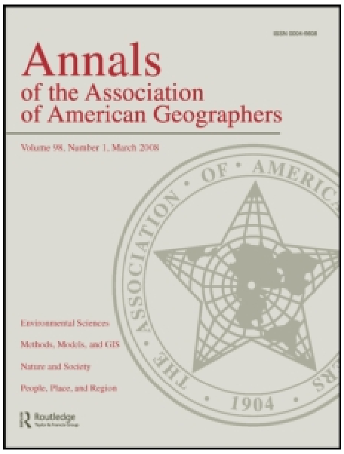

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A Paper Related to Everything but More Related to Local Things

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FORUM

A Paper Related to Everything but More Related to Local Things

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On the First Law's supposition that everything is related to everything else, let me begin with some events of August 1969. On the 15th of that month just outside Bethel, New York, on Max Yasgur's farm, nearly half a million people converged for three days of love, peace, and harmony, or as Ian Drury later put it, for sex and drugs and rock and roll, at the Woodstock Music and Arts Fair. Six days before, Charles Manson and his "family" murdered a pregnant Sharon Tate and three others in Roman Polanski's Beverly Hills mansion. At the end of August, James Callaghan, Britain's home secretary, and later prime minister, for the first time ordered British troops into Northern Ireland to quell sectarian violence between Protestants and Roman Catholics. In Viet Nam, American soldiers were engaged in the "Summer-Fall Campaign." During August, more than a thousand were killed, and a further 20 went missing in action. And in August 1969, the International Geographical Union Commission on Quantitative Methods held a conference at a newly built hotel in Ann Arbor, Michigan, and Waldo Tobler presented a paper entitled, "A computer movie simulating urban growth in the Detroit Region." On page 7 of his manuscript, Tobler wrote, "I invoke the first law of geography: everything is related to everything else, but near things are more related than distant things" (Tobler 1969, 7, quoted in Olsson 1970, 228; Olsson 2003).

In this commentary, I want both to agree and to disagree with Tobler. I agree that everything is related to everything else, including in this case, an IGU conference in Michigan and, during the same year and month, the events in a muddy field in upstate New York, in an exclusive home tucked away in one of Hollywood's canyons, in the Shankhill Road in Belfast, and in the Central Highlands of Viet Nam. But I am not convinced that invoking the vocabulary of laws is useful.

Two type of criticism can be leveled. The first is to argue that human behavior over space is not something that is describable by law-like statements. There is too much messiness, heterogeneity, and contingency; too much "interference," as John Law (2000) puts it.

I am sympathetic to this position, but here I want to pursue the second type of critique, one that aims to discard the very talk of laws altogether. Tobler's law talk derives from the philosophy of science literature (see Olsson's 1970 commentary), whereas I intend to draw upon the anti-philosophy-of-science literature, science studies, that replaces universal laws by local knowledge. In doing so, science studies neither rejects science nor its manifold accomplishments, including mathematical cartography and GIS. But it does reject the philosophy of science's representation of the practices of science couched in terms of rational inquiry, including its law-talk. To criticize law talk, then, is not to impugn the creativity of individual scientists like Tobler, only to contend, as Latour and Woolgar (1979, 31) put it, "that the precise nature of this creativity is misunderstood."

The paper is divided into three short sections. First, I define the nature of scientific laws and discuss why, from the perspective of the philosophy of science literature, Tobler thought that he had found one. Second, I very briefly define science studies and use it to provide a different interpretation of laws, one that sees them constructed at specific local sites rather than enjoying universal status. Finally, I discuss the local construction of Tobler's First Law. Here I make use of biographical material about Tobler, including an interview he granted me in Santa Barbara in March 1998.

On Science and Laws

From the 1920s until sometime in the 1970s, mainstream philosophers of science conceived scientific laws within a hypothetico-deductive framework. First systematically codified by Hempel and Oppenheim (1948), their argument was that scientific explanation and prediction proceed through a logical syllogism combining empirical statements of initial conditions with general

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laws. Gunnar Olsson (1969, 1970, 1980), a colleague of Tobler's at Michigan in 1969, wrote extensively about the hypothetico-deductive formulation. A figure Olsson used at the same Ann Arbor conference at which Tobler presented his paper illustrates the hypothetico-deductive argument (Figure 1).

