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Risk, Stress, and Capacity

Explaining Metropolitan Commitment to Climate Protection

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Climate change and mitigation policies adopted by a locality indelibly impact urban form, landscape, and economy. The Cities for Climate Protection (CCP) has become a dominant movement organizing the localities to proactively address climate change. This study examines metropolitan area commitment to the CCP. Geographic information systems (GIS) and statistical techniques are used to analyze metros on dimensions of climate change risk, stress, and civic capacity. "Climate change risk" measures a metro area's coastal proximity, ecosystem sensitivity, and susceptibility to extreme weather events. "Climate change stress" summarizes transportation, energy, and production practices that adversely affect climate systems. "Civic capacity" estimates human capital and environmental concern variables that constitute a metro area's ability to commit to policy initiatives. Statistical results indicate that high stressor areas are significantly less likely to participate in the CCP campaign, and metros high in civic capacity are significantly more likely to commit to the CCP campaign.

Keywords: *Climate change risk; stress; civic capacity; Cities for Climate Protection*

In the United States, over 100 localities have joined the Cities for Climate Protection (CCP) campaign sponsored by the International Council for Local Environmental Initiatives (ICLEI). The CCP campaign is a voluntary program in which approximately 675 municipalities globally take initiatives to mitigate the adverse impacts of climate change (ICLEI 2005). Officials in

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participating localities enact policies intended to reduce local greenhouse gas (GHG) emissions, such as promotion of public transportation and use of efficient energy sources (Betsill 2001; Betsill and Bulkeley 2004). In the United States, participating localities account for an estimated 19.63% of all carbon dioxide emissions generated annually.[1] To the extent that participation in the CCP campaign reduces a locality's climate change footprint, the collective benefits of this local policy initiative are sizable.

However, from a collective action perspective, it is irrational for a local government to assume the costs of climate change protection because reduction of local emissions will not fully protect a locality from the transboundary effects of global climate change; the costs of climate change mitigation are significantly higher than the expected benefits when participation in the CCP campaign is voluntary and commitment levels are low; the collective benefits of climate protection are nonexcludable and nonrival; and no federate mandate or significant assistance for the implementation of climate change protection programs exists. In fact, the U.S. Congress prohibits use of federal monies for programs defined as implementing the Kyoto Protocol before ratification (Betsill 2000). In response to this issue, our study empirically examines the reasons why local governments in U.S. metropolitan areas would voluntarily commit to the CCP campaign when powerful incentives favor nonaction.

To address this research question, we investigate selective incentives for CCP campaign participation that correspond with a metropolitan area's physical location, natural capital, production and transportation modalities, and socioeconomic characteristics. Using geographic information systems (GIS) analytic techniques, we map and measure a metropolitan area's vulnerability to climate change "risk," the amount of "stress" it imposes on climate systems, and its "civic capacity" to commit to climate change policy initiatives. This approach allows us to (1) empirically test propositions by environmental social scientists on the determinants of climate policy action; (2) statistically analyze risk vulnerability, stressor activities, and civic capacity variables that predict variation in CCP campaign participation; and (3) provide direction to planners and policy makers on how to widen local involvement in initiatives meant to reduce the expected impacts from global warming and climate change.

Our investigation of climate change risk, stress, and civic capacity variables to predict metropolitan area involvement in the CCP campaign is organized into four sections. First, we provide a brief background on the CCP campaign, review relevant literature, and delineate testable hypotheses derived from theories of collective action. Second, we detail our research design, including discussion of secondary data collection, variable operations, and data analysis procedures. Third, we present and discuss descriptive, geographic, correlation, and multiple regression results. In the final section, we discuss the policy implications of results and provide suggestions for future research to enhance understanding of how risk vulnerability and social structural measures influence local public policy outcomes on global climate change.

CCP, Collective Action, and Selective Incentives

World population is becoming increasingly urbanized. The Population Reference Bureau (2005) estimates 411 urban conurbations globally with 1 million or more inhabitants. A significant percentage of human activities that contribute to climate change predominate in large metropolitan areas (Betsill 2000). In 1991, to address the problem of metropolitan contribution to climate change, the ICLEI launched the Urban CO_2 Reduction Project (UCRP) to coordinate the CO_2 reduction efforts of 14 municipalities in Canada, the United States, and Europe. Under UCRP, municipalities achieved significant reductions in CO_2 emissions and made efficiency gains in economic output (Betsill 2000; Bulkeley and Betsill 2005). For example, through energy efficiency, urban reforestation, diversification of transportation, and recycling and waste prevention initiatives, officials in St. Paul, Minnesota, reduced CO_2 emissions by 940,000 tons (exceeding Kyoto Protocol objectives) and saved the local economy an estimated $59 million (St. Paul Energy Conservation Project 2005) in energy, transport, and waste management expenditures.

In 1993, the ICLEI officials transformed the UCRP into the more ambitious CCP campaign. The stated mission of the campaign is to enlist "cities to adopt policies and implement measures to achieve quantifiable reductions in local greenhouse gas emissions, improve local air quality, and enhance urban livability and sustainability" (ICLEI 2005). The CO_2 reduction target set for cities is a 20% cutback from 1990 levels (Collier and Lofstedt 1997; Betsill 2000). This "Toronto Target" is significantly more ambitious than the standards set by the Kyoto Protocol (Van Kooten 2003; Betsill 2000). With 675 municipalities globally working toward this reduction target and a reported 10% annual increase in the rate of local government participation (ICLEI 2005), the CCP campaign has the potential to significantly reduce the adverse effect of climate change. In 2002, on the basis of the ICLEI 2000 figures, the U.S. Environmental Protection Agency (EPA) reported an annual savings of $70 million in reduced fuel and energy costs along with preventing emissions of more than 28,000 tons of criteria air pollutants by action of only 68 cities and county members (Environmental Protection Agency 2002).

To join the CCP policy enterprise, a locality must pass a resolution or issue an executive decree binding it to the reduction of GHG emissions. The CCP campaign uses a performance-based approach structured around five milestones that localities commit to undertake (Strengers 2004). The milestones move localities from a baseline inventory of emissions to the adoption of targets to the elaboration and implementation of action plans accompanied by standardized progress reports (ICLEI 2005). The administrative costs of campaign involvement vary by the size and complexity of the local government, the nature and pace of plan enactment, and whether officials can galvanize community and private support to subsidize plan initiatives.

Because participation in the CCP campaign is voluntary, coordinated action across localities to mitigate the risks of climate change poses a collective action dilemma. CCP campaign initiatives produce collective and selective costs and benefits that are market and/or nonmarket in nature (Griffin 2003). A collective benefit of participation in the CCP campaign is the reduction of aggregate CO_2 emissions—a major cause of climate variability in the last century (Oreskes 2004). With greater climate stability, the expected impacts of climate change on terrestrial and marine ecosystems, infrastructure, and patterns of human mortality are reduced.

