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Modeling and Mapping Urban Bicyclists' Preferences for Trail Environments

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Bicycle trails are an important feature of some urban parks, especially now that bicycling is growing in popularity. Managers and park designers need to know what aspects of these trails are important to cyclists so that trails can be designed, maintained, and improved to increase cyclists' enjoyment of the trails. In this study we looked at the physical features of the trail setting that are more or less under a park manager's control and attempted to determine which of these features add to or subtract from cyclists' enjoyment of a trail. Trail managers will be able to use these results as a guide in trail planning, design, and maintenance.

We employed a procedure used in earlier environmental perception studies (Zube 1974, Daniel and Boster 1976, Arthur 1977, Shuttleworth 1980, Anderson 1981, Nassauer 1983). In this procedure, people view various scenes depicted in photographs and assign preference ratings to each. Each scene is then described in terms of a number of physical features, which are scored according to their prominence in the scene. These physical feature scores are then correlated with the evaluator's preference ratings to see which features are dominant in scenes that receive high ratings (positive features) and which features predominate in scenes with low ratings (negative features). We also used multiple regression to find a model with which preference ratings may be predicted knowing the prominence of certain physical features. Finally, using the predicted ratings from the model we developed, we produced a map that shows how trail enjoyment varies as one moves along the trail.

This procedure, excluding the map, has been used before to predict the most preferred aspects of urban parks. These preferred qualities include trees and forested areas, water, good maintenance, and peace and quiet (Schroeder 1982, Schroeder and Anderson 1984). The most widely pleasing park setting seems to be an open stand of large trees with mowed grass beneath (Kaplan 1984, Schroeder and Green 1985). But, other preference studies have shown that people coming from different parts of the city have different ideas of what an urban park should contain. People from the suburbs want natural areas, while those from the urban center want parks with athletic fields, playground equipment, benches, and paved pathways (Schroeder 1983).

Research concentrating on trail preferences typically has dealt with the trail itself rather than with trailside characteristics. For example, Allton and Lieber (1983) found that bicyclists prefer trails that are paved, while hikers, joggers, and cross-country skiers prefer trails covered with wood chips. Also, cross-country skiers like hilly trails while joggers dislike them. Skiers and hikers like frequent changes in trailside scenery. Joggers have a strong preference for trails close to home. Although Lieber and Allton's study provided useful information for various activities, it did not consider specific features of the trailside environment in very great detail.

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Our study is an attempt to expand our understanding of bicyclists' preferences for urban trail environments by examining preferences for visual images of particular trailside settings and analyzing individual scenes in detail for the physical features they contain.

METHOD

Site Selection

For this study we selected the North Branch Trail in Cook County, Illinois, a 22-mile paved trail that winds through diverse wooded areas, open areas, and park settings (fig. 1). Buildings, picnic tables, fences, parking lots, access roads, signs, and street lights are visible from the trail. A horse trail runs adjacent to the northern section of the bicycle trail. A recent trail user survey showed that the trail was used predominantly for bicycling (Gobster 1990). For these reasons, we thought it would be an appropriate trail for this study.

Photosampling Procedure and Evaluation

The North Branch Trail was photosampled by bicycle. Photos were taken at 1-minute intervals or about once every 0.2 mile. The photographer began at the south end of the trail (Devon Avenue) and rode north. At the north end, where the trail divides to form a loop, the photographer first rode north on the east side of the loop and then returned south along the west side of the loop until it rejoined the main trail. This was the end point of the photosample. At each of the 85 stopping points, one photo was taken looking forward along the trail and another was taken looking back along the trail. Occasionally the photographer had to change the location or the direction of a photo somewhat to exclude trail construction, other cyclists, and road crossings that might cause the evaluator to consider safety, crowding, or convenience rather than the attractiveness of the trailside setting. From this sample of 170 slides, we chose 70 that included examples of all of the important types of trailside settings and physical features along the trail.

Thirty-two seventh and eighth grade students and their teachers rated each of these slides on a scale from zero to nine according to how much they would enjoy riding through that scene. A zero represents a least enjoyable scene and a nine represents a most enjoyable scene. From these ratings, we calculated a mean enjoyment score for each slide.

The students were of a mixed racial and ethnic background and about evenly split according to gender. All were from the city of Chicago. A survey of the students following the evaluation revealed that all but 2 (94 percent) had ridden bikes before and 22 (69 percent) had used bicycle trails. When asked specifically about the North Branch Trail, 7 (22 percent) replied that they were familiar with the trail.