As in the logical syllogism more generally, there are two components to the hypothetico-deductive scheme: a minor premise that takes the form of a statement of initial empirical conditions and a major premise that takes the form of a set of hypothesized scientific laws. Bringing them together and applying logical deduction produces either explanation or prediction. Explanation is obtained by beginning with the event to be explained and working backward to locate the appropriate initial conditions and laws, while prediction is made by starting with initial conditions and laws and working forward. Note that within this scheme, "explanation and prediction are symmetrical, [with] deduction ensur[ing] the logical certainty of the conclusion" (Harvey 1969, 37).

Central to this formulation are laws. Laws are a statement of an invariant conjunctional relation among concepts, holding for all times and places. If the volume of a container increases, then pressure decreases (Boyle's Law); if two bodies of mass exist, then a force of gravity equal to the product of their two masses divided by the distance between them (the Law of Gravity); and if spatially related phenomena occur, then near phenomena are more related than distant phenomena (the First Law of Geography).

From Figure 1, it is clear why laws are critical to the scientific method. Without them, the logical syllogism has nothing on which to gain purchase. Their absence makes deduction impossible, severing the possibility of a connection between empirical statements of initial conditions and explanation and prediction. It is for this reason that laws are so important. Certainly, Tobler thought it critical to state one, especially in August 1969 in Ann Arbor when the scientific revolution in geography was at its zenith, the University of Michigan was one of geography's arch "centres of calculation" (Latour

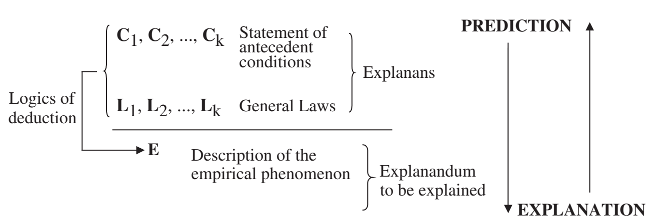

Figure 1. The logic of scientific deduction (redrawn from Olsson 1970, 224).

1987, ch. 6), and the IGU Commission on Quantitative Methods, one of its most prestigious forums.

There is one more issue. How do we know whether general laws are true? If they are not true, the consequences are incorrect explanations and bad predictions in spite of an impregnable logic. Hempel and Oppenheim (1948) circumvent the issue in their original paper by speaking of hypothesized laws. But clearly, there is a need to go beyond such circumspection. Tobler does. Declaring, "I invoke the first law of geography," is forceful, not circumspect. The empirical verification of laws, though, has proven difficult and controversial. When Hempel (1958) later wrote about the issue, he recognized that there was not always a simple translation between conceptual terms within a law and measurable empirical entities. Indeed, in the same issue of *Economic Geography* in which Tobler's (1970) paper with his now famous phrase appeared, Olsson (1970) offers a critique based precisely on the grounds of the difficulty of empirically establishing such a law.

I do not intend to follow Olsson's specific line of criticism couched in terms of different types of error that he believes casts doubt on correlation and regression analysis, the main method used to verify the First Law. But I want to pick up on his unease about the hypothetico-deductive method and the primacy it accords to laws. For Olsson, as we now know, that unease led him to the experimental prose of iconoclastic European writers such as Mallarmé, Rimbaud, Joyce, and Beckett, to his own experiments in language, and most recently to art itself (Olsson 1980, 2000). In my case, the unease led to science studies.

On Science Studies and Local Knowledge

Science studies is now a large interdisciplinary project with its own journals, conferences, lexicon, internal pecking order, and star academics (Hess 1997). Its immediate origins are the late 1960s with a group of disgruntled scientists and sociologists at the Science Studies Unit at Edinburgh University, but its roots go back further to writings by Kuhn, Merton, Mannheim, and even to Marx.

From the beginning, science studies challenged the conventional philosophy of science view of explanation and prediction, and more specifically, the nature and role of general laws (seen especially in Bloor 1976). At its broadest, science studies argues that scientific knowledge is socially constructed, a product or artifact of contingent social forces. In this view, the social goes all the way down to the very truth claims made by scientists.

As Pickering (1992, 1) puts it, "science [i]s inherently and constitutionally social all the way into its technical core: scientific knowledge ha[s] to be understood as a social product." Emphasis, therefore, should be on the social context of science, and on the peculiar social practices of individual scientists.

