The Professional Geographer

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rtpg20

Maps on Acid: Cartographically Constructing the Acid Rain Environmental Issue, 1972-1980

Brenden E. McNeil & Karen L. Culcasi

West Virginia University

Published online: 01 Jul 2014.


To link to this article: http://dx.doi.org/10.1080/00330124.2014.922016

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the “Content”) contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at http://www.tandfonline.com/page/terms-and-conditions
Maps on Acid: Cartographically Constructing the Acid Rain Environmental Issue, 1972–1980*

Brenden E. McNeil and Karen L. Culcasi
West Virginia University

This article traces how maps aided the conceptualization and ensuing debate over one of the first inherently spatial and multiscale environmental issues, acid rain. Through interviews with early acid rain ecologists and a critical cartographic analysis of printed maps, we show that mapping was central for constructing this environmental issue. Rather than static representations of a scientific reality, acid rain maps were interconnected and relational processes that operated within political and economic discourses. Accordingly, we suggest that increased critical engagement and participation with the process of mapping can productively aid dialog on many issues, including other current multiscale environmental issues, such as climate change. Key Words: acid rain, critical cartography, environmental issues, media maps.

It is raining here as this is written, and judging from a map in Scientific American, the rain is steadily eroding the tiles of my roof.

—J. K. Page, Jr., Editor, Smithsonian (1980, 22)

Most of the claims for increasing acidity are based on maps.

—Congressional testimony of Ralph M. Perhac, Director of Environmental Assessment for the Electric Power Research Institute (19 March, 1980, 86)

In early 1980, members of the 96th U.S. Congress had their minds on acid. Between the first congressional hearing held on acid rain1 on 26 February and the passage of the Acid Precipitation Act (APA) on 30 June of that year, the congressional attention2 to acid rain was sudden and remarkable. It was sudden because Congress had ignored the acid rain issue for years but then took just a few months to legislate on this “serious regional problem” (Likens and Bormann 1974, 1176). It was remarkable because the issue of acid rain conflicted with the prevailing discourse of energy independence. In response to the 1970s energy crises, securing U.S. energy independence was a central concern within Congress, as well as the Carter Administration. As demonstrated in a presidential address on 2 August 1979, President Carter noted the environmental risks posed by acid rain but affirmed the paramount need to secure energy independence, primarily through increased domestic coal combustion. But, just several months after Carter’s address, the move toward increased coal use was threatened because of its causal linkage to acid rain.

In this article, we trace the public debate that led Congress to pass the 1980 APA. More specifically, we examine how the process of mapping of acid rain instigated, framed, and shaped this debate. We follow how maps helped ecologists, the media, the electric power industry, and Congress to conceptualize and debate acid rain as one of the first inherently spatial and multiscale environmental issues. We argue that the mapping and remapping3 of acid rain facilitated a significant shift in the perception of environmental issues. Until the issue of acid rain emerged, environmental issues had generally been perceived as localized

*We thank Mark Monmonier for stimulating our ideas, encouraging our collaboration on this project, and providing comments on early drafts. We also appreciate the participation of Gene Likens and Charles Cogbill, as well as the helpful comments from three anonymous reviewers. Finally, we thank our children, Ayla and Milo, for being good sleepers while we wrote much of this article.

The Professional Geographer, XXX(X) 20XX, pages 1–13 © Copyright 20XX by Association of American Geographers.
Initial submission, July 2013; revised submission, November 2013; final acceptance, November 2013.
Published by Taylor & Francis Group, LLC.
phenomena, with local causes and effects. The mapping of acid rain, however, showed that the effects of pollution could be both local and regional. Moreover, as suggested by the epigraphs, acid rain mapping was crucial for aiding recognition of the issue and stoking fears about the widespread effects of pollution.

Although some Americans might have been skeptical of maps that implied that acid rain was eroding their tile roofs, for many, maps proved that acid rain was a threat. The assumption that maps are scientific representations that can prove the existence of some spatial phenomenon has existed since the Enlightenment and is part of a broader positivistic tradition (Edney 1993, 1999; Cosgrove 2005). Although critical cartography has questioned this common assumption about maps (Edney 2005; Crampton and Krygyr 2006), maps of environmental phenomena have rarely been examined critically (Carolan 2009). Drawing on literature in critical cartography, actor-network theory, and “maps as processes” (i.e., Del Casino and Hanna 2006; Kitchin and Dodge 2007; della Dora 2009), we posit that maps are not just a simple means to represent environmental data. Rather, we suggest that maps are actively used, interpreted, and remade as part of the wider discourses on environmental issues, which include political agendas and capital interests. Thus, our conceptual framework recognizes environmental maps as useful, necessary, and influential but explicitly considers maps as part of the process of constructing, as opposed to representing, environmental issues.

