EFFECTS OF WEATHER CONDITIONS ON TOURISM SPENDING: IMPLICATIONS FOR FUTURE TRENDS UNDER CLIMATE CHANGE

Keywords: tourism expenditure, outdoor recreation, travel behavior, boosted regression trees, nature-based tourism

ABSTRACT

Tourism is an important industry to many regions around the world and has the potential to substantially impact local communities. Climate change is expected to influence tourism since weather patterns help determine where and when people travel. In this analysis, the effect of weather conditions on tourism-related spending at three geographically distinct locations in Maine, USA was evaluated. A nonparametric method (boosted regression trees) was used to first identify the relative influence of twenty-two weather variables as predictors of tourism spending. Following this, a parametric model was constructed to statistically evaluate tourism spending across different measures and predict potential spending changes due to a warming climate. Results indicated that warmer temperatures increased tourism spending in the summer and fall, but had more varying results in the winter. Findings suggest tourism businesses in Maine and other relatively colder destinations could capitalize on potential gains in warmer months.

1. INTRODUCTION

Tourism is important to economies all over the world, accounting for 10.2% of the world's GDP in 2016, and expected to increase by 3.8% in 2017 (World Travel & Tourism Council 2017). In the United States, tourism contributed $1.51 trillion to GDP (8.1%) and supported 14.2 million jobs (World Travel & Tourism Council 2017). Because tourism plays such a critical role in the economies of many areas, it is important to examine and understand any potential changes to tourism patterns that could occur. An array of global changes have been impacting the tourism industry recently, including terrorism, environmental changes resulting from climate change, and diseases such as Severe Acute Respiratory Syndrome. These changes have been shown to impact tourism demand, which would likely impact local economies (Henderson 2003; Raza and Jawaid 2013; Min, Lim, and Kung 2011; Wilder-Smith 2006; Gössling et al. 2012).

Tourism is one of the largest industries in the state of Maine, so fluctuations in tourism could have noticeable impacts on the State's economy; for example, in 2016 tourism generated $5.99 billion in direct expenditure (Maine Office of Tourism 2017, 19). Given the low population density and high coverage of wilderness and forested areas as well as coastal assets, much of the tourism in the State is outdoor-recreation based. Popular activities include hiking, biking, boating, fishing, hunting, camping, snowmobiling, and skiing. However, most of these activities are weather-dependent, so changing weather patterns resulting from overall climate change could have an impact on visitation patterns and therefore the economy of Maine.

1.1. Weather, Climate, and Tourism

The tourism industry is highly dependent on weather and climate, since these factors help determine where people travel and the quality of their experience (Becken and Hay 2007; Becken 2012; Denstadli and Jacobsen 2014; Denstadli, Jacobsen, and Lohmann 2011). Weather is defined as the "atmospheric condition at any given time or place," whereas climate is "the average weather across a period of over 30 years" (United States Environmental Protection Agency 2013). While climate and weather are important for destination selection, weather is also influential during the trip, altering activities, travel plans, and the length of stay. Not only is the actual weather important for tourism, but visitors' perceptions of the weather can also impact travel behavior (Denstadli, Jacobsen, and Lohmann 2011). Although climate consists of many atmospheric and meteorological parameters, air temperature is thought to be the most important climatic factor for summer tourism, and snow cover for winter tourism (Matzarakis 2006).

Weather has been shown to impact visitors' travel and experiences; for example, in New Zealand, 39% of international tourists changed the timing of their trip due to weather, and 51% changed activities while on vacation (Becken and Wilson 2013). In Austria, a recent study found that weather during peak season altered domestic overnight stays, with sunshine and temperature having a positive correlation, and precipitation having a negative effect (Falk 2014). Many tourism-related business owners recognize that the weather impacts their company, although precise effects are unknown (Rauken et al. 2010). Weather impacts visitors, so changing weather patterns resulting from climate change will likely alter the behavior of tourists in a region.

Previous studies have projected that tourism demand and seasonality will shift globally based on different climate change scenarios (Amelung, Nicholls, and Viner 2007; Gössling et al. 2012). When modeling temperature and precipitation under climate change scenarios in a Canadian national park, visitation was expected to increase as a result of projected changes (Scott, Jones, and Konopek 2007). Additionally, models predict that visitation at 95% of U.S. national parks will change with future temperature projections (Fisichelli et al. 2015). Although many studies predict how visitation might change under climate change scenarios, this study is unique in that it focuses on tourism-related spending rather than visitation numbers.

1.2. Tourism Spending and Weather

Climate change is expected to have a sizeable impact on the natural amenities that support tourism, which would alter tourism demand and destination selection. Therefore, it is expected that changes in tourism flows – as a result of climate change – would impact regional economies (Amelung and Moreno 2011). Although many studies investigate the impacts of weather and climate change on visitation, there is limited research on economic impacts. Additionally, most of the research on the impacts of weather on outdoor recreation and tourism spending has focused on winter weather (Burakowski and Magnusson 2012; Shih, Nicholls, and Holecek 2009; Pütz et al. 2011; Dawson and Scott 2013; Strasser et al. 2013), but a larger gap exists on the impact of summer weather on tourism spending.

