

Center for Urban and Regional Affairs

Summer 2007

Volume 37, Number 2

UNIVERSITY OF MINNESOTA



UCURA REPORTER

*Measuring Water Clarity and Quality in
Minnesota Lakes and Rivers*



Also Inside:

- Subprime Lending and Foreclosure in Hennepin and Ramsey Counties
- 2007–2008 Fesler Lampert Chair in Urban and Regional Affairs
- Expanding Educational Opportunity Through School and Housing Choice

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The Center for Urban and Regional Affairs (CURA) is an all-University applied research and technical assistance center at the University of Minnesota that connects faculty and students with community organizations and public institutions working on significant public policy issues in Minnesota.

The *CURA Reporter* is published quarterly to provide information about CURA's programs and projects.


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This publication is available in alternate formats upon request.

 Printed with agribased ink on recycled paper, including 20% post-consumer fiber.

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Photo on Cover: *The St. Croix River near Washington County, Minnesota.*
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Measuring Water Clarity and Quality in Minnesota Lakes and Rivers: A Census-Based Approach Using Remote-Sensing Techniques

by Patrick L. Brezonik, Leif G. Olmanson, Marvin E. Bauer, and Steven M. Kloiber

Photo © The Regents of the University of Minnesota. Used with permission of the Metropolitan Design Center.



The St. Croix River near Washington County, Minnesota.

Over the past few decades, satellite-derived information has become an integral part of our daily life. It is difficult to imagine how crude and inaccurate weather forecasts would be without the daily satellite feeds that drive the complex models on which weather forecasts are based, and of course the satellite images themselves have revolutionized how we view the movement (and scale) of weather patterns. Similarly, satellite technology has become such an essential and commonplace component of global telecommunications, television, and Internet systems that few give a second thought to the technology behind these

marvels. Google Earth now provides detailed images on our television and computer screens of far-off places using high-resolution satellite images. In addition, GPS systems based on satellites now enable even “directionally challenged” drivers to head their cars to the desired destination and make it possible to locate and track people in the most remote and inaccessible locations.

Satellite technology also has had profound impacts on the Earth sciences and on science-based management of natural resources. For example, Landsat imagery has been used for several decades to analyze land-use and land-cover patterns, estimate crop

production, and monitor forest health. More recently, the MODIS satellites have been used to estimate terrestrial primary production on a continental scale and to monitor oceanic levels of chlorophyll on a global scale. Satellites also provide essential hydrologic information (e.g., snow pack, rainfall, and evapotranspiration estimates) for water resources management.

Despite many efforts reported in the scientific literature during the past three decades, however, procedures using satellite imagery to measure surface water *quality* have not been adopted on a routine basis. For the past nine years, we have been working with colleagues

and students to change this state of affairs and to develop workable procedures for routine use of satellite imagery and related technology to assess surface water-quality conditions by Minnesota's water management agencies. Most of our work has focused on lakes and water clarity as a simple measure related to users' perceptions of water quality. However, we also have explored the use of satellite imagery to measure other water-quality characteristics, such as chlorophyll (a measure of the abundance of algae in water) and humic matter (natural derivatives from plants that produce the brown stain in wetlands and water draining from forested areas), and evaluated the potential of remote-sensing techniques to identify and map aquatic vegetation in lakes and wetlands. We have explored the capabilities and limitations of several satellite sensor systems, as well as aircraft-mounted sensors with high spectral and spatial resolution that provide special capabilities for remote measurements of water quality in rivers and streams.

This article summarizes progress we have made in these areas with emphasis on water clarity and provides some perspectives on the likely future role of satellite- and aircraft-based remote-sensing techniques in water resource monitoring and management in Minnesota. The work described here has been supported by a variety of state and federal agencies, including the Metropolitan Council, Minnesota Pollution Control Agency, Department of Natural Resources, Legislative Commission on Minnesota Resources, NASA, and the U.S. EPA. The senior author was the 2003–2004 Fesler-Lampert Chair in Urban and Regional Affairs, and some of the work described in this paper was supported by that position.

Ground and Satellite Measurements of Lake Water Clarity

In essence, clarity measures the distance that light penetrates in a water body. In lakes, water clarity commonly is measured by a simple device called a Secchi disk—a 20-cm (8-inch) diameter white disk—that is lowered into the water column until it can no longer be seen. The depth of disappearance is called the Secchi depth. Three types of constituents affect water clarity: algae and algal-derived particles; natural, colored organic matter (humic matter); and soil-derived clay and silt particles. In Minnesota lakes, soil-derived turbidity usually is not important, and water clarity most commonly is related to

algal abundance. Water clarity is useful in measuring water quality because it relates directly to both human-use perceptions of quality (clear water generally being preferred, especially for swimming) and to the abundance of algae. Thus, water clarity is an indirect measure of a lake's "trophic state"—its status in terms of nutrient concentrations and biological productivity. Because of its simplicity, Secchi depth is one of the most frequently measured properties of lakes, and many citizen monitoring programs have been developed over the past quarter century to supplement the monitoring by government agencies. Nonetheless, only about 10% of the lakes in the Twin Cities metropolitan area are monitored for water clarity in any given year, and in some parts of the state, the fraction monitored is much lower.

In our early studies on potential applications of satellite imagery to measure surface water quality, we found close correlations between water clarity, as measured by the Secchi disk, and light in the blue and red bands of the spectrum reflected from lake water surfaces and measured as "brightness" by satellite sensors. We used this information to develop procedures to estimate water clarity in terms of "inferred Secchi depth" using images gathered routinely (every 16 days, assuming no interference by cloud cover) by the Landsat satellites. With financial support from the Metropolitan Council, our initial studies focused on lakes in the Twin Cities metro area, but we later expanded our coverage across the entire state. Colleagues have applied our techniques for lake clarity monitoring in Wisconsin and Michigan, and recently we conducted pilot studies to evaluate the usefulness of the technique in Ohio, Indiana, and Illinois.

Because atmospheric conditions (e.g., haze and water vapor content) affect the light reflected by land and water surfaces as it travels back toward satellite sensors, no universal predictive relationship exists between water clarity and satellite sensor response. Instead, it is necessary to calibrate the general relationship applicable to Landsat and Secchi depth data for each Landsat image. We do this using standard regression procedures and Secchi depth measurements collected by existing monitoring programs on a few lakes (at least 20 and sometimes as many as 100 per image) near the time the satellite image was taken. The ground-based Secchi depth data do not need to be collected at exactly the same time that Landsat acquires an

image; we found that measurements taken within a few days (± 3 to 7 days) of image acquisition still provide strong relationships. This is because water clarity (Secchi depth) usually does not exhibit large and rapid fluctuations in a given lake (although there are strong seasonal patterns in clarity).

The general predictive equation that we found for water clarity estimation has the form:

$$\ln(SD) = a(TM1/TM3) + b(TM1) + c$$

where a , b , and c are coefficients fit to the calibration data by the regression analysis, $\ln(SD)$ is the natural logarithm of the Secchi depth for a given lake, and $TM1$ and $TM3$ are the brightness values measured by the Landsat sensor in the blue and red bands, respectively, for a pre-defined area of the lake surface. Once coefficients have been fitted to the equation, it can be used to infer Secchi depth values for all other lakes in the Landsat image. The images are approximately 110 miles on a side and may contain hundreds of lakes and ponds. The spatial resolution (so-called pixel size) of brightness data in the Landsat images is 30 meters (roughly 100 feet) on a side. Because we need to use data only from pixels for water surfaces not affected by land or aquatic vegetation, the net effect is that the procedure is capable of obtaining high-quality results on lakes larger than about 20 acres (8 hectares). For the seven-county Twin Cities metro area, which constitutes part of one Landsat image, this translates to approximately 550 lakes and open-water wetlands.¹

Lake Water Clarity in the Twin Cities Metropolitan Area

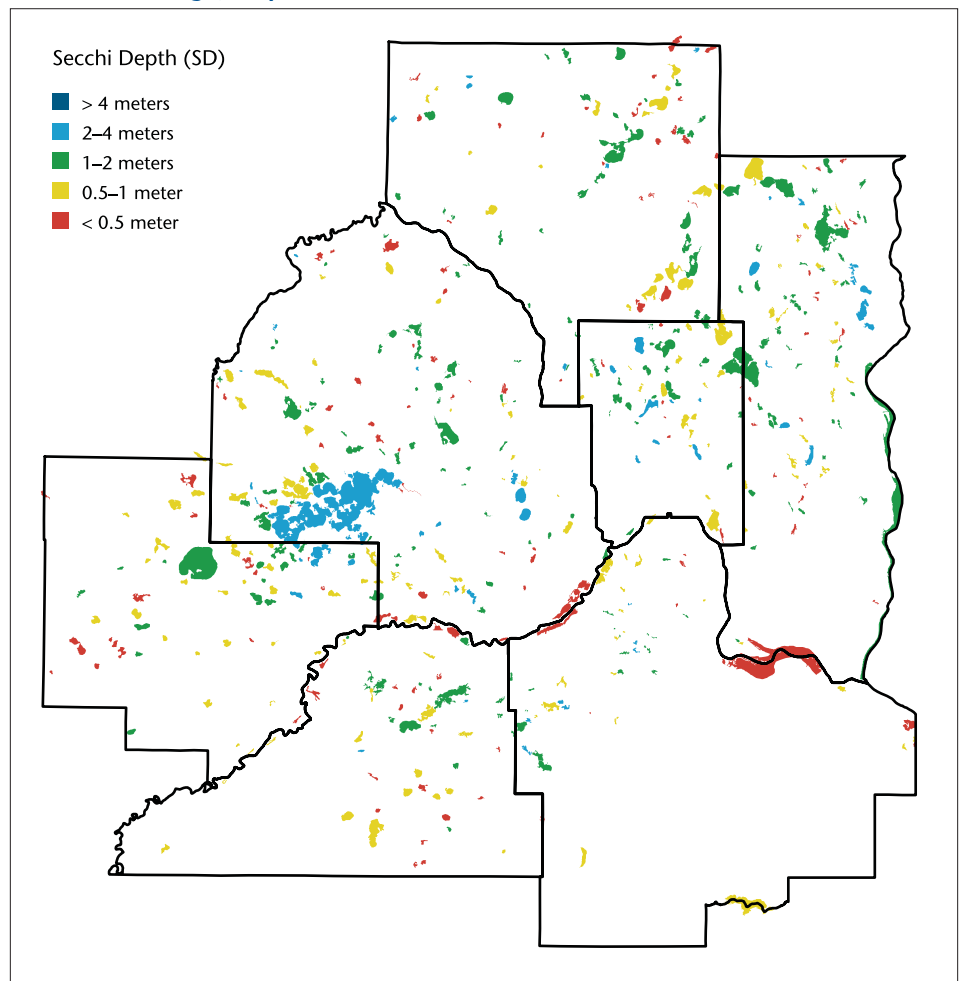
Our initial studies on the method established that it works in a practical sense and that it provides reliable data not otherwise available. Regarding practicality, historical Landsat images are available from the EROS Data Center in Sioux Falls, South Dakota, for relatively low cost (a few hundred dollars), and many images are available for free in existing local archives. Once the procedure is established for a given region, the processing time per image for an experienced analyst is less than a week, and the processing uses software that is

¹ The above description is a simplification of the procedures used to convert Landsat data into inferred lake clarity (Secchi depth) values. Details on the method are found in a manual available online at <http://water.umn.edu>.

readily available in remote-sensing laboratories. A search of historical archives showed that at least one cloud-free image is available for the Twin Cities metro area nearly every year for a late-summer index period (late July to early September), which we found to be the optimal time to assess water clarity in Minnesota lakes. Regarding data reliability, R^2 values (a measure of goodness of fit) for the regression relationships to establish the coefficients of the predictive equation normally are in the range of 0.8 to 0.9, meaning that they explain 80 to 90% of the variance in the relationship, and occasionally they are as high as 0.95 (95% of the variance). Given that ground-based measurements of Secchi depth are themselves subject to some imprecision, we consider this to be quite acceptable. In addition, excellent agreement between satellite-estimated and ground-observed Secchi depth trends can be achieved. For example, Secchi depth temporal trends during the 25-year record were found to be virtually identical in several metro-area lakes for which long-term ground-based data were available to compare with Landsat-inferred results. For Coon Lake (Anoka County), Secchi depth was found to increase at a rate of 0.062 m per year during the period 1973–1998 based on in-lake measurements, and a best-fit regression equation of the satellite-inferred Secchi depth yielded an increase of 0.067 m per year during the same time period.

In subsequent studies on water clarity in metro-area lakes, we were interested in evaluating spatial and temporal patterns in lake clarity. Specifically, we wanted to answer the following questions: (1) Does lake water clarity in the metro area vary depending on climatic conditions, such as extended periods of drought or above-average precipitation?; (2) Can long-term trends in water clarity of metro area lakes be related to well-documented changes in land-use/cover within the region?; and (3) How strong are the relationships between lake clarity and land-use/land-cover conditions in the landscape around lakes? To address these questions, we first analyzed a series of 10 images from the late-summer index period covering a 25-year interval (1973–1998). Ground-based calibration data were obtained for each image, primarily from the Metropolitan Council's citizen monitoring program, and Landsat-inferred Secchi-depth values were obtained by the procedures described above for approximately 575 lakes and open-water wetlands in the Twin Cities metro area.

Figure 1. Water Clarity (SD) for Twin Cities Metropolitan Area Lakes (inferred from Landsat TM image), September 1998



Note: One (1) meter equals 3.3 feet.

Results for 1998, the last year in this initial analysis (Figure 1), demonstrate that at any given time lakes in the metro area exhibit a wide range of water clarity. Analysis of the temporal trend results shown in Table 1 indicates that climatic conditions have an important influence on water clarity in the region's lakes. For example, 1988, which was one of the hottest and driest summers on record in the region, had the highest fraction of lakes in the lowest clarity class and one of the lowest fractions of lakes in the highest clarity class among all the study years. Hot sunny weather, combined with low rainfall that produced little flushing of water through the lakes, yielded heavy algal blooms and low water clarity in many lakes. In contrast, 1993 and 1996, which were wet and relatively cool summers, had low fractions of lakes in the lowest clarity class and high fractions in the highest clarity class. The combination of cooler temperatures, less sun, and greater flushing of water through the lakes resulted in lower amounts of algae

and higher clarity in many lakes. The 1996 image was acquired in mid-July, just outside the late-summer window that we found best represents the period of lowest water clarity in Minnesota lakes, and this also may explain the higher water clarity values in that year.

Several statistical tests were used to examine temporal differences and trends across years in lake water clarity. A Kruskal-Wallis test showed no significant differences in metro-area regional lake water clarity between the years 1983, 1986, 1991, 1995, and 1998, but water clarity was below normal in 1973 and 1988 and above normal in 1975, 1993, and 1996.

Although no simple long-term trend in lake water clarity was detected at the scale of the entire Twin Cities metro area, a Kendall Tau-b analysis for each of the approximately 500 metro-area lakes with sufficient data to conduct a trend analysis indicates that 49 lakes (10% of the total) had significant temporal trends. Water clarity improved in 34 lakes since 1973 and declined in only

Table 1. Water Clarity Trends for Twin Cities Metropolitan Area Lakes, 1973–1998

Secchi Depth (SD)	Number of lakes, by month and year									
	July 1973	Aug 1975	Sept 1983	Aug 1986	Aug 1988	Sept 1991	Aug 1993	July 1995	July 1996	Sept 1998
> 4 meters	7 (1.6%)	4 (1.0%)	14 (3.2%)	0 (0.0%)	3 (0.6%)	0 (0.0%)	0 (0.0%)	1 (0.2%)	4 (0.8%)	0 (0.0%)
2–4 meters	94 (21.1%)	79 (18.9%)	61 (14.0%)	94 (19.5%)	77 (16.4%)	75 (15.5%)	68 (14.0%)	86 (17.7%)	118 (23.9%)	96 (19.7%)
1–2 meters	192 (43.2%)	165 (39.6%)	182 (41.7%)	160 (33.3%)	120 (25.5%)	187 (38.6%)	218 (45.0%)	192 (39.6%)	245 (49.6%)	184 (37.8%)
0.5–1 meter	122 (27.4%)	137 (32.9%)	114 (26.1%)	168 (34.9%)	168 (35.7%)	173 (35.7%)	144 (29.8%)	151 (31.1%)	104 (21.1%)	149 (30.6%)
< 0.5 meter	30 (6.7%)	32 (7.7%)	65 (14.9%)	59 (12.3%)	102 (21.7%)	49 (10.1%)	54 (11.2%)	55 (11.3%)	23 (4.7%)	58 (11.9%)
Total	445	417	436	481	470	484	484	485	494	487

Note: One (1) meter equals 3.3 feet. Column percentages may not total 100% due to rounding.

