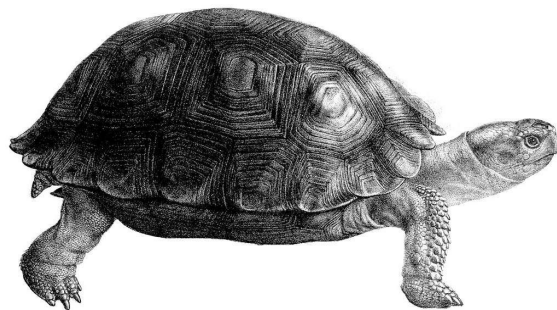


# From Core to A'Tuin: Citing Software All The Way Down The Stack

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<https://burntfen.com> || <http://richard.social>

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& Andrew Nesbitt of [ecosyste.ms](http://ecosyste.ms)



A'Tuin?



A'Tuin?



# Citing software is important!

- Recognizes contributions to science
- Enables reproducibility
- Facilitates knowledge transfer of the whole process
- Incentivizes code sharing
- Enables RSEs to use citations for funding narratives
- Developers don't know their impact. At all.
- Cheap
- Easy

# So, is it that hard?

- Not really!
- Let's look at a paper.

# Perceived heterospecific vocal mimicry in *Perisoreus jays*, sourced from community scientist observations

- Actual paper in prep.
- Has some spectrograms showing bird calls
- Involved some data science.



# Is there any data shared?

- eBird Basic Dataset. (2024) Version: EBD\_relJul-2024. Cornell Lab of Ornithology, Ithaca, New York. Jul 2024.
- Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. *Biological Conservation* 142: 2282-2292.
- & dozens of individual observations from eBird, iNaturalist, and Xeno-Canto

# Is there any code shared?

- <https://github.com/RichardLitt/perisoreus>
- Not on Zenodo yet (pending article review)
- No manifest



RichardLitt Figure 2



.gitignore



Figure\_1.png



Figure\_2.png



LICENSE



README.md



get\_attribution\_for\_sic\_jay.py



get\_data\_from\_macaulay\_library.py



get\_gryjay\_species\_comments.py



get\_recordist\_from\_ml\_data.py



get\_sicjay\_all\_comments.py



print\_species\_amounts\_from\_newline\_delim...



sort\_contributors\_by\_last\_name.py



spectrograms.py



# Let's make a manifest

- ``pip install pipreqs && pipreqs``
- ``cat requirements.txt`:`

...

`ebird_api==3.0.6`

`matplotlib==3.8.4`

`numpy==2.1.2`

`pandas==2.2.3`

`scipy==1.14.1`

...

# Cite those!

From their websites:

- Harris, C.R., Millman, K.J., van der Walt, S.J. et al. (2020) Array programming with NumPy. Nature 585, 357–362. DOI: 10.1038/s41586-020-2649-2.
- Hunter, J. (2007) Matplotlib: A 2D Graphics Environment. Computing in Science & Engineering, 9 (3), 90-95. <https://doi.org/10.5281/zenodo.10916799>
- Pandas development team. (2020). pandas-dev/pandas: Pandas (latest version). Zenodo. <https://doi.org/10.5281/zenodo.3509134> Accessed on September 11, 2024.
- Pauli Virtanen, Ralf Gommers, Travis E. Oliphant, Matt Haberland, Tyler Reddy, David Cournapeau, Evgeni Burovski, Pearu Peterson, Warren Weckesser, Jonathan Bright, Stéfan J. van der Walt, Matthew Brett, Joshua Wilson, K. Jarrod Millman, Nikolay Mayorov, Andrew R. J. Nelson, Eric Jones, Robert Kern, Eric Larson, CJ Carey, İlhan Polat, Yu Feng, Eric W. Moore, Jake VanderPlas, Denis Laxalde, Josef Perktold, Robert Cimrman, Ian Henriksen, E.A. Quintero, Charles R Harris, Anne M. Archibald, Antônio H. Ribeiro, Fabian Pedregosa, Paul van Mulbregt, and SciPy 1.0 Contributors. (2020) SciPy 1.0: Fundamental Algorithms for Scientific Computing in Python. Nature Methods, 17(3), 261-272.

