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THE DECISION-MAKING/ACCOUNTABILITY SPATIAL INCONGRUENCE PROBLEM FOR RESEARCH LINKING ENVIRONMENTAL SCIENCE AND POLICY*

PATRICIA SOLÍS, JENNIFER K. VANOS and ROBERT E. FORBIS, JR.

ABSTRACT. Increasingly, scholars engage policy makers around fundamental, complex questions on environmental change in interdisciplinary settings. Researchers attempting to develop robust contributions to knowledge that can support policymaker understandings in this context face significant inferential challenges in dealing with the spatial dimension of their phenomenon of interest. In this paper, we extend an understanding of well-defined methodological challenges familiar to applied spatial scientists by explicitly articulating the Decision-Making/Accountability, Spatial Incongruence Problem, or DASIP. Three case studies illustrate how spatial incongruences matter to researchers who work on complex, interdisciplinary problems, while seeking to understand decision-making or policy-related phenomenon: urban heat-island mitigation research in Arizona, water transfer conflicts in Kansas, and hydraulic-fracturing debates in Texas. With such examples, we aim to evoke a deeper understanding of this problem in applied research and also inspire thinking about how scholars might innovate methods for creating knowledge about environmental change that supports spatially accountable decision making. *Keywords: decision making, geographic methods, accountability.*

In an era of profound, complex, and uncertain environmental change, progressively more scientists and teams of scholars are working to engage policy makers and decision makers with the knowledge they create. This science-policy exchange—and that it is increasingly interdisciplinary—is an encouraging trend, but there remains a type of spatial methodological issue that has not yet been fully formalized. The kinds of modern environmental problems we face owe their complexity in no small part to the fact that answers to problems vary with, and depend on, the spatial scale of reliable data and subsequent analysis, as well as the rate of change for the given data. Researchers attempting to develop robust contributions to knowledge that can support environmental policy-maker understandings can face significant inferential challenges when connecting the spatial dimensions of their phenomenon of interest with the spatial dimensions of decision making.

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As an interdisciplinary team of authors, we seek to inspire an examination of these challenges by articulating the nature of a particular spatial methodological problem encountered in our applied work. We term this problem the Decision-Making/Accountability, Spatial Incongruence Problem (DASIP), and it builds upon two well-defined problems that are relatively widely known among applied spatial scientists, and to some extent, researchers in other disciplines: the Modifiable Areal Unit Problem, or MAUP (Gehlke and Biehl 1934; Openshaw 1983), and the Uncertain Geographic Context Problem, or UGCoP (Kwan 2012). In this article, we introduce and propose DASIP as a third unique methodological problem that we believe requires greater explicit scholarly attention in light of the increasing need for multidisciplinary research that provokes upfront thought on how to create and articulate scientific findings in a way that can connect with environmental policymaking. DASIP recognizes three challenges: the scale and spatial unit of the jurisdiction of decisions that are made may be incongruent with the data that influence those decisions; the impact of such decisions may affect and be affected recursively by behavior, discourse, and outcomes in yet different spatial areas of different scales; and, most importantly, the spatial unit and scale to which decision makers are held accountable for such decisions may furthermore be incongruent with either data, decisions, or impact. These challenges not only have a spatial scalar dimension, but a temporal one as well. In order to base decisions on future conditions, key actors must not only understand perceived risk, but also grasp the connections that cross geopolitical domains and that overlap with incongruous environmental boundaries, offered at a time scale appropriate for decision making and governance. Related to all three characteristics, short-term opportunities and threats are linked to longer-term dimensions; what action is implemented now will impact and be affected by a later phenomenon. Formulating the problem in this fashion provides new insight, because we can pay explicit attention to the part of the cycle where decision makers are held accountable, which is a spatial process in its own right.

Beyond Scale Mismatch

Scholars of various fields have independently identified aspects of the problem of a scale mismatch, yet have neither defined, nor articulated it with respect to the connections between science and policy that we seek to highlight with the spatial nature of the link between decisions and accountability for those decisions. Perhaps the most salient contextual framing of the need to spell out this problem as a practical rather than a theoretical one comes from Helga Leitner, Eric Sheppard, and Kristin Sziarto, who explore how multiple spatialities matter in the realm of contentious politics (2008). They refer to scale, place, networks, positionality, and mobility as factors that are implicated in the complex practice of social movements. Like Leitner and her colleagues, we argue for paying attention to the real, materiality of spatiality in taking a successful step

from research to practice, but we further seek to articulate the DASIP definition in recognition of the role of the "engaged" knowledge producer, that is, members of the research community who seek to inform decision-making processes with the most informative data possible, and proceed with defining DASIP as a specific methodological, rather than theoretical challenge.

We derive insights from work that has wrestled with spatial approaches in various disciplinary contexts, yet may still struggle to extend implications into the science-policy link because they lack the notion of linking decision making to accountability. This accountability is needed for decisions related to transportation, economics, health, environmental, and ecological applications See, for instance, Hannah Badland and others (2015) on meaningful geographic scales in urban policy health inequalities; Tim Schwanen and Donggen Wang (2014) on well-being and social capital; Russell Weaver (2014) on scale in urban electoral geography. The established terms of "scale mismatch" or "problem of fit" from the field of ecology are useful, as they point to the need to characterize links between scientific results and environmental decision making in a spatial context (Cumming and others 2006) and to understand the idea of scale itself as dynamic (Borgstrom and others 2006). Helene Ahlborg and Andrea Nightingale propose an approach using "triangulation for divergence," as a way to reveal where data sets do not match (2012). To remedy some of the shortcomings of the focus on spatial mismatch, Graeme Cumming introduces into this conversation the idea of the property of reflexivity, referring mainly to decision makers receiving feedback from their constituencies (2013). Such an idea pays no attention to the need to reflect upon the role of the researcher—or the person collecting the data—in the definition of such scales in the first place, which is an important consideration that DASIP may shed light upon.

Articulating the Problem

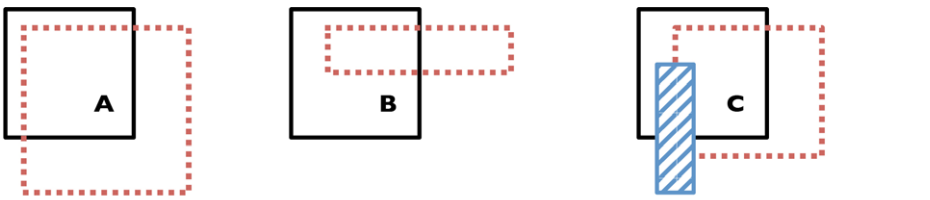
DASIP builds upon the widely understood fundamental methodological problem dealing with spatial data known as the Modifiable Areal Unit Problem, or MAUP (Gehlke and Biehl 1934; Openshaw 1983). This problem refers to a statistical bias in which results derived from spatial analysis are influenced by both the means in which point-based data is aggregated into areal units, and the size and shape of the districts into which that data is grouped. Despite nearly a century of scholarship exploring this problem, few generic and practical solutions exist to overcome or counteract this selection bias. The definition of this problem lies squarely with the agency of the researcher, as the focus is on the action of delimitation of the study.

