# THE EFFECTS OF WEATHER ON FREQUENCIES OF USE BY COMMUTING AND RECREATION BICYCLISTS

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## ABSTRACT

In this paper we investigate the effect of daily weather conditions on the frequency of road bicycling in recreation areas in Vienna. We also compare the weather effects on recreational biking and biking for commuting. A series of linear regression analyses, with the daily frequency of recreation or commuting bicyclists as the dependent variable, and precipitation and the Physiological Equivalent Temperature (PET) thermal comfort index as independent variables, show that for both user groups the number of bicyclists is influenced by both independent variables, but that recreational bicyclists are more sensitive to weather conditions than are commuters.

***KEYWORDS:*** *Weather, Bicycling, Recreation, Commuting*

## INTRODUCTION

Bicycling is a highly sustainable means of transportation and is used for both commuting and recreation purposes. Over the last two decades, the popularity of bicycling has increased tremendously among all age groups in most developed economies (1). However, this revival of bicycling has been mainly associated with recreational uses, in particular new forms of bicycling such as mountain biking, while commuting to work has not increased at the same rate.

The increasing numbers of bicyclists, their speed, and their spatial and temporal distribution may create conflicts with other user groups, or may lead to environmental impacts. Consequently, demands on recreation management as well as transportation planning in general are increasing (2, 3, 1). Well informed managers and planers require high quality investigations and data. However, in most locations adequate data are scarce (4), and the field can benefit from improved analytical

techniques. Fundamental to such improvements are a solid data base of counts and observations based on surveys.

The relationship between human behaviour and weather and climate conditions is intuitively obvious and has been acknowledged for a long time (5). Numerous studies exist on wide-scale climatic evaluation, like the relationship between weather and tourism and on recreation from a medical point of view (6, 7, 8). Some studies have focused on thermal comfort and human activities (9, 10, 11, 12, 13, 1). In transportation planning only a handful of studies have investigated the various factors (i.e. temperature, precipitation, wind, the combination of weather and time of year,) influencing road bicycling (14, 15, 4, 16, 17, 1). Nankervis (1) concluded that heavy rain is the most powerful deterrent for bicycling. The most common conclusion has been that recreational cycling is affected by variations in weather more than commuting by bicycle. One of the major problems with most of these previous studies on the relationship between weather and bicycling has been that the underlying data has not been very reliable. Hanson and Hanson observed this in 1975, and the situation has not improved significantly since.

This paper focuses on the affects of varying weather conditions on leisure-time bicycling and commuting by bicycle. Variations in the impact of weather can be related empirically to different user characteristics in order to enable a greater understanding of the determinants of the day-to-day variations in bicycle use in the areas of investigation.

In particular, the effect of thermal comfort and precipitation will be investigated, as these two measures represent the seasonal climate variations and the extremes of the day-to-day variability. Other crucial meteorological parameters (i.e., air temperature, clouds) are included in the models indirectly via the Physiological Equivalent Temperature (PET), a thermal comfort index.

Data was collected in two recreation areas in the metropolitan area of Vienna: the Wienerberg Park located in the south of the city, and the Marchfeldkanal to the north-east of the city. The areas are used for both recreation and commuting to school and work. The respective authorities managing these parks have observed steadily increasing use levels leading to more evidence that both the ecological and social carrying capacities might be exceeded.

## METHODS

At the entrance-points to the recreation areas, permanent time-lapse video recording systems were installed to monitor recreational activities (3, 18) from dawn to dusk, over a one year period (the type of video system installed did not allow the identification of individual persons, thus guaranteeing anonymity). When analysing the video tapes, the following data were registered: date, day of the week, time, video station, number of persons in the groups, direction of movement, type of user-group (bikers, hikers, joggers, ....), and number of dogs. Based on on-site interviews,

information about the visitor structure and the motivation for visiting the areas was collected (19, 20).

The two types of users, leisure-time bicycling and commuting by bicycle, were identified from the hourly use patterns of workdays. In both areas a distinct peak in the mornings of workdays, as opposed to weekends, was apparent (Fig. 1). Therefore we identified the bikers monitored during the morning peak time, i.e. seven to nine a.m., on workdays as commuters, and bikers monitored after nine a.m. on workdays as recreational bikers.

This is of course a crude simplification, but we have further confirmation that very few recreational bicyclists use the early morning hours from visitor monitoring data in the Viennese part of the Danube Floodplains National Park, which is a recreation area without any commuting. In the afternoon an equivalent separation of recreational and commuting bicyclists is impossible because of the more wide-spread time of returning from school or work and the presence of recreational bicyclists.

