

Big Data and Economics

Lecture 6a: Web Data in Research

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Prologue

Prologue

- We've spent the first month of this class on learning:
 - empirical organization skills ("Clean Code"),
 - basics of R
 - basics of data wrangling and tidy data
- Now we're going to tackle data acquisition via **scraping**
- Essentially, we're going to learn how to get data from the web
- As context, everything I am showing you today assumes you've:
 1. Found data on the web you want
 2. Found the relevant way to access it (APIs vs. CSS)
 3. Know the specifics needed to access the data (e.g. the name of a series, have an API key, the rough HTML structure)
- These data are usually messy in one way or another, so it'll give you something to tidy
- Extended demos for this lecture are available in [WEB APIs](#) and [web Scraping](#)

Plan for today

- What is scraping?
- Contrast Client-side and Server-side scraping
- Examples of scraping in economics research
- Ethical considerations
- Learn by doing with APIs (CSS will happen later -- potentially end of semester)

Attribution

- These slides take inspiration from the following sources:
 - [Nathan Schiff's web data lecture](#)
 - [Andrew MacDonald's slides](#)
 - [Jenny Bryan's textbook](#)
 - [Grant McDermott's notes on CSS and APIs](#)
 - [James Densmore's stance on ethics](#)

Worldwide Web of Data

Worldwide Web of Data

- Every website you visit is packed with data
- Every app on your phone is packed with data and taking data from you
- Guess what?
 - These data often measure hard to measure things
 - These data are often public (at some level of aggregation/anonymity)
 - These data are often not easily accessible and not **tidy**
 - Samples might be biased (have to navigate that)
 - This is legal (usually) and ethical (usually)
- Guess what? All this makes these data (and knowing how to access it) valuable
 - It also makes this a hard skill to pick up

Examples of scraping in economics research

What cool things can you do with web

- Can anyone think of examples of web data being used in economics research?

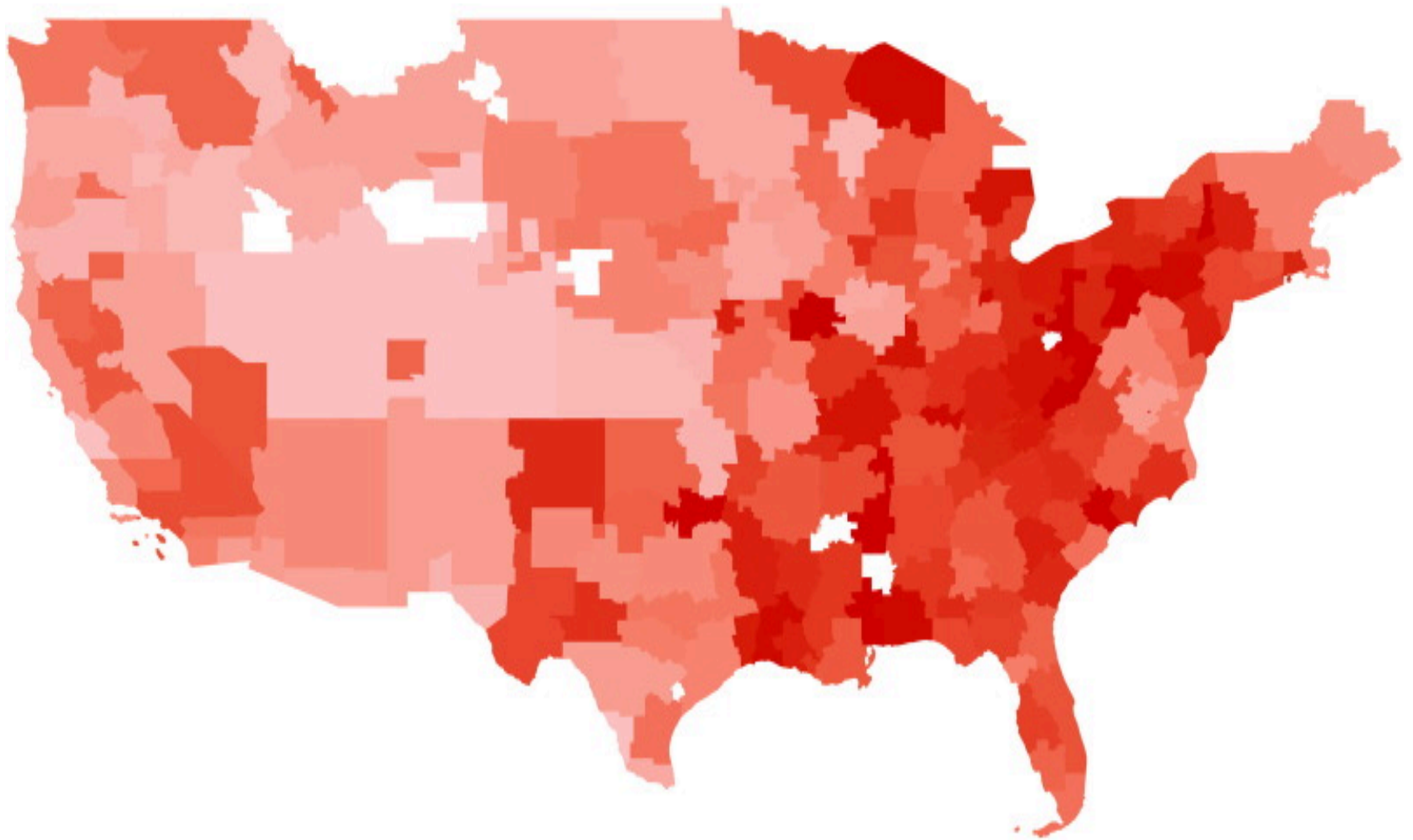
Measuring hard to measure things

- Imagine you survey a ton of people about their beliefs that a candidate is unfit to be president because of their race
- Due to social desirability bias, you get a lot of "I don't know" or "I don't think that"
- There are lots of creative survey methods to get at this, but is there some way to measure this without asking people?
- Say, why not find out the frequency that people search Google for racial epithets in connection to the candidate?
- Guess what? Stephens-Davidowitz (2014) did just that
 - Finds racial animus cost Barack Obama 4 percentage points in the 2008 election (equivalent of a home-state advantage)
 - Google search term data yield effects that are 1.5 to 3 times larger than survey estimates of racial animus

$$\text{Racially Charged Search Rate}_j = \left[\frac{\text{Google searches including the word "Word 1 (s)"} }{\text{Total Google searches}} \right]_{j, 2004-2007}$$