The problem with such collective benefits is that they cannot be withheld from nonparticipants in the CCP (Lubell et al. 2006). The nonexcludability of collective benefits significantly undermines incentives to participate, leading to suboptimal provision of policy goods (Olson 1971). Absent a coercive authority to monitor and sanction behavior, voluntary endeavors such as the CCP campaign are more likely to succeed if metropolitan areas accrue selective benefits from participation. In Mancur Olson's (1971) words, "Only a *separate and 'selective' incentive* will stimulate a rational individual in a latent group to act in group-oriented ways" (p. 51; italics in the original). Despite this dilemma, collective action to address climate change in the United States is necessary because the costs of climate change action are not likely to be assumed by individual units of local government when the incentives to participate are so weak and climate change issues are inherently transboundary in nature. Incentives for regional intergovernmental collaboration might be stronger if costs can be shared by several jurisdictions and there is already well-developed metro civic capacity. For example, Council of Governments (COGs), metropolitan transportation authorities, regional planning councils, strong county-level governments, and other regional policy making mechanisms may help overcome the problem of nonexcludable benefits.

Scholars note that the expected ecological, social, and economic impacts of climate change are geographically uneven (Mendelsohn, Nordhaus, and Shaw 1994; Mendelsohn et al. 2000). From a global standpoint, warming trends are selectively harmful to coastal, maritime, and low-lying island societies where the risks of sea level rise/inundation could render coastal settlements uninhabitable (Titus 1986). Likewise, there are potential beneficiaries to climate change (De Leo et al. 2001). Because climate models show an amplification of warming at the poles, northern Canada may benefit economically from warming trends with increased shipping activity because of deeper ports and longer navigational seasons (Watson, Zinyowera, and Moss 1997).

In the United States, climate change impact studies forecast regional differences in economic growth, loss of habitat, species, and sensitive ecosystems, costly disruptions to water supply, increases in extreme weather events and weather-related mortality, and even region-specific disruptions to recreational activities (Watson, Zinyowera, and Moss 1997; Scheraga and Grambsch 1998). Assuming uniform change across climate divisions, Mendelsohn (2001) finds that the costs of climate change to market sectors in agriculture, forestry, energy, and water are highest in the Southeast, South Plains, and Southwest, with relative economic gains for Midwest and Northeast regions of the country. Insofar as governments are rational, their willingness to participate in policy solutions to mitigate and adapt to climate change may be geographically determined by the selective risks they face (Goulder 2003; Victor 2003).

Most climate policy initiatives focus on reduction of CO_2 in the atmosphere but also include restricting development in floodplains and sub-sea-level elevations, preventing the buildup of fuel loads in forests and insulating vulnerable coastal communities with dikes and sea walls (Titus 1986, 1998). These policy instruments are designed to increase the resilience of human and natural systems to climate change and variability. However, involuntary policy instruments may create as many distributional problems as they solve. For example, efforts to curb greenhouse gas emissions may impose a greater burden on carbon-intensive societies where the abatement/compliance costs are significantly higher (Edmonds and Sands 2003; Zahran et al. 2007). Likewise, low-altitude coastal settlements stand to benefit disproportionately from the enactment of policies to attenuate the risks of climate change. Therefore, the willingness of a government to support a climate policy solution may also be geographically determined by the relative distribution of costs and benefits that accompany policy action.

Thus, Olsonian selective incentives for participation in the CCP campaign may spring from the uneven geographic distribution of expected costs and benefits of climate policy action or inaction. We investigate three sources of place-based selective incentives that may explain variation in metropolitan commitment to the CCP campaign: (1) the extent to which a metropolitan area is vulnerable to *climate change risks* as a function of its coastal proximity, susceptibility to extreme weather events, and abundance of natural capital in terms of wetland and forest cover (Watson 2001); (2) the extent to which a metropolitan area imposes *stress* on climate dynamics as a function of CO_2-intensive industrial activities, transportation, energy use, and population densities that may selectively inhibit participation (Saporito 1992; Collier and Lofstedt 1997; Betsill 2000); and (3) the extent to which a metropolitan area is civically equipped to commit to the CCP campaign as a function of levels of human social capital and demonstrated concern for the environment (Lubell et al. 2006).

Research Design

Unit of Analysis

Because climate change is largely a regional phenomenon in terms of impacts, stressors, and the civic capacity to deal with these issues, we selected the metropolitan statistical area (MSA) as the unit of analysis for this study. For example, an estimated 78% of global CO_2 emissions emanate from metropolitan areas (Betsill 2000); vulnerable populations, social networks, and economies tend to congregate at a regional level rather than within a single jurisdiction. An MSA is an ideal unit to capture this phenomenon because it is a population cluster, together with adjacent localities having a high degree of economic and social integration. To be classified formally as an MSA, a population cluster must have a core urbanized area of 50,000 or more inhabitants and a total population of more than 100,000 inhabitants. As areas of integrated social and economic activity, climate policies adopted by any government or administrative unit within an MSA necessarily implicate other jurisdictions within the same MSA. We therefore estimate the climate risk, stress, and civic capacity characteristics of MSAs as a surrogate for explaining the adoption of climate change mitigation policies by local jurisdictions within the MSAs, such as counties, cities, and towns.

Dependent Variable

The dependent variable, *CCP campaign involvement*, is a ratio measure of the number of persons in a metropolitan area that reside in a jurisdiction (county, city, or town) committed to the CCP campaign divided by the total number of persons residing in a metropolitan area (see Table 1 for a summary of variable operations). On a scale of 0-1, higher scores will represent a greater commitment by the MSA to climate change policies. Officials at the Local

Table 1
Variable Operations, Data Sources, and Expected Direction on CCP Campaign Involvement

Variable	Variable Definition	Data Source	Sign
Climate risk variables			
Precipitation	Total precipitation in excess of normal levels (1991-2000) in a metro area. Total excessive precipitation was calculated for grid cells from yearly average data. Grids in a metro were averaged.	Spatial Climate Analysis Service, 1980-2000 (2006)	+
Hazards casualties	The sum of all the deaths and injuries from weather-related extreme events from 1991 to 2000 in a metro area.	Spatial Hazard Events and Losses Database for the U.S., 1991-2000 (2006)	+
Coastal area	Calculated as the percentage of metropolitan coastal area at or below 3.5 m above average sea level.	Environmental Protection Agency Low Lying Coastal Area Map (1995)	+
Eco-sensitive area	Medium resolution vector land use data was intersected with metro area boundaries, with the combined percentage of forests and wetlands totaled for each metro area.	National Oceanic and Atmospheric Administration (1999)	+
Climate stress variables			
Population density	Total number of persons in metropolitan area divided by the total land area of the metro (square kilometers).	Census Bureau (2000)	+
Carbon employment	Total civilian population 16+ years in a metro area employed in agriculture, forestry, mining, construction, manufacturing, transportation, warehousing, and utilities divided by the total employed population 16+ years in a metro area.	Census Bureau (2000)	–
Travel alone	Number of workers 16+ years in a metro area that travel to work alone in private vehicles divided by the number of workers 16+ years in a metro area.	Census Bureau (2000)	–
Solar energy use	Number of households that use solar energy for heating purposes in a metro area divided by the number of households.	Census Bureau (2000)	+