For the analysis the dependent variable was the number of recreational or commuting bicyclists per day, and the dependent variables were meteorological measures such as precipitation and the Psychological Equivalent Temperature (PET), which incorporates both meteorological and thermo-physiological parameters (12, 21). The meteorological data were obtained from the closest meteorological stations of the Austrian Central Institute for Meteorology and Geodynamics. The values of the PET thermal index were calculated using the radiation and bio-climate program RayMan (22). The input values for the RayMan model consist of air temperature (°C), vapour pressure (hPa), wind speed (m/s), cloud cover (in 1/8), global radiation ($W/m^2$), human activity (W), and clothing insulation (clo).

## RESULTS

In the following, the results of the relationship between the current weather and the behaviour of recreational bicyclists and commuting bicyclists in the recreational areas Wienerberg and Marchfeldkanal are shown (Figure 1). We identified a total of approximately 12% commuting bicyclists in the Wienerberg Park, and around 10% in the Marchfeldkanal recreation area.

The relationship between the PET thermal index and the two bicycling types shows that both can be encountered when the weather conditions are pleasant (Figure 2). However, it becomes apparent that bicycling for the purpose of commuting is less sensitive to cooler weather conditions than bicycling for recreation. The differences between the two purposes during the warmer weather period may be the result of other external factors, such as school and public holidays.