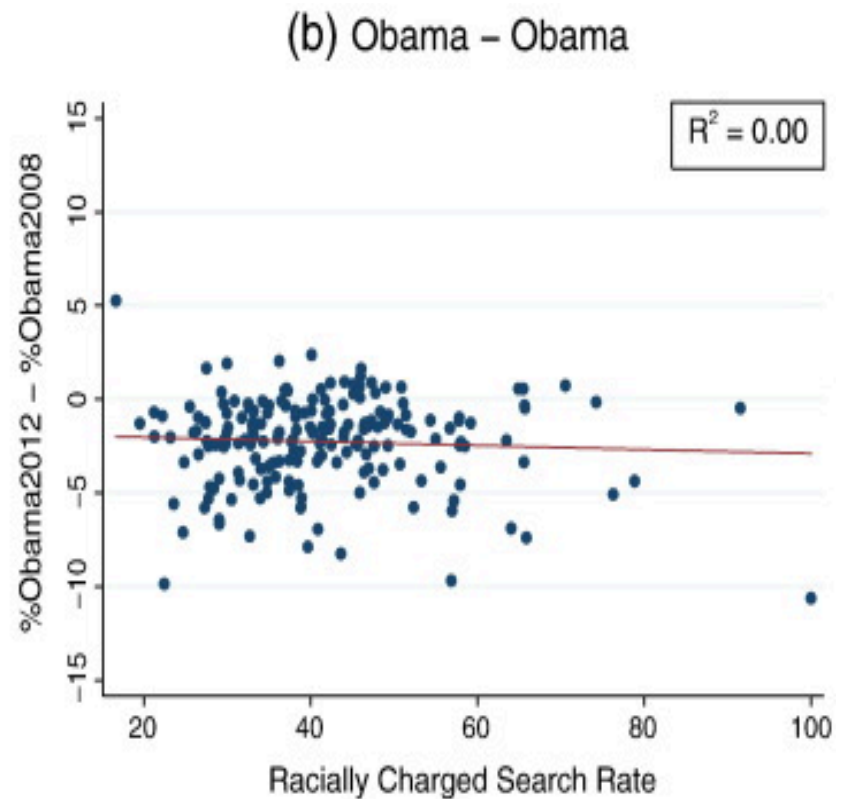
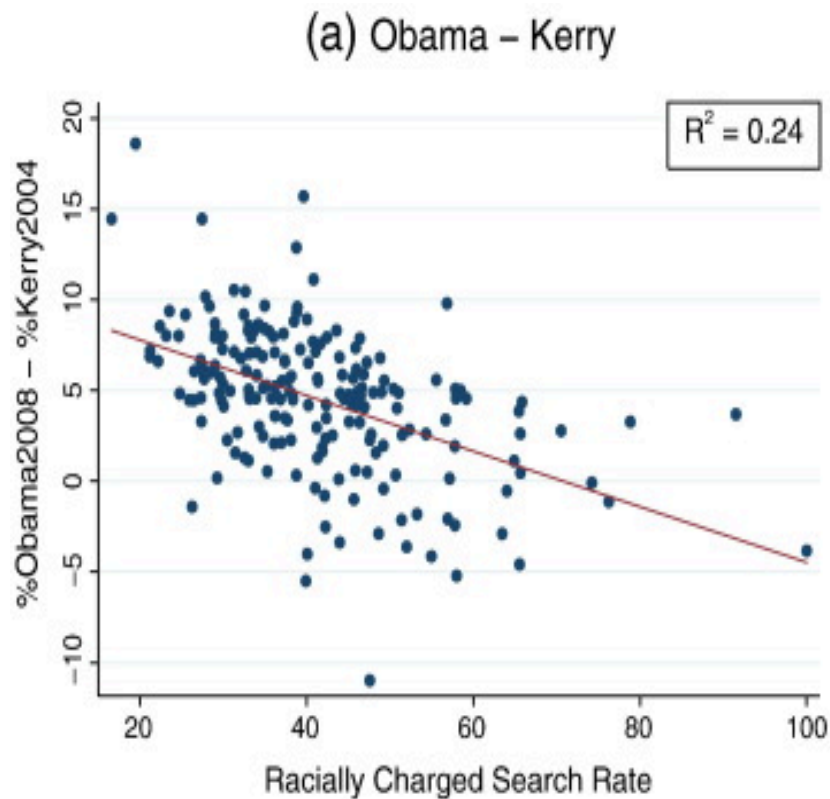
for j geographical area (state, county, etc.)

Racial Animus Map



Map of media markets by racially charged search rate from 2004 to 2007. The darker red, the more racially charged.

Election performance



Obama underperformed Kerry in areas with more racially charged search rates.