Physical Feature Encoding

Next, we chose 30 physical features visible in the slides for analysis (table 1). Some of the features were specific, measurable elements of the scenes, such as trees and grass. Other features were more subjective, general characteristics of scenes, such as openness and neatness. We rated the features according to their prominence in the trail scene depicted in the slide following a procedure used by Schroeder and Anderson (1984). Some features were rated according to the percentage of the slide image they covered, others according to their prominence (*e.g.*, 0-none, 1-one, 2-some, 3-lots).

ANALYSIS AND RESULTS

Correlations

Pearson's simple correlations between the physical features and the enjoyment ratings (table 2) show the statistical relationship between the features and the cyclists' enjoyment levels. A positive correlation indicates that a given feature increases enjoyment of the trail, whereas a negative correlation indicates that a feature decreases enjoyment.

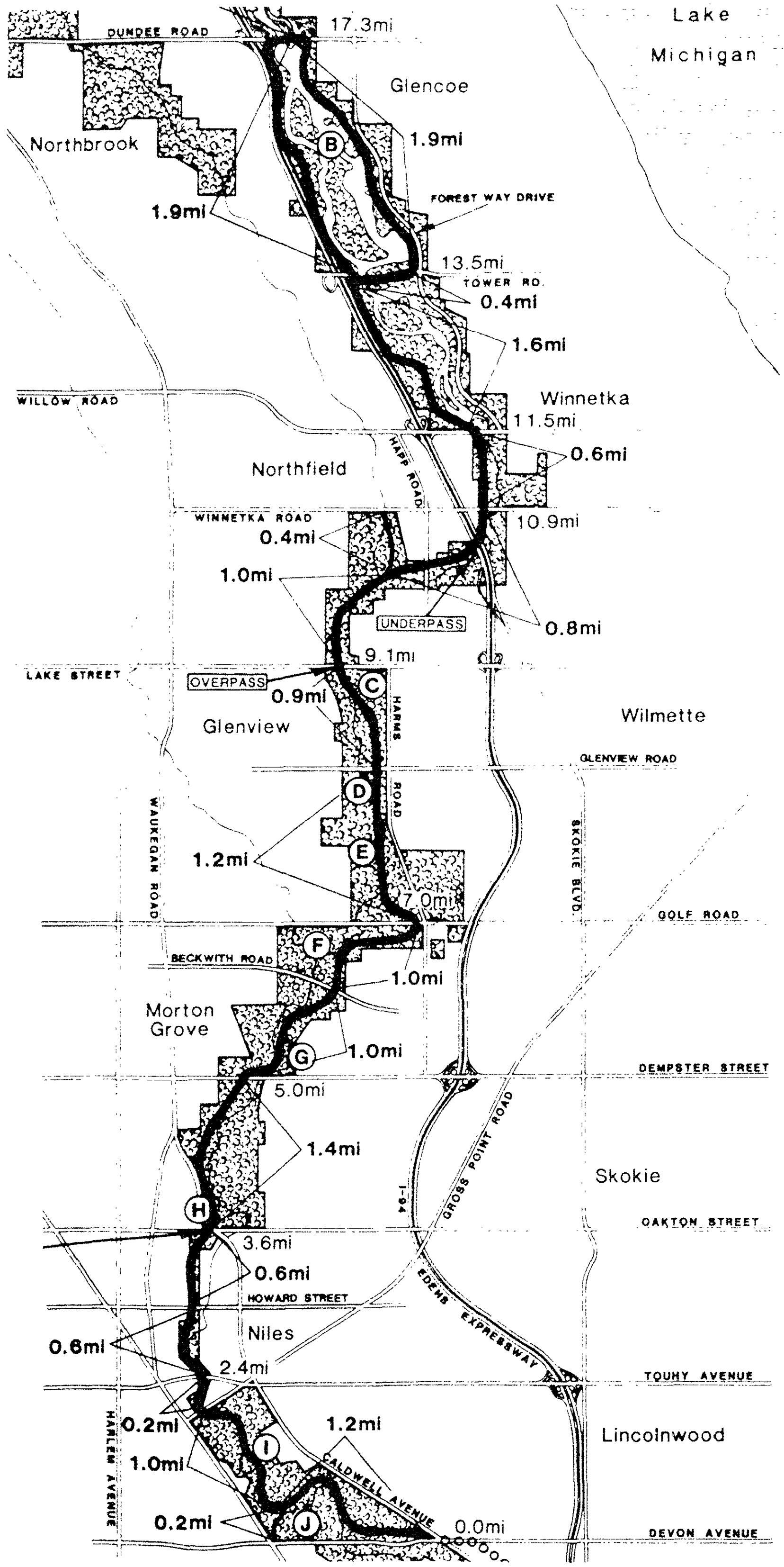

Figure 1.—*Map of the North Branch Trail.*

Table 1.—*Classification of the physical features for the trail slides*

Feature	Scale / Classification
Leafy vegetation: (includes trees, tall bushes)	Percent of photo covered by feature (0-100)
Natural grass	
Lawn	
Trail shoulder	
Bare ground	
Visible roads	
Other visible trails	
Visible building	
Amount of bicycle trail visible	
Visible sky	
Picnic tables	0=none, 1=one, 2=some, 3=lots
Garbage cans	
Signs (includes road signs, street lights, utility poles)	
Flowers	
Litter (includes fallen branches, leaves, garbage)	
Mowed grass shoulder	0=no, 1=yes
Natural grass shoulder	
Bare ground shoulder	
Wooden fence	
Wire mesh fence	
Yellow line dividing trail	
Neat, well maintained	0=no, 1=moderately, 2=yes
Paving	0=poor, 1=good
Visible cars	number of cars (0 to 9)
Degree of curve in trail	0=straight, 1=gentle, 2=moderate, 3=sharp
View distance down the trail	1=near, 2=medium, 3=far
Feeling of openness left right average	1=very enclosed, 4=very open
Shoulder width	0=none, 1=narrow, 2=wide

Table 2.—*Correlations of physical features with preference ratings*

Feature	Pearson's correlation coefficient
Leafy vegetation	0.576 ***
Bare ground shoulder	0.283 **
Bare ground	0.259 **
Litter	0.212 *
Degree of curve in trail	0.187
Wooden fence	0.164
Trail shoulder	0.103
Other visible trails	0.088
Shoulder width	0.072
Visible bicycle trail	0.046
Picnic tables	0.035
Natural grasses	0.026
Mown grass shoulder	0.023
Natural grass shoulder	-0.010
Paving	-0.016
Flowers	-0.083
Garbage cans	-0.105
Neatness	-0.133
View distance down trail	-0.143
