Climate change opinion and recent presidential elections

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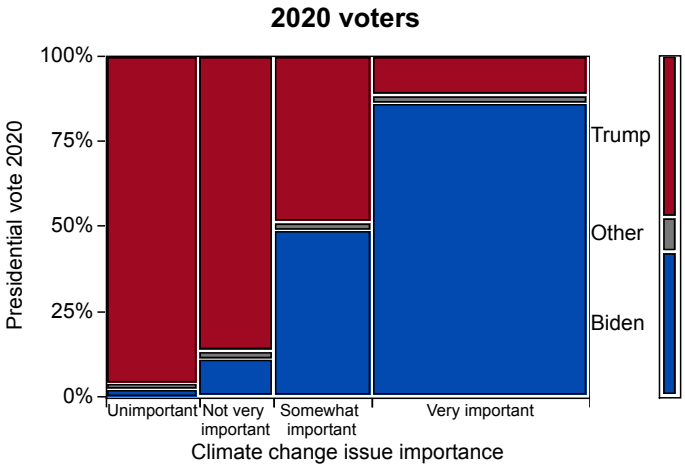
Climate change opinion and recent presidential elections

Matthew G. Burgess, Christian Suarez, Ashley Dancer, Lachlan J. Watkins, Renae E. Marshall[1]

Executive Summary

A large majority of voters are concerned about climate change. Voters who are concerned about climate change strongly prefer the Democrats, all else being equal.

There are about twice as many voters who are concerned about climate change as there are voters who are not concerned about climate change. For example, 57% of registered voters in a 2023 Yale University survey stated that they would prefer a candidate who supports action on global warming compared to 16% that preferred a candidate who opposes action on global warming.[2] In a 2023 Gallup survey, 61% of U.S. adults reported worrying "a great deal" or "a "fair amount" about climate change, compared to 39% who reported worrying "only a little" or "not at all".[3] Many other surveys have found similar results, and several specific climate change policies are supported by two-thirds of the public or more.[4]



U.S. voters' (n = 4,513) voting choices in the 2020 presidential election compared to how important they consider climate change to be as an issue. Widths of the bars represent the relative proportions of the sample within each climate change issue importance category, weighted to be nationally representative. Data from Voter Study Group.[5]

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[2] Leiserowitz, A., et al. (2023) Global warming as a voting issue. Climate change in the American mind: Politics & Policy, Fall 2023 (Yale Program on Climate Change Communication). https://climatecommunication.yale.edu/publications/climate-change-in-the-american-mind-politics-policy-fall-2023/toc/4/

[3] Saad, L. (2023) A steady six in 10 say global warming's effects have begun (Gallup). https://news.gallup.com/poll/474542/steady-six-say-global-warming-effects-begun.aspx

[4] Marshall, R., & Burgess, M. (2021) Want to reduce polarization? Pass these climate policies. *Arc Digital*. https://www.arcdigital.media/p/want-to-reduce-polarization-pass

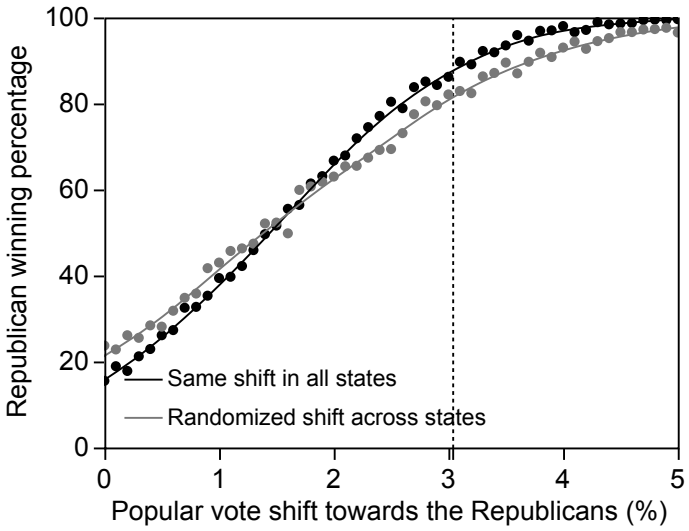
We analyzed multi-issue polling data from the voters in the 2016 and 2020 presidential elections.[5] We found that how important voters considered climate change to be as an issue was one of the strongest predictors of whom they voted for in 2020, especially among independents. Voters who stated that climate change was a "somewhat important" or "very important" issue to them represented 67% of voters, and 77% of these voters voted for the Democratic candidate (Joe Biden) (see figure on previous page).[6]

Therefore, climate change opinion represents an electoral advantage for the Democrats.

For example, 39% of U.S. adults in a 2023 ABC News and Ipsos poll trusted the Democrats more than the Republicans on climate change, compared to just 13% who trusted the Republicans more—the widest gap in trust between the two parties on any issue analyzed in the poll.[7]

We estimate that this advantage was probably large enough in 2020 to change the outcome of the presidential election in the Democrats' favor.

We use regression models to estimate how different the 2020 national popular vote might have been without the effect of climate change opinion, with everything else being equal. We use a probability forest model to estimate how different the 2020 national popular vote might have been if climate change concern had remained as it was in 2016, instead of increasing as it actually did, again holding all else equal. In both cases, we project that there would have been a swing of 3% or more in the 2020 national popular vote in favor of the Republicans. We create a probabilistic election simulator and find that a 3% swing would very likely have changed the election outcome (see figure at right). Based on this, we conclude that climate change opinion probably gave the Democrats enough of an advantage to change the outcome of the 2020 presidential election in their favor, holding all else equal.



Simulated probabilities for the Republicans to win the 2020 presidential election, given hypothetical shifts in the popular vote in their favor. Holding climate change opinion constant to 2016 levels would have swung the popular vote by roughly 3% towards the Republicans in our model (dashed line). Such a shift would probably have been pivotal to the election outcome.

Read the full report at: https://doi.org/10.5281/zenodo.10494414

[5] Voter Study Group (2023) Survey data driving the insights. https://www.voterstudygroup.org/data
[6] These percentages use population weights that make the sample nationally representative.
[7] ABC News, & Ipsos (2023) One year from election day, Republicans perceived as better at handling the economy. https://www.ipsos.com/en-us/one-year-election-day-republicans-perceived-better-handling-economy

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Summary

We review patterns of climate change opinion and polarization, and we estimate the effect of climate change opinion on recent U.S. presidential elections, bringing together three lines of evidence. First, we review recent polling studies that document climate change opinion, including: how it varies across regions and demographic groups, how it compares to other issues in importance, how it fits into broader political polarization, and the degree to which voters trust the two major political parties on the issue. Second, we use individual-level data from the Voter Study Group to estimate the effect of climate change opinion on voting behavior in the 2016 and 2020 presidential elections, controlling for demographics and other issue opinions. We do this using logistic regressions and probability forests. From these results, we project how the popular vote might have changed in the 2020 presidential election if voters' preferences for the parties' climate change stances had been different. Third, we build a model that can project Electoral College outcomes probabilistically in hypothetical popular vote scenarios. We find that climate change opinion has had a significant and growing effect on voting that favors the Democrats and is large enough to be pivotal to the outcomes of close elections. We project that climate change opinion probably cost Republicans the 2020 presidential election, all else being equal. We are aware of many possible implications of our findings for policymakers and advocates from a variety of political persuasions. However, we do not editorialize about or discuss these implications. Instead, we lay out our methods and results as matter-of-factly and objectively as possible, and we let our findings speak for themselves.

Main findings

1. **Large majorities of U.S. adults believe in human-caused climate change, are concerned about it, and think Congress and other policymakers should be doing more to address it.** Larger shares of Democrats and independents hold these opinions than Republicans. However, majorities of young (under 35) and moderate Republicans, and adults in nearly all Congressional districts, including those represented by Republicans, express support for some statements of concern about climate change and some policies aimed at addressing climate change.
2. **Although most U.S. adults consider climate change to be an important issue for the government, fewer than 5% of adults rank climate change as their single most important issue.** Top-ranked issues instead tend to be kitchen-table issues affecting immediate living standards such as the economy, healthcare, education, and crime.
3. **U.S. adults trust Democrats more than Republicans on climate change, on average. This issue advantage for the Democrats (26 points, in a recent survey) is one of the largest that either party has on any issue.** Average levels of concern about climate change within Congressional districts were strongly negatively correlated with their Republican vote shares, in the 2022 election.
4. **In the Voter Study Group sample, the importance voters assign to climate change as an issue is one of the strongest predictors of voting behavior in the 2016 and 2020 presidential elections, especially in 2020, and especially among independents.** Although it is impossible to definitively identify to what extent this pattern is causal, we consistently estimate an effect of climate change importance on voting across different types of statistical models. Voters who consider climate change to be an important issue made up roughly two-thirds of the electorate in 2020, and these voters strongly preferred the Democrats.
5. **When we simulate the 2020 presidential election with this climate change opinion effect turned off, and everything else equal, the Republicans gain 3.4% or more in the popular vote margin (i.e., Republican vote share minus Democrat vote share).** When we simulate the 2020 presidential election with climate change opinion reverted to what it was in 2016, all else equal, the Republicans gain 3% in the popular vote margin.
6. **A 1-2% popular vote margin shift towards the Republicans could have been pivotal to the outcome of the 2020 presidential election, and any larger shift almost certainly would have been pivotal.** We construct an election simulator, which accounts for variability in opinion polls and uncertainty in how the popular vote distributes across states. In our simulator's base case, which uses observed state-level election result margins and pre-election polling variance, President Biden wins the 2020 election in 85% of simulations. With a 1% increase in the popular vote margin, former President Trump wins 35% of the time. With a 2% increase, former President Trump wins over 60% of the time. With a 3% increase, former President Trump wins 86% of the time.
7. **Why climate change concern seems to be highly predictive of voting behavior, despite climate change not being ranked as the top issue for most voters, is an important question for future research.** We outline some speculative hypotheses.

Key patterns of U.S. public opinion and polarization

There are several important and somewhat underappreciated patterns in U.S. public opinion and polarization that are worth summarizing in order to situate climate change within the broader political context. First, affective political polarization—which measures how much partisans dislike each other—is at a historic high, and dwarfs affective polarization along other dimensions of social identity.[1] For example, Americans are much more likely to dislike someone, be upset if their children were to marry someone, and discriminate against someone in an academic or professional setting, if that person was from the opposing party (Democrat vs. Republican) than if that person was from another racial or religious group.[2]

Second, the median voter leans relatively liberal on economic issues and relatively conservative on social issues (Figure 1A).[3] This pattern runs contrary to a popular myth suggesting that the median voter is socially liberal and fiscally conservative. However, the true pattern makes sense if one considers that the median U.S. adult, for example: has an annual income of roughly $50,000, is without a college degree, is suburban, and is Christian.[4] These demographic characteristics are more associated with social conservatism than with economic conservatism, and they are more associated with economic liberalism than with social liberalism. Of course, American society, as a whole, arguably leans relatively conservative on economic issues and relatively liberal on social issues, compared to the societies of many other countries.

Third, those in the middle of the political spectrum far outnumber those on the extremes, or 'wings', on both sides. For example, More in Common's *Hidden Tribes* report[5] identifies the wings as those groups on each end of the spectrum whose views separate across multiple issues from the rest of the electorate. More in Common calls the rest of the electorate the "exhausted majority", and finds that it makes up roughly two-thirds of the electorate. They also find that the right wing (made up of "traditional" and "devoted" conservatives) contains more voters (25%) than the left

[1] Iyengar, S., Sood, G., & Lelkes, Y. (2012) *Public Opinion Quarterly*, 76(3), 405-431. Iyengar, S., & Westwood, S. J. (2015). *American Journal of Political Science*, 59(3), 690-707.
[2] *Ibid.*
[3] Drutman shows this pattern in 2016, using similar measures as our Figure 1A shows in 2020; see figure 2 in: Drutman, L. (2017) Political divisions in 2016 and beyond (Voter Study Group). https://www.voterstudygroup.org/publication/political-divisions-in-2016-and-beyond. Voters leaned more liberal in 2020 than in 2016 by this measure, but this shift may have reversed since 2020, due to the public salience of inflation, crime, and illegal border crossings. For an updated and expanded analysis, see: al-Gharbi, M. (2023) On populism, labor and partisan politics. https://musaalgharbi.com/2023/09/26/on-populism-labor-and-partisan-politics/
[4] Median income is based on the 2022 median of U.S. workers ($47,960), from the U.S. Census Bureau. The median household income is $74,580. U.S. Census Bureau (2023) Income in the United States: 2022. https://www.census.gov/content/dam/Census/library/publications/2023/demo/p60-279.pdf. The education statistic cited is based on U.S. Census Bureau (2022) Educational attainment in the United States: 2021. https://www.census.gov/data/tables/2021/demo/educational-attainment/cps-detailed-tables.html. The breakdown of rural, smaller metropolitan, large suburban, and urban core residents is available in: Fry, R. (2020) Prior to COVID-19, urban core counties in the U.S. were gaining vitality on key measures (Pew Research). https://www.pewresearch.org/social-trends/2020/07/29/prior-to-covid-19-urban-core-counties-in-the-u-s-were-gaining-vitality-on-key-measures/. The percentage of U.S. adults who are Christian (63%) comes from: Pew Research Center (2022) How U.S. religious composition has changed in recent decades. https://www.pewresearch.org/religion/2022/09/13/how-u-s-religious-composition-has-changed-in-recent-decades/
[5] Hawkins, S., et al. (2018) *Hidden Tribes* (More in Common). https://hiddentribes.us/media/qfpekz4g/hidden_tribes_report.pdf

wing made up of the "progressive activists" (8%). They find that those in the wings are less inclined to prefer political compromise over fighting for their beliefs. Both *Hidden Tribes* and other studies have found voters in the wings tend to be more politically engaged, on average,[6] meaning that the wings' preferences are likely overrepresented in the major political parties' platforms. Voters in the wings—on both sides of the spectrum—are also disproportionately white, affluent, and educated (Figure 1B),[7] which may further increase the overrepresentation of their preferences in major political parties' decisions (even in cases where their preferences claim to represent the interests of other groups such as racial minorities and the poor).