(continued)

Table 1 (continued)

Variable	Variable Definition	Data Source	Sign
Civic capacity variables			
Environmental cause	Total number of adults in a metro area that participated in an environmental cause in the last 12 months, divided by the total number of adults 18+ years in a metro area.	Mediamark Research Inc. Consumer Behavior Survey (2003)	+
Income	Total number of persons in a metro area in the 80th percentile of annual income divided by the total number of persons in a metro area.	Census Bureau (2000)	+
College educated	Total number of persons in a metropolitan area 25+ years with a bachelor's, master's, professional, or doctoral degree divided by the total number of persons 25+ years in a metropolitan area.	Census Bureau (2000)	+
Environmental groups	Total number of nonprofit organizations of tax-exempt status with $25,000 dollars in gross receipts required to file Form 990 with the IRS with an environmental focus (as defined in the NCCS taxonomy) in a metropolitan area.	National Center for Charitable Statistics (2003)	+
Dependent variable			
CCP campaign involvement	The number persons in a metro area that reside in a jurisdiction (county, city, or town) committed to the CCP campaign, divided by the total number of persons residing in a metro area.	Local Governments for Sustainability World Secretariat (ICLEI 2005)	

CCP = Cities for Climate Protection; ICLEI = International Council for Local Environmental Initiatives.

Governments for Sustainability World Secretariat in Toronto, Canada, were contacted to derive a valid list of participating localities. Of the 307 metropolitan areas examined (for which complete data are available), 67 had at least one jurisdiction committed to the CCP campaign as of November 2005. Several metropolitan areas had residents redundantly committed to the CCP campaign. For example, the metropolitan area of Santa Rosa, California, has numerous overlapping jurisdictions within it committed to the CCP, including Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma City, Sonoma County, and Windsor. Together,

Table 2
Descriptive Statistics of Independent Variables

	N	Minimum	Maximum	Mean	Standard Deviation
Dependent variable					
CCP campaign involvement	307	.00	100	10.6281	23.56661
Climate risk variables					
Precipitation	307	11719.50	203864.00	104000.28	34804.21
Hazards casualties	307	.00	4901.51	126.9510	333.49
Eco-sensitive area	307	.00	91.88	35.7309	26.39
Coastal area	307	.00	100.00	13.7290	28.30
Climate stress variables					
Population density	307	4.59	4124.97	158.5350	307.77
Carbon employment	307	12.30	57.67	27.5920	6.56
Travel alone	307	31.38	86.43	78.9552	5.55
Solar energy use	307	.0000	1.34	.0033	.0083
Civic capacity variables					
Environmental groups	307	40.00	2314.00	716.94	498.30
Income	307	6.68	52.71	18.00	7.25
College educated	307	26.99	64.52	52.35	5.39
Environmental causes	307	1.50	3.91	2.79	.46

these smaller political entities cover 100% of the population of Santa Rosa. Approximately 51.9 million U.S. residents reside in committed jurisdictions, constituting about 17.57% of the population. Descriptive statistics on CCP involvement and independent variables are presented in Table 2.

Climate Change Risk Variables

We measure and analyze four climate change risk characteristics that may selectively incentivize metropolitan area involvement in the CCP campaign: precipitation, extreme weather histories, coastal proximity, and ecosystem sensitivity. All measures of climate change risk are geo-referenced at the metropolitan scale. Our *precipitation* variable is measured as the total precipitation in excess of normal levels in a metropolitan area from 1991 to 2000. Annual precipitation data for the contiguous United States were downloaded from the Spatial Climate Analysis Service (2006). These data were created by interpolation of station data using a parameter-elevation regression on independent slopes model (PRISM). PRISM uses point data and a digital elevation model to generate grid estimates of monthly and annual precipitation. PRISM is suitable for localized analysis at the level of 2 km grids. Total excessive precipitation was calculated for each grid from yearly average data. In cases where multiple grid estimates intersect metropolitan boundaries, estimated values are averaged across intersecting grids. Insofar as higher observed cumulative precipitation for 1991 to 2000 results in increased climate awareness and perceptions of risk, we expect our precipitation measure to positively predict the percentage of persons in a metropolitan area governed by climate change mitigation and adaptation policies.

Our *natural hazard casualty* variable is measured as the total number of reported injuries and fatalities from natural hazard events at the county level and summarized for the MSA from January 1, 1991, to December 31, 2000. Higher values on our natural hazard casualty variable reflect more pronounced histories of injury and death from extreme weather events. Casualty data were collected from the Spatial Hazard Events and Losses Database for the United States (SHELDUS; 2006). As with our precipitation measure, insofar as localities regard future risk as a function of past risk, metropolitan areas with histories of natural calamity are perhaps more alert to climatic behavior and therefore more likely to undertake initiatives to address climate change.

Our c*oastal area* variable is measured as the percentage of metropolitan land area in EPA-defined at-risk coastal lands. Insofar as climate change induces considerable rise in average sea levels, coastal areas below 3.5 meters above average sea level are regarded as vulnerable to inundation by midcentury (Nicholls and Toll 2006). The EPA has prepared a detailed map of the U.S. coastline identifying regions ranging from 1 to 4 meters above mean sea level (Titus and Narayanan 1995). We use digital data to identify regions less than 3.5 meters above mean sea level. From a strictly rational choice perspective, metropolitan areas with a greater percentage of low lying coastal land have greater incentive to mitigate the expected climate change risk of water inundation and are therefore more likely to commit to the CCP campaign.

Our *eco-sensitive area* variable estimates that percentage of metropolitan land area covered by forests and wetlands. Scientists maintain that changes in regional climate may lead to changes in species composition and ecosystem behavior. Forests and wetlands are ecosystems particularly sensitive to climate change. Insofar as the expected loss of critical natural resources from climate change motivates policy behavior, metropolitan areas with a greater percentage of forest and wetland cover may have greater reason to join the CCP campaign. Percentages of forest and wetland cover are estimated with medium resolution vector land use data available from the National Oceanic and Atmospheric Administration's (NOAA) Coastal Assessment and Data Synthesis system vector data were intersected with metropolitan area boundaries to calculate coverage numbers.

