Simplifying Urban Geography Concepts A Teaching Tool for K-16 Educators

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Abstract

A constant struggle for teachers at all levels is finding ways to successfully teach students complex theories and concepts. Student comprehension is often enhanced by applying these theories and concepts to real world situations. This project demonstrates central place theory by examining highway billboard signs along major Wisconsin highways. In addition, the concepts of range, threshold, intervening opportunities, complementarity, and transferability are also demonstrated. Using global positioning systems (GPS) and Arcmap, data was collected on the location, distribution, and type of establishment advertised. Using statistical and spatial analysis this paper demonstrates the ease of explaining complex urban theories to many age groups. Lesson plans applicable for elementary school, middle school, high school, and post-secondary classes are included. These lesson plans will give teachers at each educational level a method for student collection of comparable data for analysis.

Introduction

Complex theories and concepts are often lost on students at all educational levels. In addition, the relevance of abstract ideas is often difficult for teachers to convey. Some of the problems encountered include: How do you increase enthusiasm? What can be done to improve retention? How can you enhance comprehension?

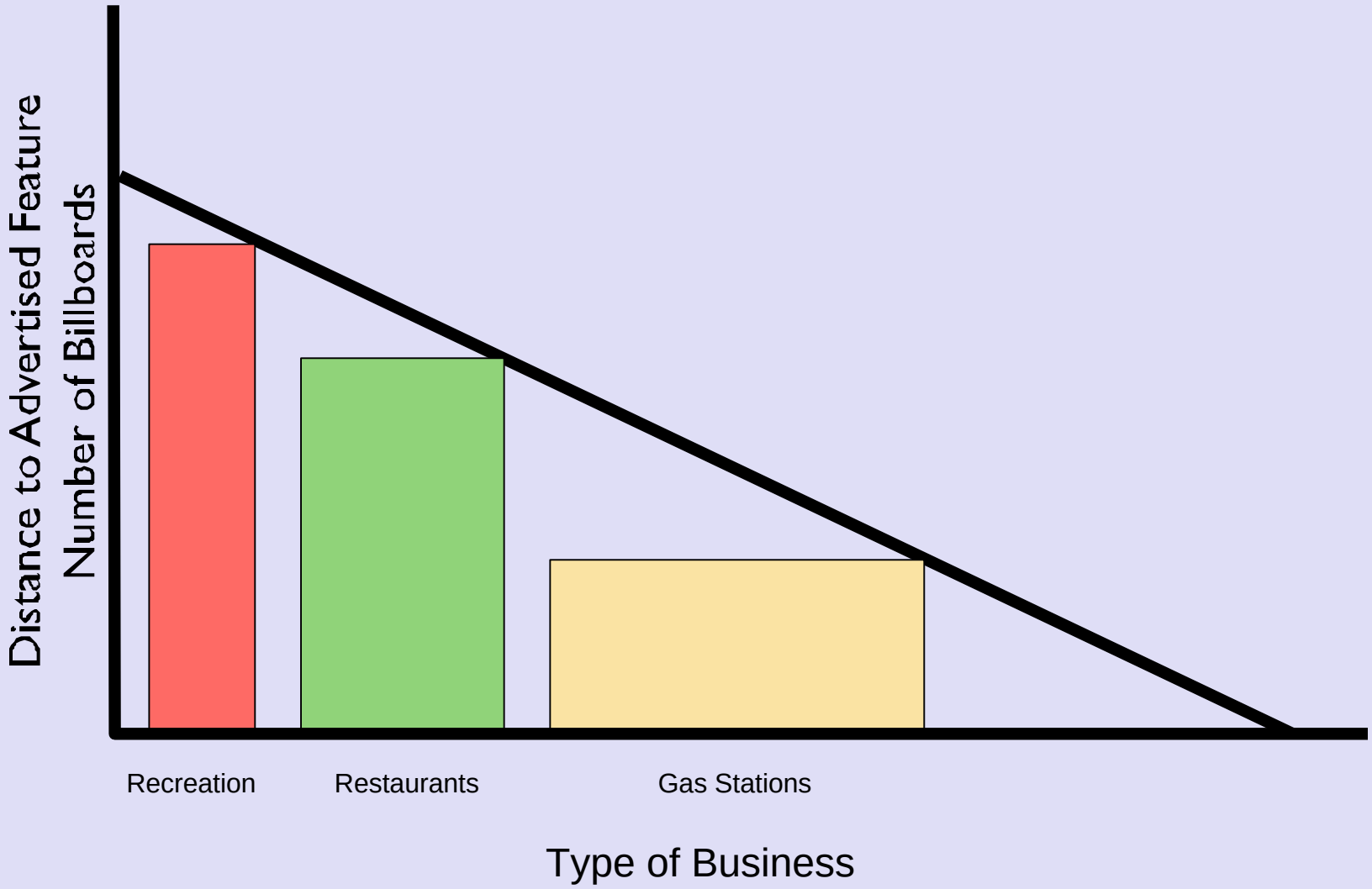
Solutions include incorporating real world applications to the classroom setting. Better yet, take the students out of the classroom, let them experience first-hand the applied side of these complex theories, and give them experience with the latest available technology. Successful application of complex theories will build students' skills and confidence, and knowledge of software and technology makes advanced students more marketable while increasing the skill set of younger students.

Introduction, cont.

A pilot study completed in November, 1999 is the basis for this current project. The pilot study proved that the location, distribution, and type of business advertised on billboards along Interstate Highway 94 between Madison and Eau Claire significantly demonstrated the concepts of the Central Place Theory. To simplify (and demonstrated in Figure 1), Central Place Theory states that a customer will travel farther to purchase a product that is unique or scarce (Foust and deSouza, 1978). The pilot study showed that fast food restaurants and gas stations tended to advertise between interstate interchanges; the majority of billboards advertising gas stations and fast food establishments were located at the next exit.

Figure 1

Central Place Theory and Billboards



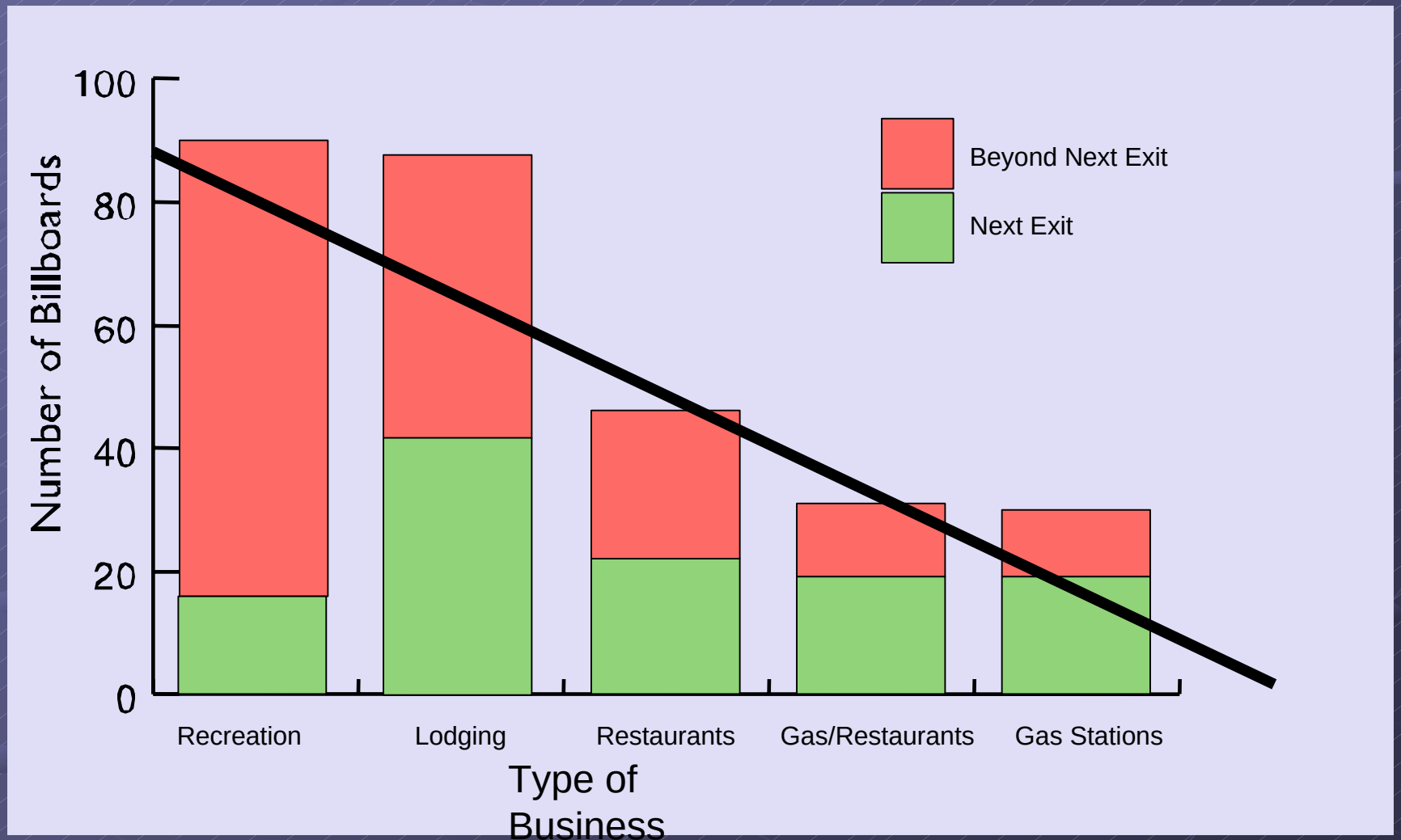
Introduction, cont.