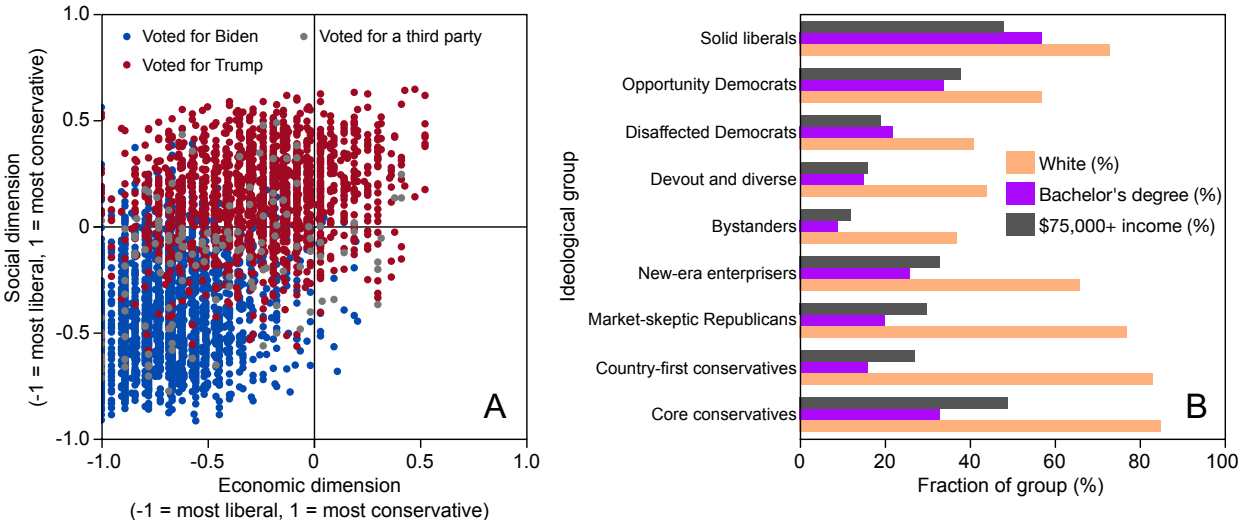


Figure 1. *(A) 2020 voters' scores on aggregate economic and social dimensions, based on their issue opinions, in the Voter Study Group sample.[8] (B) Demographics of American ideological groups, from Pew Research and the New York Times.[9]*

Fourth, there has been asymmetric polarization in government: Congressional Republicans have shifted their ideology further to the right over the past 40 years or so than Congressional Democrats have shifted their ideology to the left.[10] The opposite may be true in culture, where most mainstream cultural and sense-making institutions (i.e. media, universities, the arts) have left-leaning staff, and have shifted sharply leftward over the past decade.[11] If the right 'wing' has more people in it, that may explain why they seem to have more power in government than the left wing does. For example, the rightmost 25% of the public likely has more power in Republican primaries than the leftmost 8% has in Democratic primaries. Indeed, many progressive politicians

[6] E.g., see: Leonhardt, D. (2021) New York's lesson for Democrats. https://www.nytimes.com/2021/06/29/briefing/new-york-mayors-race-ranked-choice-democrats.html
[7] *Ibid.*
[8] Data from Voter Study Group: https://www.voterstudygroup.org/data. Methodology described by Drutman (2017) from footnote 3 above.
[9] See Leonhardt (2021), from footnote 6 above.
[10] Pew Research Center (2022) Republicans have moved further to the right than Democrats have to the left. https://www.pewresearch.org/ft_22-02-22_congresspolarization_featured_new/
[11] For discussion and review of this phenomenon, see: al-Gharbi, M. (2023) Woke-ism is winding down. *Compact Magazine*. https://compactmag.com/article/woke-ism-is-winding-down

have lost high-profile primary (or primary-like) contests recently—for example, in 2021 mayoral elections in New York City and Minneapolis, and in the 2020 Presidential election.[12] In contrast, among the ten Republican members of the House of Representatives who voted to impeach former President Trump in 2021, all but one (David Valadao) have since either lost primary contests or left politics altogether.[13] The left wing having greater cultural power than electoral power may explain, for example, why unpopular policy positions such as defunding the police and open borders have become widely discussed among progressive pundits and in intellectual institutions—so much so that they have harmed the Democrats electorally—but they have not actually been endorsed by many Democrats in Congress.[14]

Climate change opinion and polarization: Past and present

In the next section, we present statistical analyses estimating the effect of climate change opinion on voting behavior in recent presidential elections, using individual-level data on opinion, demographics, and voting. To put these results into perspective, we will first summarize some key patterns in public opinion polling on climate change that might shape one's hypothesis regarding what the effect of climate change opinion on voting might be.

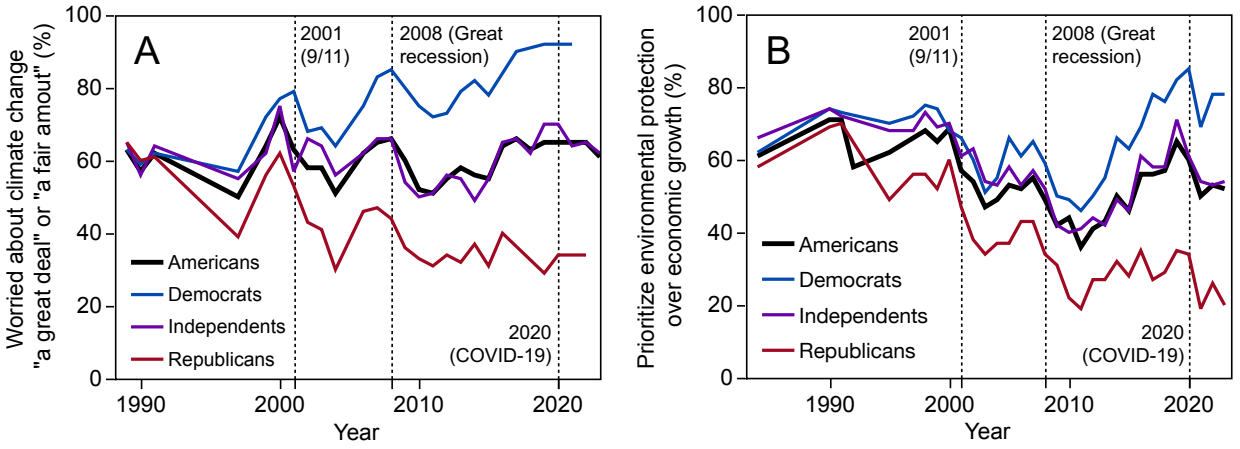


Figure 2. *(A) Trends in public concern about climate change (or global warming), and (B) willingness to prioritize environmental protection over economic growth (B), from Gallup.*[15]

[12] This refers to Eric Adams beating several progressive primary challengers including Maya Wiley in the New York City mayoral election in 2021; Jacob Frey beating progressive challengers Kate Knuth and Sheila Nezhad in the Minneapolis mayoral election 2021; and Joe Biden beating several progressive challengers including Bernie Sanders and Elizabeth Warren in the 2020 presidential primary.

[13] See: Gedeon, J. (2022) 10 House Republicans voted to impeach Trump. Cheney's loss means only 2 made it past their primaries. *Politico*. https://www.politico.com/news/2022/08/13/cheney-10-house-republicans-trump-impeachment-00050991. Note that John Katko won his 2022 primary, but lost in the general election.

[14] For example, see: Broadwater, L., & Fandos, N. (2020) Amid tears and anger, House Democrats promise 'deep dive' on election losses. *New York Times*. https://www.nytimes.com/2020/11/05/us/house-democrats-election-losses.html

[15] Data from: Gallup Analytics: https://www.gallup.com/analytics/214565/universities-colleges-using-gallup-analytics.aspx; Saad, L. (2023) A steady six in 10 say global warming's effects have begun (Gallup). https://news.gallup.com/poll/474542/steady-six-say-global-warming-effects-begun.aspx; Jones, J.M. (2023) Record party gap on environment-economic growth tradeoff (Gallup). https://news.gallup.com/poll/474218/record-party-gap-environment-economic-growth-tradeoff.aspx; Egan, P. J., & Mullin, M. (2017) *Annual Review of Political Science*, 20, 209-227.

Climate change was not always a polarizing issue. When James Hansen famously testified to Congress in 1988, warning about climate change, the issue was not polarizing at all among the public. For example, the fractions of U.S. adults worrying "a great deal" or "a fair amount" were nearly identical among Democrats, Republicans and independents in 1989 (Figure 2A). The Global Warming Prevention Act of 1989 was led by Rep. Claudine Schneider—a Republican from Rhode Island—and co-sponsored by 144 members from across the spectrum, including both Al Gore and Newt Gingrich.[16] The bill ultimately did not pass, but several aspects of it later did, including a large increase in research and development spending for renewable energy.[17]

Public polarization of climate change steadily increased over the next 25 years (Figure 2A), making climate change one of the most polarizing issues in the country by the mid-2010s.[18] Several non-mutually-exclusive explanations have been proposed for why it became polarizing. First, monied interest groups from fossil-fuel and other carbon-intensive industries influenced politics and information, for example through political contributions and think tanks, in ways designed to sow doubt and division and oppose decarbonization policies.[19] Second, the idea of government intervention in markets to address climate change clashes with libertarian worldviews that are especially common among conservatives in English-speaking countries. This may explain why, among western and post-communist countries, climate change has been more polarizing in English-speaking countries than in non-English-speaking countries.[20] Third, decarbonization policies sometimes raise the prices of energy and other staples, which is unpopular. Most Americans' willingness to pay such costs are far lower than carbon prices often used in policy.[21] Fourth, Republican voters disproportionately reside in regions with fossil-fuel-dependent economies.[22] Republicans' willingness to prioritize environmental concerns over economic concerns has steadily decreased from 1990-2010, in contrast to Democrats and independents (Figure 2B).

Climate change must also compete with other issues in the public consciousness. Concern about climate change, among voters of all political stripes, has dropped following major unrelated events, such as the September 11, 2001 terrorist attacks (9/11), the 2008 financial crisis and ensuing Great Recession, and more recently the COVID-19 pandemic starting in 2020 (Figure 2). These events can also reduce or increase support for climate policies, depending on whether the policy priorities that the events create are seen as synergistic with or antagonistic to climate change mitigation. For example, pressures on energy prices from the Russia-Ukraine war and

[16] H.R. 1078 (101st). (1989) Global Warming Prevention Act of 1989. https://www.govtrack.us/congress/bills/101/hr1078
[17] Discussed in Rich, N. (2019) When did moral clarity become radical? *New York Times.* https://www.nytimes.com/2019/04/20/opinion/alexandria-ocasio-cortez-green-new-deal.html
[18] See Egan & Mullin (2017), referenced in note 15.
[19] Oreskes, N., & Conway, E. M. (2011) *Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming* (Bloomsbury Publishing). Stokes, L. C. (2020) *Short circuiting policy: Interest groups and the battle over clean energy and climate policy in the American States* (Oxford University Press).
[20] Smith, E. K., & Mayer, A. (2019) *Climatic Change*, 152(1), 17-34.
[21] Pielke Jr. refers to this as the 'Iron Law of climate change' in: Pielke Jr, R. (2010) *The climate fix: what scientists and politicians won't tell you about global warming* (Basic Books).
[22] Egan, P. J., & Mullin, M. (2023) *PS: Political Science & Politics*, 1-6.

rising inflation, starting in 2021, coincide with declines in Americans' (especially Republicans') support for prioritizing alternative energy sources over fossil fuels.[23] Conversely, these same pressures strengthened support for nuclear energy, leading the government of California to reconsider its plan to close two Diablo Canyon reactors, originally scheduled for 2024 and 2025.[24]

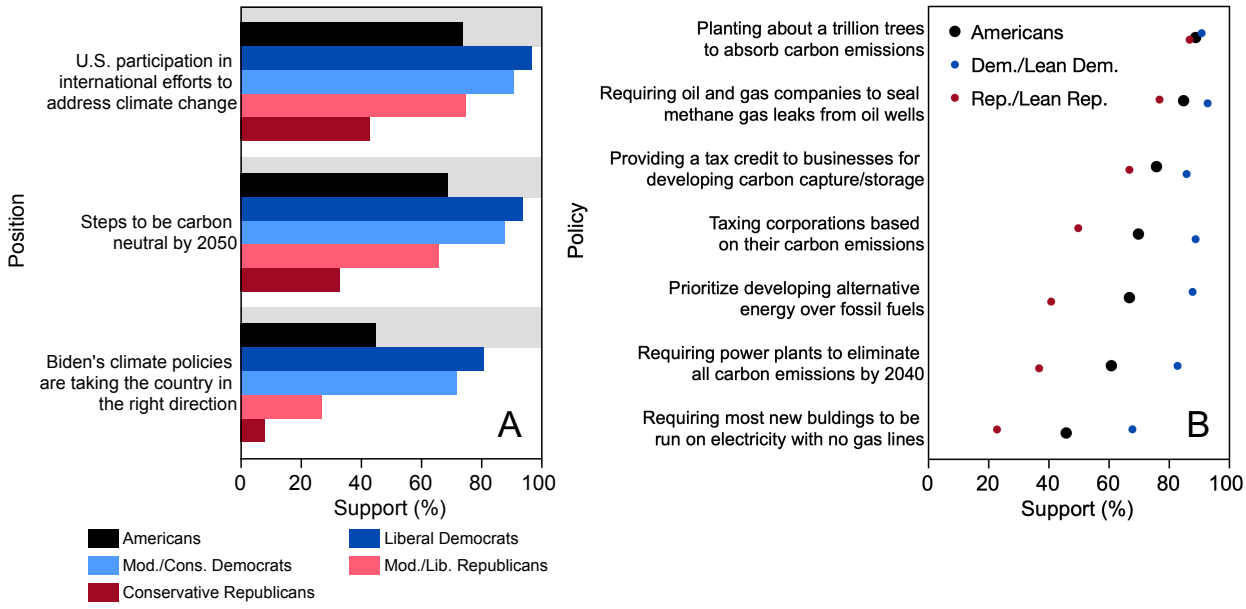


Figure 3. *Public and partisan support for (A) general positions about climate policy, and (B) several specific climate policies, from Pew Research.[25] All polls come from 2022 or 2023. The gray-shaded regions in panel A visually separate national opinion from party-level opinion.*