A second perplexing methodological issue is covered by the Uncertain Geographic Context Problem, or UGCoP, which refers to a separate but related problem whereby analytical results about the effects of area-based attributes on individual behaviors or outcomes may be affected by the "spatial uncertainty in the actual areas that exert contextual influences on the individuals being

studied and the temporal uncertainty in the timing and duration in which individuals experienced these contextual influences" (Kwan 2012, 959). Likewise, since much about context of individual spatial behavior can never be completely known, there are few methodological fixes yet identified. The definition of this UGCoP problem shifts focus to the agency of the subject to explore behavior of those being studied as it relates to the analysis.

Like the MAUP and the UGCoP, DASIP derives from the analytical challenges of determining an appropriate spatial unit of analysis relative to the data, and furthermore attempts to incorporate spatial behavior characteristics from contextually disperse influences. DASIP is, however, a unique problem that recognizes the special nature of particular types of spatial behaviors that are not routine individual decision making. Beyond this, DASIP draws particular attention to the agency of special actors and sets of actors (such as elected officials, public administrators, stakeholders, CEOs) responsible for engaging in any decision-making process that potentially shapes or informs policy outcomes. Such dynamic interactions affect the public, and the impact is felt in a spatial unit, such as a jurisdiction. Yet the scale at which a decision maker is held accountable may or may not be congruent with the jurisdiction that authorizes this actor (see Figure 1).

The implications of the MAUP for decision making is that there exists a risk for conclusions to be drawn prematurely, and hence often the spatial



Representation of MAUP: geographic analysis of data from the thick black box can differ radically from analysis with boundaries depicted by the dashed-line (red) box, both ostensibly describing area "A".

Representation of UGCoP: geographic analysis of population area B using the thick black boundaries cannot fully account without uncertainty for all spatial behaviors of inhabitants who move across boundaries into areas depicted by the dashed-line (red) box, a source of contextual influences on area B.

Representation of DASIP: decisionmaker(s) with jurisdiction C depicted with thick black boundaries make decisions that impact locations in the dashed-line (red) bounded area, which can be incongruent with their jurisdiction. Furthermore, decisionmakers with jurisdiction C can be held accountable by only some constituents within the black box and can be made to answer to actors external to their jurisdiction, depicted by the shaded (blue) box.

FIG. 1—Comparison and evolution of the Decision / Accountability Spatial Incongruence Problem relative to the Modifiable Areal Unit Problem (Gehlke & Biehl 1934; Openshaw 1983), and the Uncertain Geographic Context Problem (Kwan 2012). [Color figure can be viewed at wileyonlinelibrary.com]

evidence available to justify or deny the decision using the areal unit that fits the conclusion, such as what happens in gerrymandering. The implications of the UGCoP for decision making include that conclusions might be drawn about a given population that does not take into account all of the key behaviors that this population engages in, and which may affect or be affected by that decision. One important implication for policymaking, and related to the necessity of articulating DASIP, is that there is a risk for conclusions to be drawn about a given population that do not include information about all of the individuals who may be affected by that decision, or that some decisions inaccurately account for other individuals for whom the decision is not being made. It also implies that conclusions risk missing key insights if the anticipated consequences to decision makers of being held accountable for their decisions are not taken into the picture, particularly when accountability does not coincide with the footprint of the expected impact. While this may not be a challenge relevant to all scientists working to understand spatial influences, to those seeking to link science with policy, this additional dimension of methodological problems can be significant and warrants particular consideration.

Case Studies Illustrating DASIP

The current article explores three cases from microclimatology, geography, and political science, where instances of DASIP are seen in action. We use these cases to illustrate that this methodological problem is unique, and we convey these particular cases because they collectively inspired our attempt to articulate the concept itself. The first case explores urban heat-island mitigation research specific to surface temperature, illustrating how the scale and spatial unit of decisions that are made may be incongruent with the fine-scale physical or health data that influence those decisions. The second case explores rural-to-urban water transfer conflicts in Kansas, considering how the impact of decisions may affect behavior and outcomes in different spatial areas. Finally, the third case study illustrates how the current ongoing policy debates around hydraulic fracturing is a DASIP issue, where the spatial unit and scale to which decision makers are held accountable may furthermore be incongruent with either data, decisions, or impact. The three cases also reveal the temporal character of such methodological challenges. We suggest that DASIP gains greatest visibility when reflected upon during cases of environmental conflict, because conflict itself arises in part due to the very spatial incongruence inherent in the decision-accountability landscape.

Incongruent Decision-Scale Relative to Spatial Units of Data: A Case of Urban Heating and Multiscalar Mitigation

Numerous studies related to urban heating issues are conducted in the hot and arid city of Phoenix, Arizona, area for multiple reasons: the city possesses one of the largest urban heat island (UHI) effects worldwide (Chow and others

2012), it is the U.S. metropolitan area with the highest summer temperatures (National Oceanic and Atmospheric Administration 2012), the Southwest is projected to warm at a high rate in the coming decades (Karl and others 2009), and Phoenix has high human risks and vulnerabilities to extreme heat exposure (Harlan and others 2013; Petitti and others 2016). Jennifer Vanos and others examined multiscale surface temperature observations in Gilbert, Arizona, in the neighborhood and in playgrounds (2016). Surface temperature data were collected via *in situ* (point-based) and airborne remote sensing (area-based) methods to quantify temperatures found at three scales: neighborhood (1km resolution), micro- (6.8 m resolution), and touch-scales (1cm resolution, collected with handheld, infrared thermometers). The purpose of this case study was to quantify surface temperatures at multiple spatial scales. It is the first study to address the finest scale of 'touch-scale' (1cm) specifically to address the safety of children in playgrounds and fine-scale urban design needs (Vanos and others 2016). Here, we present a background of urban temperature research with a focus on the hot city of Phoenix, Arizona, culminating with the case study description and findings of hot temperature in children's playgrounds in the same city.