# ebird\_api?

- Not the same as eBird.
- <https://pypi.org/project/ebird-api/>
- <https://github.com/ProjectBabbler/ebird-api>

## Contributors 3



**StuartMacKay** Stuart MacKay



**mariostg**



**KateFerrandino** Kate Ferrandino

# ebird\_api?

- ProjectBabbler/ebird-api. 2020. projectbabbler/ebird-api, version 3.0.6. GitHub. <https://github.com/ProjectBabbler/ebird-api> Accessed on September 11, 2024.

Or:

- MacKay, Stuart, Farrandino, Kate, and mariostg. 2020. projectbabbler/ebird-api, version 3.0.6. GitHub. <https://github.com/ProjectBabbler/ebird-api> Accessed on September 11, 2024.

Contributors 3



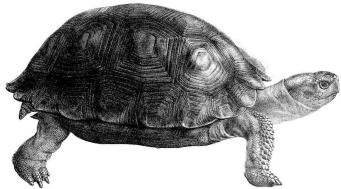
StuartMacKay Stuart MacKay



mariostg



KateFerrandino Kate Ferrandino



# Citing in the text

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# Citing in the text

**Author contributions:** RL wrote the paper and examined eBird, Xeno-Canto, and iNaturalist. RL and SD observed Canada Jays performing imitations of American Goshawk. SD edited the paper and analyzed iNaturalist. WK observed Canada Jays in Oregon and wrote their observations. **Data availability:** All used data is publicly available on eBird, iNaturalist, and Xeno-Canto. **Scripts used to massage exported data are downloadable at <https://github.com/RichardLitt/perisoreus>.** The Python libraries matplotlib (Hunter 2007), numpy (Harris et al. 2020), and scipy (Virtanen et al. 2020) were used to create the sonograms.

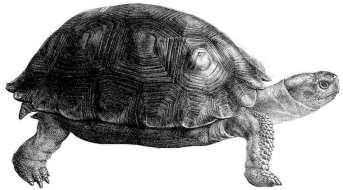
**Conflicts:** The authors declare no conflicts of interest. **Ethics:** No ethics permits or approvals were required for this research. **Funding:** This work was unfunded. **Land acknowledgement:** We acknowledge the Abenaki as the traditional stewards of the land of Ndakinna, and the Cayuse, Umatilla, Walla Walla, and Nüümü (Northern Paiute) as the traditional stewards of Harney, Oregon.

# Citing in the text

**[In text].** We used Python scripts (Python Software Foundation 2024) with native libraries, and the pandas library (Pandas development team 2020) for further analyses of checklists.

# All done!

- Cited five dependencies in our GitHub.
- (Sorta) got author information for contributors.





## But what about...?

- Python?
- Pip?
- pipreqs?
- Cat?
- Or:

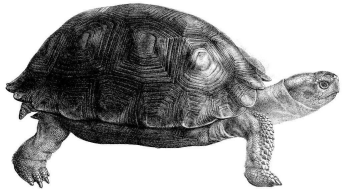
```
1  import os
2  import sys
3  import re
4  import pandas as pd
5
```

# Them too!

- Python Software Foundation. Python Language Reference, version 2.7. Available at <http://www.python.org>
- FreeBSD Project. FreeBSD Core Utilities. FreeBSD Project, 2024. <https://www.freebsd.org/src/>. Accessed on September 11, 2024.
- bdnr/pipreqs. 2023. <https://github.com/bdnr/pipreqs>, v. 0.4.13. GitHub. Accessed <https://github.com/bdnr/pipreqs> on October 17, 2024.

# All done!

- Cited eight dependencies.
- Go team!



# Open source is all about turtles.

"Open source, in general, is this collective of projects that are built on top of projects that are built on top of projects that are built on top of projects."

