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Renewable Electricity Policy in Minnesota

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Director
Thomas M. Scott

Associate Director
William J. Craig

Editor
Michael D. Greco

Map Design
Jeffrey Matson, CURA; and Cartography Lab, University of Minnesota

Production and Layout
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Correspondence to the editor:
Michael D. Greco
CURA
University of Minnesota
330 HHH Center
301—19th Avenue S.
Minneapolis, MN 55455
curaedit@umn.edu

General inquiries:
phone: 612-625-1551
fax: 612-626-0273
e-mail: cura@umn.edu
web: www.cura.umn.edu

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In This Issue:

Photo on Cover: The new 1.65 megawatt wind turbine at the University of Minnesota campus in Morris, Minnesota. Photo © 2006, Richard Walker.

Renewable Electricity Policy in Minnesota: Can We Change the Subject?

by Arne Kildegaard

This 1.65 megawatt turbine meets more than 50% of the electrical demand at the University of Minnesota campus in Morris. Because it sends little power into the wider electrical grid, negotiations with the utility were greatly simplified.

Increasingly, it looks as if the transition away from an exhaustible, carbon-based fuels economy won't happen by virtue of technological innovation alone. Two areas of public policy have an enormous role to play: emissions regulations that force traditional energy producers to internalize the full environmental costs they impose on society, and competition and access rules that enable renewable energy producers to connect with consumers. For Minnesota, poised as it is to develop nontraditional renewable energy sources from its natural resource endowments in wind and agriculture, a lot depends on getting the policy right.

In most cases, federal law and Environmental Protection Agency rules establish standards for pollution abatement. State policy is more influential in the area of competitive access. In recent years, for example, some 20 states and the District of Columbia have taken the initiative to adopt their own renewable electricity standards (RES), establishing escalating minimum requirements for the amount of electricity from renewable sources sold in their jurisdictions.

This article outlines the major contours of Minnesota's state policy with respect to renewable electricity and argues for a subtle but fundamental change in emphasis. It also presents a case study of the recent distributed generation tariff proceeding before the Minnesota Public Utilities Commission, illustrating some of the vexing access problems that independent renewable energy generators face under the current regulatory framework. The article is part of a larger research program, supported in part by a grant from CURA's Faculty Interactive Research Program, examining how the organization of the electricity industry and the current regulatory posture present obstacles to the integration of renewable energy into the power generation mix.

Quantitative Mandates and Targets: The State of Play in Minnesota

The Minnesota Senate approved an RES bill in the most recent legislative session, including targets that are both less flexible and more ambitious than current policy: a *mandate* of 20% by 2020 ("20-20") versus the current *objective* of 10% by 2015. The measure was blocked in the Republican-controlled House of Representatives which, along with Governor Tim Pawlenty, continued to favor the existing, nonbinding renewable energy objective (REO) approach. Control of the House of Representatives shifted dramatically in the November 7, 2006, election, from which the DFL party emerged with an 85–49 majority. Given the prominence of the issue during the campaign season, it seems very likely that both legislative houses will pass the mandatory "20-20" bill in the next legislative session. The governor will then have an important decision to make at that point, and the issue of mandates versus objectives is likely to feature prominently in the debate.

In practice, however, Minnesota's approach to encouraging electricity from renewable energy is already a mixture of quantitative objectives and quantitative mandates. Although the REO applies to other utilities, the state's largest utility—Xcel Energy, which sells about 50% of the state's electricity—already operates under elaborate quantitative mandates, governing the timetables and targets for adoption of a minimum number of "green" megawatts from various sources.

This peculiar utility-specific arrangement traces back to a deal struck originally in 1994, accommodating Xcel Energy's desire to store spent nuclear fuel rods onsite at its Prairie Island facility. The terms of the 1994 state statute required Xcel to acquire 425 megawatts of wind capacity by the end of 2002, as well as 125 megawatts of biomass-fueled electricity. In 1999, the Public Utilities Commission (PUC) raised Xcel's wind requirement an additional 400 megawatts by 2011. Meanwhile, in 2001, the legislature established the nonbinding REO for all utilities serving Minnesota electricity customers, setting a target of 1% of sales from renewable sources by 2005 and increasing 1% each year through 2014. In 2003, the legislature made the REO into a binding mandate for Xcel and stipulated further that the company acquire an additional 300 megawatts from local small wind developers and acquire at least 1% of its energy from biomass sources by 2015.

These mixed policies have been most consequential for wind development. By the summer of 2006, more than 756 megawatts of wind capacity was operational in Minnesota and another 27 megawatts was planned. More than 700 megawatts of this total is traceable directly to the binding mandates on Xcel Energy. Because the REO benchmarks only recently came into effect in 2005, it is perhaps unsurprising to see actual developments on the ground dominated thus far by Xcel's mandate compliance. Only a few municipal utilities failed to meet the 1% benchmark last year, but with the 2006 benchmark double that of 2005, we may soon start to see some evidence concerning how effective voluntary compliance is across the state.

Minnesota's environmental advocacy groups, for their part, have enthusiastically thrown their weight behind a policy of quantitative mandates, including relatively aggressive targets for renewable energy sources. Utilities by and large have worked for a greater degree of flexibility and less aggressive targets, but have not objected strenuously to a "targets and timetables" approach in principle. Independent power generation interests representing a variety of feedstocks have lobbied for (and frequently received) special consideration.

Despite the apparent consensus in Minnesota, quantitative targets—whether voluntary or mandatory—are a poor choice from an economic perspective. In particular, the greater the ambiguity about what sources qualify to satisfy the mandate, and the greater the number of political quantities in question (e.g., separate quantitative mandates governing minimum megawatt-hours of wind energy, solar energy, refuse-derived fuel, co-generation, geothermal energy), the greater the likely deviation from cost efficiency and the greater the potential for politics and interests to trump economics.

Whenever there are heterogeneous sources of energy generation, differing marginal costs will rule out a cost-minimizing means of reaching *any* given total quantity of renewable energy. The price a utility must pay, for example, to induce someone to build a turkey manure burning facility may in practice be several times what the utility pays a wind turbine owner in the same location for the same kilowatt-hour of energy. When this is the case, economic efficiency argues for more wind and less turkey litter in the renewable energy mix.

The example is not hypothetical: The turkey litter plant in Benson, Minnesota, has a PUC-approved power purchase agreement with Xcel Energy for $0.086 per kilowatt-hour (kWh). The Laurentian Energy Authority, a limited-liability corporation jointly formed by the towns of Hibbing and Virginia to produce electricity from fast-growth poplar trees, recently had its power-purchase agreement approved by the PUC at an average price of $0.103/kWh. Although the project ultimately was not completed, the Minnesota Valley Alfalfa Producers Co-op signed a power-purchase agreement with Xcel Energy in 2000 for $0.13/kWh. By comparison, Xcel's small-wind tariff pays only $0.033/kWh. In a 2005 publication titled "Minnesota's Biomass Mandate: An Assessment," David Morris of the Institute for Local Self-Reliance estimates the biomass mandate alone will cost Xcel customers $1.1 billion during the next 20 years, relative to a comparable amount of energy from wind. When the resources available to support renewable energy are limited, waste on this scale should not be acceptable public policy.

An analogous inefficiency arises in the case where there is a single quantitative mandate, but eligible means of satisfying that mandate are ambiguous. Minnesota's 1994 biomass mandate, for example, has resulted in repeated legislative intervention on behalf of specific companies. Minnesota Statute §216B.2424 (2001) is an interesting case in point. The statute directs Xcel Energy to negotiate a long-term contract for a 10- to 20-megawatt facility to be developed

> by a small business–sponsored independent power producer facility to be located within the northern quarter of the state, which means the area located north of Constitutional Route No. 8 . . . and that uses biomass residue, wood, sawdust, bark, chipped wood, or brush to generate electricity. A facility described in this clause is not required to use biomass complying with the definition in Subdivision 1 . . .

Itasca Power not only is singled out for the contract (being the only facility that fits the description), but also is exempted from the requirements regarding the use of biomass fuel sources. Such a transparently political allocation of resources virtually guarantees heterogeneous marginal costs among generators, which is to say, an unnecessarily expensive portfolio of renewable energy generation.

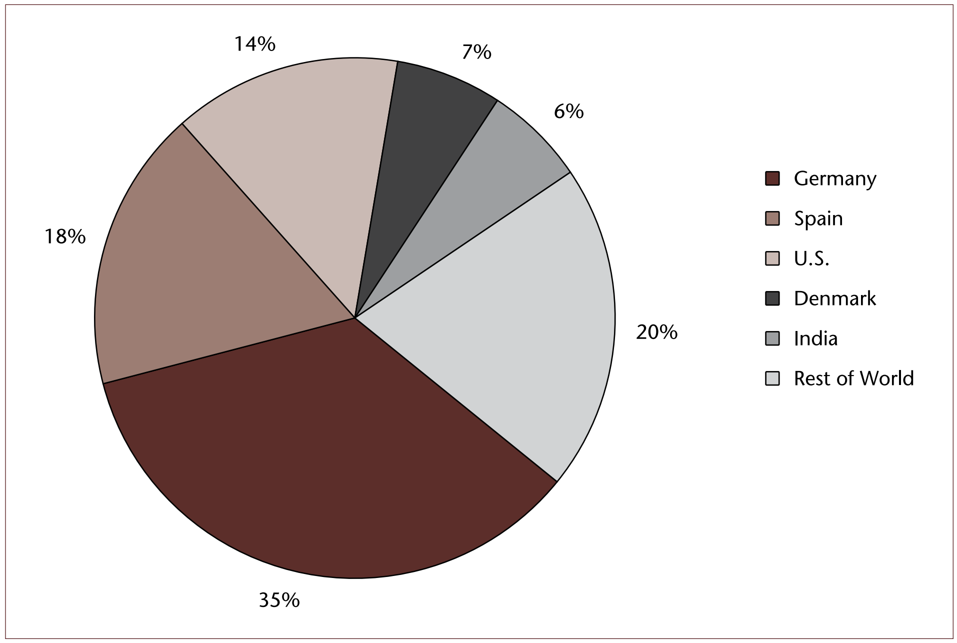
An Alternative Approach: Feed-in Tariffs

Whether it is an RES or an REO, the distinguishing feature of the quantitative targets-and-timetables policy is that the *quantities* of green power generation required are determined politically, whereas the *price* is a market phenomenon. The utility can either build generation capacity or bid it out to independent producers, but the underlying economics of each power generation source ultimately determine the minimum price that the utility pays. In contrast, Germany, Denmark, and Spain—the European countries with the best track record for actual adoption and integration of wind power—have taken an entirely different regulatory approach to encouraging renewable electricity. In these countries, the *prices* are set politically, whereas the *quantities* are driven by competition. Through the use of *feed-in tariffs,* these countries' policies obligate the grid operator to pay a posted minimum price for all energy purchased from renewable sources.

Americans typically object to any suggestion that European energy price policies have merit, but in this case, the objection is misplaced. Although retail electricity prices in countries with feed-in tariffs do generally exceed those in the United States, that is because of other energy or environmental policies that are unrelated to feed-in prices per se. In Denmark, for example, the feed-in tariffs historically have been at or below €0.06/kWh ($0.07/kWh); however, energy taxes drive the retail price more than 100% higher. In general, feed-in tariffs constitute a fraction of the before-tax retail price of electricity. Retail rates for electricity in the United States typically range from $0.05 to $0.13/kWh, depending upon the region. Minnesota's electricity rates, at least for large firms, are regulated by the PUC. According to the U.S. Department of Energy, the average retail price to consumers in Minnesota in July 2006 was $0.08/kWh (below the national average of $0.09/kWh). By comparison, the wind feed-in tariffs in Denmark, Germany, and Spain range from €0.055 to €0.11/kWh (or $0.07 to $0.14/kWh).

Figure 1 illustrates the impressive track record of European feed-in tariffs in integrating wind energy into the power generation portfolio. Spain (a newcomer to widespread wind adoption) and Germany alone account for more than half (53%) of the world total. On a per-capita basis, Denmark has 30 times the installed capacity of the United States in wind energy. Germany and Spain continued to account for 52% of new wind capacity added worldwide in 2004, and nearly 75% of the 2004 increase in wind-generation capacity worldwide occurred in Europe, where feed-in laws are common.

Figure 1. Total Installed Wind Capacity by Country, 2004



Source: American Wind Energy Association, *Global Wind Energy Market Report,* 2005, www.awea.org/pubs/documents/globalmarket2005.pdf.

Quantitative mandates—especially when eligibility is ambiguous—are a recipe for nonmarket allocation of resources. Feed-in tariffs, on the other hand, provide a direct, unified mechanism to encourage least-cost power generation through renewable energy sources. Technologies that are not viable at the specified prices will not be adopted, whereas technologies that are viable will have marginal costs at or below the feed-in tariff. The full environmental costs (externalities) of other fuel sources also can be accounted for by adjusting the level of the feed-in tariff.

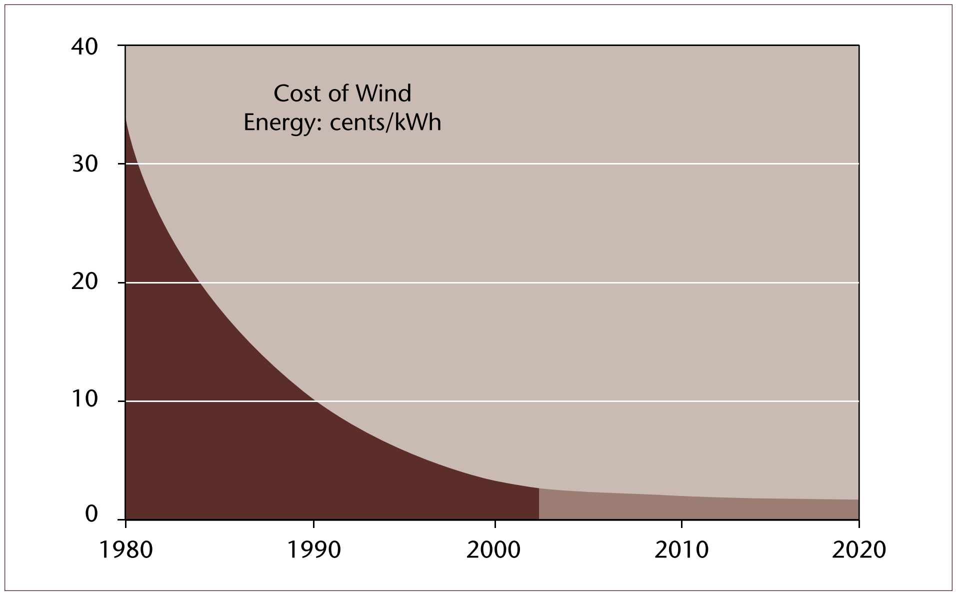
The certainty of a feed-in tariff makes financing for renewable technologies easier on more favorable terms. Independent wind development financing cannot proceed without a power-purchase agreement with the utility, yet veteran wind developers frequently complain of delay tactics and other gamesmanship when it comes to negotiating these terms. Attracting and sustaining an investor group would be dramatically simpler if this costly, arbitrary, and time-consuming step were eliminated via a guaranteed-access, fixed-price, feed-in tariff.

In comparison with the reigning regime in the United States, feed-in laws would be refreshingly transparent. The current process requires a great deal of patience, expertise, and money—to raise sufficient capital, partner with an entity with the ability to absorb the federal production tax credit, negotiate a power purchase agreement with the utility, and comprehend the grid-operator feasibility study. This is particularly relevant to potential small wind developers at the local level, who may lack the resources or the intestinal fortitude to see a worthwhile project through to completion. Ultimately, much depends on the goodwill of such people: because the resource itself is dispersed about and among us, community acceptance is critical to wind development. As the Danes say of local ownership: "Your own pigs don't stink."

Perhaps most important, however, feed-in tariffs leave the quantity of green power open-ended, to be determined by the market rather than circumscribed by legislation. The prospect of a growing market opens the possibility for turbine manufacturers to increase sales and profits by competing over price. Until recently, all of the major turbine manufacturers developed their operations in countries with lengthy regimes of feed-in laws. As Figure 2 illustrates, competition and technological progress have dramatically reduced the cost per installed-megawatt for wind energy over the years. Meanwhile, in the United States where quantitative mandates have recently grown popular and become important industry drivers, there is clear evidence of a sharp rise in turbine prices during the past two to three years. Figure 3 shows the trend since 2003, both in the price of turbines and in the price of completed projects.

With renewable energy quantities circumscribed by policy at the state level, and with the irregular heartbeat of federal incentives, instead of witnessing cost reductions that serve to stimulate clean energy adoption we are suddenly seeing the opposite. Although the explanation is extremely tentative, the effect of policy on the conditions of competition should not be dismissed as an explanation.