Related studies in Phoenix have identified that even within neighborhoods or census blocks, differences in surface and ambient temperatures can vary significantly, particularly on the warmest days (for example, Hartz and others 2006; Chow and others 2012; Middel and others 2014; Jenerette and others 2016). Researchers have linked small-scale temperature decreases in the Phoenix region to the cooling islands of parks found within compact and complex neighborhoods (see Chow and others 2011; Declet-Barreto and others 2013; Middel and others 2015). Studies have also examined the incongruence between urban climate observations and modeling using Weather Research and Forecasting (WRF) Model predictions in Phoenix related to urban energy balance and anthropogenic heat (Chow and others 2014; Shaffer and others 2015). Because many of the health impacts from urban heat (mortality, illness, burns) are at finer spatial scales than the scales of available data, difficulty arises in providing applicable information to decision makers, such as where resources should be used.

A DASIP problem occurs when linking urban temperatures to heat mitigation or health outcomes when the variance and discrepancies are not at the same scale, or at differing resolutions. Assuming that one neighborhood responds similarly to another in terms of heat-health, the UGCoP is implied, and when decisions are made or solutions implemented based on assumed similarities, the DASIP presents itself. For example, urban design guidelines and policies for cool-cities initiatives are commonly decided from sparse meteorological observations or low-resolution satellite imagery. Yet cities are complex, with differential land use characteristics; in Phoenix, the daytime shading properties of tall buildings were shown by Middel and others to play a significant

role in reducing urban heat due to their shading effects (2014). This effect, however, is misunderstood if treating the urban area as a whole, and has a different relationship overnight.

Such scalar discrepancy highlights a unique problem, which we articulate as the first dimension of DASIP: the scale and spatial unit at which urban temperature data is largely available is incongruent with the finer scale of data that is needed to influence accurate decisions for reducing urban surface and air temperatures, which may result in alternate decisions and policies being made from imprecise data. These decisions may therefore influence heat-mitigation and adaptation strategies employed by a city's office of sustainability or urban planning, and thus impacts to the environment and human health.

Techniques that attempt to understand (through theory, modeling, or observation) how intraurban areas are developing are critical for determining how urban societies will need to adapt to a changing climate (Georgescu and others 2014). Such techniques involve predicting adaptation and mitigation strategies in research applications, such as lessening energy use and water (particularly in a city like Phoenix) (Baker and others 2002; Santamouris and others 2014), improving human health and well-being (Harlan and others 2006; Vanos and others, 2015), increasing human productivity (Theeuwes and others 2015), and creating a more balanced and sustainable city (Golden 2004).

Climate adaptation occurs on a longer timescale, and thus is also a DASIP issue of temporal incongruence. Short-term opportunities for infrastructure adaptation to diminish threats of urban temperatures are linked to longer-term dimensions; what adaptation measures are implemented now will impact and be affected by a later phenomenon, such as urban space redesign (Deschenes, 2014).

The UHI effect occurs at the mesoscale (2–20 km^2 in area), yet urban areas are complex and heterogeneous, containing numerous types of urban form and arrangement, surface materials, orientations, and densities, all of which result in microscale variations in space and time (Erell and others 2012; Stewart and Oke 2012; Middel and others 2014). In order to understand urban temperatures —both air and surface—various models, observing methods, and scales are used. Microscale models and/or remotely derived airborne infrared thermometry, at scales of 1 m to 4 km, are often employed for examining land-surface temperature magnitudes and variations (see Stefanov and others 2004; Harlan and others 2013; Mishra and others 2015) (see Figure 2). The airborne, remotely sensed data commonly provide surface temperatures at resolutions ranging from 7—140 m (Stefanov and others 2004), yet surface irradiance technologies are continually improving, for example, HyspIRI (Abrams and Hook 2013; Lee and others 2015). Although past and present databases have contributed to improved understanding of the urban surface in relation to surface energy balances, they have difficulty in relating to fine-scale structural parameters that could be used to better define the urban surface for use in sensor view models

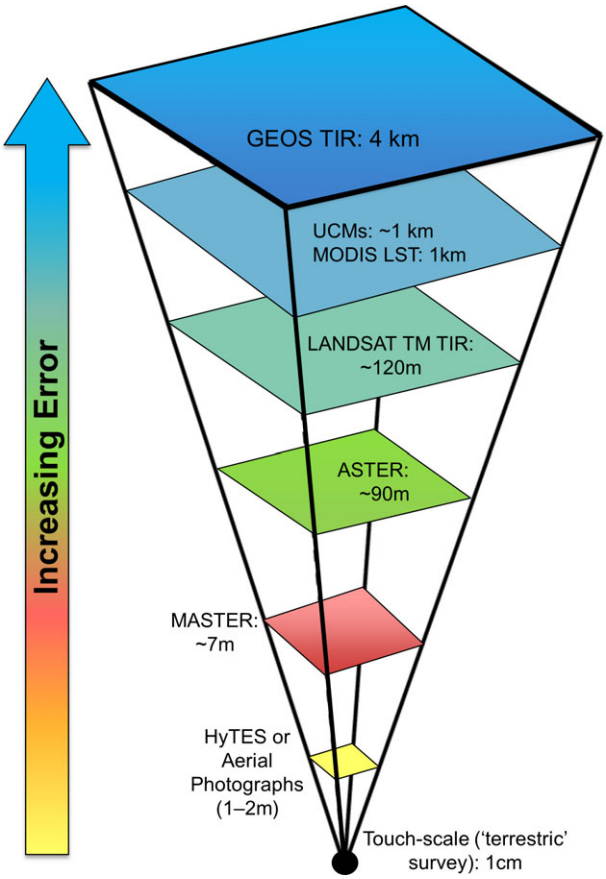


FIG. 2—Example of scales of products commonly used to provide land surface temperature data, ranging from the touch scale of 1cm for 'terrestric' surveys, to scales commonly associated with urban climate models (UCMs), or satellite remote sensing. Resolutions provided are averages commonly used for application in earth science remote sensing for urban applications. Note: Not to scale. [Color figure can be viewed at wileyonlinelibrary.com]

(Voogt and Oke 2003). Further, when compared to the human scale, these satellite remote-sensing scales are quite coarse—on the order of 1009 to 10,0009 greater than the aforementioned touch scale at 1 cm—and thus cannot resolve personal interactions with the proximate atmospheric and radiative microenvironment.

