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Predicting Daily Use of Urban Forest Recreation Sites

JOHN F. DWYER

Urban Forest Recreation Research, North Central Forest Experiment Station, 5801 N. Pulaski Road, Chicago, IL 60646 (U.S.A.)

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ABSTRACT

Dwyer, J.F., 1988. Predicting daily use of urban forest recreation sites. Landscape Urban Plann., *15: 127–138.*

A multiple linear regression model explains 90% of the variance in daily use of an urban recreation site. Explanatory variables include season, day of the week, and weather. The results offer guides for recreation site planning and management as well as suggestions for improving the model.

INTRODUCTION

There is substantial variation in daily use of individual forest preserve sites in the Chicago area over the year. We analyzed that variation in daily site use to (1) develop models to predict use of the site on a particular day, and (2) improve our understanding of the association between a number of factors and daily site use. It is anticipated that the information generated by this effort will help managers plan traffic control, parking, and the scheduling of maintenance and police patrol at these urban sites; as well as better understand use and users.

This paper focuses on one site where use has been monitored for nearly 3 years. During that time there has been little change in site attributes or the availability of other sites in the same general area. The site is a large forest preserve access area (1313 parking spaces) with more than 200 acres of greenspace, 9 major picnic groves, a 590-acre lake, a boat rental facility, two boat launching sites, a paved trail, and a number of "fishing walls" and other areas for fishing. About half of the land area is mowed grass and meadows, the other half is a fairly dense forest, much of which was planted in 1962.

Use was measured as number of automobiles entering the site per day. This was because nearly all users arrive by automobile, and a significant portion of site planning focuses on providing for automobiles. Daily use can be expected to range from 7000 vehicles on a warm sunny Sunday in June to 100 vehicles on a cold and rainy weekday in December.

Given relative stability in site attributes and the availability of substitute sites, and based on

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discussions with managers and users, we decided that the variation in daily use might be explained in terms of season, day of the week, and weather. We thought of weather as influencing the desirability of a day for a trip to the site, day of the week as influencing the availability of time to make a trip to the site, and of season as a complex combination of regular temporal patterns in weather, day length, traditional vacation, holiday, and outing schedules; as well as activities engaged in. More specifically, we hypothesized that there is a seasonal pattern of use over the year, with deviations about that pattern attributable to day of the week and deviations of weather from the seasonal average. We also expected that deviations from the seasonal pattern of use attributable to day of the week and departures from average monthly weather would vary by month over the year.

METHODS

This section outlines data collection and model construction to help the reader better understand how to construct and use the model.

Data used to estimate the model were collected on-site as well as from weather records. We obtained the number of vehicles entering the site on a day from traffic counters and actual field observations. Weather data were collected in the field and from official records for a nearby weather station (O'Hare Airport, Chicago, Illinois). The weather variables included percentage of the day that is sunny, cloudy, or raining; temperature (Fahrenheit) at 12 noon, and snow accumulation (inches) on the ground at 6.00 a.m. These were chosen because they were thought to influence the desirability of the area for recreation, could be measured in the field or from official records, and could be predicted by managers and planners with acceptable certainty. Day of the week was categorized as weekday, Saturday, or Sunday/holiday since these groupings reflected the availability of time for trips to the site, as well as the framework for traditional outdoor outings. In the absence of a strong belief about the seasonal pattern of use, individual months were used as a proxy for season. We also found that managers related well to month as representing season. Since there was essentially no change in site attributes or the availability of other sites in the general area during the period of the study, these variables were not included in the analysis. For a discussion of data collection, see Dwyer (1984) and Dwyer et al. (1985).

Several other studies have used somewhat similar approaches or variables in the estimation of site use. Howell (1979) provides an introduction to use estimation for metropolitan parks. Promnitz et al. (1976) provide a comprehensive assessment of use estimation techniques. Tolley et al. (1986) use a number of weather variables to predict attendance at swimming pools, baseball games, and an observation deck on a large building in Chicago. Emmons et al. (1975) use weather type (clear, cloudy, or rainy), by season, to explain use of the Cleveland Zoological Park. McConnell (1977) includes temperature in his model for predicting the willingness of users to pay for beach use. Van Lier (1973) uses a number of weather variables to predict use of beaches in The Netherlands. Gibbs and McGuire (1973) use seasonal variables in their model to predict use of the Kissimmee River Basin in Florida. The research reported here is, however, unique from the standpoint that it focuses on an urban forest recreation area, considers use over the entire year, and includes a wider range of seasonal and weather variables.