There are some areas of broad bipartisan consensus on climate change. Despite persistent polarization (as shown in Figure 2), some areas of consensus and common ground have been emerging over the past five-to-ten years. Large majorities of Americans now acknowledge the basic scientific fact of human-caused climate change,[26] and large majorities also support both a general desire for climate policies (Figure 3A) and several specific policies (Figure 3B). For example, recent polls have found support from over two-thirds of Americans for: participating in

[23] Tyson, A., & Spencer, A. (2022) A Majority of Americans Favor Expanding Natural Gas Production To Export to Europe (Pew Research). https://www.pewresearch.org/science/2022/05/12/a-majority-of-americans-favor-expanding-natural-gas-production-to-export-to-europe/
[24] Blood, M.R. (2022) Newsom signs bill to keep Diablo Canyon nuclear plant open. *LA Times.* https://www.latimes.com/california/story/2022-09-03/newsom-signs-bill-to-keep-diablo-canyon-nuclear-plant-open
[25] Kennedy, B., Funk, C., & Tyson, A. (2023) How Americans see Biden's climate policies (Pew Research). https://www.pewresearch.org/science/2023/06/28/2-how-americans-see-bidens-climate-policies/. Tyson, A., Funk, C., & Kennedy, B. (2022) Americans largely favor U.S. taking steps to become carbon neutral by 2050 (Pew Research). https://www.pewresearch.org/science/2022/03/01/americans-largely-favor-u-s-taking-steps-to-become-carbon-neutral-by-2050/. Tyson, A. & Spencer, A. (2022) A Majority of Americans Favor Expanding Natural Gas Production To Export to Europe (Pew Research). https://www.pewresearch.org/science/2022/05/12/a-majority-of-americans-favor-expanding-natural-gas-production-to-export-to-europe/
[26] Marlon, J. et al. (2022) Yale climate opinion maps 2021 (Yale Program on Climate Change Communication). https://climatecommunication.yale.edu/visualizations-data/ycom-us/

international efforts to address climate change; taking steps to be carbon neutral by 2050; prioritizing wind and solar energy over oil, coal and natural gas; and specific policies including net metering, tree planting and investing in carbon capture, requiring power plants to seal methane leaks, taxing corporate emissions, renewable electricity standards, and fuel efficiency standards for cars.[27]

Reasons for these areas of common ground emerging may include: the effects of climate change becoming increasingly obvious (as Figure 4A illustrates); renewable energy becoming increasingly cheap, which reduces or eliminates some costs of transitioning (Figure 4B); generational turnover (young people are more concerned about climate than older people, on average); and media coverage of the issue becoming less divided on the basic fact of global warming (Figure 4C), even as media coverage remains quite divided on climate policy.[28]

In practice, however, consensus on policy positions does not necessarily preclude partisan polarization. For example, there is little support among Republicans for the Biden administration's climate policies (Figure 3A), even though some of President Biden's policies contain similar elements to policies passed by Republican or bipartisan legislators at the state level.[29] Conversely, a 2018 study found that Democrats were about half as willing to support a carbon-tax policy if they thought it had been proposed by Republicans, compared to the exact same policy proposed by Democrats.[30] Bipartisan cooperation on climate policy therefore requires overcoming tribalism at the same time as it requires finding specific areas of policy agreement.

In addition to reduced public polarization, there has also been recent bipartisan policy, enacted at multiple levels of government. For example, there have been over 100 enacted bipartisan state-level decarbonization bills from 2015 to 2020, amounting to roughly one-third of all state-level decarbonization bills passed during that period.[31] At the federal level, the bipartisan COVID-relief package of 2021, the Infrastructure Investment and Jobs Act (a.k.a. bipartisan infrastructure law) of 2021, and the bipartisan CHIPS and Science Act of 2022 all included billions of dollars in funding for renewable energy and other low-carbon technologies.[32] In 2021, Rep. John Curtis started the Conservative Climate Caucus, which now includes 81 Republican members of the House of Representatives.[33] State-level bipartisan climate bills disproportionately have: expanded

[27] Burgess, M., & Marshall, R. (2020) What if a Presidential candidate ran on what most Americans actually wanted?. *Arc Digital* https://medium.com/arc-digital/what-if-a-presidential-candidate-ran-on-what-most-americans-actually-wanted-bd570321b428. See also: https://www.twothirdsmajorityplatform.com/
[28] Chinn, S., Hart, P. S., & Soroka, S. (2020) *Science Communication*, 42(1), 112-129.
[29] Marshall, R., & Burgess, M. G. (2022) *Climatic Change*, 171(1-2), 17. Burgess, M., & Marshall, R. (2022) A bipartisan climate playbook is emerging. *Arc Digital*. https://www.arcdigital.media/p/a-bipartisan-climate-playbook-is
[30] Ehret, P. J., Van Boven, L., & Sherman, D. K. (2018) *Social Psychological and Personality Science*, 9(3), 308-318.
[31] Marshall and Burgess (2022), referenced in note 29.
[32] 117th United States Congress. (2021) H.R.3684 - Infrastructure Investment and Jobs Act. https://www.congress.gov/bill/117th-congress/house-bill/3684/text. 117th United States Congress. (2022) H.R.5376 - Inflation Reduction Act of 2022. https://www.congress.gov/bill/117th-congress/house-bill/3684/text. 117th United States Congress. (2022) H.R.4346 - Chips and Science Act. https://www.congress.gov/bill/117th-congress/house-bill/4346.
[33] Curtis, J. (2023) Conservative climate caucus. https://curtis.house.gov/conservative-climate-caucus/

choice (e.g., incentivizing renewables instead of banning fossil energy sources), used financial incentives, and framed efforts to reduce inequality in terms of class rather than race.[34]

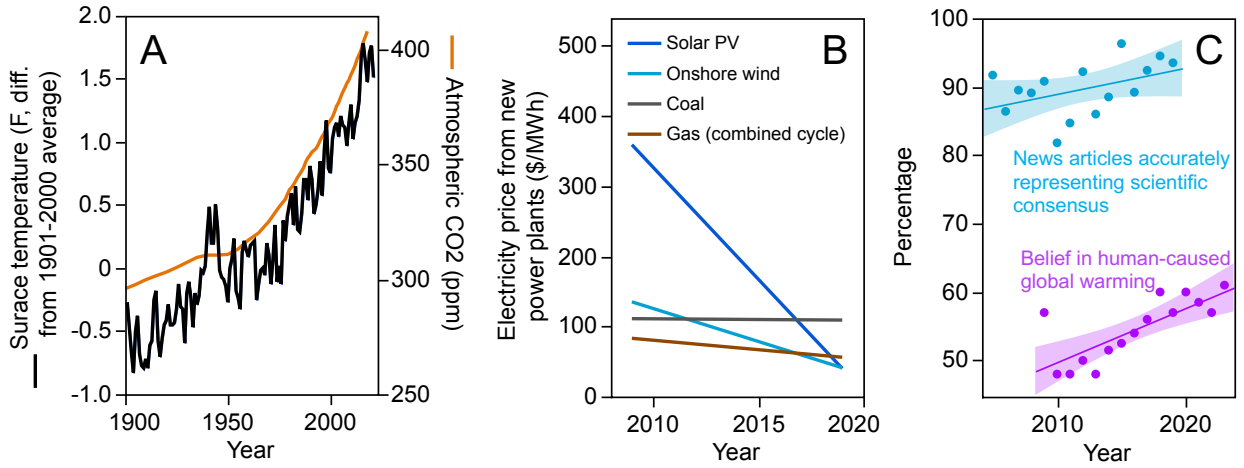


Figure 4. *(A) Trends in the Earth's surface temperature and atmospheric CO_2 concentrations, a signature of climate change;[35] (B) trends in energy prices from solar and wind, compared to coal and natural gas;[36] and (C) the fraction of Americans believing in human-caused global warming,[37] compared to the fraction of news articles accurately representing the scientific consensus on climate change.[38] Lines and shaded regions in panel C represent ordinary least squares (OLS) fits and 95% confidence intervals, respectively.*

Most voters want the government to do more to address climate change. Figure 3 above shows that large majorities (over two-thirds) of Americans support several general positions and specific policies aimed at mitigating climate change. The Yale Climate Opinion Maps project has asked U.S. adults since 2008 about whether they think their local officials, Congress, their Governor, and the President should do more to address global warming.[39] The idea that Congress should do more has been consistently popular. In 2021, 61% of Americans nationally, and majorities in nearly every state (47 out of 50, plus D.C.) and Congressional district (424 out of 436), and in most counties (2,414 out of 3,148, 77%), agreed that Congress should do more to address global warming (Figure 5A). These numbers were similar in previous surveys. The ideas that the President, Governors, and local officials should do more have also consistently been held

[34] Marshall and Burgess (2022), referenced in note 29.
[35] EPA (Environmental Protection Agency). (2022) Climate change indicators: U.S. and global temperature. https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature#ref2. NOAA (National Oceanic and Atmospheric Administration). (2022) Climate at a glance. www.ncdc.noaa.gov/cag. European Environment Agency. (2019) Trends in atmospheric concentrations of CO2 (ppm), CH4 (ppb) and N2O (ppb), between 1800 and 2017. https://www.eea.europa.eu/data-and-maps/daviz/atmospheric-concentration-of-carbon-dioxide-5
[36] Roser, M. (2020) Why did renewables become so cheap so fast? (Our World in Data). https://ourworldindata.org/cheap-renewables-growth
[37] Leiserowitz, A., et al. (2023) Americans believing in GW (2023) Climate change in the American mind: Beliefs and attitudes, Spring 2023 (Yale Program on Climate Change Communication). https://climatecommunication.yale.edu/wp-content/uploads/2023/09/climate-change-american-mind-beliefs-attitudes-spring-2023.pdf
[38] McAllister, L., Daly, M., Chandler, P., McNatt, M., Benham, A., & Boykoff, M. (2021) *Environmental Research Letters*, 16(9), 094008.
[39] Marlon et al. (2022), referenced in note 26.

by a majority of Americans as a whole, but there has been more variation across regions and time (Figure 5B illustrates this for the President).

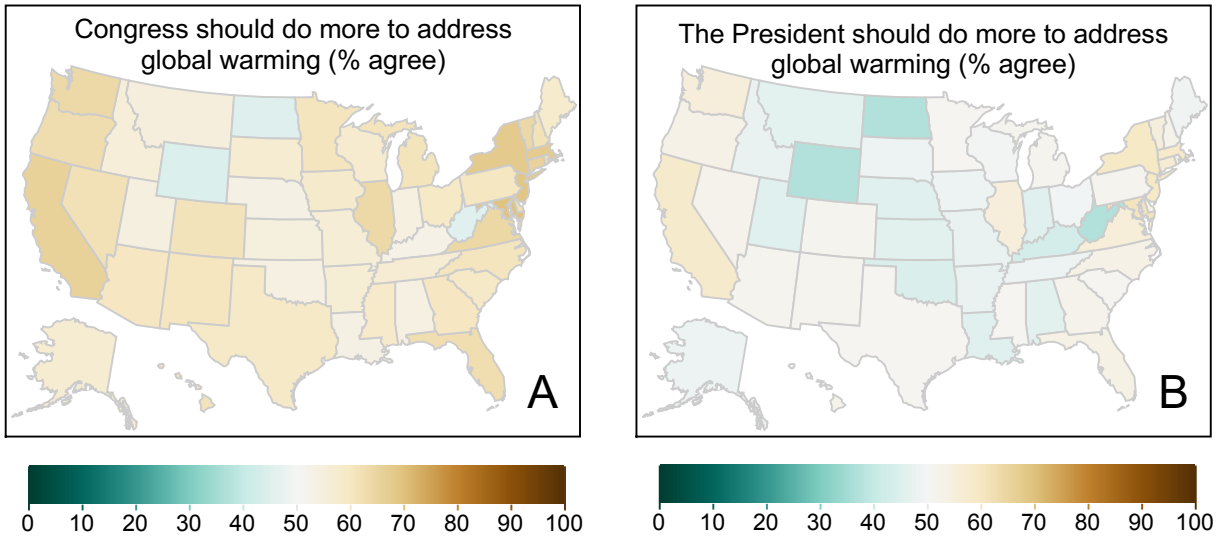


Figure 5. *The fraction of adults in each state agreeing that Congress (A) or the President (B) should do more to address global warming, in 2021. Data are from Yale Climate Opinion maps.*[40]

Among Republicans, those who are young, non-white, and moderate are especially concerned about climate change. Analyses and discussions of the partisan divide on climate change often focus on comparing Republicans and Democrats as a whole. However, there are also interesting differences within each partisan group. Figure 6 shows three important examples of this, using measures of concern about climate change, but similar patterns exist for many other measures of climate change opinion from multiple studies.