An example of recent research with potential implications to decision-making and policy involves the examination of a children's playground. Vanos and others identified that within the submeter touch-scale, influential and sometimes dangerously hot surface temperatures are found, with importance of the findings extending to material-type selection, orientation, color, and shading in urban design initiatives (2016). The significant differences found in surface temperatures from object to object demonstrate the strong relationship between an

object's material properties, the contact thermal conductance, the initial temperature, and radiation exposure in one small area (ISO 13732, 2010). Or example, rubber surfaces tended to reach 80–87°C in the sun, yet dropped to 42–46°C in the shade. Therefore, if situation-specific (that is, climate, location) policies and new urban design practices are to be implemented to mitigate hot surface temperatures in playgrounds, data in sun and shade, and thus at finer scales, are needed to capture variations.

A simple example of the spatial incongruence in the temperature data from this playgrounds study is shown in Figure 3, where the high temperature values shown by the red bars demonstrate dangerous temperatures present at the touch-scale within two playgrounds, for example, a rubber temperature of 87.2°C (Vanos and others 2016). The solid grey and black bars show the difference in the 1 cm scale from the 6.8 m (playground) and 1 km (neighborhood) scale, respectively; the greater the difference, the higher chance an incorrect application or change could be implemented that does not reflect the safety needs of the playground users, such as increasing risk of burns to children. An interesting aspect of these findings, however, is that shade—the well-studied approach to reduce urban surface temperature and energy use reduction in Phoenix (Hedquist and Brazel 2014; Middel and others 2014, 2015; Wang and others 2016)——is shown to significantly lower surface temperatures to safe

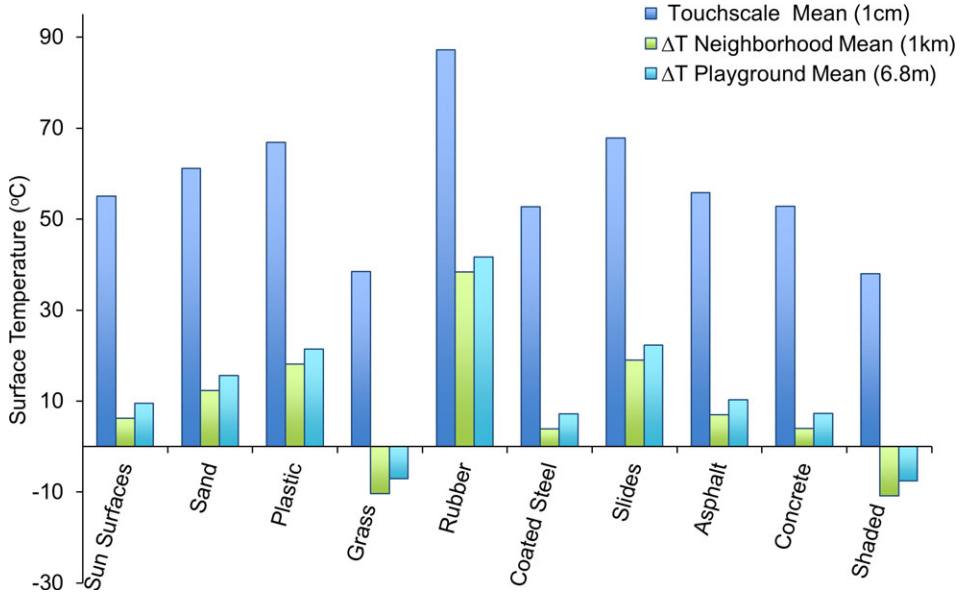


FIG. 3—Mean surface temperature of various surfaces and microclimate conditions at the 1cm touch%scale (red bars). The ΔTs between the neighborhood%scale mean (48.8°C) and the touch%scale surface measurements are shown in dark black, while the ΔTs of playground%scale mean (45.5°C) compared to the touch%scale measurements are shown in lightest grey. [Color figure can be viewed at wileyonlinelibrary.com]

values; for example, a lowering of 45.0°C on rubber and 25.6°C on plastic slides. What this highlights is a well-known drawback of airborne, remotely sensed data——the airborne sensors cannot "see" below trees or shade structures, and instead yield tree canopy and roof top temperatures rather than the actual surface temperatures that are experienced by neighborhood residents (Vanos and others 2016). The dramatic underestimation of surface temperature found by spatial means derived from remote-sensing data (Figure 3) demonstrates that the data is providing information at a different scale, yet oftentimes used for human-scale decisions. This example of children's playgrounds connects to specific policy avenues to apply findings and translate the research to policy of playground design: if it is the touch-scale extreme at which temperatures can cause burns or damage to a child's skin, then this is the scale of information needed to provide the most accurate decision-support data.

In relation to DASIP, the presented case in urban climate research shows both a spatial and temporal issue of incongruence. Spatially, area-based attributes—for example when using the size, shape, and average temperature within a 7 m grid— may be insufficient for point-based (human- or touch-scale) temperature exposure. The concern arises when using the research to link science with policy and health. The next step for moving from research to practice is to provide the new evidence base to park or urban designers, as well as city officials and urban planners, with suggested actions to take and benefits of the actions. This includes raising awareness of the spatial incongruence in their decision process.

As cities warm, populations grow, and technologies advance, acknowledgement of appropriate uses and applications of technology is invaluable in not only understanding the environment, but also in understanding the potential need for improvement. This can account for current UHI mitigation techniques that cascade from the seemingly minor influences at the fine scale, and culminate into larger impacts across a city. The benefit of spatially congruent temperature in Phoenix has been acknowledged and studied for decades, and lessons can be learned from a large, hot city that is growing and warming at high rates. Although a solid foundation is present, the current review supports an increased effort to create viable methods for applying remotely sensed data at finer environmental scales, which has the potential to improve the appropriateness of information for policy and decision support created from the data (Quattrochi and others 2000; Corburn 2009), and advance public health and urban design practice (White-Newsome and others 2013).

Recognizing this incongruence leads us to ask questions related to spatial methods applied in urban temperature research across various disciplines—policy, health, architecture, engineering—and how to do so in ways that are amenable to the decisions for those adaptations. Further, how can we tailor new earth-science products for understanding various scales of information within highly complex urban areas to benefit health, economic, and social well-being? The

answers may lie in first acknowledging DASIP, and reducing the problem in data collection/analysis and thus in its use by decision makers.

INCONGRUENT EFFECTS OF DECISIONS ON BEHAVIOR AND OUTCOMES IN DIFFERENT SPATIAL AREAS AT DIFFERENT SPATIAL SCALES: A CASE STUDY OF RURAL-TO-URBAN WATER TRANSFER CONFLICT

Publicly accountable decision makers often try to anticipate the impact of their decisions, and sometimes they turn to the scientific and academic community to make sense of these impacts. Grappling with the question of various scales and spatial extent of impacts means confronting the problem articulated as DASIP. The second DASIP case study focuses on rural-to-urban water use, illustrating that there are methodological challenges implicit in rectifying the incongruence of decision scales with the spatial unit(s) of analysis. It further explores how the impact of such decisions may affect behavior and outcomes in yet different jurisdictional areas, and be affected by them in turn. Different spatial scales that may or may not overlap or coincide characterize each of these jurisdictional areas. The temporal dimension of this dynamic and iterative relationship is important to consider, as environmental impact analysis often implies an anticipatory stance, while decision makers must also guess at the ways in which they will later be held accountable for those decisions.

