CO2 emissions and constitutional provisions that protect the environment

Authors: Adrian Treves[1]*, Kaari M. Hostler[1], Natalia I. Vonarburg[1]

Affiliations:

[1]University of Wisconsin, Madison, USA.

*Corresponding author. Email: atreves@wisc.edu

Competing interests: The authors declare no competing interest, but readers can judge for themselves by accessing a funding history for the Carnivore Coexistence Lab at http://faculty.nelson.wisc.edu/treves/archive_BAS/funding.pdf, and a complete CV for the senior author at http://faculty.nelson.wisc.edu/treves/archive_BAS/Treves_vita_latest.pdf, accessed 7 April 2024.

Adrian Treves focuses on ecology, scientific integrity, public trust principles, and agro-ecosystems where crops and domestic animals overlap carnivore habitat. He and his lab http://faculty.nelson.wisc.edu/treves/ have authored >160 scientific articles, best known for our gold-standard experiments on non-lethal prevention of predation on domestic animals, estimates of illegal wolf-killing and cryptic poaching, and our work on risk maps to predict human-carnivore conflict sites. Founder and Director of the Carnivore Coexistence Lab, and Professor of Environmental Studies at the University of Wisconsin–Madison, he earned his PhD at Harvard University in 1997.

Kaari Hostler is a graduate from the Nelson Institute of Environmental Studies at the University of Wisconsin Madison. She received a B.A. in Geography and Environmental Studies. She is a researcher with the Carnivore Coexistence Lab focusing on the influence of policy on environmental action and impacts.

Natalia Vonarburg is the Data Operations and Quality Coordinator at the Jewish Family and Children's Service of Greater Philadelphia. She has a Bachelor's Degree in Philosophy with a multidisciplinary focus in Computer Science and Environmental Studies. While pursuing her degree, she had the opportunity to work with the Carnivore Coexistence Lab at the University of Wisconsin's Nelson Institute for Environmental Studies. Natalia's current research interests at JFCS focus on improving access to mental health services, evaluating the effectiveness of cash assistance for poverty alleviation, and utilizing mobile distribution to engage diverse populations.

Acknowledgments: We thank E. Lau for comments on an early draft.

Data and materials availability: For quotations from each article of every national constitution, the full database is presented at https://faculty.nelson.wisc.edu/treves/data_archives/Constitutions_Treves_etal.csv

Funding: University of Wisconsin Foundation AAB7963

CO2 emissions and constitutional provisions that protect the environment

Abstract

Legal instruments might limit or reduce emissions and slow climate changes. Constitutional provisions that protect rights to a healthy environment or rights to an unimpaired biosphere might provide their constituents concerned with climate change with a legal tool to compel reductions in greenhouse gas emissions. Therefore, the strength of national constitutional provisions that should protect the biosphere might correlate over time with national greenhouse gas emissions. We ranked constitutional provisions that vary in strength of protections for the biosphere to test three predictions about emissions and changes over time. We reject two predictions about carbon dioxide (CO2) emission rates and changes in rates before and after ratification of changes in constitutions. We test and reject an ancillary prediction that many nations had environmental protections thrust upon them by global organizations or multilateral treaties. We report a post hoc finding that variances in CO2 emissions per Gross Domestic Product (GDP) over time were greater among nations whose constitutions included no provisions protecting the biosphere compared to nations whose constitutions included a governmental responsibility for protection of the biosphere or the strongest category of rights to protection of the biosphere. Nations that changed constitutional provisions or ratified their first constitution during the study period tended to undergo more change in CO2 emissions after the change and tended to show lower variance after the change than did nations that did not change their constitutions (e.g., US). We report a strong shift towards more biosphere-protective constitutions since 1970.

Keywords

climate change; enforcement; government duties; greenhouse gas emissions; rights

Climate change poses an existential threat to humanity and the biosphere as we know it (Ripple et al. 2017; Levy and Patz 2015; J.A. Patz et al. 2007; J. Patz and Hatch 2014). Some publics have turned to judicial remedies to address the slow pace of nations in addressing climate change; see (M. C. Wood 2022) for a review. Some of these efforts hinge on constitutional provisions that protect the biosphere (all living organisms including humans and the substrates on which we depend) or on express rights to a healthy environment. Constitutions should be the supreme laws that establish sovereign power and its delegation for a given jurisdiction—at least in democracies respecting the rule of law. There is of course variation in the texts of constitutions, variability in how governments and publics obey them, and the extent to which different branches of governments enforce them. Nevertheless, many national constitutions expressly codify rights to a clean, healthy environment or delegate authority as governmental responsibilities to protect the environment in one way or another (David R. Boyd 2011; David R. Boyd 2013; J. R. May 2005; James R. May and Daly 2009). Explicit constitutional protections for the environment allow us as environmental to evaluate the potential for correlations between laws and emissions of pollutants, such as carbon dioxide (CO2).

Standardized measures of national CO2 emissions over long time series permit global, multinational and global comparisons of emissions with political variables, e.g.,

(Chesler et al. 2023). While the latter compared emissions between types of regime (democratic versus autocratic and qualities of democracies), we consider national constitutional protections for the biosphere and how both have changed over time. Use of such data is congruent with the 'longue duree' framework sometimes attributed to the English school (Falkner 2024) to understand historical international normative change and different institutional levels at which such changes may be detected. More generally, attention in the field of global environmental politics has often focused on transnational governance initiatives such as United Nations Frameworks as a way to understand how governing takes place (Fransen and Bulkeley 2024). We consider their 'governmentality approach' here when we use constitutional language as our lens to understand how governing CO2 emissions might take place. We echo (Baker 2023) in calling for more attention to multifactorial understanding of the influence of governance on climate action. In 2018, we explicitly engaged with ideas in (Fransen and Bulkeley 2024) in our prior work leading to the current one; in 2018 we linked constitutional protections to CO2 emissions and biodiversity endangerment (Author). Our work here and previously was explicitly not only concerned with human health but also nonhuman health and wellbeing (Bliss, Visseren-Hamakers, and Liefferink 2023). We elaborate this point in the Methods. Here again we indirectly link climate change to biodiversity by cataloguing constitutional provisions that mention health of the biosphere itself (not health of humans affected by the environment) to search for evidence that nations reduced annual CO2 emissions when their constitutions codified stronger protections for the biosphere. To do this, we follow (Chesler et al. 2023) by looking for correlations between national emissions in relation to national governance variables. We discuss their dismissal of democracy (v autocracy) as influential in reducing greenhouse gas (GHG) emissions. We urge caution so as not to throw out the baby with the bathwater when it comes to correlating governance to CO2 emissions.

In 2018, we hypothesized that constitutional provisions might be correlated to biodiversity threats and protections and CO2 emissions (Author). In the absence of an experimental method to test a causal link between constitutional text and greenhouse gas emissions, here we turn to within-nation and between-nation correlations of national, annual time series of CO2 emission in relation to category of strength of constitutional protections and change in constitutional provisions for the biosphere. We test the hypothesis that nations differing in constitutional provisions that protect components of a nation's biosphere will also differ in CO2 emission rates per GDP (Prediction 1) and as constitutions change so too will the slopes of CO2 emission rates over time (Prediction 2). In 2018, we also noted the potential concern that a global wave of national constitutional ratifications in the 1970s promoted by the United Nations and Stockholm Declaration of 1972 might have imposed environmental protections on nations whose constituents did not share such values (Author)(James R. May and Daly 2009). Here we test prediction 3 by asking whether nations amended their environmental provisions to offer less protection for the biosphere, which would support the idea that environmental protection is an external imposition.

The rationale for our simple quantitative analysis of a phenomenon that is certainly multifactorial and hence more complex, is that one should leave no stone unturned when searching for effective, global interventions to an existential threat such as climate change. Given the stark awareness of harms to human health, particular

jeopardy for marginalized populations and future generations of all life, and century-long damage to the biosphere as we know it, climate change is a cross-sectoral hazard for many planetary components that are expressly protected by national constitutions. In short, most national constitutions are obligated to protect human health, natural resources, and access to clean, air, water, soil, etc. even if the constitution does not speak specifically to the climate as most do not (Table 1). Therefore, it seems reasonable to start at the beginning with quantitative analyses of the potential for national constitutions to prevent national rates of emission that contribute to climate change. This topic certainly needs qualitative work to understand the interplay of governance, emissions, and economic development, etc. Nevertheless, our motivation for empirical, quantitative analysis was to leave no stone unturned.

Table 1 here

Methods

Overview

We adopted a similar quasi-experimental approach as (Chesler et al. 2023) in that we used before-and-after comparisons of the slopes of national, annual CO2 emissions per GDP (within-nation slopes of emissions). Our comparisons grouped nations with like constitutional provisions but did not mingle different nations' emissions. We discuss the limitations of oru correlational approaches.

To operationalize our three predictions, we focused on national constitutions and CO2 emissions standardized by Gross Domestic Product (GDP). We focused on CO2 emissions because of their important role in the ongoing global climate crisis and the many years of awareness of the problem that human-induced CO2 emissions play in that crisis. Also, CO2 emissions are measured globally for each nation in a standard fashion.

We are aware that absolute CO2 emissions have continued to increase over time as economic development, industrialization, globalization, travel, etc. expanded uses of fossil fuels globally. We are also aware that CO2 emissions correlate strongly to industrialization and other measures of wealth, therefore we correct emissions for population and economic strength as CO2/GDP, permitting us to compare each nation to itself before and after any constitutional amendments. Standardizing each nation's annual emissions by its annual GDP provides a more equitable basis for between-nation comparisons—assuming that GDP reflects fossil fuel combustion and population size in some fashion independent of constitutional provisions.

Necessarily, our reductionist approach does not represent multifactorial causality, which we presume is at play. Yet, we are not searching for a single cause but rather the relative contribution of constitutions as a way to infer if constitutional texts (and ostensible enforcement) might influence CO2 emission data. We discuss the limitations of our reductionist approach and the shortcomings of human governance systems and the obvious rebuttal that laws on paper have no effect if not enforced.