Conversely, billboards advertising ski hills, the Wisconsin Dells, and House on the Rock (recreation venues) advertised much farther away from the destination (Figure 2). This implies that a much greater threshold number of customers was necessary to make these businesses profitable.

Expanding the research area to all major Wisconsin highways in the southern two-thirds of the state will help to demonstrate the range and threshold of those businesses catering to residents of densely populated urban areas as well as those catering to recreation-seeking tourists.

Figure 2

Advertised Establishments



Hypotheses

Businesses seek to maximize profits. Erecting billboards in areas of high average daily traffic (ADT) will ensure the most visibility for the advertising dollar.

High ADT will positively correlate with a high number of billboards

Recreation-dependent businesses rely on tourists and travelers. These businesses will need to advertise at much greater distances than local businesses.

Businesses with a large threshold will have a greater advertising range

Food and Gas stations are subject to ‘spur of the moment’ decisions. Advertising will need to be closer to these businesses. In addition, these are complementary businesses for travelers; it is convenient to gas up the vehicle at the same time one is stopping for a meal.

Businesses with smaller thresholds will have a smaller advertising range

Methods

Field data collection occurred July 26-July 30, 2003. Using a Global Positioning Systems (GPS) unit, one member of the research team collected lat/long data for every billboard along all major Wisconsin highways south of US Highway 29 (see Figure 3). A second researcher recorded information regarding the type of business or service advertised as well as the distance to the advertised feature. Billboards were categorized by: Lodging (motels, hotels, and camping), Recreation (ski hills, historic sites, museums, etc.), Retail (stores, car dealerships, etc.), Food and Gas (restaurants, gas stations, and travel plazas), and Miscellaneous (media, health care, public service messages, gentlemen's clubs, and billboard companies advertising available space). The third member of the research team drove the vehicle (and tried not to cause major traffic pile-ups along the highways).

Undergraduate Student Researchers Mitch Stimers and Tracey Gilbert

Interstate 94 Rest Area

Methods, cont.

Data on average daily traffic (ADT) counts were obtained from the Wisconsin Department of Transportation for all highways in the study area. The lat/long data, feature type, distance to advertised feature, and ADT were entered into an Microsoft Excel file for statistical analysis. ArcMap was used to determine the spatial distribution of the billboards. The resulting graphs and maps demonstrate the concepts of threshold, range, intervening opportunities, Central Place Theory, and the Gravity Model. Lesson plans applicable to different grade levels are easily developed based on these findings.

Highway Landscape (note the GPS data logger in the window reflection)

View from inside the research vehicle

Data Analysis

The map in Figure 3 shows all billboard types. The inset on the bottom left is centered around the south central Wisconsin recreational destination of the Wisconsin Dells. Here we see significant concentrations of lodging, food and gas, and recreation billboards. The inset on the lower right (Milwaukee metropolitan area) has higher concentrations of retail and miscellaneous billboards (many health care and service industries). The inset on the upper right (Fox River Valley) shows consistent, heavy concentrations of retail, lodging and some food and gas billboards. While billboard companies like to promote high average daily traffic (ADT), the pattern around Milwaukee suggests that a high ADT does not necessarily translate into a high number of billboards.