Signs	-0.255 **
Yellow line trail divider	-0.317 ***
Wire mesh fence	-0.330 ***
Degree of openness, right	-0.368 ***
Visible buildings	-0.373 ***
Degree of openness, left	-0.400 ***
Visible roads	-0.424 ***
Lawn	-0.434 ***
Degree of openness, average	-0.439 ***
Visible sky	-0.455 ***
Cars	-0.466 ***

* $p<0.10$
** $p<0.05$
*** $p<0.01$

Leafy vegetation (trees and shrubs) correlates positively with preference, whereas mowed lawn, visible sky, open areas, buildings, roads, cars, signs, and wire fences correlate negatively with preference. Bare ground correlates positively with preference ratings because it is usually associated with dense forest canopy. Litter receives a positive value because it includes fallen leaves and branches, which are also associated with forested areas. A yellow line dividing the lanes of the trail is negatively correlated with preference, but this may be because the few sections of the trail where there are no lines painted tend to occur in the more heavily forested areas. Flowers, surprisingly, have a negative (although nonsignificant) correlation with preference, perhaps because they occur mainly in the open areas, which are less preferred than the woods.

These simple correlations seem to indicate that urban bicyclists would most enjoy riding along a trail passing through a closed canopy of trees away from human-made objects and developed areas. This is consistent with previous results of scenic beauty studies (Brush and Palmer 1979, Anderson and Schroeder 1983, Schroeder and Anderson 1984).

Predicting Bicyclists' Preferences

Simple correlations describe the overall relationships between the physical features and the students' enjoyment ratings. To build a model to predict enjoyment levels, however, the independent contribution of each feature must be determined while adjusting for the intercorrelations among features. We used stepwise regression analysis to determine the most independent set of physical features and their relationship to bicyclists' enjoyment.

Eight physical features were chosen using stepwise regression analysis, resulting in the following best-fit equation:

$$E = 6.04 + (0.029^{***})T - (0.244^{***})R - (0.333^{***})B - (0.322^{**})S - (0.177^{*})C - (0.164^{*})VD - (2.531^{***})WF - (0.233^{**})O$$

where: E = enjoyment rating;
T = amount of trees and shrubs;
R = amount of visible road or parking lot;
B = amount of visible buildings;
S = amount of signs;
C = number of cars;
VD = distance a cyclist can see down the trail;
WF = presence of a wire fence;
O = the degree of openness (average)
(* $p<0.10$; ** $p<0.05$; *** $p<0.01$).