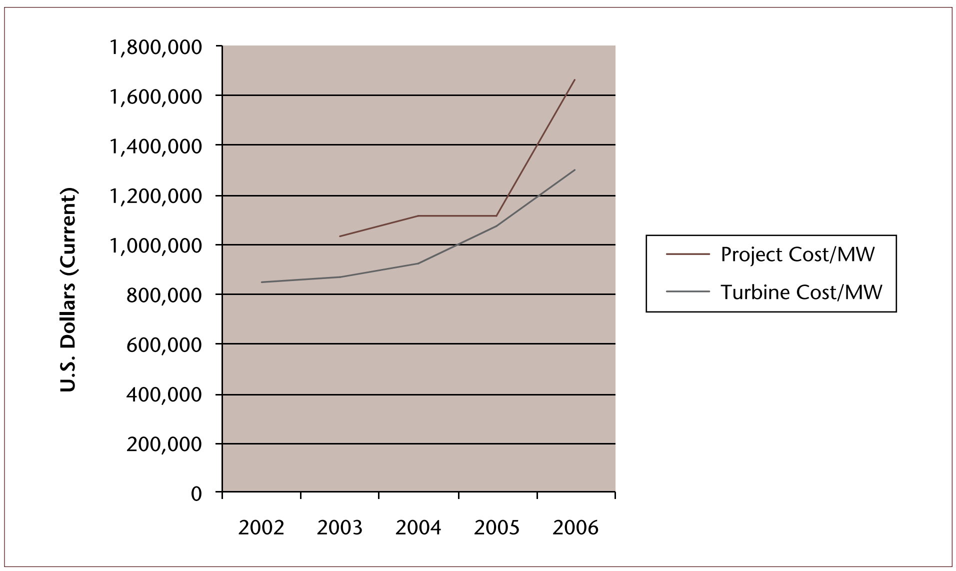
Figure 2. Historical Cost Trends for Wind Energy (in constant 2002 dollars)



Source: National Renewable Energy Laboratory, Energy Analysis Office, "Renewable Energy Cost Trends" (PowerPoint presentation), 2002, www.nrel.gov/analysis/docs/cost_curves_2002.ppt.

Note: These data are reflections of historical cost trends, not precise annual historical data.

Figure 3. Historical Trend of Turbine and Complete Wind Project Costs, 2002–2006



Source: Turbine cost data from Emerging Energy Research, "Delivering Wind Power: Meeting the Turbine Supply Challenge," slideshow presented at the American Wind Energy Association's Wind Power Conference and Exhibition, Pittsburgh, PA, June 4–6, 2006; project cost data courtesy of Paul Gipe, Ontario Sustainable Energy Association.

How Did We Get Here? A Brief History of Competition in the Electricity Sector

The original vision of market deregulation of the industry was for competitive market prices *and* competitive market quantities to determine the market portfolio. The 1978 Public Utility Regulatory Policy Act (PURPA) required utilities—which had previously exercised complete geographic monopolies over generation and distribution—to buy back electric power from certain qualifying facilities, almost exclusively small-scale renewable energy-fueled generators.

The paradigm shift entailed by PURPA owes to a fundamental shift in the technology and economics of power. Historically, the economies of scale of large, central-station power plants had been so compelling that the industry was widely viewed as a natural monopoly and competition was thought to be socially inefficient. Improvements in small-scale generation technologies (wind, solar, co-generation, geothermal), and a growing appreciation of the economic value of electrical generation located near the load of electrical demand, however, began to challenge the traditional understanding of how the industry should be organized. The case for such independent, distributed generation sources was strengthened by the decade of turbulent international energy prices in the 1970s, as well as by the fact that many of these new sources promised environmental advantages.

The 1992 Energy Policy Act opened access to the grid to a wider class of nonutility generators and authorized the Federal Energy Regulatory Commission to order local utilities to provide these generators with nondiscriminatory access to transmission service. The latter act, in particular, has given rise to competitive regional markets in wholesale power.

With respect to pricing, PURPA required utilities to pay *avoided costs,* which are all of the costs that the qualifying facility's electricity production enabled the utility to avoid. In principle, these avoided costs comprise a range of utility savings, including such things as energy generation costs, capacity costs, ancillary services costs, and reduced congestion costs. But the new competition in energy generation clearly threatened some existing utilities. There is a long-standing regulatory principle that allows utilities to build into the electricity rate base only the cost of assets that are "used and useful," and the sudden emergence of new power generators owned by third parties can make certain utility investments redundant. Now, almost 30 years after PURPA, the process of calculating avoided costs remains extremely contentious. Utilities have been directed to use complex proprietary information to calculate the fair rate at which new unaffiliated power generators will erode the utilities' own equity, and they have embraced the task with all the enthusiasm that might be expected.

To the extent that a utility's offer price for energy is based on a calculation that understates true avoided costs, the renewable energy industry is suppressed in an anticompetitive manner. The forestalled transition to renewable energy, then, would be traceable to badly designed regulatory structures rather than to a failure in the economics of renewable energy per se. Transparent accounting procedures might make it possible for a true avoided-cost estimate to be determined. Politics might then be the instrument by which this fair market price is required to be paid. Although progress has been made in this direction, as the following case study illustrates, it has been glacially slow and only modestly successful.

The Public Utilities Commission "Distributed Generation" Docket

A recent distributed generation rule-making procedure the PUC conducted provides an interesting, if somewhat exasperating, case study of the attempt to use the political process to set a price on electrical generation from non-utility sources. A 2001 act of the legislature (Minnesota Statute §216B.1611) directed the PUC to develop technical and financial standards for "interconnection and parallel operation of distributed generation fueled by natural gas or a renewable fuel . . . of no more than ten megawatts of interconnected capacity." The PUC promptly opened Generic Distributed Generation and Interconnection Proceeding (Docket No. E-999/CI-01-1023), formed separate working groups on rates and standards, and began hearings in July 2001.[1] Many of the disputes that arose in the process pitted some combination of existing interested parties (such as investor-owned utilities, rural electric cooperatives, and municipal power authorities) against incipient interests and nongovernmental organizations (such as potential distributed generators and environmental organizations). Distributed generation interests coalesced into what became known as the Distributed Generation Coalition and played an active role in the proceedings. Utilities often filed individual comments and briefs, but also coalesced into the Electric Utility Group for certain filings. The Department of Commerce assigned well-trained analysts to prepare position statements for the agency.

[1] The Institute for Local Self-Reliance maintains an excellent archive of the proceedings at www.newrules.org/dgtariff/.

After three years, most of the technical issues had been resolved, including standards for interconnection intended to protect the integrity of the grid, the quality of electrical service to other users, and the safety of utility personnel; a transparent, standardized process through which potential distributed generators might apply for interconnection service; and a list of services that utilities must offer at published prices to distributed generators that are also consumers of power.

Of particular importance for our purposes was another set of rulings—those that regulate what the utilities must pay the independent generators for the energy they purchase. There was no disagreement between parties on the following principles outlined in the September 2004 *Order Establishing Standards* issued by the PUC:

> a. Rates should reflect the value of the distributed generation to the utility, including any reasonable credits for emissions or for costs avoided on the generation, transmission, and/or distribution system.
> b. Rates should reflect the costs the utility expects to avoid. To the extent practical, these costs should reflect seasonal and peak/off-peak differences in cost. (p. 10)

The method for *calculating* avoided costs proved to be more contentious. By common practice, electricity service is priced by *energy* (i.e., the number of actual kilowatt-hours transferred) as well as by *capacity* (generally defined as the peak transfer of power). In the case of a retail customer's bill, the capacity charge is usually called the *demand charge,* and it may refer either to the customer's own peak electricity usage or to the customer's electricity usage at the moment of peak system demand. In either case, capacity charges arise because of two characteristics of the electricity industry: (1) electric energy itself is non-storable and (2) the marginal cost of energy is much higher during peak hours.

Energy charges were dealt with relatively amicably in the PUC *Order Establishing Standards*. Capacity charges were another matter. The act of bringing online a new electricity generator helps address one of the essential problems that utilities face: Electricity customers have, effectively, an unlimited call option on power, which from the utility side of the fence amounts to an imperfectly hedged obligation to supply power, regardless of quantity or marginal cost. Historically, utilities have hedged this risk by developing sufficient generation capacity in-house to meet their own peak demand. Today, it is less necessary that generation resources be held by the load-serving entities, since wholesale power markets are increasingly liquid, and other hedges such as financial transmission rights and long-term contracts with third parties are available.

The fact that an independent power producer may control a distributed generation unit is something of a distinction without a difference: The purchase contract puts that power at the disposal of the utility, which (1) lowers the risk that the utility might have to buy at premium spot-market prices on peak days and (2) defers the date when the utility would have to invest in-house in the same level of capacity. Both of these features have value to the utility.

The most controversial aspect of capacity payments proved to be the horizon over which distributed generators would be paid for providing capacity. There was agreement in general terms that the capacity payment should be based on the monthly mortgage payment that the utility would otherwise need to make on an owned power-generation asset (inclusive of fixed operation, maintenance, and start-up costs) financed over its entire (expected) productive lifetime. The specific formula spread out this payment in proportion to how far one had to project into the future before the energy capacity became "needed" (i.e., before projected demand outstripped projected capacity to supply), allowing for an 18% margin.

Critically, the original language of the working group on rates identified a utility "need"—and hence eligibility for distributed generation capacity sales to utilities—whenever the utility's integrated resource plan showed an excess of projected demand over projected supply at any point in a 15-year planning horizon. The utilities argued strenuously that the discounting formula discussed above was insufficient, and that they should not have to pay for capacity before it was needed. This, they held, was consistent with a long-standing principle that each generation should pay only for the assets from which it actually receives benefits. Not only did utilities argue against effective capacity payments to distributed generators, but they also argued in favor of capacity standby charges to be levied *against* those distributed generators that might require back-up power in case of an outage of their own distributed generation systems.

© 2006, Steve Schneider

Remote central-station electrical power requires transmission and distribution on a wide scale. The terms under which independent energy generators may access this infrastructure are fiercely contested.

The distributed generation coalition pointed out that such a prohibition on early (discounted) payment would discriminate in favor of utility-owned projects. In fact, most utility-scale generation projects are extremely "lumpy," leaving the utility with excess ("unneeded") capacity, which growing market demand only gradually absorbs. Yet the cost of all megawatts of a utility project are built into the rate base from the time the project begins—which is precisely what the distributed generation coalition was requesting for nonutility generators.

In the give-and-take before the PUC, the utilities acknowledged the point that capacity additions have value, even when the need is in the future, but they took a new approach, arguing now that 15 years was simply too long of a planning horizon to be relevant. They successfully persuaded the PUC that the threshold for "need" should be a five-year planning horizon, arguing that any demand projections further into the future were so speculative that they did not merit financial commitment and violated the pay-as-you-go principle.

Ultimately, this decision essentially means no capacity payments to distributed generators, which is unfortunate. Utilities will continue to plan large "lumpy" central station power plants to reap the economies of scale. When the timing of new facilities falls slightly behind and a "need" is perceived over the five-year horizon, a few distributed generation plants already in the works will benefit from serendipitous timing. Ironically, since these windows of opportunity are likely to be brief, these distributed generation capacity additions are likely to be rendered superfluous rather quickly, because the next lumpy utility investment will move the utility from a state of need to a state of surplus as soon as it comes online.

Many other contentious issues arose during the course of the proceedings, including allowing distributed generators to opt out of standby power, compensating distributed generators for the green attribute of their power (a marketable commodity), and the secrecy of the tariffs themselves. With respect to tariffs, the PUC ruled with the utilities and against the Department of Commerce and the Distributed Generation Coalition, holding that the tariffs for both energy and capacity may rightfully be considered trade secrets, and thus only available to petitioners who sign nondisclosure forms. And although the formulas for generating these tariffs are stipulated in the September 2004 *Order Establishing Standards,* the data used in the formulas are closely held secrets.

Conclusion

The most visible political debate over renewable energy policy in Minnesota concerns the level and flexibility of quantitative targets for megawatts of renewable electricity. On theoretical and empirical grounds, a policy of price mandates (feed-in tariffs) is actually the superior instrument for stimulating competition in the turbine market, cost-efficiency in the renewable generation portfolio, rapid adoption of new technologies, and participation by small local investors.

The introduction of wholesale competition into restructured electricity markets has posed a threat to investor-owned utilities, rural electric cooperatives, and municipal power authorities, putting in motion a serious game of "hot potato." It is in the nature of competition that innovation devalues someone's existing assets, and none of the traditional players in the industry want to find themselves with either an obsolete generator or with the legal responsibility to service an electrical load of uncertain size via wholesale purchases at an uncertain price. The botched energy market restructuring effort in California in the late 1990s is an object lesson.

As a result, attempts to derive market efficiency by establishing fair avoided-cost pricing have proceeded only haltingly. Calculation of avoided cost is a complicated managerial accounting problem in the first place, and the utilities themselves have been charged to do the calculations. It is too much to expect that vested interests and incipient interests will be evenly matched in such narrow proceedings.

The recent PUC docket to make pricing for distributed generation transparent took three years to establish standards, and another two years to approve tariffs. In the end, only a fraction of the avoided costs are included in the tariff, with none corresponding to transmission or congestion savings, and avoided capacity costs only partially included. The tariffs themselves, derived from proprietary data (which the PUC has ruled a trade secret) funneled through complex production models, are not even publicly posted.

Renewable energy advocates in the state have tried avoided-cost hearings and they have tried lobbying for quantitative mandates. By and large, the latter has proven the path of least resistance. Rather than continuing to push for demonstrably inefficient quantitative mandates, or continuing to fight the house odds on avoided-cost rulings over narrow domains, advocates should push for a legislatively mandated *unified* feed-in tariff proceeding, which might just attract enough participation from the various incipient interests to make the outcome less predictable. In Minnesota, good policy and good politics might still point in the same direction.

Arne Kildegaard is associate professor of economics and management at the University of Minnesota at Morris. His research and teaching focus on natural resource and environmental economics, with particular emphasis on the economics of renewable energy.

The research upon which this article is based was supported in part by a grant from CURA's Faculty Interactive Research Program. The program was created to encourage University faculty to carry out research projects that involve significant issues of public policy for the state and that include interaction with community groups, agencies, or organizations in Minnesota. These grants are available to regular faculty members at the University of Minnesota and are awarded annually on a competitive basis.

Project Funding Available from CURA

The Center for Urban and Regional Affairs supports community-based research projects through several different programs. If you represent a community organization or agency and are unsure which program listed below is most suitable for your project proposal, simply complete a general Community Program Application Form at www.cura.umn.edu/Programs/curaappform.html and we will route your request to the appropriate program.

■ The **Community Assistantship Program (CAP)** matches community-based nonprofit organizations, citizen groups, and government agencies in Greater Minnesota with students who can provide research assistance. Eligible organizations define a research project, submit an application, and if accepted, are matched with a qualified student to carry out the research. The deadline for applications for summer 2007 support (early June through August) is March 30, 2007. For more information, to discuss potential projects, or for assistance with applications, contact CAP coordinator Will Craig at 612-625-3321 or wcraig@umn.edu, or visit www.cura.umn.edu/cap.php.

■ **Neighborhood Planning for Community Revitalization (NPCR)** provides student research assistance to community organizations in Minneapolis, St. Paul, and metro area suburbs that are involved in community-based revitalization. Projects may include any issue relevant to a neighborhood's or community's needs and interests, including planning, program development, or program evaluation. Priority is given to projects that support and involve residents of color. Applications from organizations collaborating on a project are encouraged. Applications for summer 2007 support (early June through August) are due March 30, 2007. For more information, visit www.cura.umn.edu/npcr.php or contact NPCR program director Kris Nelson at 612-625-1020 or ksn@umn.edu.

■ **University-Neighborhood Network (UNN)** links community organizations to course-based neighborhood projects that students carry out as part of course requirements at a Twin Cities college or university. Organizations that participate in the program identify projects with which they need assistance. UNN then locates faculty who teach courses that meet the organization's needs, and students who have an interest in the proposed project. Participation in UNN is coordinated through a web database system. For more information, visit www.cura.umn.edu/unn.php, or contact UNN coordinator Jeff Corn at 612-625-0744 or unn@umn.edu.