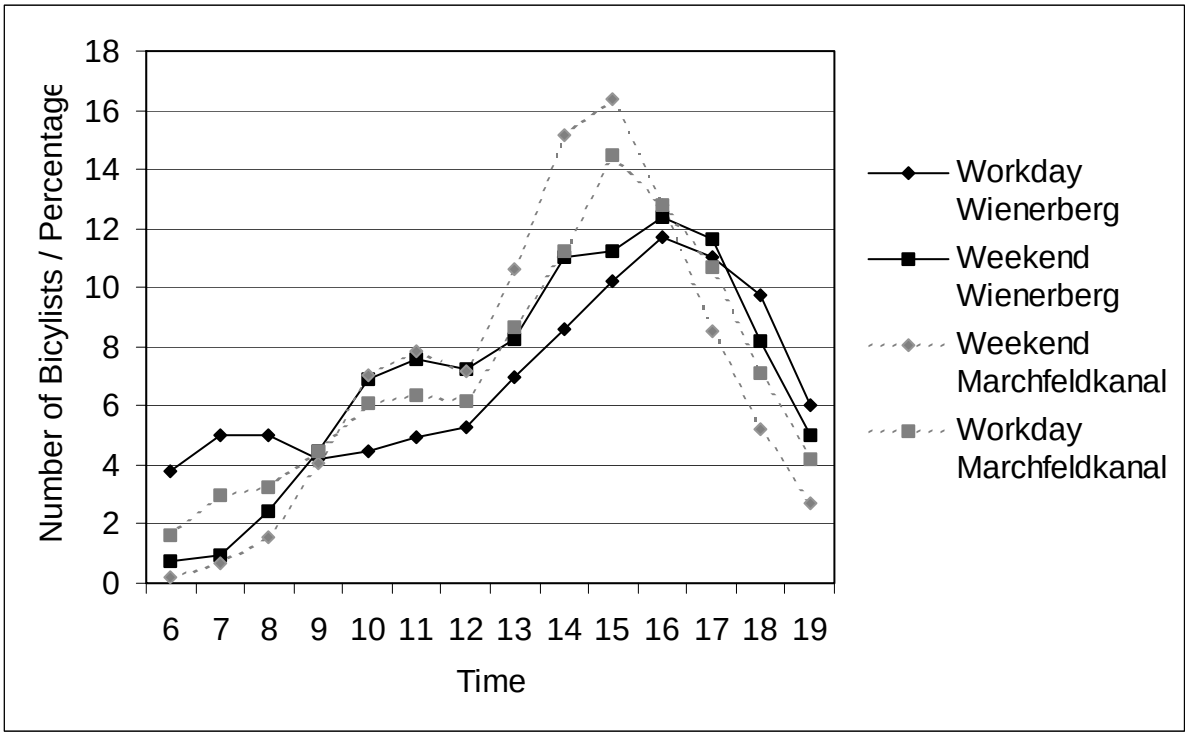


**Figure 1: Daily courses of bicyclists in the recreational areas, differentiated by workdays and weekends**

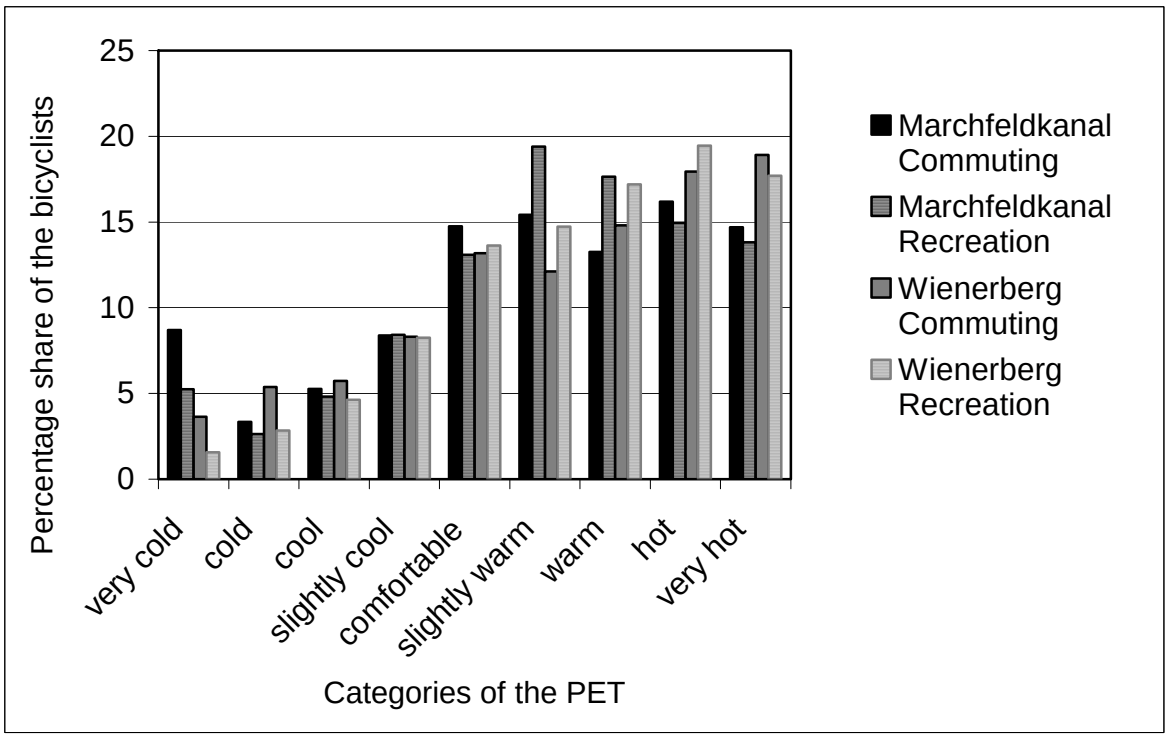


**Figure 2: Connection between the PET thermal index and both bicycling types in the recreation areas**

Next, we distinguish between the two precipitation categories – with, and without, precipitation. Following Harrison et al. (23), a day with precipitation is defined as any day receiving at least 1 mm of precipitation. Investigations on the difference between the influence of precipitation on the behaviour of both types of bicyclists clearly show that, if it is raining, approximately 10% more commuting bicyclists are on the move compared with recreational bicyclists (Figure 3).