The regression of these eight features accounts for 83 percent (adjusted R^2) of the variance in the enjoyment ratings. Trees are the only positive feature adding to cyclists' enjoyment in this equation; all other variables detract. Wire fences have a strong negative effect. A negative coefficient for view distance, VD, indicates that cyclists prefer either hills or curves in a trail to shorten the view rather than just a long, straight view down a trail. This negative relationship also suggests that tree-lined trails are more enjoyable than open areas (O). Human-made features such as cars, buildings, roads or parking lots, and signs, decrease enjoyment. These findings are consistent with the earlier correlation results.

To check the accuracy of this model, we reduced the sample size randomly to 40, and multiple regression analysis was run using the same variables as above. This equation was used to obtain predicted ratings for the 30 slides that had been withheld. The correlation between the predicted and actual ratings of these 30 slides is 0.852, which suggests that the regression equation is reasonably accurate. We were then able to use the above equation to predict ratings for the 100 slides not used in the student evaluation.

Mapping Trail Preferences

Daniel and Boster (1976) were the first to produce a map of the aesthetic quality of an area. They used a type of contour map, each line connecting areas of equal quality. Daniel *et al.* (1977) developed this approach further by using computer-assisted mapping techniques to produce and test a scenic beauty map for a forest watershed. This map could then be used as an overlay in designing scenic road and trail systems, selecting locations of scenic vistas, and as a way to connect scenic quality with manageable resources. Schroeder and Daniel (1980) used the same method to determine the scenic quality of forest road corridors. They emphasized that the psychophysical procedure was adequate for assessing the scenic quality of sections of forest roads and produced scenic profiles showing the varying quality along a road. We also feel that maps showing perceptual quality can be important information for trail management and design. For this reason we undertook to map the enjoyment levels of the North Branch Trail using the ratings predicted by our model for the slides at their corresponding photo locations.

The photosample was divided into two sets, one of the forward-looking slides and one of the backward-looking slides. Using the preference prediction model derived above, we assigned a predicted preference value to each of the 170 photos based on its measured physical features. Figure 2 shows the preference values plotted along the length of the trail, from the first point photographed to the last point, for the two directions. There is much fluctuation from one point to the next, indicating that physical features and the corresponding preference values can change quickly over relatively short distances of trail.

To see whether there are any underlying general trends in the quality of the trail over longer distances, we applied a smoothing procedure to the data[1]. The overall effect of this smoothing procedure is to remove solitary outliers and to filter out short-range fluctuations in values. The smoothed preference values are plotted in figure 3. These plots show clearly that, underlying the point-to-point fluctuations, there are more gradual rises and falls in perceived quality along the length of the trail. Comparing the plots of the two directions shows that these gradual rises and falls occur in the same places regardless of the direction being traveled.

[1] *The smoothing procedure used was Tukey's (1977) 4253H filter, which is discussed by Wilkinson (1986).*