Figure 3

All Billboards

by Type of Advertised Feature

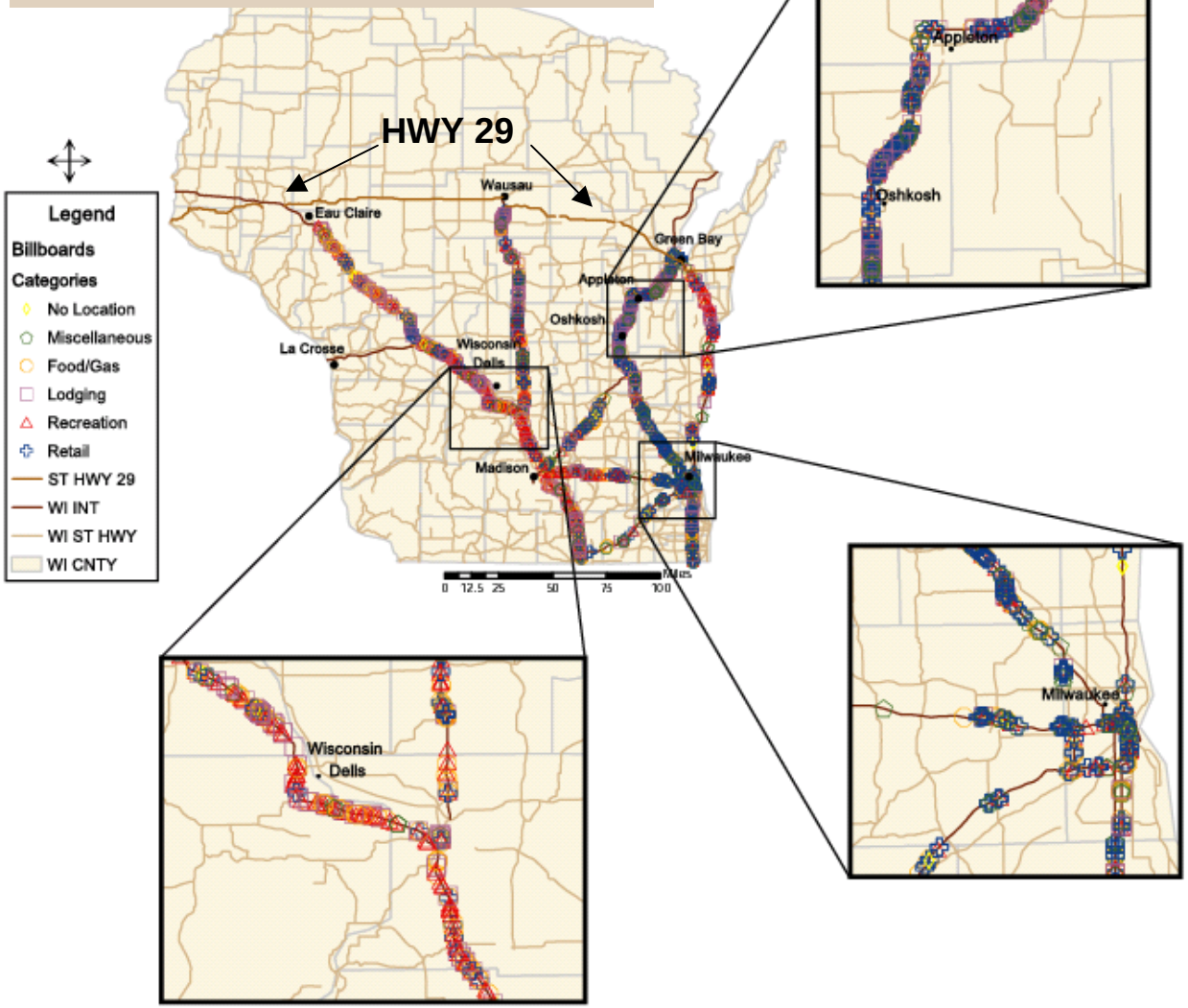


Figure 4

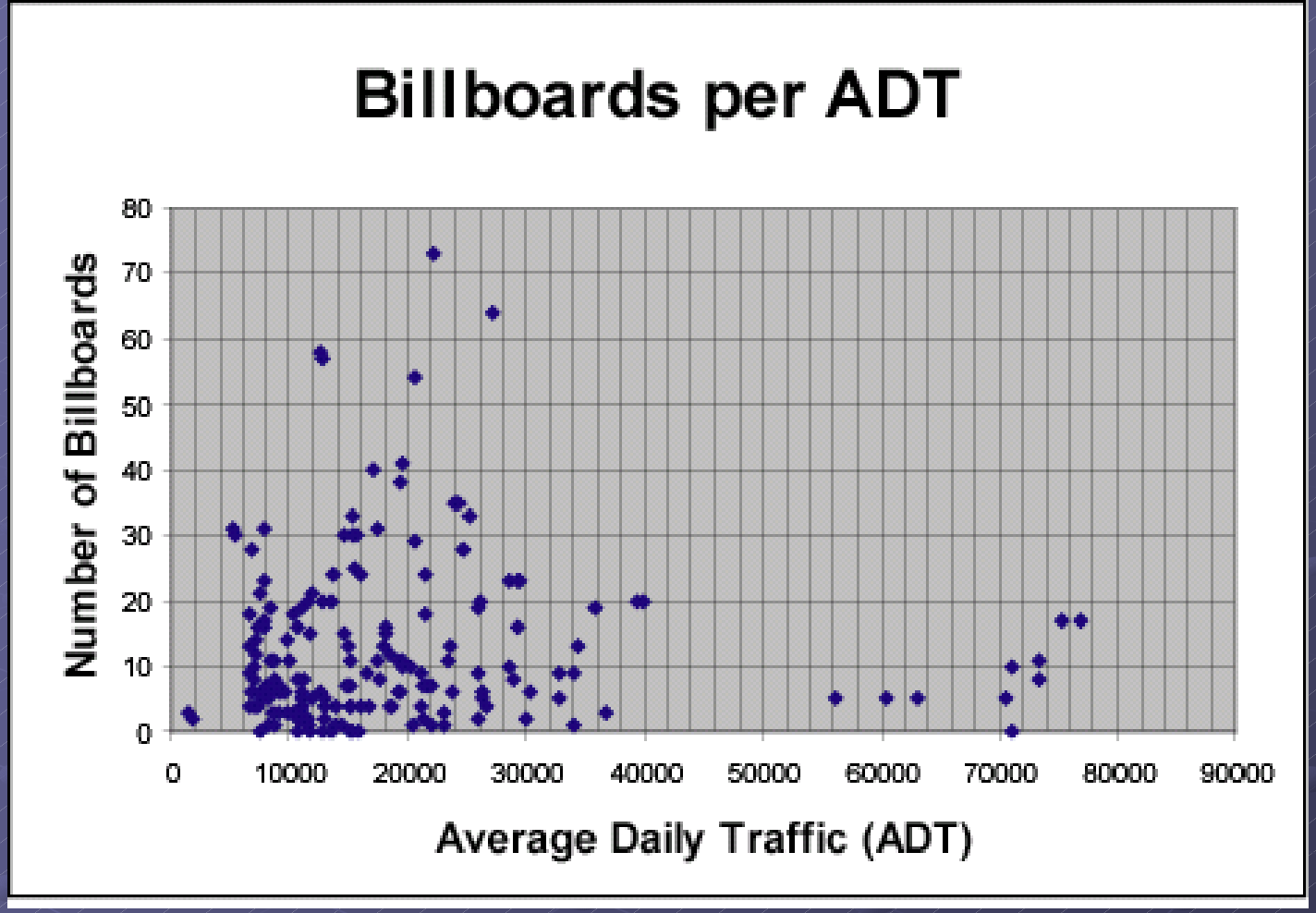


Figure 4 shows no direct correlation between Average Daily Traffic (ADT) and the number of Billboards. The areas of extremely high traffic volume (60,000 ADT and greater) have between 5 and 20 billboards, which is also true for areas of lesser volume (10,000 to 30,000 ADT). One possible reason for this is safety. Too many distractions for drivers may direct their attention away from the road.

Data Analysis, cont.

Miscellaneous Billboards are sparse in rural areas and increase significantly in the high population density regions of Milwaukee and the Fox River Valley in the eastern part of the state (Figure 5). Finance, insurance, and real estate (FIRE) and health care are all common near Milwaukee and the Fox River Valley. Public service and media are more common in low population density regions.

Since there are several different businesses represented by the miscellaneous category, it is impossible to make a statement about the range of these businesses. However, as the graph in Figure 6 shows, the distribution is fairly consistent along the trendline. Figure 7 shows great variation in regard to distance to advertised feature. Again, this is most likely due to the many unrelated businesses that are represented by the miscellaneous category.