In the next two sections of this article, we more fully detail our conceptual framework and then provide some historical context to the acid rain issue. Then, we examine the process of mapping acid rain within three interrelated institutional settings: academia, print media, and the electric power industry. Supplementing our cartographic analysis with interviews from the ecologists who published the early acid rain maps, we find that maps were integral for constructing acid rain as one of the first inherently spatial and multiscale environmental issues. In our conclusion, we suggest that increased critical engagement and participation with the process of mapping can productively aid dialog on many issues, including other current multiscale environmental issues, such as climate change.

**Mapping Environmental Issues**

In this section, we discuss our conceptual framework, which draws on critical cartography and actor-network theory to argue that maps are processes, as opposed to static representations of some reality. Although it is a common argument in critical cartography that maps are not objective, scientific representations of reality, maps are often still considered objective representations (Dodge, Kitchin, and Perkins 2011). As Wood (2010, 3–4) summarized, “once a map has been published, it is pretty much taken for a description of the way things actually are.” Moreover, maps that incorporate rate or represent scientific data, like measurements of precipitation acidity, are more likely than geopolitical maps to maintain the appearance of objectivity. This is precisely because they are based on scientific data that are ostensibly apolitical. In this vein, maps often seem to be static, final products that are outcomes of the scientific method. This perspective of maps as scientific products is evident within literature and reports on environmental issues. Within this literature, maps are often framed as tools for scientific discovery or as communication devices to be perfected (Cambridge et al. 1996; Bartels and van Beurden 1998; Lahr and Kooistra 2010; Severtson and Burt 2012).

Adding a critical perspective to literature on mapping environmental issues helps question assumptions about the scientific nature of maps (Curran 2003; Harris and Hazen 2006; Monmonier 2008; Wood and Fels 2008; Carolan 2009). A critical approach focuses on questioning what often seem like communication devices or apolitical maps and seeks to unravel the links between knowledge and power (Crampton 2009). Drawing on approaches from actor-network theory and critical cartography, we examine the relational process of mapping in the construction of the environmental issue of acid rain.

Examining maps as processes helps to draw out the ways in which maps are part of constructing what they seem to represent. In this view, maps are neither products of science nor are they a mirror or record of what has happened. Instead, they are dynamic and continuous processes that emerge within wider discourses, practices, and networks (Del Casino and Hanna 2006; Kitchin and Dodge 2007; della Dora 2009). Maps in this view are always in a state of becoming and thus necessitate a perspective that examines not only the map itself but also the broad set of practices and networks that are part of its production and reproduction.

Actor-network theory and the work of Latour (1986, 1987, 2004) has been particularly formative for approaches that focus more on processes than representations. Such a focus allows us to “literally see” (Latour 1987, 226) the complex relations in which both human and nonhuman actors work to coconstitute social, political, economic, and environmental phenomena (Whatmore 2002; Perkins 2007; Holifield 2009). Latour’s work on “immutable mobiles” is particularly informative for work in critical cartography, as it ultimately destabilizes assumptions about the scientific nature of maps. Latour (1986) argues that a map is a “dramatic example” (223) of an immutable mobile, in that maps are easily shared and ubiquitous (mobile) and their internal properties are static and stable (immutable). Through the standardization of codes and cartographic design principles (e.g., a star symbolizing a capital city or the use of grid coordinate systems), cartography became a universal scientific practice and maps became immutable objects. Latour (1987) stresses that even when a map is combined with other mobiles (i.e., graphs or other maps), the map and its internal properties are not distorted but carefully preserved. By examining the complex relations,
practices, and networks in which immutable mobiles work, we can better understand the broader processes, discourses, and networks from which maps emerge. Our examination of the networks in which acid rain maps were produced and used, however, shows that even though a map might seem scientific and immutable, maps do change as they are used, interpreted, and remapped. In this sense, we underscore in this article that a map only seems immutable (see also Kitchen et al. 2009).

