

# **EXHIBIT 1**

# An Evaluation of the Compactness of the Enacted and Alternative State Legislative Plans in Ohio

Christopher Warshaw\*

April 11, 2022

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## 1 Introduction

My name is Christopher Warshaw. I am an Associate Professor of Political Science at George Washington University. Previously, I was an Associate Professor at the Massachusetts Institute of Technology from July 2016 - July 2017, and an Assistant Professor at MIT from July 2012 - July 2016.

I have been asked by counsel representing the relators in this case to analyze relevant data and evaluate the compactness of the Commission's March 28 House and Senate plans, as well as three alternative sets of plans that have been submitted for consideration. Specifically, I was asked to compare the average compactness of districts on the Commission's March 28 plans for each chamber with Professor Rodden's Plan III, the Independent Mapmaker's Plan, and Prof. Rodden's corrected revision of the Independent Map Drawer's plan that was uploaded on April 8th.

## 2 Qualifications, Publications and Compensation

My Ph.D. is in Political Science, from Stanford University, where my graduate training included courses in political science and statistics. I also have a J.D. from Stanford Law School. My academic research focuses on public opinion, representation, elections, and polarization in American Politics. I have written multiple papers that focus on elections and two published articles that focus specifically on partisan gerrymandering. I also have a forthcoming book that includes an extensive analysis on the causes and consequences of partisan gerrymandering in state governments.

My curriculum vitae is attached to this report. All publications that I have authored and published appear in my curriculum vitae. My work is published or forthcoming in peer-reviewed journals such as: the *American Political Science Review*, the *American Journal of Political Science*, the *Journal of Politics*, *Political Analysis*, *Political Science Research and Methods*, the *British Journal of Political Science*, *Political Behavior*, *Science Advances*, the *Election Law Journal*, *Nature Energy*, *Public Choice*, and edited volumes from Cambridge University Press and Oxford University Press. My book entitled *Dynamic Democracy in the American States* is forthcoming from the University of Chicago Press. My non-academic writing has been published in the *New York Times* and the *Washington Post*. My work has also been discussed in the *Economist* and many other prominent media outlets.

My opinions in this case are based on the knowledge I have amassed over my education, training and experience, including a detailed review of the relevant academic literature.

They also follow from quantitative analysis of block assignment files of the Commission’s March 28 plans and the alternative plans I obtained from Counsel.

I have previously provided expert reports in this case, as well as eight other redistricting-related cases and several Census-related cases (see my CV for a current list). I am being compensated at a rate of \$325 per hour. The opinions in this report are my own, and do not represent the views of George Washington University.

### 3 Compactness

In this section, I examine the compactness of the districts on the Commission’s March 28 plans and three alternative plans. I focus on two commonly used compactness metrics to evaluate the compactness of the plans. First, the Reock Score is the ratio of the area of the district to the area of a minimum bounding circle that encloses the district’s geometry. Second, the Polsby-Popper measure is the ratio of the area of the district to the area of a circle whose circumference is equal to the perimeter of the district (See Figure 1 for illustrations of each metric from Ansolabehere and Palmer (2016, 751)). Each of these metrics falls within the range of  $[0,1]$  and a score closer to 1 indicates a more compact district.<sup>1</sup>