Finding and categorizing Constitutions

We follow Boyd (David R. Boyd 2011; David R. Boyd 2013) in categorizing constitutional provisions in four ways: substantive or procedural right representing the highest level of protection "right" (rank 3), "governmental responsibility" (rank 2), "Individual responsibility," (rank 1,) and "No provision" as the weakest provision (rank zero). Some constitutions articulated provisions for one or more categories, whereupon

we assigned it the strongest category. If we found that our conclusion about the strongest environmental provision f or a nation disagreed with Boyd (David R. Boyd 2011; David R. Boyd 2013), we then investigated it further and noted if we came to a different conclusion than those sources with an explanation (n=16 nations, Table 1). Although our ranking differed from Boyd (David R. Boyd 2013) for 16 constitutions, the differences often reflect his focus on "healthy environment" provisions versus our more general focus on diverse components of the environment, identified by our keyword searches and referred to hereafter as the biosphere. We build on a prior inventory of 130 nations in 2005 (J. R. May 2005), by adding 71 additional national constitutions to the database (Table 1).

Although not all jurisdictions in Table 1 are recognized as independent nations (e.g., Puerto Rico) and some are contested (e.g., Taiwan), we refer to all entries in Table 1 as nations for convenience. We collected constitutions from the websites of individual nations' governments as well as from the following sources (Constitute 2024; University of Calfornia Berkeley 2024; Georgetown University 2024). We began by reading the most recent version of each constitution, and then went back to look at past versions if further research was needed. Additionally, we used The Constitute Project to estimate the historical timelines of constitution amendments and enactments.

We created a list of 23 keywords based on reading 202 national constitutions and their environmental provisions: environment*, natur*, wild*, biodivers*, biolog*, climat*, air, water, soil, animal, fish, plant, forest*, conserv*, preserv*, sustain*, safe*, health*, ecol*, pollut*, flora, fauna, and atmospher*. We searched English, full-text copies of the constitutions using all of these keywords. We read the context of the chapters and articles containing the keywords to decide whether to label it as an environmental provision. Because our criteria differed somewhat from prior work (David R. Boyd 2011; David R. Boyd 2013)(Author), results differ somewhat. In sum, our keyword search went beyond the healthy environment construction of the latter studies to address myriad components of the biosphere.

We excluded instances where keywords were referred to in a non-environmental context, e.g., naturalized citizen or 'airspace' referring to sovereign control of territory. Likewise, we did not include a provision if it mentioned sustaining or conserving resources unless components of nature were mentioned explicitly in that provision. Some components or keywords such as fisheries and forestry, were only mentioned in the context of human uses of the environment, which we excluded entirely. Excluding human uses of the environment ruled out constructions such as Papua New Guinea's provisions for Bouganville, "The functions and powers available to the Bougainville Government– …fisheries (other than highly migratory or straddling stocks)." We often had to scrutinize provisions that protected or conserved abiotic features of the environment (e.g., water) because we wanted to evaluate, by close reading, if those were protected only for human use or health. Similarly, uses of keywords per se did not necessarily constitute protection, as in Kenya's constitution: "Parliament shall enact legislation to protect, conserve and provide access to all public land;" (Article 68); we did not consider this provision to be protective of the biosphere necessarily as public lands might not contain biodiversity yet be conserved and provide access. Naturally, our interpretations of any single provision would not necessarily overlap a putative court's interpretations of an entire constitution, but in most cases national constitutions had

more than one provision that made clear whose right or responsibility was paramount. Therefore, our categorization of provisions into four categories entails redundancies that lessen the chances that we introduced subjective error into categories fo national constitutional protections for the biosphere. We excluded provisions for human health alone because these did not seem to guarantee protections for the nonhuman environment. For example, we did not classify provisions akin to 'clean water for human wellbeing' or 'protection from pollution' as protective of the biosphere, unless the provision expressly protected nonhuman life or a component of the natural environment for future generations, posterity, its own health, or intrinsic value. While we acknowledge some provisions that protect human health from pollution might incidentally protect the health of the biosphere, we point out that many constructions such as "clean water" may lead to water purification infrastructure rather than cleaning the nations' naturally occurring waters. Therefore, given our current context, of atmospheric CO2 emissions, we focused on direct protections for the biosphere not hopeful protections that might act indirectly. The authors came to consensus on interpretation. In so doing, we agree with a prominent critique of anthropocentric global environmental governance that is speciesism and even within animal ethics prioritizes domestic animals and native species, e.g., (Bliss, Visseren-Hamakers, and Liefferink 2023). We follow Bliss and colleagues (Bliss, Visseren-Hamakers, and Liefferink 2023) in avoiding the pitfall of defining constitutional provisions that protect human health as if these protect ecological health writ large.

We copied the relevant text along with a page number and/or section reference for further analysis (see data accessibility statement).

CO2 Emissions

We defined our study period by the availability of CO2 emissions data (1970-2019). This influenced the years over which a constitution might have an effect. Some nations never amended their constitutions throughout the study period. For such nations, we chose the midpoint of the CO2 data series to define "before" and "after" periods for estimating the slope of CO2 emissions over time. This fell at 1990 for most nations which his convenient given that the calls for climate action gained international momentum in the 1990s; see also (Chesler et al. 2023) who found that analyzing time series after 1990 did not change their results finding no effect of quality of democracy on GHG emissions. For nations that amended the relevant provisions of their constitutions during our study period, 'before' included the year of amendment as did 'after' for the purpose of estimating slopes. For example, we classified Algeria's strongest environmental provision as a right added in 2016. Before 2016, Algeria's strongest provision was a governmental responsibility. Therefore, we classified Algeria as having undergone a change of +1 rank and we calculated the slope of CO2 emissions before 2016 and a slope after 2016, both inclusive of 2016. The slight redundancy (including the CO2 emissions of the year of amendment in both slope estimates is a conservative error because it reduces the probability of finding a change in slope). Because we compare slopes for years before and after a change in constitutional language (or no change), we do not assume a change in emissions occurring in a single year (one time step) but allow for lags that would affect the slopes of emissions for a minimum of 3 years before or after the change. When CO2 emissions data were unavailable (or <3 years existed) for the before or after condition, we omitted

that nation from analyses of change in emissions. Three years is arbitrary of course but it allowed us to estimate a slope using non-parametric ranked analyses, while one year would not and 4 or more years would have excluded more nations from analyses.

A majority of nations amended the environmental provisions in their constitutions during the study period (Table 1). In two cases (Armenia and Myanmar), the nation had changed its environmental provision(s) more than once (A -> B -> C), we created two entries for each before and after situation (Table 1). We defined the 'before' condition for constitutions as 'No provision' when the nation or constitution did not exist.

We obtained CO2 per GDP from 1970 to 2019 for most nations from the Emissions Database for Global Atmospheric Research, EDGAR (European Commission 2024) with missing nations' emissions found (Ritchie, Rosado, and Roser 2024) and [1]. Sudan's emissions data were too difficult to assign to the northern or southern nations during its long, intermittent civil war so we omitted the emissions data.

Hereafter, all reference to CO2 emissions is defined as CO2/GDP by a nation in a stated period, rate refers to the slope of consecutive years of CO2 emissions over a stated period, 'change in emission' refers to the rate after a year defined as above minus the rate before that year, and "throughout" refers to the years for which we had CO2 emissions data or at most 1970 to 2019.

Analysis

Using JMP 16 SAS 2019, we computed the Spearman rank correlation rho coefficients (slopes) for CO2 / GDP over three time periods (before, after, and throughout) for each nation. Note that in this way, nations that did not change constitutional provisions relating to the environment (e.g., US) could also have a "before" sample at the midpoint of the time series of CO2 emissions for comparison with nations that did change their constitutions.

We acknowledge that forcing time series of CO2 emissions into a non-parametric Spearman rho statistic for estimating the slope of emissions over time will linearize data that are sometimes curvilinear, sometimes highly variable (jagged), or sometimes linear (figures 2,3). This means we have obscured within-nation subtleties of changes in emissions by prioritizing a standard approach to estimating slopes of time series that put all nations along the same dimensions. Because the test of hypotheses mainly relied on within-nation change in slopes we assume the lost subtleties of curvilinear or variable emission patterns would not bias the tests of our hypotheses. We caution against using our derived slopes for other analyses that demand a better understanding of the shape of time series of emissions within nations. We compared slopes (ignoring p-values) in several Welch tests that permit unequal variance among groups and produce F-ratios for means and two-sided F tests. The latter test compares the difference between before slopes and after slopes in each nation of one category to the same measure for nations of other categories of constitutional provisions.

Results

Constitutional Provisions that Protect the Biosphere

Among 202 nations for which we categorized constitutional provisions that protect one or more components of the biosphere, the provision in place by 2019 was a Right in 100 nations (50%), a Governmental responsibility in 56 nations (27%), an Individual responsibility in 3 nations (1%), and contained No provision in 43 nations

[1] https://www.macrotrends.net/ accessed 23 May 2024

(21%). We found 159 nations had amended their constitutional provisions relating to the biosphere in some way during the study period, although the category of protection did not always change as a result (Table 1).

Figure 1 here

To test the prediction that amendments to constitutions weakened environmental provisions, we examined the text in 200 previous versions of national constitutions prior to the constitution in place in 2019. In 2 cases (N/A in Table 1) we could not find an English-language version of the earlier constitution online to estimate if the environmental provision (if any) had existed prior to amendment. Previous versions were almost always less protective (Figure 1). Prior versions had “no provision” in 175 cases (88%) but that dropped to 22% by 2019 (Figure 1). The median year of amendment was 1993 for the environmental provisions. The net results of amendments (or lack thereof) were zero changes in rank for 44 nations, a change in rank of +1 (more protective) for 25 nations, a change in rank of +2 for 53 nations, a change in rank of +3 for 77 nations (which includes those which had no prior constitution that ratified one with a Right), only one nation lowered its protection by -1 rank (Armenia post 2015; but see Sudan for a complicated set of changes too). These data represent a net increase of 366 ranks globally or an average increase of 1.8 ranks per nation worldwide. Therefore, we reject Prediction 3 that environmental provisions were imposed on nations by outside forces and find support for the alternative prediction that national publics sought greater protections for the biosphere over time, by amending their constitutions.