In that light, key elements of the scientific method—logical deduction, laws, and empirical verification—were critically scrutinized and found wanting in their claims to universality. Briefly, science studies critics argued that logic is only a post-hoc rationalization of a conclusion arrived at by other means and as a consequence, as Barnes and Bloor (1982, 45) put it, "of an entirely local character." Laws are fabricated within specific local circumstances involving particular machines, measurement devices, types of equipment, and trained personnel, and are not replicable outside such conditions. Finally, through the Duhem-Quine thesis, any law or theory is underdetermined by empirical facts, making irrefutable verification impossible (Hess 1997, 18). As a result, additional grounds must always be adduced for acceptance, including as Barnes, Bloor, and Henry (1996, 28) write, their "salience in the local culture."

Rather than appealing to the universal as justification, science studies argues it is better to conceive models, theories, and laws as local constructions, local knowledge. An example is Steven Shapin's (1994) work on the local geographical and historical context that intimately informed the work of the 17th-century English scientist Robert Boyle and his eponymous law. It involves Boyle's social background—he was son of the Earl of Cork—and concomitant "gentlemanly" status, independent wealth that enabled Boyle to establish his own laboratory and to remunerate various assistants, and the availability of trained craftspeople to construct necessary equipment such as an air pump (available only in particular places such as London or Oxford, and not in Dorset where Boyle had his country house, nor in Ireland where his father held large amounts of land). Boyle's social status, both class and gender, also allowed him to enlist other "gentlemen" who would be recognized as unimpeachable witnesses for the experiments on pressure and volume that he carried out, and, as a result, could vouch for their veracity to the wider scientific community. Boyle's work and the famous equation that it eventually produced were not a bolt of lightning out of the blue, but emerged from a set of closely bounded geographical and historical conditions. They provided the means and warrant for the formulation of the law. It was local knowledge.

Saying it was local knowledge does not mean it was hermetically sealed within its original context. Knowledge travels. It travels in the form of people themselves, as blueprints or pieces of scientific equipment, and as letters, scientific notes, journal articles, books, and, more recently, e-mails and attachments. That knowledge travels does not mean that it is universal. As Rouse (1987, 72) argues, what we think as universal is really the result of scientists moving "from one local knowledge to another rather than from universal laws to their particular instantiations." In order to prove Boyle's law requires taking the local conditions that existed in Boyle's laboratory and reproducing them at other local sites. At first, this is hard, but over time as equipment and practices are standardized, we come to believe that all we see is the universal law itself shorn of the local. But the local is still there. It just has been stabilized and extended to other equally local places (Latour 1993, 24). So, while Boyle's law appears universal, it is because all the local baggage that it initially carried is forgotten. In part, that is what using the label "law" does. It removes the relationship described from its local geographical and historical context, and makes it appear as if it is from nowhere and is timeless. It makes us forget the local. But for science studies—in logical deduction, in constructing laws, in empirical verification—the local is critical and needs to be consistently remembered.

Tobler's First Law as Local Knowledge

This is my task as I discuss Tobler's First Law: to remember its local origins and to unsettle its law-like status. My strategy is to describe the context in which the First Law is enunciated, and then to work backward historically to illuminate the peculiar local conditions from which it constitutively emerged. Like Boyle's Law, it is neither natural nor ready made, not titrated drop-by-drop on to the page from pure logic and naïve facts. Rather, it is utterly entangled in a mess of local historical and geographical conditions,

Following its presentation at the Ann Arbor conference, the paper in which Tobler's famous sentence is found was later published in a special supplement of *Economic Geography* in June 1970. The paper's main purpose was to simulate the population growth of Detroit from 1910 to 2,000 in the form of a computer movie. For every month over the period, Tobler calculated and displayed graphically Detroit's population growth distribution, which then became a single frame in the movie. At 16 frames a second, the simulated changing population distribution of Detroit over the 20th century could be shown in a movie clip of just over a minute. The editor of *Economic Geography,* Gerald Karaska, also suggested making a flipbook of all those maps that, when

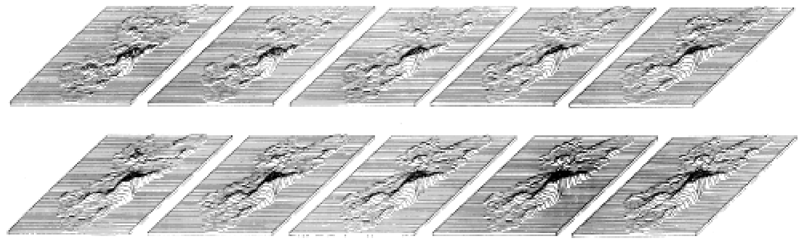

Figure 2. Simulated population growth, Detroit Region. Selection of ten-year interval frames from computer movie. Top row 1910 through 1960, bottom row 1960 through 2000 (non-linear vertical scale). *Source:* Taken from Tobler 1970, 239.

flipped appropriately, would simulate the movie simulation (Tobler 1998). But the printer objected, and only the "stills" were published (Figure 2).