Drawing on three complementary approaches—genealogy, actor-network theory, and textual analysis—we highlight that acid rain maps were not static representations or definitive statements of the location of acid rain. Instead, acid rain maps built on one another and evolved as part of scientific or academic and public debates on acid rain. We merge ideas stemming from actor-network and genealogical approaches to move away from analyzing maps as a static representations and instead trace the relations, networks, and actors that were involved in mapping projects over time. As Kitchin, Gleeson, and Dodge (2013, 484) explain, a genealogical approach to mapping helps to “untangle and make sense historically of the multiple, complex and sometimes contradictory or paradoxical iterations of mapping projects.” More specifically, this approach allows us to trace how acid rain maps worked in relation to one another over time and how they were used, shared, and changed within academic, media, and industry networks. Yet, we do not disregard the map image itself and instead open the dialog for a “more than representational” approach (Lorimer 2005) that includes a critical analysis of the map texts in relation to their wider networks (see, e.g., Monmonier 2008; Wood and Fels 2008; Crampton 2010). By examining how certain elements of map text like color, graphs, and isolats recur on successive remappings, we trace the mutability of maps as they build on one another.

Although we stress that maps are mutable objects that are not objectively formed, we also underscore that they nevertheless do work in the world (Pickles 2004; Wood 2010). More specifically, we show how maps work to make acid rain visible and to construct acid rain as an environmental issue. As Cosgrove (2008a, 2008b) argued, visual images, and specifically maps, are active material objects that are central in framing and co-constituting environmental debates. Cosgrove suggested that maps make visible environmental changes that would otherwise be beyond our normal bodily senses. Likewise, Carolan (2009, 279) argued that maps “have become an indispensable instrument in environmental science and policy due to their ability to depict aspects of reality that are otherwise difficult to see.” Indeed, we highlight how maps were produced and used within complex networks and helped make the unseen or abstract spatial phenomena of acid rain visible and that this process was instrumental in constructing the multiscale environmental issue of acid rain.

### The Environmental and Political Beginnings of the Acid Rain Issue

The issue of acid rain intersected two national discourses prevalent during the 1970s and early months of 1980—environmentalism and energy independence. First, the discourse of environmentalism originated from public outcry against conditions that endangered environmental health and human lives, such as the DDT impacts on wildlife chronicled in *Silent Spring* (Carson 1962) and the 1948 smog that killed twenty people and sickened thousands of others in Donora, Pennsylvania. This public outcry led to the passage of laws like the 1970 Clean Air Act (1970 CAA) and the creation of the Environmental Protection Agency (EPA) to enforce these laws. Notably, the state-centered, command-and-control environmental regulatory approach used by the EPA in the 1970s differed markedly from the more contemporary “liberal environmentalism” of market-based environmental regulatory approaches (Bernstein 2001; Gareau and DuPuis 2009). Important for the acid rain issue, the 1970 CAA gave the EPA considerable power to protect human health against air quality atrocities like Donora. The EPA regulated the CAA by tightly enforcing air quality standards within localized air quality regions and especially within the cities and counties of the Ohio River valley that contained many of the coal-fired power plants in the United States.

Second, the energy independence discourse originated from the energy crises of 1973 and 1979 and the resulting quadrupling of oil prices. These energy crises prompted policymakers to create policies that would lead to energy independence for the United States, primarily by promoting a switch in electricity production from foreign oil to domestic coal. However, generating electricity from domestic coal was now under the purview of the EPA and the 1970 CAA, thereby generating a direct tension among these discourses of energy independence and environmentalism.

The discourse of energy independence, perhaps unsurprisingly, intensified acid rain because power plants switched from low-sulfur foreign oil to higher sulfur domestic coal. This caused national sulfur emissions (a cause of acid rain) to rise significantly. Ironically, the discourse of environmentalism and the state-centered, command-and-control brand of environmental regulation in the 1970s also inadvertently led to increased acid rain. To comply with the EPA’s rigid enforcement of 1970 CAA demands to meet air quality standards within local air quality regions, power plant operators used two tactics that turned a local pollution problem into a broader scale, regional issue. First, by installing particle-removing devices to decrease localized particulate emissions, they inadvertently eliminated particles that had helped neutralize the sulfuric and nitric acids responsible for acid rain (Likens and Bormann 1974). Second, to reduce localized, ground-level concentrations of pollutants that could harm human health, power plant owners installed
higher smokestacks (Likens et al. 1979). These higher smokestacks released sulfur dioxide and nitric oxides into winds upward of 1,000 feet from the ground, where they were carried for hundreds of miles before falling to the ground as acids. In summary, the discourses of energy independence and environmentalism merged to transform a visible, local pollution problem known to harm human health into an invisible, regional pollution problem with less well-known ecological effects.