CO2 Emissions

Throughout the study period 1970-2019, the slope of CO2 emission per GDP declined over time on average (slope = -0.63, SE 0.03, n=199). For examples of two nations with different histories of constitutional amendments and declining emissions, see Figure 2a.b. However, 27 (14%) nations revealed positive slopes showing an increase in CO2 emissions per GDP over time. For examples of two nations with different histories of constitutional amendments and increasing emissions, see Figures 3A,B. In all, 128 nations decreased CO2 emissions per GDP strongly (slope -0.5 or higher).

Figure 2 here

Figure 3 here

In all, 199 nations provided both a constitutional category and CO2 emissions. The simplest test of prediction 1 was whether CO2 emissions throughout the study period differed by constitutional category; they did not, as indicated by a Welch test with unequal variance F-ratio=0.47, p=0.71. However, variances were unequal (Figure 4). In a post hoc analysis, we found variances were significantly different between constitutional categories after omitting the 3 nations codifying an individual responsibility (rank 1), there significant differences in variance of slopes of emissions (F- Figure 4A). We return to the test of variance below.

The above tests failed to account for independent changes in slopes within nations when constitutions changed or did not change. Therefore, we asked next if the change in slope (after–before) of CO2 emissions within nations was associated with the ‘after’ category of the constitution. Only 171 nations provided data for this test and the association was not significant (F-ratio=0.41, p=0.89).. Nevertheless, we reject

Prediction 1. Again, the F-ratio alerted us to significant differences in variance (Figure 4B).

Figure 4 here

When we tested if the number of ranks of change in constitutions correlated to the change in slopes of emissions or the slope 'after' amendment. When examining all changes in constitutional category, the slopes were |rho| <0.045, p>0.59 in every paired comparison. When we compared positive changes (towards more protection for the biosphere) to all other changes (no change or decrease in protection), again the results were similar. Therefore, we reject Prediction 2.

The heterogeneity of variances detected by F-ratio tests above seemed to deserve more scrutiny (Figures 4A,B) albeit post hoc. For one, they went in different directions. Namely, throughout the study period, variance was highest among nations with no provision (rank 0; Figure 4A) whereas when we calculated the variance of slopes after minus before, the pattern reversed (Figure 4B). These post hoc results were not an artifact of our methods we surmise. First, CO2 emissions were corrected for GDP, so this is not an artifact of a few wealthy, populous nations that have 'No provisions to protect the biosphere (e.g., US, UK, Australia), distorting the variance among the lowest-ranked constitutions. Second, because we measured change in emissions, the result is not an artifact of increasing wealth disparity over time that might disproportionately affect nations with "no provision". Had these nations and few others all accelerated or decelerated their emissions more than other nations after 1990 (the midpoint of our study period), a difference in mean slope before and after would probably have appeared. However, there may be an artefact of sample size in Figure 4B. Nations with a constitutional right (rank 3) tended to have codified their powerful provisions more recently in the study period (median 1994 versus all other nations median 1992). But the difference in median midpoint or year of change dpoes not seem influential. We assessed that potential artefact by within-nation test of mean difference in slopes. Those differences in slope (after versus before) were much smaller for rank 3 nations (mean -0.02) than for other nations rank 0=0.04 rank 1=0.37= rank 2=0.2). Therefore, nations with the strongest constitutional protections for the biosphere (right, rank 3) decreased average slope after they amended their constitutions (albeit not significantly more than other nations) and those slopes after the change resembled the slopes before the change more than the after v before comparison of slopes in other nations. This seems to affirm the initial finding that variances in slope of emissions do reveal real differences between nations. Although mean differences in slopes of CO2 emissions per GDP did not differ significantly by category fo constitution, change in those slopes did differ as revealed by measures of variability before and after changes in constitutions. Therefore, we interpret this to mean that nations that changed constitutional provisions or ratified their first constitution during the study period tended to undergo less change in CO2 emissions over time than did nations that did not change their constitutions.

Discussion

The planetary backdrop for our study was the observed decline in emissions globally, driven by 86% of nations diminishing CO2 emissions per GDP, while only 14% of nations increased those emission rates (Table 1), despite an increase in the human population from 3.7 to 7.7 billion during the period 1970-2019. That backdrop can be

considered in light of national constitutional change and stasis, as the supreme laws of the land were modified in the majority of nations to address new conditions. Constitutional protections for the biosphere also increased. From 1970-2019, >49% of nations ratified constitutions to protect the biosphere or to enhance those protections with amendments. Of nations that amended their constitutions, nearly all of them enhanced protections for the biosphere (Figure 1). Those changes included a sharp rise in the proportion of national constitutions declaring a right to a healthy environment or similar rights that increased protections for the biosphere; the strongest provision under law (James R. May and Daly 2009).

Although the keyword searches we used to classify constitutions were diverse (e.g., environment, nature, forest, wildlife, water) and therefore might not play any roles in CO2 emissions, the changes in constitutions over time tended to be in the general health of the environment category. Thus, we expected to see changes in CO2 emissions per GDP (simply emissions hereafter) correlating to more protective constitutions. However, we did not find such correlations over time within nations. First, we address what we did find and then discuss the political and governance implications of both null and significant results.

We found little or no quantitative evidence that national emissions were associated with the strength of national constitutional provisions that protect the biosphere. We found no evidence that nations with different strengths of constitutional provisions differed in average emissions measured in several ways (Figure 2-4). Nor did change in the constitution affect the average slope of emissions after the change in constitution. However, we found an unexpected difference between nations with different constitutional categories when we measured the variances in their emissions (variability over time). Nations that codified a governmental responsibility or a right to protections for the biosphere showed significantly lower variances than nations with no provision to protect the biosphere (Figure 4). This relationship is illustrated by the comparison of Libya (no provision) to Bhutan (no provision amended to a governmental responsibility in 2008 (Figures 3A,B). However, some nations with no provision also showed little interannual variance (Figure 2b Denmark), which underlines the low power of a single variable and the weak inference gained by isolating constitutional provisions from the regime that respects or does not respect those constitutions. Likewise, our analysis makes no allowance for legislative actions that might step in despite the lack of constitutional provisions nor other legal instruments that might implicitly protect the atmosphere (Michael C. Blumm and Guthrie 2012; Michael C. Blumm and Wood 2017). Such are the limitations of non-experimental quantitative studies relying on correlation; useful but not dispositive. We recommend the causes and consequences of variance in emissions be studied further and attempts made to replicate the pattern within a smaller set of nations with similar constitutional traditions or similar economies.

If governmental duties or rights to environmental protections indeed result in stability in CO2 emissions, this finding would lend support to the idea that constitutions can be employed to promote stability in national, environmental change and often in the direction of lower emissions per GDP. If, as we suspect, stronger constitutional

provisions act to regulate (decrease variance) of CO2 emissions, this could support the suggested roles for constitutional courts to compel reductions in total emissions.

Our findings are consistent with those of Chesler and colleagues (Chesler et al. 2023) whose regression model did not support regime as an important correlate of greenhouse gas emissions. Specifically, they wrote, “We find no evidence that regime type matters. Democracy may be the preferred governing arrangement for myriad reasons, but its ability to address global climate change is not one.” (Chesler et al. 2023), 210. While we agree with their empirical approach and agree partially with their conclusion, we would not go so far. First, a quasi-experimental approach to emissions is not a source of strong inference about causality it heir study or ours (Platt 1964). Many have shown in allied fields that before-and-after comparisons can mislead when temporal autocorrelation in the response variable is strong (Christie et al. 2019; Murtaugh 2002; Stewart-Oaten 2003; Underwood 1992). We simulated the rate of false discoveries and other errors associated with randomized and non-randomized study designs (Author). We noted also the rate of Type II errors (false negatives) can be high in before-and-after, non-randomized study designs. So we caution against discarding the notion that regimes or constitutions play no role in governing greenhouse gas emissions when the analysis is quasi-experimental (before-and-after comparisons without random assignment to treatment or control). Our critique of quasi-experimental approaches is equally aimed at our own analyses. Temporal autocorrelation between years is undoubtedly strong with emissions because of the interannual inertia in emission sources and the lag time required to change emission technologies. We expected to be misled by a handful of comparisons of emissions before and after changes in constitution so we went for the largest sample we could find. The trade-off, of course, was understanding each country’s trajectory, emission patterns, economic and population growths, governance, political history, etc.

To some extent the variables of regime and constitutional protections are not fully independent but may not measure the same things, given that some autocratic regimes have national constitutions that appear to place sovereign power in their publics (rather than the autocrat). Therefore, the congruence of our findings with those of Chesler and colleagues (Chesler et al. 2023) seem to us to call for further study, not less study, of national governance regimes and laws. We encourage further study and in particular, we encourage examination of nations whose courts uphold constitutional protections for the biosphere e.g., Netherlands, Urgenda (Urgenda & 886 Citizens v Dutch State 2015) by comparison with nations whose autocrats only nod at their constitutions Indeed, these hypotheses that regime type or constitutional rights and responsibilities might affect emissions should not be seen as overwhelmingly powerful variables, yet they may play roles in multifactorial causes of emissions. Hence, we urge colleagues and scholars not to abandon such analyses.