In winter months, the value added to the U.S. economy from skiing and snowboarding is $10.7 billion annually, and $1.5 billion from snowmobiling (Burakowski and Magnusson 2012). The large impacts provide an idea of how changes in winter recreation habits as a result of warmer temperatures (and less snow) have the potential to alter local and state economies. A recent study in Maine found a 14% difference in skier visits, which corresponded to a loss of $27.1 million in revenue over two years, due to lower snowfall years (Burakowski and Magnusson 2012). In Michigan, Shih, Nicholls, and Holecek (2009) found that each inch of snow depth increased daily alpine ski lift ticket sales by 7 to 9%, and that increasing temperature had a negative impact on ticket sales. Outside of the United States, Pütz et al. (2011) found that climate change is likely to damage regional economies in the Swiss Alps, although the size of the impact varies depending on the location. In general, previous studies on winter weather conditions and tourism have focused on skiing and snowboarding, whereas other winter recreation activities can include ice-fishing and snowmobiling. This is particularly the case in Maine.

Although there is limited research on the impact of weather and climate change on tourism spending in the summer, a few studies have addressed this topic. For example, Bigano et al. (2008) predicted changes in gross domestic product across all seasons around the globe resulting from sea-level rise and changing tourism flows, but these changes vary by country. In addition to long-term climatic changes altering tourism flows and spending, research has shown that daily weather does affect consumer spending as well. A recent study found that temperature, snowfall, sunlight, and humidity all had a significant impact on daily sales at a large retail store in North America, with the effect of sunlight being dependent on the temperature (Murray et al. 2010). In Maine, most of the tourism spending occurs in the summer months and could be quite sensitive to weather patterns.

1.3. Climate Change and Tourism in Maine

In Maine, average annual temperature has increased by 1.7 °C from 1895 to 2014, and average annual precipitation has increased by 15 cm (13%). Most of the precipitation increase has occurred during the fall and summer, with more frequent and intense storms (Fernandez et al. 2015). By 2050 in Maine, models project an additional 1.1 to 1.7 °C increase in average annual temperature and a 1 to 7% increase in precipitation, with more precipitation variability predicted, and more of the precipitation falling as rain and less as snow (Fernandez et al. 2015).

Fishichelli et al. (2015) modeled the change in visitation to national parks based on temperature projections and predicted Acadia National Park, located in Maine, to have an increase in visitation by 2041-2060. However, this study was based on temperature projections and did not include other climatic or ecological changes that are predicted to occur with climate change. In contrast, a recent study showed that a majority of summer visitors to Acadia National Park thought climate change would have negative consequences. In particular, visitors expressed concern over environmental changes including sea level rise, the increase in extreme temperatures, the greater frequency of rain and storms, and the effects on endemic wildlife (De Urioste-Stone, Scaccia, and Howe-Poteet 2015). Additionally, visitors to Acadia reported they were likely to change their future travel to the island if there were hurricanes, extreme weather, and increased mosquitos, and they had the highest level of risk perceptions for extreme weather (De Urioste-Stone et al. 2016). However, fewer studies have assessed the influence of observed weather on tourism spending at these locations.

In addition, climate change is also expected to impact winter tourism in Maine. Research predicts that the snowmobile season in northwestern Maine will be reduced by 21% between 2040-2069 under a low emissions scenario, or 29% under a high emissions scenario (Scott, Dawson, and Jones 2008). Of the current fourteen alpine ski locations in Maine, it is predicted that only 57% will maintain a season length of at least 100 days by 2040-2069 under low emissions scenarios, or 50% under high emissions scenarios (Dawson and Scott 2013). Given the potential economic impacts of changing weather and the fact that these impacts will vary depending on the tourism activities pursued in the area, this study examined three geographically distinct locations in Maine with different outdoor-recreation attractions.

Consequently, the objectives of this study are to (1) investigate the impacts of weather conditions on spending in three Maine tourism destinations and (2) predict how climatic changes could impact tourism-related spending in the future.

2. METHODOLOGY

2.1. Study Site

Maine, United States of America

Maine is located in the northeastern part of the United States and is the most forested state, with about 90% of land cover being forests (Forests for Maine's Future 2011). Two of the largest industries in the state are forest products and tourism. The tourism industry in Maine is primarily nature-based, and the diverse land and seascapes allow for participation in a variety of outdoor-recreation and tourism activities. In 2016, Maine had a total of 18.9 million tourism-related overnight visits and 22.3 million day visits, of which most were from out-of-state. Of overnight visitors, 51.3% visited in the summer, 32.3% visited in the fall, and 16.4% in the winter (Maine Office of Tourism 2017, 17-18).

Three study sites within the state of Maine were chosen for their well-established tourism industries and their diversity of outdoor recreation activities (Figure 1). The boundaries for each study area were drawn by using the state of Maine's boundary lines for Economic Summary Areas (ESAs), which group towns together for the purpose of collecting and sharing economic data (State of Maine Office of Policy and Management 2014). The study sites capture an array of outdoor recreational activities: (1) Mount Desert Island (MDI), the location of Acadia National Park, allows for coastal water activities such as whale-watching and going to the beach, (2) Bethel has mountains that are developed for winter recreation activities such as alpine skiing, and (3) Millinocket is a mountainous destination for both winter and summer recreational activities including backpacking and snowmobiling, but does not offer alpine skiing.