The model-building effort was based on the belief that there is a basic seasonal pattern of use over the year, with departures from that pattern attributable to day of the week and deviations of weather from the seasonal average. In the absence of knowledge of the seasonal pattern in use, months were entered into the model as variables, with the resulting coeffi-

cients for each month reflecting the seasonal pattern. Measuring weather variables as deviations from the monthly averages removed most of the correlations between weather and month, and permitted the estimation of use under average weather conditions (i.e. no weather data entered into the model) or under special weather conditions (i.e. weather data entered). Since it was expected that the associations between use and day of the week and deviations from monthly average weather conditions would change with the seasons, interactions between these variables and month were built into the model so that these associations could be identified by month.

The model was estimated with multiple linear regression techniques. The seasonal and day-of-the-week variables were expressed in binary form, this is to say, each was coded as a 1 when applicable and 0 when not. The dependent variable (use) was transformed into its natural logarithm form, but there were no logarithmic transformations of the independent variables. This provided a better fit than the model with no logarithmic transformations. In this form the regression model minimizes the percentage difference between actual and predicted use. With this "multiplicative" form the coefficients for the independent variables can be converted to "multipliers" that express the variable's association with site use as a multiple of use. This seemed reasonable since at a particular time of the year we would expect weather or day of the week to alter use by a multiple rather than an absolute amount. A similar functional form was used by Emmons et al. (1975) in their model for predicting use of the Cleveland Zoological Park.

Given expected interactions between the seasonal, day of the week, and weather-related variables; the model was estimated in a stepwise fashion starting with seasonal variables and adding successive groups of variables and interactions among variables to build an increasingly complex model for more precise predictions and a more complete understanding of the factors affecting use patterns. Month was used as a proxy for season, with a different coefficient estimated for each month of the year.

In the initial model-building step, month (season) accounted for 56% of the variance in daily use, the highest explanatory power for any variable used alone. When, in the second step, day of the week was also included (weekday, Saturday, Sunday/holiday), the model's explanatory power increased to 69%. Because we expected varying percentage differences between weekend and weekday use over the months (i.e. higher in the spring and summer), interactions between month and day of the week were entered into the model, increasing the portion of variance explained to 70%, but also making major changes in the "multipliers" for Saturday and Sunday/holiday use in each month over the year. The resulting model estimated use without regard to weather conditions. Since weather tends to be correlated with month, weather was then entered into the model as deviations from monthly averages. By reducing the correlations among variables we are better able to identify the association between individual variables and use. Because the influence of weather variables on use was expected to vary by month, interactions of each weather variable with month were also included in the model, bringing the explanatory power up to 90%. With the weather variables defined as deviations from the seasonal (monthly) average, the coefficients for month and day of the week describe patterns of use under average weather conditions, while the coefficients for weather describe changes in use expected with deviations from seasonal averages. Thus in instances where predictions of weather are not available the model can be used to predict use under average weather conditions; but when predictions of weather conditions are available, they can be used to develop predictions of use under those conditions.

We tested interactions between weather and day of the week, but they did not contribute

significantly to the explanatory power of our model, suggesting that the association between weather and use is similar on weekdays, Saturdays, and Sundays/holidays. This is not surprising because with the multiplicative form of the model the influence of weather is a percentage increase or decrease (multiplier) attributable to a specified deviation in weather from the monthly average. It seems reasonable that such a percentage change could be similar for weekends and weekdays in the same month. Consequently, interactions between weather and day of the week were dropped from the analysis.

When departure of wind chill at noon from the monthly average was entered into the analysis for winter months there was no significant improvement in the explanatory power of the model. This is apparently because with limited variations in wind speed experienced in a given month, daily deviations in wind chill are closely correlated with deviations in temperature. This is not to say that on some days wind chill may not be a useful explanatory variable, but it was dropped from consideration in the overall model.