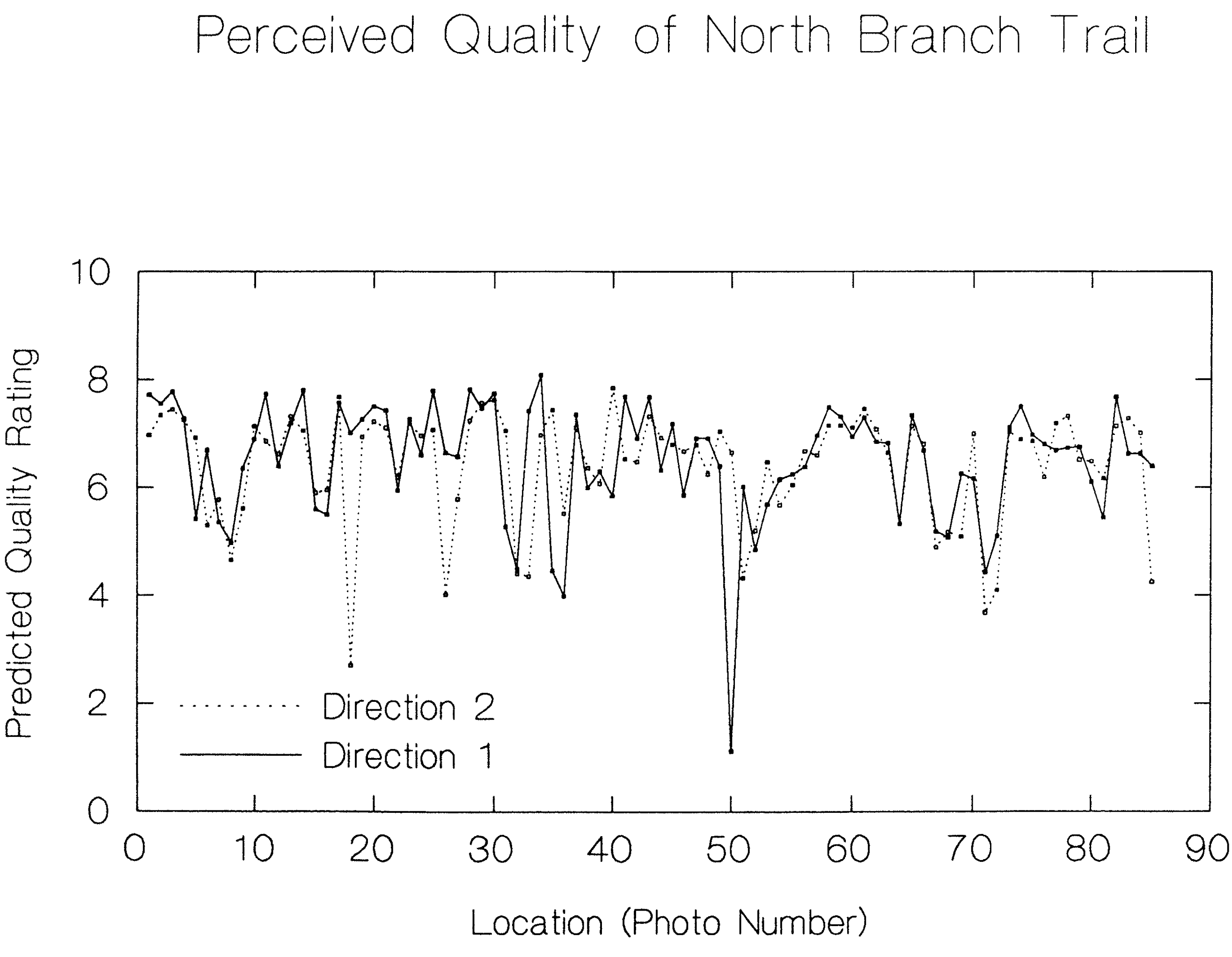

Figure 2.—*Profile of perceived quality along the North Branch Trail.*

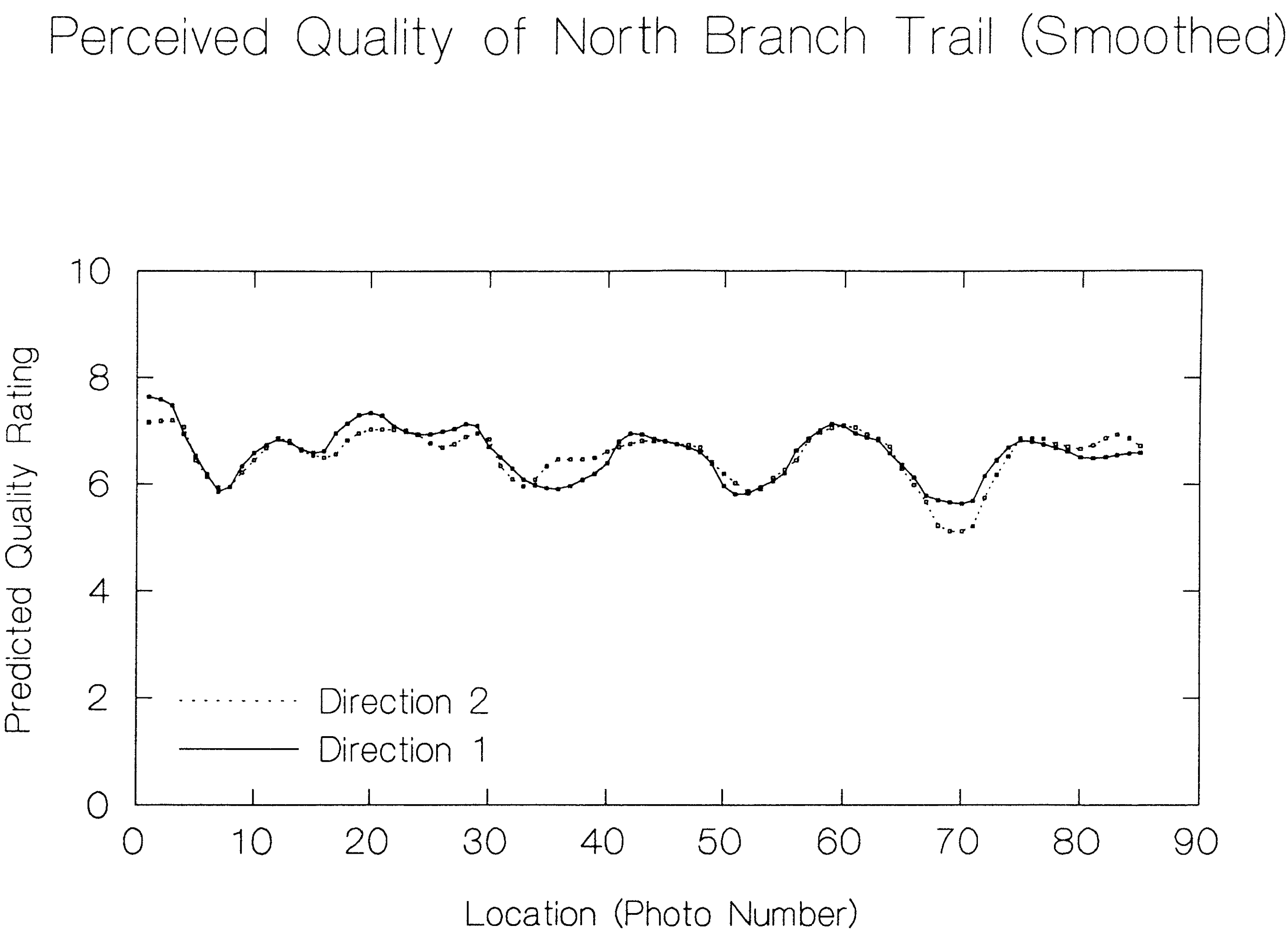

Figure 3.—*Smoothed profile of perceived quality along the North Branch Trail.*

Given the similarity of the smoothed plots in the two directions, we decided to combine the data for the two directions into a single map of trail quality. The two preference values (forward and backward) at each point of the trail were averaged together, and the resulting plot was smoothed using the same procedure as for the separate directions above. The original and the smoothed values are shown in figure 4.

To depict the variations in quality on a standard map of the trail, we broke the smoothed preference values down into four categories, from best to worst. The resulting map (fig. 5), shows where the areas of highest and lowest quality occur on the trail. The best sections are found for the most part where the trail goes through areas of natural forest with no human elements visible.

The worst areas can be attributed to a variety of circumstances. In one case, just north of Tower Road, the trail parallels a busy road with no intervening vegetation for some distance. In another case, between Lake Street and Winnetka Road, the trail crosses a railroad and a major interstate highway, and passes close to buildings, fences, and utility lines. Other low areas are associated with a large, open picnic area having few trees, and with a golf course surrounded by a chain link fence immediately next to the trail.

This map represents gradual, average trends in quality along the trail. Superimposed on these trends are large point-to-point fluctuations that depend on features present at specific points along the trail. For example, the two lowest