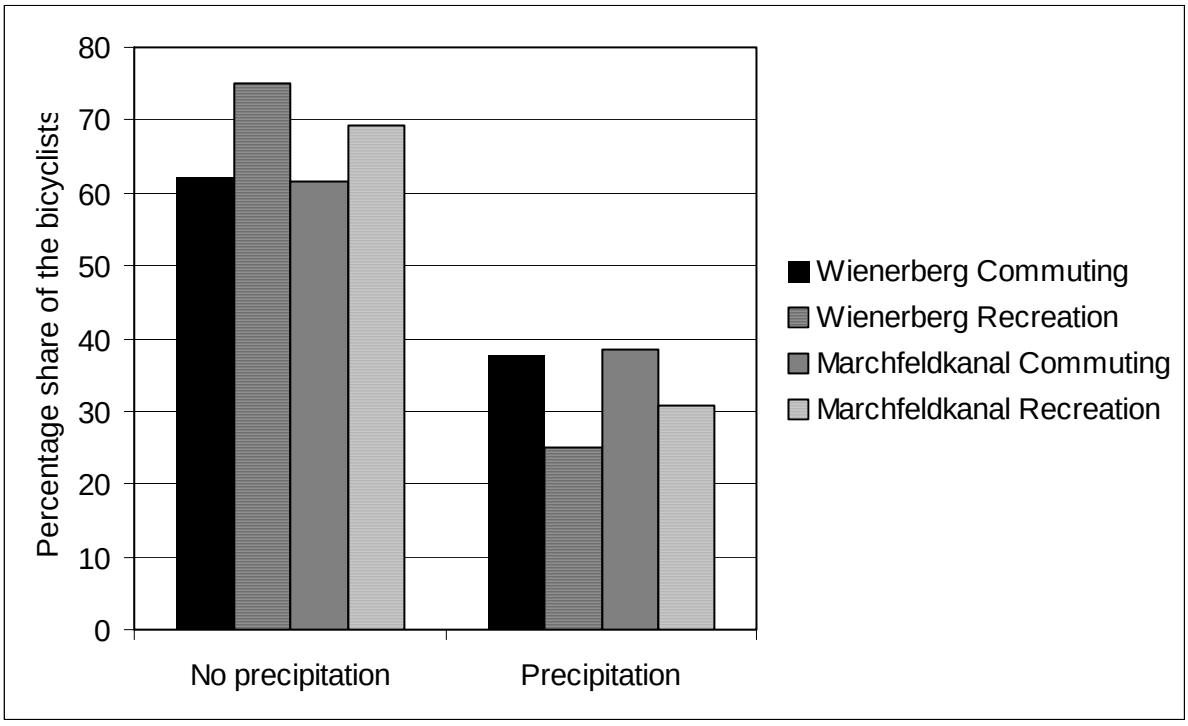


**Figure 3 Relationship between precipitation and both bicycling types in the recreation areas**

In the next step, the effect of weather on recreation bicyclists and commuting bicyclists was investigated with a general linear model. With the meteorological parameters precipitation (categorized in presence/absence of precipitation) and PET thermal index the influence of the current weather conditions enters the modeling as independent variables. This regression is based on workdays only. Because of the low significance of the interaction between the PET and the precipitation for the commuting bicyclists in the Marchfeldkanal recreation area we calculated this particular model without the mentioned interaction.

The variance explained by the various models is lower for the commuting bicyclists than for recreation bicyclists for both recreation areas (Table 1). Obviously, commuting bicyclists are less weather-sensitive. The significance of the independent factors PET and precipitation are high. The significance of the interaction between the PET and precipitation is much lower, and insignificant in one situation. The power of influence of the independent factor is indicated by the eta square value.

The PET has the highest influence. The presence or absence of precipitation has a very low influence on the behaviour of bicyclists in the recreation areas. In our investigation, the relationship between the number of bikers and the PET is, therefore, much more meaningful in contrast to the results gained by Richardson (24). He observed that rainfall has a more significant effect on bicycling behaviour than temperature.

**Table 1: Effects of weather on participation in bicycling (all models significant at the p < .05 level), significance levels and eta square of fixed factors – during workdays**

| | Wienerberg Commuting | Wienerberg Recreation | Marchfeldkanal Commuting | Marchfeldkanal Recreation |
|---|---|---|---|---|
| **$R^2$adj** | .595 | .782 | .540 | .632 |
| **Significance of PET** | .000 | .000 | .000 | .000 |
| **Significance of Precipitation** | .000 | .000 | .052 | .000 |
| **Significance of PET * Precipitation** | .029 | .116 | ns | .198 |
| **Eta Square PET** | .434 | .673 | .528 | .368 |
| **Eta Square Precipitation** | .041 | .078 | .017 | .044 |
| **Eta Square PET * Precipitation** | .072 | .055 | ns | .051 |

## DISCUSSION

The analysis above has produced a strong relationship between current weather conditions and both recreation bicycling and commuting bicycling. Participation in bicycling depends not only on actual meteorological variables, such as precipitation, but also on human thermal perception, as expressed by the PET. Furthermore, the results of the linear models indicate a differentiation between recreation bicycling and bicycling for commuting. The recreation bicyclists are more affected by the current weather conditions than are commuting bicyclists. The differences observed for recreation bicyclists in the two study areas should be interpreted as a function of their different areas of origin. About 80% of the visitors to the Marchfeldkanal area origin from within a walking distance of 15 minutes, which is equivalent to a distance of less than 5 minutes bicycling. For them it is possible to return home promptly if the weather turns worse. Therefore, these people visit the recreation areas even if at the time of decision the weather is doubtful. The short distance to their homes also makes it possible to stay for a shorter time, even when it is very cold or slightly rainy. On the other hand, only 60% of visitors to the recreation area Wienerberg live within a walking distance of up to 15 minutes. Therefore, the visit lasts somewhat longer (20) and, as a consequence, the dependence on the weather is higher.

The thermal perception and the implementation of more meteorological parameters of the current weather and, additionally, the memory or history of thermal perception – perhaps one week – would explain, with a higher significance level, the correlation between the number of different types of bicyclists and the combination of bio-climatic conditions. In future studies we will investigate the relationship between the current bio-climatic and meteorological conditions, and also the effect of memory of thermal perception for the past days for various other kinds of outdoor activities, such as jogging and walking.

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