RESULTS

The daily site use prediction model is summarized in Table 1. The coefficients are in natural logarithm form. To estimate use on a particular day, all that is necessary is to select the appropriate month and in that column add the constant to the coefficient for day of the week (if it is a weekend) and then multiply each coefficient for weather by the deviation of that variable from the monthly average (Table 2) and add them to the others. The antilogarithm of the total is the estimate of daily use

While having coefficients in logarithmic form complicates the calculation of daily use, it does have advantages for interpreting the model. For example, the antilogarithm of the coefficient for each day of the week and weather variable gives a number (i.e. multiplier) that expresses the change in use attributable to that variable. For example, in May the coefficient for Sunday/holiday is 0.9695 (antilogarithm equals 2.64) indicating that in May, with all other variables being the same, Sunday/holiday use can be expected to be 2.64 times weekday use. In May the coefficient for temperature at 12 noon is 0.0182 (antilogarithm equals 1.02) suggesting that for every degree of temperature at 12 noon above the monthly average of 64°F, with all other variables remaining constant, use will increase by 2%. Percentage changes in use that can be expected to accompany specified deviations from average weather conditions in each month are presented in Table 3.

The model will predict use on any day of the year, given data on month, day of the week, and weather. It assumes that site attributes and the availability of substitute sites remain constant. Consequently, the model cannot be used to predict changes in use that would accompany changes in the site or the availability or character of substitute sites.

Table 1 is a summary of the actual regression model to facilitate computation of daily use. The interaction (with month) terms have been combined with the variables to provide a set of coefficients for each month. The statistical significance of these "composite coefficients" cannot be presented; but in the actual regression model that was estimated, all of the weather, seasonal, and day of the week variables were significant at the 0.05 level, as were nearly all of the interactions of those variables with month.

Several patterns are implied by the coefficients for each set of variables. The patterns are discussed here in an effort to identify important factors that influence use patterns. It has been our experience that this kind of a discussion often provides valuable insights into user behavior.

TABLE 1

Variables and coefficients[1] for the daily site use prediction model

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Constant	5.5570	5.6492	5.9828	6.4950	6.9616	7.1391	7.0475	6.7872	6.2407	5.9760	5.5570	4.8910
Saturday	0.6535	0.3857	0.4280	0.7771	0.5714	0.6530	0.6241	0.7386	0.7640	0.3681	0.4460	0.2751
Sunday/holiday	0.8155	0.4983	0.8039	0.8270	0.9695	0.8801	0.9562	1.1298	1.2877	0.8349	0.7262	0.3452
Temperature noon monthly average[2]	0.0431	0.0182	0.0339	0.0259	0.0182	0.0017	−0.0105	0.0012	0.0173	0.0281	0.0202	0.0131
Percentage sun monthly average[2]	0.0031	0.0029	0.0071	0.0086	0.0044	0.0063	0.0034	0.0025	0.0022	0.0049	0.0066	0.0058
Percentage rain monthly average[2]	0.0000	−0.0063	−0.0074	−0.0015	−0.0121	−0.0105	−0.0139	−0.0098	−0.0109	−0.0056	−0.0071	−0.0002
Snow depth monthly average[2]	−0.0602	−0.0063	0.4193	–	–	–	–	–	–	–	–	0.1370

$n=480$, $R^2=0.90$, standard error $=0.26614$.

[1]Dependent variable is the natural logarithm of daily use.

[2]Monthly average weather data are presented in Table 2.

TABLE 2

Monthly average 1983–1985 weather data used for the daily site use prediction model

	Temperature at noon (°F)	Sun (%)	Rain (%)	Snow on ground (inches)
Jan.	23	44	0	4.5
Feb.	32	42	13	3.2594
Mar.	40	43	9	0.0429
Apr.	53	42	11	
May	64	61	10	
Jun.	76	73	5	
Jul.	81	72	6	
Aug.	81	69	6	
Sep.	71	58	7	
Oct.	59	45	12	
Nov.	43	32	2	0.0083
Dec.	25	46	9	0.4452

Seasonal patterns

Under average weather conditions, the general pattern of use over the season is a peak in June followed by a long slow decline through December; then some increase in January and February followed by substantial increases in March, April, and May until the June peak. This general pattern which persists, with some important deviations, for weekdays, Saturdays, and Sunday/holidays is presented in Table 4. The estimates of average daily use, by month, upon which Table 4 is based were developed from the coefficients in the first three rows of Table 1.