Figure 5

Miscellaneous Billboards

by Type of Advertised Feature

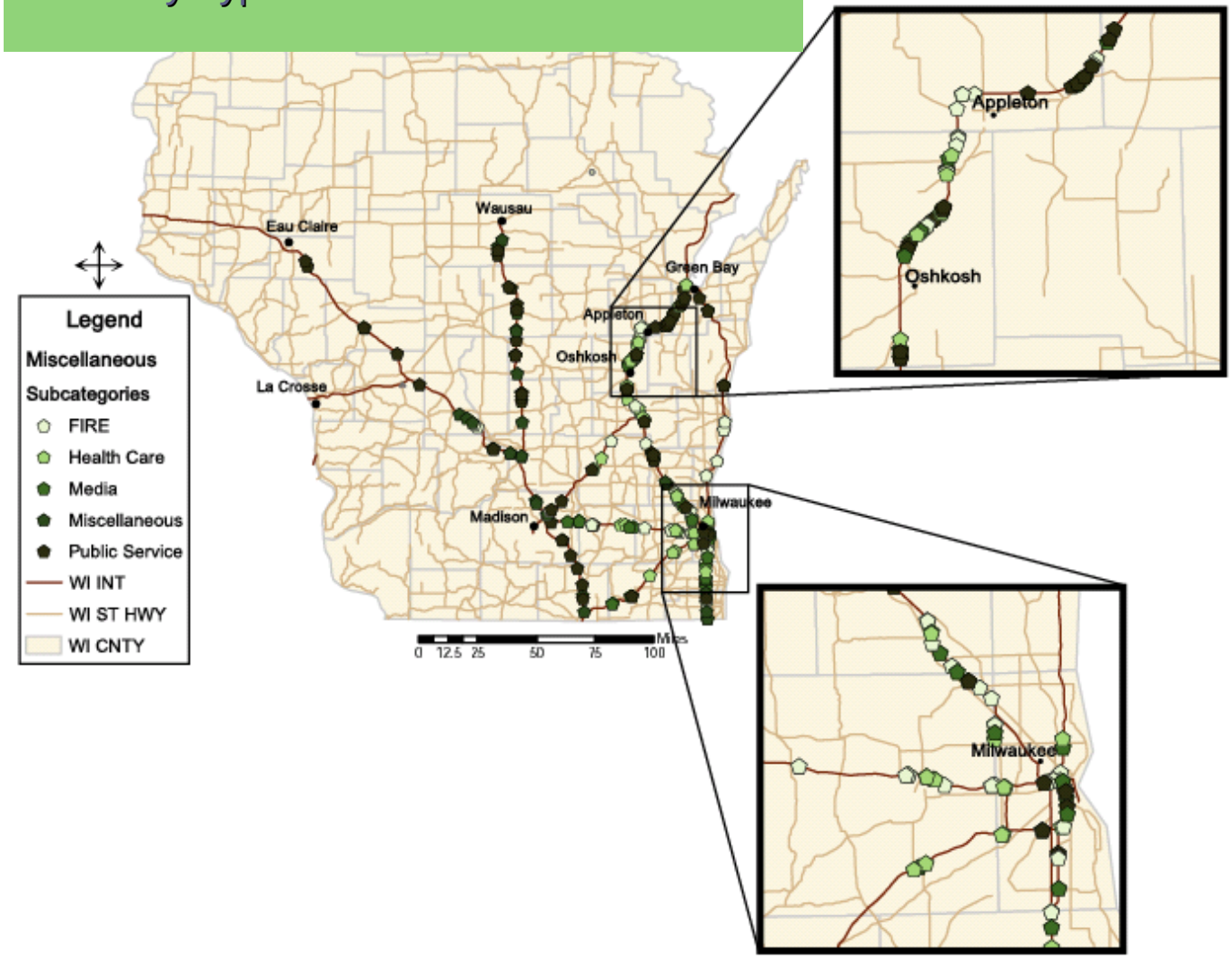


Figure 6

Miscellaneous – Empty

Miscellaneous

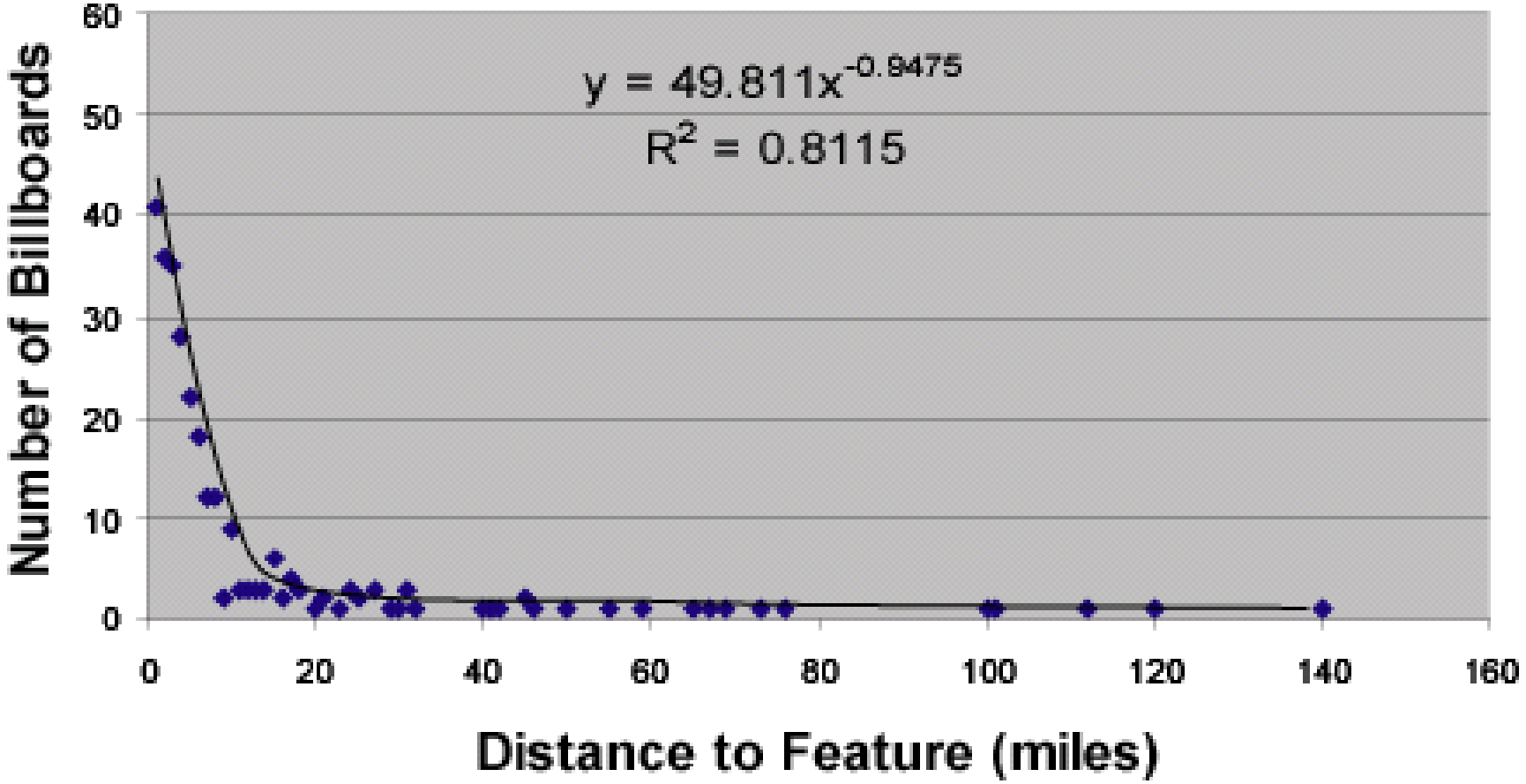


Figure 7

Miscellaneous Billboards

by Distance to Advertised Feature

Miscellaneous – Media

Data Analysis, cont.

The map in Figure 8 shows a fairly well dispersed pattern of billboards advertising Food and Gas businesses. A different pattern appears near major highway intersections, where we see an abundance of larger symbols (indicating greater distances to the advertised feature). This could indicate larger businesses such as truck stops which seek to entice customers away from the closest exit.

Food and Gas related businesses appear to have a shorter advertising range demonstrated by the clustering of billboards between 10 and 50 miles from the advertised feature (Figure 9). Because there are many gas stations and restaurants along any given stretch of highway, intervening opportunities influence consumer decisions. The points at the far end of the X-axis are probably larger businesses, such as plaza-style truck stops.

Figure 8

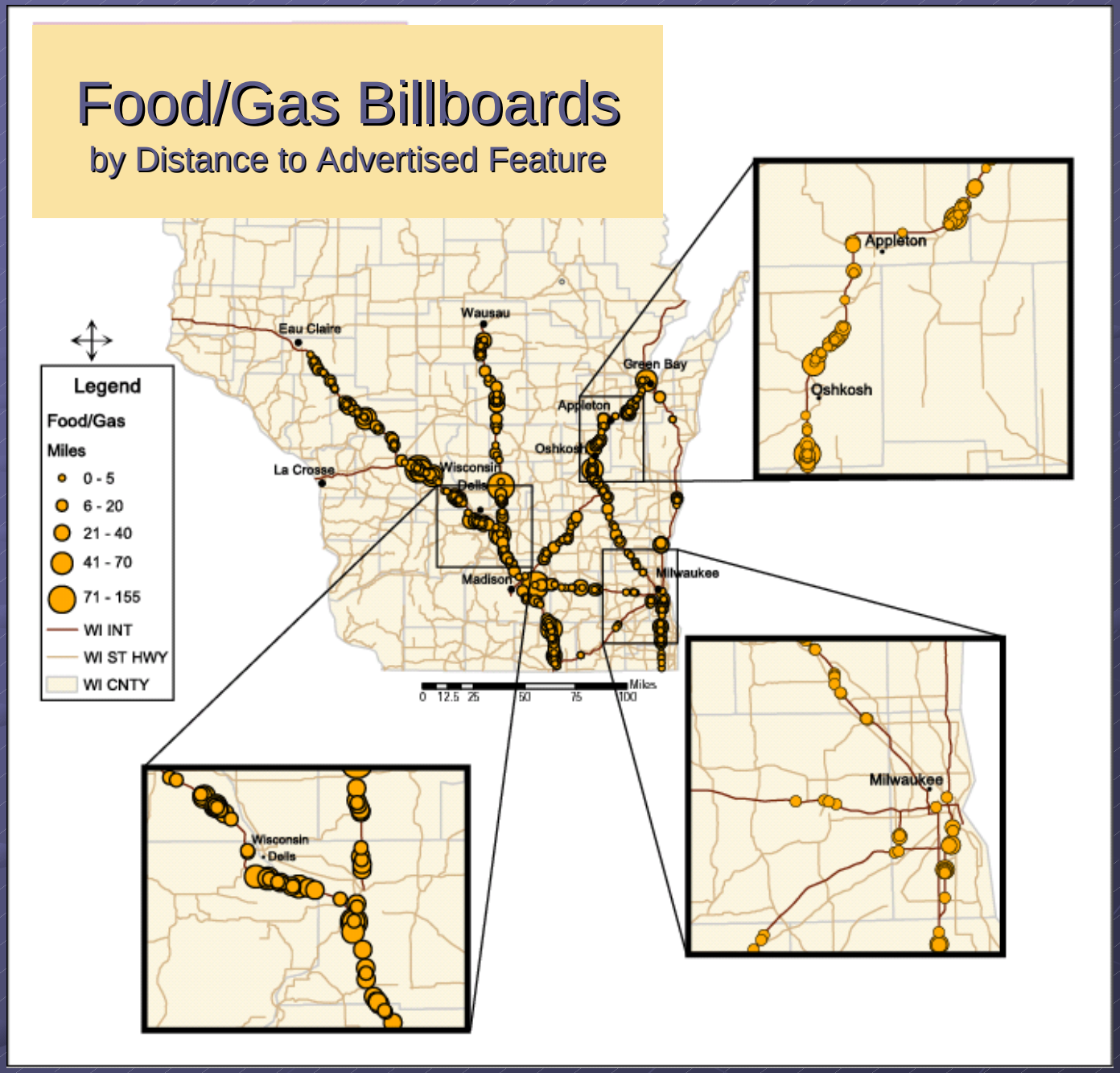

Food/Gas Billboards
by Distance to Advertised Feature
Legend
Food/Gas
Miles
0 - 5
6 - 20
21 - 40
41 - 70
71 - 155
WI INT
WI ST HWY
WI CNTY
Eau Claire
Wausau
Green Bay
Appleton
Oshkosh
La Crosse
Wisconsin Dells
Madison
Milwaukee
Miles
0 12.5 25 50 75 100
Appleton
Oshkosh
Wisconsin Dells
Milwaukee