The Mapping of Acid Rain

In the remainder of this article, we follow the mapping of the acid rain issue from the first published report on the existence of acid rain in North America in 1972 through the legislation of the APA on 30 June 1980. We examined many different maps of acid rain produced and used during this period, but we discuss here the most widely referenced acid rain maps from three different institutional settings: academia, print media, and the electric power industry. We review the maps created within these institutional settings separately but emphasize how they built on one another as part of a continuous process that helped construct the acid rain issue.

Academic Mapping

In the first article documenting acid rain in North America, Likens, Bormann, and Johnson (1972) presented a graph showing covarying monthly trends in precipitation acidity for three sites in the Northeastern United States. This graph was superimposed on a regional map locating the three sites (Figure 1). Although the authors could not yet map acid rain because of the temporal and geographic limitations of their measurements, the juxtaposition of the graph and locator map helped support the article’s claim that acid rain was a regional problem in the Northeastern United States. In particular, the figure showed that rainwaters across the region were always abnormally acidic. Moreover, by also showing that all of the sites varied in unison through the year, the figure suggested that this was not a local issue but a regional one caused by an external driver.

Likens and his colleagues recognized that mapping was a critical tool for understanding this complex issue of acid rain. In our interview with Likens, he described...
his desire to "always do science that I could explain to my grandmother," and he noted that maps provided the simplest way to visualize and communicate the regional scope of acid rain. Given the limited temporal and geographic scope of their own measurements of rainwater acidity (i.e., Figure 1), Likens and his colleagues searched for other data that could be used to map acid rain. Through converting other researchers' rainwater measurements into predicted pH values, Likens's graduate student, Charles Cogbill, used isoplats, or lines of equal acidity, to map the regional distribution of acid rain. Cogbill illustrated increases in acidity and a change in the spatial pattern of acidity by mapping the data from 1955–1956 (map not shown here) and 1965–1966 (Figure 2). These maps were shown as separate figures on the same page (Cogbill and Likens 1974). For each map, Cogbill used a light table to hand interpolate regularly spaced isoplats, beginning from the chemically significant reference value of a 4.52 pH. In our interview with Cogbill, he commented, "The map presentation seemed straightforward, if a bit simple integration of the phenomenon." He went on to add, "Most of the work was done for its own sake and driven by its own interesting findings." Yet, Cogbill also realized that the "findings had tremendous implications." Indeed, this map was the...
first one to show the geography of acid rain and particularly that the most intense acid rain was falling on New England. Nevertheless, the “tremendous implications” of the map in Figure 2 were not immediately recognized. Cogbill’s map would later serve, however, as a foundation for subsequent acid rain remappings; thus, this “straightforward” academic map would become a mutable object that was a central part of the process that constructed the environmental issue of acid rain.

Print Media Mapping

The media are central in both constructing environmental issues and initiating debate about such issues (Schoenfeld, Meier, and Griffin 1979; Bendix and Liebler 1991; Adler 1995). In late 1979 and early 1980, the media played a pivotal role in framing the acid rain issue as an environmental “crisis” (Bendix and Liebler 1991). But it was not just the typed text that was important; maps were a vital part of the media’s framing and construction of the issue. Media mapping, more generally, can shape and frame perceptions and discourses of different events and issues. As Monmonier (1999, 19) stated, the media is “society’s most significant cartographic gatekeeper and most influential geographic educator.” Precisely because media maps are so influential, it is essential to examine them not only critically but also as relational processes that are connected to other maps and discourses (Culcasi 2006). For example, Kitchin, Gleeson, and Dodge (2013, 488) found that after publishing their academic mapping of “ghost estates,” or vacant homes in Ireland, “the mapping then started a new life” in the media. Different media outlets modified their ghost estate maps (most notably from dot-distribution to choropleth maps) to emphasize the counties in which the problem was most acute. Likewise for acid rain, the media remapped Cogbill and Likens’s academic maps and gave them new lives, emphasizing where acid rain was most acute and problematic.