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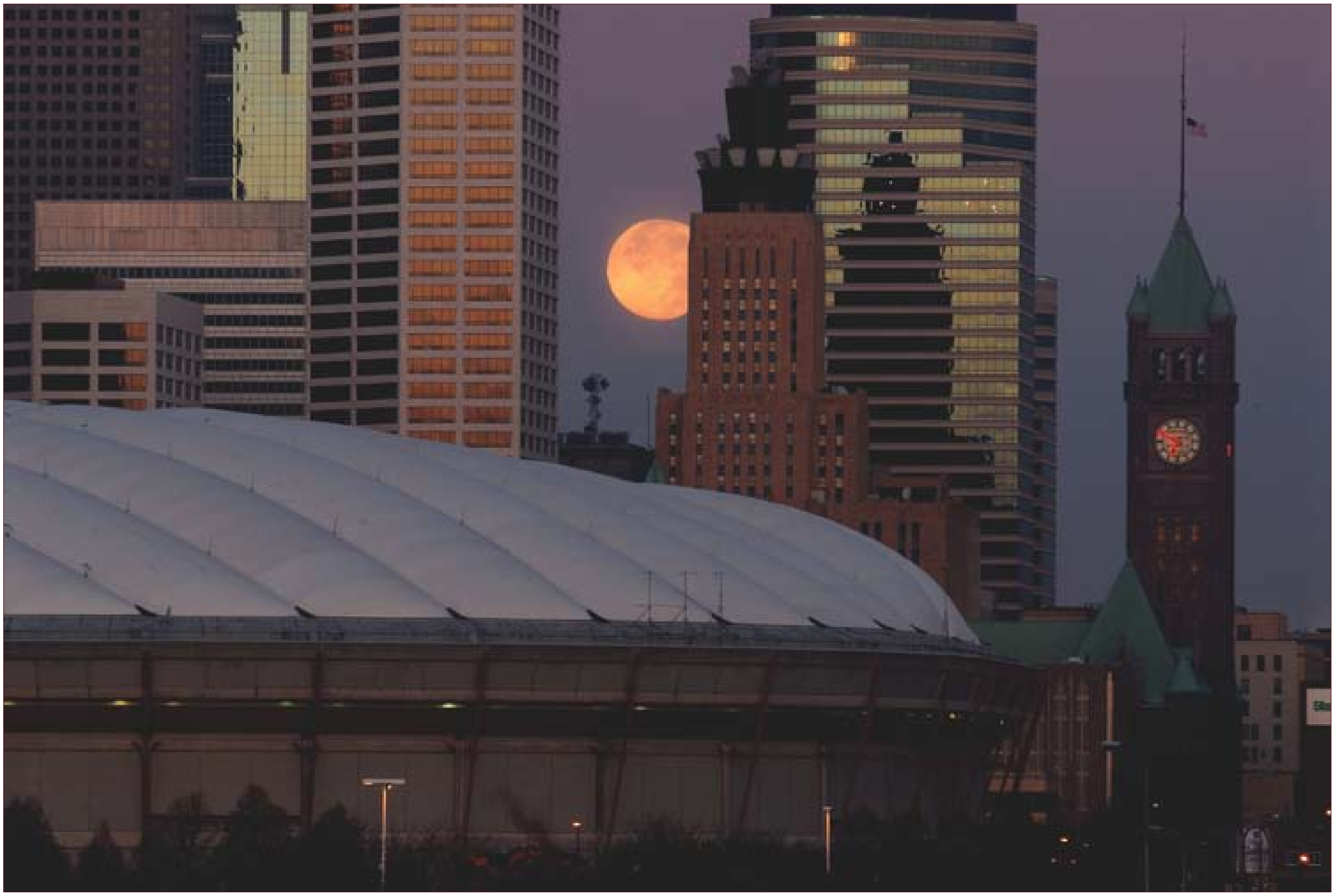
■ The **Fesler-Lampert Chair in Urban and Regional Affairs** is an endowed position that supports, for one year, the research activities of a University of Minnesota faculty member for work on a project related to urban and regional affairs in Minnesota. The award is made possible through the generosity and vision of David and Elizabeth Fesler. Funds may be used to obtain release time or other support for the project, and may be used for either new or current projects. A formal announcement for the 2007–2008 academic year competition will be made in January 2007, with proposals due in late March. For more information, visit www.cura.umn.edu/fesler-lampert.php, or contact CURA director Tom Scott at 612-625-7340 or scott001@umn.edu.

■ The **New Initiative** program accepts project proposals from community organizations, government agencies, and University of Minnesota faculty and students for projects that are inappropriate for or unrelated to other CURA programs. CURA is always looking for a good new idea, and supports many new projects outside of our existing program areas. The best approach is to call us to discuss the idea; if it looks worthwhile, we will encourage you to write a brief proposal. For projects supporting government agencies, we usually seek matching funds. Maximum support for a project is generally a half-time graduate student research assistant for one academic year; support for one semester is more typical. For more information or to discuss a project idea, contact CURA associate director Will Craig at 612-625-3321 or wcraig@umn.edu.

A New Twin Cities: The Shape of Things to Come

by John S. Adams



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A useful way to describe the economic geography of the United States is to see it as a mosaic of metropolitan-centered regional economies, each competing with one another and with the rest of the world. Among the 300-plus metro-centered regional economies in the United States, the Twin Cities ranks 16th in population size and has been one of the fastest growing since the early 1990s.

Fast growth brings price inflation for land, housing, offices, and existing fixed investment, plus wealth effects that stimulate household consumption, an influx of investment capital, above-average job creation rates, and high rates of domestic in-migration and immigration. The multiplied effects of these trends feed one another, expanding and sustaining high rates of growth and land development. Disposable incomes rise, jobs follow disposable incomes, ambitious and future-oriented people migrate to jobs, additional jobs deliver more local disposable incomes, and the cycle continues—with positive as well as negative consequences.

This dynamic has fueled expanded Twin Cities–area economic flows during recent decades. There is little prospect of a letup in rates of growth, although there is mounting evidence of deterioration in the Twin Cities' natural environment, built environments, human capital, and economic position vis-à-vis its competition. Consumer spending expands while maintenance of public infrastructure and new investment in public goods languish. The result is regional assets drawn down to sustain land development and aspects of growth whose beneficiaries often fail to pay fair prices for the resources they extract from the regional system.

On the surface, the expanded economic flows (e.g., more jobs, higher incomes, expanded consumer spending) can be seen as net gains for the region. On the other hand, the regional assets that sustain those flows (e.g., human capital, regional transportation systems, the built environment, natural environments, research and educational institutions) appear to be fraying around the edges. New businesses and residents arrive eager to take advantage of what the region offers in the way of opportunity, taking for granted the investments previous generations made, but often are unaware of the costs they impose on the system and are unwilling to pay for them. The result is expanded economic flows but a weakened asset base as the Twin Cities region confronts its future.

This article presents an overview of (1) the expanding size and geographical extent of the Twin Cities area in recent decades, (2) how the building and rebuilding of Twin Cities housing landscapes reflect demographic and economic change distorted by misplaced subsidies, and (3) how these trends present challenges for local government and metrowide planning in the years ahead. The research on which this article is based was supported in part by my appointment as the 2001–2002 Fesler-Lampert Chair in Urban and Regional Affairs at the University of Minnesota, with additional support from the University's Center for Transportation Studies.

The Expanding Twin Cities Metropolitan Area

The Twin Cities area grew robustly in both size and geographical extent between 1950 and 2000. In 1950, the newly defined Standard Metropolitan Area included just four counties (Anoka, Dakota, Hennepin, and Ramsey), covered 1,721 square miles, and was home to 1.1 million persons. The central cities of Minneapolis (population 521,460) and St. Paul (311,232) housed three of four metro residents (75.7%), on 109 square miles—only 6% of metro-area land. About one of four residents lived in a handful of former streetcar suburbs adjacent to the central cities (e.g., Richfield, Edina, Morningside, St. Louis Park, Golden Valley, Robbinsdale, Crystal, Brooklyn Center, Columbia Heights, New Brighton, Roseville, West St. Paul) or in industrial suburbs farther from the Twin Cities (Hopkins, South St. Paul).

By 2000, the Office of Management and Budget–designated Metropolitan Statistical Area (MSA) had expanded to 13 counties (including two in Wisconsin) covering 6,118 square miles with 3 million residents. As area population grew, it dispersed. By 2000, the population of both central cities had declined (to 382,618 in Minneapolis and 287,151 in St. Paul), and together accounted for only one in five (22.6%) metro residents on 1.8% of MSA land, whereas the remaining 77% lived in more than 600 communities throughout the Twin Cities commuting field (Figure 1).

Looking Ahead. In an article titled "America's Megapolitan Areas," published in the July 2005 issue of the Lincoln Institute of Land Policy's journal *Land Lines,* researchers Robert E. Lang and Dawn Dhavale coined the term "megapolitan areas" to describe sets of contiguous, integrated, metropolitan and micropolitan areas that function as regional economies and compete with similar regional economies in Europe and Asia. To date, 10 megapolitan areas have been defined in the United States (Figure 2). In 2003, these 10 areas contained less than one-fifth of all land area in the lower 48 states, but more than two-thirds of the U.S. population—almost 200 million people.

In the decades ahead, a Twin Cities–centered megapolitan area is almost certain to emerge. Today's commuting patterns provide a forecast of the future geographical extent of such an area. At present, 25 counties (including four in Wisconsin; see Figure 1) send at least 5% of their daily commuters into the seven-county metropolitan core, implying that during the next two decades the commute field will intensify northeast toward Duluth, northwest to St. Cloud and beyond, southwest to Mankato, southeast toward Rochester, and east across the St. Croix River. This is the likely configuration of a Twin Cities–based megapolitan area, competing with the rest of the nation and the rest of the world. Its competitive success will depend on leadership, cooperation of governments, and investments made in the region in coming years.

Inside the Twin Cities Region

As the Twin Cities competes with the rest of the world in coming years and draws a share of national and international growth into our region, important demographic and economic changes will force a continuing remodeling of local landscapes—more people, greater diversity, additional housing, and land steadily converted to urban uses.

Population. As the Twin Cities region grows in population, its composition changes in age structure and in racial and ethnic composition.

<u>Age Composition</u>. The median age of the Twin Cities population declined after 1950 under the impact of the postwar baby boom, which peaked around 1960. It was 31.4 years in 1950, dropped to 25.8 by 1970, rose to 28.9 by 1980, and reached 34.2 in 2000. But medians fail to reflect changes within age cohorts that affect the needs of different groups for education, jobs, housing, healthcare,

Figure 1. Expansion of the Twin Cities Metropolitan Area, 1950 to Present

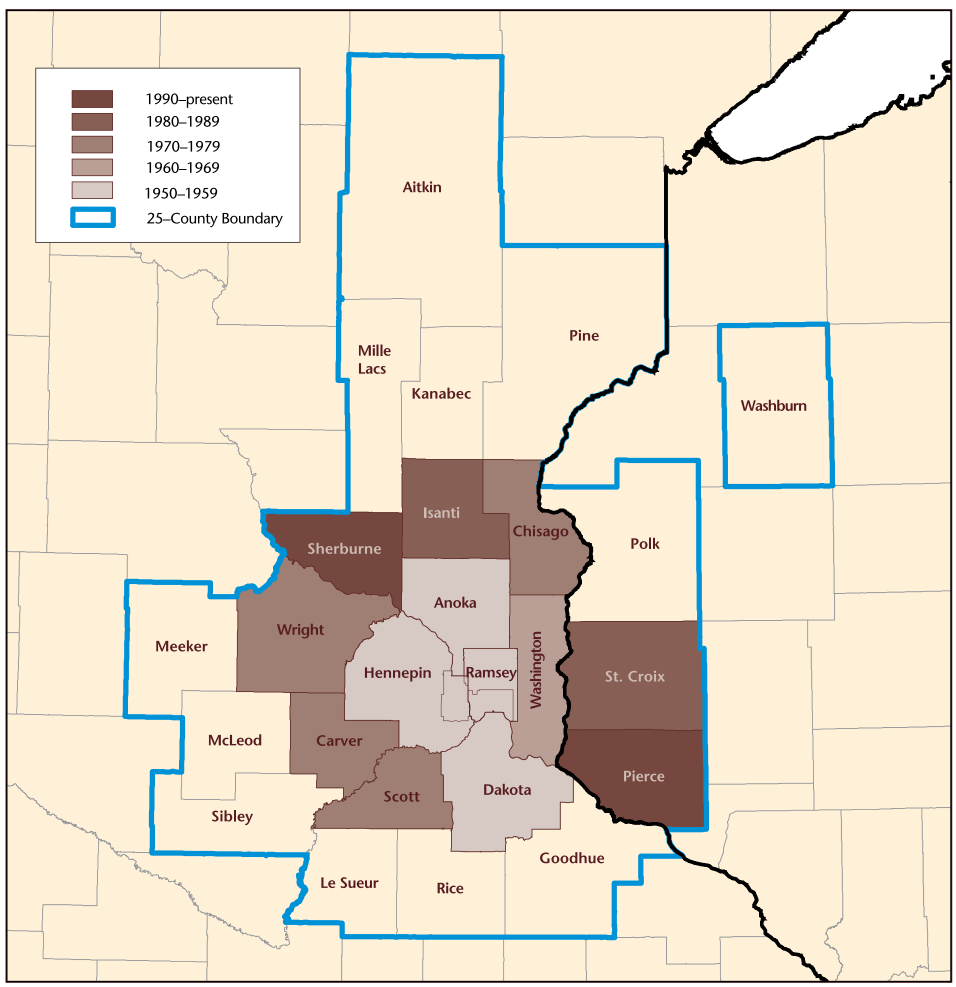
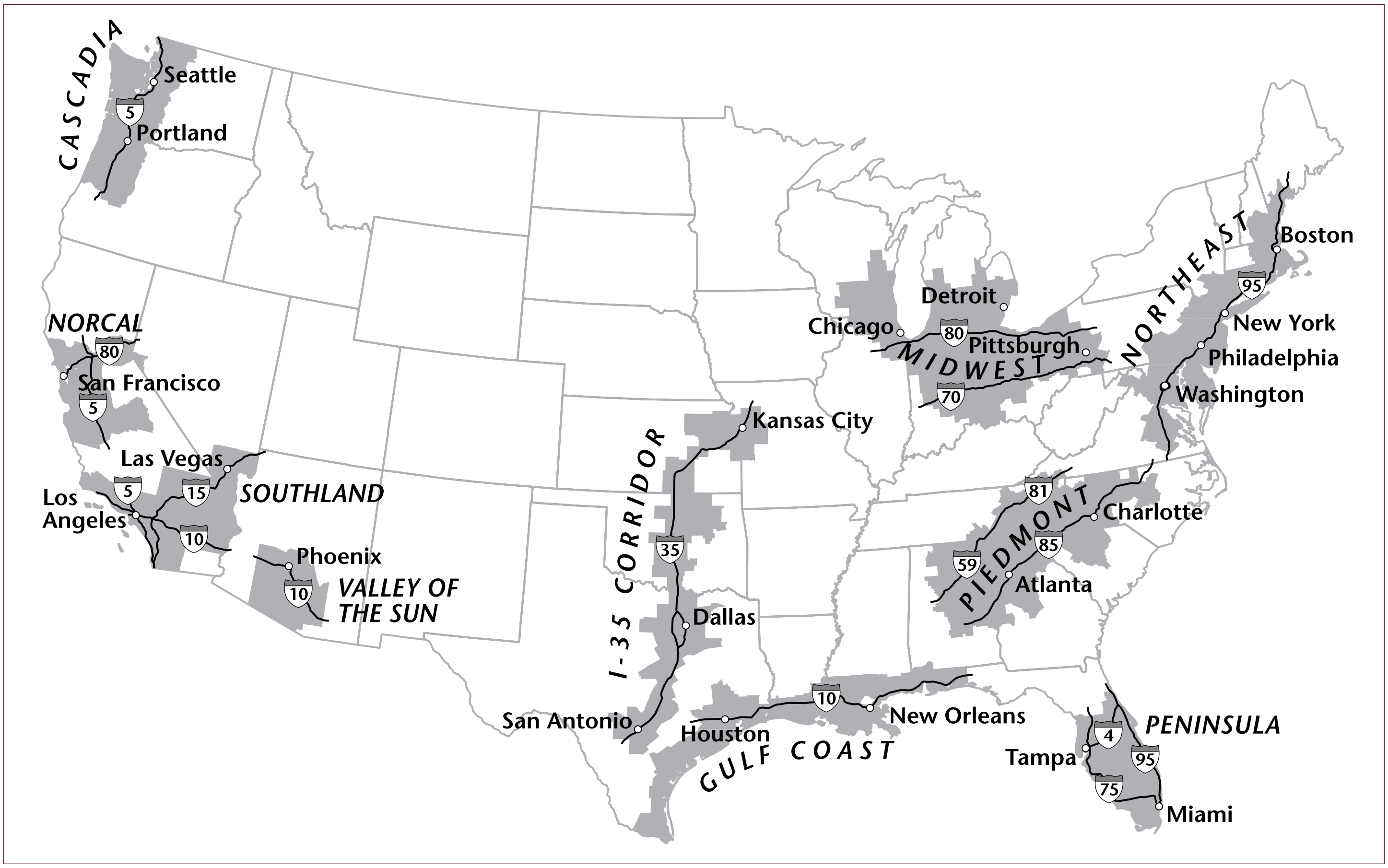


Figure 2. Recognized Megapolitan Areas in the United States



Source: Adapted with permission from Robert E. Lang and Dawn Dhavale, *Beyond Megalopolis: Exploring America's New "Megapolitan" Geography,* Metropolitan Institute Census Report Series (Blacksburg, VA: Metropolitan Institute, Virginia Polytechnic Institute and State University, 2005).

and transportation. For example, in the 1990s, the biggest population gains in the seven core counties were among those aged 45–54, whereas the number of persons in the 20–34 age group declined.