Climate Change Stress Variables

We analyze four variables to estimate the degree to which metropolitan areas stress climate systems: population density, carbon employment, travel behavior, and solar energy use. All measures are derived from the U.S. Census Bureau's Population and Housing Files (Census Bureau 2000). *Population density* is measured as the total number of persons residing in a metropolitan area divided by the total land area in square kilometers. The logic of this measure is that urban density is a reasonable estimate of energy and resource efficiency. Higher density land uses are less consumptive. Transportation in high density areas is more efficient because of shorter distances traveled and the general availability of public transportation. Adjusted for population size, high density metropolitan areas impose lower stress on climate systems. Moreover, from a collective action perspective, low stressor areas (or areas of high population density) are more likely to commit to the CCP campaign because of the lower expected costs of climate policy enactment.

Carbon employment is measured as the number of persons 16 years or older employed in carbon dioxide intensive industries such as agriculture, mining, construction, manufacturing, transportation, and utilities divided by the total employed population 16 years or older in a metro area. Metropolitan areas with a high percentage of labor employed in carbon intensive industry impose greater stress on climate systems and are probably less likely to commit to policy mechanisms designed to reduce carbon dioxide emissions because of the potential economic harm done to local residents and commerce (Saporito 1992).

Our third climate stress variable estimates travel behavior. *Travel alone* is measured as the number of workers in a metro area that travel to work alone in private vehicles divided by the number of workers in a metro area. Vehicular use is a mobile source of climate stress. All things held equal, persons that travel alone to work impose greater stress on climate systems than persons that travel in groups. Policy solutions to reduce mobile sources of climate stress encourage group travel such as car sharing and use of public transportation. Metropolitan areas with higher percentages of persons that travel alone to work in private vehicles face greater transition costs in the enactment of policies that encourage group travel and are therefore selectively disincentivized to participate in the CCP campaign.

Last, we measure the use of solar energy in a metropolitan area as a low stress, more ecologically sustainable energy practice. *Solar energy use* is measured as the number of households that use solar energy for heating purposes in a metro area divided by the total number of households. We test whether metropolitan areas with higher solar energy use values are more likely to commit residents to the CCP campaign. All things held equal, metropolitan areas with comparatively high solar energy use face lower expected costs with regard to policy adoption. With lower expected costs, solar energy using metros are probably more likely to commit residents to CCP initiatives.

Civic Capacity Variables

As with climate change risk and stress variables, all measures of civic capacity are geo-referenced and summarized at the metropolitan scale. Two measures of environmental concern are used: percentage involvement in environmental causes and nonprofit environmental organization activity. The percentage involvement in the *environmental cause* variable is derived from the Mediamark Research Inc. (MRI) Consumer Behavior database (Mediamark Research Inc. 2003). Researchers at Applied Geographic Solutions Inc. have configured MRI household records to various levels of political, administrative, and statistical scales, using a mosaic coding technology based on a cluster algorithm (i.e., iterative relocation) to derive geo-demographic profiles of metropolitan areas (Applied Geographic Solutions Inc. 2006). Our *environmental cause* variable is measured as the total number of adult respondents indicating "yes" to a question on whether they participated in an environmental cause in the last 12 months divided by the total number of adults 18 years of age and older residing in a metropolitan area. Our *nonprofit environmental organization* variable is measured as the total number of nonprofit environmental organizations located in a metro area. Nonprofits are defined as organizations of tax-exempt status with $25,000 dollars in gross receipts required to file Form 990 with the Internal Revenue Service. Data are derived from the National Center for Charitable Statistics, core files, 2001.

Because of the significant correlation between human capital and willingness to support climate policy solutions (O'Connor, Bord, and Fisher 1999; Jaeger et al. 1993; O'Connor et al. 2002; Zahran et al. 2007), two human capital variables are included in our analysis: percentage college educated and percentage high income. Both measures are derived from the U.S. Census Bureau, Population and Housing Files (Census Bureau 2000). *College educated* is measured as the total number of persons in a metropolitan area 25 years and older with a bachelor's, master's, professional, or doctoral degree divided by the total number of persons 25 years and older in a metro area. *Income* is measured as the total number of persons in a metro area in the 80th percentile of annual income divided by the total number of persons in a metro area.

Table 3
Top 30 Metropolitan Areas on Percentage of Population Involved in the CCP Campaign

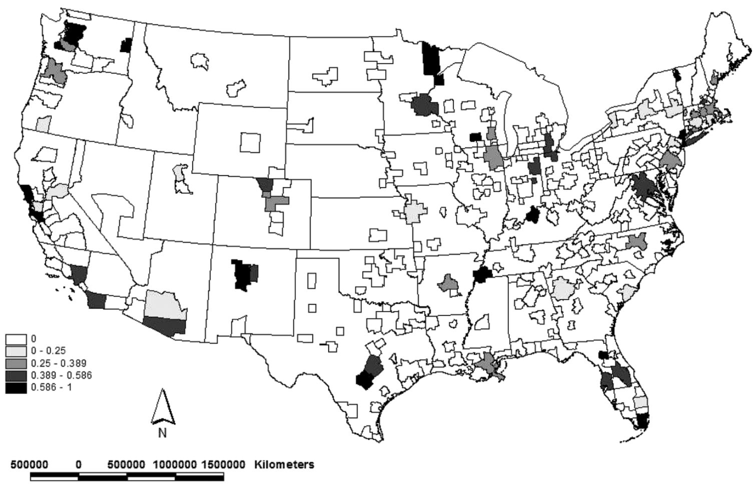
Rank	Metropolitan Area	State	CCP Population	Population Total
1	Gainesville	FL	1.000000	217,955
1	Honolulu	HI	1.000000	876,156
1	Louisville	KY	1.000000	1,025,598
1	Madison	WI	1.000000	426,526
1	Olympia	WA	1.000000	207,355
1	San Jose	CA	1.000000	1,682,585
1	Santa Rosa	CA	1.000000	458,614
1	Spokane	WA	1.000000	417,939
9	New York	NY	.976118	9,314,235
10	Burlington	VT	.865282	169,391
11	Duluth-Superior	MN-WI	.754671	243,815
12	Seattle-Bellevue-Everest	WA	.719383	2,414,616
13	San Antonio	TX	.718826	1,592,383
14	Miami	FL	.717860	2,253,362
15	Corvallis	OR	.631095	78,153
16	Albuquerque	NM	.629414	712,738
17	Memphis	TN-AR-MS	.599471	1,135,614
18	Missoula	MT	.595530	95,802
19	San Francisco	CA	.592107	1,731,183
20	Nassau-Suffolk	NY	.586314	2,753,913
21	Tucson	AZ	.576831	843,746
22	Muncie	IN	.567741	118,769
23	Ann Arbor	MI	.557931	578,736
24	Minneapolis-St. Paul	MN	.548111	2,968,806
25	Orlando	FL	.545035	1,644,561
26	Austin-San Marcos	TX	.525349	1,249,763
27	Toledo	OH	.507307	618,203
28	San Diego	CA	.500014	2,813,833
29	Barnstable-Yarmouth	MA	.495018	162,582
30	Fort Collins-Loveland	CO	.471789	251,494

CCP = Cities for Climate Protection.