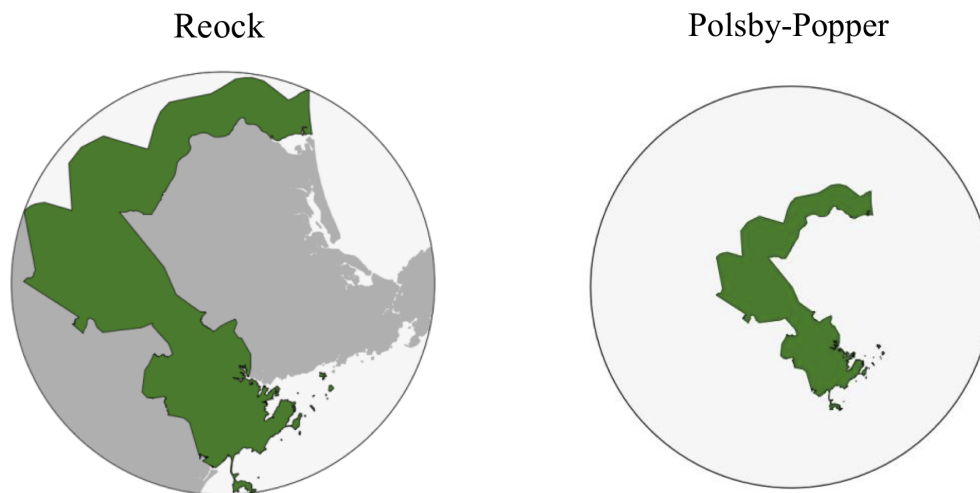


Figure 1: Illustration of Compactness Measures from Ansolabehere and Palmer (2016)

Table 1 shows the compactness metrics for the Commission’s March 28 plans and

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1. The Reock and Polsby-Popper metrics are closely related both theoretically and empirically. At the district-level, they have a correlation of about .62 across state legislative districts in usage in 2020. At the state-level, they are even more closely related. The average Reock and Polsby-Popper scores for each state legislative chamber have a correlation of .72 in 2020.

the three sets of alternative plans.<sup>2</sup> The Commission’s March 28 Plans have the lowest compactness scores on both the Reock and Polsby-Popper metrics. For the House, all three alternative plans are clearly more compact than the Commission’s March 28 plan. Moreover, all three alternative plans have similar compactness scores.

The alternative Senate plans are also more compact than the Commission’s March 28 plan. Here, Professor Rodden’s Plan III is more compact, especially on the Polsby-Popper metric, than the Independent Mapmaker’s plan or the revised version of this plan.

	Reock	Polsby-Popper
<b>Ohio State House</b>		
Commission’s March 28 Plan	0.39	0.31
Prof. Rodden’s Plan III	0.42	0.35
Independent Mapmaker’s Plan	0.41	0.33
Prof. Rodden’s corrected revision of the Independent Mapmaker’s plan	0.41	0.33
<b>Ohio State Senate</b>		
Commission’s March 28 Plan	0.39	0.28
Prof. Rodden’s Plan III	0.44	0.37
Independent Mapmaker’s Plan	0.43	0.31
Prof. Rodden’s corrected revision of the Independent Mapmaker’s plan	0.43	0.31

Table 1: Compactness Metrics for Districts on the Commission’s March 28 Plan and alternative plans. Higher scores indicate higher levels of compactness.

## 4 Conclusion

This report has examined the compactness of the Commission’s March 28 plans and compared them to three alternative sets of plans. It finds that the Commission’s plans have the lowest compactness scores. Each of the alternative plans have higher compactness scores than the Commission’s plans.

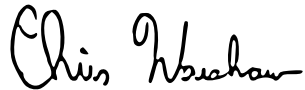
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2. The compactness scores were calculated using the open source software program, **R**, with the **redistmetrics** package. I also verified the scores using the PlanScore.org website, and obtained nearly identical scores there.

## References

Ansolabehere, Stephen, and Maxwell Palmer. 2016. "A two-hundred year statistical history of the gerrymander." *Ohio St. LJ* 77:741.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 11th day of April, 2022.

A handwritten signature in black ink that reads "Chris Hesch". The signature is written in a cursive style with a large initial "C".

# Christopher S. Warshaw

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## Academic Employment

### **George Washington University**, Washington, DC

Associate Professor (2020-present)

Assistant Professor, 2017 - 2020

### **Massachusetts Institute of Technology**, Cambridge, MA

Associate Professor of Political Science (without tenure), 2016 - 2017

Assistant Professor of Political Science, 2012 - 2016

## Education

### **Stanford University**, Ph.D., Political Science, 2012

Fields: American Politics, Comparative Politics, and Political Methodology (Statistics)

### **Stanford Law School**, Juris Doctorate, 2011

### **Williams College**, B.A., *magna cum laude*, 2002

## Research Interests

American Politics, Representation, Elections, Public Opinion, State & Local Politics, Environmental Politics and Policy, Statistical Methodology

## Research

### *Publications*

#### **Book**

"Dynamic Democracy: Public Opinion, Elections, and Policy Making in the American States." In Press. University of Chicago Press. (with Devin Caughey)

#### **Peer Reviewed Articles**

24. "The Effect of Television Advertising in United States Elections." Forthcoming. *American Political Science Review*. (with John Sides and Lynn Vavreck).