Another influence on age composition is migration. Although there was net out-migration of 40,000 people in the 1970s, there was net in-migration of about 100,000 people per decade in the 1950s, 1960s, and 1980s and 135,000 people in the 1990s. The main movers are young adults and the young children who come with them. A third influence is life expectancy; people are living longer.

Race and Ethnic Composition. Between passage of the immigration restriction laws of 1921 and 1924 and the Immigration Act of 1965, relatively few immigrants entered the United States and fewer still arrived in Minnesota, which was geographically remote from major ports of entry. During those four decades, migrants to the Twin Cities came from non-metropolitan parts of Minnesota and the Upper Midwest and consisted almost entirely of American Indians relocating from reservations, and European ethnic groups identical to those already present.

In 1950, people of color comprised only 1.4% of the Twin Cities–area population, a share that rose to 1.8% in 1960, 2.7% in 1970, and 5.0% in 1980. But racial change came rapidly after 1980 so that by the 2000 U.S. Census, persons reporting their race as "White only" accounted for 86.1% of the population, whereas "Black only" (5.3%), "Indian only" (0.7%), "Asian only" (4.1 %), and "Other races and mixed race" (3.7%) made up the increasingly diverse balance of the remaining 13.9%, or about one in seven Twin Cities residents. In addition, almost 100,000 persons (3.3%) of diverse races reported "Hispanic or Latino" origins.

Looking Ahead. The Metropolitan Council expects the population of each five-year age group to rise between now and 2030 as the region adds one million more persons and up to 400,000 additional housing units. For those under age 55, the projected increase is 19% compared with 111% for those aged 55 and over—partly due to the aging of the baby boom, and partly to longer life expectancy. Yet despite the steep percentage increases forecast for the population over age 65, it will remain a modest share of the total population—9.7% in 2000, 13.4% in 2020, and 16.6% by 2030.

The traditional cultural homogeneity of the Twin Cities population is also a thing of the past. Today, the younger the age group, the more diverse is its racial and ethnic composition (Table 1). This means that during the next two decades, the diversity of young people attending school, entering the workforce, and seeking housing will continue to increase in all parts of the metropolitan area.

Housing Markets and Changing Housing Landscapes. Population growth, an expanding number of households, and improvements in purchasing power all serve to increase demand for housing. The types of housing units added will depend on the mix of household types, tastes, and needs, as well as the share of income and wealth households devote to housing compared to other expenditures. The ultimate location of additional units will depend on land prices, regulatory frameworks, government subsidies, and how the region's transportation and land use arrangements evolve in coming decades.

Table 1. Age Composition of the Twin Cities Metropolitan Area, 2000

Age Classes	Non-White males	Percentage of all males in the age class (%)	Non-White females	Percentage of all females in the age class (%)
Under 5 years	24,244	22.3	23,810	22.9
5 to 9 years	25,551	21.2	23,260	21.2
10 to 14 years	22,601	19.6	21,724	19.7
15 to 17 years	12,066	18.1	11,944	18.9
18 and 19 years	7,692	18.8	7,544	19.2
20 years	3,756	19.3	3,709	19.3
21 years	3,731	19.7	3,700	20.1
All age groups	**208,946**	**14.3**	**203,009**	**13.5**

Source: U.S. Bureau of the Census, 2000 U.S. Census data for the Minneapolis–St. Paul–Bloomington, MN/WI MSA. These are race data, as self-reported to the U.S. Census Bureau. Hispanic-Latino persons may be of any race. Therefore, the race-based numbers above understate minority proportions to the extent that Hispanic-Latino persons report their race as "White," as many do.

Housing Supply. Changes in the housing inventory result mainly from demolition of existing units and from new construction. Of the 276,200 Twin Cities–area housing units counted in the 1950 U.S. Census, 13,800 disappeared by 2000, with the remainder comprising only 22.4% of the total stock of 1.17 million units, which had a median year of construction of 1971.

Recent additions to the housing inventory include new developments on suburban greenfield sites, plus redevelopment of parcels in the central cities and first-ring suburbs. Redevelopment takes several forms: (1) replacement of single detached units; (2) replacement of obsolete commercial corners and strips along transit lines with new apartment buildings and blocks of condos (e.g., University Avenue, Excelsior and Grand, Downtown St. Paul, Downtown Minneapolis); (3) replacement of entire neighborhoods (e.g., Heritage Park); and (4) housing and mixed-use developments replacing obsolete industrial and warehousing districts (e.g., Minneapolis Warehouse District, Minneapolis Milling District, St. Paul Mears Park).

Housing Demand. As the housing inventory changed in composition and location over the years, household demand changed as well—in household numbers, tastes, preferred locations, and purchasing power allocated to housing. In 1950, almost 9 out of 10 Twin Cities households (88.2%) consisted of families (i.e., two or more persons related by marriage or blood); by the 2000 U.S. Census, that fraction had dropped to only 2 out of 3 (65.5%). Meanwhile, average household size dropped from 3.24 in 1950 to 2.56 by 2000 due to a variety of factors: more persons living alone, smaller families, single-parent families, a rise in unmarried couples living together, and roommates sharing the rent.

Housing Preferences. Housing preferences and expectations have risen with increases in household income and wealth. The 900-square-foot four-room houses on large lots that GIs and their families lined up to buy in Richfield, Brooklyn Park, Roseville, and West St. Paul in the 1950s have steadily slipped downward on the desirability scale for today's middle-class families. These families prefer newer, larger, low-density suburban housing over older, high-density options in the central city and older suburbs; meanwhile, middle-class adult households are drawn to high-priced condos and town houses. Moreover, the new, more expensive options are often a better deal financially because of average-cost utility pricing, tax deductions for real estate taxes and mortgage interest, and price inflation due to the capitalized value of subsidies.

Upwardly mobile households typically move to newer, larger, higher-priced housing as means permit. As households vacate older units, the households are replaced by others of lesser means. Over time, housing units on the edge of the built-up area that were once new and ranked in the upper quartile of value slowly filter downward to lower rankings. Because older, cheaper housing is concentrated in the central cities and first-ring suburbs, low-income newcomers to the Twin Cities tend to concentrate in these segments of the housing stock.

Looking Ahead. When population increases at the same time average household size is dropping, demand for additional housing units rises faster than the population. But the size, quality, and density of units demanded depends on the income and wealth positions of households, as well as their priorities for spending on housing compared with allocations for other goods and services. There is no reason to expect that the patterns of housing consumption that were common during the last half of the 20th century will repeat in coming decades.

Smaller households with fewer children imply different configurations of inside and outside space needs and wants. Longer life expectancy, general prosperity of seniors, and more seniors living alone means that housing needs and wants not met by family-oriented housing carried over from earlier decades. Only about one-third of Twin Cities households in 2000 consisted of families with children under age 18, but that fraction could rise in coming decades depending on patterns of marriage and family formation by today's diverse young populations.

In "Twin Cities Age Trends and Forecasts, 1970–2030," a demographic analysis and forecast for the Twin Cities area, the Metropolitan Council summarized the situation this way:

> One of the most significant impacts of changing age structure has been on the region's housing market. Housing choice is affected by age through the relationship between age and income and age and life style. Younger people have lower incomes on average and less equity. Retired people may also have lower incomes, but typically

have more equity. Age also relates to life style, which can influence housing choice. . . . (p. 7)

People aged 60 or older are increasingly likely to move from large single-family units to apartments, condos, or town houses as they age. As demand expands for high-density units, often on redeveloped sites, the demand for new development on suburban and exurban greenfield sites may be muted. One thing is certain: Twin Cities housing production and consumption patterns will be increasingly diverse in coming decades.

The diverse trends of new housing demand, more variety in increments to the housing supply, and mixed patterns of housing use that are increasingly common across the central cities and older suburbs provide a vivid forecast of the Twin Cities housing landscape of the future. Although new suburban housing is normally occupied first by young families, as housing ages it passes through successive stages of occupancy as the community household mix becomes more heterogeneous.

As each community ages, it competes with other communities in attracting households, housing maintenance dollars, and commercial reinvestment. Some communities succeed in maintaining (and occasionally enhancing) their attractiveness relative to other communities, whereas others begin a long downward slide on the scale of relative desirability.

The combination of these trends within the central cities and older suburbs is introducing an increasing mix of housing types in those settings, with old housing adjacent to new units on redeveloped sites, high-density apartments and condos near single-unit detached housing, high-priced units next to low- and moderate-priced units. The housing is occupied by an increasingly diverse array of household types—one- and two-parent families, retired singles and couples, elderly households with the good health and financial means to live independently, unmarried male/female couples, gay and lesbian households, and young singles living alone or with roommates.

Creating the Future: The Emerging Land Use–Transportation Landscape

Financial incentives and consumer preferences prompt middle-class and upper-middle-class Twin Cities households to relocate to larger, lower-density housing on suburban sites while encouraging developers and builders to respond to those preferences. The result since the 1940s has been a steady outward expansion of the built-up area, a relocation of wealth and purchasing power into outer counties and away from the central cities and older suburbs, and a slow transformation of the financial positions of the counties that comprise the metropolitan area. The older urbanized and largely built-up counties

Redevelopment can take several forms, including replacement of obsolete industrial warehousing districts with housing and mixed-use developments, as happened in the Minneapolis Milling District (left), or replacement of entire neighborhoods, as happened with the Heritage Park redevelopment on Minneapolis' north side (right).

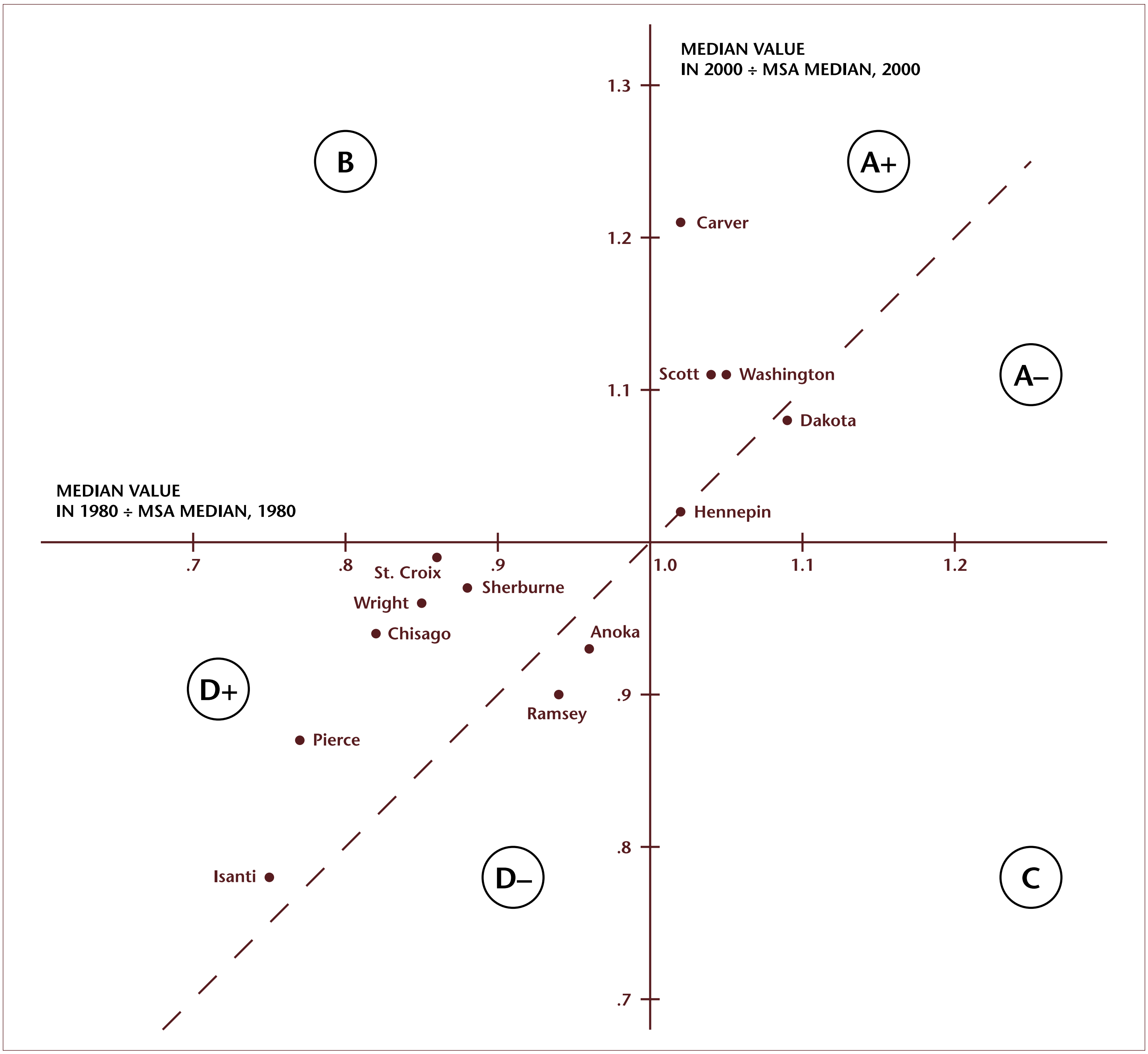
see demands for government services rising faster than their resource bases; meanwhile, fast-developing counties farther out confront demands for new roads, schools, parks, and other public services carrying price tags exceeding residents' willingness to pay.

The County Landscape. A useful index of the changing fortunes of a county government's resource base is the median value of its owner-occupied housing compared with the metro-wide average. Counties that maintain or improve their median compared with the metro median are better positioned to handle fiscal stresses that accompany growth and change. But counties that experience a decline in the median value of their housing compared with the metro median not only have a harder time attracting and retaining middle-class and upper-middle-class households, but also face rising demands for public facilities and services without a corresponding improvement in ability to pay for them.

The 13 counties that made up the Twin Cities metro area in 2000 vary significantly in terms of the impact of growth and change between 1980 and 2000 on the average value of their housing stocks. The counties fall into four main types (A, B, C, D) (Figure 3). Type A counties are those that had housing stock prices above the metro median in both 1980 and 2000. Three classes of Type A counties exist:

- Type A+: Counties above the metro median in 1980 that remained above the metro median in 2000 while improving their ratio. Examples include counties that added population and disposable incomes fast in the 1990s (Carver—46%; Scott—55%; Washington—38%). These fast-growing, attractive settings added new housing stocks with above-average prices, while existing units increased

Figure 3. Counties in the Twin Cities Metropolitan Area Arrayed by Median Value of Owner-Occupied Housing, 1980 vs. 2000



Note: MSA stands for Metropolitan Statistical Area.

in value at above-average rates, pushing up the county medians.

- Type A–: Counties above the metro median in 1980 that remained above the metro median in 2000 but with a lower ratio. The sole example is Dakota County, which grew at 29% in the 1990s while broadening its mix of housing.
- Type A: Counties above the metro median in 1980 that remained above the metro median in 2000 with exactly the same ratio. The only example is Hennepin County—in most ways the functional center of the metro area—which added population at a rate of only 8% in the 1990s, but which contains prosperous, fast-growing suburban cities that more than offset declines in older suburbs and certain Minneapolis neighborhoods.

No counties were of Type B, that is, with medians below the metro median in 1980, but above in 2000.

Similarly, no counties were of Type C, with medians above the metro median in 1980 but below in 2000.

There are two classes of Type D counties—that is, counties with median values of owner-occupied housing below the metro median in 1980:

- Type D+: Counties below the metro median in 1980 that had a higher ratio by 2000, due mainly to new housing construction. These include Chisago (36% of its single-unit housing built in the 1990s); Isanti (25%); Sherburne (42%); Wright (32%); Pierce, Wisconsin (20%); and St. Croix, Wisconsin (27%).
- Type D–: Counties below the metro median in 1980 that slipped to still lower ratios by 2000. Anoka (22% population increase in the 1990s) and Ramsey (5.2% increase) are largely built-up areas that have limited room to grow (Ramsey), cater mainly to moderate-income clientele (Anoka), and have older housing stocks that hold down median values.

The City Landscape. At a local, subcounty scale, individual cities compete with one another for new housing, commercial-industrial development, property tax base, population, wealth, and disposable incomes as city governments (and local school districts) struggle to raise revenues and provide needed services. As the Twin Cities area grows larger and expands outward, some cities are winners in this struggle, displacing others that slip in housing value rank and competitive strength.

It is difficult for a city to maintain its rank over many decades. The median value of owner-occupied housing in a city compared with the metro median reveals which cities are gaining, which are holding their own, and which are falling behind. A comparison of 37 major cities in the Twin Cities area in 1980 illustrates their changing fortunes (Figure 4). During the period 1980 to 2000, seven cities (Type A+), led by Edina, Plymouth, Minnetonka, and Woodbury, not only began the period with housing stock valued well above the metro median, but also saw their ratios rise through new construction and significant inflationary increases on their existing stock.