- Nicholas Zakas

<https://podcast.sustainoss.org/142>

<https://humanwhocodes.com/blog/2022/06/sponsoring-dependencies-open-source-sustainability/>

# Open source privileges a few

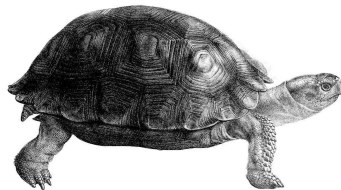
- Charismatic projects get more mind-share
- More funding
- More bug-fixes
- Leaving the rest in the lurch.

## This is a problem.

- Maintainers who aren't thanked aren't incentivized.
- Funds don't trickle down.
- Vulnerabilities trickle up.
- Citations are the currency of academia.

# Citation.cff?

- Plain text files
- With human- and machine-readable citation information
- Meant for software (and datasets).
- Need to be **manually** included.



# Can we find those automatically?

- Yes!
- Let's start with ebird-api.
- ``gem* install pbom``



```
→ pbom git:(main) ./exe/pbom generate --input ../ebird-api --output ../test/.
Generating a new PBOM...
Looking up pkg:pypi/black@24.10.0...
Downloading CITATION.cff from psf/black...
Looking up pkg:pypi/build@1.2.2.post1...
Looking up pkg:pypi/bump2version@1.0.1...
Looking up pkg:pypi/cachetools@5.5.0...
Looking up pkg:pypi/certifi@2024.8.30...
Looking up pkg:pypi/cffi@1.17.1...
Looking up pkg:pypi/chardet@5.2.0...
Looking up pkg:pypi/charset-normalizer@3.3.2...
Looking up pkg:pypi/click@8.1.7...
Looking up pkg:pypi/colorama@0.4.6...
Looking up pkg:pypi/coverage@7.6.1...
Downloading CITATION.cff from nedbat/coveragepy...
Looking up pkg:pypi/cryptography@43.0.1...
Looking up pkg:pypi/distlib@0.3.8...
Looking up pkg:pypi/docutils@0.21.2...
Looking up pkg:pypi/filelock@3.16.1...
Looking up pkg:pypi/flake8@7.1.1...
```

# Black the Uncompromising.cff

```
1  cff-version: 1.2.0
2  title: "Black: The uncompromising Python code formatter"
3  message: >-
4      If you use this software, please cite it using the metadata from this file.
5  type: software
6  authors:
7      - family-names: Langa
8        given-names: Łukasz
9      - name: "contributors to Black"
10 repository-code: "https://github.com/psf/black"
11 url: "https://black.readthedocs.io/en/stable/"
12 abstract: >-
13     Black is the uncompromising Python code formatter. By using it, you agree to cede
14     control over minutiae of hand-formatting. In return, Black gives you speed,
15     determinism, and freedom from pycodestyle nagging about formatting. You will save time
16     and mental energy for more important matters.
17
18     Blackened code looks the same regardless of the project you're reading. Formatting
19     becomes transparent after a while and you can focus on the content instead.
20
21     Black makes code review faster by producing the smallest diffs possible.
22  license: MIT
```

# Black the Uncompromising.bib

```
@software{Langa_Black_The_uncompromising,  
author = {Langa, Łukasz and {contributors to Black}},  
license = {MIT},  
title = {{Black: The uncompromising Python code formatter}},  
url = {https://github.com/psf/black}  
}
```

# The rest

PBOM generated at ../test/.