First, while levels of concern about climate change among conservative Republicans have held steady for the past 15 years, concern has increased among all of: moderate or liberal Republicans, independents, moderate or conservative Democrats, and liberal Democrats (Figure 6A). Roughly two-thirds or more within each of these groups (besides conservative Republicans) reported being "somewhat" or "very" worried about climate change in 2022.[41]

Second, younger Americans report greater concern about climate change, on average, and this age difference is especially large among Republicans. The fractions of Republicans aged 18-34 reporting being somewhat or very worried about climate change, and believing that climate

[40] Marlon et al. (2022), referenced in note 26. We note that the values shown are estimates from multilevel regression and poststratification models. See: Howe, P. D., Mildenberger, M., Marlon, J. R., & Leiserowitz, A. (2015) *Nature Climate Change*, 5(6), 596-603; and Mildenberger, M., Marlon, J. R., Howe, P. D., & Leiserowitz, A. (2017) *Climatic Change*, 145, 539-548.
[41] Leiserowitz, A. et al. Climate Change in the American Mind: National Survey Data on Public Opinion (2008–2022) (OSF, 2022) https://doi.org/10.17605/OSF.IO/JW79P. Ballew, M. T. et al. (2019) *Environ. Sci. Policy Sustain. Dev.* 61, 4–18.

change will harm future generations, were roughly 10% higher than the fractions of Republicans older than 55 expressing these sentiments, from 2018 to 2022 (Figure 6B). A majority of Republicans under the age of 35 (59%), independents (72%), and Democrats (92%) agreed that climate change will harm future generations. Nearly half of Republicans under 35 (44%) reported being "somewhat" or "very" worried about climate change, along with large majorities of independents (63%) and Democrats (91%) under 35.[42]

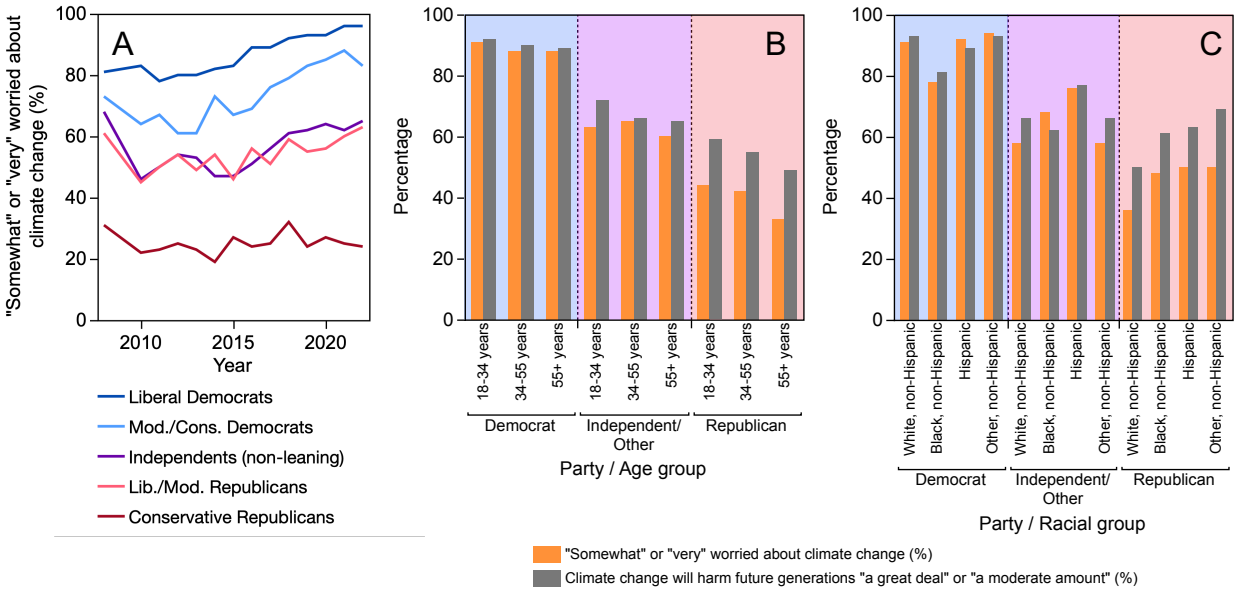


Figure 6. *Measures of concern about climate change by political party affiliation, separated out by ideology (A), age group (B), and race (C). Panels B and C aggregate responses from 2018 to 2022. Data from Climate Change in the American Mind.*[43]

Third, non-white Americans report greater concern about climate change, on average. Additionally, climate change is especially polarizing among white Americans: white Democrats report higher levels of concern than non-white Democrats, and non-white Republicans report higher levels of concern than white Republicans, on average (Figure 6C). The fractions of Hispanic and non-Hispanic black Americans reporting being "somewhat" or "very" worried about climate change are more than 10% larger than the fraction of white Americans reporting such worry, from 2018 to 2022, with white Democrats having the highest fraction (91%) worried, while white Republicans had the lowest fraction (36%). Majorities of all racial sub-groups within each party believed that climate change will harm future generations (Figure 6C).[44]

[42] *Ibid.*
[43] *Ibid.*
[44] *Ibid.*

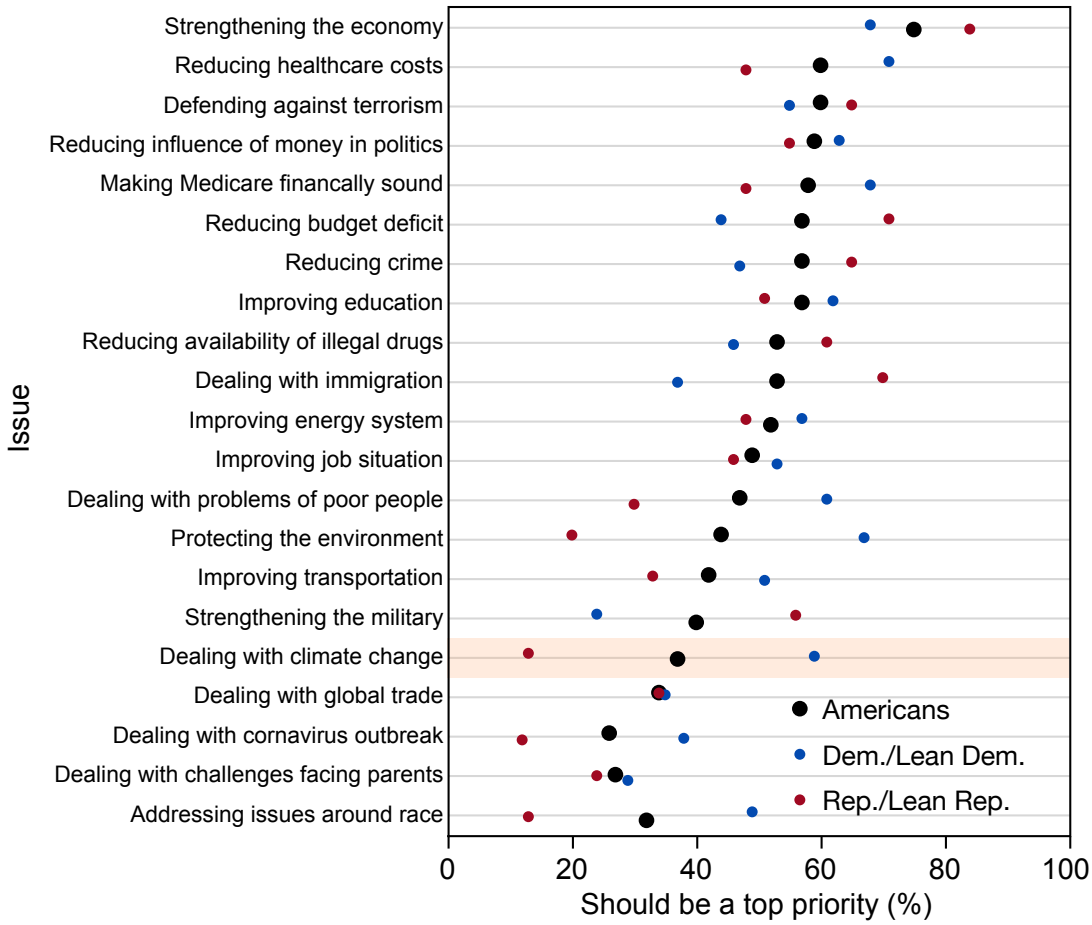


Figure 7. *Fractions of U.S. adults reporting that each of several issues should be a top priority for the President and Congress in 2023, from Pew Research.*[45]

Most Americans rate climate change as <u>an</u> important issue, but most Americans <u>do not</u> rate climate change as <u>the most</u> important issue. Figure 7 shows the results of a 2023 Pew Research survey,[46] which asked U.S. adults to state whether each of several issues should be a top priority for the President and Congress this year. While 37% of respondents stated that climate change should be a top priority, most other issues were endorsed as top priorities by higher fractions of respondents. However, climate change and the environment were the two most polarizing issues on this measure, with a larger-than 45% difference between the fractions of Democrats and Republicans who endorsed them as top priorities (59% of Democrats and those leaning Democrat vs. 13% for Republicans and those leaning Republican, for climate change). In fact, only healthcare issues were rated as a top priority by a higher fraction of Democrats and those leaning Democrat than the environment and climate change (Figure 7).

[45] Pew Research (2023) Economy remains the public's top policy priority; COVID-19 concerns decline again. https://www.pewresearch.org/politics/2023/02/06/economy-remains-the-publics-top-policy-priority-covid-19-concerns-decline-again/.
[46] *Ibid.*

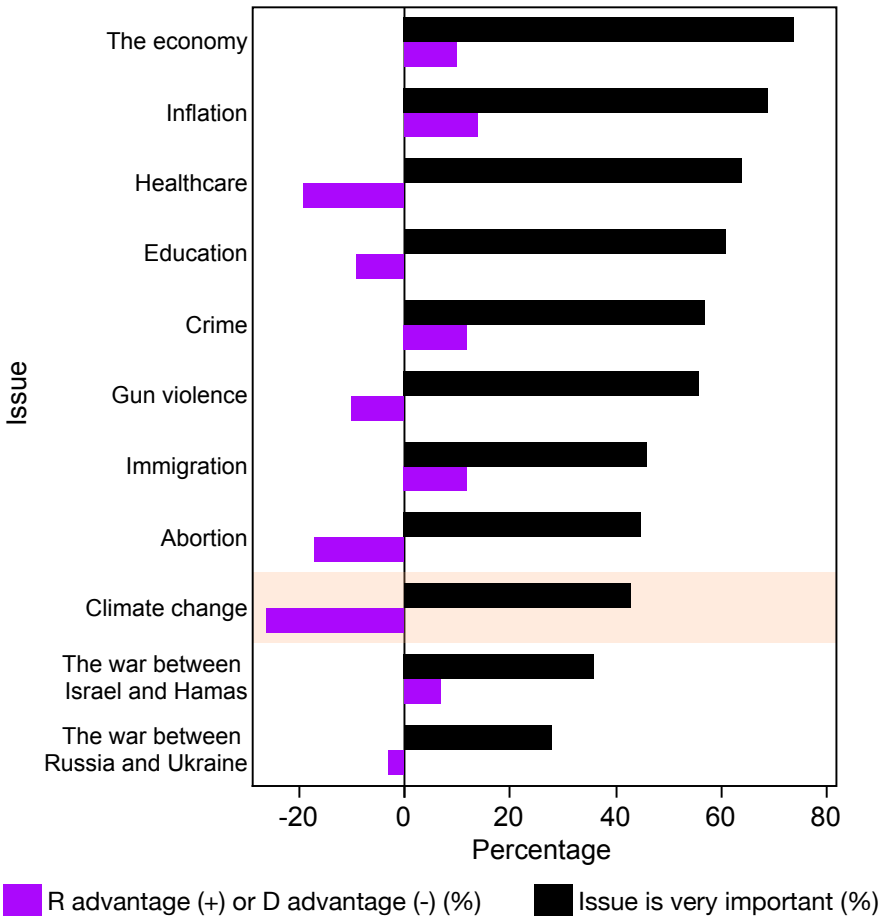


Figure 8. *Importance and parties' advantages (measured as the fraction who trust Republicans more minus the fraction who trust the Democrats more) for each of several issues, from a 2023 ABC News and Ipsos poll.*[47]

Other surveys have found similar results. For example, a 2022 Gallup poll[48] found 45% of registered voters rating climate change as "extremely important" or "very important", but each of six other issues (the economy, abortion, crime, gun policy, immigration, and relations with Russia) were rated as important by a higher share of voters. However, among Democrats, only abortion was rated as important by a larger fraction of voters than climate change was. When asked what the United States' single most important problem was in a series of monthly 2023 Gallup polls, the fractions saying the most important problem was the environment, pollution, or climate change was consistently less than 5%.[49]

[47] ABC News, & Ipsos (2023) One year from election day, Republicans perceived as better at handling the economy. https://www.ipsos.com/en-us/one-year-election-day-republicans-perceived-better-handling-economy
[48] Saad, L. (2022) Economy is top election issue; abortion and crime next (Gallup). https://news.gallup.com/poll/404243/economy-top-election-issue-abortion-crime-next.aspx
[49] Gallup. (2023) Most important problem. https://news.gallup.com/poll/1675/Most-Important-Problem.aspx

Voters trust Democrats more than Republicans on climate change, on average. A November 2023 ABC News and Ipsos poll[50] asked U.S. adults which party they trust to do a better job handling each of several issues. They also asked respondents to rate the importance of each issue. Nearly half (43%) of respondents rated climate change as "very important", and over two-thirds (70%) rated climate change as "very" or "somewhat" important. Similar to the polls discussed above, most other issues were rated as important by larger fractions of respondents (Figure 8).

