THE INFLUENCE OF CLIMATE VARIATIONS ON VISITOR ACTIVITIES IN PENNSYLVANIA'S STATE PARKS

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ABSTRACT: State parks represent key areas of human environment interactions. In 2002 more than 47 million people visited Pennsylvania's 109 State Parks. The most common recreational activities included pleasure driving, picnicking, and hiking. More than 50% of these activities took place in the summer, and only about 10% in winter. There is some interesting spatial variability in these activities. In the warmer, more urbanized southeast, activities are more evenly distributed throughout the year, while in the north and west activities are even more concentrated in the summer. Many of the recreational opportunities available at State Parks are weather dependent. In winter a significant portion of park visits are for snow related activities such as skiing and snowmobiling. Recent climatological data suggest that increasing winter temperatures may be harming the state's ability to provide these activities. In the other seasons, warm weather activities such as camping, boating, and swimming dominate. Temperature and precipitation data in these seasons show that, while there are no significant climate trends, considerable interannual variability can potentially have large effects on park visitation. Climate variations and trends will continue to affect Pennsylvania in the future, and one of the most direct ways that these fluctuations will impact the majority of people is through the recreational activities at State Parks.

INTRODUCTION

One of the most common ways in which humans encounter the environment is through their recreational activities. Whether it is a weekend autumn hike, a summer boating trip, or a winter ski vacation, millions of Americans spend their free time in parks. The National Association of State Park Directors reports that in 2001 more than 750 million people visited the 5,616 State Parks in the United Pennsylvania's State Park system is States. composed of 109 parks spread throughout the commonwealth. More than 47 million recreation visits occurred in Pennsylvania's State Parks in 2002. Throughout the year, pleasure driving, hiking, and picnicking are among the most frequent recreational activities. While extreme temperatures or heavy rain might curtail these kinds of events, they are not strongly influenced by normal weather variations. Other activities such as camping, boating, beach swimming, and especially winter events such as skiing, snowmobiling, and ice fishing though, are

much more susceptible to weather events. Throughout the state, park visitation rates are likely to be influenced by climate patterns and certain recreational activities in some locations are likely to be more vulnerable to climate variations than others. In this paper, recreation vulnerability is assessed by examining common activities in light of a regional climatology.

PENNSYLVANIA CLIMATOLOGY

The climate of Pennsylvania is characterized by a large seasonal range of temperatures and precipitation evenly distributed throughout the year. Summer temperatures generally average in the upper 70's Fahrenheit while mean winter temperatures hover right around the freezing point. Average annual precipitation is roughly 40 inches with slightly higher amounts occurring in the summer. The local topography of the Appalachian Mountains and proximity to the Atlantic Ocean and Great Lakes

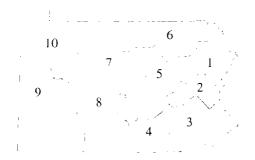


Figure 1. Pennsylvania's ten climate divisions.

result in regional climatic differences. The National Climatic Data Center (NCDC) recognizes ten climate divisions within the state (Figure 1). Mean monthly temperature and precipitation data for each climate division are available from NCDC. Divisional data are created by averaging many individual station records and thus represent regional conditions that are less affected by data quality issues at individual locations (Guttman and Quayle, 1996). In this study climate data from Pennsylvania's ten divisions are used from 1956 to 2002. Long-term mean conditions show subtle, yet distinct climate patterns (Table 1). The southeastern portion of the state has the highest temperatures which decline towards the north and west. The lowest average temperatures are found in the northeastern divisions. Precipitation is also highest in Divisions Two and Three in the Southeast, reaches a minimum in the central part of the state, and then increases again in the west.