Figure 9

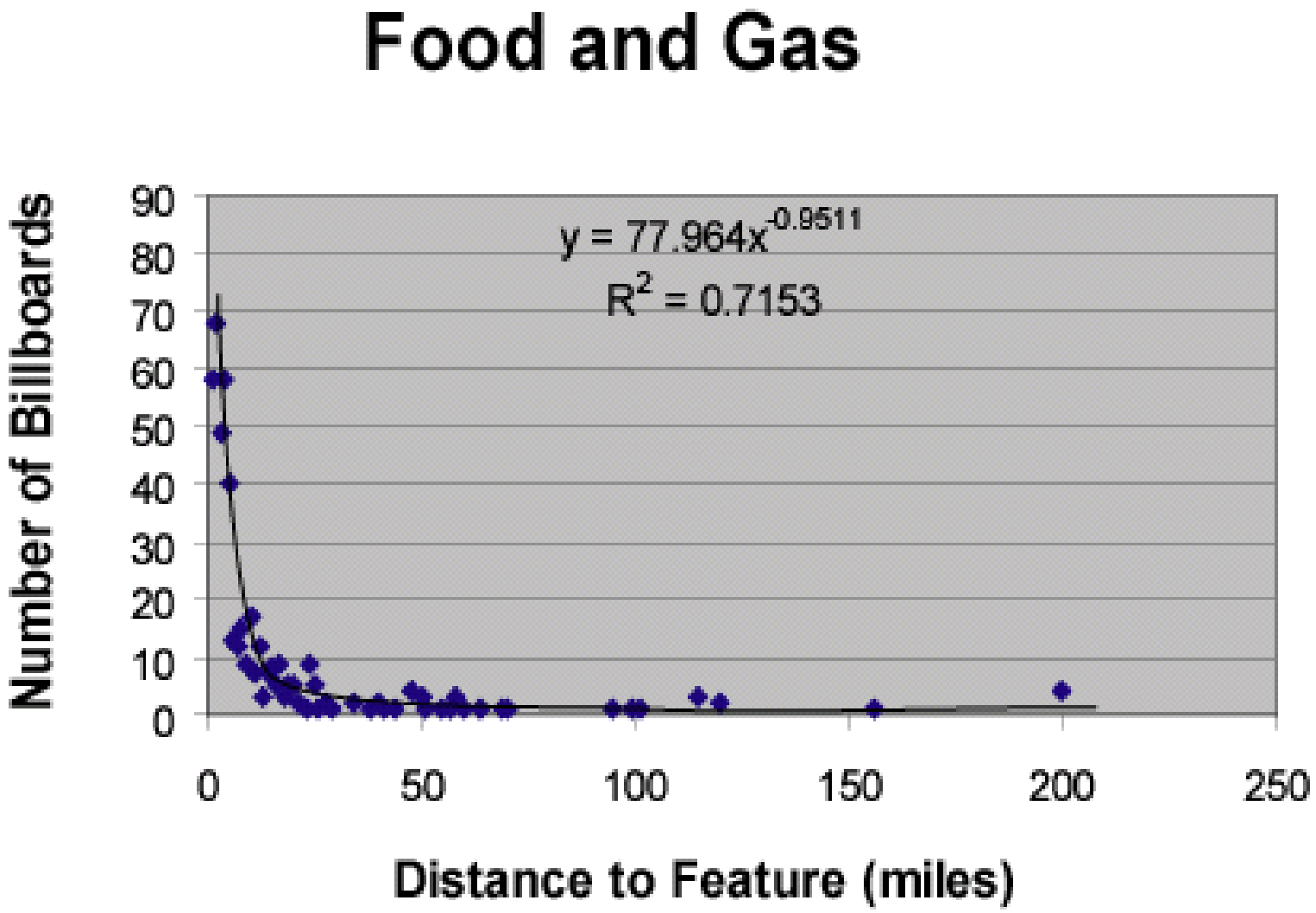
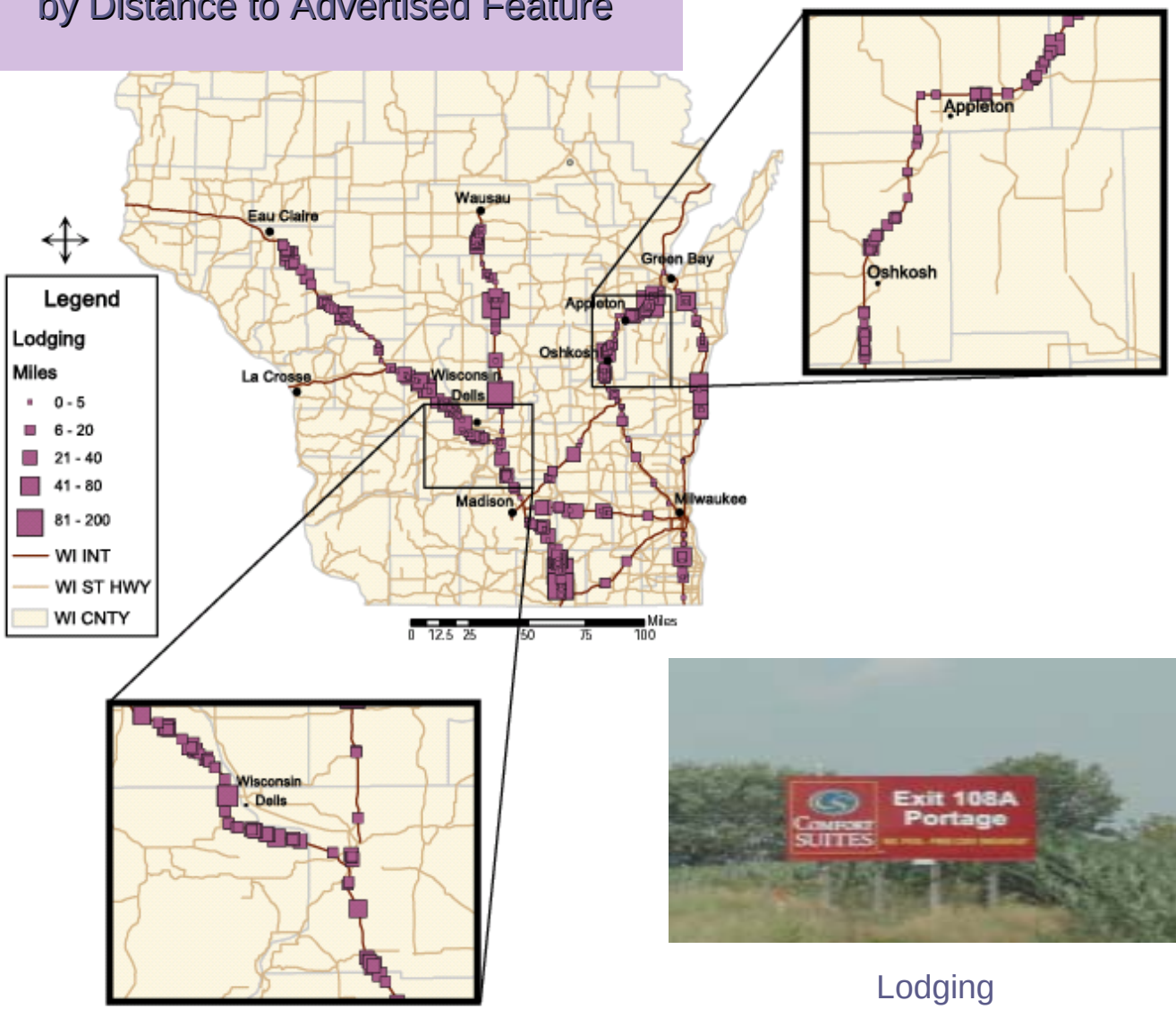

Food and Gas
y = 77.964x^-0.9511
R^2 = 0.7153
Number of Billboards
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
Distance to Feature (miles)