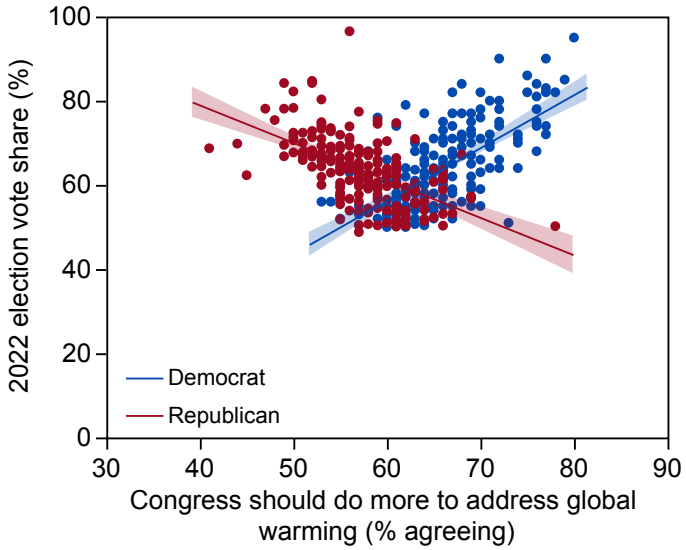


Figure 9. *Correlation between vote shares for members of Congress elected in 2022 and the fractions of voters in their districts that believe Congress should do more to address global warming, measured in 2021.*[51] *Lines represent fits of bivariate linear ordinary least squares (OLS) regression models. Shaded regions represent 95% confidence intervals on these model fits.*

Comparing the fraction of respondents who trust Republicans more on an issue to the fraction who trust Democrats more creates a measure of the net advantage or disadvantage each party has on that issue. The Democrats' net advantage on climate change (26%) was the largest for either party on any issue. Democrats also had large net advantages on healthcare (19%) and abortion (17%). Republican net advantages were largest for inflation (14%), crime (12%), and immigration (12%) (Figure 8). Again, these results are similar to the results of other polls.[52] For example, a 2023 Yale University and George Mason University poll found that 57% of registered

[50] ABC News & Ipsos (2023), referenced in note 47.
[51] Opinion data come from Marlon et al. (2022), referenced in note 26. Election outcome data come from the *New York Times* (2022) U.S. House Election Results: Republicans win (January 10). https://www.nytimes.com/interactive/2022/11/08/us/elections/results-house.html?action=click&pgtype=Article&state=default&module=election-results&context=election_recirc&region=NavBar.
[52] For example, Reuters and Ipsos conducted a May 2023 poll with very similar results: Reuters, & Ipsos. (2023) Core political data: May 10, 2023. https://www.ipsos.com/sites/default/files/ct/news/documents/2023-05/2023%20Reuters%20Ipsos%20Tracking%20-%20Core%20Political%20Presidential%20Approval%20Tracker%20May%202023.pdf

voters prefer a candidate who supports action on global warming, compared to 16% who prefer a candidate who opposes action on global warming.[53]

Real election results also bear this out: for example, in 2022, the winning vote margins for Republican members of Congress were strongly negatively correlated with the fractions of adults in their districts that believed Congress should do more to address global warming; with Democratic members having the opposite correlation; and districts with high levels of climate change concern much more commonly electing Democratic representatives (Figure 9).

Estimating the effect of climate change opinion on elections

We use data from the Voter Study Group[54] to estimate the effect of climate change opinion on voting behavior in the 2016 and 2020 presidential elections. Then, in the next section, we construct an Electoral College simulator that we use to simulate the consequences of these effects on the 2020 presidential election outcome. We focus on presidential elections since we do not have sufficient data to precisely estimate regional (state-level, district-level) effects. However, national-level results for Senate, House, and gubernatorial election outcomes would be qualitatively similar to those we find for presidential races.

The Voter Study Group has conducted regular large surveys of U.S. adults since 2010. We focus on the voters in the November 2016 (n = 7,607) and November 2020 (n = 4,513) samples–corresponding to the past two presidential elections. The Voter Study Group did not ask respondents about their climate change opinions in their 2012 sample. The Voter Study Group samples have been nearly nationally representative on several important demographic dimensions (e.g., sex, race, political affiliation), and the data contain weights that allow statistical analyses to correct for deviations of the sample demographics from a nationally representative sample. We use these weights in our analyses.

The main climate change opinion measure in the Voter Study Group data asks respondents to rate the importance of climate change as an issue on a four-point scale: “unimportant”, “not very important”, “somewhat important”, or “very important”. They ask voters to rate several other issues in this way, of which we include 22 in our statistical analysis: crime, the economy, immigration, the environment, religious liberty, terrorism, gay rights, education, family and medical leave, health, money in politics, social security, infrastructure, jobs, budget, poverty, taxes, Medicare, abortion, size of government, racial equality, and gender equality. We also include the following demographic variables in our analysis: sex, race, ethnicity (Hispanic or non-Hispanic), age[55], region (south, northeast, midwest, southwest, west)[56], marital status, children, gun ownership,

[53] Leiserowitz, A., et al. (2023) Global warming as a voting issue. Climate change in the American mind: Politics & Policy, Fall 2023 (Yale Program on Climate Change Communication). https://climatecommunication.yale.edu/publications/climate-change-in-the-american-mind-politics-policy-fall-2023/toc/4/
[54] Voter Study Group (2023) Survey data driving the insights. https://www.voterstudygroup.org/data
[55] Our probability forest analysis considers both region and the similar variable census division (“division”).
[56] Our probability forest analysis considers both age and the similar variable birth year.

employment status, religious affiliation, party affiliation, and ideology (five-point scale from very liberal to very conservative).

In our analyses of the Voter Study Group data, we are interested in answering the following four questions:

(i) How large is the effect of climate change opinion on voting behavior, and how strong is it? By 'strong', we mean how precisely can the effect be measured and how statistically confident can we be that it exists (i.e. that it is not zero)?
(ii) How does the effect of climate change opinion on voting behavior compare in size and strength to the effects of other variables on voting behavior?
(iii) How has the effect of climate change opinion on voting behavior changed over time (between 2016 and 2020)?
(iv) How has climate change opinion changed over time?

We estimate the effect of climate change opinion on voting behavior in two ways: logistic regressions and probability forests. We also examine raw correlations between climate change opinion and voting behavior, for comparison.

Logistic regressions estimate the effect of one or more explanatory variables (i.e. *x* variables) on a binary response variable (i.e., *y* variable). In our case, the explanatory variables are voters' issue opinions and demographics, and the response variable is which party they voted for in the Presidential election. Given that there are more than two voting options, we divide voters into those who voted for Democrats, those who voted for Republicans, and those who voted for a third party, and we run simultaneous models comparing each pair of these categories. We could also construct a binary variable by either comparing Democrat votes to non-Democrat votes, Republican votes to non-Republican votes, or Democrat votes to Republican votes and excluding voters who voted for third parties from the sample. We find that all of these approaches produce nearly identical results, and so we focus on the approach comparing the three categories (Democrat vote, Republican vote, or third-party vote).

Logistic regression—often called 'logit'—models assume a specific relationship between the explanatory variables and the probability of the response variable taking on a particular value. Our logistic regression analyses make the standard assumption of a linear relationship between the explanatory variables and the logarithm of the odds ratio of the two response-variable outcomes. We construct dummy variables for categorical explanatory variables such as race and gender. The models can treat the issue opinion variables as either categorical or ordinal; we find either approach produces qualitatively similar results. Equation (1) below provides an example of a logistic regression equation.

$$(1)\ \ln\left(\frac{p[Y=R]}{p[Y=D]}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n.$$

Here, 'ln' refers to the natural logarithm (i.e., logarithm with base *e*); $p[Y = R]$ and $p[Y = D]$ represent the probabilities of voting for the Republican and Democratic candidates, respectively (where *Y* denotes whom one voted for); the X_1, X_2, etc., represent the *x* variables; and the βs represent the estimated coefficients.

Probability forests are a machine-learning approach to estimating the probability of a categorical response variable taking a particular outcome, as a function of a set of explanatory variables. Probability forests sequentially divide the sample based on the explanatory variables to try to improve their predictions of the response variable. These sequential divisions are referred to as splits and generate the 'branches' of a particular tree. We perform this 2,000 times over bootstrapped samples, which is where the term "forest" comes from. In particular, we rely on 'honest' probability forests, which determine the splits of each tree using one faction of the data and a different fraction to generate the predictions, reducing bias.[57] We use the *grf* ("generalized random forests") R package[58] to conduct our probability forest analyses.

Probability forests have two main advantages over logistic regression models. First, they do not require assuming a specific relationship, such as a linear one, between explanatory and response variables. Second, they do not require assuming a binary response variable, which means we can simultaneously estimate the effects of our explanatory variables on participants' probabilities of voting for Democrats, Republicans, and third parties. Furthermore, probability forests are local estimators and can be used to estimate heterogeneous effects and provide more sophisticated counterfactual predictions.

Imputing missing data

A statistical analysis can only include participants with complete information for all variables. With the large number of variables in our analysis, missing data reduces the sample size substantially–to 1,669 participants from 4,513 in 2020, for example. Furthermore, missing data may be correlated with the variables of interest. To address these concerns, we perform our statistical analyses on a dataset in which we impute missing data. For some variables, this imputation is straightforward. For example, someone's race and birth year do not change throughout their lifetime, so if a participant with this information missing in a particular survey has provided it in a previous survey, we can use that information to update the current survey record. For other variables, this process is more complicated. The foundation of the procedure to impute the remaining variables is based on the *missForest* R package by Stekhoven and Buehlmann[59]. This procedure is a multiple imputation chain where imputation is performed several times until a convergence criterion is minimized or the maximum number of imputations is performed. We adapted the *missForest* R package to run honest random forests to reduce bias and improve the speed of the algorithm. See Stekhoven and Buehlmann (note 59) for a complete discussion on the *missForest* algorithm.

[57] Athey, S., Tibshirani, J., & Wager, S. (2019) *The Annals of Statistics* 47(2), 1148-1178.
[58] Tibshirani, J., et al. (2023) Package 'grf'. https://grf-labs.github.io/grf/index.html
[59] Stekhoven, D. and Buehlmann, P. (2012) *Bioinformatics*, 28(1):112–118.

Raw correlations

Figure 10A shows the raw correlation between the importance voters assign to climate change as an issue and their voting choices in the 2020 election, weighted to make the sample nationally representative. Figure 10C shows the same thing for the 2016 election. Figures 10B, D, and F show these correlations among 2020 independents, Republicans, and Democrats, respectively. Correlations do not imply causation, of course, but examining them nonetheless offers a starting point for exploring the relationship between climate change opinion and voting behavior.

The correlations are very strong in both election years, and they are slightly stronger in 2020 than in 2016 (Figure 10A,C). In 2020, Joe Biden had a 75-point advantage among all voters rating climate change as "very important" and a 72-point advantage among independents with this climate opinion (Figure 10A,B). Donald Trump had a similar advantage among voters who rated climate change as "not very important" and a slightly larger advantage among voters who rated climate change as "unimportant". More than a quarter of Republican respondents rating climate change as "very important" voted for Joe Biden (Figure 10D), and nearly half of Democratic respondents rating climate change as "unimportant" voted for Donald Trump (Figure 10F). This correlation between climate change opinion and voting behavior—overall and among independents—is similarly strong or stronger as correlations between voting behavior and all other variables, including variables such as ideology (i.e., how liberal or conservative participants rate themselves) (Figure 10A vs. 10E). These variables are, of course, also correlated with each other. For example, liberal independents more commonly rate climate change as very important than conservative independents. However, as we show below, we can construct models that control for all other variables, and climate change issue importance still has a significant partial correlation with voting behavior, especially in the 2020 election.

In addition to being correlated with voting for the Democrats, the fraction of voters who rate climate change as a "somewhat important" or "very important" issue has also been increasing over time. Figure 11 shows the trends in the importance of climate change across the 2016, 2017, 2019, and 2020 Voter Study Group samples. The fraction of voters rating climate change as "very important" increased from 38% to 46% (in the weighted sample) from 2016 to 2020 (Figure 11A), while the fraction rating climate change as "somewhat important" or "very important" increased from 63% to 67% (Figure 11B).