Other uses

- "Billion prices project" (Cavallo and Rigobon 2015) : collect prices from online retailers to look at macro price changes
- Davis and Dingell (2016): use Yelp to explore racial segregation in consumption
- Halket and Pginatti (2015): scrape Craigslist to look at housing markets
- Wu (2018): undergraduate hacked into online economics job market forum to look at toxic language and biases in the academic economics against women
- Glaeser (2018) uses Yelp data to quantify how neighborhood business activity changes as areas gentrify (**Student presentation**)
- Tons leverage eBay, Alibaba, etc. to look at all kinds of commercial activity
- Edelman B (2012) gives an overview of using internet data for economic research

Access methods

Access methods

There are three ways to data off the web:

1. **click-and-download** on the internet as a "flat" file, like a CSV or Excel file
 - What you're used to
 2. **Client-side** *websites contain an empty template that _request* data from a server and then fills in the template with the data
 - The request is sent to an API (application programming interface) endpoint
 - Technically you can just source right from the API endpoint (if you can find it) and skip the website altogether
 - I consider this a form of scraping
 - **Key concepts:** APIs, API endpoints
 3. **Server-side** websites that sends HTML and JavaScript to your browser, which then renders the page
 - People often call this "scraping"
 - All the data is there, but not in a tidy format
 - **Key concepts:** CSS, Xpath, HTML
- Key takeaway: if there's a structure to how the data is presented, you can exploit it to get the data

Click and Download

- You've all seen this approach before
- You go to a website, click a link, and download a file
- Sometimes you need to login first, but if not you can automate this with R's `download.file()` function
- Below will download the Occupational Employment and Wage Statistics (OEWS) data for Massachusetts in 2021 from the BLS

```
download.file("https://www.bls.gov/oes/special.requests/oesm21ma.zip", "oesm21ma.zip")
```

Client-side scraping

- The website contains an empty template of HTML and CSS.
 - E.g. It might contain a “skeleton” table without any values.
- However, when we actually visit the page URL, our browser sends a request to the host server.
- If everything is okay (e.g. our request is valid), then the server sends a response script, which our browser executes and uses to populate the HTML template with the specific information that we want.
- **Webscraping challenges:** Finding the “API endpoints” can be tricky, since these are sometimes hidden from view.
- **Key concepts:** APIs, API endpoints

APIs

- APIs are a collection of rules/methods that allow one software application to interact with another
- Examples include:
 - Web servers and web browsers
 - R libraries and R clients
 - Databases and R clients
 - Git and GitHub and so on

Key API 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), but other common methods are POST, PUT and DELETE.
- **Requests:** What the client asks of the server (see Methods above).
- **Response:** The server’s response. This includes a Status Code (e.g. “404” if not found, or “200” if successful), a Header (i.e. meta-information about the response), and a Body (i.e. the actual content that we’re interested in).
- Not covered? Explicit directions for each API we cover today
- Instead, we're covering the nuts and bolts so you can figure out how to use any API

API Endpoints

- Web APIs have a URL called an **API Endpoint** that you can use to access view the data in your web browser
- Except instead of rendering a beautifully-formatted webpage, the server sends back a ton of messy text!
 - Either a JSON (JavaScript object notation) or XML (eXtensible Markup Language) file
- It'd be pretty overwhelming to learn how to navigate these new language syntaxes
- Guess what? R has packages to help you with that
 - `jsonlite` for JSON
 - `xml2` for XML
- Today we're going to work through a few of these
- That means the hardest parts are:
 - Finding the API endpoint
 - Understanding the rules
 - Identify the words you need to use to get the data you want
- To be clear, that's all still tricky!

Easy API: New York City Open Data

- NYC OpenData provides a ton of data on New York City
- It offers it as something easy to download
- It also offers it as

Trees of NYC

The screenshot shows the NYC OpenData website interface. At the top, the URL is <https://data.cityofnewyork.us/Environment/2015-Street-Tree-Census-Tree-Data/uvpi-gqnh>. The NYC OpenData logo is on the left, and navigation links (Home, Data, About, Learn, Alerts, Contact Us, Blog) and a search bar are on the right. The main heading is "2015 Street Tree Census - Tree Data" with a sub-tab "Environment". Action buttons include "View Data", "Visualize", "Export", "API", and a menu icon. A descriptive paragraph states: "Street tree data from the TreesCount! 2015 Street Tree Census, conducted by volunteers and staff organized by NYC Parks & Recreation and partner organizations. Tree data collected includes tree species, diameter and perception of health. Accompanying blockface data is available indicating status of data collection and data release citywide." A right-hand sidebar shows "Updated September 13, 2018" and "Data Provided by Department of Parks and Recreation (DPR)". The "About this Dataset" section contains a table with metadata.

Updated	
September 13, 2018	
Data Last Updated	October 4, 2017
Metadata Last Updated	September 13, 2018
Date Created	June 3, 2016

Update	
Update Frequency	Historical Data
Automation	No
Date Made Public	6/3/2016

Read the trees JSON

```
# library(jsonlite) ## Already loaded
nyc_trees =
  fromJSON("https://data.cityofnewyork.us/resource/nwxe-4ae8.json") %>%
  as_tibble()
nyc_trees

## # A tibble: 1,000 × 45
##   tree_id block_id created_at      tree_dbh stump_diam curb_loc status health
##   <chr>   <chr>   <chr>         <chr>    <chr>        <chr>   <chr> <chr>
## 1 180683 348711 2015-08-27T00:00... 3         0          OnCurb  Alive Fair
## 2 200540 315986 2015-09-03T00:00... 21        0          OnCurb  Alive Fair
## 3 204026 218365 2015-09-05T00:00... 3         0          OnCurb  Alive Good
## 4 204337 217969 2015-09-05T00:00... 10        0          OnCurb  Alive Good
## 5 189565 223043 2015-08-30T00:00... 21        0          OnCurb  Alive Good
## 6 190422 106099 2015-08-30T00:00... 11        0          OnCurb  Alive Good
## 7 190426 106099 2015-08-30T00:00... 11        0          OnCurb  Alive Good
## 8 208649 103940 2015-09-07T00:00... 9         0          OnCurb  Alive Good
## 9 209610 407443 2015-09-08T00:00... 6         0          OnCurb  Alive Good
## 10 192755 207508 2015-08-31T00:00... 21        0          OffsetF... Alive Fair
## # i 990 more rows
## # i 37 more variables: spc_latin <chr>, spc_common <chr>, steward <chr>,
## #   guards <chr>, sidewalk <chr>, user_type <chr>, problems <chr>,
## #   root_stone <chr>, root_grate <chr>, root_other <chr>, trunk_wire <chr>,
## #   trnk_light <chr>, trnk_other <chr>, brch_light <chr>, brch_shoe <chr>,
## #   brch_other <chr>, address <chr>, zipcode <chr>, zip_city <chr>,
## #   cb_num <chr>, borocode <chr>, boroname <chr>, cncldist <chr>, ...
```