A second group of 10 cities (Type A–), led by Eden Prairie, had a housing stock valued above the metro median in 1980 and remained above the median in 2000, but with diminished ratios due to housing stock aging (e.g., Bloomington, Roseville, Golden Valley, and New Brighton) or a widening array of housing types and values (e.g., Eden Prairie, Maple Grove, and Apple Valley).

Among the 37 cities, there are no examples of Type B cities, where a city had a below-average-value housing stock in 1980 and subsequently jumped above the metro median in 2000. But five cities formerly above the metro median dropped below it between 1980 and 2000 (Type C), including Cottage Grove, New Hope, Maplewood, Brooklyn Park, and White Bear Lake. In some cases their aging housing stock triggered a decline in ratios, whereas in others their relative desirability compared with competitor cities nearby led to below-average price appreciation.

The places facing the most serious demographic and fiscal challenges among the 37 sample cities are the more than one dozen cities (mainly Minneapolis, St. Paul, and older suburbs) that had median housing values ranked below the metro median in 1980, then slipped to still lower levels by 2000 (Type D–).

Challenges for Local Government and Metropolitan Planning

Metropolitan area growth and change challenges us to maintain what we have and to invest in the infrastructure and facilities we will need to remain competitive with the rest of the country and the world. Two areas present special challenges: transportation needs and problems created by misplaced subsidies that distort the land development and redevelopment processes.

New Transportation Needs. The Twin Cities received an extra ration of interstate highways in the 1950s and 1960s, namely I-35E and I-35W serving the two downtowns, plus the extensive I-494/I-694 beltway enclosing an already sprawling urban area. The new freeways spoiled local drivers for many years by permitting high-speed travel among all parts of the metro area. But steady growth in the region and increasing vehicle traffic since 1990 has exhausted the extra capacity the freeway system once provided. What is needed now is a 50-year transportation and land-use plan with a dedicated funding source, deployed in cooperation with the counties and cities of the evolving Twin Cities megapolitan region.

The transportation plan should include an integrated system of highways, heavy rail, light rail, bus service, and bicycle routes. Land-use plans developed at the local level must be developed in response to the transportation plan and in support of it. But it will be necessary for the region to catch up before it can move ahead. A December 2004 forecast by the Minnesota Department of Transportation titled “Performance-Based Investment Plans: Preliminary Draft Summary,” reported annual unmet needs for state trunk highways of about $1 billion each year between 2008 and 2030.

Fair Prices and Development Impact Fees. A series of reports prepared by the University of Minnesota’s Center for Transportation Studies as part of its Transportation and Regional Growth Study (see www.cts.umn.edu/trg/index.html) illustrate how public and private policies have subsidized migration outward from the central cities, leaving core areas with the problems but without the financial means to resolve them. Since World War II, fast-growing suburban areas have regularly received public goods, services, infrastructure, and utilities for which they failed to pay full price, while the costs accumulated elsewhere and at later times, namely in the central cities and eventually the older suburbs.

For example, government subsidies for local roads and highways serving new areas, as well as average-cost (rather than full marginal cost) pricing of utility extensions into new areas, mean that residents and businesses in previously developed areas pay much of the cost for extending infrastructure and services to newly developing areas. Likewise, the more expensive the house that one buys, the greater the share of the cost of that house that can be passed on to the state and federal government in the form of reductions

Figure 4. Cities in the Twin Cities Metropolitan Area Arrayed by Median Value of Owner-Occupied Housing, 1980 vs. 2000

Note: MSA stands for Metropolitan Statistical Area.

Steady growth and increasing vehicle traffic have exhausted the extra capacity of the Twin Cities freeway system. The region would benefit from a 50-year transportation plan that includes an integrated system of highways, heavy rail, light rail, bus service, and bicycle routes.

in income tax obligations. Households buying houses for $75,000 or less and using the standard deduction on their tax returns typically receive no tax advantage at all. At the other extreme, households buying houses worth $500,000 receive tax reductions of more than $12,000 per year on a continuing basis.

Government subsidies, average-cost pricing, and tax reductions all reduce the out-of-pocket costs of buying a home, enhancing the attractiveness of expensive houses and elevating their prices by an amount that is in addition to the capitalized value of the tax advantage. So it makes financial sense for middle-income and upper-middle-income households to acquire a more expensive house on a large lot rather than a less expensive house on a compact lot because the annual out-of-pocket expense increases less rapidly than does the price of the house. Also the household's balance sheet improves fast when the value of the expensive house rises faster than the rate of inflation, as it often does. But part of that improvement in balance sheets for the fortunate few on the expanding metropolitan edge comes at the expense of those households and businesses in previously settled areas that see their balance sheets eroding prematurely.

The authorization of development impact fees by the legislature, and their implementation by counties and cities in the greater Twin Cities area, would produce several consequences:

- Developers, builders, and their customers would pay something closer to the full costs of off-site improvements required to serve their new developments rather than passing along those costs to property owners and taxpayers at other places and at later times.
- Over a several-decade period, there would be an increase in development densities as land would be used less extravagantly with lower subsidy attached.
- Higher development densities would promote transit development and support transit use.
- Reinvestment in built-up areas would compete on a more even playing field with new development on greenfield sites.

But the introduction of development impact fees would address only part of a larger challenge: financing vital investments to ensure that the Twin Cities region becomes and remains competitive with other megapolitan regions around the country and around the world in the decades ahead. The evidence to date is not encouraging, but fresh thinking and vigorous, forward-looking political leadership could make the difference by reducing unwarranted subsidies that promote short-term consumption by the few and replacing them with long-term public and private investments that enhance future competitive strength and well-being for the many.

Conclusion

In the 1960s, the Twin Cities ranked as the economic capital of the Upper Midwest and functioned within an essentially domestic post-WWII economy. The United States produced most of the goods and services that it consumed, while consuming most of the goods and services it produced. The Twin Cities area changed fast in terms of both its economic profile and its links with the rest of the country and the world after 1970. Formerly it competed with other large metro areas across the United States; today it competes within a global economy in ways only dimly understood. Its competitive success will depend on leadership, cooperation of governments, and regional investments in transportation and other public goods.

The final report of the Transportation and Regional Growth Study emphasized that, with respect to land development and transportation services, as the metropolitan area grows larger and more complex, it is vital that households and businesses pay fair prices for the benefits they receive from their participation in the metropolitan system. Failure to pay fair prices means that cities and counties in older-settled parts of the metropolitan area end up subsidizing development in developing areas and that regional assets (e.g., transportation infrastructure, built environments, the natural environment, human capital, state and local institutions) are drawn down, weakening the Twin Cities region's balance sheet at a time when it needs to be strengthened to ensure its competitive position in an increasingly competitive and unforgiving world.

A confluence of geographic changes (a spatially expansive and fragmented metro area), challenging demographic trends (a diversifying and aging population), and housing and land use planning issues (increased demand for housing, diversifying housing needs) are combining to put the Twin Cities on a precarious course with respect to transportation and land development issues while eroding regional assets needed to keep the region competitive. Moreover, these challenges are emerging at a time when the Twin Cities no longer compete on a regional basis with other parts of the United States, but rather globally with vibrant metropolitan economies around the world.

John S. Adams is professor in the Department of Geography and the Humphrey Institute of Public Affairs at the University of Minnesota. He was named the first Fesler-Lampert Chair in Urban and Regional Affairs in 2000. His research and teaching focus on the American city, regional economic development, intra-urban migration, housing markets, urban transportation and urban development in the United States, and the states of the former Soviet Union.

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CURA Launches Minnesota 3-D Mapping Application

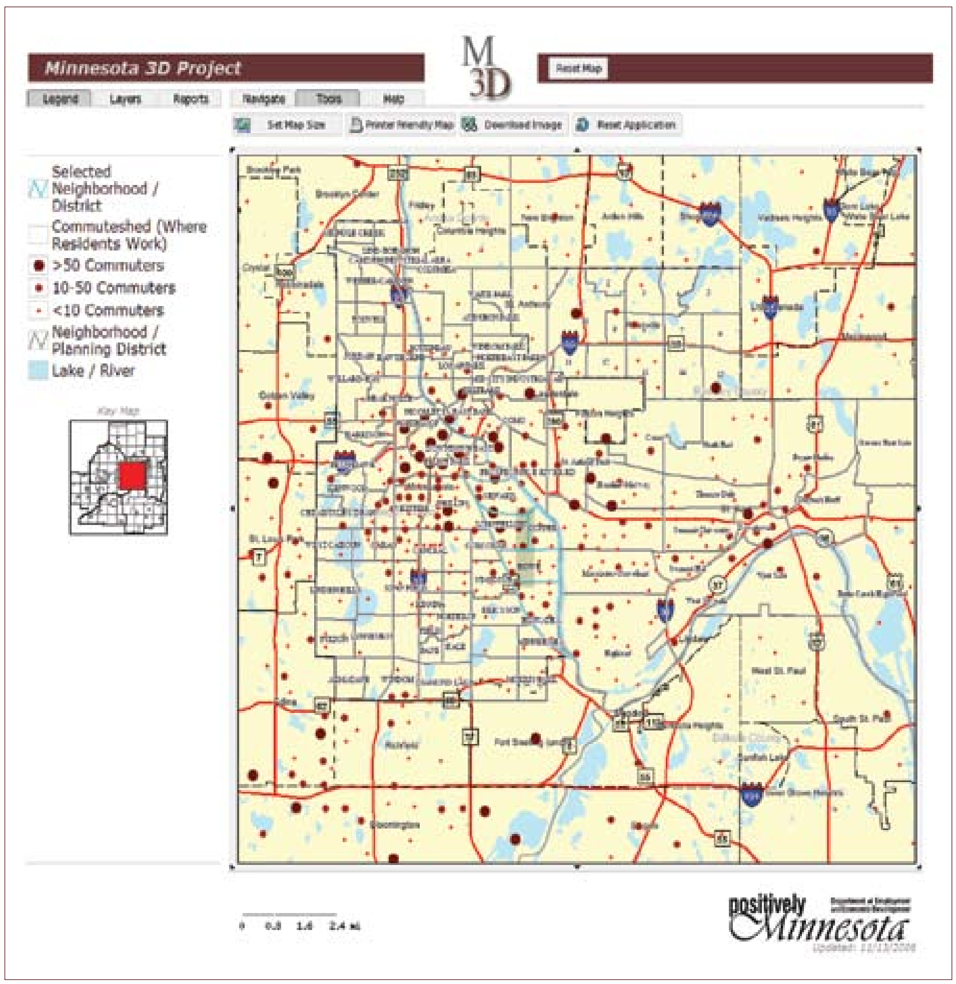
CURA is pleased to announce the launch of Minnesota 3-D (M3D), a dynamic, GIS-based Internet application that brings together labor market, housing, and development information and analysis for the Twin Cities metro area into one easy-to-use tool for economic and community developers. This first-of-its-kind application brings together more than 90 datasets that can be displayed visually on a map and in report format using geographic information systems (GIS) technology.

According to a recent study by the Center for Housing Policy titled *A Heavy Load: The Combined Housing and Transportation Burdens of Working Families*, working families in the Twin Cities metropolitan area spend 30% of their household income on transportation (more than the 27% consumed for housing). The report recommends that “regions coordinate their housing and transportation policies to ensure they fully reflect the needs of working families—one example includes building more affordable housing near existing and planned transit hubs.”

By combining labor market origin–destination data on Minnesota jobs and workers with housing and transportation data, M3D increases the capacity of project partners to plan and develop housing and economic development programs that narrow the growing spatial mismatch between housing and employment in the Twin Cities region. “The future vitality of our region depends on our ability to efficiently connect housing, jobs, and services,” said Kris Nelson, project director for M3D at CURA. “M3D provides a significant tool for communities to inform policies and implement strategies for efficient and sustainable development to assure the well being of working families.”

During the next year, CURA and other community partners will be working to apply M3D to planning and development projects to achieve greater balance between housing and employment opportunities within communities.

The Minnesota 3-D project is a partnership between CURA, the Minnesota Department of Employment and Economic Development (DEED), the Minnesota Housing Finance Agency, the Minnesota Office of Revenue, the Metropolitan Council, Ramsey and Hennepin Counties, and various Twin Cities neighborhood organizations and community development corporations. The project was made possible through a $600,000 Technology Opportunities Program (TOP) grant from the U.S. Department of Commerce awarded to the University of Minnesota in 2004. M3D is part of CURA’s continuing effort to develop GIS tools and understanding for local communities to plan and develop vital places for people to live and work. The M3D mapping application can be found at http://map.deed.state.mn.us/M3D/.



By combining labor market origin–destination data with housing and transportation data, M3D can inform projects that help to narrow the spatial mismatch between housing and employment in the Twin Cities region.

Visitor Management and Revegetation Efforts on a Degraded Lake Superior Cliff Edge

by Ken Gilbertson, Dave Olfelt, and Phillip Leversedge

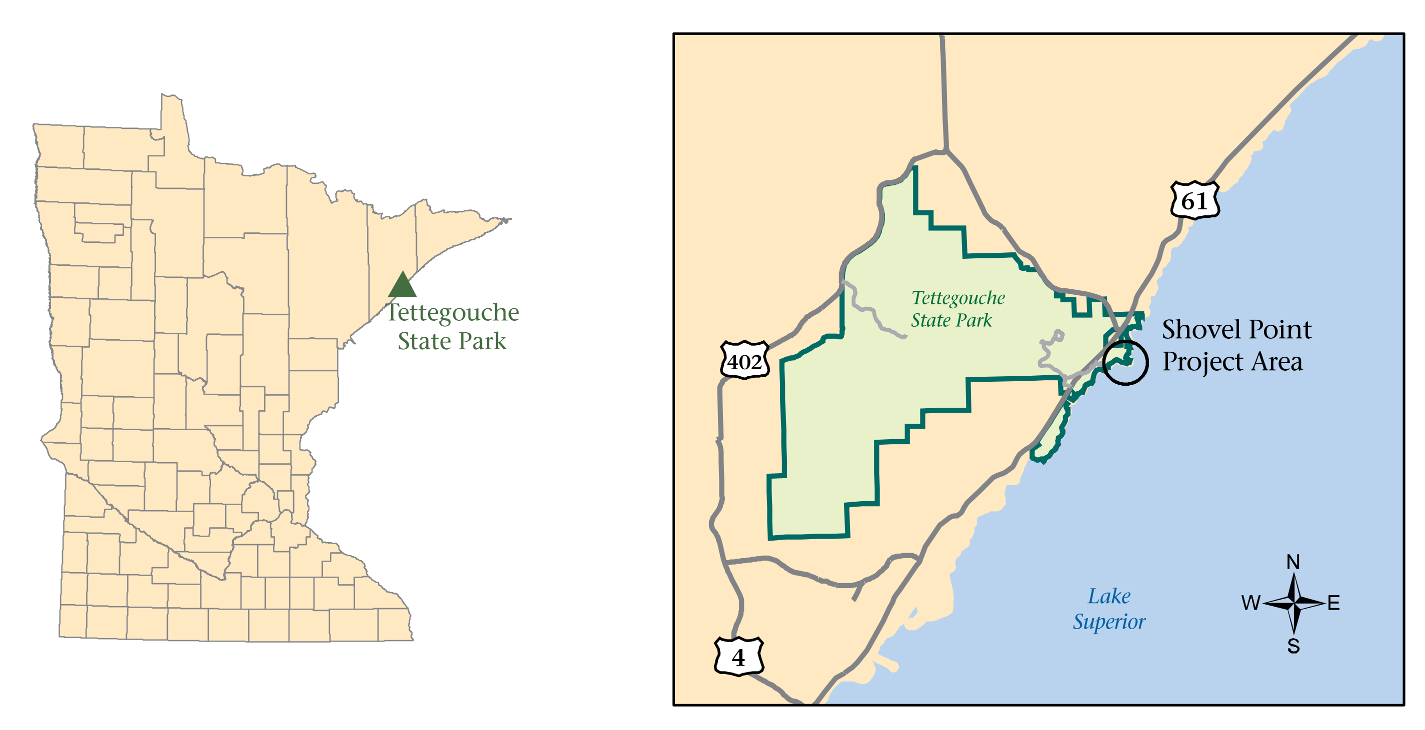
Photo courtesy Minnesota Department of Natural Resources (DNR)

Shovel Point, Tettegouche State Park

Rock climbing has grown to be a major recreational sport in the United States, and Minnesota has become one of the leading states in the nation for rock climbing because of its well-known and excellent climbing sites. One of the premier climbing sites in the state is Shovel Point, a spectacular cliff along the North Shore of Lake Superior that lies within the boundaries of the Tettegouche State Park (Figure 1). In addition to being a sought-after rock climbing site, Shovel Point is also a popular hiking destination for tourists. The pressure on the land from recreational users has caused vegetation to die along the cliff edge. This die-back, or kill zone, has occurred because of severe soil compaction and erosion problems. Shovel Point is considered a unique micro-habitat because of the combination of poor, shallow-depth soils and a short growing season from the cold climate. The result is a significant negative environmental impact from human recreational use on a particularly sensitive landscape.