TABLE 3

Percentage change in daily use associated with specified deviations from monthly average weather (assuming all other variables remain constant)

	+10° temperature at noon	+10% percentage sun	+10% percentage rain	+3 inches snow on ground
Jan.	+54	+3	−0	−17
Feb.	+20	+3	−6	−2
Mar.	+40	+7	−7	+252
Apr.	+29	+9	−1	
May	+20	+4	−11	
Jun.	+2	+6	−10	
Jul.	−10	+4	−13	
Aug.	+1	+2	−9	
Sep.	+19	+2	−10	
Oct.	+32	+5	−5	
Nov.	+22	+7	−7	
Dec.	+14	+6	−0	+51

TABLE 4

Estimated[1] daily use, by month and day of the week under average weather conditions

	Vehicles entering the site per day		
	Weekday	Saturday	Sunday/holiday
Jan.	259	498	585
Feb.	284	418	467
Mar.	397	609	887
Apr.	662	1440	1514
May	1055	1868	2782
Jun.	1260	2421	3038
Jul.	1150	2147	2992
Aug.	886	1854	2742
Sep.	513	1101	1859
Oct.	394	569	908
Nov.	259	405	535
Dec.	133	175	188

[1]Derived from Table 1.

Weekend and weekday patterns

Under similar weather conditions, in all 12 months the model will predict higher levels of use on weekends (Saturday, Sunday/holiday) than on weekdays, and more use on Sundays/holidays than on Saturdays. However, the percentage difference between weekdays, Saturdays, and Sunday/holidays changes over the seasons. Overall, the percentage differences between weekdays and weekends were lowest in the winter and early spring, but increased through the summer to a peak in September before declining sharply. Sunday/holiday use ranges from 1.4 times daily use in the winter to 3.6 times daily use in September; Saturday use ranges from 1.3 to 2.2 times daily use over the same period. The percentage difference be-

tween Saturdays and Sundays/holidays also tends to increase through the summer. Thus the general trend is for weekend use (especially Sundays/holidays) to increase at a faster rate than weekdays during the spring, and then decrease at a slower rate than weekdays over the summer. Progressing through the fall and winter, the decline in weekend use is even more abrupt than for weekdays (Table 4).

Patterns in the popularity of group outings appear to contribute significantly to the differences in the seasonal patterns for weekend and weekday use because groups are an important component of weekend use that continues at high levels throughout the summer. Groups of 25 or more individuals must reserve a designated picnic grove by obtaining a permit. The limited number of groves must be reserved on a first-come first-served basis. All groves in this access area are reserved for all Saturdays, Sundays, and holidays from Memorial Day to Labor Day. This reservation process appears to spread group picnics and the associated weekend use over the summer. Although an accurate count of visits attributed to group picnics is not possible, an analysis of estimated group sizes from picnic permit applications in 1983 suggests that as the summer progresses, individuals participating in groups with permits increase as a percentage of weekend use. However, in late fall, winter, and early spring, large group outings decline in popularity as weekend activities. The decline in group outings most likely contributes to the sharp decline in weekend use over the fall and early winter, as well as to the small difference between weekend and weekday use over the winter. Weekday visits do not drop off as fast as weekend visits in the fall and winter; perhaps partly because the study area is close to a number of factories, businesses, offices, and a large shopping mall – making lunch-time trips feasible as well as visits by individuals traveling to or from such establishments. Many individuals who make weekday visits during these times do not leave their automobile and are not deterred by cooler temperatures and higher levels of precipitation. The decline in weekend and weekday use over the winter at this site may be moderated somewhat by the closing of a number of nearby forest preserve sites during that period and the resulting shift of use to the study site.

Weather

The previous discussion of seasonal and day-of-the-week patterns in daily use has assumed average weather conditions for each month. The following is an example of how weather influences predictions of use. If we assume average weather conditions, the model will predict 3038 vehicles on a Sunday in June. However, with a temperature of 90°F and 100% sun, the model will predict 3888 vehicles; but only 677 vehicles under poor weather conditions (100% rain and 50°F). Thus ignoring weather variables can give predictions that are quite inappropriate for days when the weather conditions depart significantly from the monthly average.

Subsequent discussion focuses on the association between each weather variable and use, given that all other weather, seasonal, and day-of-the-week variables are included in the model. The variables are discussed in terms of decreasing contribution to the explanatory power of the model. Table 3 summarizes the percentage changes in use that are associated with specified deviations from average monthly weather. Table 2 presents the monthly averages used to calculate the deviations.