To us, the most likely explanation for the lack of strong relationships between emissions and constitutional protections for the biosphere is that constitutions do not generally, consistently, or strongly affect human behaviors or government policies that lead to lower or higher CO2 emissions. A lack of influence might reflect personal

behavior or governmental policy. Also, constitutional provisions and emissions are independent. We suggest the alternative hypothesis that constitutional changes arise from societal changes in behaviors or attitudes in the general public and so do emissions, but the two are distinct, independent sub-national processes without obvious correlations. Another possible explanation is that nations responded in one way and other nations responded in contrasting ways to their constitutions. This alternative would include the possibility that our use of diverse keywords encompassing different components of the biosphere made some constitutions protective of those components alone, and not the atmosphere or pollution. This alternative would result in an inconsistent pattern with regard to emissions. Similarly, the force of constitutional provisions or the effort invested in enforcing them probably varies by nation because constitutional provisions are not one force felt by all nations, but rather idiosyncratically felt and expressed by each nation independently (James R. May and Daly 2009). Our approach assumes constitutions are enforced, i.e., they are worth more than the paper on which they were ratified. Still, we note that some national constitutions have provided the legal basis for action against climate change (Michael C. Blumm and Wood 2017; M. C. Wood 2022), which suggests that causal connections may be strengthened through legal actions accumulating over time and jurisdictions educating other jurisdictions about what judicial action might be legitimate and which remedies a court might entertain (James R. May and Daly 2009). Also, a nation's respect and compliance with its own constitution may vary over time, as will the judicial culture and energy of plaintiffs to sue for rights (James R. May 2003; J. R. May 2005). As the latter authors demonstrated, respect for rights and their recognition, as substantive, or procedural rights, will affect how judiciaries handle them, publics amend them, and governments fulfill their associated duties. Likewise, governments may learn to enforce or implement new policies sometime after their constitutional courts rule or their publics amend constitutions.

Changes in society, judicial respect for fundamental rights to a healthy environment, and executive and legislative protections for the environment are likely to be slowed by interest group action such as the petroleum industry's science denialism in the face of scientific consensus on climate change (Oreskes 2019) and judicial reluctance to act on common law in the absence of explicit legislative commands (West Virginia v. Environmental Protection Agency 2022; Sax 1970; Wilson 2023). The pace of change is expected to be slow under these conditions. Nationalism may further hinder respect for fundamental human rights. Indeed, we never ran into a constitutional provision that explicitly protected the "global environment". Assuming nationalism generally supersedes global environmentalism, then competition between nations may win over environmental protection. To wit, a nation and its public may elect to emit more greenhouse gases to achieve their short-term goals while damaging the environment for all other life. Hence, national constitutions are, by definition, parochial about the national interest. If nationalism outcompetes global environmentalism when governments or publics act upon constitutional provisions, the independence of nations and their competition with each other for economic and political advantage might explain the disconnect we detected here between constitutional provisions for the local biosphere and undeterred (local and global) emissions over time. Global environmental degradation seems to be one cost of nationalism as predicted in the mid-20th century

by E.B. White (White 2019) in his many essays calling for a world federation and planetary laws.

Ever since, legal, and environmental scholars have noted the difficulties in organizing multilateral actions and enforcement on the environment whether the jurisdiction is Indigenous, international, local, or planetary (M.C. Wood 2014; Chapron et al. 2017; Attfield 1998; Constitutional Law Foundation 2017; Cooper and Palmer 1995; Suryawan and Aris 2020; M. C. Wood 2022). Examples from the USA and Philippines seem instructive as contrasting cases.

In the USA, two common rebuttals to legal constitutional challenges to climate policy argue that the USA constitution lacks express provisions to protect the environment, and in the absence of legislative will to enact statutes that explicitly transform the U.S. Bill of Rights into protections for the biosphere, plaintiffs will be forced to use novel arguments (M.C. Wood 2013, 2014). Alternately, the rebuttal holds that the USA did not create climate change wholly or even emit a majority of GHG and therefore the USA should not be liable for reducing emissions. Blumm & Wood (Michael C. Blumm and Wood 2017) and Wood (M. C. Wood 2022) specifically rebut both claims by charging that the USA constitution is predicated on the fundamental principle of sovereignty that a democratic government cannot legally threaten the future wellbeing of its current and future publics; also that the nations who emit the most are most responsible, regardless of if they emit the majority of GHG globally. Some USA state and federal courts seem to agree summarized in (M. C. Wood 2022) and specifics in (Robinson Township, Washington County et al. v Commonwealth of Pennsylvania et al. 2012; Isabel Kain et al. v Department of Environmental Protection 2016; Juliana et al. v U.S. et al. 2020; Juliana et al. v U.S. et al. 2016; Wilson 2023). Also, other nations' courts are increasingly finding for atmospheric trust plaintiffs, summarized in (M. C. Wood 2022) with specifics in (Urgenda & 886 Citizens v Dutch State 2015; Isabel Kain et al. v Department of Environmental Protection 2016; Rabab Ali v Federation of Pakistan et al. 2016); albeit with notable exceptions (Greenpeace Nordic Association et al. v The Government of Norway represented by the Ministry of Petroleum and Energy 2016). Most recently, a Montana, USA district court upheld youth plaintiffs' claim that their state constitution's provision of a clean and healthful environment prohibited state statutes that shielded fossil fuel industry from environmental protections and associated subsidies for exploitation (Held, Rikki et al. v State of Montana et al. 2023).

Another important example comes from the Philippine Supreme Court decision in Oposa (Oposa v Factoran 1993). The Philippine's Supreme Court vindicated its national constitution's right to a healthy environment by supporting the plaintiff's suit to stop permitting clearing of native rainforest. In 1993, Oposa sued on behalf of his children, friends' children, and all future generations. That call for intergenerational equity echoes today in other lawsuits calling for public trusteeship obligating the government to protect the environment and other fundamental human rights.

We assumed that national constitutions reflected the will of the broad public of each nation. However, they might reflect multilateral or extra-national pressures. A number of nations ratified constitutions during a wave catalyzed by the United Nations and the Stockholm Declaration of 1972 (David R. Boyd 2011; James R. May and Daly 2009), and there may not have been optimal, subnational democratic participation at the time. That might have created constitutions that were more UN-centric or global-centric

than appropriate for the national constituents. However, our database (Table 1) shows how many environmentally protective constitutions and amendments were ratified since that UN wave of the 1970s. Therefore, it seems that global human society has shifted towards stronger legal protections for the biosphere at least nationally. We predict a new wave of constitutional amendments that protect the global atmosphere or global biosphere generally. The timeline for such amendments might take as long as the one we found here (20 years give or take). This may one day be reflected in constitutional challenges to governments that subsidize polluters, ignore their contributions to global emissions, or deny the welfare of our posterity.

Conclusions

We did not find straightforward correlations between the strength of national constitutional provisions that protect the biosphere and rates of CO2 emissions over time. There was a significant difference in variability of CO2 emissions over time for nations with the strongest provision (right to environmental protections) compared to nations with weaker provisions. The cause of this association remains undiscovered; one should consider the possibility of spurious effects. Growing interest in constitutional remedies for the climate crisis should spur further research in this vein. The atmosphere is a planetary public trust left to future generations of all life. Constitutions are the supreme laws of each nations, so in principle, these should protect the right to life for our posterity.