Pennsylvania's midlatitude location on the east coast of North America exposes it to considerable climatic variation. Lying along the polar front, small changes in the ridge/trough pattern of the Rossby Waves can result in considerable intraannual and interannual variability (Yarnal and Leathers, 1988). Average temperatures can vary by as much as 15° F in winter, while summers have a more stable pattern, with the largest differences on the order of 5° F. Precipitation is also highly variable. Small changes in the track of storms and moisture advection patterns can cause large year-toyear differences in precipitation (Henderson, 2000). Across the state winter precipitation has been as low as two inches in some divisions, but has also exceeded 17 inches in others. Summer rainfall has varied between as little as four inches and as much as 21 inches. This amount of variability is likely to impact society in a numbers of ways, including the number of times people visit State Parks and the recreational activities they pursue there.

STATE PARK VISITATION

Visitation data from Pennsylvania's State Parks were obtained from the Pennsylvania Department Conservation and Natural Resources. While total annual park visitation data were available over many years, monthly data on individual recreational activities were only available for 2002. Results show that over 47 million people visited State Parks that year. Figure 2 shows how the total number of parks and visitors are distributed among Pennsylvania's ten climate divisions. The number of parks varies from a minimum of six in Division Two, to a maximum of 15 in Divisions Three and Nine. These latter two divisions contain the state's two largest cities, Philadelphia and Pittsburgh, so it is not

| Table 1: Mean Seasonal Tem | perature (°F) and Precipit | tation (inches) for Pennsyl | Ivania's Climate Divisions |
|----------------------------|----------------------------|-----------------------------|----------------------------|
| | | | |

| | Winter | | Spring | | Summer | | Autumn | |
|-------------|--------|------|--------|------|--------|------|--------|-------------|
| | Temp. | Ppt. | Temp. | Ppt. | Temp. | Ppt. | Temp. | Ppt. |
| Division 1 | 25.6 | 8.9 | 45.1 | 11.2 | 66.8 | 12.0 | 49.8 | 11.4 |
| Division 2 | 29.2 | 9.4 | 48.5 | 11.4 | 70.2 | 12.5 | 52.3 | 11.5 |
| Division 3 | 31.9 | 9.5 | 50.8 | 11.2 | 72.5 | 11.9 | 54.8 | 10.8 |
| Division 4 | 31.2 | 8.8 | 50.5 | 10.9 | 72.0 | 10.7 | 53.9 | 10.1 |
| Division 5 | 28.9 | 8.1 | 48.5 | 10.4 | 70.0 | 11.4 | 51.9 | 10.5 |
| Division 6 | 24.8 | 7.3 | 44.0 | 9.6 | 65.9 | 10.9 | 48.3 | 9.9 |
| Division 7 | 26.6 | 7.5 | 45.9 | 10.4 | 67.1 | 12.1 | 49.6 | 9.9 |
| Division 8 | 28.7 | 8.3 | 47.9 | 11.2 | 68.7 | 11.2 | 51.3 | 9.7 |
| Division 9 | 29.0 | 8.5 | 48.2 | 11.3 | 68.9 | 12.1 | 51.7 | 9.5 |
| Division 10 | 25.6 | 8.5 | 44.9 | 10.7 | 66.4 | 12.8 | 49.4 | <u>10.9</u> |

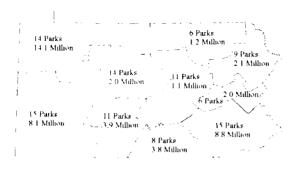


Figure 2. Total number of State Parks and 2002 visitors by climate division.

surprising that a number of smaller parks have sprung up around their edges. Total visitation statistics do not completely follow the same pattern. The most visits in 2002, over 14 million, occurred in Division 10 in the northwestern portion of the state. This division contains the popular Presque Isle State Park on Lake Erie. Parks in the Philadelphia and Pittsburgh areas experienced between eight and nine million visits, while Division Five in the eastern interior only had 1.1 million visits.