By the late 1970s, ecologists had made considerable progress in detailing the environmental implications of acid rain, and several international conferences helped to build scientific knowledge on the linkage of acid rain to environmental impacts such as acidified lakes and streams (Cowling 1982). Nevertheless, it was not until the publication of an October 1979 article in *Scientific American*, the oldest and most widely read popular science publication, that the media and congressional attention to acid rain began. While Likens and his colleagues wrote the text to the *Scientific American* article and provided data for the maps, a professional graphic artist on staff at *Scientific American*, Andrew Tomko, did the remapping.\(^{10}\)

The *Scientific American* article displayed, side-by-side, two large-format (nearly full-page) acid rain maps: one remapping of European data (map not shown here) and another remapping of North American data (Figure 3). Each map used red and black isoplats to show how the distribution of acid rain changed over time; red isoplats indicated the most recent data (from 1975–1976) and black isoplats indicated the 1955–1956 data that were published in Cogbill and Likens (1974). This remapping also used red shading to indicate “acid-sensitive areas,” or areas with a low ability to neutralize acids. For the first time on one image, this remapping showed that acid rain had expanded in geographic scope and intensified over time. Further, this map also showed for the first time that the most intense acid rain was not only falling on heavily populated regions (e.g., New York) but also that acid rain was falling on acid-sensitive regions (e.g., the Adirondack Mountains of New York). Relative to black-and-white academic maps (e.g., Figure 2), the use of red coloring helped facilitate the idea that acid rain was an imminent threat. Thus, this media remapping was influential in helping to construct acid rain as an acute environmental crisis with a very specific geography.

Other media outlets immediately noticed this *Scientific American* article and map. We searched for the term “acid rain” in the *Reader’s Guide to Periodical Literature Retrospective* and found thirty-one articles published before the APA was passed on 30 June 1980. Of these thirty-one articles, eleven included maps, and most of these were remapped from the *Scientific American* map. Additionally, using Lexis-Nexis, we searched major U.S. newspapers for reports on “acid rain” and found 158 reports published before the APA. Of these 158 reports, we found that 130 were published in the nine months following the October 1979 publication of the *Scientific American* article and map. Most of the 130 newspaper articles explicitly mentioned the *Scientific American* maps, and many included their own remapping. This prevalence of maps in the print media is remarkable. Maps are much less common than other graphics (i.e., photos or cartoons) in the print news, greatly because of the expense and expertise that is often associated with making maps (Monmonier 1999). The remarkable prevalence of media maps on acid rain is a testament to the central role of maps in framing and coconstituting environmental debates (Cosgrove 2008a, 2008b).

Two maps from influential print mass media sources are illustrative of how the media used maps to help construct acid rain as a multiscale geographic crisis. First, a 22 October 1979 *Newsweek* article entitled “Death in the Sky” (Gwynne, Hager, and Carey 1979) discussed the impending danger and doom of acid rain for the Eastern United States. This article included a map titled “Pollution and Acid Rains” (Figure 4). This *Newsweek* map used gray shading to demarcate the “areas of acid rain,” which included all land within the 2.5 microequivalents per liter isoplats on the *Scientific American* map. By removing all other isoplats and eliminating the acid-sensitive areas that were in the *Scientific American* map, this simplified and generalized remapping implied that a broad swath of the Eastern United States was uniformly affected by acid rain. Additionally, in a darker shade of gray, the map showed the main source areas of acid rain pollution.
In doing so, the map, like the article, placed blame on the Ohio Valley and large urban areas for causing acid rain. By assigning blame, remappings like this one that specifically located the polluters elevated the contentiousness of the acid rain issue. This Newsweek article and map helped constitute the frame that much of the Eastern United States was threatened by acid rain and that the polluters in potentially far-off states or cities were to blame.

Second, a 6 November 1979 feature article in the Science Times of The New York Times included an article and map (Figure 5) that likewise constructed the issue of acid rain as a present and certain threat. The map was built from the Scientific American maps but used a stylized “relief” map of stacked isoplats to aid interpretation of where acid rain was more intense. The threat of acid rain is powerfully portrayed as a huge ominous cloud, forming directly from power plants and automobiles and looming over the continental United States. By expanding the geographic scope to include the entire continental United States, this map suggested that acid rain was a national issue, while also dramatically emphasizing the abnormally high levels of acidity in the Northeast, compared to the low levels in the rest of the country.