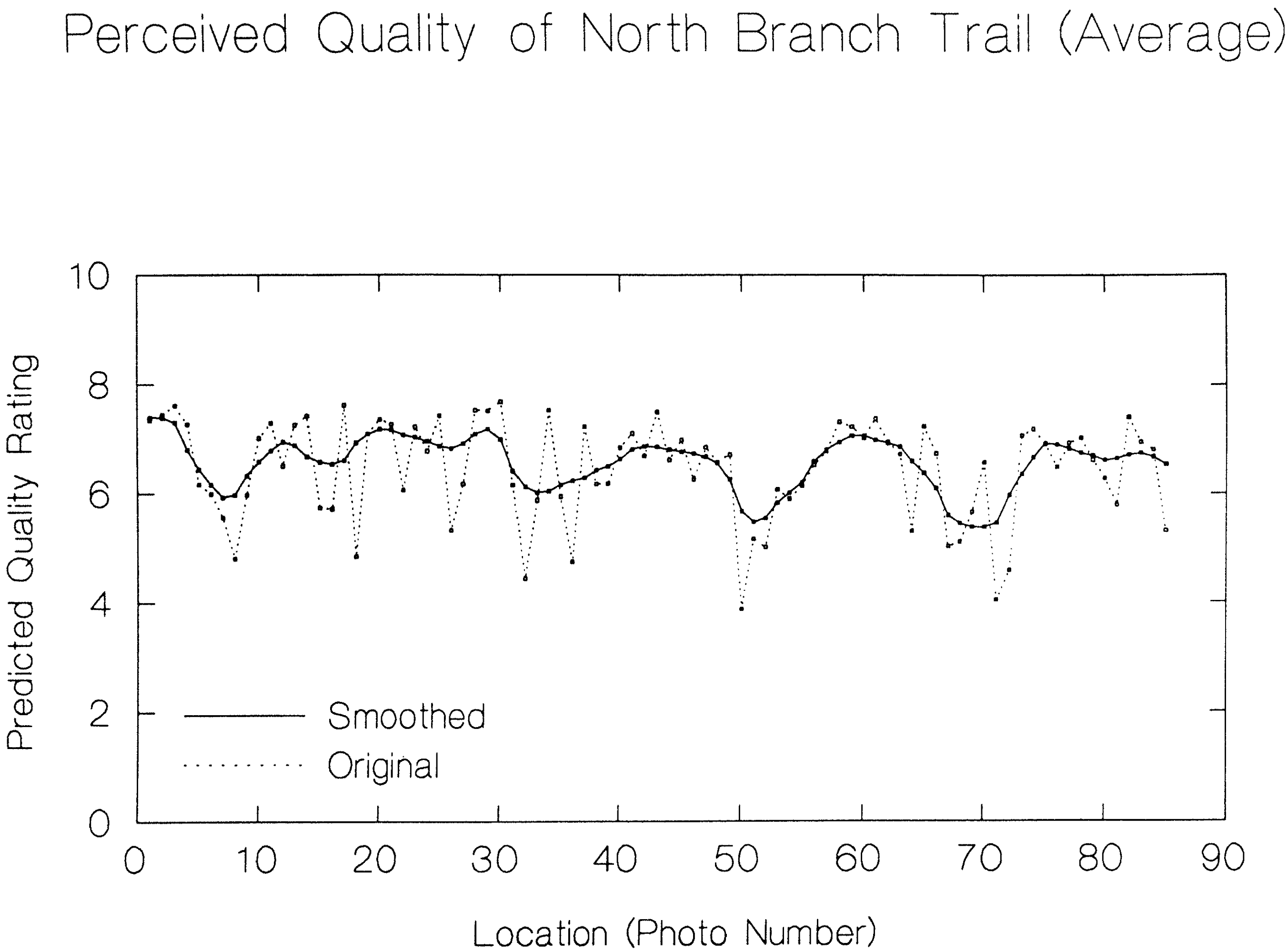

Figure 4.—*Profile of perceived quality - two directions averaged together.*

points in figure 2 are due to a brick wall with graffiti next to the trail, and a railroad crossing in what appears to be an industrial area. Both of these features have a strong negative effect but are visible only for a very short distance on the trail.

IMPLICATIONS

In this study we have shown which environments are most enjoyable for urban cyclists and which features of a trail detract from their enjoyment. We have also produced a model to predict enjoyment levels of urban trail scenes and a map showing the perceived quality along the North Branch Bicycle Trail. The results are consistent with those of past studies on urban park preferences that show that the most preferred scenes are forested areas away from human-made objects. This does not mean, however, that a trail should be entirely enclosed in forested areas. The student evaluators emphasized the need for variety in a discussion after the slide evaluation. None of them seemed to want a completely forested trail.

The need for variety, however, does not seem to extend to some of the negative features. No one seems to enjoy wire fences, roads, and buildings, even though they increase the variety of the trail. If these features cannot be avoided in trail planning, buffer zones of trees, shrubs, or bushes can be used to hide unattractive features and thereby increase enjoyment. For example, a wire fence covered with vegetation received a rating of 6.2 by the students, a much higher rating than scenes of wire fences with no vegetation on them. Another option is to replace wire mesh fences with wooden rail fences. In this study, scenes with wooden fences received higher enjoyment ratings than scenes with wire mesh fences. Apparently, wood fences are more compatible with the natural setting.

These guidelines may not be applicable to all trails. Other variables may be more important to enjoyment than the ones considered here. For example, one factor that was not included in this study was the importance of water scenes. The North Branch Trail follows the North Branch of the Chicago River for its entire length. The northern section of the trail encompasses the Skokie Lagoons. But due to the procedure used for photosampling the trail, no water was visible in the slides. It is quite possible that the enjoyment ratings would be significantly different if views of water were shown. Another limitation is that all of the scenes are typical of midlatitude regions. Perhaps people in the South or Southwest would prefer scenes more common to their areas.

Overall, we feel this study adequately covers the type of trail predominant in most urban areas. If managers work to gain more of the "good" features pointed out in this study and reduce the "bad" features, urban trails will be even more enjoyable than they already are.

FURTHER RESEARCH

This study dealt only with the physical aspects of a bicycle trail in the summer. It would be interesting to study trails at different times of the year to see if preferences change with the seasons. Do cross-country skiers prefer deciduous trees or conifers that are green in winter? Are fall colors important? Would people prefer open areas in early summer before the sun becomes too intense?

Another interesting aspect to study is the importance of variety in people's enjoyment. Perhaps various individuals could be asked to lay out their "perfect" trail using a slide sample, each slide corresponding to a certain distance along the trail.