23. "Using Screeners to Measure Respondent Attention on Self-Administered Surveys: Which Items and How Many?" 2021. *Political Science Research and Methods*. 9(2): 430-437. (with Adam Berinsky, Michele Margolis, and Mike Sances)
22. "The Impact of Partisan Gerrymandering on Political Parties." 2020. *Legislative Studies Quarterly*. 45(4): 609-643. (with Nicholas Stephanopoulos)
21. "Fatalities from COVID-19 are reducing Americans' support for Republicans at every level of federal office." 2020. *Science Advances*. (with Lynn Vavreck and Ryan Baxter-King)
20. "Accountability for the Local Economy at All Levels of Government in United States Elections." 2020. *American Political Science Review*. 114(3): 660-676. (with Justin de Benedictis-Kessner)
19. "Politics in Forgotten Governments: The Partisan Composition of County Legislatures and County Fiscal Policies." 2020. *Journal of Politics*. 82(2): 460-475. (with Justin de Benedictis-Kessner)
18. "On the Representativeness of Primary Electorates." 2020. *British Journal of Political Science*. 50(2): 677-685. (with John Sides, Chris Tausanovitch, and Lynn Vavreck)
17. "Geography, Uncertainty, and Polarization." 2019. *Political Science Research and Methods*. 7(4): 775-794. (with Nolan McCarty, Jonathan Rodden, Boris Shor, and Chris Tausanovitch)
16. "Policy Ideology in European Mass Publics, 1981-2016." 2019. *American Political Science Review*. 113(3): 674-693. (with Devin Caughey and Tom O'Grady).
15. "Does Global Warming Increase Public Concern About Climate Change?" 2019. *Journal of Politics*. 81(2): 686-691. (with Parrish Bergquist)
14. "Local Elections and Representation in the United States." 2019. *Annual Review of Political Science*. 22(1): 461-479.
13. "The Ideological Nationalization of Party Constituencies in the American States". 2018. *Public Choice*. Keith Poole Symposium. 176(1-2): 133-151. (with James Dunham and Devin Caughey)
12. "Policy Preferences and Policy Change: Dynamic Responsiveness in the American States, 1936-2014." 2018. *American Political Science Review*. 112(2): 249-266. (with Devin Caughey)
11. "Does the Ideological Proximity Between Candidates and Voters Affect Voting in U.S. House Elections?" 2018. *Political Behavior*. 40(1): 223-245. (with Chris Tausanovitch)
10. "Partisan Gerrymandering and the Political Process: Effects on Roll-Call Voting and State Policies." *Election Law Journal*. December, 2017. 16(4): 453-469. Symposium on Partisan Gerrymandering and the Efficiency Gap. (with Devin Caughey and Chris Tausanovitch)
9. "Incremental Democracy: The Policy Effects of Partisan Control of State Government." 2017. *Journal of Politics*. 79(4): 1342-1358. (with Devin Caughey and Yiqing Xu)
8. "Renewable energy policy design and framing influences public support in the United States." 2017. *Nature Energy*. 2(17107). (with Leah Stokes)
7. "Estimating Candidates' Political Orientation in a Polarized Congress." 2017. *Political Analysis*. 25(2): 167-187. (with Chris Tausanovitch)
6. "The Dynamics of State Policy Liberalism, 1936-2014." 2016. *American Journal of Political Science*. 60(4): 899-913. (with Devin Caughey)
5. "Mayoral Partisanship and Municipal Fiscal Policy." 2016. *Journal of Politics*. 78(4): 1124-1138. (with Justin de Benedictis-Kessner)

4. "Dynamic Estimation of Latent Opinion Using a Hierarchical Group-Level IRT Model." 2015. *Political Analysis*. 23(2): 197-211. (with Devin Caughey)
3. "Representation in Municipal Government." 2014. *American Political Science Review*. 108(3): 605-641. (with Chris Tausanovitch)
2. "Measuring Constituent Policy Preferences in Congress, State Legislatures and Cities." 2013. *Journal of Politics*. 75(2): 330-342. (with Chris Tausanovitch)
1. "How Should We Measure District-Level Public Opinion on Individual Issues?" 2012. *Journal of Politics*. 74(1): 203-219. (with Jonathan Rodden)