Coincident with these media remappings, many editorial articles in media outlets such as The New York Times, The Washington Post, The Christian Science
Monitor, and The Smithsonian made explicit reference to acid rain maps and then went on to call for congressional action. As has been well documented, the media often serves as a congressional “agenda setter” for environmental issues (Bendix and Liebler 1991; Ader 1995), and the extensive media attention on acid rain helped prompt three congressional hearings on the issue. During these hearings, the electric power industry provided their own remappings.

Industry Mapping
During the congressional hearings on acid rain, the electric power industry sought to cast doubt on the
many academic acid rain maps that were being presented as evidence. In his testimony to the U.S. Senate on 19 March 1980, the Director of Environmental Assessment for the Electric Power Research Institute, Ralph M. Perhac, critiqued the methodology that Cogbill and Likens used to create their highly influential map (Figure 2). In addition to the preceding epigraph, Perhac argued, “We do not have a sound scientific basis for defining whether or not the acidity of precipitation is truly increasing.” He then offered as evidence a new map produced in a study funded by his organization (Figure 6). This map was later published in *Science*, where the article claimed the map to be the first legitimate acid rain map: “For the first time in two decades, the United States has begun to produce a body of data that can be used to examine the chemistry from individual storms as they move across the eastern part of the country” (Pack 1980, 1145).

Compared to previous academic maps that actually did summarize the previous three decades of research on acid rain (e.g., Figures 2 and 3), this new industry-funded map was markedly different. First, the industry chose to map sulfate concentrations. Although sulfate is a precursor to acid rain, it carries far less connotation of danger or death than acid itself. Second, by switching to mapping sulfate, the location of the isobars shifted upwind, and the apparent epicenter of
Acid rain map produced by a study funded by the Electric Power Research Institute. Along with other maps (e.g., Figure 2), this map was used within congressional hearings in early 1980 and was later published in Science (Pack 1980).
action on acid rain. There were numerous, complex processes that constructed the environmental issue of acid rain. The biophysical processes that academics observed were constructed into the issue of acid rain as they intersected political discourses and economic interests (Herrick and Jamieson 1995). As we highlighted throughout this article, the process of mapping was integral to all stages of the construction of acid rain as an environmental issue. Mapping helped people see the unseen threat of acid rain. It enabled people to conceive of the multiscale nature of acid rain—the localized sources of emissions and the regions of the country that were most threatened. The process of mapping effectively worked in connecting the localized phenomenon of emissions from power plants to broader regional effects like acidified lakes or eroding tile roofs. Thus, for the first time, an environmental issue was widely recognized as an inherently spatial and multiscale process.

By tracing the different maps and remappings of acid rain, and following how they built upon and even questioned one another, we can see, as Del Casino and Hanna (2006, 47) argue, that “maps, though never final, never determinate, and frequently contentious, still wield influence and do work in the world.” As we have shown, none of the maps presented here represented some definitive statement about the extent or threat of acid rain. Instead, these maps were relational and built on one another. Academic maps provided key data sources for future maps that took on “a new life” in the media (Kitchin, Gleson, and Dodge 2013, 488). In the media, these new maps helped launch and frame a public debate over the threat of acid rain. In this public debate, the remapping from the electric power industry then provided a rhetorical counterpoint. By analyzing these maps in relation to one another, as well as in relation to the political context of the time, we show that these maps were not static representations of some scientific reality but that they worked as an integral part of the continuous and contingent process that constructed the environmental issue of acid rain.

Our examination of mapping acid rain can be particularly instructive for other multiscale environmental issues, like climate change. As it did with acid rain, we suggest that mapping also holds tremendous potential for linking localized causes like automobile tailpipe emissions to global implications like sea level rise. As observed by Monmonier (2008, 131) in his book *Coastlines*, maps are already forcing policymakers in coastal states to pay attention to climate research. Considering how influential mapping was for acid rain, we are encouraged that mapping can be a productive part of the dialog on climate change. We urge increased critical engagement and participation with mapping climate change from all institutional settings—from academia, the media, and industry, as well as other settings such as community-based participatory mapping (Valdivia et al. 2010).