The vast majority of recreational activities took place in the summer (Table 2). Overall, just over 50% of visits occurred in the months of June, July, and August. This time of year offers the warmest weather, when numerous swimming, beach, and camping activities are available, and also is the time when many families take summer vacations with out-of-school children. Spring and Autumn experience roughly equivalent visitation rates of about 20%, leaving approximately 10% of the recreational visits for winter. As with total visitation data, there are also some interesting geographic variations in the overall pattern. In the southeast, the percentage of visits is much more evenly distributed among the seasons than in all the other regions. This uniqueness may be caused by the type of activities that are popular in this area, but is probably also influenced by the fact that Division Three has the highest overall temperatures in the state. Summer activities can begin early and extend later into the Autumn, causing the peak of activity to spill into the transition seasons. Conversely, Divisions Eight and Ten in the cooler, western portions of the state have a concentrated summer season. Seasonal visitation data from Division Six in the north-central area is interesting in that there are a much higher percentage of autumn visits than any other division which is offset by much lower percentages in the winter and spring. Northeast Pennsylvania's autumn weather and activities draw many more people to the Northeast than the bleaker winter and spring. Pennsylvania's weather and climate not only influences the location people choose to visit, but also the time of year. Clearly the warm summers are most popular, yet millions still take advantage of

| | Winter | Spring | Summer | Autumn |
|-------|--------|--------|--------|--------|
| 1 | 6.2 | 21.4 | 54.9 | 17.6 |
| 2 | 7.9 | 19.9 | 52.2 | 20.0 |
| 3 | 14.1 | 25.3 | 36.9 | 23.8 |
| 4 | 7.8 | 21.9 | 51.7 | 18.6 |
| 5 | 6.8 | 21.2 | 48.9 | 23.0 |
| 6 | 2.8 | 13.7 | 56.0 | 27.6 |
| 7 | 6.8 | 21.2 | 56.4 | 15.6 |
| 8 | 8.1 | 17.3 | 59.7 | 14.9 |
| 9 | 9.1 | 16.5 | 51.8 | 22.6 |
| 10 | 5.9 | 20.5 | 58.1 | 15.5 |
| Total | 8.4 | 20.4 | 51.9 | 19.2 |
| Total | 8.4 | 20.4 | 51.9 | |

Table 2: Percentage of Visitation by Season

The Influence of Climate Variations on Visitor Activities in Pennsylvania's State Parks

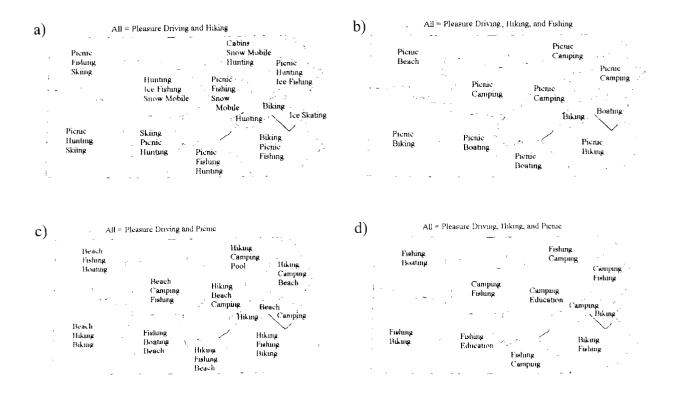


Figure 3. Five most popular recreational activities by climate division in a) winter, b) spring, c) summer, and d) autumn.

winter opportunities. Climate variations are likely to impact the popularity of these seasonal activities on an annual basis.

CLIMATE VULNERABILITY

The popularity of each individual recreational activity is likely to be affected to some extent by weather conditions. From the condition of the snow pack in winter, to cool, rainy summer periods, the weather will influence people's decision to go skiing or camping. Since State Parks in all climate divisions offer similar recreational opportunities, but have different climate conditions, some are going to be more vulnerable to weather changes than others. As an initial attempt to assess this vulnerability I compare the five most popular activities in each division to climate variations and identify a few key issues that might be examined in more detail in future work.