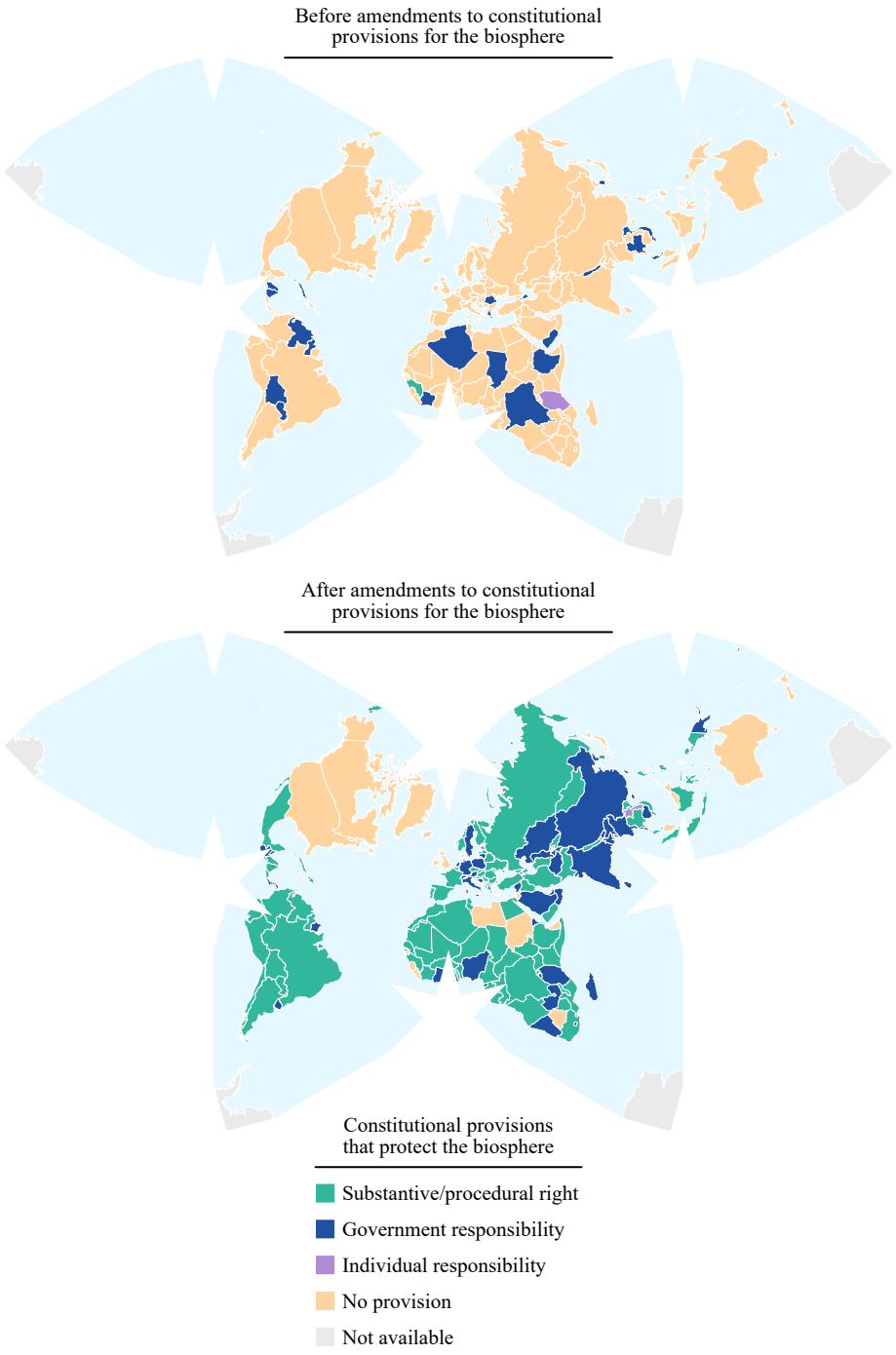
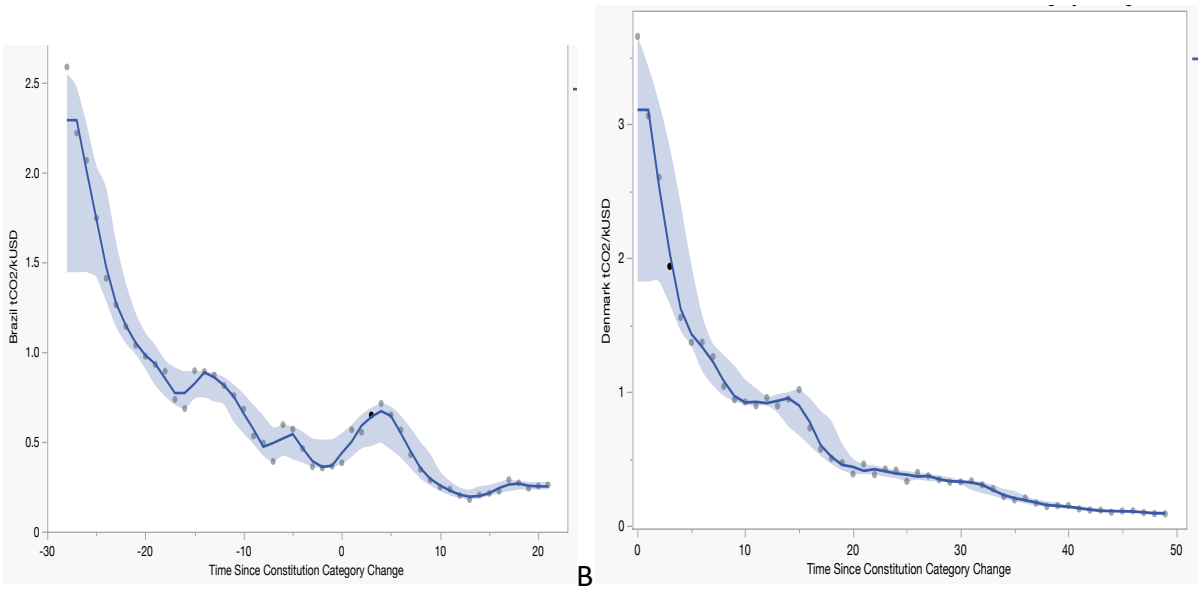


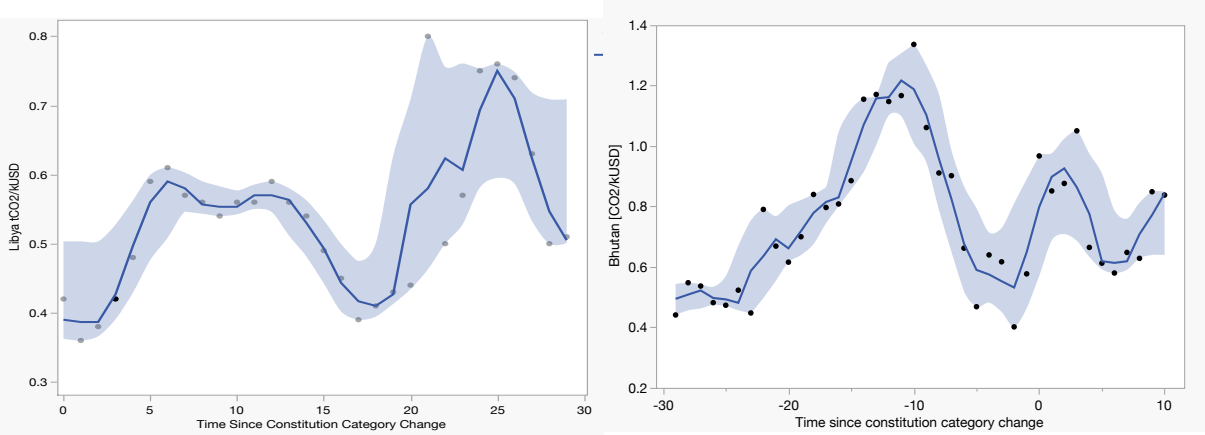
Figure 1. World Map of Nations Showing Four Categories of Constitutional Provisions that Protect the Biosphere. in Butterfly projection and categories defined Following Boyd (20111, 2013; Author) and Methods. (A) Before the latest amendment to the constitutional provisions and (B) after the change. Data from Table 1.



A B

Figure 2. CO2 Emissions OVER Time. CO2 emitted per GDP (y axis) by year (x axis). The curves are moving averages of 2 years with 95% confidence interval for the slope (shaded). Both panels show net negative slopes with (A) Brazil‘s constitution wa amended from no provision to a right in 1998; (time zero on the x axis, with before sown by negative numbers and after show by positive numbers). (B) Denmark’s constitution started with no provision and remained unchanged throughout the study period, so we chose the midpoint of the time series to estimate slopes for ‘before’ and ‘after’ in Table 1’.

A.



583
584 **Figure 3**. CO2 Emissions OVER Time. CO2 emitted per GDP (y axis) by year (x axis).
585 The curves are moving averages of 2 years with 95% confidence interval for the slope
586 (shaded). (A) Libya, showing a net positive slope in emissions with no provision to
587 protect the biosphere in its constitution and no amendment during the study period, so
588 we chose the midpoint of the time series to estimate slopes for before and after (Table
589 1); and (B) Bhutan changed from 'no provision' for protection of the biosphere to a
590 'Governmental responsibility' in 2008 (time zero on the x axis, with before sown by
591 negative numbers and after show by positive numbers).
592

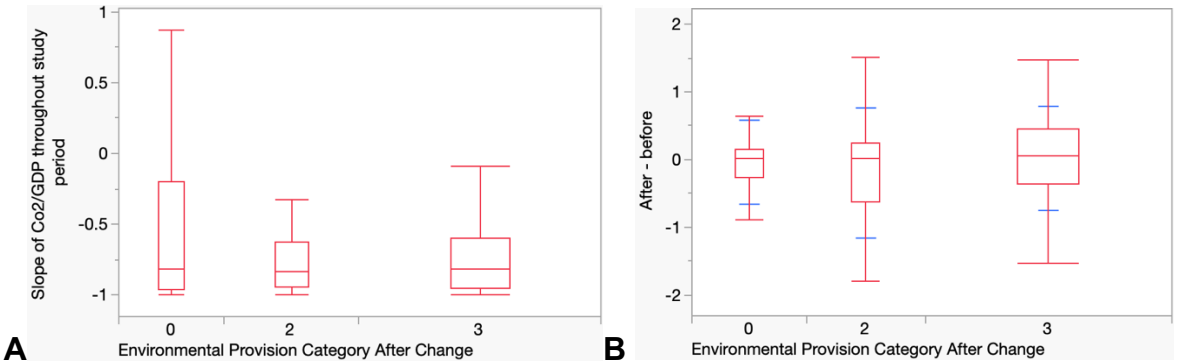


Figure 4. Box Plots of Three Constitutional Categories Against Slopes of Annual, National CO2 Emissions per GDP. Averages do not differ statistically in either frame, but variances do. (A) throughout the study period, Levine's F-ration=4.5 .p =0.011; and (B) slope after change in constitution (or midpoint if no change) minus slope before (F-=ratio =0.035).

602

603 **Table 1.** National Constitutional Categories, Changes in category, Dates of Changes, and Slopes of CO2 Emissions per
604 GDP 1970-2019.