Figure 10

Lodging Billboards

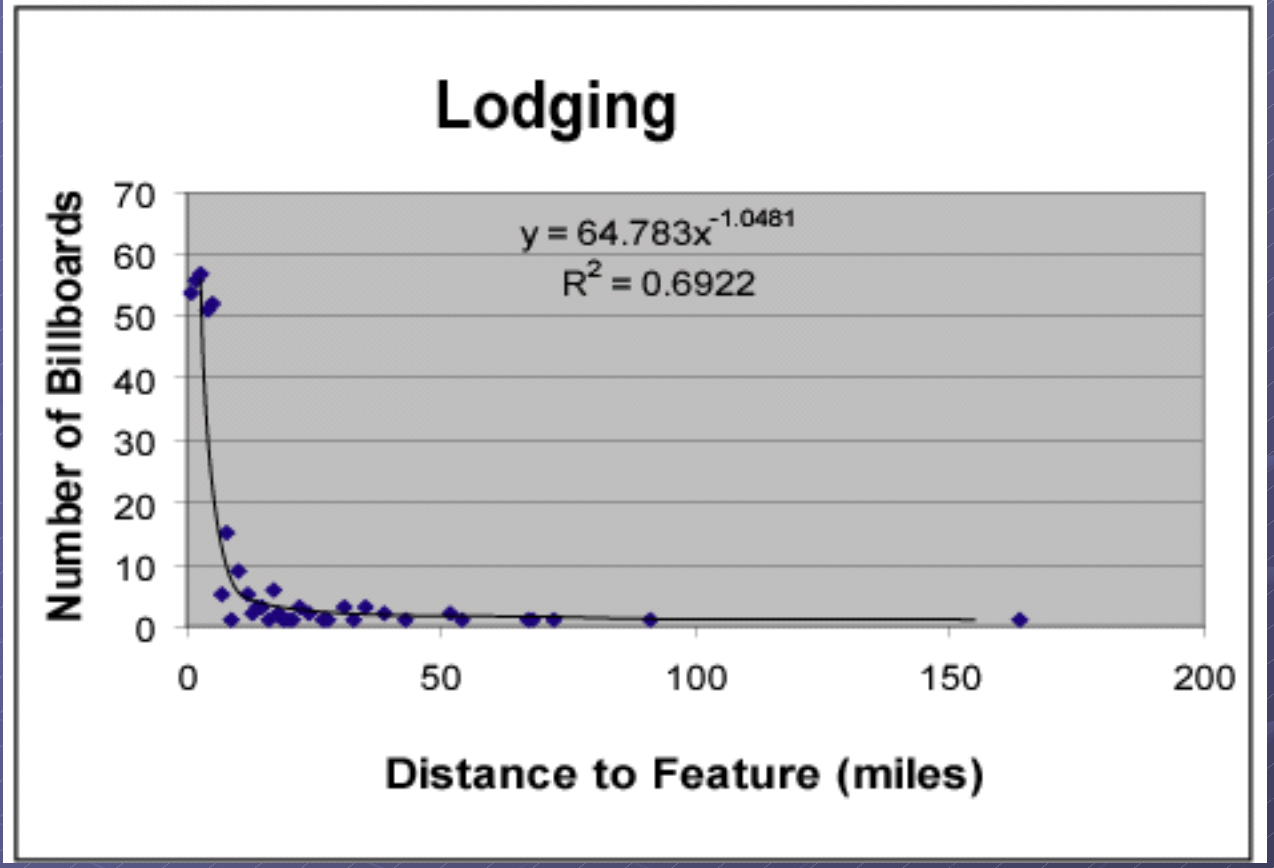
by Distance to Advertised Feature



Lodging

Because much of the daily traffic on highways in the highly populated eastern part of the state consists of commuters, Lodging Billboards are sparse (Figure 10). Highways that service a higher number of long distance travelers (longer distances between urban centers) have many more Lodging Billboards.

Figure 11



Intervening opportunities, such as illustrated in the food/gas graph (Figure 9), reappears here in lodging (Figure 11). The range is between 10 and 50 miles, but the volume is fairly low. Lodging appears to have a relatively small threshold. The values at the high end of the Y-axis are probably businesses near recreation areas, where the competition for guests is greater.

Lodging

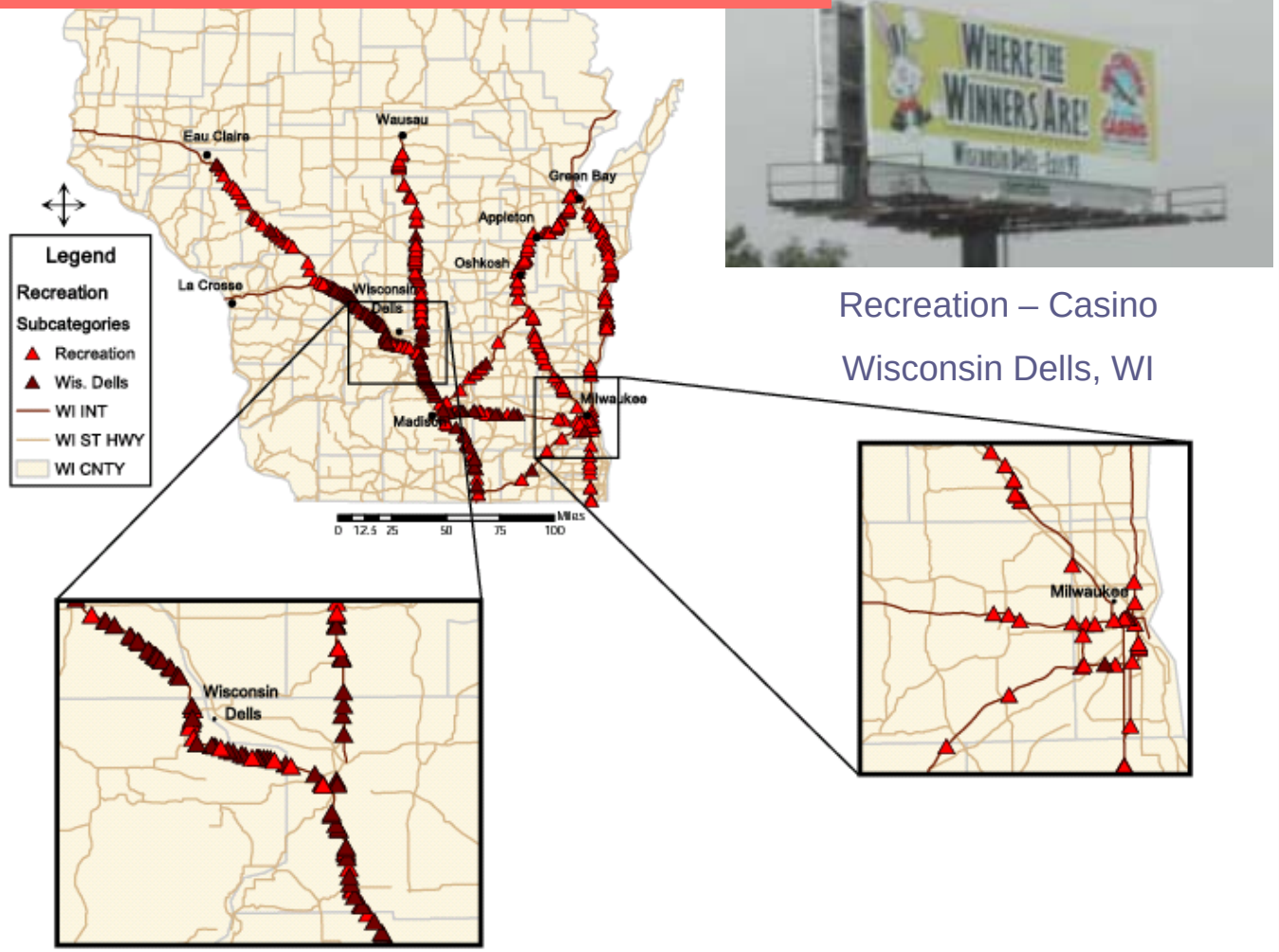
Data Analysis, cont.

Figure 12 shows Recreation Billboards (Northwoods, rafting, fishing, boating, historic sites, Wisconsin Dells, etc.) Wisconsin's economic dependency on tourism is exhibited by the dispersion of these billboards throughout the state. Recreation billboards exist in significant numbers along every major Wisconsin highway again with the exception of the high traffic areas of the Milwaukee metropolitan area. Some clustering occurs around the south central Wisconsin community of Wisconsin Dells (a tourism destination for over a century). Figure 13 demonstrates the high advertising range of recreational venues. Larger symbols indicate a longer distance to the advertised feature. Perhaps most notable with this type of billboard is the number of billboards that occur between large urban settlements indicating a non-local, tourism customer.