Where does the First Law fit? It emerges from Tobler's discussion of the mathematical prediction of the future geographical movement of Detroit's population. If one takes seriously the notion that everything is related to everything else, then to predict the population of a given place means taking into account for the previous time period not only the population of that place and its immediate adjacent area, but in all places, everywhere. As Tobler (1970, 236) writes, to predict the population growth of, for example, Ann Arbor "from [say] 1930 to 1940 depends not only on the 1930 population of Ann Arbor, but also on the 1930 population of Vancouver, Singapore, Cape Town, Berlin, and so on. Stated as a giant multiple regression, the 1940 population of Ann Arbor depends on the 1930 population of everywhere else, that is, it is a function of about 1.6×10^4 variables, if population data are given by one-degree quadrilaterals." But not even computer facilities at the University of Michigan that Tobler (2002, 310) describes as "very advanced for their time," could manage such machine-jarring calculations. It is precisely at this impasse that Tobler invokes the First Law. With a single stroke it cuts through the Gordian knot of complicated calculation by asserting an ostensible foundational statement of geography: near things are more related than distant things.

In the interview, Tobler (1998) said the First Law "was part of a sentence in an article. And if you see it within the context of that article, it is much easier to understand. What I did there, instead of doing something very complicated, I said, okay, I can parse this down by saying this is what I expect to happen. And that's the context of that First Law." With his talk of parsing, Tobler is clearly calling on simplification to justify his invocation. That said, the particular parsing he makes is still not especially simple, given that, as is clear from his paper, it requires knowledge of matrix algebra, differential and integral calculus, inferential statistical techniques, computer programming, mathematical cartography, formal models of spatial population change, and the literature in disciplines as varied as botany and meteorology. What kind of world does Tobler come from that make these types of knowledge a simplified solution requiring the First Law? There is no complete and final answer, but as Shapin's study argued for Boyle, it is possible to identify some particular local constituents of that world. For brevity's sake, I focus on just one, Seattle in the second half of the 1950s, and in particular, the Department of Geography on the University of Washington campus. I am not claiming this one local context explains everything. Certainly, Tobler moved out of Seattle (see Tobler 2002), but my argument is that we can't take Seattle out of Tobler. Experiences in that place were central to forming his sensibility that later produced among other things the First Law.

The significance of Seattle and the Department of Geography at the University of Washington (where Tobler undertook all three of his degrees, finishing his PhD in 1961) is that while he was there, geography's quantitative and theoretical revolution was forged. The local matters here at a number of different scales. Most directly, it is found in Smith Hall that houses the geography department at the University of Washington. It is there that Tobler in a fourth floor room nicknamed the "Citadel" interacts with a remarkable group of graduate students including Brian Berry, Bill Bunge, Art Getis, Duane Marble, Richard Morrill, and John Nystuen. It is deliberate policy of Donald Hudson, the chair of the department, "to put all the graduate students in desks together in [one] big room" (Tobler 2002, 305). The result is continual interchange. They teach one another mathematical, statistical, and computer-programming techniques they often had only just learnt themselves (Brian Berry [1993] speaks about this practice as "bootstrapping"). They engage in constant debate whether in the shared office, or through the circulation of mimeo discussion papers (prompted by the generosity of Hudson with paper and the Gestetner machine), or in the evenings at the nearby Red Robin or the Reservoir Tavern (Morrill 2003).

In the interview, Tobler stated that the most influential of those students was Bill Bunge (Tobler 1998). Like Tobler, Bunge was concerned with map transformations, forming as they did a central part of his later monograph, *Theoretical Geography* (1966, chs. 2, 7–8), based on his PhD thesis. Bunge also pressed the importance of recognizing first, mathematical (which for him meant geometrical) similarities among different substantive processes—he called this "spatial cross fertilization" (Bunge 1966, 27). And second, the principles of simplification and parsimony, defined as "finding the spatial arrangement of interacting objects, often of different dimensions, and placing these objects as near to each other on the earth's surface as possible" (Bunge 1966, 210–11; also see Bunge 1969).