Nation	Date Range CO2/GDP	Year of change in environmental provisions	Environmental Provision Category Before Change	Environmental Provision Category After Change	Slope of Co2/GDP over time Before	Slope of Co2/GDP over time After	Slope of Co2/GDP throughout study period	Sources (see supplementary Table 1 for full list of sources
Afghanistan	1990-2019	2004	No provision	Governmental responsibility	-0.7220	0.7956	0.5107	
Albania	1984-2019	1998	No provision	Right	-0.8901	-0.7211	-0.9120	
Algeria	1970-2019	2016	Governmental responsibility	Right	-0.7531	0.4000	-0.7736	
Andorra	1990-2019	1993	No provision	Right	-1.0000	-0.7833	-0.7935	
Angola	1980-2019	1992	No provision	Right	-0.9860	-0.8358	-0.7964	
Anguilla	1990-2019		No provision	No provision	0.1488	0.9548	0.6410	
Antigua & Barbuda	1977-2019		No provision	No provision	-0.9729	0.5104	-0.7140	
Argentina	1970-2019	1994	No provision	Right	-0.9157	-0.5460	-0.8565	
Armenia pre 2015	1990-2015	1995	No provision	Right	-0.9000	-0.9442	-0.9692	
Armenia post 2015	1995-2019	2015	Right	Governmental responsibility	-0.9353	-0.3000	-0.9385	
Australia [a]	1970-2019		No provision	No provision	-0.9500	-0.8585	-0.9623	
Austria	1970-2019	1984	No provision	Governmental responsibility	-0.9692	-0.9338	-0.9723	
Azerbaijan	1990-2019	1995	Governmental responsibility	Right	0.9000	-0.8231	-0.8719	
Bahamas	1970-2019		No provision	No provision	-0.9531	-0.3169	-0.8990	

Bahrain	1980-2019	1973	No provision	Governmental responsibility		-0.8289	-0.8289	
Bangladesh [a]	1970-2019	2011	No provision	Governmental responsibility	0.5991	-0.9333	0.1085	
Barbados	1974-2019		No provision	No provision	-0.6586	0.5583	0.1774	
Belarus	1990-2019	1994	No provision	Right	0.2000	-0.8701	-0.9128	
Belgium	1970-2019	1994	No provision	Right	-0.9652	-0.9015	-0.9793	
Belize	1970-2019	1981	No provision	Governmental responsibility	-0.8656	-0.6235	-0.8047	
Benin	1970-2019	1990	No provision	Right	-0.8466	0.5849	-0.1160	
Bermuda	1970-2019		No provision	No provision	-0.9130	-0.7299	-0.9525	
Bhutan	1980-2019	2008	No provision	Governmental responsibility	0.3465	-0.1888	0.2445	
Bolivia	1970-2019	2002	Governmental responsibility	Right	-0.5821	-0.8906	-0.8293	
Bosnia & Herzegovina [a]	1990-2019	1995	No provision	Governmental responsibility	-0.9000	0.9095	0.2102	
Botswana	1970-2019		No provision	No provision		-0.9297	-0.9297	
Brazil	1970-2019	1998	No provision	Right	-0.9677	-0.6815	-0.9203	
British Virgin Islands	1990-2019	2007	No provision	Right	-0.7946	0.6621	0.4886	
Brunei Darussalam	1970-2019		No provision	No provision	-0.6217	-0.8379	-0.8171	
Bulgaria	1980-2019	1991	No provision	Right	-0.6091	-0.9690	-0.8730	
Burkina Faso	1970-2019	1991	No provision	Right	-0.8234	-0.0961	-0.1684	
Burundi [a]	1970-2019	2005	No provision	Governmental responsibility	0.7524	-0.8571	0.1113	

Cabo Verde / Cape Verde	1980-2019	1992	No provision	Right	-0.8196	0.4444	-0.1612	
Cambodia	1970-2019	1993	No provision	Governmental responsibility	-0.5629	0.6366	0.1008	
Cameroon	1970-2019	1996	No provision	Right	-0.3470	-0.8087	-0.6572	
Canada	1970-2019		No provision	No provision	-0.9904	-0.9179	-0.9736	
Cayman Islands	1990-2019	2009	No provision	Right	-0.5036	0.2652	0.4973	
Central African Republic	1970-2019	2004	No provision	Right	-0.0567	0.4353	-0.0364	
Chad	1970-2019	1996	Governmental responsibility	Right	-0.8386	-0.5609	-0.8731	
Chile	1970-2019	1980	No provision	Right	-0.6727	-0.9000	-0.9462	
China	1970-2019	1978	No provision	Governmental responsibility	-0.6190	-0.9942	-0.9872	
Colombia	1970-2019	1991	No provision	Right	-0.8104	-0.9010	-0.9657	
Comoros	1980-2019	2001	Governmental responsibility	Right	-0.2696	0.7767	0.3740	
Congo-Brazzaville (Republic of the Congo)	1970-2019	1992	No provision	Right	-0.8543	-0.7980	-0.8097	
Costa Rica	1970-2019	1994	No provision	Right	-0.9357	-0.9836	-0.9902	
Cote d'Ivoire	1970-2019	2000	Governmental responsibility	Right	-0.7006	-0.9158	-0.7485	
Croatia	1990-2019	1990	No provision	Right		-0.9477	-0.9477	
Cuba	1970-2019	2019	Governmental responsibility	Right	-0.9880		-0.9880	
Cyprus	1975-2019		No provision	No provision		-0.9675	-0.9675	
Czech Republic	1990-2019	1992	No provision	Right		-0.9622	-0.9680	

Democratic Republic of Congo	1970-2019	1994	Governmental responsibility	Right	-0.1278	-0.8974	-0.6560	
Denmark	1970-2019		No provision	No provision	-0.9600	-0.9836	-0.9917	
Djibouti	1970-2019		No provision	No provision	-0.1794	-0.9779	-0.8509	
Dominica	1977-2019		No provision	No provision	0.4156	0.0954	0.4363	
Dominican Republic	1970-2019	2010	No provision	Right	-0.7981	-0.9273	-0.8961	
Ecuador	1970-2019	1984	No provision	Right	-0.9604	-0.8669	-0.7553	
Egypt	1970-2019	2014	No provision	Right	-0.8810	0.6000	-0.9104	
El Salvador	1970-2019	1893	No provision	Right		-0.9460	-0.9460	
Equatorial Guinea	1970-2019	1982	No provision	Governmental responsibility	0.5538	-0.9024	-0.8571	
Eritrea	1990-2019	1997	No provision	Governmental responsibility	0.9910	-0.7486	-0.3260	
Estonia	1990-2019	1992	No provision	Individual responsibility	-1.0000	-0.9093	-0.9263	
Eswatini (Swaziland)	1970-2019	2005	No provision	Governmental responsibility	-0.5860	-0.8786	-0.7903	
Ethiopia	1981-2019	1994	Governmental responsibility	Right	0.0055	-0.7723	0.3142	
Fiji	1970-2019	2013	No provision	Right	-0.7860	-0.7857	-0.8558	
Finland	1970-2019	1995	No provision	Right	-0.9562	-0.9531	-0.9714	
France	1970-2019	2005	No provision	Right	-0.9591	-0.7536	-0.9794	
Gabon	1970-2019	1991	No provision	Right	-0.7727	-0.7975	-0.9272	
Georgia	1990-2019	1995	No provision	Right	0.2000	-0.7377	-0.8429	

Germany	1970-2019	1994	No provision	Governmental responsibility	-0.9530	-0.8858	-0.9764	
Ghana	1970-2019	1992	No provision	Governmental responsibility	-0.8532	-0.7657	-0.6594	
Gibraltar	1990-2019		No provision	No provision	0.4083	0.7811	0.8734	
Greece	1970-2019	2002	Governmental responsibility	Right	-0.9179	-0.4303	-0.9496	
Grenada	1977-2019		No provision	No provision	0.3875	0.4351	0.2397	
Guatemala	1970-2019	1965	No provision	Governmental responsibility		-0.8032	-0.8032	
Guinea	1986-2019	1990	Right	Right	-0.4753	-0.2817	-0.6265	
Guinée-Bissau	1970-2019		No provision	No provision	0.5557	-0.9412	-0.1394	
Guyana	1970-2019	1980	Governmental responsibility	Right	-0.7091	-0.7248	-0.7528	
Haiti	1970-2019	1987	No provision	Governmental responsibility	-0.9583	-0.7413	-0.9196	
Honduras	1970-2019	1982	Governmental responsibility	Right	-1.0000	0.1568	-0.3037	
Hungary	1990-2019	1989	No provision	Right		-0.9849	-0.9849	
Iceland	1970-2019		No provision	No provision	-0.9670	-0.8051	-0.9604	
India	1970-2019	1976	No provision	Governmental responsibility	-0.9429	-0.6736	-0.7769	
Indonesia	1970-2019	2000	No provision	Right	-0.4007	-0.8090	-0.7038	
Iran	1970-2019	1979	No provision	Right	-0.9833	0.2238	-0.7714	
Iraq	1990-2019	2005	No provision	Right	-0.6381	0.3971	-0.6229	
Ireland	1970-2019		No provision	No provision	-0.9713	-0.9904	-0.9953	

Israel	1970-2019		No provision	No provision	-0.9574	-0.9268	-0.9828	
Italy	1970-2019	1948	No provision	Governmental responsibility		-0.9697	-0.9697	
Jamaica	1970-2019	2011	No provision	Right	-0.9493	-0.4667	-0.9690	
Japan	1970-2019		No provision	No provision	-0.9948	-0.3593	-0.8955	
Jordan	1970-2019		No provision	No provision	-0.2887	-0.9925	-0.7936	
Kazakhastan	1990-2019	1995	No provision	Governmental responsibility	0.7000	-0.9609	-0.9642	
Kenya	1970-2019	2010	No provision	Right	-0.8981	-0.7939	-0.9450	
Kiribati [a]	1970-2019	1979	No provision	Right	-0.7167	-0.7751	-0.7698	
Kosovo	2008-2019	2008	No provision	Right		-0.7203	-0.7203	
Kuwait	1970-2019	1962	No provision	Governmental responsibility		-0.8338	-0.8338	
Kyrgyzstan	1990-2019	1993	No provision	Right	-1.0000	-0.3587	-0.5330	
Laos	1984-2019	1991	No provision	Individual responsibility	0.8214	-0.0049	0.2607	
Latvia	1990-2019	1998	No provision	Right	-0.7857	-0.9299	-0.9685	
Lebanon [a]	1988-2019	1926	No provision	Governmental responsibility		-0.9806	-0.9806	
Lesotho	1970-2019	1993	No provision	Governmental responsibility	-0.8923	0.5134	-0.5065	
Liberia	1990-2019		No provision	No provision	-0.3190	0.9258	0.0387	
Libya	1990-2019		No provision	No provision	0.1714	-0.8857	0.3717	
Liechtenstein	1990-2018		No provision	No provision	-0.9626	-0.9000	-0.9783	