15 lakes. The most common trend (43% of lakes with trends) was an increase in clarity of 4 to 8% per year. Lakes with decreasing clarity generally were small or quite shallow, suggesting that morphometry (the physical shape and size characteristics of a lake) may predispose a lake to respond more strongly to changes in natural or human-induced stresses. The finding that more lakes had improving rather than worsening clarity during the 25-year record at first was surprising, given the major geographic expansion of the Twin Cities footprint that occurred during that time period. However, suburban sprawl has occurred largely at the expense of agricultural lands rather than more pristine forested areas, and croplands often produce higher levels of nutrients in storm-water runoff than do suburban residential areas. Moreover, the salutary effects of efforts to manage the quality of urban and suburban storm-water runoff, and also to directly manage water-quality conditions in lakes, should not be discounted.

Since the studies described above were completed, we have continued to assess lake water clarity across the Twin Cities metro area. Additional information for 2000, 2003, and 2005 is available on the “Twin Cities Lake Browser” (see <http://water.umn.edu>), through which one can locate individual lakes of interest and obtain data for the entire period of record. Perhaps more significant is the fact that the Metropolitan Council Environmental Services (MCES) has

adopted the procedure and is conducting annual assessments of water clarity in metro-area lakes. Results for 2003, 2004, and 2005 are available from MCES.

Water Clarity in Ponds and Small Lakes

The relatively modest spatial resolution of the Landsat sensor (30 m) limits the usefulness of Landsat imagery to assess water clarity conditions in small lakes and ponds. Newer commercial satellites with spatial resolution (pixel sizes) of 1 to 4 meters overcome this limitation and allow assessment of water clarity in neighborhood ponds much smaller than an acre in area. Two such commercial satellites, IKONOS and Quickbird, are the primary sources of the amazing aerial images shown increasingly in television news broadcasts and the imagery that provides the basis for Google Earth. Both satellites have sensors similar to the Landsat TM sensors in spectral characteristics (e.g., three broad bands in the visible spectrum and one in the near infrared).

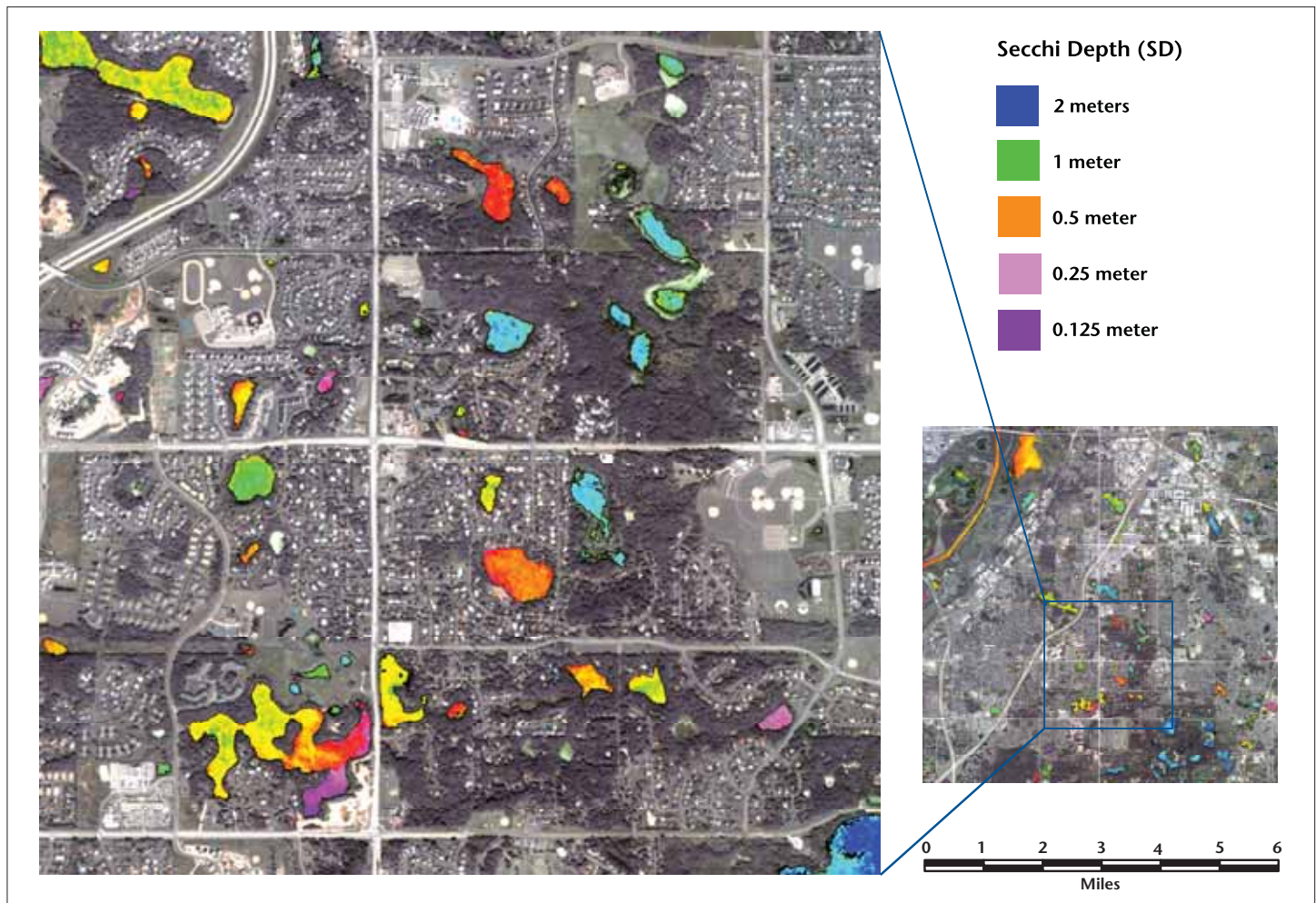
Figure 2 shows an image for Eagan, Minnesota, acquired on August 23, 2000, by the IKONOS satellite. The city of Eagan, located in the southeastern metro area (just southeast of the Minneapolis–St. Paul Airport) and roughly 6 by 6 miles (about the size of an IKONOS image), has about 375 small lakes, ponds, and open-water wetlands greater than one acre in area. The image was processed using the basic procedures we developed for Landsat imagery. Multiple regression analysis of the

brightness signatures from 19 lakes with Secchi depth measured within three days of the image date yielded a strong fit to the equation model described earlier ($R^2 = 0.82$, meaning that the relationship explains more than 80% of the variation in the data). We created a pixel-level map of water clarity of small lakes and ponds in Eagan, as shown in Figure 2. Only 14 of Eagan’s 375 lakes, ponds, and wetlands were large enough to be included in our previous metro-area assessments and 22 were included in our statewide assessments (see below), but the IKONOS image assessed 236 water bodies. The wide range of water clarity in small ponds within a small geographic area is striking and likely reflects both natural factors (pond depth and watershed area) and effects of landscape use and management practices. We found similar results for images obtained in 2001 and 2002. The cost of IKONOS data (\$2,500 to \$4,000 per image) probably would be too large for many cities just for lake-clarity assessments, but should be justifiable if the images also are used to monitor changes in land use, land cover, and wetland status.

Statewide Census-Level Assessment of Lake Water Clarity

Starting in 2000, we expanded our analysis of lake water clarity in Minnesota from the metro region to the entire state. Since that time, we have completed five censuses at approximately five-year intervals for the 20-year period 1985–2005. Each census

Figure 2. IKONOS Image Showing Water Clarity for Lakes and Ponds in Eagan, Minnesota, August 23, 2000



comprises information on more than 10,000 lakes and open-water wetlands across the entire state of Minnesota. The techniques used to produce these results are similar to those we developed for the metro-area assessments. For the statewide assessments, we generally sought Landsat images where ideally each entire path across the state yielded useable information (clear skies). Landsat orbits Earth such that it traverses Minnesota in southwest-to-northeast paths that are approximately 110 miles wide, and the trajectory is such that successive paths partially overlap. By using entire paths across the state rather than single images, we were able to extend the geographic range with available ground data for calibration purposes; some remote areas in northern Minnesota, for example, have very limited ground-based measurements. The overlapping nature of the Landsat paths also meant that multiple satellite-inferred Secchi depth measurements were obtained for approximately 60% of the state's lakes in each census. Because clouds sometimes obscure

Landsat images for parts of the state during the late-summer measurement period, the statewide censuses usually are composites of analyzed images acquired within plus or minus one year of the nominal year for a census.

We currently are in the process of analyzing this data set, which we believe is unprecedented in size and scope, for

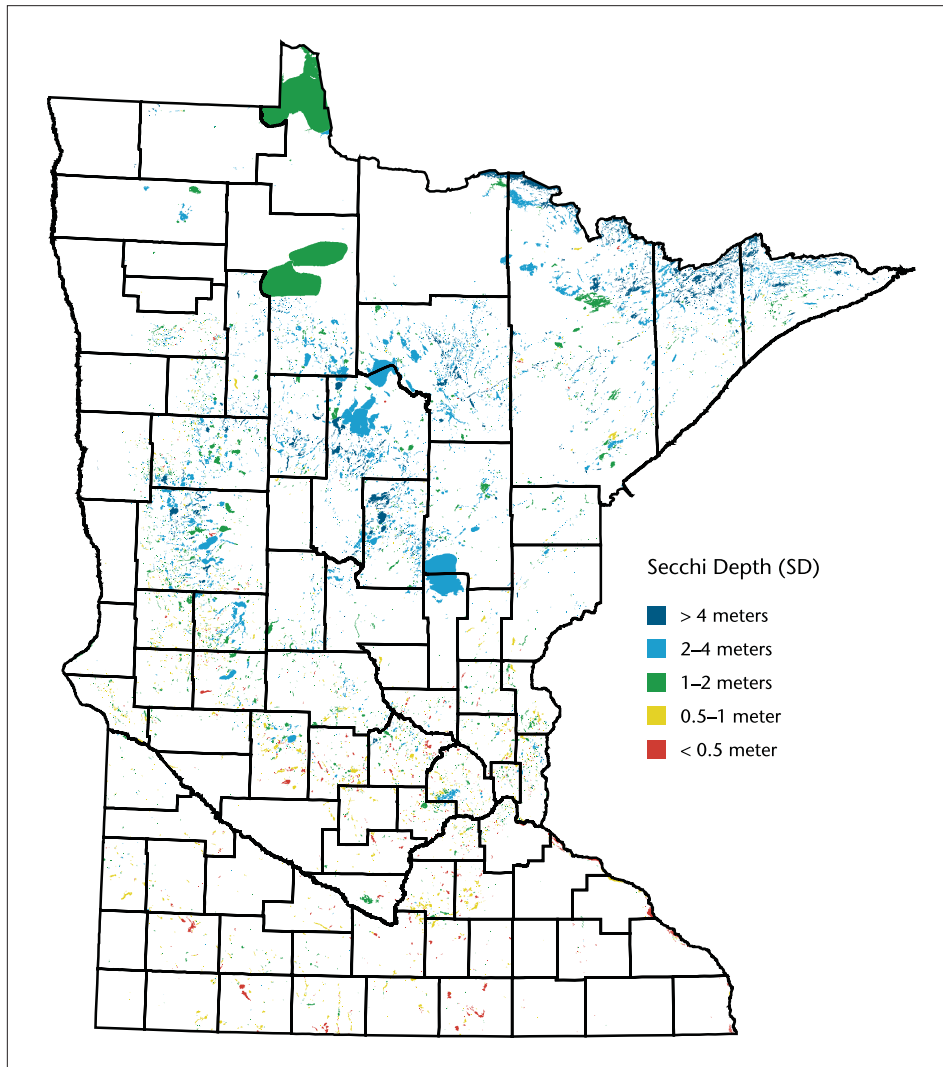
spatial and temporal trends. Figure 3 illustrates the distribution of lake water clarity across the state for the year 2005 (a similar image for 2000 is available from the authors as a large poster suitable for framing and classroom use), and Table 2 summarizes temporal trends in the numbers of Minnesota lakes in different water-clarity classes for the

Table 2. Water Clarity in Minnesota Lakes Based on Landsat-Inferred Secchi Depth (SD), 1985–2005

Secchi Depth (SD)	Number of lakes, by year				
	1985	1990	1995	2000	2005
> 4 meters	1,043	1,213	1,059	909	1,254
2–4 meters	4,917	3,981	4,649	4,641	4,363
1–2 meters	3,080	3,150	3,356	2,637	3,091
0.5–1 meter	1,627	1,898	1,670	1,729	1,902
< 0.5 meter	469	490	254	600	631
Total	11,136	10,732	10,988	10,516	11,241

Note: One (1) meter equals 3.3 feet.

Figure 3. Landsat-TM-Based Census of Water Clarity in Minnesota Lakes, 2005



period of record. Overall, the distribution of lakes across the water-clarity classes is fairly stable throughout the 20-year period 1985–2005, but a few differences stand out. For example, substantially fewer lakes were found in the lowest water clarity class (< 0.5 m) in 1995 than in all other years, and in 2000 there were fewer lakes with water clarity values in the 1 to 2 m range but more lakes with values in the 3 to 4 m range than in other years. Information on trends in lake clarity for individual counties and across Minnesota’s ecoregions can be found at <http://water.umn.edu>, and the “Lake Browser” on this site allows users to locate individual lakes across the state and obtain water clarity and other information.

Of interest regarding the statewide census information is how it extends the earlier information on lake clarity within the Twin Cities metro area. Figure 4 shows the distribution of TCMA lakes in four “swimming use-support”

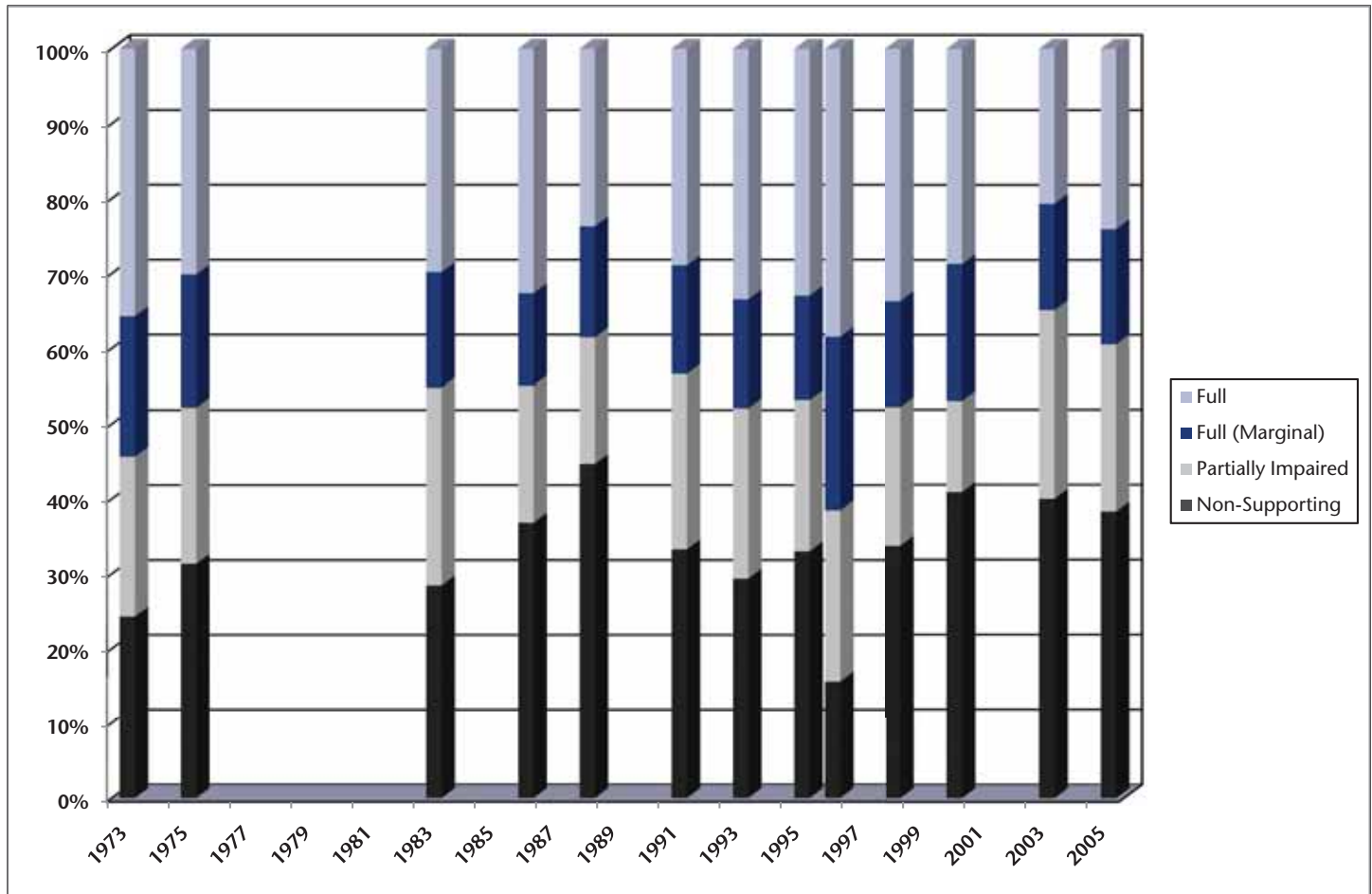
classes based on water clarity over the extended period of record, 1973–2005. The Minnesota Pollution Control Agency developed criteria for these use-support classes based on algal bloom problems associated with various concentrations of total phosphorus (TP) in lakes. Based on established relationships between TP and Secchi depth, we converted the criteria into equivalent Secchi depth values. For example, a TP concentration of about 80 micrograms per liter ($\mu\text{g/L}$) corresponds to a Secchi depth of 0.62 m (or 2.0 ft) in lakes where phosphorus controls the growth of algae. Lakes with higher TP concentrations (hence, lower Secchi depth values) than that are considered to be “non-supporting” (that is, unfit) for swimming because they have a high frequency of nuisance algal blooms. The results in Figure 4 suggest a gradual trend in the fraction of metro-area lakes in the non-supporting category during the first half of this decade, compared with results for the end of the earlier