Temperature at noon

Deviations of the daily temperature at noon (Fahrenheit) from the monthly average contribute significantly to the explanatory power of our model, with the percentage change in daily use associated with a given deviation varying with month. The highest percentage increases in use with a given increment of temperature above the monthly average occur dur-

ing the winter; during the summer we find the smallest increases, and in July a decrease (Table 3). This suggests that temperature may be limiting use in the cooler months; but not necessarily in the warmer months. Warm weather in the summer may result in a shift of use to the other sites that provide swimming opportunities, or to air-conditioned environments.

Percentage sun

Increases in the percentage of the day with sun (percentage sun) over and above the monthly average are associated with significant increases in use throughout the year, but those increases tend to be greatest in March and April and lowest in July, August, and September. There appear to be two patterns at work over the year: (1) greater responses in months that generally have a lower percentage of sun, and (2) greater responses in the spring than in the late summer and early fall. It may well be that bright sunny days trigger early spring crowds, but do not have a similar influence later in the year after a summer of sun. Perhaps sunny days in March and April are especially appealing to winter-weary individuals, or perhaps they signal the beginning of the sunbathing season.

Percentage rain

An increase in the percentage of the day when it is raining (percentage rain) over and above the monthly average tends to decrease use, particularly in the summer. In winter, there is little or no decrease in use associated with increases in percentage rain above the monthly average. However, the percentage decrease in use associated with a given increment in rain above the monthly average increases through the spring to a peak in July, then decreases through the fall and winter. The higher decrease in use associated with above-average rain during the summer may be a result of the influence of rain on outdoor activities such as picnics, softball games, and related summer activities. In the spring, fall, and winter, there appears to be a higher proportion of "driving through" or "sightseeing" and rain may be less of a deterrent to these activities than to summer outings. In the winter, rain may signal clear roads, which facilitate access and boost sightseeing.

Snow

On-the-ground snow cover above the monthly average significantly improves the explanatory power of our model, but changes in use associated with above-average accumulations of snow vary significantly by month. During January and February, which are the "heart" of a Chicago winter, snow accumulations above the monthly averages bring small decreases in use; in December and March, which are on the fringe of winter, additional snow brings significant increases in daily use.

Snow is perhaps the most difficult weather variable to interpret because it can have so many different influences on use. The amount of snow may be as likely to change the activities engaged in as the amount of use. Snow may reduce opportunities for ice skating, but enhance opportunities for cross-country skiing. Heavy accumulations may restrict access to ice fishing. A snow cover, particularly newly fallen snow, can make the area very attractive for sightseeing or a number of other activities; but substantial accumulations of new snow can restrict the flow of vehicles and reduce use. The study area is not especially attractive for cross-country skiing, tobogganing, or sledding because there are few hills, no special facilities for tobogganing, and the trail system is in open and often windswept areas. In addition, another forest preserve about 10 miles to the north has long been known for providing excellent opportunities for these activities. Although heavily used, this other area may compete with the study site for snow sports; but not necessarily at other times of the year, except perhaps for viewing fall colors.

The amount and seasonal distribution of snowfall in the Chicago area is sufficiently un-

certain to raise doubts about any analysis of the influence of snow accumulations on use – particularly one based on only 2 years of data. However, the results do suggest that above-average snow accumulations early and late in the winter may bring the largest snow-induced increases in use. We might speculate that such "unexpected" snowfalls may bring out a significant amount of "sightseeing" or "drive-through" use or the opportunity for the first or last snow sport outing of the year. The prospect for decreased levels of use accompanying above-average accumulations of snow in January and February may be related to difficulties in travel and the area's limited attractiveness for cross-country skiing, tobogganing, and other snow sports.

DISCUSSION

The daily use prediction model accounts for a substantial portion (90%) of the variation in daily use of a forest preserve site. The model is not particularly difficult to develop. It requires only daily observations of site use and weather conditions. Weather observations may be made in the field or taken from official records. Standard multiple linear regression techniques are sufficient for estimating the model. The magnitude and signs of the explanatory variables are reasonable and offer insight into many of the influences on an individual's decision to travel to a site at various times during the year. These good predictions of daily use and the explanations of use patterns offered by the completed model provide some useful guides for management, but also pose some areas for improving the model. Subsequent discussion will include implications for both management and future modeling efforts.