The original study for this historic case was performed during the height of, and in the aftermath of, a controversy surrounding the first potential interbasin water transfer within the state of Kansas. In 1995, the midsized city of Hays, Kansas, purchased the Circle K Ranch from the rural community of Edwards County, with the intention of piping water north for municipal and industrial uses. Incongruent with the results of a traditional impact analysis that suggested very little material negative effect on the source community, resistance resulted in the city eventually canceling plans for the project and selling the land to the state. The opposition was situated within a natural resource politics of the rural plains, a specific framework of water law, and a history of agricultural development and stark decline. Each of these domains—sociopolitical, environmental, and economic—had a specific spatial footprint that complicated analysis to understand the ultimate impact of the eventual decision. Reflection on the incongruencies of this case leads us to ask questions such as: How can we do a better job of determining who would be affected where, and how? To what extent are decision makers ultimately held accountable to which constituent places? How are impacts at different scales contradictory and how does that affect the decision-making process? At which scales do impacts matter for a particular set of decisions?

In Kansas, the 1983/1993 Water Transfer Act regulates projects that move water from one basin to another within the state. The legal precedent for an interbasin water transfer, which promised to be a test case of new state laws, appeared in February 1995, as the city of Hays finalized the purchase of the

Circle-K Ranch in Edwards County for $4.2 million. The population of Hays had grown amidst a sea of communities experiencing decline, where total water consumption decreased by nearly 47% to hit the lowest per capita water usage in the state (Kansas Water Office 1992). The Circle-K Ranch, located 1.6 km south of Kinsley—population 3,787 at the time of purchase—was selected as a much needed new water source, because it offered the largest amount of groundwater rights under a contiguous farm in the region (Clarkin 1994; KCCED 1994). Irrigated agriculture and cattle grazing had been the mainstay of the county's economy and employment profile, and accompanied a traditional rural lifestyle. The ranch's land use was to be converted to natural grassland under the water transfer plans that included a 107 km long pipeline to move the water along U.S. Highway 183 north to Hays and Russell, Kansas, a town that was a 21.7% partner in the deal (see Figure 4).

The right to use water in Kansas is a complex mixture of usufruct prior appropriation legislation; in other words, both "first in time, first in right" and "use it or lose it" are terms to describe water regulation, and representative of the legal fact that all water in Kansas belongs to the people of the state (K.S.A. 82a-718, 1945; Kraenzel 1955; Fund 1984; Peck and others 1988). By the late 1980s, Kansas entered a new era, where water rights began to be "obtained primarily by purchase or condemnation rather than by filing with a state official" (Peck and others 1988, 21). A new mechanism for water transfers also appeared in this new era, when the 1983 Water Transfer Act was passed to regulate sale and movement of water beyond 35 miles and 2,000 acre feet (2.5 million m^3) per year (K.S.A. 82a-1501–82a-1505, 1983; Pope 1984; Peck 1992).

Decisions on allowing transfer plans were to be made by a three-person panel, comprising the chief engineer of the Division of Water Resources, the director of the Kansas Water Office, and the secretary of the Department of Health and Environment. The criterion on whether to allow or prohibit transfer applications rested with what was in "the best interest of the State." The panel was also required to specifically consider a number of matters which may concern third parties, including any current beneficial use, minimum desirable streamflow requirements; any reasonable foreseeable future beneficial use; the economic, environmental, public health, and welfare impacts, and other factors, allowing third party input (Peck 1992). As common to such procedures elsewhere, the state's legal and regulatory means of addressing the interests of third parties involved some form of impact analysis (Howe and Easter 1971; Schaffer and Schaffer 1984; White 1984; Loucks 1990; Smith 1993; Torrey 1995). But while the state has clear spatial boundaries, and the spatial extent of beneficiaries of the transferred water could be identified, the area that would be affected by the decision was not clear and precisely determinable. Who filed for the transfer for whom, who would protest on behalf of whom, and who adjudicated these questions and answers, were overlapping, and incongruent with the environmental systems about which the decisions were being made.