Figure 3 shows the recreational activities which were most popular at State Parks within each climate division for each season. In every region and in every season pleasure driving was among the top five. This result may be a product of counting cars as they travel along roads that pass through park areas, but is probably more indicative of modern American society where everything, including nature, is something you drive to see. Hiking and picnicking also frequently appeared among the top five activities. None of these three activities would be drastically affected by weather conditions, and small changes in temperature and precipitation would not likely lead to large changes in the popularity of the functions. However there are a number of other popular activities which are much more weather dependent. These are highlighted by season below.

Winter

During the winter months, popular activities in every division except the southeast involve snow and ice (Figure 3a). Downhill skiing, snowmobiling,

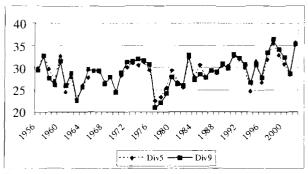


Figure 4. Average winter temperature (°F) for divisions five and nine.

ice skating, and ice fishing all appear in the top five activities in some divisions. Sledding and crosscountry skiing also attract large numbers of people, though they are outside the top five. All of these activities require low temperatures to preserve a stable snow pack or frozen water body. While winter precipitation is usually ample, the physical state of that precipitation depends on the temperature. Temperature also affects the ability to create artificial snow on ski runs. Because Pennsylvania's average winter temperatures are very close to freezing, small variations may make the difference between a good snow year and a poor one.

This temperature variability will make areas to the south and east especially vulnerable. For example, Divisions Five and Nine have mean winter temperatures just three degrees below freezing. Small changes in midlatitude circulation may cause temperatures to creep above 32° F and hinder winter recreation. Figure 4 shows the interannual variability of winter temperatures for these two regions from 1956 to 2002. It is readily apparent that the mean temperature exceeds the freezing point in many years. Even more interesting is the obvious trend in the data following the extremely cold winters of the 1970's. The winters of 1977 through 1979 were among the coldest on record in the eastern United States (Namias, 1980). However, since then a noticeable warm-up has occurred. Nine of the last 12 years have had average temperature above freezing in these two divisions. The consensus on global warming is that winter temperatures are likely to be affected more than summer (IPCC, 2001). Whether the trends identified here are indicative of a larger warming trend or not is unknown at this point. However, the trend raises concern for the

vulnerability of winter activities in these divisions. Though winter experiences the fewest number of park visits, Division Nine alone still had 40,000 snow or ice based activities which would be placed at risk.

Spring

By spring, snow-related events have ceased and more warm weather activities begin. Camping, fishing, biking and boating become popular activities in many of the divisions (Figure 3b). Beach activities in Division Ten also enter the top five where more than 250,000 people are enjoying the beaches at Presque Isle State Park. These warm weather events require a run of high temperature days during a set of months which are often highly variable in Pennsylvania. Mean seasonal temperatures can be as low as 42° F and also well over 50° F. This eight degree range in average temperatures conceals a much larger range in daily temperatures. Though spring temperatures have been relatively high since the mid-1980s, there have been a few years in the late 1990s that experienced cooler springs more common in previous decades. These cooler periods could reduce the number of people getting outdoors in the spring months. On the other hand a stable period of warmer weather will continue to send larger groups of people to the State Parks earlier in the year, perhaps causing managers to have to adjust staffing needs and infrastructure.