Analysis and Results

Table 3 lists the top 30 metropolitan areas by the percentage of residents within an MSA involved in the CCP campaign. Results indicate that eight metropolitan populations are fully committed to the CCP campaign: Gainesville, Florida; Honolulu, Hawaii; Louisville, Kentucky; Madison, Wisconsin; Olympia,

Figure 1
Percentage Metropolitan Area Involved in the Cities for Climate Protection Campaign



Note: See Table 5 for index construction statistics.

Washington; San Jose, California; Santa Rosa, California; and Spokane, Washington. With the exception of San Jose, California, and Louisville, Kentucky, fully committed MSAs are small to middle range in population size. The top 30 list also includes many MSAs anchored by land-grant institutions such as the University of Vermont in Burlington, Washington State University in Olympia, Oregon State University in Corvallis, the University of Michigan in Ann Arbor, and Colorado State University in Fort Collins. Small- to mid-sized metros anchored by a flagship university appear more receptive to policy initiatives that protect the environment. The top 30 MSAs also consist of comparatively large metropolitan areas that consistently vote Democratic in presidential elections, including San Francisco; Austin, Texas; Los Angeles; and New York. From a geographic standpoint, as illustrated in Figure 1, highly committed metropolitan areas (in darker colors) appear to be disproportionately coastal or proximate to large water bodies, such as the Great Lakes. These committed MSAs concentrate in the Atlantic Northeast, Pacific Northwest, and the Bay Area of California; several are situated near the Great Lakes and Gulf Coast regions of the country.

Next we examine the influence of characteristics related to risk, stress, and civic capacity on the degree to which MSAs commit to the CCP initiative. Table 4 presents bivariate correlations between percentage CCP involvement and three groups of independent variables. The majority of independent variables examined are significantly (but modestly) associated with CCP involvement, where $p = < .05$. On climate risk measures, both the hazard casualties ($r = .134$) and coastal area ($r = .115$) variables are positively correlated with CCP involvement. MSAs with histories of human death and injury from extreme weather events also appear more likely to commit to the CCP plan. Similarly, MSAs that face greater risk from sea level rise/inundation (as a function of coastal proximity and relative elevation) appear responsive to the notion of climate change mitigation. Our precipitation and eco-sensitivity variables are statistically insignificantly related with CCP involvement, where $p = <.05$. Because the CCP campaign is a relatively new policy movement (with an unmeasured effect on climate change risk outcomes), one can safely assume causal direction in interpretation of climate risk variables.

All climate stress variables behave as expected. In terms of energy and resource consumption measures, correlation results indicate that more densely organized and energy efficient metropolitan areas are more likely to commit residents to climate change mitigation initiatives. Both population density ($r = .218$) and solar energy use ($r = .146$) measures correlate positively with metropolitan involvement in the CCP initiative. Conversely, as the percentage of persons employed in carbon dioxide intensive industries increases, the percentage of metropolitan residents involved in the CCP campaign decreases ($r = –.202$). Similarly, private vehicle use for work travel is negatively related to campaign involvement ($r = –.327$). From a political economic standpoint, the costs of climate change mitigation are decidedly higher for CO_2 and vehicular intensive MSAs.

All civic capacity variables are significantly associated with metropolitan area involvement in the CCP campaign. Variables that estimate the level of environmental concern in a metropolitan area behave as hypothesized. Results show positive a relationship between the percentage of residents involved in environmental causes ($r = .350$) and the degree of CCP commitment. Similarly, as the number of nonprofit environmental organizations in a metropolitan area increases ($r = .130$), the percentage of residents obligated by the CCP campaign also increases. Human capital variables of education ($r = .196$) and income ($r = .381$) are also positively correlated with our dependent variable. Metropolitan areas with higher percentages of college educated and

Table 4
Correlations Between CCP Campaign Involvement and Independent Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Percentage CCP (1)	1.000												
Climate risk variables													
Precipitation (2)	–.014	1.000											
Hazard casualties (3)	.134*	–.011	1.000										
Eco-sensitive area (4)	.040	.570*	–.030	1.000									
Coastal area (5)	.115*	.310*	–.018	.213*	1.000								
Climate stress variables													
Population density (6)	.218*	.073	.025	–.100*	.057	1.000							
Carbon employment (7)	–.202*	.003	–.087	–.066	–.207*	–.086	1.000						
Travel alone (8)	–.327*	.087	–.043	.019	–.189*	–.624*	.395*	1.000					
Solar energy use (9)	.146*	–.237*	–.037	–.084	–.004	–.021	–.138*	–.163*	1.000				
Civic capacity variables													
Environment cause (10)	.350*	.033	.014	.000	.126*	.140*	–.412*	–.176*	.197*	1.000			
Environment groups (11)	.130*	–.190*	.043	.019	.117*	.208*	–.076	–.350*	.025	.023	1.000		
Income (12)	.381*	.041*	.056	–.060	.144*	.336*	–.161*	–.293*	.094*	.723*	.145*	1.000	
College educated (13)	.196*	.218*	–.032	.132*	.065	.032	–.101*	.191*	.010	.557*	–.105*	.410*	1.000

Note: *Reject null hypothesis of $r = 0$. CCP = Cities for Climate Protection.
$p = <0.05$ (one-tailed).

Table 5
Reliability Statistics for Risk, Stress, and Capacity Indices

Index Items	Item Total Correlation	Alpha	Variance	SD
Climate change risk index		**.632**	**.7589**	**.576**
Precipitation	.565			
Eco-sensitive area	.484			
Coastal area	.295			
Climate change stress index		**.637**	**.7610**	**.579**
Population density	.425			
Carbon employment	.267			
Travel alone	.692			
Civic capacity index		**.796**	**.8555**	**.732**
Environmental cause	.762			
Income	.645			
College educated	.523			

high income residents appear more likely to assume costly climate change mitigation and adaptation reforms.