record (through 1998). However, when the entire 32-year study period is examined, no simple linear trend is apparent regarding the extent to which metro-area lakes support swimming. Instead, a cyclic pattern is evident that may be related to climatic conditions. For example, the fraction of lakes in the non-supporting category reached a maximum in the late 1980s, corresponding to the end of a long-term drought, and a minimum in the mid-1990s, corresponding to a period of above-average rainfall in the region. The fraction of lakes in the fully supporting category showed the opposite trend (minimum in the late 1980s and maximum in the mid-1990s). Thus, it appears that climatic conditions play an important role in the temporal pattern of lake water clarity at the region scale.

With the larger database available from the statewide censuses, we also have been able to examine relationships between lake clarity and land-use/land-cover conditions in the surrounding terrestrial landscape, a goal we were not able to achieve in our earlier studies focused only on the Twin Cities metro area. For example, contrasts in land use/land cover among the three largest ecoregions in the state (Figure 5) are obvious, and patterns of lake clarity appear to reflect these differences. The Northern Lakes and Forests (NLF) ecoregion in northeastern Minnesota is more than 60% forested and only roughly 6% agricultural; the Western Cornbelt Plains (WCP) ecoregion in southern Minnesota is only 4% forested, and agricultural land occupies more than 80% of the region; and the North Central Hardwood Forest (NCHF) ecoregion in the center of the state has intermediate land-use/land-cover conditions (12% forested and 50% agricultural land). Reflecting these ecoregion differences, water clarity in NLF lakes averages slightly more than 3 m, and about 70% of the lakes have values in the 2 to 4 m range. In contrast, water clarity in WCP lakes averages just less than 1.0 m, and only about 8% of the lakes in this region have clarity values in the 2 to 4 m range (and very few have values greater than 4 m). Lakes in the NCHF exhibit a wide range of clarity, but the average value is about 1.5 m, and roughly 40% of the lakes have clarity values in the 1 to 2 m range.

Of course, other factors aside from land use/land cover affect lake clarity—water column depth, underlying geology, and population density in lake catchments also play important

Figure 4. Swimming Use Support for Twin Cities Metropolitan Area Lakes, 1973–2005



Note: Swimming use support based on water clarity (Secchi depth, SD). SD values defining the use-support classes are as follows: full, > 1.60 meter; full (marginal), 1.21–1.60 meter; partially impaired, 0.80–1.20 meter; non-supporting, < 0.80 meter. One (1) meter equals 3.3 feet.

roles. In general, lakes in the NLF tend to be deeper than lakes in the WCP, and geology and climate are important factors that predispose the NLF to be much more forested than the WCF.

Striking relationships between lake water clarity and land use/cover also were found when the data were examined at the county level (Figure 6). Across Minnesota counties, average lake clarity increases with increasing percentages of forested land and decreases with increasing percentages of agricultural and urban land. The rate of decrease with degree of urban land is especially dramatic; average lake clarity declines to only about 1.0 m (3.3 ft) at 10% urban land in a county. Others have reported similar effects of urbanization and extent of impervious area on the biotic integrity of streams. Digital map layers delineating individual lake catchments are becoming available for Minnesota, and it will be interesting to see whether relationships with lake clarity improve when land-use analyses are conducted at the scale of individual lake catchment areas.

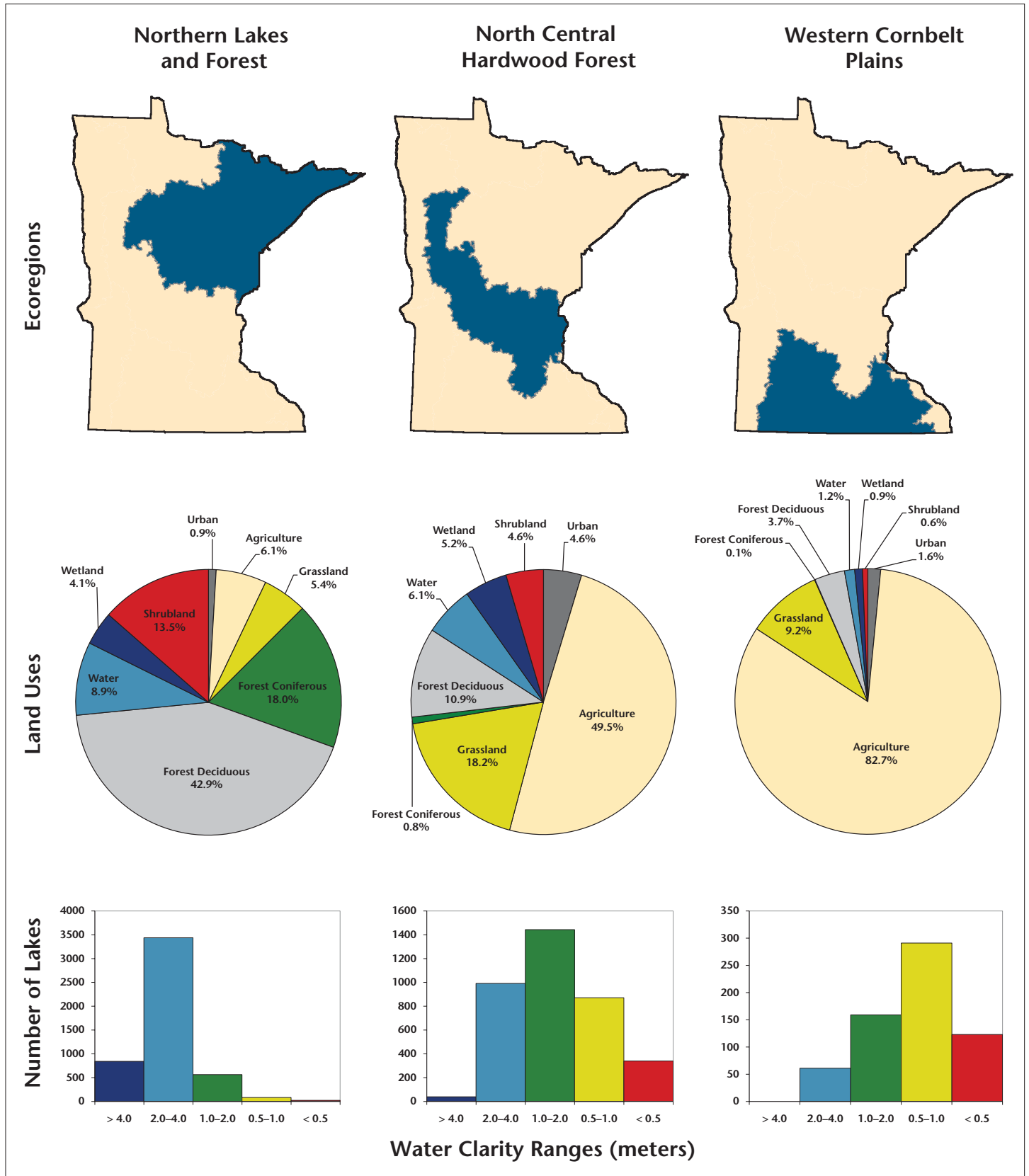
Aircraft-Based Remote Sensing of Water Quality in Rivers and Streams

Satellite imagery works well to assess water clarity and related optical properties of lakes (such as chlorophyll and humic color), but geometric considerations make satellite imagery a poor choice for remote sensing of rivers and streams. As they pass through the Twin Cities metro area, only large rivers like the Minnesota and Mississippi Rivers are wide enough to have pixels representing water surfaces that are not affected by shoreline and land surfaces. High-resolution satellites like IKONOS do have the required spatial resolution, but acquisition of such images for a particular date and time is not a straightforward proposition, and the relatively small areas these images cover lead to impractically large costs per river mile monitored.

Multispectral sensors similar to those in satellites like Landsat and IKONOS (or with higher spectral resolution) that are deployable in small aircraft are commercially available. Because aircraft can be flown precisely on flight paths along river reaches, they

offer an attractive possibility for monitoring river water quality and obtaining more complete spatial coverage than is possible with ground-based sampling. To explore the usefulness of this technique, we conducted a series of studies in the summers of 2004 and 2005 on rivers in the Twin Cities metro area and nearby areas using a small plane and sensor system operated by the University of Nebraska. In contrast to the Landsat TM and IKONOS sensors, which have only a few, broad spectral bands, the sensors we used in the aircraft studies collected reflected light in many (narrow) spectral bands, and this provided much better opportunities to develop stronger predictive relationships for various optically related water-quality characteristics. Support for this work was provided by the Legislative Commission on Minnesota Resources through the Minnesota Pollution Control Agency (MPCA), and collection of ground-based calibration data was achieved by a collaborative effort of the MPCA and the Metropolitan Council Environmental Services.

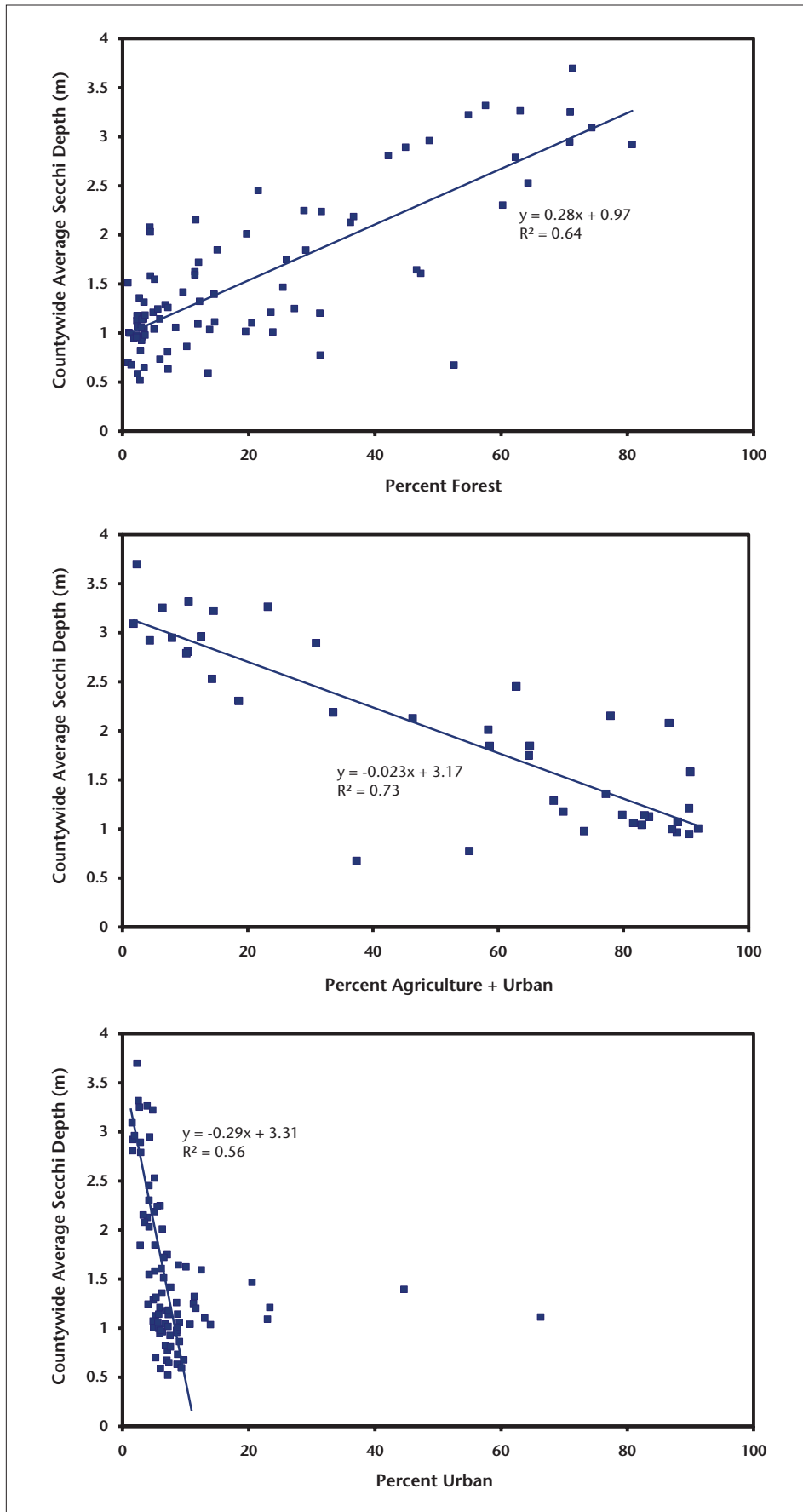
Figure 5. Land-Use/Land-Cover Distribution and Water Clarity in Three Minnesota Ecoregions



Source: Land-cover data are from 1990 Minnesota Land Cover GAP. Secchi depth data are from 2000.

Note: One (1) meter equals 3.3 feet.

Figure 6. Relationship between Average Secchi Depth (SD) for Lakes in each Minnesota County and Percentage of Forested, Agricultural, or Urban Land



Note: One (1) meter equals 3.3 feet. Trend line for urban area is based only on counties with urban area < 11%.