"Map" the trees

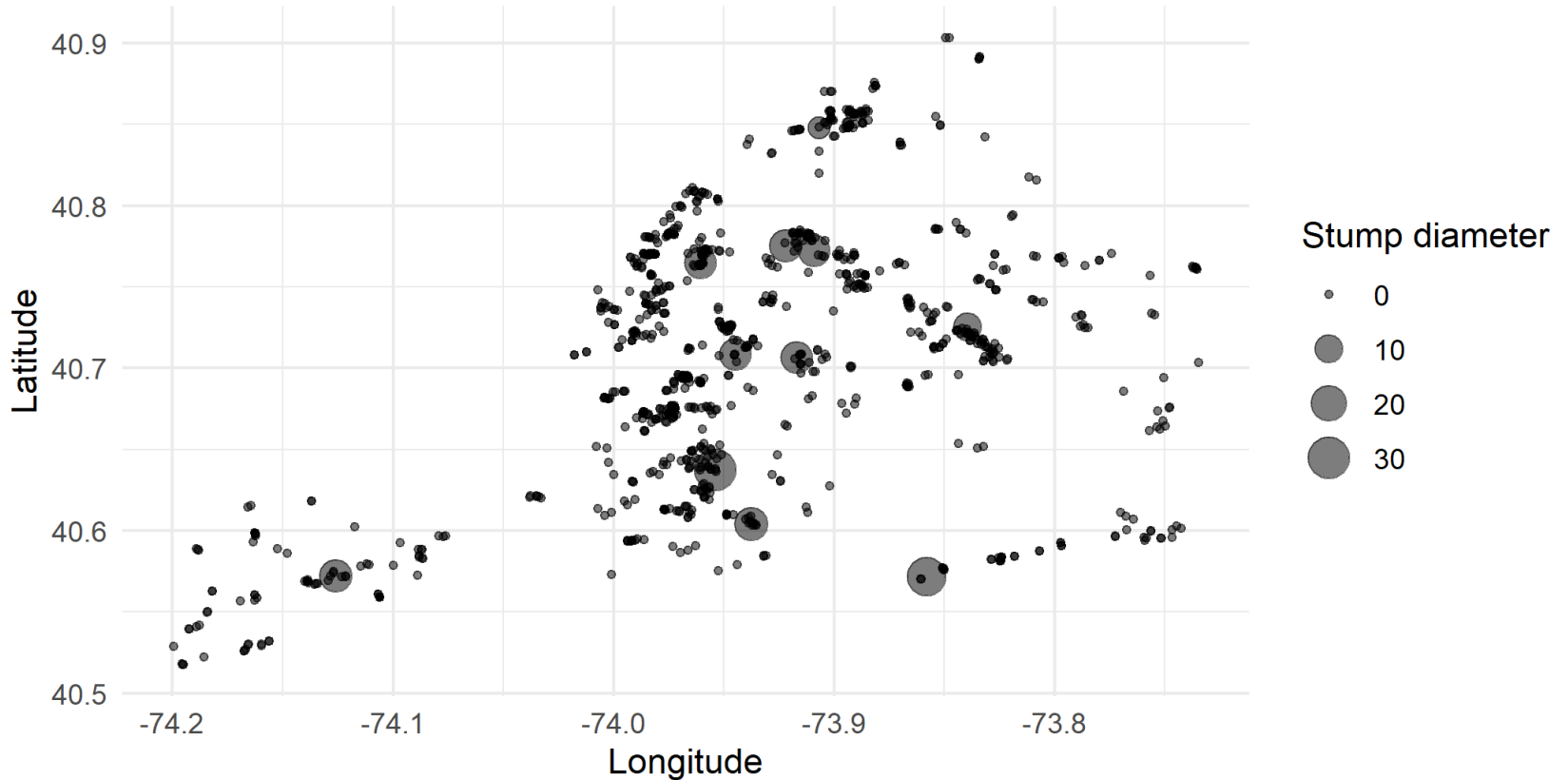
- Don't worry, better looking maps to come

```
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"  
  )
```