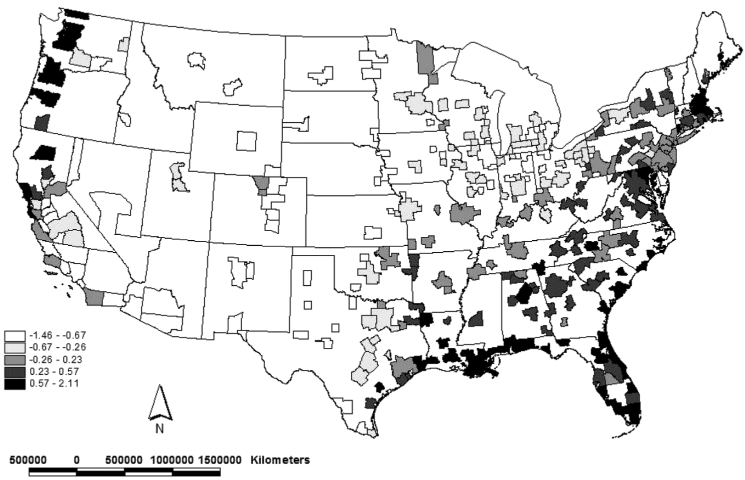
In the next phase of analysis, we simplify the number of factors examined by organizing variables into three statistically reliable indices. Reliability statistics are presented in Table 5. The climate change risk index (*alpha* = .632) averages standardized values (z scores) for precipitation, eco-sensitivity, and coastal proximity variables. The climate change stress index (*alpha* = .637) averages z scores for population density, carbon employment, and work travel measures. The population density variable is flipped to enable proper addition of climate stressor items. Finally, the civic capacity index (*alpha* = .796) averages standardized scores on citizen participation in environmental causes and human capital estimates of income and education.

Table 6 ranks the top 30 metropolitan areas on indices of climate change risk, stress, and civic capacity. Figures 2, 3, and 4 illustrate the distribution of these phenomena geographically—risk, stress, and civic capacity estimates are divided into quintiles, with darker colors reflecting higher values. On the dimension of climate change risk, Table 6 (column 1) and Figure 2 show that high risk metropolitan areas (at least one standard deviation above average) are located in the Gulf Coast, Florida Atlantic, and Northeast shorelines. On CCP campaign involvement, high risk metropolitan areas have about 15.5% of citizens committed compared to only 9.1% of residents from lower risk metros. This difference, though notable, is not statistically discernable from

Table 6
Top 30 Metropolitan Areas of Climate Risk, Stress, and Civic Capacity Indices

Rank	Metro Area	Risk	Metro Area	Stress	Metro Area	Capacity
1	Houma, LA	2.11	Elkhart-Goshen, IN	1.57	Stamford-Norwalk, CT	2.92
2	Tallahassee, FL	2.07	Kokomo, IN	1.49	San Francisco, CA	2.37
3	Miami, FL	1.98	Hickory-Morganton, NC	1.44	Danbury, CT	2.28
4	Jacksonville, NC	1.96	Sheboygan, WI	1.32	Nassau-Suffolk, NY	2.04
5	Bremerton, WA	1.94	Decatur, AL	1.31	Middlesex-Somerset, NJ	2.04
6	Wilmington, NC	1.90	Appleton-Oshkosh, WI	1.11	Washington, DC	1.95
7	Savannah, GA	1.85	Mansfield, OH	1.01	Boulder-Longmont, CO	1.91
8	Lawrence, MA-NH	1.76	Lima, OH	.97	San Jose, CA	1.82
9	New Orleans, LA	1.76	Wausau, WI	.95	Santa Fe, NM	1.78
10	Baton Rouge, LA	1.74	Decatur, IL	.95	Nashua, NH	1.73
11	Fitchburg-Leominster, MA	1.55	Rockford, IL	.95	Boston, MA-NH	1.68
12	Seattle-Bellevue, WA	1.55	Brazoria, TX	.95	Seattle-Bellevue, WA	1.64
13	Fort Lauderdale, FL	1.51	Fort Wayne, IN	.94	Bergen-Passaic, NJ	1.62
14	Daytona Beach, FL	1.38	Steubenville-Weirton, OH	.94	Oakland, CA	1.60
15	Eugene-Springfield, OR	1.37	Florence, AL	.93	Santa Cruz-Watsonville, CA	1.60
16	Naples, FL	1.36	Janesville-Beloit, WI	.91	Ann Arbor, MI	1.57
17	Santa Rosa, CA	1.34	Danville, VA	.90	Monmouth-Ocean, NJ	1.54
18	Biloxi-Gulfport, MS	1.31	York, PA	.89	Rochester, MN	1.54
19	Salem, OR	1.24	Fort Smith, AR-OK	.89	Santa Rosa, CA	1.49
20	Tacoma, WA	1.24	Wichita, KS	.88	Trenton, NJ	1.45
21	Fort Pierce-Port St., LA	1.22	Jackson, TN	.87	Madison, WI	1.44
22	Gainesville, FL	1.21	Grand Rapids, MI	.86	Newark, NJ	1.42
23	Pensacola, FL	1.18	Benton Harbor, MI	.85	Portsmouth-Rochester, NY	1.37
24	Bellingham, WA	1.18	Johnson City, TN	.85	Minneapolis-St. Paul, MN	1.36
25	Charleston, SC	1.16	Joplin, MO	.85	Hartford, CT	1.28
26	Ocala, FL	1.15	Green Bay, WI	.82	Portland, ME	1.27
27	Worcester, MA	1.13	Evansville-Henderson, IN	.81	New London-Norwich, CT	1.25
28	Sarasota-Bradenton, FL	1.09	Racine, WI	.79	Lowell, MA-NH	1.24
29	Lowell, MA-NH	1.08	Saginaw-Bay City, MI	.79	Bridgeport, CT	1.22
30	Jacksonville, FL	1.07	Greenville, SC	.78	West Palm Beach, FL	1.18

Figure 2
Distribution of Climate Change Risk for Metropolitan Areas in the United States

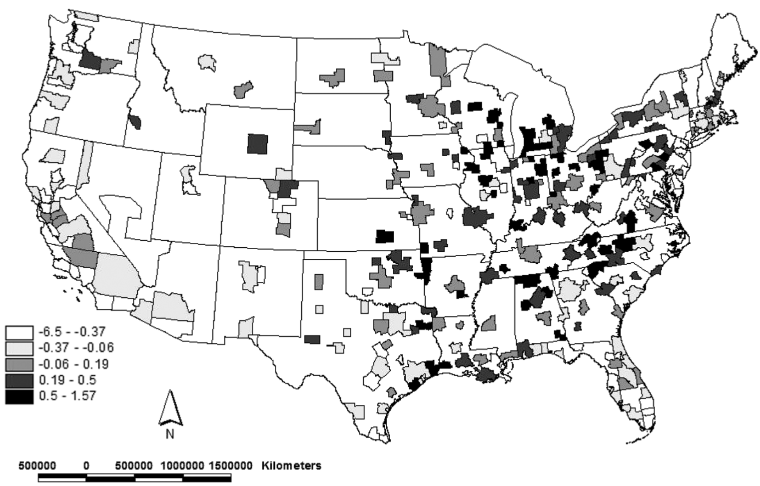


Note: See Table 5 for index construction statistics.

zero ($t = 1.486$, $p = .138$). A modest positive correlation ($r = .122$) is observed between climate change risk and civic capacity, where $p = <.05$.