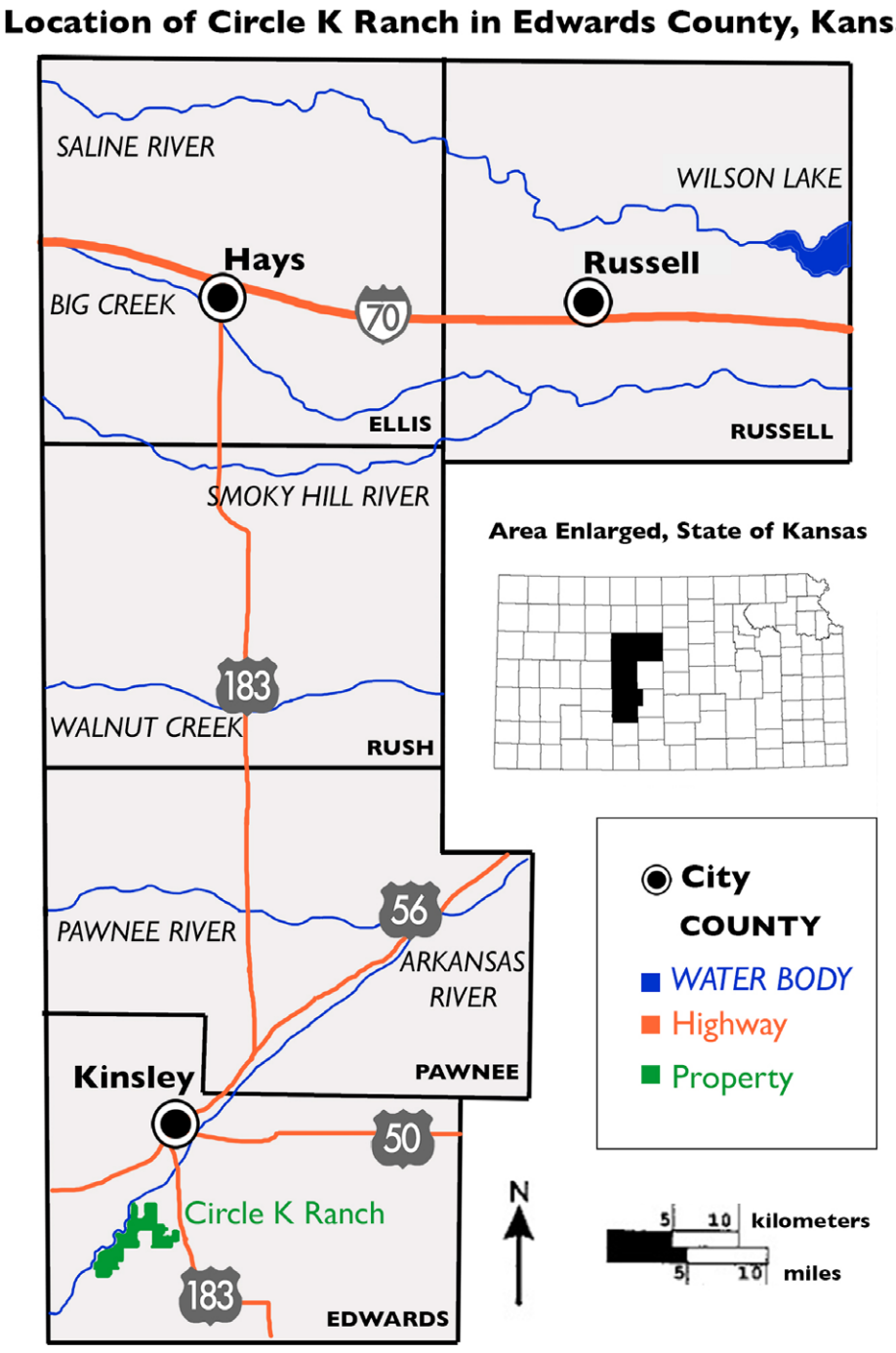


FIG. 4—Location of the conflict over the anticipated first test case of the interbasin water legislation in Kansas. The Circle-K Ranch is in Edwards County. [Color figure can be viewed at wileyonlinelibrary.com]

Resource conflicts are generally poorly understood by impact analyses since they underestimate the risk of controversy, partly because they consider social impacts as just one dimension of impact analysis, providing insufficient insight into the incongruent ways that places are evoked in resource-use debates. nor how politics of spatialities—including resource-based, cultural identifies tied to place—may be at play (Schaffer and Schaffer 1984; Moench 1991; Smith 1993). Indeed, a traditional impact analysis demonstrated little basis for even the existence of a conflict over the interbasin water transfer in Kansas (Bennett 1996). Environmental impacts of the movement of the water out of its alluvial aquifer would have been modest with no reduction of water quantity, slight improvement in water quality, reduction in soil erosion, and mixed impacts for local biota. Because of reliance upon irrigated agriculture, a generally negative economic impact on Edwards County was anticipated, but the degree of economic loss directly attributable to the project would have been minimal, given already weak linkages between the ranch and the local businesses and employment sector (Bennett 1996).

Contrary to this assessment, for Edwards County residents, the problem with allowing the transfer was expressed as the loss of water, standing in as a symbol for the loss that affected resident's lives in a different nature. "In light of decades of decline due to economic frustration, political marginalization, and demographic outmigration, rural communities maintain the symbols of natural resources, in this case, water as heritage, in order to legitimate their struggle against what are seen as intrusive, destructive elements of changing resource use precipitated by an ever-changing capitalist agricultural system" (Solís 2005, 64). The themes of protests asserted that water was rural heritage and it belonged to a particular place, implying a scale that includes some and excludes others as outside of that (masculine) belonging:

> "If we let our water be pumped out, we will be selling the heritage of our sons and grandsons." (Edwards County resident)

As this case revealed, "the notion of water as 'heritage' is implicitly embedded within, if not explicitly evoked by rural discourse on resources, usually in contradictory ways" (Solís 2005, 55). As an object of inheritance, imagined as passed from male offspring to male offspring, water is also naturalized in place as being locally owned and an inalienable resource for their long-term future at the small community scale.

The conflict itself must also be interpreted as an attempt to (re)shape the meaning of "what is in the best interest of the State," especially along the lines of how to define the spatial impact of the decision-making process. Water was believed to belong to a local scale in contrast to the legal fact that all water in Kansas belongs to all residents of the state, at the full scale of the state. Thus geographical scale and spatial nature of the Kansas public is already embedded within the conflict to localize nature and render it rural. The spatial abstraction

was broadened to include other rural communities and to legitimate claims that Edwards County residents speak for a larger (rural) constituency, even of Kansas as a whole, presumably to garner greater political leverage in the conflict since Kansas is thought of as a rural state. The efficacy of a rural-based resistance to the transfer may have thus rested within the rural community's ability to manipulate the definition of Kansas by appealing to a rural farming heritage for which natural resource use implies irrigated agricultural production (Olwig 1984; Anderson 1991; Short 1991).

The Edwards County strategy was somewhat politically efficacious. Because the city expected rejection from the state decision makers due to intense opposition, they scrapped plans and sold the land to the state itself (Wolf 1999; Kansas Water Office, 2003; Solís 2005). The Kansas water transfer event served as an oppositional reference point and relied upon spatial-discursive expressions that ultimately rendered the water transfer politically infeasible. Its efficacy relied on "symbolic discontent" to legitimize a real struggle focused on profound material loss and to affirm community identity, enabling the oppositional discourse to broaden its scale to that of the decision making body (Solís 2005). The utility of looking at this case with respect to DASIP is that it reveals a lesson for decision makers and for the scientific and academic community, who aid in the production of knowledge to inform such decisions. At a minimum, decisions should be based upon spatially aware understanding that goes beyond traditional impact analysis and the static spatial entities implied therein. Most importantly, we see that the scale of accountability for decisions (state) can be incongruent with both the impact of those decisions (Edwards County) and with the political constituency of the environmental decision makers themselves (city of Hays). Without a clear means to sort through these incongruences, public decisions in the best interest of the public is confused and can lead to exacerbation of conflict and failure to fully mitigate genuine underlying concerns of people affected by these decisions. After all, what good is it if the call for evidence-based decision making is heeded, but decision makers are not held accountable on the basis of evidence? By recognizing DASIP as a unique problem from the very beginning of a case, methodological innovations can be contemplated to improve the kinds of impact analysis that inform difficult resource allocation decisions that are going to inevitably be made, one way or another, in the face of growing environmental conflict.