"Map" the trees

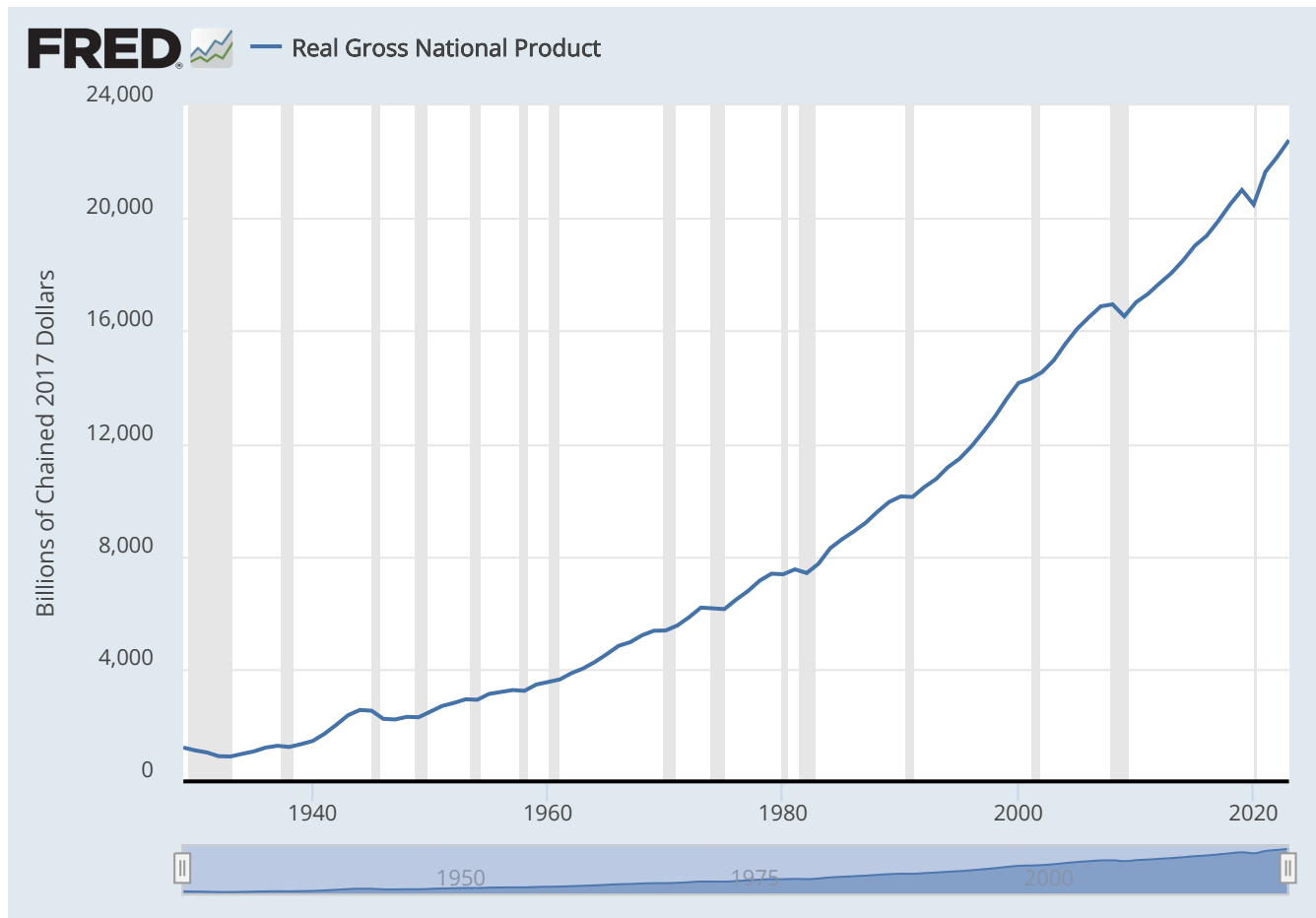
- Don't worry, better looking maps to come

Sample of New York City trees



Source: NYC Open Data

You've likely used FRED before



Source: U.S. Bureau of Economic Analysis

[Customize](#) | [Download Data](#) | [FRED - Economic Data from the St. Louis Fed](#)

Underneath is an API!

- The endpoint is https://api.stlouisfed.org/fred/series/observations?series_id=GNPCA&api_key=&file_type=json
- Just sub an your API key and you're good to go
- What's an API Key? It is a unique identifier that is used to authenticate access to the data
 - It's like a password, but it's not a password
 - It tracks who is using the API and how much they're using it
 - Fake example: `asdfjaw523a3523414at43sad`
 - FRED gives you one for free if you [register an API key](#)

```
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "observation_start": "1600-01-01", "observation_end": "2024-02-03", "series_id": "GNPCA", "file_type": "json"}
[{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1929-01-01", "value": "1202.659"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1930-01-01", "value": "1100.67"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1931-01-01", "value": "1029.038"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1932-01-01", "value": "895.802"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1933-01-01", "value": "883.847"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1934-01-01", "value": "978.188"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1935-01-01", "value": "1065.716"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1936-01-01", "value": "1201.443"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1937-01-01", "value": "1264.393"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1938-01-01", "value": "1222.966"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1939-01-01", "value": "1320.924"},
{"realtime_start": "2024-02-03", "realtime_end": "2024-02-03", "date": "1940-01-01", "value": "1435.656"}]
```

What do I need to know?

- The base URL: <https://api.stlouisfed.org/>
- The API endpoint (fred/series/observations/)
- The parameters:
 - series_id="GNPCA"
 - api_key=YOUR_API_KEY
 - file_type=json

```
endpoint = "fred/series/observations"
params = list(
    api_key= "YOUR_FRED_KEY", ## Change to your own key
    file_type="json",
    series_id="GNPCA"
)
```