#### **Editor Reviewed Articles in Journals and Law Reviews**

4. "A preference for constant costs." 2020. *Nature Climate Change*. News & Views. 10: 978-979
3. "Public Opinion in Subnational Politics." 2019. *Journal of Politics*. 81(1): 352-363. Editor reviewed for Symposium on Subnational Policymaking. (with Devin Caughey)
2. "Spatial variation in messaging effects." 2018. *Nature Climate Change*. News & Views. April, 2018.
1. "Business as Usual? Analyzing the Doctrinal Development of Environmental Standing Doctrine since 1976." 2011. *Harvard Law and Policy Review*. Volume 5.2. (with Gregory Wannier).

#### **Book Chapters**

5. "Elections and Parties in Environmental Politics." 2020. *Handbook on U.S. Environmental Policy*. David Konisky, ed. (with Parrish Bergquist)
4. "Latent Constructs in Public Opinion." 2018. *Oxford Handbook on Polling and Polling Methods*. R. Michael Alvarez and Lonna Atkeson, ed. Oxford: Oxford University Press.
3. "The Application of Big Data in Surveys to the Study of Elections, Public Opinion, and Representation." 2016. *Data Analytics in Social Science, Government, and Industry*. R. Michael Alvarez, ed. Cambridge: Cambridge University Press.
2. "The Political Economy of Expropriation and Privatization in the Oil Sector." 2012. *Oil and Governance: State-Owned Enterprises and the World Energy Supply*. David G. Victor, David Hults, and Mark Thurber, eds. Cambridge: Cambridge University Press.
1. "Democratization and Countermajoritarian Institutions: The Role of Power and Constitutional Design In Self-Enforcing Democracy." 2012. *Comparative Constitutional Design*. Cambridge: Cambridge University Press. (with Susan Alberts and Barry R. Weingast).

#### **Policy Reports**

1. "Reforming Baltimore's Mayoral Elections." 2020. Abell Foundation Report.  
<https://www.abell.org/publications/reforming-baltimores-mayoral-elections>

#### **Articles Under Review**

- "The Effect of Fox News Channel on U.S. Elections: 2000-2020" (with Elliott Ash, Sergio Galletta, and Matteo Pinna)  
(Invited to revise and resubmit at the *American Political Science Review*)
- "Moderates" (with Anthony Fowler, Seth Hill, Jeff Lewis, Chris Tausanovitch, Lynn Vavreck)  
(Invited to revise and resubmit at the *American Political Science Review*)

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"Partisan Polarization in the Mass Public in South Korea and the United States"

"How Partisanship in Cities Influences Housing Policy" (with Justin de Benedictis-Kessner and Dan Jones)

### Works in Progress

"Electoral Accountability for Ideological Extremism in American Elections" (with Devin Caughey)

"Gerrymandering in Local Governments" (with Yamil Valez)

"When Mass Opinion Goes to the Ballot Box: A National Assessment of State Level Issue Opinion and Ballot Initiative Results" (with Jonathan Robinson and John Sides)

"Inequalities in Participation, Voting, and Representation in Local Governments" (with Justin de Benedictis-Kessner and John Sides)

"The Ideology of State Party Platforms " (with Justin Phillips and Gerald Gamm)

### Non-Academic Writing

"Here are six big takeaways from the 2020 elections." *Washington Post*. November 7, 2020. (with Emily Thorson)

"TV ads still win elections. And Democrats are buying a lot more of them." *Washington Post*. October 28, 2020. (with John Sides and Lynn Vavreck)

"How Local Covid Deaths Are Affecting Vote Choice." *New York Times*. July 28, 2020. (with Lynn Vavreck)

"Allowing Only Older Americans to Vote by Mail Leads to Severe Racial Disparities." *Election Law Blog*. July 1, 2020.

"A coronavirus recession would hurt all kinds of Republican candidates – not just Trump." *Washington Post*, Monkey Cage. March 18, 2020. (with Justin de Benedictis-Kessner).

"The Supreme Court is deciding a gerrymandering case. Here's the social science that the Justices need to know." *Washington Post*, Monkey Cage. June 1, 2019.