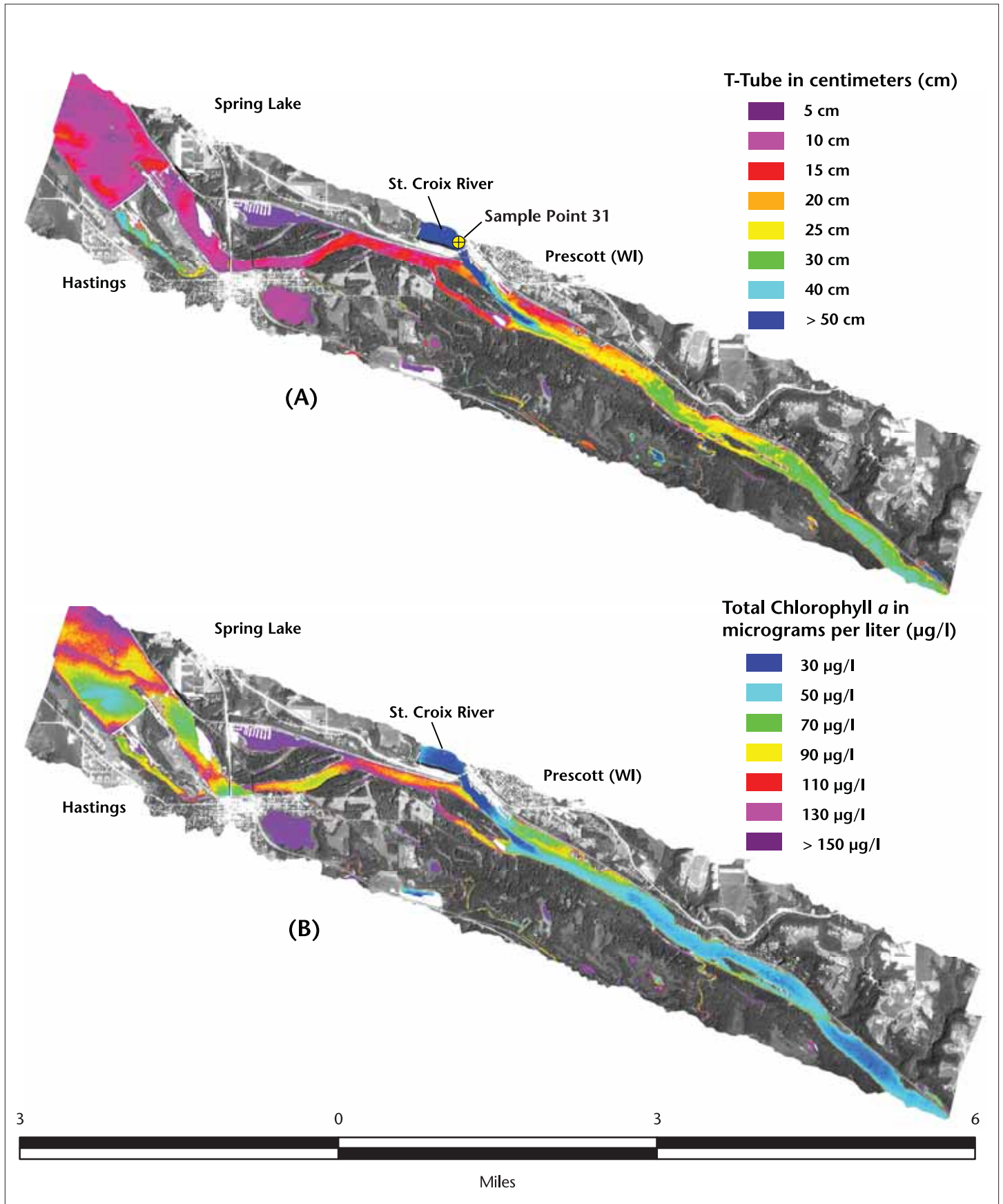
Procedures used to obtain and analyze data from the aircraft-mounted sensor were generally similar to those we have been using for satellite data. Because of the high degree of spatial and temporal variability in optical properties (such as turbidity, water clarity, and chlorophyll concentrations) of flowing waters, collection of water samples from the rivers was coordinated to occur near the same time as the aircraft overpass. Water clarity was measured on river samples using a Transparency Tube (T-tube) that provides data analogous to Secchi depth but is easier to use in flowing waters. Statistically strong relationships were found between ground-based measurements of water-quality characteristics and the brightness of light at specific wavelengths collected by the aircraft-mounted sensor ($R^2 = 0.94$ for T-tube water clarity and 0.72 for chlorophyll *a*).

The exploratory studies were successful and yielded maps for several optically related water-quality characteristics, including turbidity, water clarity, suspended solids, and chlorophyll, along several major river reaches in the region. Typical results are shown in Figure 7, which illustrates the distribution of water clarity (a) and chlorophyll (b) along a stretch of the Mississippi River starting at highly turbid Spring Lake (above Lock and Dam No. 2) near Hastings, Minnesota. The influence of water low in suspended matter from the St. Croix River on clarity in the Mississippi River is apparent, and the figure shows that water clarity improved further as suspended matter settled out over a distance of about 3 to 4 miles from the confluence of the St. Croix. Chlorophyll levels were very high in parts of Spring Lake (but spatially highly variable) and the Mississippi River downstream of the lake, but concentrations decreased markedly after confluence with the cleaner waters of the St. Croix River. As illustrated in Figure 7, in typical ground-based routine monitoring programs on rivers, one or perhaps a few sampling locations along the river would be sampled and the high spatial variability of water quality would be missed.

Concluding Comments: Prospects for the Future

Effective management of natural resources depends on accurate and complete information, as well as an informed public. We view the remote-sensing techniques for information

Figure 7. Spatial Distribution of (a) Water Clarity Measured by a T-tube and (b) Total Chlorophyll a in the Mississippi River from Spring Lake to Downstream of the Confluence with the St. Croix River



Note: Based on aircraft-based imagery collected August 19, 2004.



This photo shows the dramatic difference in water clarity at the confluence of the St. Croix River (blue water) and the highly turbid Mississippi River.

gathering on surface water described in this article as tools that will help achieve both of these goals. Satellite imagery provides a cost-effective means to obtain comprehensive spatial coverage on the status and trends in key characteristics of surface-water quality, and the results can be made readily available to the public in easily understood formats. Of course, these methods cannot tell us everything we would like to know about water quality; satellite sensors cannot detect the presence of potentially harmful metal pollutants, organic pollutants, or bacterial pathogens in water. However, the sensors do provide accurate information about water clarity and the occurrence of algal blooms in water, and these are common issues affecting the usability as well as the economic value of Minnesota lakes.

Scientists in other states have adopted the methods we developed to study Minnesota lakes, and resource management agencies in Minnesota and elsewhere are starting to adopt these same methods as routine. Prospects for future improvements of the techniques are bright, because satellite sensors likely to be developed during the next decade should provide better spectral, spatial, and temporal resolu-

tion. Development of techniques for automated correction of satellite data to account for atmospheric effects should be possible, and this would eliminate the need to gather ground-based calibration data for every image.

Our recent work with aircraft-mounted sensors is especially promising in that it provides a means of gathering spatially comprehensive information on water quality in rivers and streams heretofore not practical with ground-based sampling programs. Such comprehensive information, as shown for the Mississippi River in Figure 7, could be used to provide much more robust validation of models used to forecast water-quality conditions than current ground-based methods allow. Moreover, the compelling nature of the visual images themselves should help both scientists and the public to gain a deeper appreciation and better understanding of our aquatic resources.

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Science Foundation since August 2004. His research focuses on understanding human perturbations on biogeochemical cycles of nutrients and metals in aquatic systems, and applications of remote sensing to regional-scale assessment of water quality. **Leif G. Olmanson** is a research fellow in the Department of Forest Resources and the Remote Sensing and Geospatial Analysis Laboratory at the University of Minnesota, and a Ph.D. student in the Natural Resources Science and Management Program. His research focuses on development of satellite imagery and aircraft-based remote-sensing tools to measure the status and trends of ecological conditions in lakes, rivers, and wetlands. **Marvin E. Bauer** is a professor in the Department of Forest Resources and director of the Remote Sensing and Geospatial Analysis Laboratory at the University of Minnesota. His research focuses on applications of digital remote sensing to inventory, monitor, and analyze land, vegetation, and water resources. **Steven M. Kloiber** is a senior planner with the Metropolitan Council Environmental Services in St. Paul. His Ph.D. dissertation in civil engineering on the application of satellite imagery to measurement of lake water clarity trends in the Twin Cities metro area provided a foundation for our research. His current research focuses on understanding the impacts of urban and suburban development on surface water quality and nutrient export from watersheds.

The research upon which this article is based was supported in part through funds provided by the Fesler-Lampert Chair in Urban and Regional Affairs, one of four endowed chairs and two named professorships made possible through a generous contribution to the University of Minnesota by David and Elizabeth Fesler. The Fesler-Lampert Endowment in Interdisciplinary and Graduate Studies was initially established in 1985 to stimulate interdisciplinary research and teaching through the appointment of distinguished, broadly learned scholars to endowed faculty positions at the University of Minnesota. Additional support was provided by the Metropolitan Council, Minnesota Pollution Control Agency, Department of Natural Resources, Legislative Commission on Minnesota Resources, National Aeronautics and Space Administration (NASA), and the U.S. Environmental Protection Agency (EPA).

Subprime Lending and Foreclosure in Hennepin and Ramsey Counties

by Jeff Crump

In the first three months of 2007, there were 678 foreclosure sales in the city of Minneapolis, an increase of more than 100% since 2006. More than 50% (384) of these foreclosures were located in North Minneapolis, an area particularly hard hit by predatory lending and foreclosure. As city officials struggled to cope with what the *Minneapolis Star Tribune*, in an April 24, 2007 article, termed a “foreclosure epidemic,” the Minnesota Family Housing Fund announced an \$11 million loan to the city of Minneapolis to purchase foreclosed homes on the Northside and resell them.

In highly impacted locations such as North Minneapolis, scrappers remove copper pipes from foreclosed and abandoned homes, a practice that has resulted in at least four natural gas explosions. Arson fires are also on the increase in North Minneapolis. Yet, the neighborhood distress is not limited to one community or city. In fact, a 2006 study titled *Mortgage Foreclosure and Vacant Building Trends in St. Paul* conducted by the City of St. Paul found that there are more than 800 abandoned buildings in the city, the highest number since the city began keeping track in the 1980s. Foreclosures and abandonment are also on the rise in suburban locations such as Brooklyn Park, where city officials struggle to keep pace with the growing problem.

The rapid rise in foreclosures is not unique to the Twin Cities. Throughout the United States, a wave of foreclosures has swept through residential neighborhoods. Associated with subprime and predatory lending, the default rate among borrowers holding subprime mortgages soared to 12.6%. Consequently, several large subprime mortgage companies such as New Century Mortgage Corporation have gone bankrupt because they were unable to obtain the needed credit to remain solvent. Jittery investors were also jolted by a 2006 report published by the Center for Responsible Lending titled *Losing Ground: Foreclosures in the Subprime Market and Their Cost to Homeowners*, which predicted 1.1 million new foreclosures in the United States.

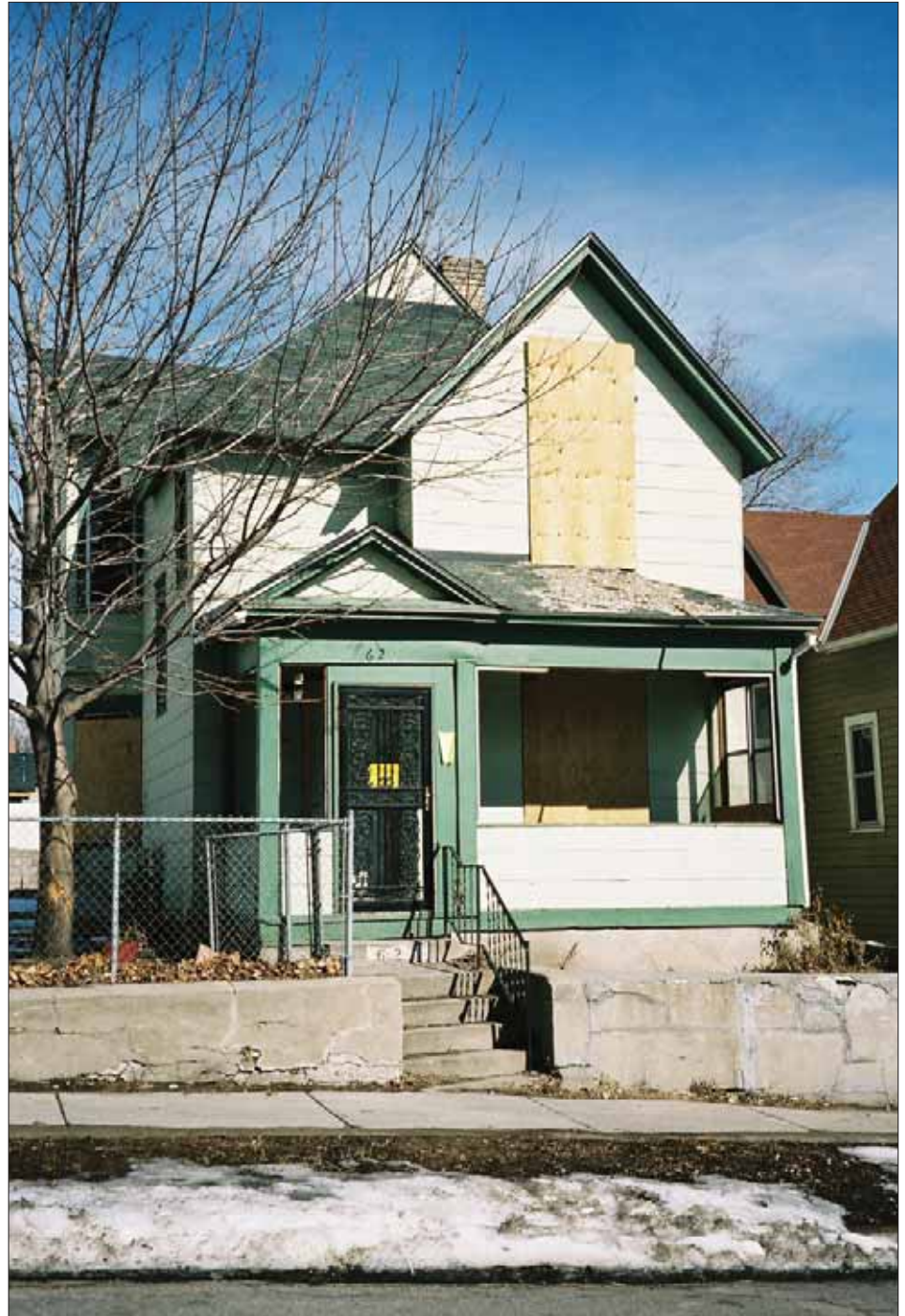


Photo by David Lyons

Abandonment, arson, and removal of copper pipes are growing problems in areas with high levels of foreclosure.

The foreclosure epidemic is part of a slow-moving crisis that is engulfing the U.S. mortgage lending industry. In recent

months, the connections among Wall Street, the subprime mortgage business, and local housing markets have become

increasingly evident. For example, on February 27, 2007, the U.S. stock market fell by more than 400 points for the biggest one-day loss since September 11, 2001. According to an article titled "What's an Investor to Do?" in the February 28, 2007, business section of the *Minneapolis Star Tribune*, problems in the subprime mortgage industry were the "straw that broke the camel's back" and were the single most important factor in causing the stock market decline.

In a *CURA Reporter* article published in Spring 2005, I argued that, "The high cost of subprime loans may put many families in financial jeopardy and increase the risk of foreclosure. Foreclosures in turn threaten the viability of entire neighborhoods, as the increase in vacant homes lowers property values, encourages crime, and discourages business development." Sadly, the concern I expressed with respect to subprime lending and foreclosures appears to have been entirely justified.

In this paper, I update my earlier *CURA Reporter* article, which used data from 1996 to 2002, with data on mortgages and foreclosures for 2005, the most recent year for which the Home Mortgage Disclosure Act (HMDA) data is currently available. To begin, I outline the characteristics and limitations of the mortgage and foreclosure data. Next, I analyze the subprime mortgage market in Hennepin and Ramsey Counties with particular attention to racial patterns of mortgage lending in 2005. Following that, I present a comparison of foreclosures in Hennepin and Ramsey Counties for 2002 and 2005. To conclude, I provide a legislative update on bills concerning foreclosure and subprime mortgage lending currently before the Minnesota State legislature.

Data and Methodology

The data I use to describe and analyze demographic and geographic patterns in subprime lending come from the HMDA data for 2005. There are some important limitations to the HMDA information and there are some significant differences between the 1996–2002 data set I used in my earlier analysis and the 2005 data.

The most important difference between the 1996–2002 HMDA data and the 2005 HMDA data is that, beginning in 2004, lenders were required to report the rate spread for what are termed "high-cost loans." The rate spread is the difference between adjusted annual percentage rate (APR), which includes both the fees and points in addition to the interest rate, and a treasury security of comparable maturity.

Photo by David Lyons



Abandonment and foreclosure lower the value of neighboring houses, impairing the ability of other homeowners to sell or refinance their homes.