Reading FRED's JSON

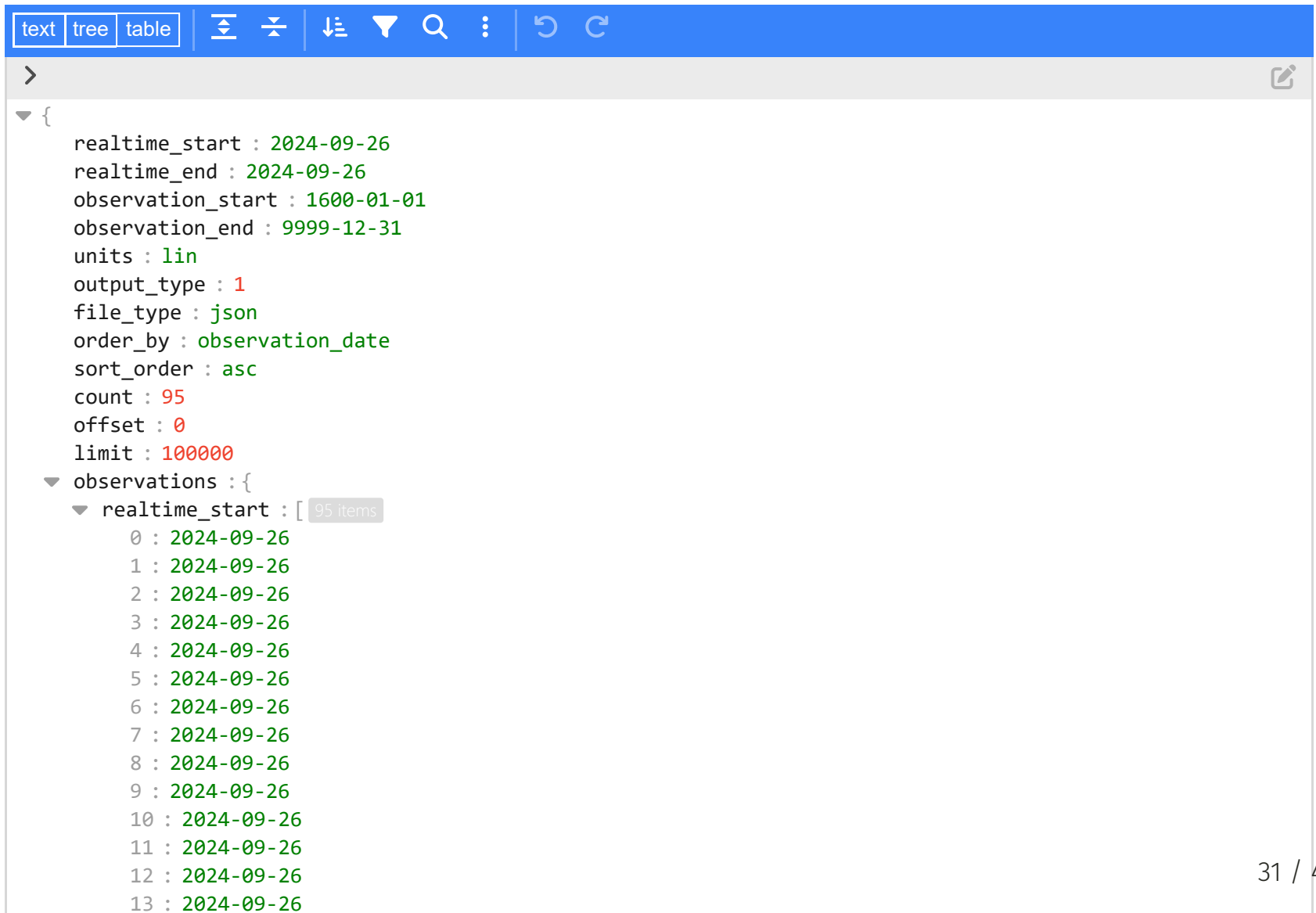
```
fred =  
  http::GET(  
    url = "https://api.stlouisfed.org/", ## Base URL  
    path = endpoint,      ## The API endpoint  
    query = params        ## Our parameter list  
  ) %>%  
  http::content("text") %>%  
  jsonlite::fromJSON()
```

- What's in there?

```
fred
```

```
## $realtime_start  
## [1] "2024-09-26"  
##  
## $realtime_end  
## [1] "2024-09-26"  
##  
## $observation_start  
## [1] "1600-01-01"  
##  
## $observation_end  
## [1] "9999-12-31"
```

What's in that object?



The screenshot shows a data viewer interface with a blue header bar containing tabs for 'text', 'tree', and 'table', along with various icons for filtering and navigation. The main area displays a JSON object with the following structure:

```
> {  
  realtime_start : 2024-09-26  
  realtime_end : 2024-09-26  
  observation_start : 1600-01-01  
  observation_end : 9999-12-31  
  units : lin  
  output_type : 1  
  file_type : json  
  order_by : observation_date  
  sort_order : asc  
  count : 95  
  offset : 0  
  limit : 100000  
  observations : {  
    realtime_start : [ 95 items  
      0 : 2024-09-26  
      1 : 2024-09-26  
      2 : 2024-09-26  
      3 : 2024-09-26  
      4 : 2024-09-26  
      5 : 2024-09-26  
      6 : 2024-09-26  
      7 : 2024-09-26  
      8 : 2024-09-26  
      9 : 2024-09-26  
      10 : 2024-09-26  
      11 : 2024-09-26  
      12 : 2024-09-26  
      13 : 2024-09-26
```

The interface includes a search bar and a list of observations, each with an index and a date value (2024-09-26).

Turn it into data

```
fred =  
  fred %>%  
  purrr::pluck("observations") %>% ## Extract the "$observations" list element  
  # .$observations %>% ## I could also have used this  
  # magrittr::extract("observations") %>% ## Or this  
  as_tibble() ## Just for nice formatting  
fred
```

```
## # A tibble: 95 × 4  
##   realtime_start realtime_end date      value  
##   <chr>          <chr>      <chr>    <chr>  
## 1 2024-09-26    2024-09-26 1929-01-01 1202.659  
## 2 2024-09-26    2024-09-26 1930-01-01 1100.67  
## 3 2024-09-26    2024-09-26 1931-01-01 1029.038  
## 4 2024-09-26    2024-09-26 1932-01-01 895.802  
## 5 2024-09-26    2024-09-26 1933-01-01 883.847  
## 6 2024-09-26    2024-09-26 1934-01-01 978.188  
## 7 2024-09-26    2024-09-26 1935-01-01 1065.716  
## 8 2024-09-26    2024-09-26 1936-01-01 1201.443  
## 9 2024-09-26    2024-09-26 1937-01-01 1264.393  
## 10 2024-09-26   2024-09-26 1938-01-01 1222.966  
## # i 85 more rows
```


Clean it up a bit and plot it

```
# library(lubridate) ## Already loaded above

fred =
  fred %>%
  mutate(across(realtime_start:date, ymd)) %>% # make all the dates, dates
  mutate(value = as.numeric(value)) # Make the values numeric
head(fred,3)
```