Figure 12

Recreation Billboards

by Type of Advertised Feature



Recreation – Casino

Wisconsin Dells, WI

Recreation

Wisconsin Dells, WI

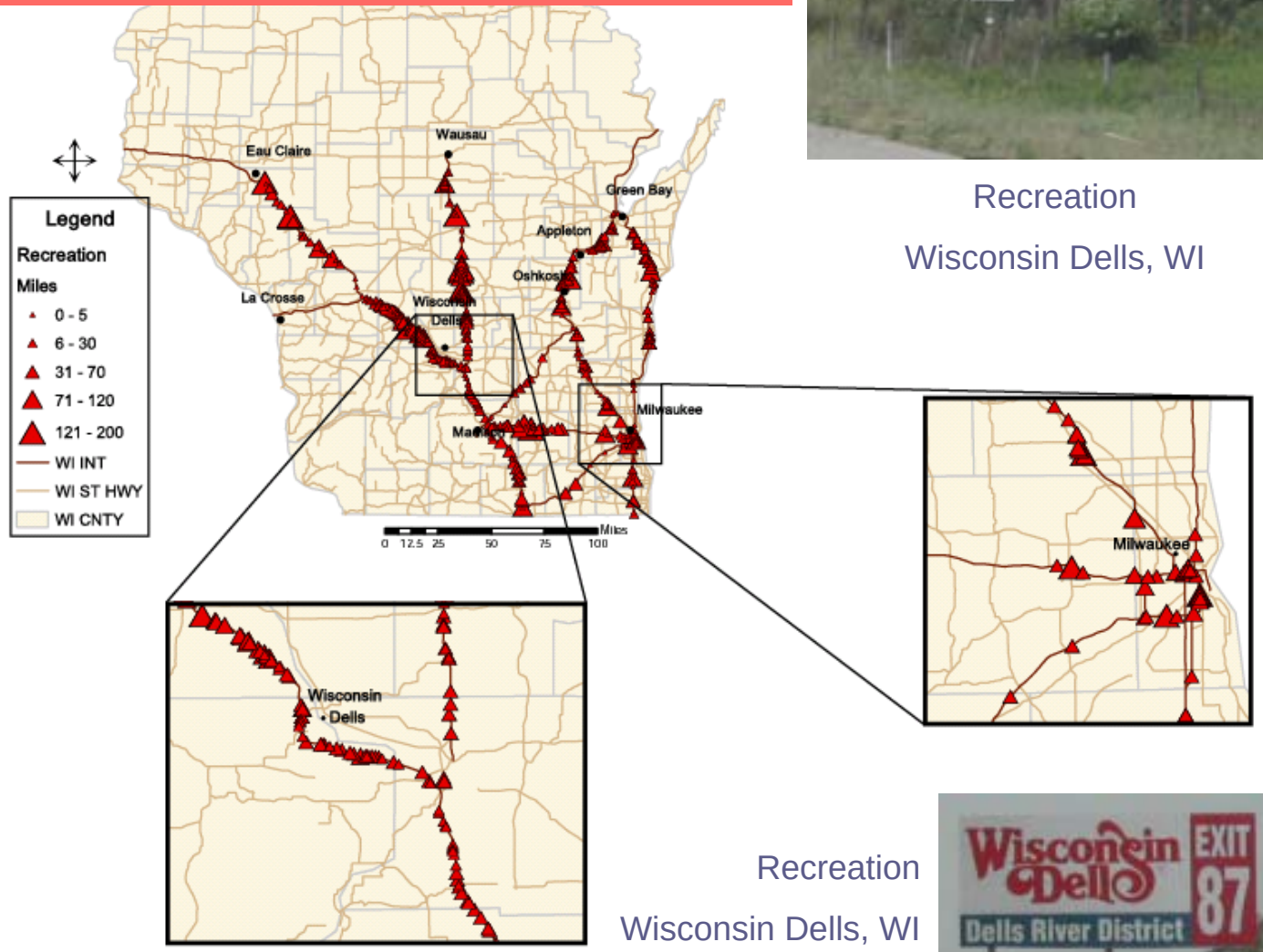
Figure 13

Recreation Billboards

by Distance to Advertised Feature

Recreation

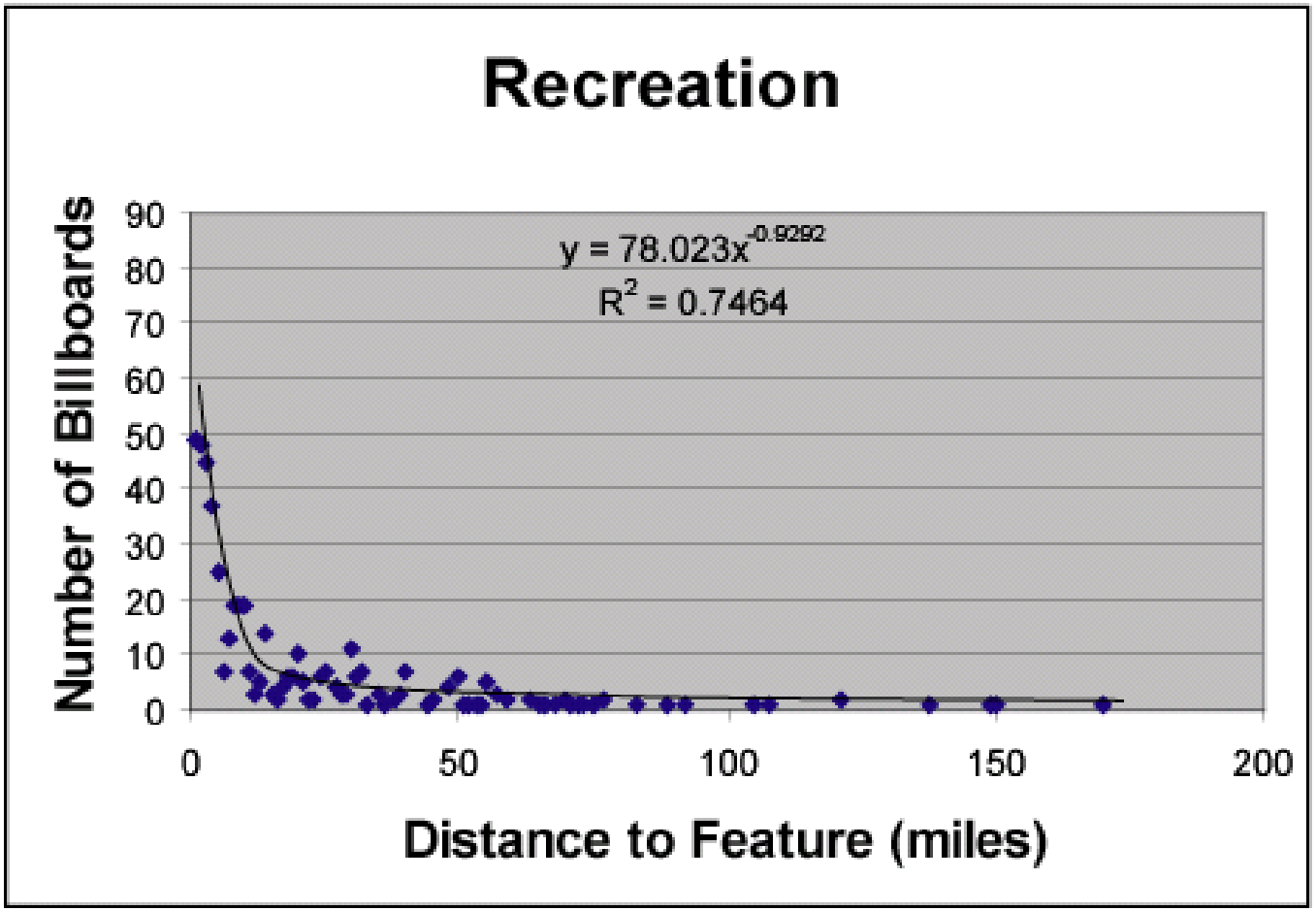
Wisconsin Dells, WI



Recreation

Wisconsin Dells, WI

Figure 14



Recreation

Wisconsin Dells, WI

Using regression analysis to determine the relationship between volume of billboards and distance to advertised feature, Figure 14 demonstrates an exponential relationship. There is a cluster of billboards from about 10 miles to 100 miles. A recreation-based business's advertising range stretches from 0 to 100 miles away from the attraction. Past 100 miles, there is very little advertising for a particular recreation-based business.

Data Analysis, cont.