In 2005, a loan was considered high cost if the APR of a first-lien mortgage was more than 3 percentage points above a treasury security. For second-lien mortgages, the threshold was set at 5 percentage points. According to the Federal Reserve Bank, these thresholds were chosen, "in the belief that they would exclude the vast majority of prime-rate loans and include the vast majority of subprime-rate loans."¹ Although complex, the inclusion of the rate spread data does greatly improve our ability to analyze the subprime mortgage market. However, the very different method used to identify subprime loans precludes easy comparison of the 1996–2002 HMDA data and the 2005 data.

An additional and ongoing problem with the HMDA data set concerns missing racial and lender information. In particular, data on the race/ethnicity of mortgage applicants is not reported for applications taken through the mail, over the phone, or via the Internet. In terms of loan applications in Hennepin and Ramsey Counties, 13.2% of the racial data was missing in 2005 because the application was taken by mail, telephone, or over the Internet; and on an additional 9.1% of the applications, the racial variable was marked "not applicable." Therefore, a total of 22.3% of all applications were lacking important information on racial

¹ Federal Reserve Bank, "Frequently Asked Questions About the New HMDA Data" (2006).

patterns of mortgage lending. With so much missing racial data, the estimates presented here very likely underestimate the prevalence of subprime lending in Hennepin and Ramsey Counties.

Subprime and High-Cost Mortgage Lending in Hennepin and Ramsey Counties, 2005

In 2005, there were more than 200,000 mortgage loan applications, and high-cost subprime loans comprised 11.2% (22,690) of them. In terms of mortgage loan originations, 25.1% of the 2005 loan originations were high-cost loans (Table 1). In Hennepin and Ramsey Counties (like the rest of the United States), high-cost subprime loans comprise a very significant share of the mortgage market. This finding is not terribly surprising given the fact that according to the Federal Deposit Insurance Corporation, 33% of all home loans in the United States were considered subprime in 2005.

High-cost Subprime Lending and Race. Virtually all studies of high-cost lending find that minority borrowers receive higher proportions of such loans than Whites. In 2005, African Americans received 3.9% of all mortgages, but they obtained 17.4% of all the high-cost mortgages (Table 1). Nearly 60% of all the mortgages received by African Americans were high-cost loans. Although credit availability has increased among African Americans, the prevalence of high-cost loans raises important concerns about the cost of the credit extended.

Among Hispanics, nearly half (48.0%) of all mortgages obtained were high-cost loans and 8.4% of all high-cost loans went to Hispanics in 2005. High-cost loans were also prevalent in the Asian community where 35.9% of all mortgage originations were considered high cost, accounting for 7.9% of all high-cost loans.

By comparison, even though 60.7% of all high-cost subprime loans went to Whites in 2005, only 20.1% of all loan originations to Whites were in the high-cost subprime category.

To summarize, it is clear that high-cost lenders play an important role in providing expensive credit to the growing minority communities of Hennepin and Ramsey Counties. Communities (such as African Americans) that were formerly unable to obtain home loans due to discrimination, now can get loans. However, the cost burdens associated with high-cost subprime lending fall heavily on minority communities and neighborhoods.

Table 1. Mortgage Loan Originations by Race/Ethnicity, Ramsey and Hennepin Counties, 2005

Race/Ethnicity	Percentage of all prime loans originated	Percentage of all high-cost subprime loans originated	Percentage of all loans originated	Percentage of loans that are high-cost subprime	Likelihood of receiving a high-cost loan*
American Indian	0.4% (268)	0.9% (207)	0.5% (475)	43.6%	39%
Asian	4.8% (3,226)	7.9% (1,803)	5.6% (5,029)	35.9%	48%
African American	3.9% (2,657)	17.4% (3,941)	7.3% (6,598)	59.7%	64%
Hispanic	3.1% (2,068)	8.4% (1,910)	4.4% (3,978)	48.0%	49%
White	80.8% (54,777)	60.7% (13,766)	75.8% (68,543)	20.1%	25%
Hawaiian/Pacific Islander	0.4% (185)	0.3% (99)	0.3% (284)	34.9%	32%
Information not provided	8.9% (6,064)	12.5% (2,827)	9.8% (8,891)	31.8%	—
Not applicable	0.2% (609)	0.9% (47)	0.7% (656)	7.2%	—
Total †	74.9% (67,786)	25.1% (22,690)	(90,476)		—

Source: Author's calculations from Home Mortgage Disclosure Act data set, 2005.

* The likelihood of receiving a high-cost subprime loan was calculated with income held constant.

† Columns do not add up to the figures shown under Total because "Hispanic" is an ethnic category and was not included in the calculated totals. People of Hispanic origin can be of any race.

The penetration of the minority market by high-cost subprime mortgage loans is further illustrated via the use of logistic regression analysis. Using a statistical equation identical to the one I used in my previous article, I found that, irrespective of income, the likelihood of receiving a high-cost subprime loan is significantly higher among minority borrowers (Table 1). African Americans (regardless of income) had a 64% likelihood of receiving a high-cost loan, Asians a 48% likelihood, and Hispanics a 49% likelihood. The chance of Whites getting a high-cost loan was 25%. These findings lead to the conclusion that high-cost lending is targeted toward the minority communities of the Twin Cities.

The Geography of High-Cost Lending. In my previous article, the spatial analysis of the geographic distribution of high-cost subprime loans indicated that such loans were concentrated in minority neighborhoods. In particular, neighborhoods that were predominantly African American were especially hard hit by high-cost subprime lending.

Although direct comparisons are problematic, analysis of the 2005 data shows a very similar spatial pattern (Figure 1). In 2005, high-cost loans were more than 20% of all mortgages in many census tracts in North Minneapolis; several census tracts in St. Paul have similar proportions. High-cost subprime loans remain concentrated in minority neighborhoods and the proportion of loans has achieved startling proportions. Not surprisingly, the areas with the highest percentage of high-cost loans are also those where foreclosure rates are the greatest (Figure 1).

High-Cost Lending and Foreclosure in Hennepin and Ramsey Counties, 2002 and 2005

It is no exaggeration to say that foreclosures in Hennepin and Ramsey Counties increased at a frightening pace between 2002 and 2005. In 2002, there were 907 foreclosures in Hennepin County; by 2005 there were 1,681, an increase of 85%. In 2006, there were more than 3,000 foreclosures in Hennepin County, an astounding increase of 235% since

2002. Similar increases are evident for Ramsey County. In 2002 there were 353 foreclosures, by 2005 there were 626, and in 2006 foreclosures had increased to 1,407. In percentage terms, Ramsey County foreclosures increased by 77% between 2002 and 2005 and by an astonishing 299% between 2002 and 2006.

When the 2005 foreclosures are mapped, two facts stand out. First, the spatial pattern of foreclosure is very similar to that of 2002. Second, the intensity of the patterns has been greatly accentuated. Foreclosures in North and South Minneapolis are especially striking. The pattern in St. Paul is somewhat less concentrated, but it is clear that many St. Paul neighborhoods are experiencing a very high number of foreclosures. Of particular note is the spread of foreclosures to suburban locations. In particular, Brooklyn Park and other suburbs northwest of Minneapolis are experiencing high numbers of foreclosures. The growth in foreclosures is an alarming trend and indicates that financial distress and neighborhood decline are serious and growing problems.

Conclusion

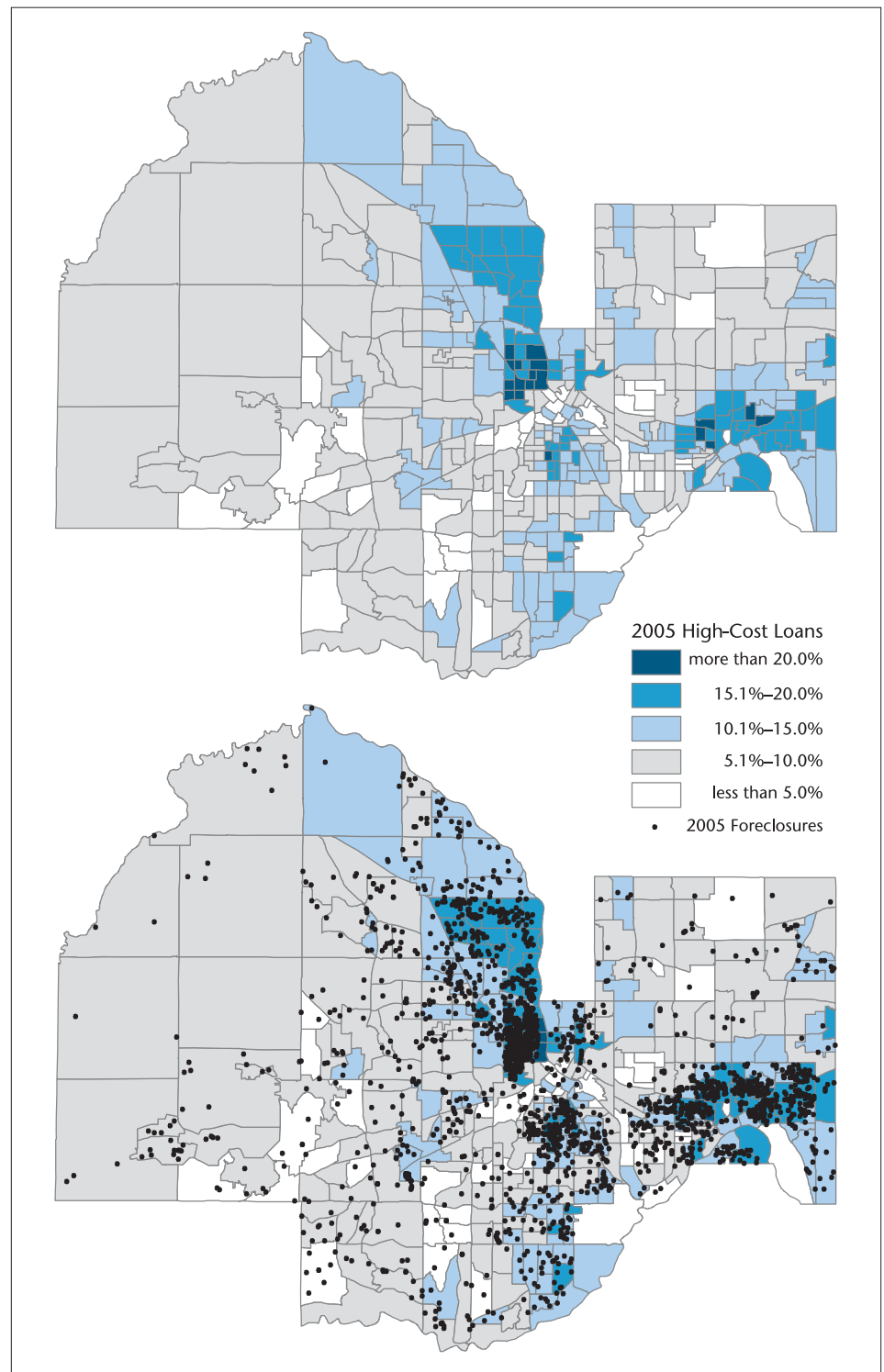
The results reported in this article indicate that the number of high-cost mortgages is concentrated in minority communities, and is especially prevalent among African Americans. In tandem with the growth of high-cost subprime loans, the number of foreclosures increased at a very high rate. Especially hard hit were minority neighborhoods where high-cost subprime loans are common. However, it is important to note that significant numbers of the foreclosures are related to investors using subprime loans to purchase rental properties.

These patterns indicate a state of crisis in many neighborhoods. As I see it, many high-cost subprime lenders, although they claim to be providing increased opportunity for homeownership, have systematically stripped the wealth of vulnerable communities, leaving in their wake a trail of financial distress that will likely take years to recover from.

Through interviews with housing market professionals, I have gained some insight into the process of wealth removal from homeowners. It began with an increase in home prices that led to increased equity among minority homeowners. Responding to home equity accrual, subprime or predatory lenders gained access to this equity by extending high-cost credit to borrowers who had few other alternatives. In most instances, homeowners were encouraged to refinance their homes multiple times (“loan churning”), each time netting profitable origination and other fees for lenders. And every time a mortgage refinance occurred, the homeowner lost some of the equity he or she had built up in the home. After three or four mortgage refinances, the homeowner was left with little or no equity. It is at this point that many go into foreclosure. Their financial and emotional resources exhausted, foreclosed homeowners are forced to seek rental housing in the same neighborhoods where they once were homeowners.

The impact of foreclosure is not only devastating to the homeowner. It also has significant negative neighborhood impacts as well. As homes are foreclosed, they may remain vacant or become rentals. Vacant homes lead to further declines in home values in the community. The ability of homeowners in the neighborhood to refinance their homes is thus further restricted, reinforcing the downward spiral and leading to even more foreclosures.

Figure 1. High-Cost Mortgage Originations and Foreclosures, 2005



Source: Home Mortgage Disclosure Act 2006; Hennepin County 2006; foreclosures.com 2006; City of St. Paul 2006

I would argue that just such a cumulative downward process is occurring throughout our metropolitan region.

It is important to note that although some media accounts of subprime and predatory lending emphasize the poor credit histories of subprime borrowers, research by Eric Stein in 2001 (*Quantifying the Economic Cost of Predatory Lending*) indicates that up

to 50% of those who have expensive subprime products could have qualified for a prime loan with its lower costs. Due to the marketing practices of the subprime industry, however, such borrowers are never offered the prime loan products they are qualified for. Instead they are steered toward the costly (and profitable) products offered by subprime or predatory lenders.

Minnesota Legislative Action on Subprime Lending

During the 2007 legislative session, the Minnesota State Legislature passed two significant bills addressing predatory lending. Below is a brief summary of these important bills.

HF1004/SF0809: Predatory mortgage lending practices prohibited.

This bill passed the Minnesota House and Senate and was signed by Governor Pawlenty on April 20, 2007. The main provisions of the bill are as follows:

- ▶ Requires that lenders verify the borrower's ability to repay the loan, including real estate taxes and property insurance. This provision addresses concerns around loans that use stated income or no documentation of income (so-called "liar's loans").
- ▶ Prohibits "churning" of mortgage loans. The churning provision requires that mortgage refinancing only be done when there is a "reasonable and tangible" benefit to the borrower.
- ▶ Prohibits loans that will result in negative amortization. Here, the intent is to ban no interest or other loans where, although the borrower makes payments, the loan balance continues to increase.
- ▶ Places a 5% limit on closing costs, other fees, and fees paid by the lender to a mortgage broker. This provision places a cap on the fees that can be included in the mortgage amount.
- ▶ Establishes a duty of agency for mortgage brokers. Requires that mortgage brokers act in the borrower's best interest, account for all funds, and disclose material facts that may affect borrower's rights.

SF0988/HF0931: Predatory mortgage lending practices prohibited, criminal penalties prescribed and remedies provided. This bill passed the Minnesota House and Senate and was signed by Governor Pawlenty on May 14, 2007. The main provisions of the bill are as follows:

- ▶ Prohibits lenders from making misleading or false statements.
- ▶ Prohibits selling a borrower a subprime loan if that borrower qualifies for a prime mortgage.
- ▶ Prohibits the refinancing of special mortgages (e.g., loans obtained via Habitat for Humanity) without written certification from a qualified loan counselor.
- ▶ Prohibits prepayment penalties.
- ▶ Provides for a right to private action for borrowers.
- ▶ Defines and prohibits mortgage fraud.

Policy makers are now beginning to address the issues surrounding high-cost subprime lending and foreclosure (see sidebar). Two bills, one that outlaws predatory lending and another that adds civil penalties and enforcement provisions, have passed the Minnesota legislature and been signed by Governor Pawlenty. These are important first steps to address the problems associated with subprime lending and foreclosure.

Additional measures will be needed. For example, people who still hold mortgages that put them in financial jeopardy need assistance to refinance or otherwise address their financial distress. Unfortunately, because of the losses associated with the subprime mortgage industry debacle, tightening credit standards will make it difficult to refinance many of the costly subprime loans.

Foreclosure, family distress, and widespread neighborhood deterioration are just some of the lasting consequences of the profitable and heretofore unregulated subprime mortgage industry. It is sad to note that those who profited from subprime lending will not bear the consequences. Instead, the people who bought into the American Dream of homeownership via subprime and predatory mortgages will deal with its lasting nightmares.

Jeff Crump is associate professor in the Housing Studies program in the College of Design at the University of Minnesota. An economic geographer by training, his research interests include public housing policy, housing markets and finance, and labor geography.

This study is an update on a project originally supported 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.