Summer

Summer represents the peak of the visitation cycle. More than 20 million people are flocking to Pennsylvania's State Parks for a variety of activities. Camping, biking, boating, and beach activities are among the most popular (Figure 3c). In this season, temperature effects are probably minimal. If anything, warmer weather may send more people to the parks. The one weather event to which all of these events are vulnerable is summer rainfall. A period of cloudy, wet weather would restrict the number of visitors taking advantage of these opportunities. A number of recent studies have indicated that precipitation in the United States is increasing and that the northeastern part of the country has experienced some of the more significant changes (e.g. Karl and Knight, 1998; Polsky et al., 2000). The recent divisional data used in this study

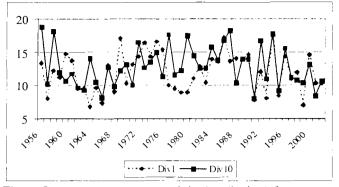


Figure 5. Average summer precipitation (inches) for divisions one and ten.

does not confirm these results for Pennsylvania in Nevertheless, considerable summer (Figure 5). precipitation variability is evident. Average seasonal rainfall totals range more than ten inches in most divisions. Even without a long-term trend, this scale of variability illustrates the vulnerability of activities such as camping and beach use. Particularly wet years such as the early 1990s may have had an effect on the number of recreational visits to these types of locations, though longer term visitation data would be needed to answer this question definitively. Conversely, the small decreases in precipitation evident since then may be increasing the popularity of parks in recent years. Even if only a small proportion of the total population decided to go to the park in a dry year or stay home in a wet year, it would affect State Park visitation rates by 100,000s.

Autumn

As the warmer weather fades in autumn, the popularity of beach use, swimming, and boating dissipate. Instead, the most popular activities include camping and fishing (Figure 3d). Again, precipitation and hydrologic conditions most likely have the greatest climatic impact. Regional studies have again indicated that the northeastern United States has experienced its largest precipitation increases during the autumn (Karl et al., 1996; Henderson 2000). Pennsylvania's divisional data shows some indication of an upward trend, but even more evident is the large variability of autumn rainfall in the last 15 years. Seasonal rainfall totals have oscillated between seven and 15 inches. Certainly the popularity of camping late in the season will decline during these wet years. Interestingly 2002 was one of the wetter years during the study

period suggesting that the one year of visitation data used here may underestimate activities such as camping. On the other hand fishing, which attracted more than 120,000 people in Division Three alone, would most likely benefit from a wetter autumn. Stream flows are often at their lowest point in this season and consequently water quality issues may arise. Increases in autumn precipitation could help alleviate this problem. Hydrologic measures, such as the Palmer Drought Severity Index, indicate that the majority of recent years have had above average moisture conditions, and thus it may be assumed, Significant variability still ample stream flows. exists however, as the summer and autumn of 2001 illustrates.

SUMMARY

Each year close to 50 million people interact with the environment by visiting Pennsylvania's State Parks. In parts of the country like Pennsylvania, where climate variability is high, these people are likely to feel the impacts of climate variations directly. Small changes in temperature and precipitation patterns may alter the number of people visiting parks and the activities they choose to pursue. On an average basis the vast majority of State Park visits are made during the summer season to enjoy activities such as boating, swimming, and Significant variability in precipitation camping. during the warm seasons of the year makes these outdoor activities particularly vulnerable. Summer rainfall has been relatively low over the last decade, benefiting park usage. However, if a postulated return toward wetter weather does occur in the

Northeast, it has the potential to influence visitation Park funding, staffing, and rates significantly. facilities must be flexible enough to handle the range of variations in climate impacts. Even more vulnerable are winter activities such as skiing and snowmobiling. Though less popular than summer uses of the parks, these off-season visitors are even more likely to be affected by an apparent increase in winter temperatures that would shorten the snow season. Historical use rates in the state's parks, particularly in the southeastern portions of the state, could be overoptimistic if winter temperatures continue to rise. At the very least, the type of activity visitors engage in may change. Not only do these effects have financial and management implications for park managers, but they also have an impact on all of us as individuals. Outdoor recreation is one of the most direct ways in which people are affected by the climate. Given the population of Pennsylvania and the popularity of its parks, this paper demonstrates how even small variations or trends in climate can potentially affect the lives and activities of millions of people. A future study with longer term records of park visitation may be able to more fully examine some of these interesting cases of climate vulnerability.

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