- 56 unique packages found
- sbom.json
- references.bib

To cite all packages in your research, add the following to your LaTeX document:

```
\cite{pypi:black}, \cite{pypi:build}, \cite{pypi:bump2version}, \cite{pypi:cachetools}, \cite{pypi:certifi}, \cite{pypi:cffi}, \cite{pypi:chardet}, \cite{pypi:charset-normalizer}, \cite{pypi:click}, \cite{pypi:colorama}, \cite{pypi:coverage}, \cite{pypi:cryptography}, \cite{pypi:distlib}, \cite{pypi:docutils}, \cite{pypi:filelock}, \cite{pypi:flake8}, \cite{pypi:idna}, \cite{pypi:importlib-metadata}, \cite{pypi:iniconfig}, \cite{pypi:isort}, \cite{pypi:jaraco-classes}, \cite{pypi:jaraco-context}, \cite{pypi:jaraco-functools}, \cite{pypi:jeepney}, \cite{pypi:keyring}, \cite{pypi:markdown-it-py}, \cite{pypi:mccabe}, \cite{pypi:mdurl}, \cite{pypi:more-itertools}, \cite{pypi:mypy-extensions}, \cite{pypi:nh3}, \cite{pypi:packaging}, \cite{pypi:pathspec}, \cite{pypi:pkginfo}, \cite{pypi:platformdirs}, \cite{pypi:pluggy}, \cite{pypi:pycodestyle}, \cite{pypi:pyparser}, \cite{pypi:pyflakes}, \cite{pypi:pygments}, \cite{pypi:pyproject-api}, \cite{pypi:pyproject-hooks}, \cite{pypi:pytest}, \cite{pypi:pytest-cov}, \cite{pypi:pywin32-ctypes}, \cite{pypi:readme-renderer}, \cite{pypi:requests}, \cite{pypi:requests-toolbelt}, \cite{pypi:rfc3986}, \cite{pypi:rich}, \cite{pypi:secretstorage}, \cite{pypi:tox}, \cite{pypi:twine}, \cite{pypi:urlllib3}, \cite{pypi:virtualenv}, \cite{pypi:zipp}
```

# Publish?

*Abstract*—Citing software is important for research, as it improves reproducibility, reuse, and incentivizes software development in the sciences. Current best practices encourage citing major software used in the development of research, uploading code to a data repository, and licensing software appropriately. But only citing charismatic projects leaves gaps in the literature, disincentivizes work on low-level modules, and ignores the transitive nature of most software. Here, we discuss alternatives, by citing all software used in an open source software project, including dependencies. We point out issues with software citation, and suggest best practices for the field going forward.

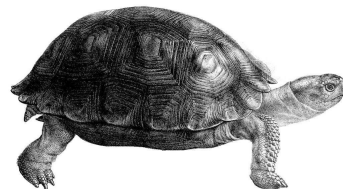
## ACKNOWLEDGMENT

- [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13]<sup>[24]</sup>  
[14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24],  
[25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35]<sup>[25]</sup>  
[36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [46]<sup>[26]</sup>  
[47], [48], [49], [50], [51], [52], [53], [54], [55], [56]

## REFERENCES

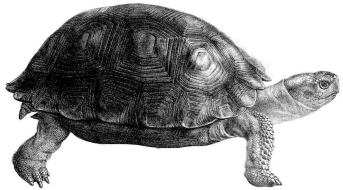
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# Ok! All done.

- But this was just for ebird-api...
- What about the other projects?

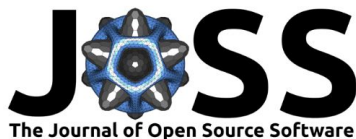


# Dependencies

- Tough in Python
- This uses `poetry`
- But it's not perfect.

```
→ perisoreus git:(main) ✖ poetry show --tree
ebird-api 3.0.7 Wrapper for accessing the eBird API
matplotlib 3.8.4 Python plotting package
├── contourpy >=1.0.1
│   └── numpy >=1.23
├── cyclor >=0.10
├── fonttools >=4.22.0
├── kiwisolver >=1.3.1
├── numpy >=1.21
├── packaging >=20.0
├── pillow >=8
├── pyparsing >=2.3.1
├── python-dateutil >=2.7
│   └── six >=1.5
numpy 2.1.2 Fundamental package for array computing in Python
pandas 2.2.3 Powerful data structures for data analysis, time series, and statistics
├── numpy >=1.26.0
├── python-dateutil >=2.8.2
│   └── six >=1.5
├── pytz >=2020.1
└── tzdata >=2022.7
pip 24.2 The PyPA recommended tool for installing Python packages.
scipy 1.14.1 Fundamental algorithms for scientific computing in Python
└── numpy >=1.23.5,<2.3
```