Expanding Educational Opportunity Through School and Housing Choice

by Myron Orfield and Nicholas Wallace

Many Twin Cities schools are segregated. Segregated schools harm children, communities, and the metropolitan region. Segregated schools intensify the region's segregated residential patterns, concentrating poverty and magnifying its harms. This isolates the most disadvantaged children from educational and economic opportunity. To help integrate schools, and ensure equal access to opportunity, affordable housing should not be concentrated in racially or economically segregated areas, and deci-

sions to site units should be coordinated with an expanded school choice program so opportunities are available for families to live near their children's schools in places where job opportunities also are more abundant. In addition to describing the harms of growing regional economic and racial segregation in the Twin Cities region, this article encourages integration through expanded school and house choice.

The research on which this article is based was supported in part by the senior author's appointment

as the 2005–2006 Fesler-Lampert Chair in Urban and Regional Affairs at the University of Minnesota.

Segregation Hurts Everyone

According to Russell W. Rumberger and Gregory J. Palardy in *Does Resegregation Matter?* (2005), more than three-quarters of the difference in academic achievement among students is explained by the socioeconomic status of their peers, rather than general differences in school facilities and programs. Not only do racially and economically segregated schools hurt all children, they harm disproportionate numbers of non-White children. As Gary Orfield et al. report in *Losing Our Future* (2004), among the harms of *economically* segregated schools (and neighborhoods) include the harms associated with *racially* segregated schools and dropping out of school such as unemployment, imprisonment, and impoverishment.

There is nothing short of integration to substitute for the benefits of integration. Even beyond the academic achievement and attainment benefits, "the networking effects of desegregation may be far more important than [even] the cognitive effects."¹ For children to have a fair chance, these benefits must, as public schools were envisioned to do,

¹ Richard Kahlenberg, *All Together Now: Creating Middle-Class Schools through Public School Choice* (Washington, D.C.: Brookings Institution Press 2001), 30 (quoting Gary Orfield, interview by author).

Table 1. Poverty Enrollments by School District, 2005

District	Poverty enrollment
Minneapolis	67%
Bloomington	27%
Hopkins	18%
Edina	6%
Mnetonka	3%

Source: Minnesota Department of Education, *School Report Card*, 2005. Data for each district can be accessed at <http://education.state.mn.us/ReportCard2005/index.do>.



Photo © Thinkstock/Corbis

The concentration of race and poverty in Twin Cities public schools disproportionately harms children of color.

offer these opportunities equally. Effectively desegregating schools is a “tide that can raise all boats,” narrowing gaps that weigh on a metro region’s vitality.

During the 1980s and 1990s, as the suburbs grew rapidly, schools closed in some districts whereas other districts on the edge of the region built new ones. During those decades, the region, especially its central cities, became more racially and ethnically diverse. According to the National Center for Education Statistics (<http://nces.ed.gov/datatools/>), Minneapolis gained increasingly higher shares of minority and poverty enrollments, the latter increasing from 43 to 66% between 1990 and 2000. The middle class increasingly chose to locate away from high-poverty schools farther out into the suburbs, and the schools they left became severely racially and economically segregated. By 2003, 46% of reporting Minneapolis schools were hyper-segregated, with enrollments

between 81 and 100% non-White. In addition, according to the Minnesota Department of Education’s *2005 School Report Card: Minneapolis*, 67% of Minneapolis students presently are on free or reduced-price lunch (Table 1). The proportion of students receiving free or reduced-price lunch indicates the level of poverty within a particular school. This concentration of poverty is extreme in

the national context and is especially so within the Twin Cities regional context.

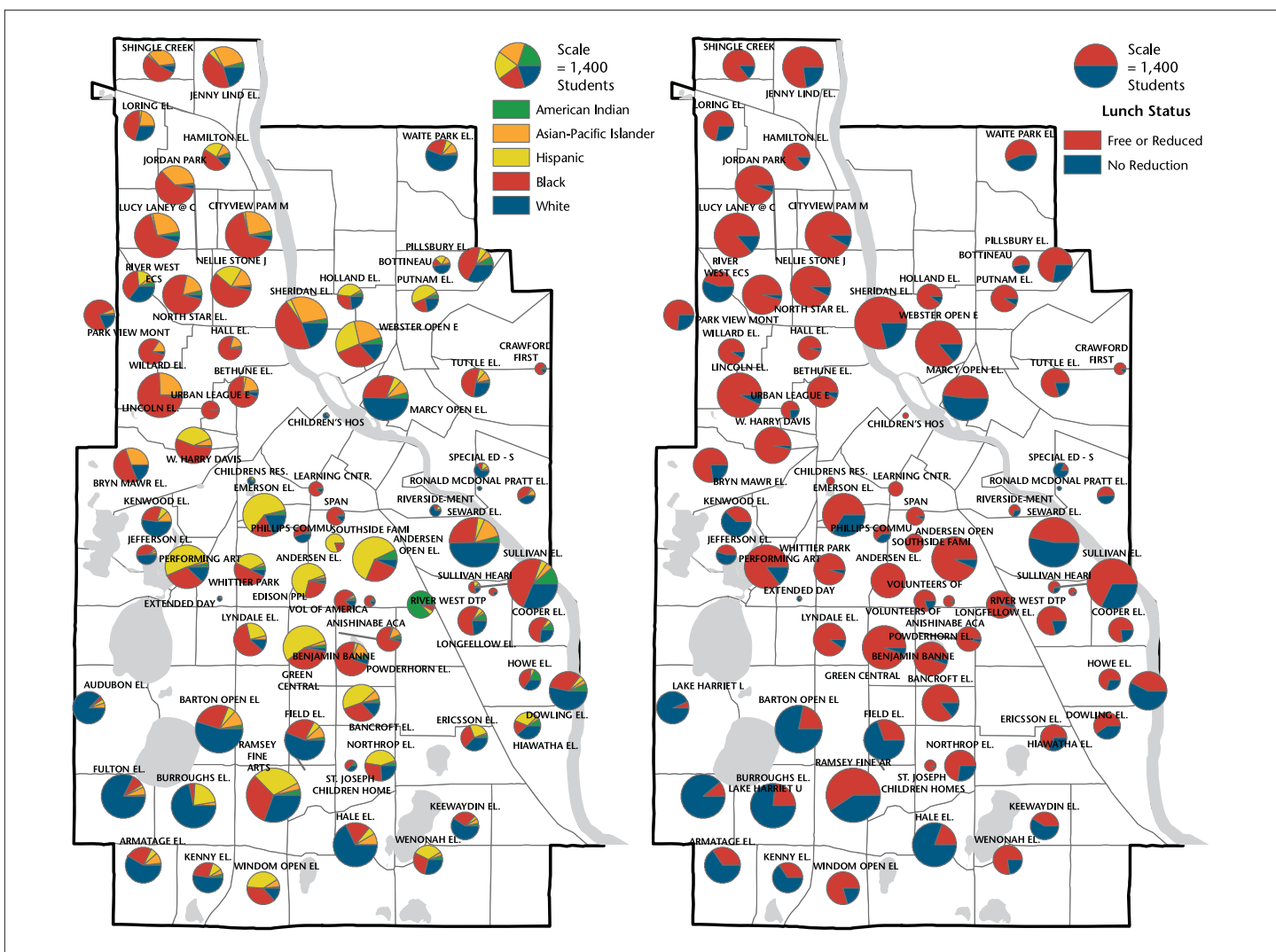
The concentration of race and poverty in Twin Cities schools is revealed in maps of the region’s elementary school enrollments. Figure 1 displays the racial distributions in Minneapolis public elementary schools for the 2004–2005 school year. With the exception of a cluster of schools in southwest Minneapolis and a few

Table 2. Percentage of Students Passing Basic Skills Tests for Selected Minnesota Districts, 2005

	Poverty enrollment	Pct. who passed reading	Pct. who passed math
Minneapolis	67%	63.6%	48.4%
Richfield	47%	75.3%	63.5%
Bloomington	27%	87.5%	74.4%
Edina	6%	94.9%	91.7%

Source: Minnesota Department of Education, *School Report Card*, 2005. Data for each district can be accessed at <http://education.state.mn.us/ReportCard2005/index.do>.

Figure 1. Racial-Ethnic Enrollment and Lunch Status Distributions, Minneapolis Public Elementary Schools, 2004–2005



Source: Minnesota Department of Children, Families and Learning, Data Center, June 22, 2005.

others in the city, the overwhelming majority of schools are racially identifiable by a minority group. Nearly all of the schools in north Minneapolis are majority Black, and many of the schools in central Minneapolis are majority Latino. The few stably integrated schools in southeast Minneapolis do not offset a clear pattern of segregation elsewhere in the city.

The second map in Figure 1 displays the school lunch status of children in Minneapolis public elementary schools. It shows that the majority of Minneapolis elementary schools are majority poor. The concentration of poverty virtually mirrors the racial enrollment data in the first map.

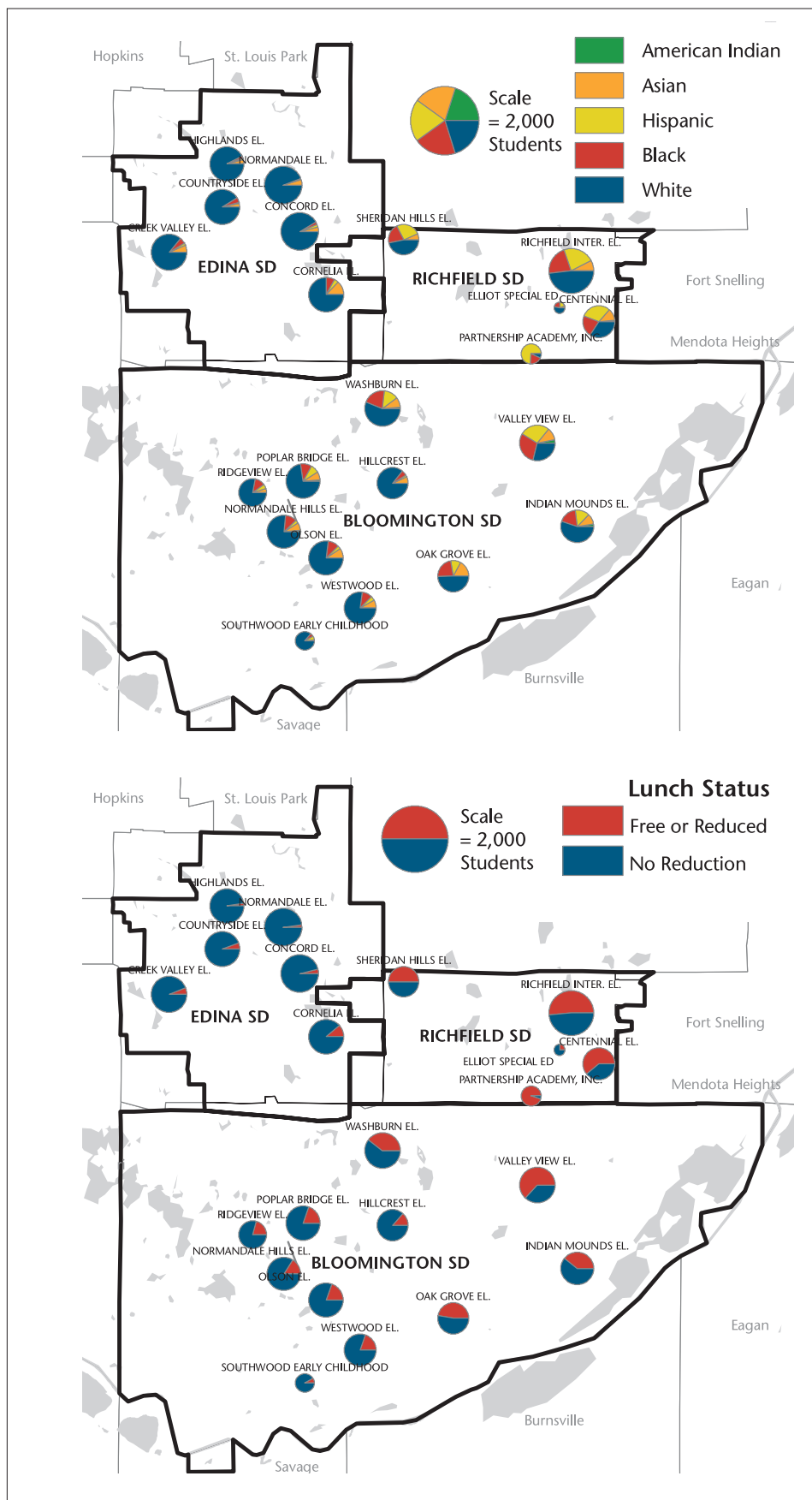
The Minneapolis School District graduates only 55% of its students.² Yet more than 91% of adults in the Twin Cities region have at least a high school diploma,³ and more than 33% have at least a college degree. In contrast to the 55% graduation rate in Minneapolis, adjacent school districts graduate 88 to 100% of their students, according to the Minnesota Department of Education's 2005 *School Report Card: Statewide*.

The city's 55% graduation rate compares poorly with rates of 88 to 100% in adjacent districts. As Table 2 reflects for a sample of districts contiguous to Minneapolis, the percentage of students passing the February 2005 basic skills tests further illustrates how poor performance results correlate with a school district's level of poverty.

When families make these comparisons, those who can afford to will "vote with their feet," accelerating patterns of middle-class flight. According to the Minnesota Department of Education's 2005 *School Report Card*, Minneapolis enrollments have dropped sharply, declining 18% between 2000 and 2004, from 48,000 to 39,913 students. In contrast, public school enrollments declined only 2.1% statewide during the same period.

Racial segregation in Twin Cities schools reflects a larger pattern of residential segregation in the Twin Cities region. As Figure 2 shows, patterns

Figure 2. Racial-Ethnic Enrollment and Lunch Status Distributions, Southwest Suburban Public Elementary Schools, 2004–2005



Source: Minnesota Department of Children, Families and Learning, Data Center, June 22, 2005.

² "According to the most recent [Minneapolis] district data, the city's seven high schools had a 78 percent graduation rate. However, add in the contract alternatives, such as the Center School, 2421 Bloomington Ave. S.; The City, Inc., 1315 12th Ave. N.; and others, and the graduation rate drops to 54.5 percent." Scott Russell, "Schools Become a Big Issue in Mayor's Race," *Downtown Journal* (October 3, 2005), online.

³ According to 2000 U.S. Census data, the percentage of adults in the 13-county Twin Cities region's with high school diplomas was 90.6%; nationwide, it was 80.4%.

of segregation are emerging in the near-south suburbs of the Twin Cities. Schools such as Valley View Elementary and Partnership Academy have become clearly racially identifiable, while others such as Oak Grove Elementary and Washburn Elementary are quickly headed in that direction. As with the Minneapolis public elementary schools, economic segregation is mirroring the racial segregation in southern suburbs. Some schools are already more than two-thirds poor.