Lithuania	1990-2019	1992	No provision	Governmental responsibility	1.0000	-0.9925	-0.9934	
Luxembourg	1970-2019	2007	No provision	Governmental responsibility	-0.9806	-0.9505	-0.9913	
Madagascar	1970-2019	1959	No provision	Governmental responsibility		-0.0747	-0.0747	
Malawi	1970-2019	1994	No provision	Right	-0.9496	-0.7470	-0.7798	
Malaysia	1970-2019	1996	No provision	No provision	-0.7162	-0.8530	-0.7350	
Maldives	1980-2019	2008	No provision	Right	0.1702	-0.7692	-0.3889	
Mali	1970-2019	1992	No provision	Right	-0.8984	-0.8380	-0.9409	
Malta [a]	1970-2019		No provision	No provision	-0.7643	-0.9850	-0.9700	
Marshall Islands	1992-2019		No provision	No provision	0.2724	-0.8106	-0.4227	
Mauritania	1970-2019	2012	No provision	Right	0.1310	0.8810	-0.0936	
Mauritius	1976-2019		No provision	No provision	-0.8610	-0.8498	-0.8135	
Mexico	1970-2019	1999	No provision	Right	-0.8837	-0.8506	-0.9663	
Micronesia	1992-2016		No provision	No provision	0.6492	-0.3497	-0.5932	
Moldova	1990-2019	1994	No provision	Right	-0.4000	-0.9723	-0.9753	
Monaco	1970-2016		No provision	No provision	-0.5686	-0.4200	-0.1950	
Mongolia	1981-2019	1992	No provision	Right	0.6455	-0.8938	-0.5658	
Montenegro	2000-2017	1992	No provision	Right		-0.8865	-0.8865	
Morocco	1970-2019	2011	No provision	Right	-0.8476	0.5000	-0.8883	

Mozambique	1990-2019	1975	No provision	Right		0.2397	0.2397	
Myanmar (Burma) pre 1988	1970-1988	1974	No provision	Governmental responsibility	-0.4000	-0.3393	-0.6368	
Myanmar post 1988	1988-2019	2008	No provision	Governmental responsibility	0.1083	0.7972	-0.6235	
Namibia	1980-2019	1990	No provision	Governmental responsibility	0.4061	-0.6338	-0.8034	
Nauru	1970-2019		No provision	No provision	-0.2976	-0.9091	-0.6920	
Nepal	1970-2019	2006	Governmental responsibility	Right	0.6075	0.8593	0.3101	
Netherlands [a]	1970-2019	1983	No provision	Governmental responsibility	-0.9560	-0.9604	-0.9781	
New Zealand	1970-2019		No provision	No provision	-0.9174	-0.8988	-0.9482	
Nicaragua	1970-2019	1986	Governmental responsibility	Right	-0.9941	-0.8273	-0.8491	
Niger	1970-2019	1992	No provision	Right	-0.2129	-0.7187	-0.6477	
Nigeria	1970-2019	1999	No provision	Governmental responsibility	-0.3187	-0.8896	-0.7885	
North Korea	1990-2019	1992	No provision	Governmental responsibility	1.0000	-0.7953	-0.8333	
North Macedonia	1990-2019	1991	No provision	Right		-0.9337	-0.9308	
Norway	1970-2019	1992	No provision	Right	-0.9898	-0.8407	-0.9685	
Oman	1970-2019	1996	No provision	Governmental responsibility	-0.8974	-0.5643	-0.8555	
Pakistan	1970-2019	1973	No provision	Right	0.5000	-0.7265	-0.7668	
Palau	1990-2019	1981	No provision	Governmental responsibility		-0.7673	-0.7673	
Panama [a]	1970-2019	1972	No provision	Governmental responsibility	-1.0000	-0.9285	-0.9367	

Papua New Guinea [a]	1970-2019	1975	No provision	Governmental responsibility	-0.9000	-0.7688	-0.8312	
Paraguay	1970-2019	1992	Governmental responsibility	Right	-0.7007	-0.7252	-0.7509	
Peru	1970-2019	1979	No provision	Right	-0.7667	-0.9563	-0.9666	
Philippines	1970-2019	1987	No provision	Right	-0.9387	-0.8984	-0.9568	
Poland [a]	1990-2019	1997	No provision	Governmental responsibility	-0.8929	-0.9978	-0.9977	
Portugal	1970-2019	1976	No provision	Right	-1.0000	-0.9381	-0.9543	
Puerto Rico	1970-2019	1952	No provision	Governmental responsibility		-0.9319	-0.9319	
Qatar	1970-2019	2003	No provision	Governmental responsibility	-0.6046	-0.5221	-0.8655	
Romania	1987-2019	2003	Governmental responsibility	Right	-0.9471	-0.9461	-0.9866	
Russia	1988-2019	1993	No provision	Right	0.9000	-0.8315	-0.7731	
Rwanda	1970-2019	2003	No provision	Right	0.3421	-0.9289	-0.3463	
Saint Kitts & Nevis [a]	1990-2019	1983	No provision	Governmental responsibility		0.7873	0.7873	
Saint Lucia	1990-2019		No provision	No provision	0.6899	0.7216	0.8427	
Saint Vincent & the Grenadines	1990-2019		No provision	No provision	0.5939	0.6914	0.6983	
Samoa	1982-2019		No provision	No provision	-0.8977	-0.8526	-0.9630	
Sao Tome & Principe	1990-2019	1990	N/A	Right		-0.2353	-0.2353	
Saudi Arabia	1970-2019	1992	No provision	Governmental responsibility	-0.5889	-0.8320	-0.7718	
Senegal	1970-2019	1991	No provision	Right	-0.8766	-0.2103	-0.5269	

Serbia	1995-2019	2006	No provision	Right	0.0636	-0.2747	-0.7769	
Seychelles	1970-2019	1993	No provision	Right	-0.7747	-0.2882	-0.7374	
Sierra Leone	1970-2019		No provision	No provision	0.1922	-0.7060	-0.5674	
Singapore	1970-2019		No provision	No provision	-0.9678	-0.9419	-0.9883	
Slovakia	1990-2019	1992	No provision	Right	1.0000	-0.9941	-0.9938	
Slovenia	1990-2019	1991	No provision	Right		-0.9877	-0.9836	
Solomon Islands	1971-2019		No provision	No provision	-0.4190	-0.5357	-0.8515	
Somalia	1990-2019	2012	No provision	Right	0.8109	-0.6274	0.7255	
South Africa	1970-2019	1993	No provision	Right	-0.8557	-0.7814	-0.9307	
South Korea	1970-2019	1980	Governmental responsibility	Right	-1.0000	-0.9621	-0.9805	
South Sudan [b]	1990-2019	2011	No provision	Right	N/A	N/A	N/A	
Sudan [b]	1990-2019	2019	No provision	No provision				
Spain	1970-2019	1978	No provision	Right	-0.9762	-0.9206	-0.9528	
Sri Lanka	1970-2019	1978	No provision	Governmental responsibility	-0.7381	-0.8130	-0.8747	
Suriname	1970-2019	1987	No provision	Governmental responsibility	-0.9657	-0.7169	-0.7224	
Sweden	1970-2019	1987	No provision	Governmental responsibility	-0.9657	-0.9011	-0.9702	
Switzerland	1970-2019	1971	No provision	Governmental responsibility		-0.9842	-0.9851	
Syrian Arab Republic [a]	1970-2007		No provision	Governmental responsibility	-0.1947	-0.7140	0.3991	

Tajikistan	1990-2019	1994	No provision	Governmental responsibility	-0.2000	-0.7855	-0.8587	
Tanzania	1988-2019	1977	Individual responsibility	Governmental responsibility		-0.6763	-0.6763	
Thailand	1970-2019	2007	Governmental responsibility	Right	-0.3905	-0.8846	-0.7511	
The Gambia	1970-2019	1996	No provision	Governmental responsibility	-0.7805	0.6391	-0.6239	
Timor-Leste / East Timor	1990-2019	2002	No provision	Right	0.2715	-0.2148	0.5040	
Togo	1970-2019	1992	No provision	Right	-0.7832	-0.2638	-0.2914	
Tonga	1975-2019		No provision	No provision	-0.8272	-0.6700	-0.7510	
Trinidad & Tobago	1970-2019		No provision	No provision	-0.2739	-0.8906	-0.5218	
Tunisia [a]	1970-2019	2014	No provision	Right	-0.9150	1.0000	-0.8971	
Turkey	1970-2019	1982	No provision	Right	-0.9580	-0.8917	-0.9082	
Turkmenistan	1990-2019	2008	No provision	Right	0.5106	-0.9562	-0.5997	
Turks and Caicos Islands	1990-2019	2011	No provision	Governmental responsibility	0.1529	-0.6272	0.6653	
Tuvalu	1990-2019		No provision	No provision	-0.7607	-0.6214	-0.9230	
Uganda	1970-2019	1995	No provision	Right	-0.5215	-0.3323	-0.4390	
Ukraine	1987-2019	1996	No provision	Right	-0.7833	-0.9043	-0.9041	
United Arab Emirates	1975-2019	1971	No provision	Governmental responsibility		-0.8374	-0.8374	
United Kingdom	1970-2019		No provision	No provision	-0.9670	-0.9781	-0.9933	
United States	1970-2019		No provision	No provision	-1.0000	-0.9993	-0.9999	

Uruguay	1970-2019	2004	N/A	Governmental responsibility		-0.9332	-0.9332	
Uzbekistan	1990-2019	1992	No provision	Governmental responsibility	1.0000	-0.9858	-0.9600	
Vanuatu	1979-2019	1980	No provision	Individual responsibility		-0.8899	-0.8967	
Venezuela	1970-2014	1999	Governmental responsibility	Right	-0.4488	-0.8971	-0.8171	
Vietnam [a]	1985-2019	2013	Governmental responsibility	Right	-0.1899	0.7143	-0.3936	
Yemen	1990-2019	2015	Governmental responsibility	Right	0.8686	0.5270	0.1127	
Zambia	1970-2019	1991	No provision	Governmental responsibility	-0.7273	-0.7852	-0.9308	

N/A indicates we could not find an English-language version online.