Table 6 (column 2) and Figure 3 organize and rank metropolitan areas on anthropogenic stressors of climate change. High stressor areas predominate in so-called rustbelt states of Michigan, Indiana, Ohio, Pennsylvania, and Wisconsin, as well as the newly industrialized Southeastern states of Alabama and Tennessee. Generally, the top 30 stressor metros are involved in the automotive industry. Steel and car part manufacturers in Indiana, Pennsylvania, Michigan, and Ohio feed "Big Three" assembly operations in Detroit-Windsor and East Asian car assembly plants in Alabama and Tennessee. Descriptive results suggest that high stressor metros are less likely to undertake policy initiatives to reduce CO_2 emissions. Only one metro in the top 30 on climate stress, Fort Wayne, Indiana, has a percentage of its population committed to the CCP campaign. We also observe a significant negative correlation between our climate stress index and CCP campaign involvement ($r = -.322$, $p = .000$). Data also indicate insignificant covariance between climate stress

Figure 3
Distribution of Climate Change Stress for Metropolitan Areas in the United States

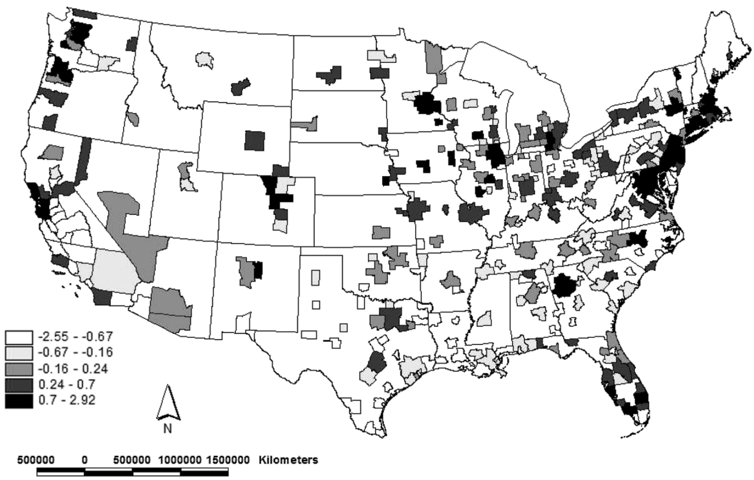


Note: See Table 5 for index construction statistics.

and climate risk (p = .186). Among top 30 stressor MSAs, risk levels are significantly lower when compared to lower stress metros (t = –2.567, p = .014). In fact, high stressor metros are among the least likely to be harmed by climate dynamics they disproportionately induce.

Table 6 (column 3) and Figure 4 summarize characteristics that theoretically increase the civic capacity of a metropolitan area to assume that costs of climate change policy initiatives. As mentioned above, capacity to act on local climate policy is estimated as an index of environmental concern and human capital items. Theoretically, if the concept of civic capacity is sensibly measured, it ought to be inversely related with climate change stress. Correlation results indicate that capacity and stress are negatively correlated (r = –.255, p = .000). With few exceptions, MSAs scoring high on civic capacity cluster geographically in the Atlantic Northeast, mirrored by a corridor of high capacity metros on the West Coast stretching from Southern California to the Pacific Northwest. Connecticut and California have the greatest number of metros appearing in the top 30 list.

Figure 4
Distribution of Civic Capacity for Metropolitan Areas in the United States



Note: See Table 5 for index construction statistics.

In the final stage of analysis, we test the degree to which indices of stress, risk, and civic capacity influence MSAs to commit to the CCP. Ordinary least squares regression results with unstandardized coefficients and standard errors are presented in Table 7. We ran six models, with numerous variable combinations tested. Coefficients are relatively stable across models. Based on the fully saturated model 6, approximately 20% of the variation in the percentage of metropolitan residents committed to the CCP campaign is explained by our suite of predictors. Results show that climate change risk is insignificantly correlated with CCP involvement ($\beta = .001$, $p = .977$). On average, the threat of sea level rise/inundation, ownership of natural capital in terms of sensitive ecosystems, and patterns of excessive precipitation provide insufficient motivation for MSAs to engage in climate policy reforms.

Conversely, the social and economic characteristics of a metropolitan area, as summarized in climate stress and civic capacity indices, significantly explain variation in CCP campaign involvement. As expected, climate stress is negatively associated with CCP campaign involvement ($\beta = -.249$, $p = .000$). Metropolitan areas with high dependence on CO_2 intensive industry, low

Table 7
OLS Regression Models Predicting Percentage Involvement in the CCP Campaign

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Climate change risk	.0050			.0034		.0001
	(.006)			(.005)		(.005)
Climate change stress		–.0320**		–.0318**	–.0240**	–.0240**
		(.005)		(.005)	(.005)	(.005)
Civic capacity			.0333**		.0279**	.0279**
			(.005)		(.005)	(.005)
(Constant)	.0336**	.0335**	.0323**	.0335**		.0325**
	(.004)	.(.004)	(.004)	(.004)		(.004)
Adjusted *R*-squared	.004	.108	.148	.106	.204	.202
Std. error estimate	.0733	.0693	.0677	.0694	.0654	0.0655
F-test	1.100	37.870	54.318	19.109	40.245	26.74
N	306	306	306	306	306	306

Note: Cell entries are unstandardized OLS regression coefficients, with standard errors in parentheses. Null hypothesis test of coefficient equals zero. CCP = Cities for Climate Protection.
**p = <.01.

population density, and less efficient transportation modalities are significantly less likely to commit residents to the CCP campaign. Again, these stressor characteristics are suggestive of the comparatively high cost MSAs face with regard to climate policy enactment. Such expected costs appear to selectively disincentivize metropolitan area participation in the CCP campaign.

Last, civic capacity is significantly and positively associated with metro involvement in CCP initiatives (β = .325, p = .000). As civic capacity increases, so too does the percentage of metropolitan residents committed to the CCP campaign. Our civic capacity index is the strongest predictor of indices tested, alone covering almost 15% of variation in our dependent variable (as shown in model 3). From a collective action perspective, officials in jurisdictions with high human capital and high percentages of residents involved in environmental causes derive selective benefits from participation in the CCP campaign by satisfying citizen preferences for climate protection.