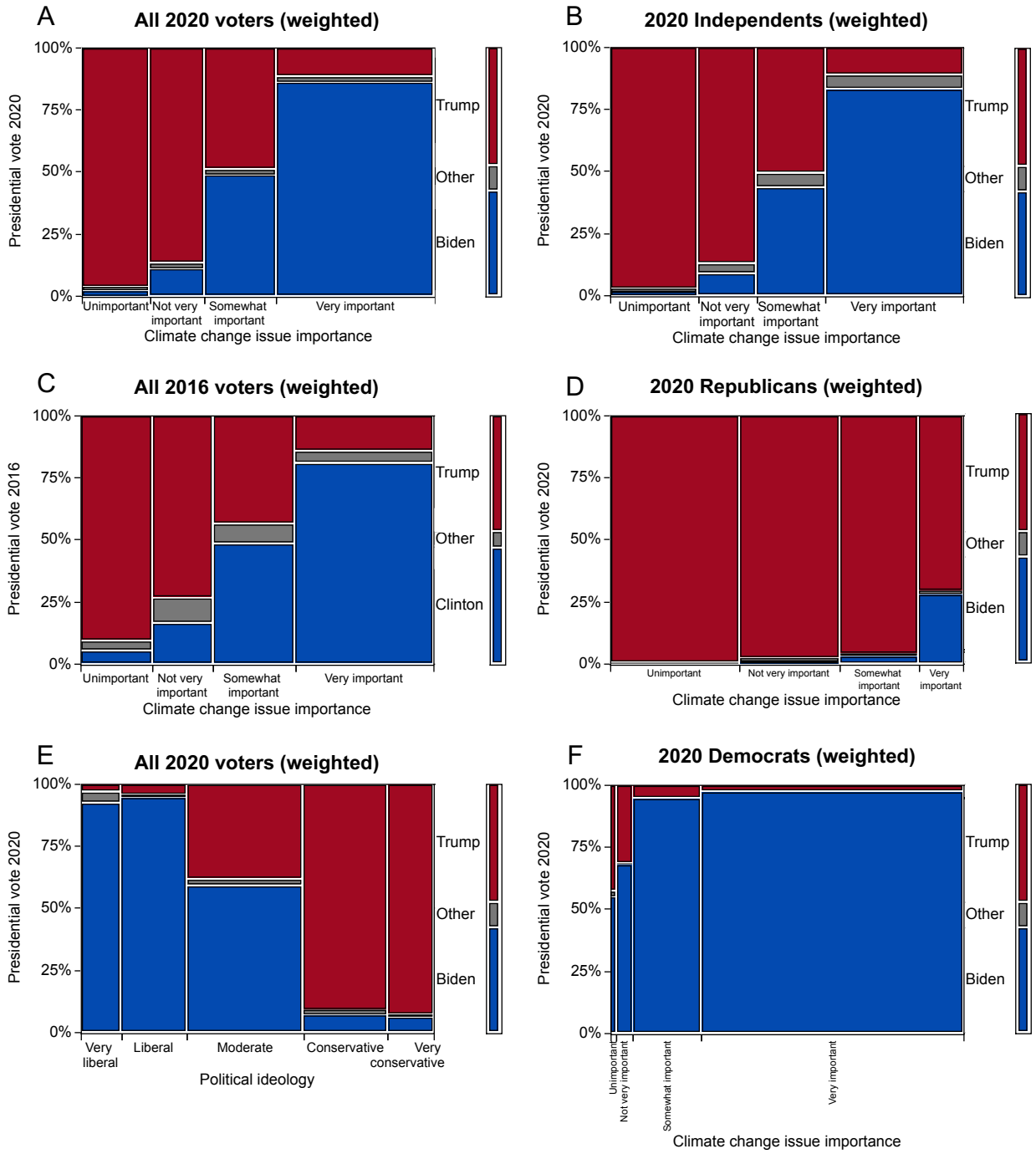


Figure 10. *Raw correlations between climate change issue importance and voting in the 2020 (panels A, B, D, F) and 2016 (C) presidential elections, and the correlation between political ideology and voting in the 2020 presidential election, for comparison. All correlations are weighted using the Voter Study Group general population weights, to correct for unrepresentativeness in the sample. Sample sizes (unweighted) are: for 2020: n = 4,513, including 1,851 Democrats, 1,170 Republicans, and 1,326 independents; and for 2016: n = 7,607. R^2(U) = 0.39 (A), 0.40 (B), 0.26 (C), 0.24 (D), 0.42 (E), 0.16 (F). Widths of the bars represent the relative sizes of each subset of the sample, weighted to be nationally representative.*

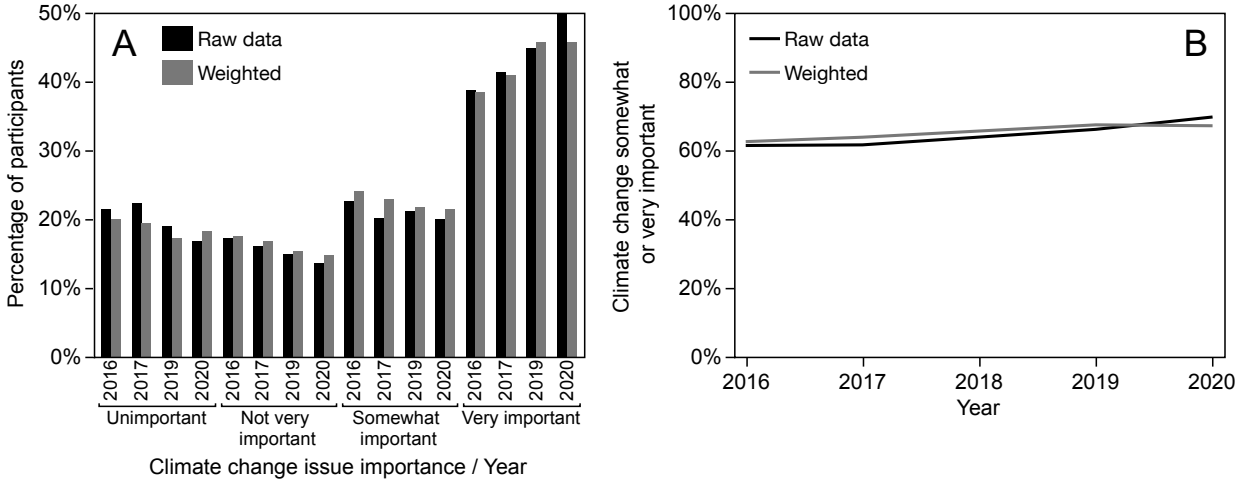


Figure 11. *Trends in climate change issue importance, across the 2016, 2017, 2019 (January) and 2020 (November) Voter Study Group surveys. Both raw trends, and trends weighted using the general population weights, are shown.*

In sum, the belief that climate change is important is a majority (~two-thirds) opinion (Figures 10 and 11); this opinion is becoming more widespread over time (Figure 11); and this opinion predicts voters preferring Democratic candidates (Figures 9 and 10). These patterns together would seem to suggest that there is a political cost of climate change opinion to the Republicans, a cost which is increasing over time. We use our logistic regression and probability forest models to estimate how much climate change opinion may have cost Republicans in the popular vote of the 2020 presidential election. We then use our Electoral College simulator to project the consequences of this popular vote cost to Republicans in the 2020 election outcome.

Regression models

When we regress presidential votes on political affiliation, ideology, demographics, and issue opinions, voters' ratings of climate change's issue importance have a consistent and statistically significant effect. The more important voters think climate change is, the more likely they are to vote for the Democratic candidate (Table 1). The estimated effect of climate change importance is larger in magnitude and statistical significance (i.e., predictive power) in 2020 compared to 2016 (Table 1). The magnitude of the climate change effect is similar in models that use the unweighted sample. The results shown in Table 1 use the sample weights, to make the analysis more nationally representative.

Table 1. *Summary of main logistic regression models, focusing on the estimated effect of climate change importance on the log odds of voting for a Democratic vs. a Republican presidential candidate. Full models include all variables listed. Parsimonious models select variables using forward stepwise regression, minimizing Bayes' information criterion (BIC). All models weigh the samples according to the general population weights provided by the Voter Study Group. R^2 values shown are McFadden's pseudo R^2(U).*

Variable	Full Model				Parsimonious model			
	2016	**2020**	**2016**	**2020**	**2016**	**2020**	**2016**	**2020**
Climate change "not very important" vs. "unimportant"	0.51 (0.31)*	0.83 (0.47)*			0.39 (0.23)*	0.66 (0.34)*		
Climate change "somewhat important" vs. "not very important"	0.67 (0.19)***	1.36 (0.27)***			0.66 (0.16)***	1.29 (0.23)***		
Climate change "very important" vs. "somewhat important"	0.62 (0.17)***	1.28 (0.23)***			0.60 (0.15)***	1.60 (0.17)***		
Climate change important vs. not important			0.93 (0.17)***	1.87 (0.25)***			0.93 (0.13)***	1.88 (0.20)***
Fixed effects	Party affiliation, Region, Ethnicity, Gender, Race, Religious affiliation, Marital status, Children, Gun ownership, Employment status, Household labor				Party affiliation, Ethnicity (2016), Race, Gun ownership (2016)			
Ordinal variables	Political ideology, Education, Crime importance, Economy importance, Immigration importance, Environment importance, Religious liberty importance, Terrorism importance, Gay rights importance, Family leave importance, Healthcare importance, Money in politics importance, Social security importance, Infrastructure importance, Jobs importance, Budget importance, Poverty importance, Taxes importance, Medicare Importance, Abortion importance, Government size importance, Education importance, Racial equality importance, Gender equality importance				Political ideology, Education (2016), Crime importance (2020), Immigration importance, Environment importance (2016), Religious liberty importance, Terrorism importance, Gay rights importance, Budget importance (2016), Poverty importance, Taxes importance (2016), Government size importance, Education importance (2016), Racial equality importance, Gender equality importance			
Continuous variables	Age, Income				Age			
	n = 7,607 R^2 = 0.63	n = 4,513 R^2 = 0.71	n = 7,607 R^2 = 0.63	n = 4,513 R^2 = 0.70	n = 7,607 R^2 = 0.59	n = 4,513 R^2 = 0.67	n = 7,607 R^2 = 0.59	n = 4,513 R^2 = 0.66

*p < 0.1, **p < 0.05, ***p < 0.01

The importance of climate change is also one of the strongest predictors of voting choice, especially in 2020. We can see this pattern in three different measures. One measure is the raw correlation, shown in Figure 10. The second measure is log worth. In a regression model, log worth compares the importance of the different explanatory variables. It is a transformation of the *p*-value, which measures how likely the partial correlation between the explanatory variable (e.g., climate change importance) and response variable (voting choice) would be to occur simply by chance, if there were not a genuine relationship between the variables. A smaller *p*-value indicates a correlation that is less likely to occur by chance and is therefore more important. A smaller *p*-value translates into a larger log worth. In 2020, climate change importance was the third-most important effect, by this log-worth measure, after only party identification and ideology (Figure 12B). In 2016, it was the seventh-most important effect (Figure 12A).

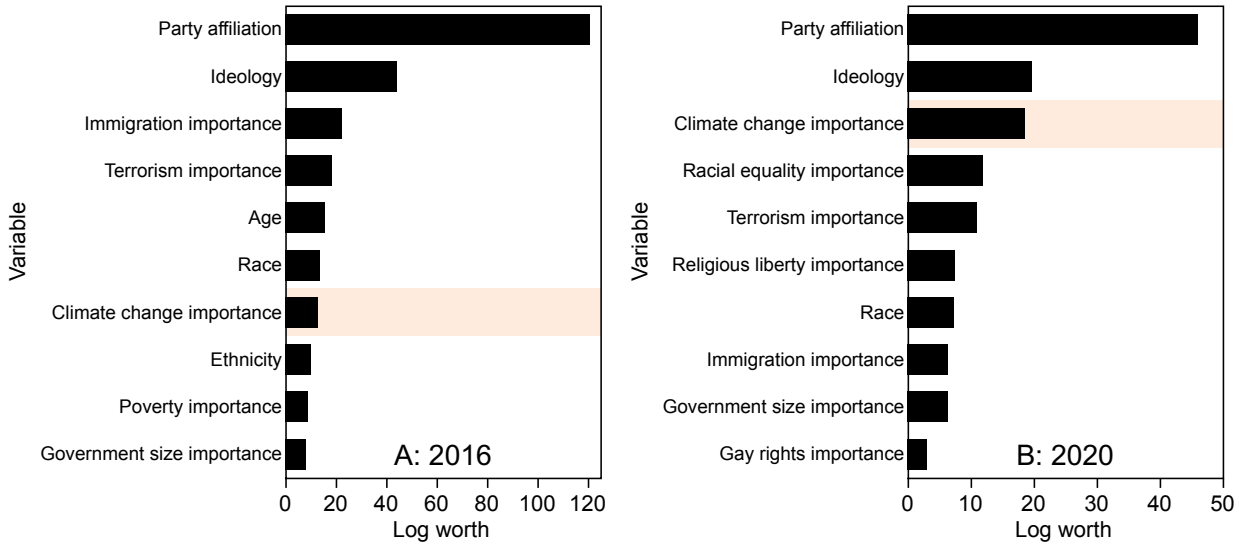


Figure 12. *The top ten effects in the (A) 2016 and (B) 2020 logistic regression models, as measured by log worth, which measures how much explanatory power a variable adds to the model. Both models use the demographic weights, to be nationally representative.*

The third measure of importance is the order in which a variable is selected in a stepwise regression. A stepwise regression starts with a response variable (voting choice) and a list of explanatory variables. It selects explanatory variables one at a time according to which provides the most additional explanatory power (we measure this using Bayes' information criterion, BIC). Climate change importance is selected third (after ideology and party affiliation) when we run the stepwise regression on the 2016 data, and climate change importance is selected first in 2020.

Probability forest models

Our probability forests also find climate change importance to be one of the strongest predictors of both 2016 and 2020 presidential vote choices. Similar to the regression (logit) models, the estimated effect of climate change importance was stronger in 2020 than in 2016. Figures 13 and 14 summarize these results.