In 1995, the Minnesota Department of Natural Resources (DNR) established a management plan to reduce impacts from rock climbers and recreational hikers while protecting and restoring the natural landscape along the cliff edge at Shovel Point. To implement the plan, the park manager at Tettegouche State Park began an innovative program to encourage self-regulation among recreational users of the park. Through a citizens advisory committee and in consultation with natural resource and recreation professionals, the park manager sought to develop a plan to minimize user impacts, stop the kill zone

Figure 1. Location of Tettegouche State Park and Shovel Point Project Area



from moving farther inland, and restore native vegetation while minimizing restrictions on rock climbers and hikers.

Beginning in June 1998, our research team began a long-range, multipart study in support of the Tettegouche State Park Management Plan, which we describe below. This research was funded in part by the Center for Community and Regional Research (CCRR) at the University of Minnesota at Duluth through a grant from CURA, with additional funding from the Minnesota DNR.

Methods

There were five distinct parts to the study we undertook in support of the management plan:

1. creation of a geo-referenced map of human-made and natural features at Shovel Point;
2. a survey of recreational users of Shovel Point regarding their attitudes toward the proposed management plan;
3. identification of the kill zone area;
4. analysis of revegetation potential on the site using native species;
5. a review of rock climbing management practices in other state parks, national parks, and national forests.

In the remainder of this section, we discuss each of these methods in turn.

Geo-Referenced Map. We created a geo-referenced map of human-made and natural features at Shovel Point using ArcView 3.2 geographic information system software and global positioning system technology. The map includes topographic contours, as well as the location of trails, signage, and restoration areas on the site. The purpose of the map is to guide physical management features such as trail development and aid in physically monitoring the cliff-edge kill zone.

Visitor Behavior Survey. We surveyed rock climbers and hikers regarding their attitudes toward the proposed management procedures, including marking trails, restricting access to some trails, installing decked staging areas, installing fixed anchors for climbing, and requiring climbers to access Shovel Point from a designated trailhead. Respondents were also asked about the degree to which they believed they and other climbers would adhere to the proposed procedures. The survey was field-tested to ensure validity. Interviews were conducted on alternating Saturdays, Wednesdays, and Fridays from July 15 to August 15, 1998, during either the morning or the afternoon. During this time period, we surveyed a total of 639 visitors (430 hikers and 209 rock climbers).

Overall, rock climbers had a positive attitude toward the management plan, with at least an 80% favorable response toward all recommendations. Although most respondents were supportive of the efforts to protect the land from negative user impacts, negative comments from some respondents revealed a strong desire for a nature-based recreational experience with minimal to no contrivances. Thus, manipulating the land was considered unacceptable, even if the manipulation was intended to preserve the native character of the land. Finally, a few respondents indicated a distrust for human-made climbing supports, primarily because of unreliability due to malicious tampering.

Primary findings of the survey can be summarized as follows:

- Respondents showed a strong willingness to comply with proposed park management actions that focus on—and in some cases restrict—how they use Shovel Point. Willingness to comply was related to understanding that rehabilitation and development efforts were intended to protect the land. Otherwise there was strong initial resistance to the management plan.
- Respondents believed that other climbers would be willing to comply with proposed actions.
- Follow-up comments some respondents provided indicated that, even if they disagreed with elements of the proposed management plan, they would support the plan if they

Photo by Deborah Rose, courtesy of the Minnesota DNR

Rock climbers who were surveyed had a positive attitude toward the Shovel Point management plan, and most believed other climbers would be willing to comply with proposed regulations.

believed it would help maintain climbing access at Shovel Point.

- Tallies of trail use showed heavy use of some trail segments and very light to no use on others. These results suggest where trails might be easily closed and revegetated, where "hardening" with gravel or boardwalks might be appropriate, and where visitor patterns may be difficult to change.

Kill Zone Expansion and Trail Rehabilitation. At the beginning of the study, we conducted a vegetation analysis using guidelines provided by the Minnesota DNR. This involved identifying a specific zone to be monitored over time. To document the extent of the kill zone, we took photographs and catalogued vegetation type and counts. These data established a baseline for measuring the success of the management plan and various trail rehabilitation efforts.

Based on our analysis, trail rehabilitation efforts appear to have succeeded in reducing the expansion of the kill zone over time. Through the use of wooden curbs and gravel, trails have been marked in a manner that is unobtrusive to the scenic value of the site but that guides visitors along designated trails more effectively. In addition, roped-off areas with accompanying signs reading "revegetation site" have succeeded in eliminating the appearance of informal spur trails. The use of signage has been key in gaining compliance from rock climbers. Low boardwalks have been constructed in some locations to identify paths to climbing areas, and wooden platforms have been erected at key staging areas where groups of climbers place their gear and plan climbs. These platforms have reduced soil compaction and erosion, resulting in protection of plant root systems. Based on our analysis, the expansion of the kill zone has been stopped.

Revegetation Potential. To evaluate regeneration potential on the site, we chose a trampled, eroding hillside on which to conduct plant trials. We chose to plant poverty grass (*Danthonia spicata)* and three-toothed cinquefoil (*Potentilla tridentata),* two species that are common at Shovel Point and that appear to colonize disturbed areas. We collected seed from shoreline habitats near Shovel Point and grew seedlings in a greenhouse over the winter. In spring, we established 36 plots, with 25 plants per plot. Various soil amendments were added at planting time to evaluate their effectiveness in ameliorating the harsh soil conditions. Several plots were established but not planted (one was tilled and one was left untilled) to assess the ability of vegetation to colonize without assistance. We also used several techniques to guide hikers and climbers around the planting site, including roping off areas and placing signs at critical points. We assessed plant survival rates by counting all live plants at 13 weeks and at 1 year.

Results of the revegetation effort were as follows:

- Overall survival rates were high at 13 weeks (98.7% for *D. spicata* and 86.9% for *P. tridentata*) and remained high after one year (96.7% for *D. spicata* and 79.1% for *P. tridentata*).
- After 13 weeks, *D. spicata* treated with hydrogel and fertilizer had significant growth compared to other soil treatments. *P. tridentata* treated with hydrogel, sterile soil, or a mixture of sterile and forest soil had significant growth compared to other treatments. After one year, *D. spicata* growth appeared poorest in plots amended with fertilizer or woodchips. After one year, *P. tridentata* growth appeared best in plots amended with a mixture of sterile and forest soil.
- After one year, the tilled but unplanted plots yielded nine *D. spicata* seedlings. The three untilled, unplanted plots yielded no *D. spicata* or *P. tridentata.*

Review of Management Practices. Finally, we interviewed park managers at climbing sites around the nation, and conducted a literature review of existing research on rock climbing and natural resource protection. Our literature review revealed no specific information about resource management practices to reduce rock climbing impacts. In addition, we found that few sites around the United States have implemented management practices similar to those in the Tettegouche State Park Management Plan. More common, some agencies we spoke to have simply banned rock climbing. For example, the Ohio Department of Natural Resources manages a park near Yellow Springs, Ohio, called Clifton Gorge. Access to the southern half of the park was restricted to protect sensitive and endangered plant life, whereas the northern half of the park was designated for hiking and rock climbing. Because of intensive use, the impact on the gorge became so negative that the park managers closed the park to climbing.

Less extreme approaches have been undertaken in some location. Acadia National Park in Maine has installed fixed anchors for climbers at its Otter Cliff climbing site, and has placed signs instructing climbers to use the fixed anchors instead of trees. The park also has roped off protected areas and placed signs asking people to stay away from those areas. Park personnel reported that the fixed anchors have helped in the recovery process, and that after only one year, small amounts of vegetation regrowth has occurred in roped-off areas. Interviews with a representative from the Access Fund, a nonprofit organization dedicated to promoting the sport of rock climbing while conserving natural resources, indicates that decks and benches along with the use of signs can help to protect staging areas and keep climbers on trails.

During the final implementation stage of the Tettegouche State Park Management Plan in summer 2006, fixed metal anchors were installed in the rock to reduce destruction to tree bark and roots by rock climbers.

Conclusion

Based on our findings, it would appear that a combination of trail marking and rehabilitation techniques, along with revegetation efforts, can halt and perhaps even reverse vegetative degradation in heavily used recreational areas. Surveys of recreational users gave the Minnesota DNR sufficient confidence to spend the time, money, and effort to redirect hiker and climber activity away from degraded areas, and the techniques used appear to have succeeded at altering climber behaviors. Revegetation efforts were surprisingly successful given the harsh, bare nature of the site, and minimal use of barriers and signs prevented revegetated areas from being trampled. Finally, it is clear that educating visitors about the value of natural resource rehabilitation and management can go a long way toward encouraging acceptance of and compliance with recreational management techniques.

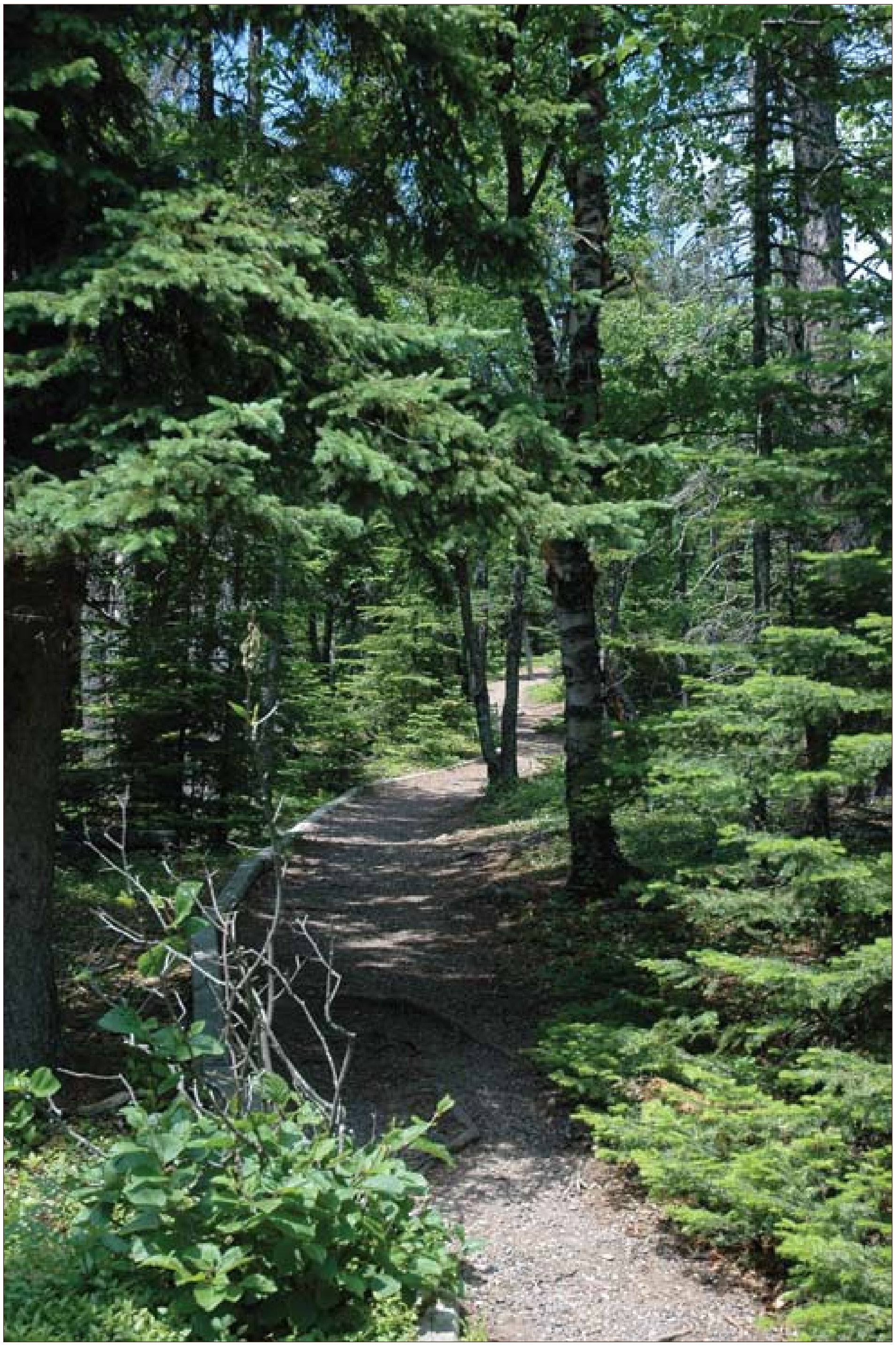


Photo by Deborah Rose, courtesy of the Minnesota DNR

Trail rehabilitation efforts at Shovel Point have succeeded in reducing the expansion of the vegetative kill zone on the site.

Ken Gilbertson is associate professor in the Department of Health, Physical Education, and Recreation at the University of Minnesota at Duluth. Dave Olfelt is a regional ecologist with the Minnesota Department of Natural Resources. Phillip Leversedge is manager of Tettegouche State Park with the Minnesota Department of Natural Resources.

This research was funded in part by the Center for Community and Regional Research (CCRR) through a grant from CURA, which provides CCRR's base funding. Located on the University of Minnesota at Duluth (UMD) campus, CCRR supports cooperative research involving UMD faculty, UMD students, and community agencies in northeastern Minnesota. Additional funding for the project was provided by the Minnesota Department of Natural Resources.

Precipitation Design Values for Minnesota: Are They Adequate?

by Richard H. Skaggs and Kenneth A. Blumenfeld

Stalled cars along Interstate 35W near the 42nd street overpass in south Minneapolis on July 1, 1997. Three inches of rain fell in 30 minutes in some areas, causing widespread flash flooding.

Virtually every year, some location in Minnesota experiences extreme, short-duration precipitation. At times the local infrastructure is impacted causing inconvenience, property damage, and even loss of life. Whether damage to infrastructure occurs depends in part on the design specifications for and capacities of storm sewers, holding ponds, or reservoirs. The precipitation design value used in design and construction is fundamental to whether the infrastructure will fail, leading to societal costs.

During the past few decades, questions have been raised about the validity of the precipitation design values typically used in Minnesota. Generally, these questions were some variation on the theme, "Are we experiencing more extreme rainfall events, with rainfall amounts in excess of the 100-year storm?" Climatologists have been hard pressed to provide satisfactory answers. But beginning in the 1960s under the farsighted leadership of the late Earl Kuehnast and Professor Emeritus Donald Baker, the Office of the State Climatologist encouraged and grew a dense network of precipitation measurement sites to provide the needed information. Recently, the length of the precipitation record reached the point where analysis of the data became possible. The Minnesota High Spatial Density Precipitation Network, which is shown in Figure 1 and described in Table 1, is a truly remarkable and valuable state resource.

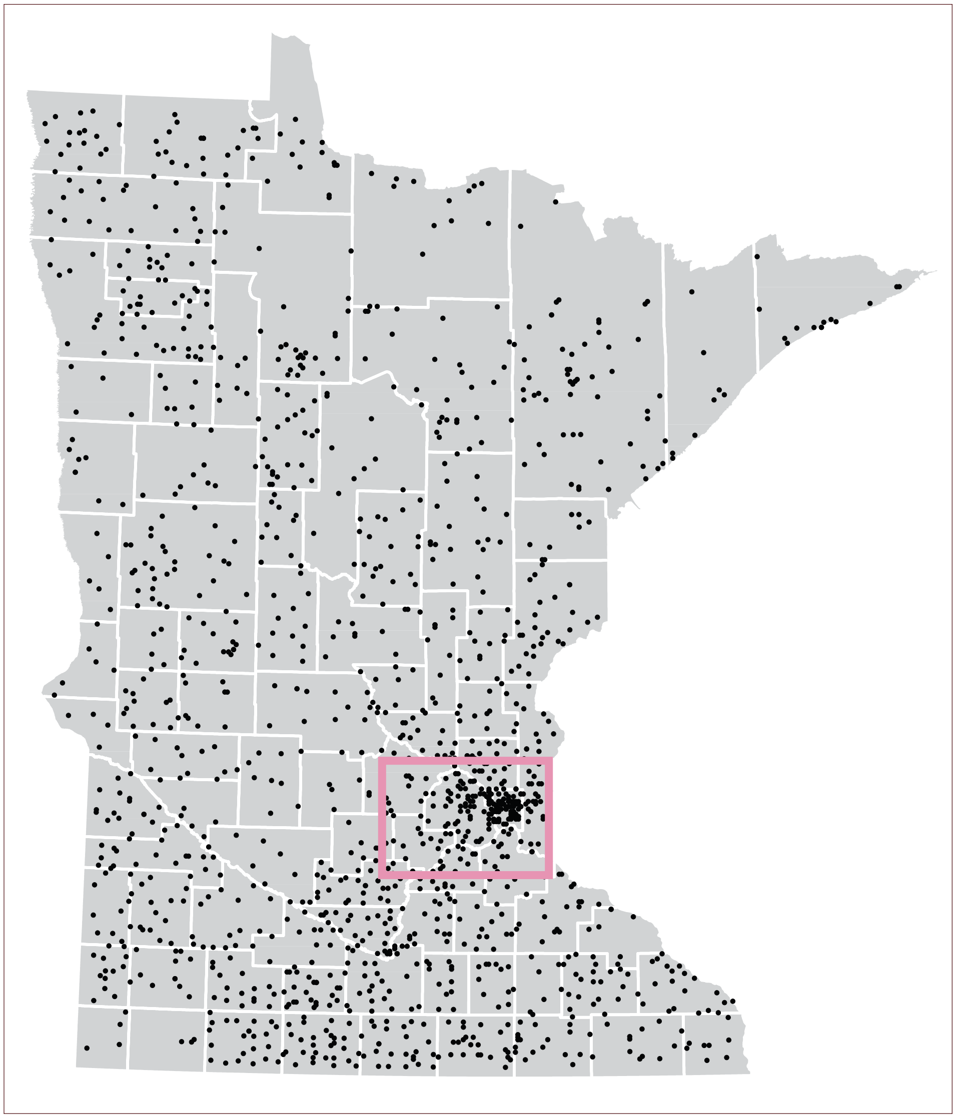
In this article, we report results of a study of extreme precipitation amounts and frequencies using the Minnesota high-density precipitation data. We provide information for the Twin Cities metropolitan area and Greater Minnesota. We begin with a brief description of precipitation design values and the potential inadequacies of the standard sources for such values in Minnesota. A description of our analyses and results follows. We conclude by arguing that the currently used precipitation design values underestimate extreme precipitation events. We also make the case that engineers, concerned with a fixed-point construction project, and managers, concerned with several projects over a larger area, are likely to have quite different perspectives on the adequacy of the current precipitation design values. The research upon which this article is based was supported in part through a New Initiative grant from CURA. Additional funding was provided by the Minnesota Department of Transportation.