Discussion and Conclusion

Based on the results of our study, several factors may influence MSAs to adopt or reject climate change policies, as measured by the degree of involvement in the CCP campaign. Specifically, those metropolitan regions contributing most to the problem through CO_2 emissions are the least likely to participate in the CCP. In general, MSAs most at risk from the adverse impacts of climate change, such as sea level rise, appear to be uninspired to adopt policy reforms when controlling for other factors. Finally, MSAs with high levels of civic and environmental capacity are the most likely to engage in the CCP.

These results signify a possible disconnection between those metros most vulnerable to the adverse impacts associated with climate change and those metros contributing most to the problem. The first aspect of this disconnect is spatial in nature. MSAs exacerbating the problem (i.e., stressor communities) are located in different areas of the country (mostly interior) than those metros most at risk from the negative consequences of climate change (mostly coastal). This spatial pattern creates a disincentive for stressors to adopt costly climate change mitigation policies because they are most likely to avoid the adverse impacts associated with climate change.

The second aspect of this potential disconnect may be perceptual. MSAs most at risk from the predicted adverse impacts of climate change (as summarized in our climate change risk index) manifest insignificant commitment to the CCP campaign, unless the risk signals are obvious, such as human casualties from natural hazards or large land areas vulnerable to sea level rise. As indicated in correlation results presented in Table 4, both natural hazard history and coastal proximity are positively associated with CCP campaign involvement. Another explanation for the general lack of interest in the CCP campaign by at-risk MSAs is that policy makers in these regions feel a lack of control over the problem since they are generally not the ones causing the problem (as indicated by the negative correlation between risk and stress indices). Moreover, the MSAs most committed to climate change reduction strategies have little to do with exacerbating the problem or being vulnerable to its consequences. For example, Stamford, Connecticut; Boulder, Colorado; and Santa Fe, New Mexico, are neither major stressors nor high risk MSAs. These metros commit to the CCP because of their strong socioeconomic and environmental activism profiles.

The apparent disconnect between climate change stress and risk could feed a collective action dynamic that may present the largest barrier for attaining a concerted climate change mitigation effort at the local/regional levels in the United States. The CCP campaign is designed to encourage localities and metropolitan areas to reduce anthropogenic sources of climate change, namely carbon dioxide emissions. Assuming that coordinated reduction of CO_2 emissions will intercept warming trends and corresponding expected risks, the collective benefit of participation in the CCP campaign is climate stability. Because climate is a transboundary phenomenon, the achievement of the collective benefit of climate stability requires near universal participation from metropolitan areas. Theoretically, near universal participation in the CCP campaign is complicated by the nonexcludability of collective benefits—that is, climate stability cannot be withheld from nonparticipants when involvement in a policy effort is voluntary and no central authority exists to reward or punish nonparticipants. To the extent that CCP metros can achieve climate stability, individual metros benefit from climate stability whether they participate in the CCP campaign or not. The nonexcludability of climate stability undercuts CCP campaign recruitment efforts.

Scientific evidence on the risks of nonaction (or allowing climate change to unfold unabated) and appeals to collective responsibility and intergenerational equity insufficiently motivate all local governments to participate. Moreover, economic forecasts indicate that some regions and metropolitan areas actually stand to benefit from climate change, deepening the recruitment dilemma (De Leo et al. 2001). Collective action theorists note that voluntary group enterprises are more likely to succeed if individual actors accrue material, psychological, or social rewards that outweigh participation costs in time, money, and energy. In other words, individual actors join groups if the net rewards of participation are greater than the net rewards of nonparticipation. In our study, we find that low stress plus high capacity can significantly tilt this narrowly defined rational calculation in favor of participation in the CCP campaign.

Given the apparent spatial and perceptual disconnect associated with metropolitan area adoption of climate change reduction initiatives, a more systematic effort across the United States seems unlikely. However, based on the results of our study, we recommend several strategies that may encourage populations to adopt the CCP or similar initiatives. First, local governments need to provide financial incentives for individual actors in stressor MSAs to adopt $C0_2$ reduction strategies. Tax incentives or cost sharing programs may encourage industry to take measures to lower emissions from stationary sources. Also, providing more extensive public transportation options may reduce the reliance on commuting in low occupancy vehicles that are a growing source of $C0_2$. Enhancing public transportation infrastructure is the domain of local planning agencies and regional transit authorities that need to collaborate to achieve an integrated system. Second, local governments need to boost their civic environmental capacity by initiating environmental awareness campaigns and directing more resources toward programs that engage the public in recycling, energy conservation, and public transportation activities. Third, local and regional governments need to better articulate the risks of climate change to all communities, including indirect costs that increase understanding of climate change as a transboundary, regional phenomenon. Communication strategies, including various streams of print and electronic media, school programs, workshops, festivals, and so forth, can help convey the importance of the risks of climate change and the opportunities to take concerted action. Participation by local residents can increase ownership over the problem of climate change and in turn leads to a collective commitment to address the issue.

While this study provides several insights into why metropolitan areas in the United States may commit to the CCP, it should be considered only a first step in examining the topic of policy adoption. First, we analyzed only a few indicators of stress, risk, and civic capacity. Future research should include additional measures for all categories of predictors and map them at a greater level of spatial specificity. For example, urban economic competitiveness and related measures of environmental amenities may also prove to be important predictors of climate change policy adoption. Also, other major sources of $C0_2$, such as airports, could also improve the statistical model. Second, our study was purposely focused on the MSA level. Future research should examine specific communities within these regions to better understand why some engage in climate change policy while others do not. Third, our analysis of every MSA in the United States provides important information at the broad statistical level but is limited when it comes to understanding local and regional contextual factors. Future research should select MSAs at both ends of the CCP commitment spectrum for case study analysis. This research approach will provide a detailed level of contextual understanding of the factors motivating CCP participation that broad statistical analysis cannot accomplish. Intensive case study research of interest groups and coalitions involved in climate change issues could reveal more about the motives of and pressures on localities to adopt climate change policies. Fourth, our study only examined the degree to which an MSA is involved in the CCP campaign based on a percentage of its total population. Additional study should be done on the specific policies these regions and associated jurisdictions have adopted and the degree to which they are being implemented throughout the community.

Note

1. No comprehensive carbon dioxide emissions data are available at the substate level. We use hazardous air pollutant (HAP) data (Environmental Protection Agency n.d.) at the county level as a proxy to estimate CO_2. For 1999, at the state level, we observe a .811 Pearson's correlation

between the total estimated annual HAP emissions in pounds (a sum of the major, area and other, on-road mobile, and nonroad mobile source emissions) and the state CO2 emission inventories from fossil fuel combustion (in millions of metric tons of carbon dioxide).

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