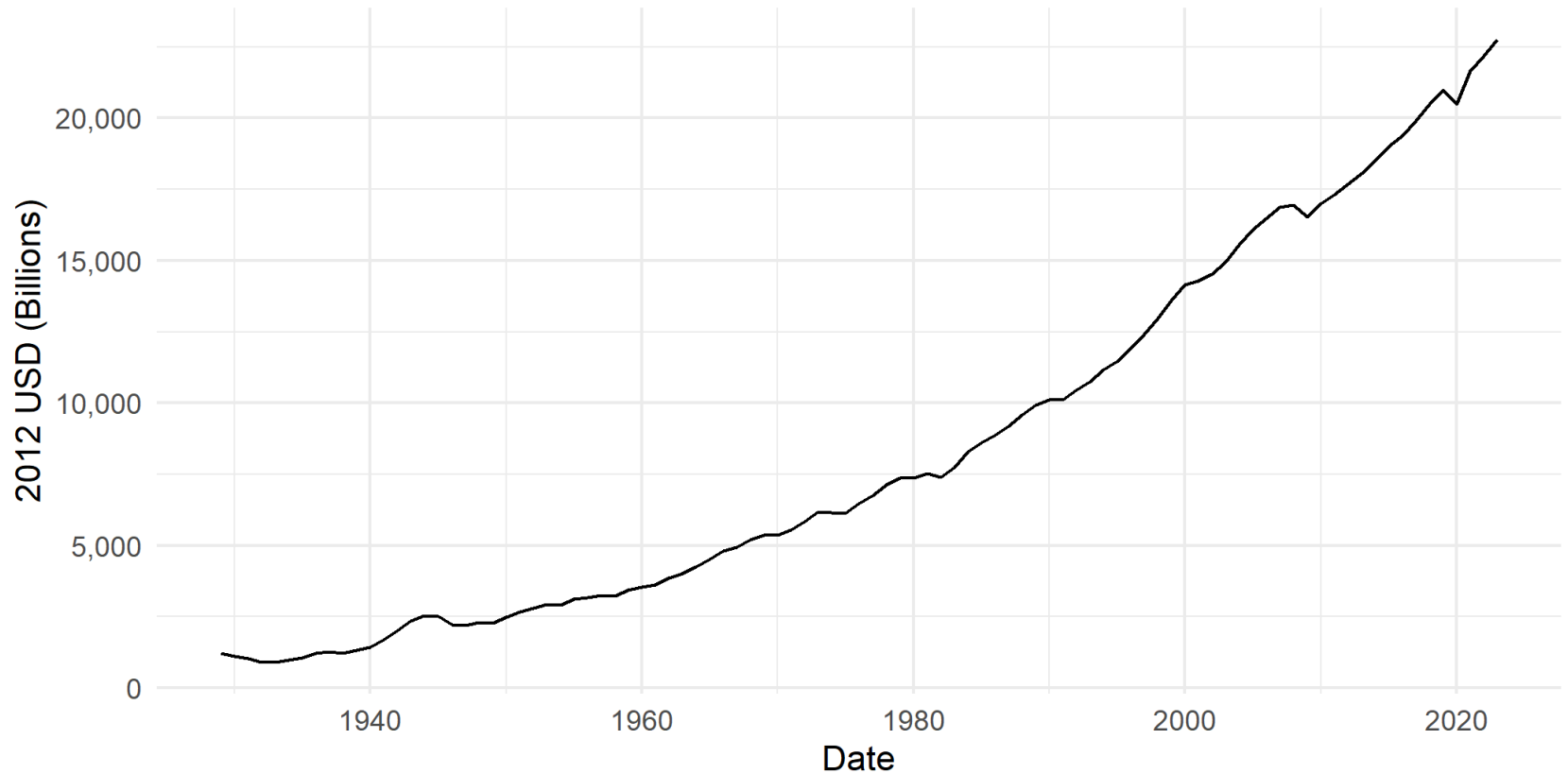
```
## # A tibble: 3 × 4
##   realtime_start realtime_end date      value
##   <date>         <date>      <date>    <dbl>
## 1 2024-09-26     2024-09-26  1929-01-01 1203.
## 2 2024-09-26     2024-09-26  1930-01-01 1101.
## 3 2024-09-26     2024-09-26  1931-01-01 1029.
```

Plot it

```
ggplot(fred, aes(x=date, y=value)) + # set your ggplot df and aesthetics
  geom_line() + # what geom?
  scale_y_continuous(labels = scales::comma) + # Make the scale prettier
  labs(
    x="Date", y="2012 USD (Billions)",
    title="US Real Gross National Product", caption="Source: FRED"
  )
```

Plot it

US Real Gross National Product



Source: FRED

Hide your API Key

- In general, you don't want to share your API key with anyone
- Instead, you can make it an environment variable either for a single session or permanently

```
Sys.setenv(FRED_API_KEY_TEST="abcdefghijklmnopqrstuvwxyz0123456789")  
FRED_API_KEY_TEST = Sys.getenv("FRED_API_KEY_TEST")  
FRED_API_KEY_TEST
```

```
## [1] "abcdefghijklmnopqrstuvwxyz0123456789"
```

- You can also permanently add it to your `.Renviron` file, by running the `edit_r_environ()` function from the **usethis** package
- Then just type in `FRED_API_KEY_TEST=abcdefghijklmnopqrstuvwxyz0123456789`, save, and re-read

```
usethis::edit_r_environ() # open R environment to edit  
readRenviron("~/Renviron") # read the .Renviron file
```