ACCOUNTABILITY FOR DECISIONS AS INCONGRUENT WITH DATA, DECISIONS, OR IMPACT: A CASE STUDY ON HYDRAULIC FRACTURING DEBATES

The third critical dimension of DASIP is that the spatial unit and scales at which decision makers are held accountable is often incongruent with areas where impacts are realized or where data that influences decisions is measured. This reality makes it difficult for researchers to methodologically trace factors that influence discourse, particularly around environmental conflict. One way

to understand this aspect of DASIP is to consider incongruences across domains where public debate ensues, the scales where such discourse are made legitimate (or not), and the spaces where implications of policies are debated. The ongoing policy conflict of hydraulic fracturing (hereafter referred to as "fracking") in the United States is an illustrative case in point.

Public debate concerning modern-era development of energy resources is framed by strategic use of political symbolism and rhetoric by rival interest groups (Edelman 1964; Popkin 1991; Schneider and Ingram 1997; Jones and McBeth 2010). In communities where fracking to develop oil and gas resources is debated, contending policy arguments are simplified by competing interests groups. Their efforts—framed by narrative device(s) wrought with symbolic-laden rhetoric—are communicated to the public regarding the costs and benefits associated with fracking. Yet because the transference of policy information is often symbolic in nature, the use of symbolism as a form of political communication is defined as a "political short-cut" (Edelman 1964; Popkin 1991). Ann Schneider and Helen Ingram argue that transference of policy information can also take shape in the strategic use of rhetoric (1997). Rhetorical symbolism in the context of policy deliberations has the effect of limiting the culpability of government and the advantaged group, while suppressing participation of the disadvantaged group in the democratic process of policy making. This is akin to boundary drawing during the policy making process and reflects and redraws real boundaries in real places—designating what is within and outside of a space of a discourse, where opposing sides seek to vilify each other with political symbolism and rhetoric.

Content analysis of policy conflicts, where rival interest groups use symbolism and rhetoric, is referred to as "framing," and this too has spatial implications and gives rise to incongruencies, although it typically does not specifically account for the spatial scale of symbolism and rhetoric used to shape public opinion and, ultimately, transference of those opinions in policy outcomes (for example, the Narrative Policy Framework, Jones and McBeth 2010). Whether congruent or not, accounting for the spatial boundaries—the scaling of policy information being communicated as means of influencing policy outcomes—is a problem that becomes a more sophisticated one when DASIP is articulated. It is significant that scholars better understand how interest groups seek strategic advantage in shaping public opinion of policy issues—like that of fracking—in their use of political symbolism and rhetoric. In relation to DASIP, scholars could explore further possibilities to better understand how strategic advantage is gained or lost over a real space, such as a jurisdiction—and how that space is produced through conflict discourse. Since space invariably has a scale to it, yet is not conflated with it, means constructing a "local" we versus an "outsider" them and at other times a "scaling-up" of the issue affecting the entire population and, by default, the accountability of elected policy makers at all levels of government.

To illustrate, the use of symbolism and rhetorical device by profracking as well as antifracking groups is an ideal case for analyzing discourse for determining spatial boundaries; scaling of policy information being communicated; and measuring success or failure in policy outcomes.

Modern-era energy policy is affected by three overarching categories of variables: energy markets, energy technology, and energy politics (Forbis 2010; Kear 2011). These categories of variables shape federal energy policy, and in doing so establish conditions under which the national energy debate is framed. These categories are intertwined and dependent on each other to shift energy policy. Thus, energy policy is highly complex and therefore quite difficult for making fully informed decisions regarding energy preferences. In the face of such complexity —scientifically based or otherwise—interest groups seek to persuade the public by simplifying their message (Lindblom 1959; Sabatier 2007). In the energy policy debate, simplifying that which is inherently complex is an "informational short-cut." This impacts the manner in which opposing interest groups craft their respective message via symbolism and rhetoric on the benefits and/or perils of modern-era energy development. In turn, these short cuts undermine the public's capacity to hold elected decision makers accountable.

The implication of DASIP to policy analysis has consequences for determining the strengths and weaknesses of democratic feedback loops. The use of DASIP in measuring democratic "accountability" is relevant if the objective is to better understand the policy-making process. Explicitly, the stratification of framing narratives produces incongruent results in voters' holding elected policy makers accountable. Importantly, stakeholders' use of symbolic rhetoric to simplify the scientific and legal complexity of fracking is used in similar manner by elected officials, even though elected officials have far greater access to empirically derived analysis to better inform their policy-making decisions. Oftentimes, those politically based decisions differ greatly with the expressed policy preferences of the voting public across varied jurisdictions within the Federalist system and differentially account for the scaling of symbolism and rhetoric, as well as the empirical analyses that shape policy-making decisions and accountability across and within a highly layered Federal system of governance.

This accountability dichotomy has played out in Denton, Texas—among other localities—who voted to ban fracking. While these democratically articulated policy preferences result from localized narrative/symbolic/rhetorical informational short cuts communicated by opposing community-based stakeholders, these same short cuts are effectively shaped and stratified across political boundaries by national/state-based stakeholders (Gullion 2015). Unlike their local counterparts in Denton, state-elected decision makers were not bound by the vote to ban fracking. The result was Texas House Bill 40 (HB40), effectively prohibiting any Texas municipality to engage in policy-making processes for the expressed purpose of prohibiting and/or limiting fracking (Malewitz 2014, 2015a, 2015b). Instead of citizens holding elected officials accountable, it appears

that with HB40, elected officials are holding the citizens accountable for their collective policy decision.

Data indicates citizen-based responses are grounded in concern for fracking's potential to despoil common pool natural resources (Forbis and Kear 2011). This results in disparate policy narratives and outcomes across political boundaries. Conflicts triggered by broad expansion of fracking have resulted in local, state, and federal policy responses. The result is that while most political activity at local levels has been decidedly antifracking, most at state and federal levels has been decidedly profracking as evidenced by the aggressive opening of hydraulic fracturing beginning in the Clinton administration and codified through the Energy Policy Act of 2005 under the George W. Bush administration (Forbis 2010; Kear 2011).

The question raised by localized profracking and antifracking interests is reflective of the broader public debate regarding national energy policy. Americans are now bombarded with a rhetorical fork-in-the-road: fossil fuels or renewable/alternatives? To paraphrase the American Petroleum Institute's (API) national ad campaign: "Which of these paths ensures a safe, reliable, and proven technology that will help fuel America's future?" The message being conveyed by API on behalf of the profracking lobby is that the issue of fracking is not simply a "local" problem, but is one of "national" concern. That a carefully framed message is conveyed to all strata of American society, and importantly, that the effect of such message—as it is scaled up and/or down—exemplifies the contradictions in scale that often plague holding decision maker accountability that an understanding of DASIP may help researchers tease out.