Also in Smith Hall are the offices of faculty including Bill Garrison who teaches Tobler an advanced statistics class (Geography 426), the first anywhere in a geography Department in North America, and location analysis (Geography 442) that takes in models of spatial interaction. Edward Ullman also teaches spatial interaction model in his urban geography field course in which Tobler enrolls in his first year (Tobler 1998). Finally in Smith Hall is the office of John Sherman, the departmental cartographer, who was to be Tobler's PhD supervisor.

Outside of Smith Hall, but on the University of Washington campus, are other significant sites. In the attic of the chemistry building is the first university computer, an IBM 650. With access only during the early hours of the morning, Tobler engaged in then state-of-the-art programming. "With your best coding," Tobler (2002, 303) says, "you could get two pieces of data on one revolution of the . . . 'huge' two thousand byte rotating storage drum." In Savery Hall, Tobler enrolled along with several of his graduate cohorts in an econometric course from a newly hired young faculty member, Arnold Zellner, who in a soporific voice after lunch intoned from Lawrence Klein's recently published primer, *A Textbook in Econometrics* (1953) (Morrill 2003). And in the mathematics building Tobler took Carl Allendoerfer's course on differential geometry, which became "invaluable" for his work on map projections and transformations forming part of his doctoral thesis (Tobler 1998).

But, as a place, the University of Washington campus was not some static entity, set in aspic, isolated from other places. It was positioned within wider networks and connections. Things and people both traveled to and from it. Traveling to Smith Hall were various visitors; perhaps the most important for the emergence of the First Law was Ross MacKay, a professor, specializing in Arctic permafrost, from the University of British Columbia. MacKay taught a class that Tobler attended that "compared the methodology of statistics with that of cartography" (Tobler 2002, 304–5). Bringing in visitors like MacKay and keeping students like Tobler in the program required money. That, too, flowed onto the campus. There was money from the university because of burgeoning enrolments that allowed Tobler to be a TA. There was money from the State of Washington that filtered down as RA stipends, such as the one Tobler received for working on a project evaluating highway construction that had originated in civil engineering, led by Ed Horwood and Bob Hennes. And sometimes money came from Washington, DC—Tobler worked for Ullman on an Office of Naval Research project. In the other direction went the University of Washington discussion paper series begun in 1958. The series was to prove influential in spreading and solidifying the revolution. For example, Peter Haggett (1965, preface) speaks of its importance in writing his critically important book, *Locational Analysis in Human Geography.* The series also later gave rise to the Michigan Interuniversity Community of Mathematical Geographers (MICMOG) discussion papers, edited and funded "off budget" by John Nystuen at Tobler's home department of the University of Michigan, and which became the basis for the journal *Geographical Analysis* (Tobler 2002, 309). Finally, people themselves traveled from Seattle, including Tobler who took up a position at Ann Arbor, partly on the recommendation of Nystuen, who was hired there a year earlier, and partly because Donald Hudson knew the Michigan chair, Charles Davis.

Tobler, then, did not go to Michigan an empty vessel, but one already filled by a series of local experiences at Seattle that would later contribute to a 1969 paper entitled "A computer movie simulating urban growth in the Detroit Region," and to its now famous sentence. As in the case of Boyle, Tobler's work is constituted by a set of local circumstances, and which help produce the First Law. And just as Boyle's law travels by reproducing in other places the local conditions under which it was formulated, so Tobler's First Law travels by making other places like the geography department at the University of Washington. Geography departments in, say, Lund, or Bristol, or Chicago, or Ohio recognized the First Law because, like the one in Seattle, they engaged in the mathematics of map transforms, statistical cartography, and computerization.

Conclusion

Is there a relationship between the IGU conference in Ann Arbor in August 1969 and those other events listed at the beginning of the paper that occurred during the same month and year? And is the IGU conference more related to Woodstock, the nearest of those events, than to fighting in the Central Highlands of Viet Nam, the most distant of those events? It is hard to imagine that such a claim is true, but under the First Law, it should be. I recognize the examples are tendentious, but they illustrate the difficulty in making philosophy-of-science, law-like connections among the locations of such variegated social events as youth culture ebullience, psychopathic cult behavior, sectarian hatred and violence, an unpopular war, and an academic conference.

In making this argument, I am not casting aspersions on Tobler's substantive work. Adding law talk, though, does not contribute anything to it substantively; it is like paying the work an empty compliment. Instead, my claim is that to understand and to appreciate fully that substance, we need to examine specific local practices, and, in this paper, I focused on Tobler's formative experiences at the University of Washington in Seattle. The problem with Tobler invoking the First Law is that it makes his view appear as if it is from nowhere, whereas my argument is that in so many ways it is the view from somewhere.

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