- Any time you need it, use `Sys.getenv("FRED_API_KEY_TEST")`

Popular APIs

- Many popular APIs are free to use and have a lot of documentation
- Sometimes the documentation gets a bit cumbersome though
- So kind souls have developed R packages to help you "abstract" these details (**Clean Code**)
- For example, the `tidycensus` package is a wrapper for the US Census API
 - You'll use it on your problem set
- Others include: `fredr`, `blsAPI`, `rgithub`, `googlesheets4`, `googledrive`, `wikipediR`, etc.
- Here's a curated list: <https://github.com/RomanTsegelskyi/r-api-wrappers>

Tidycensus

```
#library(tidycensus) # Already loaded
census_api_key("YOUR API KEY GOES HERE")
get_acs(geography = "county",
  state="ME",
  variables = "B19013_001E", # Median household income
  year = 2017,
  show_call = TRUE,
  survey='acs5')
```

```
## # A tibble: 3 × 5
```

	GEOID	NAME	variable	estimate	moe
	<chr>	<chr>	<chr>	<dbl>	<dbl>
## 1	23001	Androscoggin County, Maine	B19013_001	49538	1293
## 2	23003	Aroostook County, Maine	B19013_001	39021	1177
## 3	23005	Cumberland County, Maine	B19013_001	65702	1115

Note

- You still need to go find a series ID (ChatGPT is your friend)
- But documentation works too.
 - Census has documentation organized by year and survey:
<https://api.census.gov/data/variables.html>
 - tidycensus' `load_variables(YYYY, "sub-survey")` syntax will help you find the variables you need

Hidden APIs

- Sometimes the API endpoint is hidden from view
- But you can find it by using the "Inspect" tool in your browser
- It will require some detective work!
- But if you pull it off, you can get data that no one else has

Server-side scraping

- The scripts that “build” the website are not run on our computer, but rather on a host server that sends down all of the HTML code.
 - E.g. Wikipedia tables are already populated with all of the information — numbers, dates, etc. — that we see in our browser.
- In other words, the information that we see in our browser has already been processed by the host server.
- You can think of this information being embedded directly in the webpage’s HTML.
 - So if we can get our hands on the HTML, we can get our hands on the data.
 - We just have to figure out how to strip off the HTML and get the data into a tidy format.
- **Webscrapping challenges:** Finding the correct CSS (or Xpath) “selectors”. Iterating through dynamic webpages (e.g. “Next page” and “Show More” tabs).
- **Key concepts:** CSS, Xpath, HTML
- **R package:** `rvest` has a suite of functions to help convert HTML to a tidy format

Underneath Wikipedia

W List of Olympic records in athlet

en.wikipedia.org/wiki/List_of_Olympic_records_in_athletics

Google Voice - Inbo... us.megabus.com/ab... Gmail YouTube Maps Random Econ Ideas DND Columbia Stuff Life Jazz All Bookmarks

Contents hide

(Top)

Men's records

Women's records

Mixed records

See also

References

External links


Beamon's compatriot, [Mike Powell](#), jumped farther in the [1991 World Championships in Athletics](#) in [Tokyo](#).^[1]

Note, only those events currently competed for and recognised by the IOC as Summer Olympic events are listed.^[8]


Men's records [edit]

♦ denotes a performance that is also a current [world record](#). Statistics are correct as of August 3, 2021.

Event	Record	Athlete(s)	Nation	Games	Date	Ref(s)
100 metres	9.63	Usain Bolt	 Jamaica (JAM)	2012 London	August 5, 2012	^[9]
200 metres	19.30	Usain Bolt	 Jamaica (JAM)	2008 Beijing	August 20, 2008	^[10]
400 metres	♦43.03	Wayde van Niekerk	 South Africa (RSA)	2016 Rio de Janeiro	August 14, 2016	^[11]
800 metres	♦1:40.91	David Rudisha	 Kenya (KEN)	2012 London	August 9, 2012	^[12]
1,500 metres	3:28.32	Jakob Ingebrigtsen	 Norway (NOR)	2020 Tokyo	August 7, 2021	^[13]
5,000 metres	12:57.82	Kenenisa Bekele	 Ethiopia (ETH)	2008 Beijing	August 23, 2008	^[14]
10,000 metres	27:01.17	Kenenisa Bekele	 Ethiopia (ETH)	2008 Beijing	August 17, 2008	^[15]
Marathon	2:06:32	Samuel Wanjiru	 Kenya (KEN)	2008 Beijing	August 24, 2008	^[16]
110 metres	12.91	Liu Xiang	 China (CHN)	2004	August 27, 2004	^[17]



[Usain Bolt](#) currently holds three Olympics records, two individually and one with the Jamaican 4 × 100m relay team.



The HTML source

- If we can just cut out all the HTML and get the data into a tidy format, we're golden
- Better yet, we can use some of the HTML to help us find **harvest** the data we want

```
<caption>List of men's Olympic records in athletics
</caption>
<tbody><tr>
<th scope="col" width="12%">Event
</th>
<th class="unsortable" width="5%">Record
</th>
<th scope="col" width="10%">Athlete(s)
</th>
<th scope="col" width="15%">Nation
</th>
<th scope="col" width="10%">Games
</th>
<th scope="col" width="5%">Date
</th>
<th scope="col" class="unsortable" width="3%">Ref(s)
</th></tr>
<tr>
<th scope="row"><span data-sort-value="00100&#160;!"><a href="/wiki/100_metres" title="100 metres">100
</th>
<td align="right">9.63&#160;
</td>
<td><span data-sort-value="Bolt, Usain"><span class="vcard"><span class="fn"><a href="/wiki/Usain_Bolt"
</td>
<td><span class="mw-image-border" typeof="mw:File"><span>% html_elements(CSS_SELECTORS) %>% html_table()`.
  - You might need other functions depending on the content type (e.g. `html_text`).
- Just because you can scrape something doesn't mean you should (i.e. ethical and possibly legal considerations).
- Webscraping involves as much art as it does science. Be prepared to do a lot of experimenting and data cleaning.



Next: Onto scraping and API activities!

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