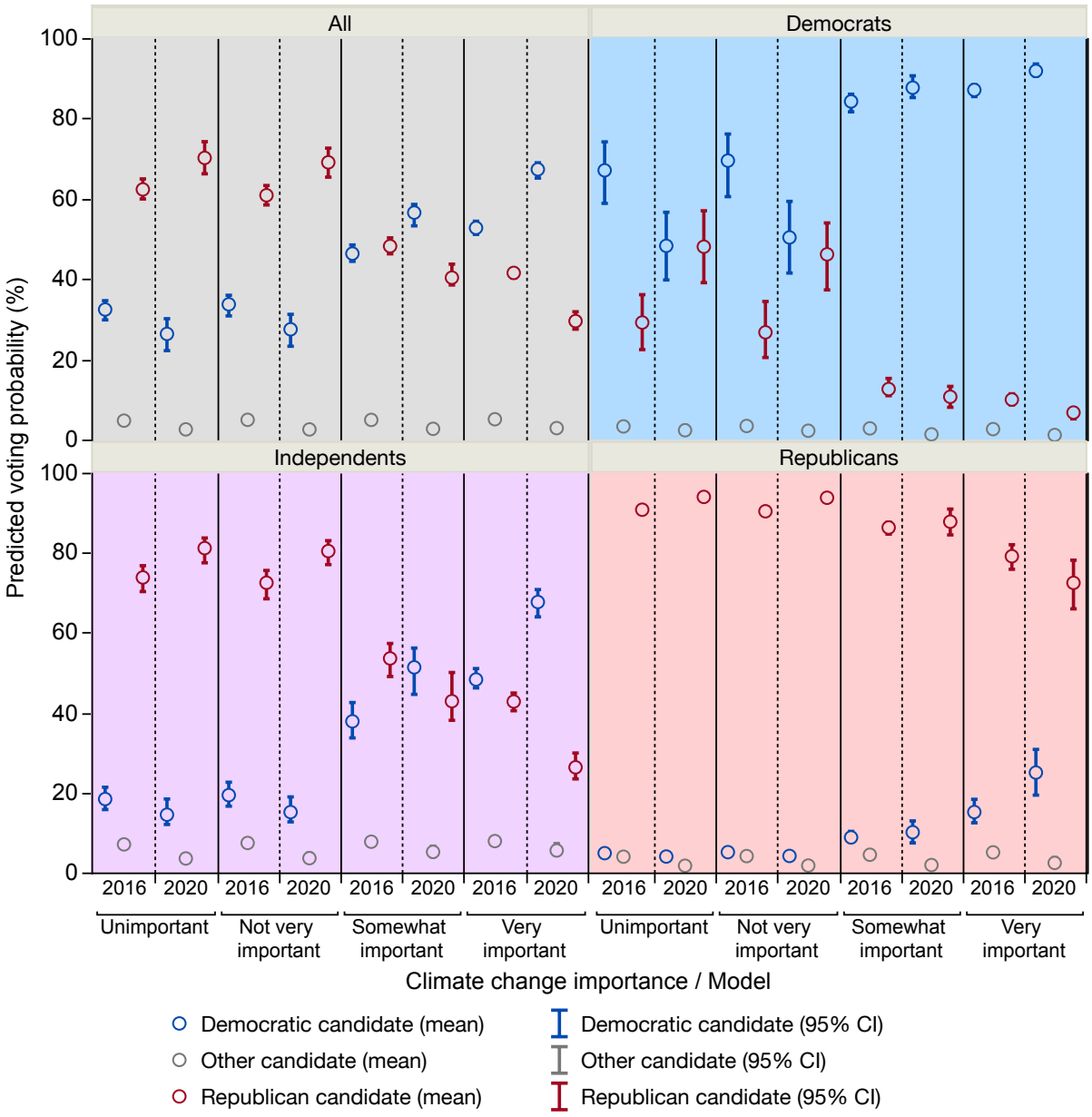


Figure 13. *Probability forest results, showing the predicted average probabilities (dots, with bars showing 95% confidence intervals) of voting for Republicans, Democrats, and third parties (other), if all voters had their climate change issue importance set to the value shown. The probability forest uses the Voter Study Group general population weights, to correct for unrepresentativeness in the sample.*

For each voter in each year, the probability forest estimates probabilities of voting for each candidate (Democrat, Republican, or other), based on the voter's demographics and issue opinions. We can then manipulate this prediction by asking what the voting probabilities would change to if every voter rated climate change as "unimportant", "not very important", "somewhat important", or "very important", while holding all of their other opinions and demographics equal. Figure 13 shows these predicted probabilities, averaged across voters, with bootstrapped 95%

confidence intervals, as a measure of uncertainty. The figure shows these results for all voters, as well as for Democratic voters, Republican voters, and independent voters separately.

As we found in the raw correlations (Figure 10) and in the logistic regression analyses (Table 1), increasing climate change importance—especially from "unimportant" or "not very important" to "somewhat important" or "very important"—shifts voters' preference substantially towards Democratic candidates. If all voters rated climate change as "unimportant" or "not very important", the probability forest estimates a mean probability for voting Republican of roughly 65%, with a slightly smaller mean preference for the Democrats if all voters rated climate change as "somewhat important" or "very important" (Figure 13). Recall that the fraction of voters who rate climate change as "somewhat important" or "very important" is roughly two-thirds of the electorate (Figure 11). These preferences therefore represent an advantage for the Democrats. Indeed, even Republicans who rated climate change as "very important" would be expected to vote for Democratic candidates in non-trivial numbers (~25%) (Figures 10 and 13).

Similar to the regression analysis, we find climate change importance to be one of the top 10 most important variables in the 2016 probability forest analysis and the single most important variable in 2020. Variable importance in this context is a simple measure of how many times a particular variable was chosen by the random forest algorithm to possess the best split of the data that minimizes the prediction error. One of the tuning parameters of a random forest is how many variables from the full set of all potential variables are tested to find a separation of the data that minimizes the objective function. Of this subset of variables, the algorithm searches among all possible splits to find the variable-split combination that minimizes the split function (Gini impurity measure in the case of probability forests).

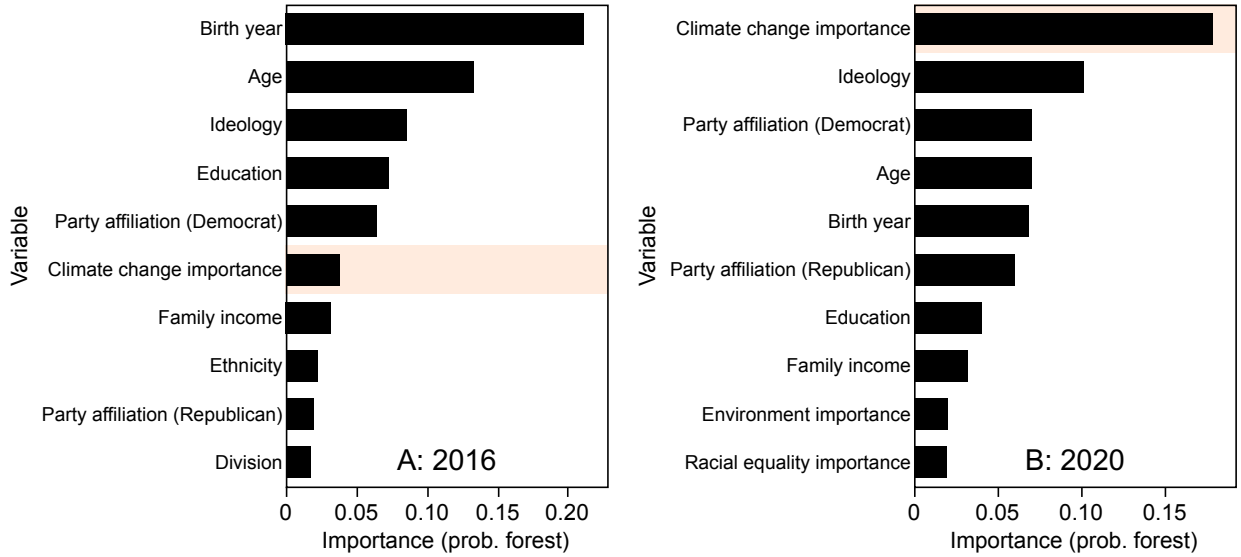


Figure 14. *Variable importance in the probability forest analysis in 2016 (A) and 2020 (B).*

Election scenario simulations

In the sections above, we have provided multiple lines of evidence suggesting that: (i) U.S. voters who are concerned about climate change outnumber those who are not concerned by roughly a two-to-one ratio; and (ii) voters who are concerned about climate change were much more likely to vote for Democratic candidates than Republican candidates in the 2016 and 2020 presidential elections, all else being equal. Next, we turn to the question of: how large of an impact did these effects have on the 2020 election? We focus on the 2020 election because imagining a world without a climate change effect (or one with a smaller effect) would benefit the Republicans, who already won in 2016. Therefore, climate change opinion could not have been pivotal in 2016 (because it benefitted the Democrats and the Republicans won anyway), but it might have been pivotal for the Democrats in 2020.

We use a two-step approach to answer this question. First, we use our regression and probability forest models to ask how the popular votes in 2020 might have changed if climate change opinion had been different. We focus on two scenarios here: (a) a scenario where we imagine climate change opinion in 2016 staying constant to 2020 (whereas in reality concern about climate change increased between 2016 and 2020); and (b) a scenario where climate change opinion was not predictive at all of voter preferences. We explore scenario (a) in the probability forest model and scenario (b) in the logistic regression model. It would be conceptually impossible to explore scenario (a) in the logistic regression model or scenario (b) in the probability forest model, as we explain below.

Second, we build a model that simulates the Electoral College. This model allows us to translate changes in the popular vote to changes in the outcome of the elections. Our Electoral College model is probabilistic: it runs a series of simulations, each capturing one of the different ways polling variation and a change in the popular vote can affect state-level results. Next, the model calculates the Electoral College outcome in each simulation. Finally, it reports the fraction of simulations in which the Republicans (or Democrats) won the election.

We stress that these are exploratory exercises. It is impossible to precisely identify what effect changing climate opinion would have had on voting outcomes, all else being equal, using observational data. Fundamentally, we are using our statistical models to ask what would have happened in situations that have never existed, which the data cannot directly tell us. We can estimate partial effects of climate change opinion on voting (logit) or we can measure how climate change opinion predicts voting (probability forest), in context with other observed opinions and demographics, but we cannot ask the data directly what would have happened in a different context. It might be possible to conduct contrived survey experiments, in which voters are asked if they would change their vote if candidates changed their policy positions on climate change and nothing else changed. However, we are unaware of any such experiment having been conducted. This would be a worthwhile follow-up study.

How climate change opinion might have changed the 2020 presidential popular vote

The logistic regressions estimate linear models that predict the log odds ratio of two voting choices (e.g., Democrat or Republican) as a function of voter demographics and opinions. From these estimated equations [having the form of equation (1) above], we can calculate the probabilities for each voter of voting for each candidate. The mean (average) of these probabilities for a candidate equals the observed voting percentage for that candidate, among voters in the sample. However, we can then change the estimated equations to remove the effect of climate change importance and recalculate the mean voting probability for each candidate. The difference between this recalculated voting probability and the original voting percentage (in the weighted sample) becomes our estimate of what effect removing the importance of climate change would have had on the popular vote.

This approach has two important challenges. First, logit models estimate the effects of ordinal variables (i.e. variables where we know the order of values but not the absolute distance between them, like climate change importance) or categorical variables in comparison to a reference category. For example, rating climate change as "unimportant" might be the reference category and the model would then estimate the effect of a voter rating climate change as each of the other three importance levels, compared to if they rated it as "unimportant". If we set all of these estimated effects to zero, we would be effectively assuming that all voters thought climate change was unimportant—which is a non-neutral rating that favors Republicans—rather than assuming that voters were neutral on the climate issue (which is what we would like to do). Conversely, if we assumed that rating climate change as "very important" was the reference category, then zeroing the estimated effects of other climate change importance ratings would provide a large advantage to the Democrats.

To address this challenge, we perform two types of analyses. First, we re-run our full model in Table 1 in JMP Pro 16,[60] with the binary climate change importance variable programmed as categorical (instead of ordinal), and we save the probability formulas. These formulas assign estimated coefficients to each binary level of climate change importance, and the coefficients are invariant to which importance category is left out in the main output table, and thus they account for the portion of the intercept term that comes from the left-out category. We then set these coefficients to zero, and we calculate the difference in voting probabilities (using the sample weights) for Democrats and Republicans compared to what was observed. Second, we construct a continuous version of the climate change importance variable (1 = "unimportant", 2 = "not very important", 3 = "somewhat important", 4 = "very important"); we insert this variable into our full model from Table 1 in place of the ordinal climate change importance variable; we estimate the probability formula; and then we change it such that the estimated climate change importance coefficient is multiplied for each voter by the weighted sample mean of climate change importance across all voters, instead of multiplying it by their observed individual climate change importance rating.

[60] JMP Statistical Discovery LLC (2021) JMP Pro 16.

The second challenge arises from the correlations between climate change importance and other variables (e.g., ideology), and the possibility that we are missing important unobserved variables in our dataset. These factors make it difficult to interpret the effects that we estimate—of climate change importance on voting—as necessarily causal. However, zeroing an estimated effect as a counterfactual implies a causal interpretation, and we should therefore interpret our estimates cautiously.

In the probability forest, we are also calculating the probability of each individual voting for each candidate, as a function of the voter's demographics and opinions, but we are making this calculation non-parametrically (meaning without an equation). This means that we cannot simply zero the climate change effect and recalculate probabilities as we did in the logit model. Instead, we use the probability forest to predict voters' climate change opinions in 2016 from their demographic characteristics and other opinions, and we apply that prediction to 2020 voters' demographics and opinions to generate a dataset in which we imagine that voters had a similar distribution of climate change opinion in 2020 as they did in 2016, with all other 2020 demographics and opinions remaining as they were in 2020. We use the estimated probability forest in this dataset to project the voting probabilities for each candidate in 2020, and we compare the means from this exercise to the actual voting percentages in 2020 (again using the sample weights). The difference between these represents our estimate of how much voting probabilities would have changed in 2020 if the observed shifts in climate change opinion from 2016 to 2020 (towards more concern about climate change) had not occurred. This approach has the advantage over the logit-based approach that it does not require assuming that the probability forest is estimating causal effects (probability forests are predictive, not causal). Its disadvantage over the logit-based approach is that it is asking what would happen if we turned off part of the climate change effect on voting (the part caused by shifts in opinion from 2016 to 2020), rather than what happened if we turned off all of the climate change effect. Therefore, we would expect the probability forest approach to project a smaller gain for the 2020 Republicans in the 2016 climate change opinion scenario than we would expect to project in the logit-based approach that imagines a world with no climate change opinion at all. Indeed, this is what we find.