While Texas HB 40 is a state response to the local Denton ban, federal-level responses to broadly based citizen concerns over fracking is evidenced by congressional attempts to close the so-called "Halliburton Loophole" within the Energy Policy Act of 2005 via the Fracturing Responsibility and Awareness of Chemicals Act (FRAC Act) having failed repeatedly in 2009, 2010, and 2011 (Williams 2011). This failure and the conflicting discourses surrounding them indicate a more spatially complex set of incongruences than a simple hierarchical local-state-federal legal resolution would imply. Consequently, the desire to strike a greater balance between competing policy preferences of anti and profracking stakeholders across thirty-three states where fracking is now commonplace, vis-a-vis federal legislation—like the FRAC Act—suggests that resolving the accountability dichotomy requires clever methodological approaches that can mitigate the problem we articulate as DASIP.

Even though fracking is but a sliver of the broader national energy debate, it has captured the attention of scholars, perhaps because of its operatic, even melodramatic, qualities. Beyond a mere NIMBY story, it has the character of a national policy debate, which can be scaled up from being a local issue and vice versa, while not all issues can do this. The reason for this attention may be because public debate on fracking is fraught with controversy, misinformation,

disinformation, demonization, truths, and half-truths emanating from all levels of stakeholder and politically based interests at every scale. In addition, scientific claims and scientific counterclaims are made regarding fracking costs and benefits to consumers, voters, national security, human health, environmental, and economic well-being also at every level (Gullion 2015; Hauter 2016; Sernovitz 2016). DASIP gives rise to a fundamental policy question: What does "winning" really mean? If winning is the adoption of a preferred policy, in this case, either fracking or no fracking is the preferred "policy outcome." Policy makers are ultimately held responsible for places where they have jurisdictional responsibility, but this not to say that other levels of governance cannot hold them accountable, and thus the public in other jurisdictions can, too. Consequently, because jurisdictional-based accountability is a hallmark of American Federalism, this again affords an opportunity to explore where DASIP is at play.

The fracking debate itself is operating at multiple scales, and with differing, conflicting boundaries, but the decision where the policy is "won" or "lost" does have a particular scale (size, boundaries) of the jurisdiction where it operates. The impacts of those decisions reach beyond those scales, which is one reason that environmental policy debates are sometimes waged elsewhere. More troubling is that accountability for making these decisions may never come back as a feedback at all, either in space or time, to elected decision makers. In effect, DASIP could better enable researchers to more accurately produce preliminary determinations regarding effectiveness of these strategies on the decision-making behavior of voters and elected policy makers. If this is the case, findings generated by DASIP-aware analysis will encourage development of a stronger lens from which broader national policy debate, public opinion, and policy making is clarified. Meanwhile, this incongruence is at the heart of methodological problems for improving scientific understanding of critical issues such as fracking. Finding effective ways to trace these connections should be on our scholarly agenda.

Considering the Decision-Making/Accountability, Spatial-Incongruence Problem

Insights from these case studies make it apparent that there is a need to innovate methodologically around decision making as a particular category of spatial behavior, and policy making as a specific instance of decision making, leading to new, insightful approaches to the spatial characteristics of the important environmental issues in question.

From the example of the urban heat-island mitigation research in Arizona, making this problem explicit helps us to grapple with the fact that spatial scale of urban planning decisions are often incongruent with fine-scale environmental data due to lack of data or information applied from coarse scales. Similarly, water transfer conflicts in Kansas demonstrate how decision makers are

influenced by the ways in which the impact of their decisions about one area may affect behavior and outcomes in different spatial areas, leading to different categories of questions about what is in the best interest of the public. And finally, hydraulic fracturing in Texas engenders environmental policy debates in ways that confound a simplistic understanding of accountability to constituents in established jurisdictions. These examples together reveal where the spatial unit and scale to which decision makers are held accountable—or not at all—for such decisions may be incongruent with either data, decisions, or impact, as well as the temporal character of such methodological challenges.

The Decision-Making/Accountability, Spatial-Incongruence Problem, DASIP, following the path of the MAUP and the UGCoP, defines a particularly unique analytical challenge of determining spatial unit of analysis relative to the data, and attempts to incorporate spatial behavior characteristics from contextually disperse influences. Beyond these similarities, DASIP further recognizes the spatiality of collective, accountable decision-making behaviors as distinct from independent, individual choices. The engagement in practice of divergent perspectives of various disciplines, through the social process of creating knowledge that can be informative or insightful to decision makers or policy makers, informs our understanding of how DASIP must be defined. Since DASIP is focused on methodological problems, we understand that innovations in response to it may vary in character, depending on the applied research in question. The case study on mitigation of high surface temperatures in urban areas, for instance, implies that advances in instrumentation would serve to link how scientists study climatic phenomenon in places, so that they can provide decision makers the most accurate data to enhance the benefit of their decisions in a city. The water transfer conflict demonstrates, among other things, a need for methodological innovation related both to spatial scales, but also to temporal scales, and indeed future time, within the context of anticipatory analyses that typically inform juridical resolutions ahead of impacts realized. The third issue presented—the controversy over fracking and energy policy—reveals the potential for innovation in the methods of policy analysis itself. With these three examples, we propose DASIP as a practical definition that can be used across applied disciplines, drawing from empirical reality. Certainly, the consideration of theoretical implications in light of this identification of a problem can be restarted from many different perspectives (such as materialism, political ecological, production of space, actor-network theory, poststructuralism; see Latour 1998, 2004; Brown and Duguid 2000; Hermann and Neumeier 2008; Gober and others 2010). Nor is there a shortage of potential cases of contemporary environmental conflict to consider. For instance, the Dakota Access pipeline involving the Standing Rock Sioux Tribe in rural North Dakota, with overlapping jurisdictions of the Army Corps of Engineers, the federal court system, the Justice Department, Tribal Nations (Meyer 2016); the Flint Water crisis implicating public and private sector alike (Sanburn 2016); and the debate over

the relationship between earthquakes and fracking in Oklahoma (Reuters 2016) are examples of cases rife with real-time opportunity to analyze DASIP.

Future research is thus needed that involves interdisciplinary teams of scientists engaged reflexively in practice with policy makers to explore potential methodological solutions and experiments to overcome or mitigate these spatial methodological challenges throughout a research project. Such reflexivity may lead to an increased application of research developed by the scientific and scholarly community but also to enhance benefits to society from environmental change research that understands, accepts, and applies the underlying principles of the spatial incongruences across the landscape of decisions and public accountability for those decisions.

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