"New research shows just how badly a citizenship question would hurt the 2020 Census." *Washington Post*, Monkey Cage. April 22, 2019. (with Matt Barreto, Matthew A. Baum, Bryce J. Dietrich, Rebecca Goldstein, and Maya Sen)

"G.O.P. Senators Might Not Realize It, but Not One State Supports the Health Bill." *New York Times*. June 14, 2017. (with David Broockman)

### Invited Talks

2021-2022: American University

2020-2021: University of Maryland; Stony Brook University

2019-2020: Princeton; UC Berkeley

2018-2019: Stanford; Northeast Political Methodology Meeting at NYU; University of Maryland

2017-2018: USC PIPE Symposium on Studying Subnational Policy Making; BYU; University of Chicago Conference on Political Polarization

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2016-2017: University of Virginia; UCLA

2015-2016: Washington University in St. Louis; Texas A&M; Arizona State University Conference on Campaigns, Elections and Representation

2014-2015: Yale; Columbia; Duke

2013-2014: Princeton; Boston University; Rochester University

2012-2013: MIT American Politics Conference; Columbia Representation Conference; Princeton Media & Politics Conference; Annual Meeting of the Society for Political Methodology

## Grants

Russell Sage Foundation, 2019-2021 (\$119,475)

GW UFF, 2019-2020 (\$14,433)

MIT Elections Lab, 2019-2020 (\$14,000)

Jeptha H. and Emily V. Wade Award, 2014-2016 (\$59,686)

MIT Energy Institute (MITEI) Seed Grant, 2014-2016 (\$137,147)

MIT SHASS Research Fund, 2012-2014 (\$8,734)

## Software

dgo: Dynamic Estimation of Group-Level Opinion. 2017. R package. <https://CRAN.R-project.org/package=dgo>. (with James Dunham and Devin Caughey)

## Awards and Honors

OVPR Early Career Scholar at George Washington University, 2019.

APSA award for best journal article on State Politics & Policy in 2016.

Award for best paper on State Politics & Policy at the 2014 American Political Science Conference.

Graduate Fellowship, Dept. of Political Science, Stanford University, 2006-2012

David A. Wells Prize in Political Economy for Best Undergraduate Economics Thesis, Williams College, 2002

Phi Beta Kappa, Williams College, 2002

## Teaching Experience

### **Instructor:**

Measurement Models (Graduate-level) (GW), 2020

Political Representation (Graduate-level) (GW), 2019

Elections (GW), 2018, 2019, 2021

Multi-level and Panel Models (Graduate-level) (GW), 2017, 2018, 2019, 2021

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Public Opinion (GW), 2017  
American Political Institutions (Graduate-level) (MIT), 2014, 2016  
Public Opinion and Elections (MIT), 2016  
Energy Policy (MIT), 2013  
Democracy in America (MIT), 2013, 2014  
Constitutional Law & Judicial Politics (MIT), 2013, 2015  
Making Public Policy (MIT), 2012, 2014

**Teaching Assistant:**

Introduction to American Law (Stanford University), 2010  
Judicial Politics and Constitutional Law (Stanford University), 2009  
Political Economy of Energy Policy (Stanford University), 2008  
Introduction to International Relations (Stanford University), 2008  
Introduction to Public Policy (Stanford University), 2007  
Introduction to Econometrics (Williams College), 2002

## Graduate Advising

**George Washington University:**

Alex Beck (Dissertation committee chair)  
Dickson Su (Dissertation committee chair)  
Kerry Synan (Dissertation committee co-chair)  
Jared Heern (Dissertation committee member)  
Colin Emrich (Graduates in 2021, Dissertation committee member)

**Massachusetts Institute of Technology:**

Leah Stokes (Graduated in 2015, Dissertation committee member)  
Krista Loose (2016, Dissertation committee member)  
Tom O'Grady (2017, Dissertation committee member)  
Justin de Benedictis-Kessner (2017, Dissertation committee member)  
Alex Copulsky (2017, Masters thesis committee member)  
James Dunham (2018, Dissertation committee member)  
Parrish Bergquist (2018, Dissertation committee member)  
Meg Goldberg (2019, Dissertation committee member)

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## University Service

### **George Washington University:**

Member, Academic Program Review Committee, Sociology Dept., 2021  
Coordinator, Graduate Political Science Admissions Committee, 2019-2020  
Coordinator, American Politics Workshop, 2018-2020  
Member, Methods Exam Committee, 2017-2020  
Member, Graduate Political Science Admissions Committee, 2018-2019