The projected shift towards the Republicans in the 2020 popular vote margin (i.e., the Republican vote shift minus Democrat vote shift) ranges from 3% in the probability forest model (simulating 2016 climate change opinion in 2020, and everything else equal to what it was in 2020) to 6.3% in the logit model with the binary categorical climate change importance variable included, and its estimated coefficients zeroed in the probability formula (Figure 15). The shift in the popular vote margin was 3.4% in the model with a continuous climate change importance effect turned off (Figure 15).

For comparison, among voters in the Voter Study Group sample who voted in both the 2016 and 2020 elections (n = 2,843), roughly 10% (283) changed their vote, and 2.6% (73) changed their votes between the Republicans and Democrats (the others changed between other and either Republican or Democrat). It is worth remembering that a certain percentage of voters swinging from one party to the other changes the vote margin by twice as much. For example, if the

Republicans gained 1.5% of voters and the Democrats lost the same 1.5%, the Republican margin would increase by 3%. However, it is not necessarily surprising that the actual fraction of vote switchers is smaller than the changes some of our scenarios imagine, since our scenarios (e.g. a party preference on climate change instantly vanishing) are extreme compared to what actually happens over the course of a political cycle.

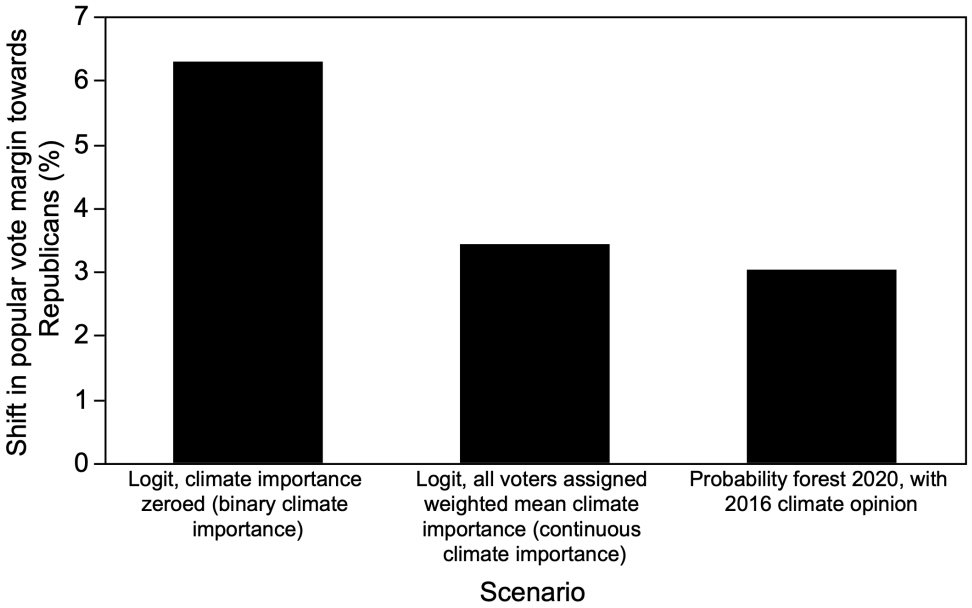


Figure 15. *Simulated changes in the 2020 presidential popular vote margins in hypothetical scenarios. Each scenario negates the effect of climate change issue importance, or some aspect of it, on voting behavior, as estimated by our statistical models.*

How changing the popular vote might have changed the 2020 election outcome

Our Electoral College simulator asks how the likelihood of each candidate winning the 2020 presidential election might have changed with hypothetical changes to the popular vote. The model tracks electoral votes in the 21 most competitive states, plus two "super states", which aggregate the least competitive Republican-leaning and Democrat-leaning states (Table 2). Aggregating safe states allows us to simulate uncertainty in how the national popular vote is distributed through independent draws in each competitive state, where the super states can absorb the non-independence. This procedure is based on Volkening et al. (2020).[61] We then obtain 2020 popular vote results in each state and super state from the *New York Times*,[62] and we obtain polling data from the preceding 11 months from *Five Thirty Eight*,[63] and clean these data using MATLAB code publicly available from Volkening et al.[64] We measure the standard deviations in the popular vote margin (Republican support minus Democrat support) in each state and super state from these polling data. Our base-case model (with no hypothetical vote shift

[61] Volkening, A., Linder, D. F., Porter, M. A., & Rempala, G. A. (2020) Forecasting elections using compartmental models of infection. *SIAM Review*, 62(4), 837-865.
[62] Election results came from the *New York Times* (2020) election results by state; for example: https://www.nytimes.com/interactive/2020/11/03/us/elections/results-wisconsin.html
[63] Five Thirty Eight (2020) Latest polls. https://projects.fivethirtyeight.com/polls/president-general/2020/
[64] Volkening et al. (2020), referenced in note 61.

towards the Republicans) draws a popular vote in each state and super state, from a normal distribution with these standard deviations, and a mean equal to the observed vote margin from the actual 2020 results. It calculates who won the Electoral college, and repeats this procedure 1,000 times. The Democratic candidate (Joe Biden) wins 85% of the time in this base-case scenario. Figure 16A shows the distribution of Electoral college votes each party receives across these 1,000 runs.

Table 2. *Super states, battleground states, and 2020 corresponding Electoral College votes. Following Volkening et al.,[65] we aggregate electoral votes within each of Maine and Nebraska in our simulations.*

State or super state	Abbreviation	Voting-age population	Electoral votes
Safe Red	Red	35,458,261	92
Safe Blue	Blue	90,050,694	186
Alaska	AK	553,622	3
Arizona	AZ	5,528,989	11
Colorado	CO	4,430,329	9
Florida	FL	17,070,244	29
Georgia	GA	8,013,724	16
Iowa	IA	2,425,378	6
Kansas	KS	2,205,544	6
Michigan	MI	7,831,247	16
Minnesota	MN	4,308,564	10
Mississippi	MS	2,280,389	6
Missouri	MO	4,749,622	10
Nevada	NV	2,345,395	6
New Hampshire	NH	1,098,288	4
New Mexico	NM	1,613,275	5
North Carolina	NC	8,082,975	15
Ohio	OH	9,096,117	18
Pennsylvania	PA	10,158,149	20
South Carolina	SC	3,978,182	9
Texas	TX	21,303,746	38
Virginia	VA	6,647,893	13
Wisconsin	WI	4,537,465	10

Next, we simulate the electoral consequences of hypothetical shifts in the 2020 popular vote margin, towards Republicans, in 0.1% increments (Figure 16B). First, we repeat the base-case simulation with the same Republican vote margin shift added to each state and super state (black in Figure 16B). Second, we allow the vote margin shift in each state to deviate randomly from the national shift (following the variance in the state polling data) (gray in Figure 16B).

[65] Volkening et al. (2020), referenced in note 61.

In both cases, a hypothetical shift in vote margin (Republican vote share minus Democrat vote share) of 1.5% or more, favoring the Republicans, allows Donald Trump (the Republican candidate) to win the 2020 election in more than 50% of runs. A shift of 2% allows former President Trump to win roughly two-thirds of the time; a shift of 3% allows him to win over 80% of the time; and a shift of 5% allows him to win over 95% of the time. Our analyses in Figure 15 imply that climate change opinion might have cost former President Trump 3% or more in the popular vote margin in 2020. Therefore, our results suggest that climate change opinion likely would have been pivotal to President Biden winning the 2020 election, holding everything else equal.

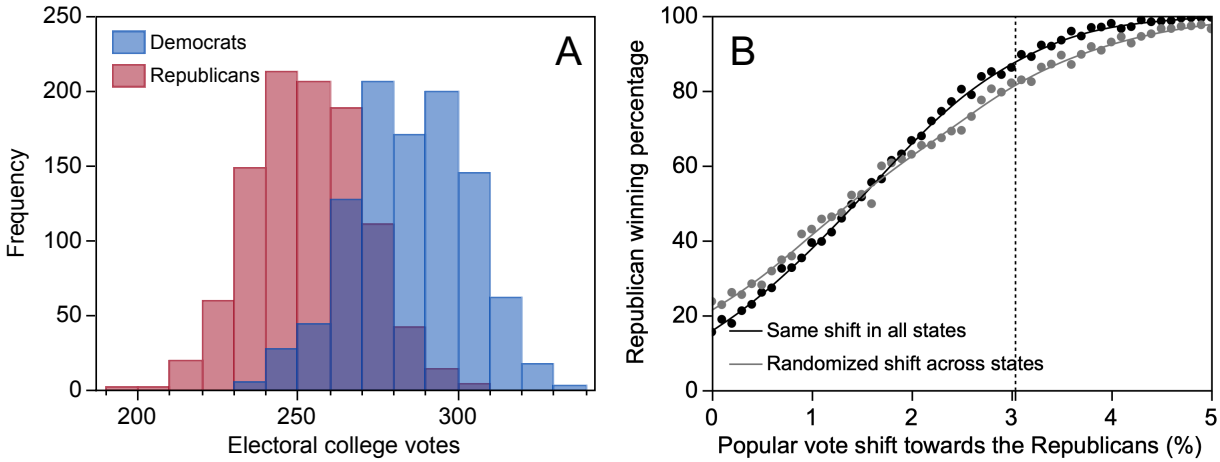


Figure 16. *Panel A shows the distribution of 2020 Electoral College votes across 1,000 runs in the base-case scenario with no popular vote shift. Panel B shows the relationship between a hypothetical popular vote shift in favor of the Republicans and the Republican winning percentage in 2020 from our election simulator. Each dot represents 1,000 runs. Black dots represent scenarios where all states receive the same shift in the popular vote, and gray dots represent scenarios where the shift is applied with random, normally distributed noise, based on state polling. Figure 15 shows our estimates of the possible sizes of such popular vote shifts; and smallest of these estimates is denoted with a dashed line in panel B here.*

Discussion and conclusion

This report has outlined evidence for the following three factual (as opposed to subjective or normative) claims. First, voters who are concerned about climate change, and who want the government to take action on climate change, outnumber voters who are not concerned about climate change, by roughly a two-to-one ratio. We show this across multiple different polls and studies in Figures 2, 3, 5, 6, 10, and 11. Second, voters who are concerned about climate change strongly prefer the Democrats to the Republicans, all else being equal. We show this, across multiple data sources, in Figures 8, 9, and 10. These two claims together imply that public opinion about climate change represents an electoral advantage for the Democrats, all else being equal. Third, using the Voter Study Group data, we attempt to quantify the size of this advantage, and we estimate that it could have cost the Republicans 3% or more in the popular vote margin in the 2020 presidential election. Our Electoral College simulator suggests that this effect was large enough to change the outcome of the 2020 election in favor of President Joe Biden.

We are highly confident in our findings that climate-conscious voters are a majority of voters, and that climate-conscious voters prefer the Democrats. These patterns are plainly evident across multiple independent lines of evidence, and together these two patterns imply that climate change opinion provides the Democrats with an electoral advantage. We are more cautious and circumspect about our estimates of the specific magnitude of this electoral advantage (3% or more in the 2020 presidential election popular vote margin). As we outline in the relevant section of the report above, our methods for simulating counterfactual scenarios in which climate change opinion is different, but everything else is the same, are unavoidably speculative. In an ideal world, we would run an experiment asking voters about hypothetical situations in which candidates' climate change stances are different, but everything else is the same. We hope to conduct such an experiment in the future. Nevertheless, given that climate change opinion was one of the strongest correlates of 2020 voting choices, and given that it was consistently one of the strongest effects in our statistical models of 2020 voting choices, it is reasonable to hypothesize that climate change opinion gave the Democrats a substantial advantage in the 2020 presidential election, even if we cannot say for sure how large this advantage was.

Our results raise an interesting question: if climate change opinion has such a strong effect on voting outcomes, why do voters seldom rate climate change as their most important issue (as we show in Figures 7 and 8)? Our results cannot answer this question, and it is an important question for future research. One hypothesis is that climate change may serve as a bellwether issue for some voters. For example, voters with a broad range of opinions on which climate policies are best, and on which other issues are most important, may be concerned about voting for a candidate who does not acknowledge the issue of climate change at all. If such voters see the evidence for climate change as overwhelming and they see climate change as a real and serious issue, they may question the broader judgment of a candidate who does not acknowledge climate change as an issue, and they may assign such a candidate lower trust on other issues. Another related hypothesis is that climate change is important to voters because it indirectly affects other issues that the voters consider more important. For example, climate change has the potential to affect the economy, housing, national security, and possibly even crime, to name a few.[66]

Although our results suggest that climate change opinion currently provides an electoral advantage to the Democrats, this does not mean that any specific climate change policy supported by Democratic leaders is necessarily popular, nor that climate change will always provide the Democrats an electoral advantage in the future. There are certainly many fiercely contested debates about, for example, whether, where, and when to phase out specific fossil fuel sources such as natural gas and coal; how much public money to spend on climate change and how to pay for it; whether and how to address other issues like inequality within climate change policies; and how the U.S. should engage in international climate change governance. Public opinion varies widely on these questions. Nonetheless, our results suggest that there is a broad public appetite for some sort of government action to address climate change in the United States.

[66] See the U.S. Fifth National Climate Assessment: https://nca2023.globalchange.gov/; and Carleton, T. A., & Hsiang, S. M. (2016) *Science*, 353(6304), aad9837.