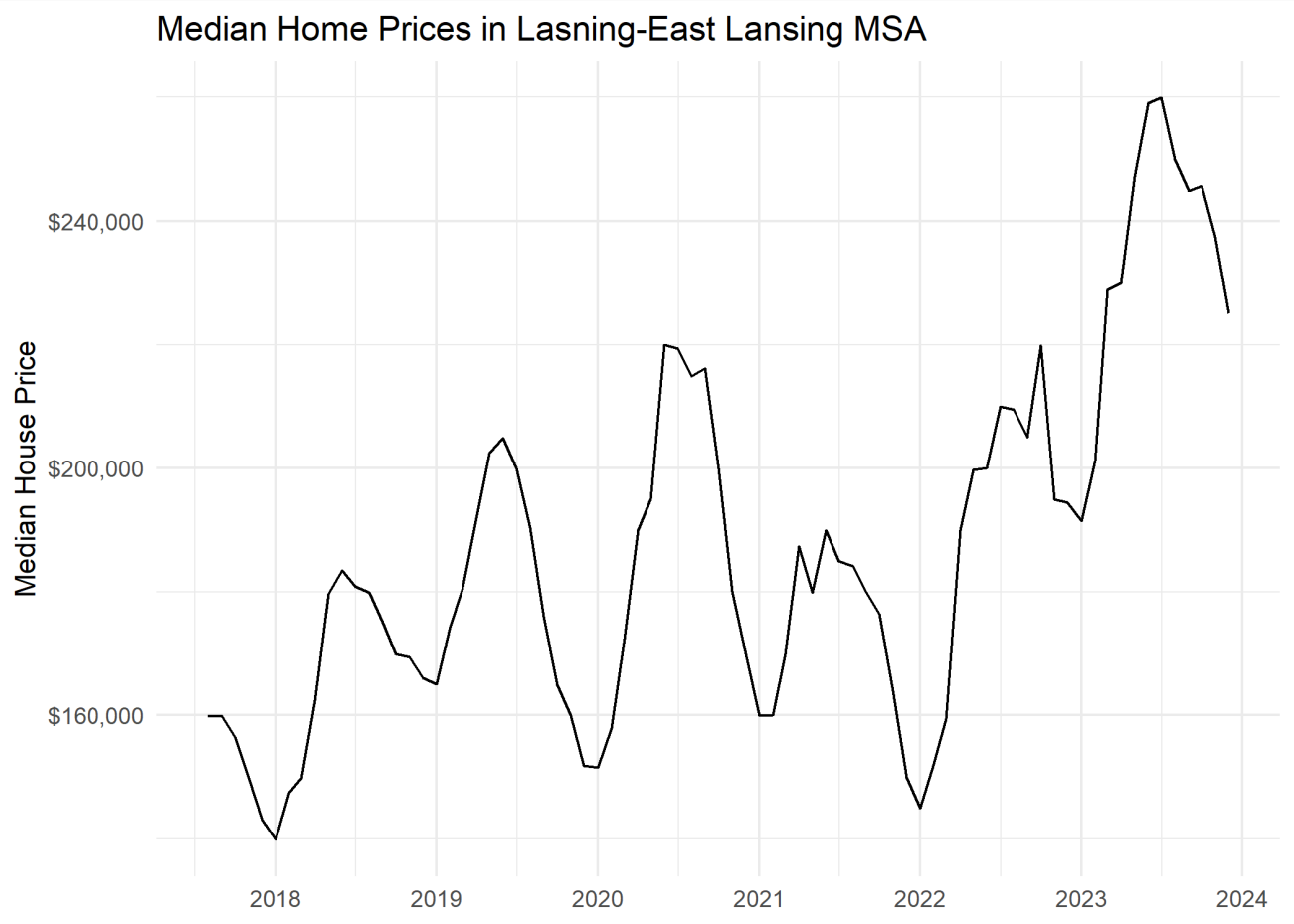
Using the FRED API

Plotting:

```
drop_na(el_house_prices) %>%
ggplot(aes(x = date, y = median_price)) +
  geom_line() +
  theme_minimal() +
  scale_y_continuous(labels = scales::label_dollar(),
                     name = "Median House Price") +
 scale_x_date(name = NULL,
              date_breaks = "1 year",
              date_labels = "%Y") +
  labs(title = "Median Home Prices in Lasning-East Lansing MSA")
```

Using the FRED API

Plotting:



Challenge

How has East Lansing's pandemic housing market compared with other cities?

- Get similar data from 2-3 other housing markets you're interested in.
- Plot time-series graphs for each housing market.
- More advanced: combine all the results in 1 dataframe (keep it tidy!).

Hidden APIs

Hidden APIs

The third kind of APIs are known as **Hidden APIs**.

These are endpoints used for a website's **Internal page generation** and is not intended for public use.

- For example, Airbnb uses or has used a hidden API to display search results on its web interface.
- Grant McDermott has an **example** of how to find and use hidden APIs.
- We're not going to go in-depth into hidden API access because...

Hidden APIs

One caveat: the legality of using hidden APIs is **less clear**

- In April 2022 (*HiQ Labs v. LinkedIn*), the Ninth Circuit Court of Appeals held that webscraping is legal in the U.S. so long as the data is **publicly available**
- Do hidden APIs constitute publicly available information?

Even if generally legal, web scraping may be a violation of a website's Terms & Conditions

- Airbnb: "Do not use bots, crawlers, scrapers, or other automated means to access or collect data or other content from or otherwise interact with the Airbnb Platform."
- Your IP could be blocked or your account could be blocked/blacklisted

Considerate Web Scraping

Considerate Web Scraping

In addition to our internal evaluation of

> Just because we can, doesn't mean we should

another useful tool in this process is **checking for and reading the robots.txt file**.

Many sites have a `robots.txt` file that outlines what parts of the site web crawlers *can* and *can't* access.

- Specific pages or API endpoints
- Specific types of users

Considerate Web Scraping

The `robotstxt` package makes it easy to check for and read these files. For example, Wikipedia:

```
get_robotstxt(domain = "https://www.wikipedia.org")
```

```
## [robots.txt]
## --------------------------------------
##
## # robots.txt for http://www.wikipedia.org/ and friends
## #
## # Please note: There are a lot of pages on this site, and there are
## # some misbehaved spiders out there that go _way_ too fast. If you're
## # irresponsible, your access to the site may be blocked.
## #
##
## # Observed spamming large amounts of https://en.wikipedia.org/?curid=NNNNNN
## # and ignoring 429 ratelimit responses, claims to respect robots:
## # http://mj12bot.com/
## User-agent: MJ12bot
## Disallow: /
##
## # advertising-related bots:
## User-agent: Mediapartners-Google*
## Disallow: /
##
## # Wikipedia work bots:
```

Considerate Web Scraping

Best Practices for considerate web scraping:

- Check the `robots.txt` file and scrape what's allowed
- If no `robots.txt` file exists, stick to
  1. Public information
  2. Scraped at a reasonable speed (i.e. human frequency)
- Scrape the data **once**, not **every time you run the script**
- Ask yourself: "would I feel comfortable having an undergrad RA scrape this?"

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