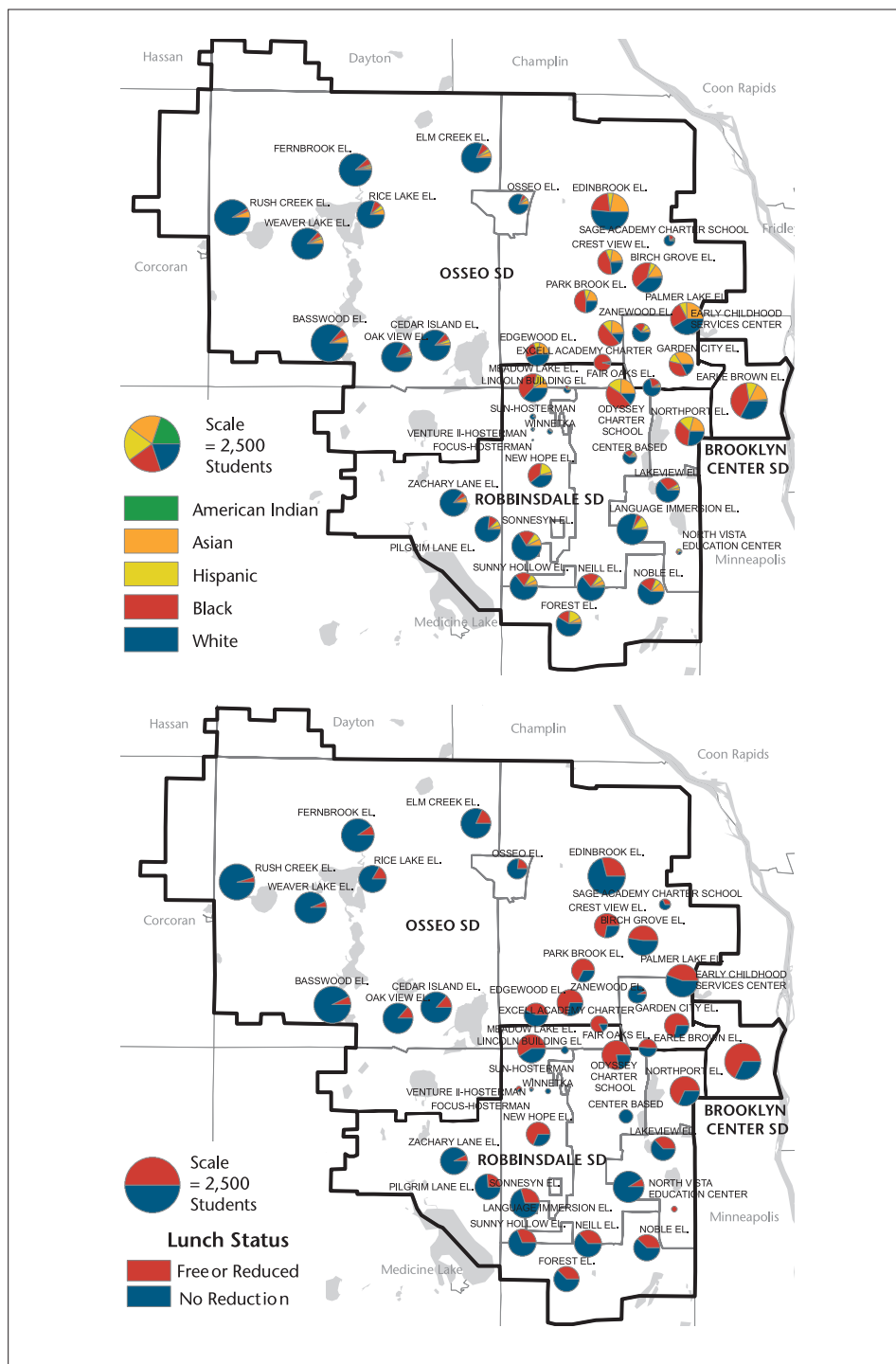
The northwest suburbs of Minneapolis are facing even greater patterns of segregation than the southwest suburbs. More than half of the elementary schools in the Osseo school district are racially identifiable and majority poor (Figure 3).

Housing Segregation Underlies School Segregation. Housing segregation still exists nationwide. Federal policy, along with public and private discrimination, enable housing segregation to affect communities nationwide. Families living in concentrated poverty send their children to neighborhood schools, which then become schools of concentrated poverty. Economically segregated housing is also racially segregated. Housing segregation reinforces the harms of school segregation by limiting not only school networks, but community networks as well.

Residential racial segregation today does not merely reflect economic differences—*race* is the difference. For example, on average a Black family in the United States that earns more than \$60,000 per year “lives in a neighborhood with a higher poverty rate and lower educational attainment than the average White family earning less than \$30,000.”⁴ Compared to other groups of comparable economic status, segregation results in Blacks living in neighborhoods that are 15–20% less affluent. Indeed, “Black homeowners reside in neighborhoods that are more segregated and less affluent than their renting counterparts.”⁵

Steering in Real Estate Markets. Minorities and Whites are consistently shown different segments of the housing market, thereby increasing residential segregation. John Yinger’s 1989

Figure 3. Racial-Ethnic Enrollment and Lunch Status Distributions, Northwest Suburban Public Elementary Schools, 2004–2005



Source: Minnesota Department of Children, Families and Learning, Data Center, June 22, 2005.

housing discrimination study found that perspective homebuyers of color were shown fewer homes, received less attention from brokers, and were more likely to see homes in racially integrated suburban neighborhoods than were Whites.⁶ This results in people of color

often settling for less than an optimum purchase and higher housing costs.

In April 2006, the National Fair Housing Alliance (NFHA) completed a three-year, 12-city housing discrimination study titled *Unequal Opportunity—Perpetuating Housing Discrimination in America*. Using 145 sales tests in three geographic regions across the country, the NFHA found three patterns of discrimination:

⁴ John Logan, Deirdre Oakley, and Jacob Stowell, *Segregation in Neighborhoods and Schools: Impacts on Minority Children in the Boston Region* (Cambridge, MA: Metro Boston Equity Project of the Civil Rights Project, Harvard University, 2003).

⁵ Camille Zubrinsky Charles, “The Dynamics of Racial Residential Segregation,” *Annual Review of Sociology* 29 (2003): 179.

⁶ John Yinger, “Cash in Your Face: The Cost of Racial and Ethnic Discrimination in Housing,” *Journal of Urban Economics* 42 (1997): 339.

- ▶ outright denial of service to Blacks and Latinos;
- ▶ significant financial incentives offered to Whites but not to Blacks or Latinos; and
- ▶ steering of potential purchasers on the basis of race or national origin.

The NFHA tests revealed steering at a rate of 87% among testers who were given an opportunity to see homes. Out of 290 total visits, there were 51 instances where Black or Latino testers were offered no service or reduced service. Testers were generally steered to neighborhoods based on race or national origin, as well as religion and family status. The NFHA also reports that schools are used as a proxy for racial or ethnic composition of neighborhoods and communities. Rather than telling White testers to avoid certain neighborhoods because of racial or ethnic composition, many real estate agents would tell the tester to avoid certain schools—schools that were racially identifiable.

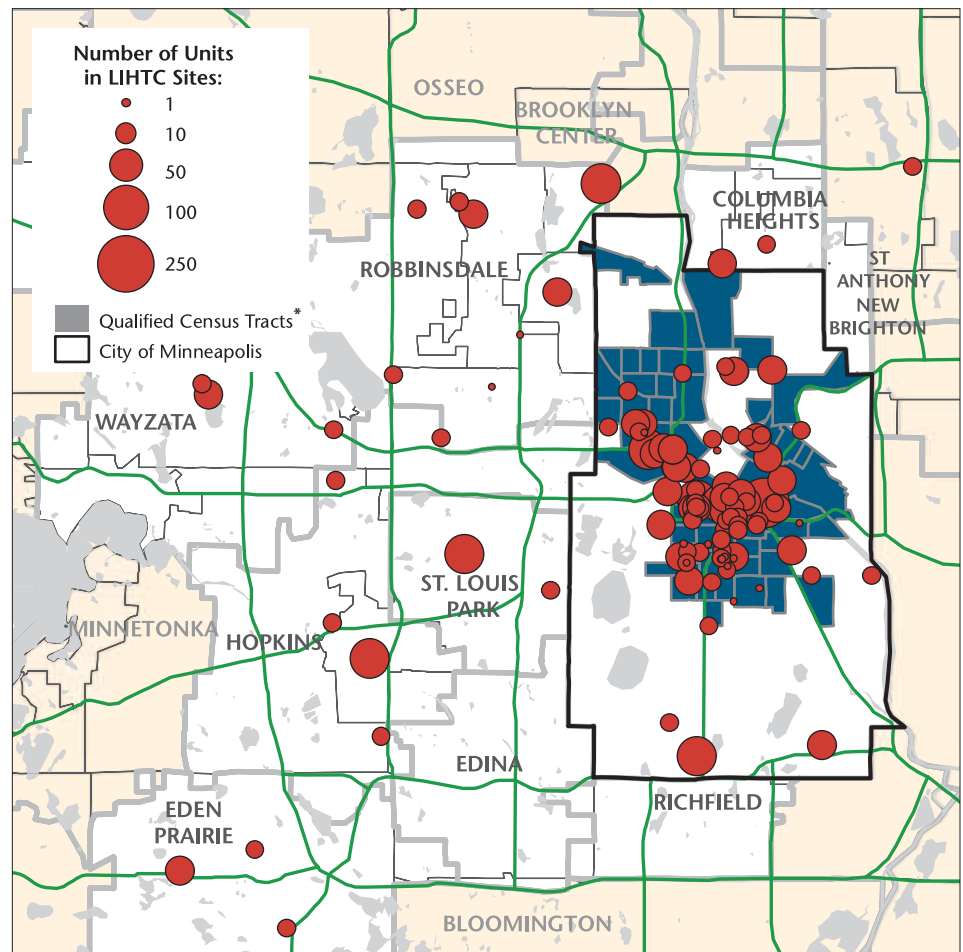
Segregated Affordable Housing.

Housing and school segregation is also caused by the government placing disproportionate amounts of low-income family housing in poor, segregated neighborhoods. This became such a problem that the 1968 Fair Housing Act ordered the Department of Housing and Urban Development (HUD) and all federal and state grantees of federal funds to affirmatively further fair housing. Specifically, these regulations state that there is a presumption that building low-income family housing in poor, segregated, or racially resegregating areas violates the Fair Housing Act.

In a case called *Shannon v. HUD*, the Third Circuit Court of Appeals stated that affirmatively furthering fair housing requires federal and state grantees of federal funds to take racial and socio-economic data into consideration—a colorblind approach is “impermissible.” The court said that in placing affordable housing several factors should be taken into account. These include the racial composition of neighborhoods and their schools; the location of public, middle-class, and luxury housing; the racial effect of local regulations; and past and current practices of local authorities. This command has often been ignored.

Despite the mandates in the Fair Housing Act, some public affordable housing programs continue to contribute to segregated housing patterns. For instance, units receiving support under the federal Low Income Housing Tax

Figure 4. Low Income Housing Tax Credit (LIHTC) Housing Sites in Minneapolis and Surrounding Suburban Schools, 2005



Source: 2005 HousingLink Inventory of Assisted Rental Housing.

* Qualified census tracts, as defined by HUD, are census tracts in which at least 50% of households have an income that is below 60% of the region’s adjusted gross median income.

Credit (LIHTC) in the Twin Cities are disproportionately located in areas that already have greater than average shares of poverty and affordable housing—the central cities and certain inner-ring suburbs. The majority of LIHTC sites are clustered in qualified census tracts which, as defined by HUD, are census tracts in which at least 50% of households have an income that is below 60% of the region’s adjusted gross median income (Figure 4).

These patterns have affected suburbs as well as the central cities. During the 1980s and 1990s when the Twin Cities’ share of non-White residents increased from 5 to 15%, the region lacked school and housing policies to inspire development in ways that did not confine its small share of impoverished residents to a few neighborhoods of concentrated poverty. Thus, as segregation’s patterns carve deeper into the landscape of the central cities, they also are being etched onto suburban school districts and neighborhoods.

Overall, these patterns mean that affordable housing provided under LIHTC not only tends to concentrate low-income households in areas already experiencing significant poverty, but also concentrates non-White households in racially segregated neighborhoods, creating more racially identifiable schools with staggering poverty enrollments.

Integration Helps Everyone

Students benefit from economically and racially integrated schools, and so do neighborhoods and metro regions. Research confirms that both White and Black children who attend desegregated schools are “more likely to attend integrated colleges, live in integrated neighborhoods as adults, and send their children to integrated schools.”⁷

⁷ Richard Kahlenberg, *All Together Now*, 44, citing *Milliken v. Bradley*, 418 U.S. 717, 783 (1974) (Marshall, J. dissenting).

Integrated Schools Increase Achievement and Attainment. Based on social science research surveys reviewing four decades of research, Janet Ward Schofield has concluded that “[M]inority students who attend more racially integrated schools show increased academic achievement and progress, which are typically measured by scores on achievement tests.”⁸ Schofield finds that test scores for Latino students are higher on average when they attend desegregated schools. In a 1983 article in the *American Journal of Sociology* titled “The Effect of Research Methodology on Desegregation Achievement Studies: A Meta-Analysis,” Robert Crain and Rita Mahard note that for Black students, achievement gains are especially consistent when their desegregated school experience began in the primary grades.

Black students who attend racially integrated and economically integrated schools complete more years of schooling than those who attend segregated schools. College attendance rates are higher as well. In addition, both White and Black students tend to have higher educational aspirations if they have cross-race friendships, as contrasted with students who had only same-race friendships.⁹

Integrated Schools Help Communities. If school integration involves all of a region’s socioeconomic groups, the benefits to all students and neighborhoods are significant. Students experience greater performance gains when desegregation plans extend beyond a region’s central city to include its middle- and upper-class students.¹⁰ Communities and the region benefit because metro-wide desegregation plans help stabilize integrated neighborhoods.

⁸ Janet Ward Schofield, “Maximizing the Benefits of Student Diversity: Lessons from School Desegregation Research,” in Gary Orfield and Michael Kurlaender (eds.), *Diversity Challenged: Evidence on the Impact of Affirmative Action* (Cambridge, MA: The Civil Rights Project, Harvard University, Harvard Education Publishing Group, 2001), 99.

⁹ See Michael A Boozer, et al., *Race and School Quality Since Brown v. Board of Education*, Brookings Papers Econ. Activity, 1992; Richard Kahlenberg, *All Together Now*; Robert Crain and Rita Mahard, “School Racial Composition and Black College Attendance and Achievement Test Performance,” *Sociology of Education* 51 (1978): 81; and Maureen Hallinan and Richard Williams, “Students’ Characteristics and the Peer Influence Process,” *Sociology of Education* 63 (1990): 122.

¹⁰ Richard Kahlenberg, *All Together Now*, 37, citing James Coleman et al., *Equality of Educational Opportunity* (1966).

Federal and State Legal Issues in Education

Segregated schooling is not equal educational opportunity. This is what *Brown v. Board of Education* declared in 1954. The Supreme Court’s decree in *Plessy v. Ferguson* that “separate but equal” schools violate the Equal Protection Clause of the U.S. Constitution was met by inaction for more than a decade. Federal court intervention was required to force local and state officials to cease operating racially separate schools. Yet, even while much progress was made during the 1970s and 1980s, the Court’s geographic limitations on desegregation remedies ensured that they could not succeed in many metro regions, especially in the North.

Unconstitutional Segregation. In the 1971 case *Swann v. Charlotte-Mecklenburg Board of Education*, the Supreme Court ruled that “[S]tate-imposed segregation by race in public schools denies equal protection of the laws.” In a later case, *Keyes v. School Dist. No. 1* (1973), the Court established that to prove a constitutional violation in federal court, plaintiffs denied equal educational opportunity must show that they are subject to a segregated education and that “it was brought about or maintained by intentional state action.” Evidence of this segregative (discriminatory) intent can include decisions affecting the following:

- ▶ attendance zones and district boundaries
- ▶ school site location
- ▶ school size
- ▶ school construction and renovation
- ▶ student assignment and transfer options
- ▶ mobile classroom units
- ▶ transportation
- ▶ faculty and staff assignments

Keyes also confirmed that districts that have operated unconstitutionally segregated schools in the past are presumed to have acted unconstitutionally in the present if they maintain any “racially identifiable schools.”

The Limited Scope of Federal Remedies. In *Swann v. Charlotte-Mecklenburg Board of Education*, the Supreme Court detailed the scope of federal courts’ “broad” equitable powers to impose a range of desegregation remedies, including mandatory desegregation. Federal desegregation law began breaking *Brown’s* promise just three years later. In its 1974 Detroit desegregation case, *Milliken v. Bradley*, the Supreme Court essentially limited federal remedies for school segregation to the area within the

boundaries of a single school district. *Milliken* required that Detroit schools be “desegregated” only by rebalancing enrollments within the boundaries of Detroit’s isolated, non-White district. In 1986, 12 years after *Milliken* was decided, the typical Black student in Detroit attended a school with White enrollment under 12%. By the 1990s, Detroit was the nation’s most segregated school district, and White enrollments had evaporated to 4%. Although an interdistrict remedy may work in a metropolitan area that has a large, metro-wide, school district, such single-district remedies cover far too small an area compared with the relevant housing markets in metro areas that are carved into myriad school districts.

The Promise of Equal Access to Educational Opportunity under State Law. Unlike the U.S. Constitution, the Minnesota State Constitution creates a fundamental right to public education.¹¹ This is significant because whether plaintiffs must prove *intentional* racial discrimination, in addition to proving racially unequal outcomes, can depend on whether a fundamental right is involved. When a fundamental right is affected, plaintiffs are not required to prove that the government intended to discriminate. In *Sheff v. O’Neill*, the Connecticut Supreme Court (citing the U.S. Supreme Court’s ruling in *Reynolds v. Sims*) ruled that proving governmental awareness and *inaction* in the face of racially disparate impacts on the fundamental right is sufficient evidence to establish that the government violated the Constitution. This standard offers great promise for state court-ordered interdistrict remedies.