[a] We differ from Boyd 92013) or (United Nations 2024) based on (Constitute 2024) as summarized below.

Australia: Boyd (2013) wrote “Y/N” to a governmental responsibility. Australian constitutional scholars corrected this error in (Author).

Bangladesh: Boyd (2013) is inconsistent on this national constitution.

Bosnia & Herzegovina: Boyd (2013) reported no provision.

Burundi: The 2018 preamble reads, "Solemnly reaffirm our attachment to the respect of fundamental rights to the human person as prescribed by international texts concerning the rights of man ratified by Burundi." So they cut out the specifics and generalized. Boyd (2013) reported 2005 version and claims that it counts as a constitutional right. We disagree.

Kiribati: Boyd (2013) reported a right, individual duty, and governmental duty. We found no provision before 2014.

Lebanon: Boyd (2013) reported no provision.

Malta: Boyd (2013) reported governmental duty. We disagree.

Netherlands: Boyd (2013) reported a right.

Panama: Boyd (2013) reported a right and governmental responsibility. We found only governmental responsibility.

Papua New Guinea: Boyd (2013) reported individual duty. We disagree.

Poland: Boyd (2013) reported every category of duty including a substantive right.

Saint Kitt & Nevis: Boyd (2013) reported a right. We disagree.

Syrian Arab Republic: Boyd (2013) reported individual responsibility.

Tunisia: The UN reported no provision. We disagree.

Vietnam: Boyd (2013) reported governmental responsibility. By 2013 it had amended the constitution to a right.

Zimbabwe: Boyd (2013) reported no provision. By 2013 it had amended the constitution to a right.

[b] The civil war and division of Sudan and interim constitutions make this case difficult to interpret.

References

Attfield, R. 1998. "Environmental ethics and intergenerational equity." *Inquiry* 41: 207-222.

Baker, Jack Kessel. 2023. "Keeping Promises? Democracies' Ability to Harmonize Their International and National Climate Commitments." *Global Environmental Politics* 23 (4): 170-200. https://doi.org/10.1162/glep_a_00709.

Bliss, Cebuan, Ingrid J. Visseren-Hamakers, and Duncan Liefferink. 2023. "Most (Un)wanted: Explaining Emerging Relationships Between "Invasive Alien" Species and Animal Governance." *Global Environmental Politics* 23 (4): 26-51. https://doi.org/10.1162/glep_a_00715.

Blumm, Michael C. , and Mary Christina Wood. 2017. ""No Ordinary Lawsuit": Climate Change, Due Process, and the Public Trust Doctrine." *American University Law Review* 67 (1): 1-83. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2954661.

Blumm, Michael C., and R.D. Guthrie. 2012. "Internationalizing the Public Trust Doctrine: Natural Law and Constitutional and Statutory Approaches to Fulfilling the Saxion Vision." *UC Davis Law Review* 45: 741-808.

Boyd, David R. 2011. "The Implicit Constitutional Right to Live in a Healthy Environment." *RECIEL: Review of European Community & International Environmental Law* 20 (2): 171-179.

Boyd, David R. . 2013. The Status of Constitutional Protection for the Environment in Other Nations. British Columbia, Canada: The David Suzuki Foundation.

Chapron, G., Y. Epstein, A. Trouwborst, and J. V. López-Bao. 2017. "Bolster legal boundaries to stay within planetary boundaries." *Nature Ecology & Evolution* 1 (0086): doi:10.1038/s41559-017-0086.

Chesler, Angela, Debra Javeline, Kimberly Peh, and Shana Scogin. 2023. "Is Democracy the Answer to Intractable Climate Change?" *Global Environmental Politics* 23 (4): 201-216. https://doi.org/10.1162/glep_a_00710.

Christie, Alec P. , Tatsuya Amano, Philip A. Martin, Gorm E. Shackelford, Benno I. Simmons, and William J. Sutherlan. 2019. "Simple study designs in ecology produce inaccurate estimates of biodiversity responses." *Journal of Applied Ecology* 56: 2742–2754. https://doi.org/ 10.1111/1365-2664.13499.

Constitute. 2024. "The Constitute Project" https://www.constituteproject.org/.

Constitutional Law Foundation. 2017. "The Stewardship Doctrine: Intergenerational Justice in the United States Constitution." Constitutional Law Foundation. Accessed 7 February 2017. http://www.conlaw.org/Intergenerational-Intro.htm.

Cooper, David E, and Joy A Palmer. 1995. *Just Environments: Intergenerational, International and Interspecies Issues*. New York: Routledge.

European Commission. 2024. "EDGAR" https://edgar.jrc.ec.europa.eu/report_2020.

Falkner, Robert. 2024. "The Longue Durée of International Environmental Norm Change: Global Environmental Politics Meets the English School of International Relations." *Global Environmental Politics* 24 (1): 124-137. https://doi.org/10.1162/glep_a_00718.

Fransen, Anouk, and Harriet Bulkeley. 2024. "Transnational Governing at the Climate–Biodiversity Frontier: Employing a Governmentality Perspective." *Global Environmental Politics* 24 (1): 76-99. https://doi.org/10.1162/glep_a_00726.
Georgetown University. 2024. "Constitutions and Comparative Constitutional Study Constituciones Políticas y Estudio Constitucional Comparativo" https://pdba.georgetown.edu/Constitutions/constudies.html.
Greenpeace Nordic Association et al. v The Government of Norway represented by the Ministry of Petroleum and Energy. 2016. Oslo District Court.
Held, Rikki et al. v State of Montana et al. 2023. 1st Distrist Court Mont Montana.
Isabel Kain et al. v Department of Environmental Protection 2016. Supreme Judicial Court of Massachusetts.
Juliana et al. v U.S. et al. 2016. U.S. District Court Oregon.
Juliana et al. v U.S. et al. 2020. U.S. 9th Circuit Court of Appeals.
Levy, BS, and JA Patz. 2015. "Climate change, human rights and social justice." *Annals of Global Health* 81 (3): http://dx.doi.org/10.1016/j.aogh.2015.08.008.
May, J. R. 2005. "Constituting fundamental environmental rights worldwide." *Pace Environmental Law Review* 23 (1): 13-182.
May, James R. . 2003. "Now More than Ever: Trends in Environmental Citizen Suits at 30." *Widener law Review* 10 (1): 1-48.
May, James R., and Erin Daly. 2009. "Vindicating Fundamental Environmental Rights Worldwide." *Oregon Review of International Law* 11 (2): 365-440.
Murtaugh, P.A. 2002. "On rejection rates of paired intervention analysis." *Ecology* 83 (6): 1752–1761. https://doi.org/https://doi.org/10.2307/3071993.
Oposa v Factoran. 1993. Philippines Supreme Court.
Oreskes, Naomi. 2019. *Why Trust Science?* Princeton, NJ: Princeton University Press.
Patz, J.A., H.K. Gibbs, J.A. Foley, J.V. Rogers, and K.R. Smith. 2007. "Climate change and global health: quantifying a growing ethical crisis." *EcoHealth* 4: 397–405.
Patz, JA, and MJ Hatch. 2014. "Public Health and Global Climate Disruption." *Public Health Reviews* 35 (1).
Platt, J. R. 1964. "Strong inference." *Science* 146: 347–353.
Rabab Ali v Federation of Pakistan et al. 2016. Supreme Court of Pakistan.
Ripple, W. J., Christopher Wolf, T.M. Newsome, Mauro Galetti, M. Alamgir, E. Crist, M.I. Mahmoud, W.F. Laurance, and 364 scientist signatories from 184 countries and 15. 2017. "World Scientists' Warning to Humanity: A Second Notice." *Bioscience* 67 (12): 1026–1028.
Ritchie, Hannah , Pablo Rosado, and Max Roser. 2024. "CO_2 and Greenhouse Gas Emissions" https://ourworldindata.org/co2-and-greenhouse-gas-emissions.

Robinson Township, Washington County et al. v Commonwealth of Pennsylvania et al. 2012. Supreme Court of Pennsylvania

Sax, J.L. 1970. "The Public Trust Doctrine in natural resource law: Effective judicial intervention." *Michigan Law Review* 68: 471-566.

Stewart-Oaten, A. 2003. "On rejection rates of paired intervention analysis: comment." *Ecology* 84: 2795–2799.

Suryawan, I. Gusti Bagus, and Ismail Aris. 2020. "Strengthening Environmental Law Policy and Its Influence on Environmental Sustainability Performance: Empirical Studies of Green Constitution in Adopting Countries." *International Journal of Energy Economics and Policy* 10 (2): 132-138. https://doi.org/https://doi.org/10.32479/ijeep.8719. https://doi.org/10.32479/ijeep.8719.

Underwood, A.J. 1992. "Beyond BACI: The detection of environmental impacts on populations in the real, but variable, world." *Journal of Experimental Marine Biology and Ecology* 161: 145-178.

United Nations. 2024. "Harmony with Nature" http://harmonywithnatureun.org/environmentalProvisions/.

University of Calfornia Berkeley. 2024. "Berkeley Law Linrary Catalog" https://lawcat.berkeley.edu/record/367145?ln=en.

Urgenda & 886 Citizens v Dutch State. 2015. District Court of the Hague.

West Virginia v. Environmental Protection Agency. 2022. U.S. Supreme Court.

White, E. B. 2019. *On Democracy*. Vol. New York. Harper Audio.

Wilson, M. 2023. Hawaii Eelectric Lict Co. Inc. Public Utilities Commission Concurring opinion.

Wood, M. C. 2022. "'On the Eve of Destruction': Courts Confronting the Climate Emergency." *Indiana Law Journal* 97 (1): 1-57. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4017861.

Wood, M.C. 2013. *Nature's Trust*. New York: Cambridge University Press.

Wood, M.C.. 2014. "Tribal trustees in climate crisis " *American Indian Law Journal* 2 (2): 518-546.