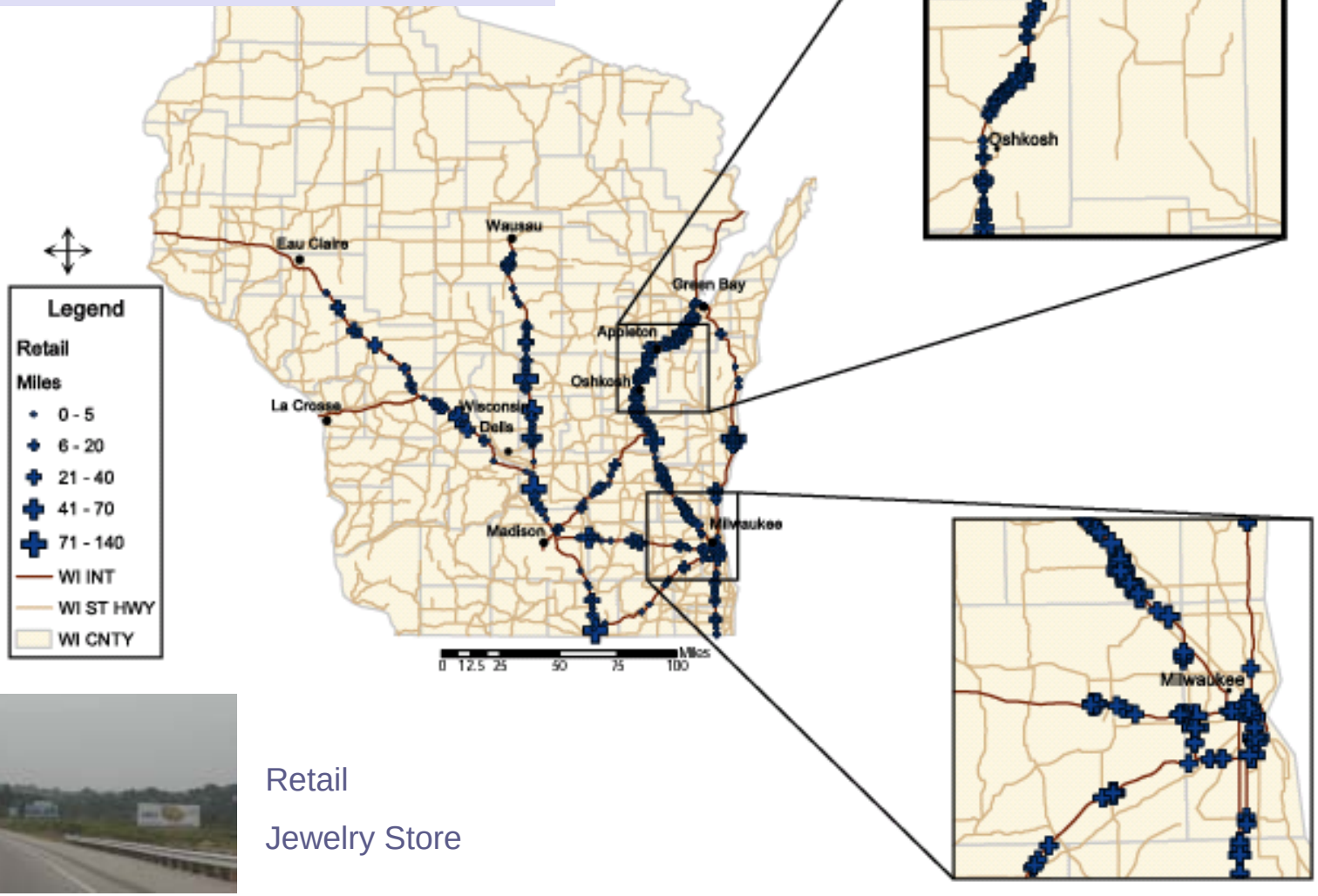
Retail advertisements are abundant in the high population density regions of the Milwaukee metropolitan area and the Fox River Valley (Figure 15). Rural sections of highways have a significantly lower number of retail advertisements.

The correlation of retail advertising and distance illustrates something not seen in food/gas and recreation (Figure 16). In this analysis, clustering occurs higher on the Y-axis and the range is shorter. This demonstrates that retail outlets advertise closer to the feature, but in higher numbers. Stiff competition for the consumer dollar may be the reason for this. The points at the far right of the X-axis are probably large shopping centers or one-of-a-kind specialty stores.

Figure 15

Retail Billboards

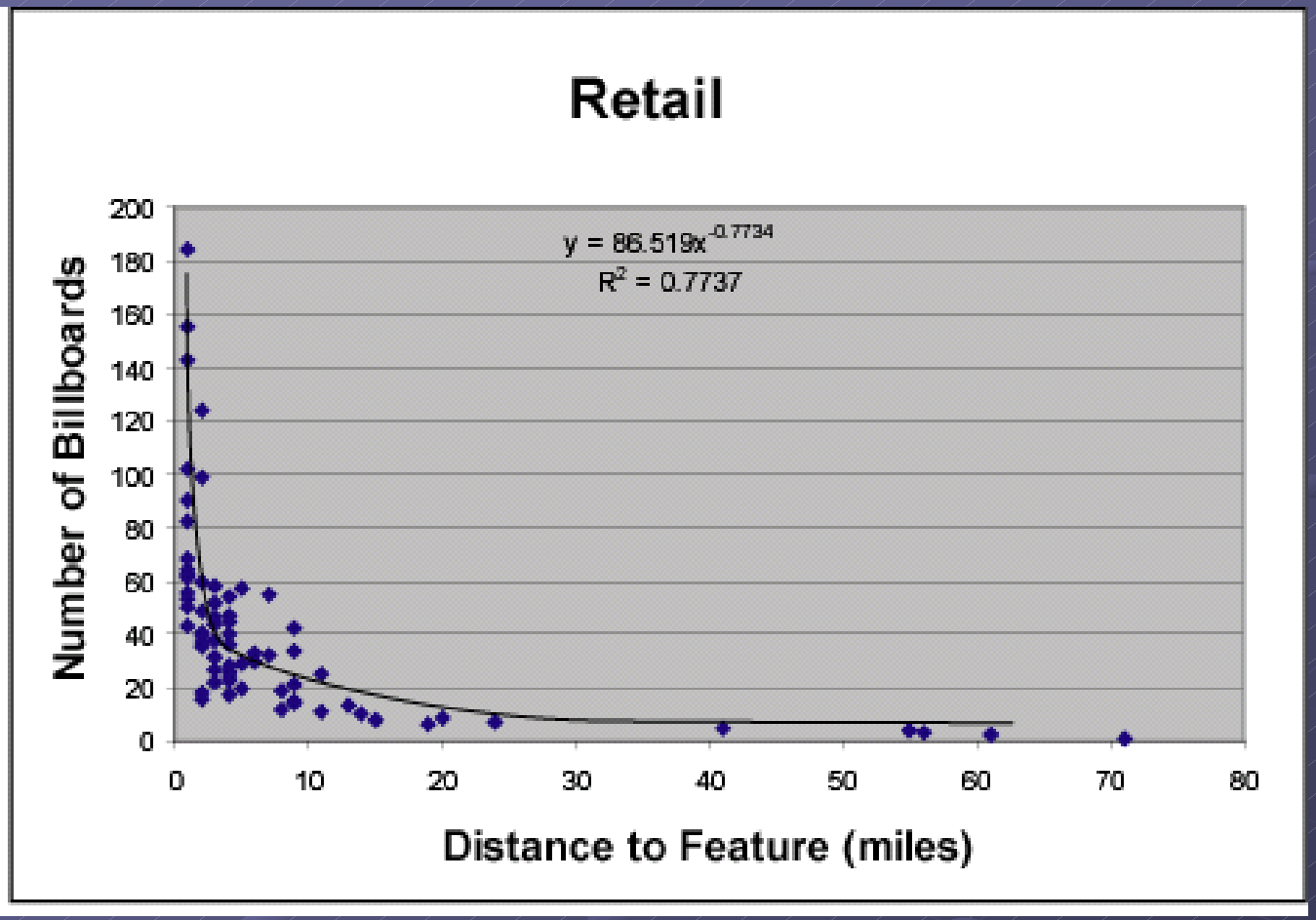
by Distance to Advertised Feature



Retail

Jewelry Store

Figure 16



Retail – Fireworks

Retail – Cheese Store

Conclusion

Using Global Positioning Systems (GPS), data management/processing programs (such as Microsoft Excel), and Geographic Information Systems (GIS), data was collected and analyzed on the location, distribution, and type of establishment advertised on billboards along all major Wisconsin highways. Using statistical and spatial analysis, this research demonstrated that the greater the distance (range) between a billboard and its advertised business, the larger the threshold (the minimum population necessary for a particular business to be successful). The data were used to create a series of maps and graphs applicable for multiple grade levels. While this research was conducted by undergraduate university students and faculty, lesson plans were also created for elementary school, middle school, and high school classes. These lesson plans will give teachers at each level a method for student collection of comparable data for their own analysis.

Conclusion, cont.

While the initial hypothesis was that a higher Average Daily Traffic (ADT) count would translate into a higher number of billboards, our research does not support this. Type of business and distance to the advertised feature are more significant indicators of billboard numbers.

The skills required for this project were a good match for undergraduate students. However, the project could easily be amended for other grade levels. For example, high school and middle school students could learn the basics of GIS using the free applications available on the ESRI website. Many students have had experience with GPS even though schools might not have access to high-end units (most students in the Midwest have family or friends that use GPS regularly while hunting or fishing). Even without GIS and GPS, students can draw maps and collect data by hand. Statistical analysis can be combined with math courses, integrating the curriculum. Elementary school students can also learn the basic concepts demonstrated here.

Conclusion, cont.

Devoting a large amount of time to a project of this scale is probably not feasible for any of the K-12 classes. However, if data were collected in conjunction with a previously scheduled fieldtrip, there would be no additional cost or time needed. Using elementary school students as an example, students would work in teams of four to collect data for an assigned billboard type. One student would tally the number of billboards between mile markers along the highway. Another student would assign a number to the billboard (in order) while a third would write down the same number and determine the distance to the advertised feature. The fourth student would be responsible for looking ahead for the next billboard and calling out the information to the other three students. After returning from the required fieldtrip, students would tally the data and create maps based on their skill level.

Conclusion, cont.

This project demonstrates how easy it can be to incorporate urban theories, statistics and mathematics, geography, and technology into one lesson plan. By challenging students to “read the landscape,” they learn to think critically and learn to apply complex theories and concepts to real-world situations.

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