### **Massachusetts Institute of Technology:**

Member, Energy Education Task Force, 2012-2017  
Parking and Transit Committee, 2013-2017  
Member, Graduate Political Science Admissions Committee, 2013-2015  
Faculty Fellow, Burchard Scholars, 2013-2015

### **Stanford University (as graduate student):**

President, Stanford Environmental Law Society, 2009-2010  
Executive Board Member, Stanford Environmental Law Society 2008-2010  
Member, University Committee on Graduate Studies, 2007-2009  
Member, University Library Committee, 2007-2008  
President, Political Science Graduate Students Association, 2007-2008

## Professional Service

**Reviewer:** American Political Science Review, American Journal of Political Science, Journal of Politics, Political Analysis, Political Behavior, Econometrica, Quarterly Journal of Political Science, Legislative Studies Quarterly, Political Research Quarterly, American Politics Research, British Journal of Political Science, Journal of Law and Courts, Public Opinion Quarterly, Political Science Research and Methods, State Politics and Policy Quarterly, Journal of Experimental Political Science, Nature Climate Change, Urban Affairs Review, Journal of Health Politics, Policy and Law, Perspectives on Politics, Review of Economics and Statistics, Cambridge University Press

**Member,** Best Dissertation Committee, Urban Politics Section of the American Political Science Assoc., 2021

**Member,** Program Committee, Midwest Political Science Association Conference, 2020

**Lead Organizer,** Local Political Economy APSA Pre-Conference at George Washington University, 2019

**Member,** Planning Committee, Cooperative Congressional Election Study (CCES), 2018

**Member,** Best Paper Committee, State Politics Section of the American Political Science Assoc., 2018

**Editorial Board,** Journal of Politics, 2017-18

**Executive Committee,** Urban Politics Section of the American Political Science Association, 2015-2017

**Organizing Committee,** Conference on Ideal Point Models at MIT, <http://idealpoint.tahk.us>, 2015

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**Member**, Best Paper Committee, Urban Politics Section of the American Political Science Assoc., 2015

## Consulting

### **Partisan Gerrymandering:**

Expert, *Alonzo et al. v. Schwab et al.*, 2022CV90 (consolidated into 2022CV89) (Wyandotte County Dist. Ct. Feb. 14, 2022), Congressional districts

Expert, *Benninghoff vs. Pennsylvania Legislative Reapportionment Commission*; and invited expert for the Pennsylvania Legislative Reapportionment Commission as it considered potential plans (2021-2022)

Expert, *League of Women Voters of Michigan vs Michigan Independent Citizens Redistricting Commission* (2022), State House Districts

Expert, *League of Women Voters of Ohio v. Ohio Redistricting Commission* (2021), Congressional districts

Expert, *League of Women Voters of Ohio v. Ohio Redistricting Commission* (2021), State Legislative Districts

Expert, *League of Women Voters vs. Kent County Apportionment Commission* (2021), County districting plan

Expert, *APRI et al. v. v. Smith et al.* (2018-2019), Congressional districts

Expert, *League of Women Voters of Michigan v. Johnson* (2018-2019), Congressional and state legislative districts

Expert, *League of Women Voters of Pennsylvania v. the Commonwealth of Pennsylvania* (2017-18), Congressional districts

### **Census:**

Expert, *La Union del Pueblo Entero , et al. v. Trump*, Effect of Excluding Undocumented Immigrants from Census on Apportionment (2020)

Expert, *Common Cause et al. v. Trump*, Effect of Excluding Undocumented Immigrants from Census on Apportionment (2020)

Expert, *State of New York v. Trump*, Effect of Excluding Undocumented Immigrants from Census on Apportionment (2020)

Expert, *New York Immigration Coalition v. US Dept of Commerce & State of NY v. US Dept of Commerce*, Effects of Undercount on Census due to Citizenship Question (2018)

### **Policy Reports:**

Consultant, *Abell Foundation*, Report on Potential Institutional Reforms for Baltimore's City Elections

## Community Service

PlanScore: Social Science Advisory Team (2020-2021)

Sierra Club: National Board of Directors (2009-2015)