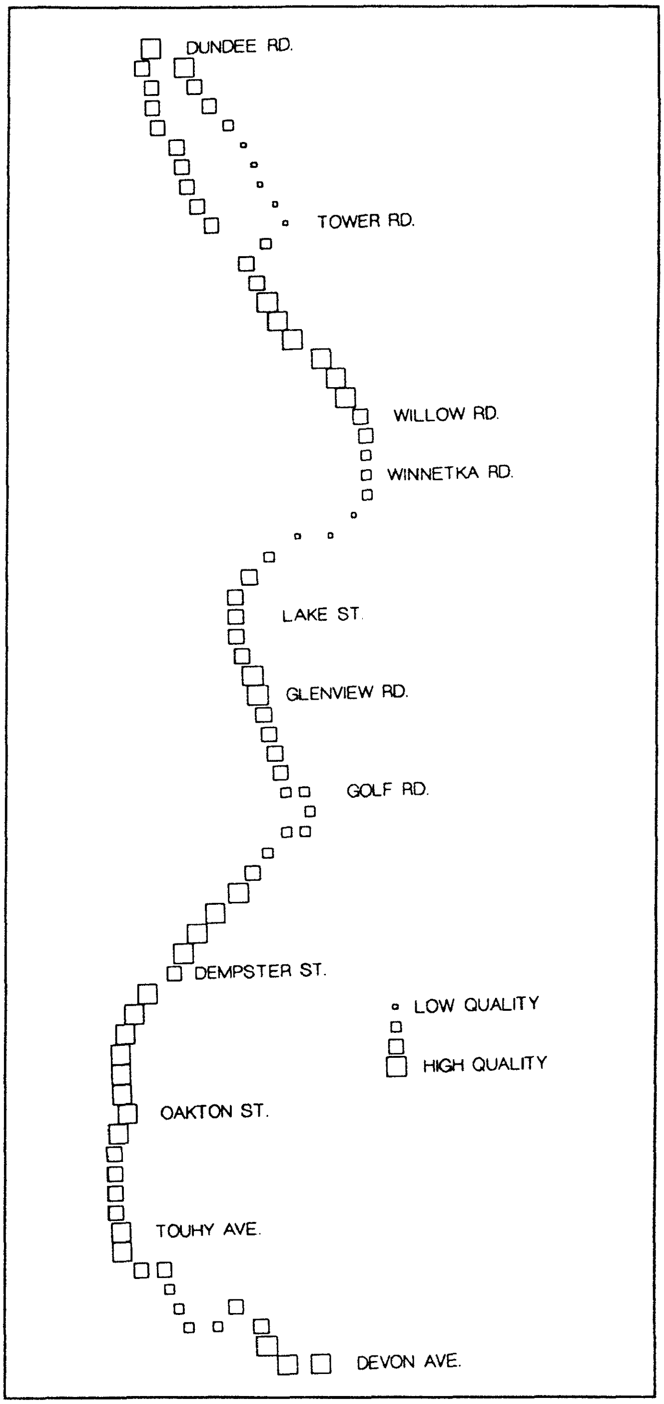

Figure 5.—*Map of perceived quality in four categories.*

Other important aspects to consider, especially in urban areas, are road intersections and safety. Do people feel safe on the trails or crossing a street? What contributes to their feelings of safety? Is it safe to have multiple use trails? Is there enough room for bicyclists, joggers, walkers, skaters, and even commuters? Picnic areas are a particular concern for cyclists on the North Branch Trail, because the trail passes through several heavily used picnic areas. Picnics generally involve large numbers of people, children, and pets. A trail close to these areas and playing fields may pose dangers for both cyclists and picnickers.

To really understand people and trails, these other issues should be studied. Perhaps then the results could be compiled into some type of handbook for trail managers that would include pictures showing which scenes are the most enjoyable and most safe, and others showing which elements to avoid.

Another question concerns the optimal density for a photosample to map the perceived quality of a trail. The point-to-point fluctuations in quality suggest that a fairly dense sample is required to give a complete picture of variations in trail quality. Some features that are only visible at a single point on the trail may still seriously affect perceived quality. The 0.2-mile spacing of the photos in this study may have missed many such features. Further research is needed to see whether increasing the number of photo points will significantly improve the accuracy of the map.

Urban trails are well used. People like to get out and enjoy the scenery and relax. Further studies will bring a better understanding of how urban trails benefit urban residents so that managers and designers can build more enjoyable trails.

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Derives a model for predicting preferences of seventh and eighth graders for settings along an urban bicycle trail. The rises and falls in preference along the length of the trail are profiled and mapped to display the areas of highest and lowest perceived quality.

KEY WORDS: Bicycle trails, mapping, environmental perception, urban recreation.