Background

A *precipitation design value* is the quantity of precipitation in inches expected to fall in a specified time period (the duration) on average once every *N* years (the return period). Precipitation design values are calculated for durations ranging from one minute to several days, and for return periods from one year to more than 10,000 years. Perhaps the most widely known precipitation design value is the 24-hour, 100-year event—often referred to as the "100-year storm"—which represents the maximum amount of precipitation expected, on average, to fall in a 24-hour period every 100 years. For the remainder of this article, the 24-hour, 100-year design value will be used as the benchmark.

Unlike many common climate measures such as normal daily temperature, precipitation design values are not recomputed regularly. In fact, the precipitation design values most commonly used in Minnesota were first published in 1961 by David Hershfield in U.S. Weather Bureau Technical Paper 40, *Rainfall Frequency Atlas of the United States* (hereafter referred to as TP 40). TP 40 is based on weather observations up to 1957. In 1992, Floyd Huff and James Angel updated TP 40 for the Midwest using fewer weather stations but longer observation records in their *Rainfall Frequency Atlas of the Midwest*. However, these values

Figure 1. Minnesota High Spatial Density Precipitation Network, 1992



Note: The pink rectangle denotes the Twin Cities study area (shown in Figure 2).

Table 1. Components of the Minnesota High Spatial Density Precipitation Network

Network	Number of Stations	Quality	Coverage
National Weather Service	About 150	Good	Observations 12 months per year
Department of Natural Resources	About 80	Good	Observations 12 months per year
Metropolitan Mosquito District	About 60	Good early records, but declining	Observations 9 months per year
State Climatologist Backyard Volunteers	About 300	Good	About 50% 12 months per year and 50% 9 months per year
Future Farmers of America	Declined from 1,000 in 1970s to 10 or so today	Poor	Variable
KSTP Network	About 30	Good	Discontinued, but 12- and 9-month observations from 1980 to early 1990s
Soil and Water Conservation Districts	700 to 1,000	Good	Variable, with most in summer
Miscellaneous (e.g., WCCO network)	Variable	Variable	Variable

differ little from TP 40 and engineers and hydrologists in Minnesota seldom use them; TP 40 remains the standard source for precipitation design values.

For a variety of reasons, the validity of the precipitation design values for Minnesota in TP 40 can be questioned. First, the precipitation data Hershfield used ended in 1957. The average length of the daily precipitation records used was less than 30 years. Thus our precipitation design values are based on records that are nearly 50 years out of date and that cover a much shorter time span (and thus contain less information) than records available today. In addition, relying on TP 40 data implicitly assumes that climate has not changed or fluctuated significantly in the past half century or so. We know that the 30-year period prior to 1957 was relatively dry and that the annual precipitation has increased in recent decades. Because there seems to be a correlation between increased annual precipitation and higher daily maximum precipitation within that year, there is reason to believe that TP 40 precipitation design values could be underestimates.

The second reason to question the TP 40 precipitation design values has to do with the analysis methods Hershfield used. Precipitation design values are calculated based on a time series of annual maximum daily precipitation (AMP), the highest amount of precipitation received during a given year. The distribution of precipitation events in the AMP time series is generally considered to be heavy-tailed. This means that there are a few very large values (that is, several particularly large rainfall events) that are far from the mean (average) value. In TP 40 for return periods of 20 years or more, the design values were calculated based on a statistical model called the Gumbel extreme value distribution. Recent studies, however, strongly indicate that a more comprehensive statistical approach, called the generalized extreme value (GEV) distribution, is a more appropriate method for analyzing heavy-tailed distributions such as those characteristic of the AMP time series. In short, because the Gumbel approach does not adequately account for a few extreme precipitation events, it may result in precipitation design values that are too low, something the GEV model can overcome.

A third reason to question the precipitation design values used in Minnesota is the extreme variability in the location of heavy precipitation within a storm. It is unlikely that the most intense rains within a given storm conveniently will fall directly into a rain gauge. Thus, a measurement taken at a fixed point, such as a rain gauge, is not likely to record the heaviest amount of precipitation in an area during a particular year. The precipitation design values Hershfield estimated are, however, based on measurements at fixed points, of which there were fewer than 100 such measurement locations used for all of Minnesota in Hershfield's analysis. Hershfield's estimates of design values at these points were placed onto maps on which smooth contours were then drawn connecting areas with similar values. To obtain location-specific precipitation design values, users extrapolate the value for a specific location from the smoothed contours on the maps. This raises an important question: What would the precipitation design values be if they were based on the AMP for an *area* rather than for a *point within the area?*

The remainder of this article addresses these doubts about currently used precipitation design values and advocates an area-based approach as the best way to overcome them.

Analyses and Results

The influences of record length, climate fluctuations, and spatial variability of extreme precipitation can be demonstrated by comparing precipitation records for Minneapolis and St. Paul. For both cities, we have composite records of daily precipitation beginning in 1887 with few missing observations. For each city, we applied the GEV to three different record lengths and periods: 1887–2002 (all usable data and information), 1887–1957 (to approximate the data Hershfield may have used), and 1960–2002 (to approximate the effect of climate fluctuation in the last half of the twentieth century). We used the 24-hour duration, 100-year return period precipitation design value as the benchmark for comparison (Table 2). Extrapolating from the appropriate contour map in TP 40 gives a value of about 6 inches. As the table shows, this value is appropriate for St. Paul regardless of the record length or period. However, 6 inches is clearly an underestimate for Minneapolis for the periods 1960–2002 and 1887–2002. It is also clear that there is a substantial difference in the 24-hour, 100-year precipitation design values between Minneapolis and St. Paul when the 1960–2002 records are used or included in the calculations. Based on these observations, it seems likely that the sites that made up the Minneapolis record did experience the 100-year event during the period 1960–2002, whereas the St. Paul sites did not. This illustrates the influence of spatial variability in extreme rainfall on precipitation design value estimates.

These differences again lead us to ask what the precipitation design values would be if the estimate was based on a record of AMP over the area rather than at a fixed point in the area. How does one obtain a record of AMP over an area? The most obvious answer would seem to be a moving rain gauge that tracks the heaviest 24-hour precipitation event over the area. Unfortunately, such a moving rain gauge does not exist, although Doppler radar may be able to provide one in the future. In the meantime, one possible way to approximate a moving rain gauge is to create a dense network of observers, such as the one originated and maintained by the Office of the State Climatologist (Figure 1). The observations in this network come from a variety of sources (Table 1), and the observations are most numerous in the Twin Cities metropolitan area.

We used digitized daily rainfall records from the Minnesota High Spatial Density Precipitation Network for the period 1958 to 2002. Initially, we selected a 9,600-square-kilometer (3,706-square-mile) area that covers the Twin Cities metropolitan area and divided the area into 10-kilometer by 10-kilometer (6.2-mile by 6.2-mile) grid cells (Figure 2). The number of observers scattered over the study

Table 2. Comparison of Minneapolis and St. Paul Estimated 24-Hour, 100-Year Precipitation Design Values

Record period	St. Paul (inches)	Minneapolis (inches)
1887–2002	6.12	7.65
1887–1957	5.85	6.41
1960–2002	6.32	9.36

Figure 2. Twin Cities Study Area with Observer Locations, 1992

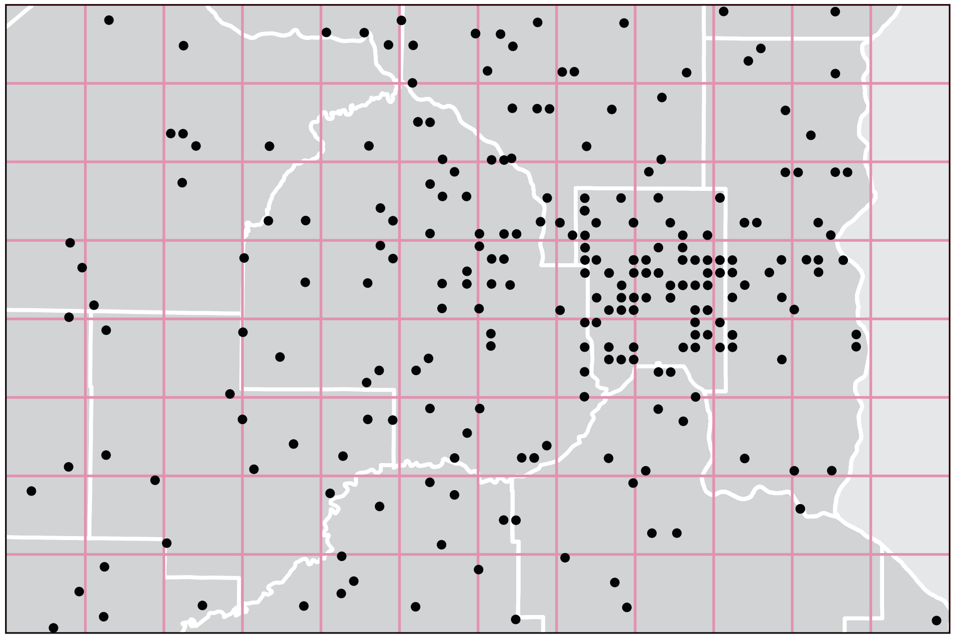
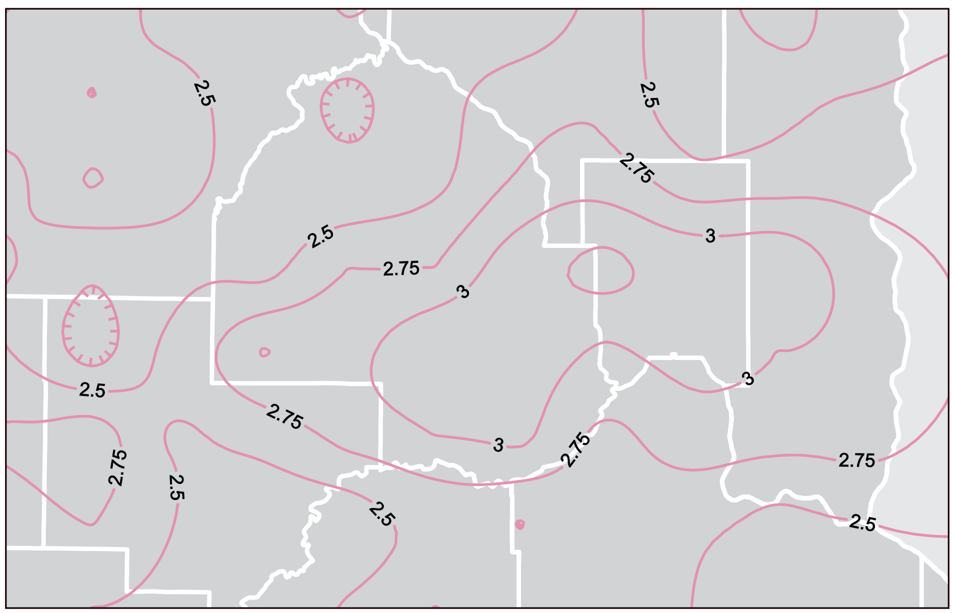


Figure 3. Mean Annual Maximum Precipitation (AMP) for the Twin Cities Study Area

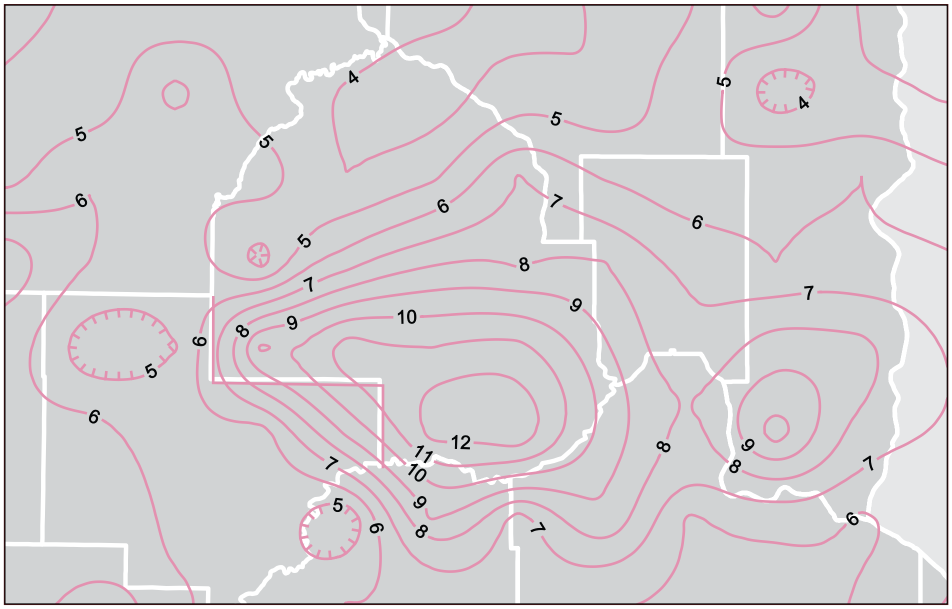


area ranged from around 100 at the beginning of our record to, at times, nearly 400 after 1969. Quality control is extremely important with these data because of the fact that most observers are volunteers. Possible sources of error include accumulating precipitation over multiple observation days, as well as reading, transcription, and data entry errors. Software developed by the Minnesota State Climatologist identified the largest daily rainfall amount in each cell for a given year and, based on spatial or temporal discrepancies in the record, indicated which values required further scrutiny. We were then able to inspect questionable values by cross-comparison. For example, while examining the proposed AMP value for a given cell, we could find out the date of the precipitation event in question, locate the values from neighboring stations on the same date, view reported amounts from other cells on the same date, and view the entire record of any of the stations to look for patterns of bad observing habits. We removed spurious values—and, occasionally, entire records—from our data set. These actions, however, never cost us more than 4% of our values in any year, and we removed from the record completely only about 1% of the stations. The editing resulted in time series of AMP for 91 of the 96 cells in our sample. In total, we had 3,031 cell-years worth of data. Five cells had no data because they are in Wisconsin and are not part of the Minnesota network.

Our first analyses, to gain a feeling for the spatial pattern of extreme precipitation over the Twin Cities, involved mapping the mean AMP (Figure 3) and the record maximum 24-hour precipitation (Figure 4). These maps raised several issues. First, there is little correspondence between the spatial patterns of mean AMP and the record maximum. Second, we found the largest mean AMP values over the heart of the Twin Cities, which we did not expect based on other studies of the effect of urban areas on precipitation. Third, the spatial differences in mean AMP are larger than expected. After further analysis, we found a strong correspondence between the number of observers in each cell and the mean AMP of each cell for up to nine observers. Above nine observers, there is no correlation. Based on a statistical model between observer number and mean AMP, we “corrected” each observed cell mean AMP to “what it would have been” if there were nine observers in the cell. The resultant map (not shown) has much less spatial variability and a pattern more consistent with what we know about urban climatology. We draw two conclusions from these results. First, a fixed-point observation represents only a small area, about 11 square kilometers. Thus, there are many independent fixed points over the Twin Cities. Second, we cannot calculate the precipitation design values for individual cells and map them because we are seriously underestimating the AMP when we have fewer than nine observers in a cell, and we are not able to devise a method to correct the individual year observations for observer numbers.