Although climate change and other multiscale environmental issues are the more obvious parallels to acid rain, there are numerous other complex societal issues in which mapping plays an essential role. Our analysis of maps within the issue of acid rain serves to amplify a call made by Dodge and Perkins (2008) urging increased critical engagement with map production and use. Maps play key roles in decision making on a wide range of social issues (Dodge, Perkins, and Kitchin 2009). And, compared to the time period of our study, the now ubiquitous and instantaneous access to mapping technologies has likely only served to intensify and further entrench the role of maps in decision making. Thus, we suggest that our critical examination of mapping acid rain can provide a useful model for further studies seeking to draw out how the process of mapping helps construct other societal issues.

**Notes**

1 We use the term _acid rain_ throughout this article because it was the term used during the time period of our study. Acid rain is now understood as part of the broader process of acidic deposition. Briefly, acidic deposition is caused by the emission to the atmosphere of acid-forming pollutants, primarily SO2 and NOx, through the combustion of fossil fuels or other industrial processes (e.g., metal smelting). Once emitted, these acid-forming pollutants are oxidized and hydrolyzed in the atmosphere to form sulfuric and nitric acids that fall to the ground in the form of precipitation, cloud-water mist, and dry deposition.

2 Three long, multiday hearings were held in Congress: (1) “Acid Rain”: Hearings before the Subcommittee on Oversight and Investigations of the Committee on Interstate and Foreign Commerce, House of Representatives, 26 and 27 February 1980, Serial No. 96-150; (2) “Environmental Effects of the Increased Use of Coal”: Hearings before the Subcommittee on Environmental Pollution of the Committee on Environment and Public Works, U.S. Senate, 19 March, 21 and 24 April 1980, Serial No. 96-H45; (3) “Effects of Acid Rain”: Hearings before the Committee on Energy and Natural Resources, U.S. Senate, 28 May and 21 June 1980, Serial No. 96-126.

3 We use the term _remapping_ to emphasize the ways in which maps build on one another.

4 We use the term _process of mapping_ to refer to the multiple contexts of map production, the social and political discourses that frame map production, and how people encounter and interpret maps. This term is meant to be broad in meaning to emphasize the ways in which maps are part of many interconnected processes. Throughout this article, we often use the term _mapping_ as shorthand for process of mapping.

5 Wood and Fels (2008), Peluso (1995), and Scott (1998) all highlighted the highly political act of mapping nature, but these studies do not focus on environmental issues per se.

6 Emphases on the process or practice of mapping echo the movement of many artists to reject aesthetics as the defining criteria of their work and instead define their art by the creative processes and practices of creation. In both cases it is not the final product but the process that leads to the product that matters (Cosgrove 2005).

7 Measured pH below a value of 5.6 can only be due to the dissociation of strong sulfuric and nitric acids, which are principally contributed to the atmosphere by burning fossil fuels. Because of the logarithmic nature of pH, the mapped value of 5.52 is more appropriate on these maps,
so subsequent intervals of 10 µeq/L would retain round number pH values. Hydrogen ion (H⁺) microequivalents per liter (µeq/L) directly translate to pH via: H⁺/µeq/L = −log (pH).

8 Interview with Likens by the first author at Hubbard Brook Experimental Forest, New Hampshire, on 9 July 2004.

9 E-mailed responses by Cogbill to interview questions from the first author on 23 February 2004.

10 Interview with Likens on 9 July 2004.


12 Quote from testimony on 19 March 1980, 86. See note 2 for full citations.

13 For a useful review on the acid rain debate since 1980, see Herrick and Jamieson (1995).

Literature Cited


Carolan, M. 2009. “This is not a biodiversity hotspot”: The map reader: Theories of mapping practice and cartographic representation. West Sussex, UK: Wiley.


BRENDE E. McNEIL is an Assistant Professor in the Department of Geology and Geography at West Virginia University, Morgantown, WV 26506. E-mail: bemcneil@mail.wvu.edu. His research uses field work, remote sensing, and geographic information systems to explore how atmospheric deposition and other drivers of environmental change affect spatial patterns of nutrient cycling within forest ecosystems.

KAREN L. CULCASI is an Assistant Professor in the Department of Geology and Geography at West Virginia University, Morgantown, WV 26506. E-mail: karen.culcasi@mail.wvu.edu. Her research uses critical cartographic and feminist geopolitical frames to examine contested places and identities, particularly in the Arab world.