As in Minnesota, there is a fundamental right to a public education in Connecticut. Like the Twin Cities, Connecticut was faced with segregated non-White central-city schools in Hartford, and mostly White schools in suburban districts. As in Minnesota, funding was “substantially equalized.” The court in *Sheff v. O’Neill* held, however, that adequate funding to segregated schools does not provide “a substantially equal educational opportunity” when schools are severely segregated. The court was interpreting the state’s education clause, as well as Connecticut’s unusual equal protection clause—which, like the constitutions of Hawaii and New Jersey, prohibit both discrimination and segregation. Connecticut was found liable for violating children’s education and equal

¹¹ *Sheff v. O’Neill*, 678 A.2d at 1279. See also Article 13, Section 1, of the Minnesota Constitution.

protection rights irrespective of existing district boundaries, and irrespective of the absence of discriminatory intent by state officials. Connecticut was ordered to integrate the severely segregated schools.

In Minnesota, the reasoning of *Sheff* and the promises of Minnesota's education and equal-protection clauses were harnessed in the two 1990s cases out of which the Choice Is Yours program was created. These cases, and the program, are discussed in the next section.

The Choice Is Yours Program: Using School and Housing Choice to Achieve Integration

As Minneapolis became more diverse during the 1990s, the Minneapolis School District and the State of Minnesota took actions that worsened school segregation. Despite severe residential segregation in Minneapolis, the school district resumed assigning students to "neighborhood schools." The State concurrently granted Minneapolis a waiver from the "15%" desegregation rule. It also implemented an integration revenue program that the Office of the Legislative Auditor, in its *Evaluation Report: School District Integration Revenue* (2005), concluded not only lacks focus and oversight, but even has provisions that discourage school integration.

In 1999, the State of Minnesota along with several other state entities (including the Minnesota Department of Education and the Metropolitan Council) were sued in state court. Filed on behalf

of all children enrolled in Minneapolis public schools, the complaint in *NAACP v. State of Minnesota* argued that a segregated education violates the Minnesota State Constitution's education and equal protection clauses. The plaintiffs alleged that the State of Minnesota had not taken effective action to desegregate Minneapolis schools.

When it became uncertain whether the Minneapolis NAACP would vigorously prosecute the case on behalf of the plaintiff class, a nearly identical case, *Xiong v. State of Minnesota*, was filed on behalf of Minneapolis students and consolidated with *NAACP*. The *NAACP* and *Xiong* cases settled in 2000, producing the agreement creating the Choice Is Yours interdistrict transfer program.

The Choice Is Yours Program: A Promising School Choice Model for School Integration. At the beginning of the 2005–2006 school year, approximately 1,680 children were enrolled in the Choice Is Yours (CIY) program; 1,090 of these students were returning from the previous year. The majority of students who came from Minneapolis Public Schools and who took advantage of CIY had previously attended overwhelming poor Minneapolis schools.

In its 2006 publication *Minnesota Voluntary Public School Choice 2004–2005: Evaluation Report*, the Minnesota Department of Education reported significant achievement gains by students participating in CIY. Students from grades 3 through 7, averaged across all

demographics, made consistent and significant improvements in reading and mathematics. In comparison with CIY-eligible, but nonparticipating students, the CIY suburban students made annual gains that were three times higher.

Benefits to Districts and Taxpayers.

Although incoming students in other city-suburban transfer programs around the country have experienced hostility in the suburbs, CIY students have not, partly because of this enrollment dynamic and partly because of financial incentives built into the program. Minnesota's school finance law rewards suburban districts for taking CIY transferees because incoming CIY students bring with them what is known as "compensatory revenue" in addition to the base amount of state aid allocated to all students. Compensatory revenue is awarded under a state formula based on the number of low-income children in each district. This means that suburban districts receive more state aid for CIY students than they do for other students. Thus, to avoid making tough decisions about closing schools due to steep enrollment declines, districts can instead aggressively market toward CIY-eligible children and raise attendance and revenue. Without CIY students, many districts would be facing even steeper declines in enrollment.

Spending Cannot Replicate the Benefits of a Diverse Study Body.

Expanded school choice can succeed where other ideas have not. Minnesota's school finance scheme provides increased funding for each low-income child, as well as additional funds for schools with concentrated poverty. These funds are allocated directly to each school building. According to the Minnesota Department of Education's (DOE) *K–12 Education Finance Overview 2004–2005*, in 2005, Minnesota allocated an average of \$8,516 on each student in the state. The DOE's *School Report Card* reports that the Minneapolis district now averages about \$3,000 more per pupil than the state average, or about \$11,393 per student.

Some schools within the school district spend much more than even the Minneapolis per-pupil average and invariably these are schools of concentrated poverty. For example, Barton Elementary is integrated (47% minority) and has a much lower than average percentage of students eligible for free or reduced-price lunch. According to the DOE's *School Report Card*, the school spends about \$9,101 per pupil, 20% less than the district-wide average. By comparison, Birchview Elementary, a CIY-receiving



Photo © Little Blue Wolf Productions/Corbis

Poverty enrollments in Minnesota charter schools are nearly twice that of traditional public schools. Roughly 54% of charter school students in the state are eligible for free or reduced-price lunches, compared with only 29% of traditional public school students.

school in the Wayzata school district, is overwhelmingly White, low-poverty, and only spends about \$7,200 per student.

At the other end of the spending spectrum, Bethune Elementary is 99% students of color; more than 95% of students are eligible for free or reduced-price lunch, and it spends nearly \$14,000 per pupil. These differences result because state financing allocations require more funding to schools with high proportions of poor students. This financing scheme, however, has done nothing to address the concentration of poverty in these schools or the likelihood of poor performance that will flow from the concentration of poverty.

Charter Schools Are Unproven and Severely Segregated. A skyrocketing number of non-White families are choosing charter schools as alternatives to traditional public education. This trend provides cause for concern because segregation is more severe in charter schools than in traditional public schools, and there is little evidence that charter schools are bridging the achievement gap. Results have been mixed at best. Additionally, a significant number of charter schools have closed soon after opening because of financial mismanagement or noncompliance with reporting and disclosure requirements.

In Minnesota, the number of charter schools grew from 1 to approximately 130 between 1992 and 2006. By 2004, Minnesota charter schools enrolled 17,544 students, or roughly 2% of Minnesota students. Nearly 70% of charter students are in the Twin Cities region and nearly half of those are in the two central cities.¹²

Poverty enrollments in Minnesota charter schools are nearly twice that of traditional public schools. A total of 54% of Minnesota's charter students are eligible for free or reduced price lunch, compared with only 29% of its traditional public school students. Minneapolis and St. Paul charter school poverty enrollments are nearly 80%, a rate 10 or 11 percentage points higher than the already high poverty concentrations in those districts' traditional public schools.¹³

Minnesota's charter schools also are racially segregated. In 2004, 53% of Minnesota's charter school students were non-White, compared with only 19% of all public school students. Similarly, Black students make up one-third of Minnesota's charter school enrollments, yet are only 8% of the State's students.¹⁴ This racial gap continues to grow.

The Bush Administration's 2004 *Evaluation of the Public Charter Schools Program: Final Report*, found that charter schools were less likely to meet state standards than traditional public schools, even after studying only those states with considerable numbers of charter schools, sufficient data, and a state performance standard. The share of charter schools meeting state standards trailed that of traditional public schools by between 8 and 32 percentage points.

The Bush Administration's researchers conducted regression analyses of the results for two states with the most data to determine whether charters' weak performance was explained by race, poverty, number of students, and student mobility. Even controlling for those factors, charter schools showed lower performance than traditional public schools.

It Is Possible for Choice to Integrate Twin Cities Schools. A comprehensive strategy to fully integrate Twin Cities schools is beyond the scope of this article. That being said, greater housing choice can be an effective strategy when linked with school integration efforts. A neighborhood that is racially integrated has a better chance of having schools that are also integrated. Families that currently have their children traveling great distances to attend school should have first choice to live in the affordable housing that exists near those schools.

The Metropolitan Council's Housing Policy 13 (later renumbered Policy 39) helped the region to make a greater amount of affordable housing available in the region. Under Policy 13/39, the Metropolitan Council used its authority as an agency designated by the federal government to review applications for federal grants to implement a housing policy that encouraged subsidized housing development in the suburbs. According to the Metropolitan Council's *An Overview of Regional Housing Policy and Implementation: 1967–2002*, Policy

13/39 resulted in the regional construction of 11,000 units of Project-Based Section 8 housing in the suburbs. The Metropolitan Council still possesses great power to guide the development of low-income housing in suburban areas—authority increased by the passage of the Livable Communities Act in 1995. If exercised in coordination with expanded school choice, the resulting increase in low-income housing would also strengthen regional integration efforts by deconcentrating the poverty from units clustered in Minneapolis and St. Paul.

Conclusion

Attending racially and economically integrated schools will result in lower dropout rates, more children going to college, increased law-abiding taxpayers, and less challenging lives for our poorest youth. The Choice Is Yours program means more opportunity. Integration does not solve all the problems of inequality, but integration has demonstrated clearer effects on expanding opportunity than any other type of solution. Money by itself is not working. Charter schools are unproven. Integration is the core upon which all other solutions are built. We must start here and build upon the foundation that integration provides.

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The research upon which this article is based was supported in part through funds provided by the Fesler-Lampert Chair in Urban and Regional Affairs, one of four endowed chairs and two named professorships made possible through a generous contribution to the University of Minnesota by David and Elizabeth Fesler. The Fesler-Lampert Endowment in Interdisciplinary and Graduate Studies was initially established in 1985 to stimulate interdisciplinary research and teaching through the appointment of distinguished, broadly learned scholars to endowed faculty positions at the University of Minnesota.

For more information on expanded school and housing choice, visit www.irpumn.org.

¹² Enrollment data from Jon Schroeder, *Ripples of Innovation: Charter Schooling in Minnesota, the Nation's First Charter School State* (Washington, D.C.: Progressive Policy Institute, 2004), 9–10, 17; and Martha McMurry, *Enrollment Declines Are Widespread Since 2000*, OSD-05-118 (St. Paul: Minnesota State Demographic Center, 2005), 5.

¹³ Poverty enrollment data from Schroeder, *Ripples of Innovation*, 10; and McMurry, *Enrollment Declines*, 7.

¹⁴ Student racial data from Schroeder, *Ripples of Innovation*, 11; and McMurry, *Enrollment Declines*, 4, 7.

Susan Galatowitsch Named 2007–2008 Fesler-Lampert Chair in Urban and Regional Affairs

Susan Galatowitsch, professor of restoration ecology in the Department of Horticultural Science, has been named the 2007–2008 Fesler-Lampert Chair in Urban and Regional Affairs. Galatowitsch's appointment, announced this past May, was made by the vice provost and dean of the Graduate School, Gail Dubrow, based on recommendations from CURA's nominating committee. In making the announcement, Dubrow praised Galatowitsch's focus on restoration science and the connections to public policy as "timely and especially appropriate for the Fesler-Lampert Chair."

The Fesler-Lampert Chair in Urban and Regional Affairs is one of four endowed chairs and two named professorships made possible through a generous contribution to the University of Minnesota by David and Elizabeth (B.J.) Fesler. The Fesler-Lampert Endowment in Interdisciplinary and Graduate Studies was initially established in 1985 to stimulate interdisciplinary research and teaching through the appointment of distinguished, broadly learned scholars to endowed faculty positions at the University of Minnesota.

Galatowitsch's research to date has focused primarily on smaller scale wetland ecosystem restoration projects and methods for re-establishing native plant populations, controlling invasive plant species, and analyzing related wildlife habitat loss and recovery. However, Galatowitsch believes there is a critical need to "scale up" the size of restoration projects. For one thing, growing concerns about global climate change and related interest in cellulose-based biofuel production potentially could involve large-scale restoration of Minnesota's tallgrass prairies. In addition, restoration of some sensitive ecosystems—such as the bottomland hardwood forests along the Upper Mississippi River—are inherently large endeavors that require different restoration approaches. "Ecosystem restoration practice has developed over the past few decades largely through trial and error on small tracts of land," Galatowitsch explains. "For restoration to be part of global change and a renewable fuels strategy, we have



Susan Galatowitsch

to be able to successfully revegetate hundreds of thousands of acres of forests, grasslands, and wetlands."

The resources provided by her appointment as Fesler-Lampert Chair will allow Galatowitsch and her research team to focus on several related projects that will advance understanding of landscape-scale restoration projects in the Midwest. The first project involves collecting and analyzing data from a long-term study of restorations sponsored under the federal Conservation Reserve Program (CRP), a program that rewarded farmers for retiring marginal agricultural land from crop production. In one of the largest and longest-running studies of its kind, Galatowitsch and her colleagues have been tracking 64 CRP restoration projects in the southern prairie pothole region of Minnesota, Iowa, and South Dakota—once home to tallgrass prairie, but now dominated by corn fields—since 1988. This summer, they will survey participating landowners enrolled in CRP and conduct field surveys of the restoration sites to evaluate the success of the projects. Information gathered from this study can potentially help decision makers to make informed choices about corn-based versus cellulose-based biofuel

production, both by isolating the key factors to successful large-scale tallgrass prairie restoration projects and by identifying what factors affect landowner decisions to participate in long-term conservation programs like CRP. This information is particularly important in light of the U.S. Department of Agriculture's recent decision to relax restrictions on CRP unenrollment, allowing farmers to convert CRP land back to cropland to maximize corn production for biofuels.

A second project Galatowitsch and her colleagues will pursue involves restoration of bottomland hardwood forests along the Upper Mississippi River. Among other things, these forests provide crucial habitat for migratory birds and other wildlife. However, many of these forests are succumbing to canary reed grass, a particularly noxious invasive plant species that chokes out trees and inhibits forest regeneration, potentially threatening the loss of these precious natural resources. Although the factors that contribute to reed canary grass invasion are well understood, effective management practices for bottomland hardwood forests are difficult to identify because of the many variables and contingencies present in such large ecosystems. With additional

funding from the U.S. Geologic Survey and the U.S. Fish and Wildlife Service, Galatowitsch and her team will work with resource managers from 10 wildlife preserves along the Mississippi, Minnesota, and Missouri Rivers to identify successful management practices using an iterative “adaptive management” framework that identifies, field tests, and refines management practices while accounting for the contingencies of large-scale restoration efforts.

Finally, Galatowitsch will use funds from her Fesler-Lampert appointment to support a science and public policy forum on “Ecosystem Restoration in an Era of Climate Change” this fall. Designed to mark the tenth anniversary of the Spring Peeper Meadow wetland restoration project that Galatowitsch helped complete at the Minnesota Landscape Arboretum, the forum will focus on how to approach landscape restoration in light of the challenges posed by global climate change. Most restoration projects in Minnesota (and

elsewhere) are premised on restoring what was on the site immediately prior to human conversion of the land in the 1800s, an approach Galatowitsch describes as “potentially misguided” given the ecological effects of global climate change since that time. In addition, restoration ecologists have not adequately examined the best way to facilitate the movement of plants and animals with limited mobility as climate change renders their existing habitats unsuitable. Although the “wildlife corridor” approach is currently favored by conservation organizations, other alternatives—such as physically moving organisms from their current location to more favorable locations in restored ecosystems—have received little attention. The forum would offer an opportunity for scientists and policy makers to discuss issues at the interface of conservation and climate change mitigation.

Susan Galatowitsch joins a distinguished list of University faculty who have held the Fesler-Lampert Chair

in recent years, including Katherine Fennelly from the Humphrey Institute of Public Affairs; Myron Orfield of the School of Law; Ann Markusen of the Humphrey Institute of Public Affairs; Patrick Brezonik of the Department of Civil Engineering; Eugene Borgida of the Department of Psychology; Dennis Ahlburg, formerly of the Department of Industrial Relations and now dean of the University of Colorado School of Business; and John Adams of the Department of Geography.

The Fesler-Lampert Endowment is intended as a tribute to David Fesler’s grandfathers, Bert Fesler and Jacob Lampert. The Fesler-Lampert Chair in Urban and Regional Affairs is appointed for a one-year period and receives approximately \$40,000 for research, salary, and logistical support. The funds are jointly administered by the University of Minnesota Foundation and the University of Minnesota.



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