An alternative method that approximates a moving rain gauge is to form a time series of the maxima over the full study area—that is, one maximum precipitation value per year. We applied the GEV to this time series and calculated a 24-hour, 100-year precipitation design value of 12.41 inches, which is about twice the TP 40 value for the Twin Cities metro area. This disparity in the estimated 24-hour, 100-year precipitation design value starkly illustrates the difference between a fixed-point estimate and an area-wide estimate. The TP 40 estimate

Figure 4. Record Maximum 24-Hour Precipitation for the Twin Cities Study Area



may be valid for a particular fixed point in the area (we believe that it also is too small for a fixed point, although perhaps not by such a large amount). However, because of the spatial variability of heavy precipitation, there are many independent fixed points in the area, each of which has a nominal probability of 1% each year of experiencing the 24-hour, 100-year precipitation event. Thus, for the 91 cells in our Twin Cities sample, we should expect to observe rainfall at or above the TP 40 24-hour, 100-year return period value of 6 inches virtually every year. On the other hand, the 12.41-inch precipitation design value is what we should expect one time each 100 years on average anywhere in the 9,600-square-kilometer study area.

Our analysis of the Twin Cities metropolitan area can be extended to the rest of the state with a few modifications. First, we increased the initial cell size to 50 kilometers by 50 kilometers (31 miles by 31 miles). Second, because the density of observers outside the Twin Cities was low until the early 1970s, we used data for the period 1973 through 2003 inclusive in our analysis. We combined the 50-kilometer cells to correspond to six areas in the state (northwest, northeast, west central, east central, southwest, and southeast) of nominally 40,000 square kilometers (24,855 square miles) each. We calculated the 24-hour, 100-year precipitation design value for each area based on the 31-year time series of annual maximum 24-hour precipitation over each area (Table 3). In addition, there are 41 fixed-point stations in Minnesota for which there are about 100 years of daily precipitation values. We calculated the 24-hour, 100-year precipitation design values for each of these long-record stations; we averaged the values for the stations within each area for comparison (Table 3). Consistent with the results for the Twin Cities metropolitan area, we found that the 24-hour, 100-year precipitation design values based on the time series of maxima over an area are about twice the design values based on fixed-point observations.

Conclusions and Recommendations

The Minnesota High Spatial Density Precipitation Network afforded us an opportunity to undertake a high spatial resolution investigation of extreme precipitation frequencies across the Twin Cities metropolitan area and Minnesota as a whole. We found that the network was especially useful in refining our understanding of annual maximum precipitation. We were able to demonstrate that what first appeared as a possible urban influence on extreme precipitation was actually a result of local observer density disparities. Thus, the high values over the heart of the Twin Cities faded away when we assumed that outer suburbs had nine observers per 100 square kilometers. Some of this information could be used for calibration and gauge location assignment purposes, because we have good evidence that about one observer per 11 square kilometers (roughly a 2-kilometer radius) should capture most within-storm intensity variability, at least for the large AMP events. However, a correction for individual AMP values is not feasible. We propose calculating design values that would apply to an area by approximating a moving rain gauge that captures the largest AMP each year. The precipitation design values calculated from an area AMP are about twice the magnitude of the fixed-point calculations.

The choice of which estimate to use (fixed-point or area) is a policy and regulatory decision. Obviously, designing for the larger values would be costly initially. Arguably, however, selecting the area precipitation design values would lead to fewer infrastructure failures and, therefore, lower maintenance and replacement costs. In addition, there would be fewer reports of so-called 100-year events and fewer questions about the precipitation design values used. Designing for smaller values entails lower implementation costs, but results in more failures and higher maintenance costs, especially as the population grows, exposing more infrastructure to precipitation events exceeding the fixed-point precipitation design value. An effort would be needed to inform the public that exceeding the fixed-point, 24-hour, 100-year (or other) precipitation design value is to be expected and is not the result of incorrectly calculated values or climate change.

Water resource managers, infrastructure managers, and design engineers may

Table 3. Area-Maximum and Fixed-Point 24-Hour, 100-Year Precipitation Design Value Estimates for Greater Minnesota

Area	Area-Maximum Estimate (inches)	Fixed-Point Average Estimate (inches)
Northwest	10.84	5.02
Northeast	12.48	5.81
West Central	12.65	6.11
East Central	10.65	5.89
Southwest	10.25	6.17
Southeast	14.14	6.78

have quite different perspectives on the applicability of fixed-point versus area-based estimates of precipitation design values. The engineer, who is concerned fundamentally with a structure at a fixed point, may feel justified in using fixed-point precipitation design values. On the other hand, managers dealing with several, perhaps many, individual and spatially independent projects within an area for which they are responsible are likely to be more comfortable with area-based precipitation design values. Reconciling these differing perspectives may be difficult.

In any case, our research indicates that the data and methodology used in TP 40 produced precipitation design values that were valid and the best estimates available when TP 40 was published in 1961, but that are probably too low now. If these design values are not reevaluated, we believe that our local infrastructure may be more susceptible to flooding and damage than planners and designers imagine, and will become more susceptible in the future as population and infrastructure expand.

Richard H. Skaggs is professor emeritus in the Department of Geography at the University of Minnesota. His research and teaching has centered on climatology, especially of severe local storms, drought, and Minnesota climate fluctuations. Kenneth A. Blumenfeld is a doctoral student in the Department of Geography at the University of Minnesota. His undergraduate and graduate studies have been in climatology, especially severe local storms, extreme rainfall, and synoptic climatology of heavy snow.

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Needs Assessment of Foreign-Trained Healthcare Professionals in Minnesota

by Wilhelmina Holder and Nancy Omondi

The number of immigrants to Minnesota from sub-Saharan West and East African countries has increased substantially during the last decade, due in large part to various national and tribal conflicts in these regions. Today, these new Americans make up the second largest immigrant group in Minnesota. Although many of these individuals are qualified professionals in their countries of origin, most discover they cannot practice in their field when they arrive in the United States because their licensure does not transfer to this country. This is particularly true in the healthcare field. Consequently, immigrants trained as doctors or nurses often have to take low-paying jobs outside of their field of expertise.

In 2005, the African American Friendship Association for Cooperation and Development, Inc. (AAFACD, www.aafacd-inc.org) received a grant from CURA's Neighborhood Planning for Community Revitalization (NPCR) program in support of a project to assess the needs of foreign-trained healthcare professionals in Minnesota. Under the supervision of AAFACD, Nancy Omondi, a graduate student in the Division of Health Services Research and Policy at the University of Minnesota's School of Public Health, identified barriers to and opportunities for transferring medical licensure to the United States so foreign healthcare professionals could continue to work in the medical field after emigrating to Minnesota.

A foreign-trained healthcare professional from Kenya.

Employment Opportunities and Professional Licensure

Established in 2002, AAFACD engages locally established African immigrants in Minnesota to provide culturally sensitive employment, healthcare, and other support services to more recently arrived refugees and immigrants through programs and referrals to other service providers. The goals of the organization include empowering new immigrants to succeed in their new location and helping immigrants assimilate into American culture. The organization's primary constituency is the estimated 50,000 to 100,000 immigrants to Minnesota from Kenya, Liberia, Ethiopia, Somalia, Tanzania, Uganda, Sierra Leone, Nigeria, Togo, Ivory Coast, Gambia, and Sudan. According to the 2000 U.S. Census, more than 50% of these immigrants live in the Twin Cities metropolitan area, clustered primarily in Brooklyn Center, New Hope, Minneapolis, St. Paul, Eagan, Maplewood, and Woodbury.

Many newly arrived African immigrants come to Minnesota with a broad range of medical education and training. In spite of their professional qualifications, roughly 80% are relegated to entry-level medical positions as nursing aides—or, worse, unskilled jobs as taxi drivers or parking lot attendants—simply because they lack the necessary licensing required for professional medical employment.

Labor analysts and healthcare experts predict alarming shortages in almost all healthcare positions during the next few decades. According to the Ramsey County Workforce Investment Board's *Annual Report 2005,* Minnesota Department of Employment and Economic Development (DEED) employment projections indicate growth in the healthcare industry in the Twin Cities of more than 26,000 jobs between 2000 and 2010, in addition to 22,000 expected replacement openings. According to a June 2006 report titled *Health Care Work Force,* the Minnesota Hospital Association expects the gap between supply and demand of registered nurses to reach more than 8,000 by the year 2020. Given these trends, it is clear that properly licensed foreign-trained healthcare professionals could play an important role in preventing or reducing these shortages.

Project Method

Our project was undertaken in collaboration with the International Institute of Minnesota and the Rochester Workforce Center. The purpose of the study was to conduct focus groups with foreign-trained healthcare professionals to identify the barriers that prevent them from practicing in their professions and contributing meaningfully to their community in their new home in Minnesota.

Participants for the research were recruited through collaborations with the International Institute of Minnesota, Rochester Workforce Center, and Kaplan Test Preparation and Admissions. We conducted five focus groups of 29 unlicensed foreign-trained healthcare professionals: two with doctors and three with nurses. The focus groups were held mainly at AAFACD's offices in St. Paul. We also conducted multiple telephone interviews. In addition, we made one trip to Rochester to conduct a focus group with five Sudanese medical doctors.

We encountered some difficulties recruiting participants due to perceptions about the study, scheduling issues, transportation, and privacy issues related to agencies providing names and contact information of potential participants. These challenges were ultimately overcome in the following ways:

- establishing a stronger working relationship with the staff of one of our refugee relocation agency collaborators, the International Institute of Minnesota
- holding focus groups in locations where participants normally congregate—for example, at the Rochester Workforce Center and at Kaplan in St. Paul
- conducting a survey of participants who, for different reasons, could not attend a focus group but agreed to a telephone interview

We also conducted a literature review to examine barriers to foreign-trained healthcare professionals becoming certified in the United States, opportunities for overcoming these barriers, and system adaptations and changes that would assist foreign-trained healthcare professionals to work in their chosen profession. In addition, we compared the licensure process for foreign-trained healthcare professionals in Minnesota to those used in other states with large immigrant populations, including California, Florida, and New York.

Results

Through our research, we learned that the International Institute of Minnesota, AAFACD, and Rochester Workforce Center together serve roughly 165 foreign-trained medical doctors and nurses who desire to gain licensure in their professions. Based on the focus groups and literature review, we were able to identify the types of problems that foreign-trained healthcare professionals encounter at various stages of the licensing process. These include the following:

- lack of access to information from foreign colleges that is required by accreditation bodies (this proves especially difficult for refugees)

Nurses practice bandaging on a dummy in a hospital in Ghana. In spite of their professional qualifications, many foreign-trained healthcare professionals are relegated to entry-level medical positions when they arrive in the United States simply because they lack the necessary licensing required for professional medical employment.

- institutional disregard for past professional healthcare experience, resulting in requirements for retraining or externship/volunteer work
- lack of a central location for information about the complex licensure process in the United States
- transportation problems stemming from lack of a driver's license or money to afford a car
- communication barriers that prevent applicants from understanding information that is provided
- high costs associated with the licensure process
- the need to study again for licensing exams basic material that they have already learned
- lack of computer skills necessary to take licensing exams, all of which are computer-based
- the need for coaching, advocacy, family, and peer support

In addition, we looked at the extent to which identified barriers were influenced by race, country of origin, and language competence.

On the basis of the findings from the focus groups and literature review, we compiled the following specific recommendations for improving access to the profession, which were then disseminated to stakeholders:

1. formulate strategies to provide advocacy, peer, and mentor support
2. form support groups with other healthcare professionals pursuing their licensure
3. support research that addresses the transition of foreign-trained healthcare professionals into the Minnesota healthcare system
4. establish a scholarship fund to assist with licensing fees and studying costs
5. allow international medical graduates to complete rotations at American hospitals to provide exposure to the U.S. medical system
6. allow international medical graduates to have audit privileges at American universities for classes that can help prepare them for licensing exams
7. create a liaison office to assist new foreign-trained healthcare professionals, modeled on successful programs in other states
8. identify ways the international medical graduate community can become more involved in the bodies that oversee licensing activities
9. create a one-stop website with links to all available resources for foreign-trained healthcare professionals seeking licensure in Minnesota
10. provide a mechanism to assess the knowledge and skills of foreign-trained healthcare professionals to make them eligible for temporary and appropriate jobs in the healthcare industry while they complete licensure requirements

The results of our study provided critical information that enabled us to mobilize and advocate for foreign-trained healthcare professionals to obtain their licensure. In March 2006, this effort culminated in Representative Karen Clarke (DFL–Minneapolis) proposing a bill in the Minnesota state legislature, House File 3578, that appropriated money from the workforce development fund for a pilot project to encourage licensure of foreign-trained healthcare professionals in Minnesota. Representative Clarke's bill passed, allocating $450,000 for implementation of the program from July 1, 2006, to June 30, 2007. Three organizations—AAFACD, the International Institute of Minnesota, and the Rochester Workforce Center—were awarded $150,000 each to undertake the Foreign-Trained Healthcare Professionals Licensure Project. Representatives from these three organizations, as well as the Minnesota Department of Employment and Economic Development (DEED), serve as members of a steering committee with oversight of the project.

Under the program, scholarships are made available to foreign-trained healthcare professionals for specific training related to studying for the board licensing exam. To date, 39 doctors, 20 nurses, and 1 physical therapist have been interviewed and approved to receive scholarships to study at Kaplan and take licensure exams. In addition, AAFACD received a grant for $5,000 from the Headwaters Foundation to develop a Multicultural Foreign-Trained Healthcare Professionals Advocacy Task Force, comprised of foreign-trained healthcare professionals and various stakeholders. This task force is charged with discussing the identified barriers to licensure and employment for foreign-trained healthcare professionals; identifying strategies for addressing these barriers; and providing foreign-trained healthcare professionals with the knowledge, information, and skills to become empowered. The task force's goals are to increase skills in communication, leadership, and advocacy and to create a foreign-trained healthcare professionals advocacy agenda to present to Minnesota legislators, licensure boards, and professional associations.

Related Publications from CURA

More information about this project can be found in the following publications:

Nancy Omondi. 2005. "Assets and Needs Assessment of Foreign Trained Medical and Nursing Graduates in Minnesota and Utilization of Foreign Trained Healthcare Professional Graduates." Unpublished report, NPCR 1233. 87 pp. www.cura.umn.edu/publications/NPCR-reports/npcr1233.pdf

Nancy Omondi. 2006. "Foreign-Trained Health Care Professionals Assets and Needs Assessment: A Focus Group Study." Unpublished report, NPCR 1245. 26 pp. www.cura.umn.edu/publications/NPCR-reports/npcr1245.pdf

Wilhelmina Holder, M.D., is a consultant with African American Friendship Association for Cooperation and Development, Inc. She is originally from Liberia. Nancy Omondi is a graduate student in the Division of Health Services Research and Policy at the University of Minnesota's School of Public Health. She holds a master of business administration from the Carlson School of Management at the University of Minnesota, and is originally from Kenya.

This project was supported by CURA's Neighborhood Planning for Community Revitalization (NPCR) program, which provides student research assistance to community organizations in Minneapolis, St. Paul, and metropolitan-area suburbs that are involved in community revitalization.

CURA Work Study Program Receives $25,000 Grant

The Community Development Work Study Program (CDWSP), a joint effort of CURA and the University of Minnesota's Humphrey Institute of Public Affairs, has received a $25,000 grant from the Wells Fargo Foundation Minnesota. The award was made December 7 by Mary S. (Muffie) Gabler, Wells Fargo vice president of community development and community development manager. Gabler said that "Wells Fargo knows how important it is to nurture the next generation of community leaders who will work in the communities in which we do business," and praised the CDWSP for "giving students time to reflect on and work in communities that need their expertise to flourish." The funds from the award will be used to help provide internship stipends for students participating in the program.

The CDWSP is a national effort of the U.S. Department of Housing and Urban Development (HUD) and provides financial support to educational institutions to recruit and support economically disadvantaged students of color committed to community development. Students accepted into the program are provided tuition to pursue a graduate degree in urban and regional planning or public policy. During their degree program, they also gain practical experience through internships with nonprofit organizations or public community development agencies in the Twin Cities. As a result of the program, a new generation of community planners, policy analysts, and specialists will become trained to serve culturally and racially diverse, low-income communities and solve some of the most pressing issues facing our inner cities.

The program at the University of Minnesota is jointly administered and funded through CURA and the Humphrey Institute, with additional support from HUD Community Work Study grants (through 2007), foundations, and the organizations in which students are placed. The program contributes to CURA's mission to engage University of Minnesota students and faculty to assist communities in Minnesota.

For more information about the Community Development Work Study Program, visit www.cura.umn.edu/CDWSP.php.

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CURA
University of Minnesota
330 HHH Center
301—19th Avenue S.
Minneapolis, MN 55455

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