Implications for management

The daily use prediction model can be solved with a hand calculator or readily programmed into a computer to provide estimates of use for a particular day and expected weather conditions. This can provide useful guides for planning a number of management activities. An interactive "user friendly" computer program makes it relatively easy for managers to estimate use at different times of the year under various weather conditions. Monthly average predictions can be expanded to provide estimates of use over a season or year, thus indicating the significance of a site to users. If models are available for several different sites, it is possible to predict shifts in use from one area to another (i.e. changing market shares) under different circumstances.

The general patterns of use over the year suggest that managers prepare for rapid increases in use over the spring and early summer. This calls for early placement of picnic tables and trash cans, as well as preparation for trash collection and police patrol. Consistently high levels of use on weekends (particularly Sundays) in the spring and early summer suggest paying particular attention to police patrol on those days as well as trash collection on the following Mondays.

During our data collection, it became clear that more than 3500 vehicles per day is likely to create significant traffic congestion. This usually takes the form of long lines waiting to get out of the area during the afternoon (often 2–4 p.m.). Under such conditions, police must close off entry until the crowd is down to a manageable size. Our model suggests that such crowds are most likely on warm and sunny Sundays in June, but they can also occur on warm sunny weekend days in late spring and early summer. The key ingredients appear to be lots of sun and unusually warm temperatures. The model can be solved to identify those conditions when use can be expected to exceed 3500 vehicles, and managers can be alerted to those conditions.

Current use levels suggest that the area is at or near capacity on pleasant weekends in the late spring and early summer. Consequently, it would not appear wise to encourage use during

those periods. However, there is ample room for increased use on weekends at other times of the year or weekdays throughout the year. Perhaps distributing information that the area is especially crowded in the spring, and particularly on Sundays, would encourage some to change their use patterns to take advantage of times when the area is not heavily used. It might be useful to encourage groups to have picnics on weekday noontimes or evenings when a wide choice of groves is available and there is little congestion. Limiting picnic permits at traditionally busy times would not appear to resolve the congestion problem because when groups that have reserved groves do not show up others rapidly fill up the area.

High levels of use that are the equivalent of five vehicles entering per parking space per day point out the substantial volume of on-site traffic and frequent "turnover" of users. This calls for careful attention to roadways, traffic flows, and parking. Several modifications in the study area have been made to accommodate larger than expected traffic flows. Site use models such as ours may be useful in predicting traffic flows and guiding site designs to accommodate those flows.

The sheer volume of use summed over a year, season, or any other time period provides a sound indication of public response to the facilities and their operation. In the present instance, this information was useful in documenting use of a new project and arguing against efforts to change the water release schedule for the lake that would subsequently increase the risk of flooding important recreation areas.

The data gathered in this study and the use prediction models that have been developed provide a base line against which to measure changes in use over the years ahead. This might be useful for monitoring trends in use and for evaluating changes in use attributable to a new trail or other changes in site attributes, as well as changes in use resulting from the opening or improvement of other areas.

Implications for future modeling efforts

Using the daily site use prediction model has raised questions about ways to improve the usefulness of the model, and has suggested some related research efforts to assist site managers and planners.

More precise definition of the site use and weather variables would improve the model's explanatory power and usefulness. The present model predicts total number of vehicles entering the site per day, regardless of activity, on the basis of average weather over the day (i.e. percentage sun, percentage rain) or single-point daily weather observations (temperature at noon, snow cover at 6.00 a.m.), regardless of variation in a particular weather variable over the day.

Because use was not monitored by activity, separate models could not be estimated for activities or activity groups. However, field observations suggest that the mix of activities changes with season, day of the week, and weather. Fishing is particularly popular in the spring and fall, and ice fishing in the winter. Analysis of boat rentals and boats brought on site suggests an especially prominent peak of activity in June followed by steady decline. Models to predict boating activity suggest that it is particularly responsive to weather. Driving for pleasure or sightseeing appears to be particularly prominent in the spring; group picnics are more prominent in the summer, particularly on weekends. On rainy days there is often a substantial amount of "drive-through" or "sightseeing" activity. Consequently, it seems reasonable to expect that there might be some important differences in use prediction models developed for particular activities. It is likely that greater precision in total use predictions and improved understanding of use patterns could be obtained from separate models by activity or activity groups. These predictions could be summed if estimates of total use were required. In addition, if clear seasonal and weather-related patterns

can be identified for particular activities or activity groups, then sites can be planned with activities that will have limited temporal conflict and that use the site effectively over the year.