# How about JavaScript?



## jsPsych: Enabling an Open-Source Collaborative Ecosystem of Behavioral Experiments

Joshua R. de Leeuw <sup>1¶</sup>, Rebecca A. Gilbert <sup>2,3</sup>, and Björn Luchterhandt <sup>4</sup>

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DOI: [10.21105/joss.05351](https://doi.org/10.21105/joss.05351)

### Software

- [Review](#) 
- [Repository](#) 
- [Archive](#) 

### Summary

It is common practice to research human behavior using experiments that participants can complete online. Researchers use a variety of methodological approaches to conduct these



# Jspsysh

- Only 9 devDependencies.
- ``cat package-lock.json | jq .packages | jq 'keys | length'`` shows 1677 transitive deps

## Citing All the Software Dependencies, from Core to Attn

Editorial Board Chairman: David Skuse – <a href="mailto:David.Skuse@kcl.ac.uk">David.Skuse@kcl.ac.uk</a>	Section Editors Neurotic Disorders Tanya Gold – <a href="mailto:Tanya.Gold@kcl.ac.uk">Tanya.Gold@kcl.ac.uk</a>	Book Reviews Editor: David Skuse <a href="mailto:David.Skuse@kcl.ac.uk">David.Skuse@kcl.ac.uk</a>
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3	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162	165	168	171	174	177	180	183	186	189	192	195	198	201	204	207	210	213	216	219	222	225	228	231	234	237	240	243	246	249	252	255	258	261	264	267	270	273	276	279	282	285	288	291	294	297	300
4	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200	204	208	212	216	220	224	228	232	236	240	244	248	252	256	260	264	268	272	276	280	284	288	292	296	300	304	308	312	316	320	324	328	332	336	340	344	348	352	356	360	364	368	372	376	380	384	388	392	396	400
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TABLE 1									
Summary of the results of the 1990-1991 survey of the 100 largest U.S. corporations									
	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Total number of corporations	100	100	100	100	100	100	100	100	100
2. Total number of subsidiaries	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
3. Total number of employees	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
4. Total number of shareholders	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
5. Total number of products	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
6. Total number of patents	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
7. Total number of trademarks	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
8. Total number of licenses	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
9. Total number of franchises	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
10. Total number of joint ventures	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
11. Total number of acquisitions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
12. Total number of divestitures	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
13. Total number of spin-offs	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
14. Total number of restructurings	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
15. Total number of mergers	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
16. Total number of bankruptcies	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
17. Total number of liquidations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
18. Total number of reorganizations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
19. Total number of conversions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
20. Total number of dissolutions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
21. Total number of liquidations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
22. Total number of reorganizations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
23. Total number of conversions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
24. Total number of dissolutions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
25. Total number of liquidations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
26. Total number of reorganizations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
27. Total number of conversions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
28. Total number of dissolutions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
29. Total number of liquidations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
30. Total number of reorganizations	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
31. Total number of conversions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
32. Total number of dissolutions	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
33. Total number of liquidations	1,000	1,000							

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## Further problems:

- What about getting code contributors?
- Can we automatically get ORCID? DOIs?
- What about citing dependencies of FreeBSD and Python, too? What does that look like?
- How about Firefox, Google Docs, and OSX?

# Where does it end?

- Right now - nowhere.
- Journals limit citations. You'll need editors to be on board with you citing all of these.
- Citations aren't all equal. Not every dependency is always used.
- Transitive dependencies aren't easy to get.

# SBOMs

- A manifest of all of your work
- Include it with your data
- Or include it as an appendix
- Cite all citation.cff files in it.

# Saying "Use an SBOM" isn't enough.

- How do we incentivize it?
- 1. Fund open source by funding science.
- 2. Count SBOM inclusion as altmetrics.
- 3. ???
- 4. Draw the owl turtle.

# Cite what you can.

- If people have included Citation.cff files, they have explicitly asked you to cite them.
- Find and cite every one.

Thank you.

<https://github.com/andrew/PBOM/>

[http://richard.social.](http://richard.social)