Information about the distribution of sun, rain, and temperature over the day may also improve the precision of use estimates. It would seem reasonable to expect that rain or clouds late in the day would have less of an impact on use than if they occurred at mid-day when a substantial portion of users arrive. Poor weather in the morning may make some potential users expect that it will last all day and cancel trips. Their response may be conditioned, in part, by previous weather predictions.

Weather predictions may be better explanatory variables than actual weather because in many instances decisions about traveling to a site are made before the actual day and are based on expected weather. However, weather predictions were not used in this analysis because it was not possible to locate data on daily predictions. Even if such data could be found, we were not confident of whose predictions to use or how far in advance of the day our predictions should be taken from. Because the trips to urban sites are generally short and travel plans may be altered at short notice, we also suspect that predictions of weather may not be as important to the planning of urban trips as they might be for longer trips. In fact, predictions of poor weather may induce individuals to forego longer trips to other areas and then take a shorter trip to the study area if the weather turns out to be acceptable. For this reason, it is not clear if the complexity brought on by the introduction of weather predictions into the analysis will bring forth an improvement in the model that will justify the effort.

Another approach to improved predictions would be to give attention to short-term patterns in weather. The current model predicts use on the basis of weather on a particular day in comparison with the monthly average. However, comparing weather on a given day with the pattern over previous days might be even more useful. For example, will a warm sunny day bring an especially large crowd after a period of cold rainy days? A difficulty here might be in defining the duration of relevant weather patterns.

Snow on the ground was not a highly useful variable in the analysis, and more detailed analyses of snow depth were not successful in explaining use patterns. Perhaps additional attention should be given to the identification of snow conditions that influence cross-country skiing, tobogganing, sledding, and other winter sports. Winter road conditions might also be built into the use model as they may well be at least as important to daily use as snow conditions for the activity.

Because various activities may respond differently to weather, it may be useful to undertake a simultaneous effort to look at specific activities as well as more precise weather data. Such efforts should be undertaken with appropriate consideration of the implications for data collection and information required for managers to use the model.

Estimating use prediction models for a number of diverse sites would permit comparisons among sites and perhaps provide some insight into variations in use patterns associated with particular activities or environments. Where possible it may also be useful to model use of particular areas within a site. With a number of daily site use models to evaluate, it will be possible to analyze how site attributes and locations influence the patterns of daily use over the year.

The present daily site use prediction model is limited to the single site and the circumstances under which it was estimated. Because it does not include site attributes, the location and attributes of alternative sites, or characteristics of the market area; the model is not directly useful for predicting changes in site use that may be expected to accompany changes in those variables. Furthermore, the model can-

not be applied directly to another site unless that site has similar attributes, nearby sites, and market area. A generalized daily site use model that could be applied to diverse existing and planned sites, as well as evaluate changes in those sites, would be derived from analysis of use patterns at a number of diverse sites, each with a range of alternative sites within the market area. In characterizing the market area, commercial establishments in the area should be considered because many weekday visits are associated with lunch-time or after-work outings; traffic flows through the area should also be considered because many visits are incidental to travel near the area. Important site attributes might include size, number of parking spaces, water resources (lakes, ponds, rivers), opportunities for group outings (number and size of groves), and facilities for particular activities (fishing, boating, bicycling, cross-country skiing, tobogganing). Preliminary efforts to estimate such a model suggest that correlations among site attributes (i.e. large areas at lakes) may make it difficult to estimate the association between some site attributes and use.

CONCLUSIONS

A multiple linear regression model including variables that reflect season, day of the week, and weather explains 90% of variance in daily use of an urban recreation site. The model provides good predictions of daily site use with average percentage errors that average 19%. The predictions provide useful guides for site management and planning – particularly traffic control, parking, and the scheduling of maintenance and police patrol. Promising areas for enhancing the model and its usefulness include the development of separate models for different activities or activity groups as well as the use of more precise weather variables, short-term trends in weather, and perhaps forecasts of weather.

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