(FIGURE 1)

Mount Desert Island (MDI), Maine

Mount Desert Island is a 280 km^2 island on the Eastern coast of Maine in the Downeast and Acadia tourism region. This study site is defined by the Bar Harbor ESA and includes all four towns on the island. The island has a total population around 10,000, with Bar Harbor being the largest town (United States Census Bureau 2010). Acadia National Park is the main attraction on the island, occupying over 120 km^2 and receiving 2.5 to 3 million visits each year, most of whom visit in the summer (National Park Service 2012). In 2016, 93% of 3.3 million visits occurred from May-October, with July and August being the most popular months (National Park Service 2017). The towns on Mount Desert Island rely heavily on tourism, as many visitors to Acadia shop, dine, and lodge at communities on MDI.

The Millinocket region, Maine

The Millinocket region is in the Maine Highlands tourism region and is within the boundaries of the Millinocket ESA, which has a total population of around 7,800 (United States Census Bureau 2010). One of the main attractions in this area is Baxter State Park, the largest state park in Maine, which features the end of the Appalachian Trail and Maine's tallest mountain, Katahdin. This area also has popular winter recreation activities, including Nordic skiing, ice fishing, snowshoeing, and snowmobiling. It is especially known for having an extensive snowmobile trail network, with options to rent snowmobiles or go on guided tours.

The Bethel region, Maine

The Bethel region is in the Maine Lakes and Mountains tourism region and is defined by the Rumford ESA. The largest towns are Rumford (population 5,840) and Bethel (population 2,607), but the total population of this ESA is around 21,000 (United States Census Bureau 2010). This area has two ski resorts and is known for its alpine skiing. Bethel also promotes a variety of outdoor recreation activities, including dogsledding, fishing, hiking, ice-skating, tubing, snowshoeing, and snowmobiling. This area is mostly known for winter tourism, but has focused on increasing summer tourism through promoting the region as a great hiking, wedding, and golfing destination (Bethel Area Chamber of Commerce 2014).

2.2. Study Design

The purpose of this study is to better understand the impacts of changing weather patterns in the three Maine tourism destinations over the past ten years, in order to aid decision-making and better understand how climatic changes could alter tourism spending. The researchers hypothesize that temperature would have a positive correlation with summer and fall tourism-related spending, but a negative correlation with winter tourism-related spending. This is predicted because Maine is a colder destination compared to the rest of the U.S. so increasing temperatures might attract more people during the summer, but increasing temperatures in the winter decreases the likelihood of there being snow for winter recreation. Additionally, it is predicted that precipitation would decrease tourism spending in the summer and fall, but increase spending in the winter because it allows for snow-related outdoor recreational activities.

The research design approach is ex post facto since all data collection is from the past, and the independent variables (weather) cannot be manipulated (Black 1999). Tourism-related spending, which is the dependent variable in the analysis, was estimated using monthly taxable restaurant, lodging, and retail sales from January 2004 to December 2014 for each of the three Economic Summary Areas (State of Maine Office of Policy and Management 2014). To adjust for inflation, all spending was converted to December 2014 dollars. The explanatory variables of main interest are the weather conditions, described below, that were compiled from the National Oceanic and Atmospheric Administration (NOAA). The weather stations used were located in Acadia National Park, Millinocket, and Rumford, each inside of the study sites. All data was compiled on a monthly temporal resolution, utilizing all 18 weather variables NOAA recorded on a monthly scale from Jan 2004 to Dec 2014 (NOAA 2014). These variables include different measures of temperature (mean minimum temperature, highest temperature, number of days with maximum temperature under 32 °F, etc.) and precipitation (total precipitation, maximum snow depth, number of days with certain amounts of precipitation, etc.).

In addition to all of the NOAA monthly weather variables, four other independent variables were created to test their possible influence on spending: Number of days per month with storm events, proportion of days with any snow, proportion of days with six inches or greater of snow, and proportion of days with twelve inches of snow or more. The number of days with severe storm events was created using the NOAA storm database, and this includes events such as tornados, lightning, hailing, flooding, blizzards, heavy snowing, and tropical storms (NOAA 2014). The proportion of days with certain amounts of snow was created using daily weather data and categorizing it by month. These variables were added to test the potential impact of storm events and the ability of visitors to participate in winter activities.

Although we expect weather conditions to affect visitor spending in Maine, a wide range of other factors related to overall economic conditions are apt to influence tourist behavior. To account for these factors, the regression models include an explanatory variable that measures monthly tourism-related spending in Maine, but outside the region of interest. This variable captures effects on tourism spending related to, among other things, recessions (i.e, the entire state experienced a reduction in tourism spending), and fluctuations in gasoline prices (i.e., high gas prices during the period of analysis could affect tourist behavior).

2.3. Data Analysis

The first step of the analysis was to perform nonparametric boosted regression trees (BRTs). This approach was used to identify the most influential variables – among the 22 weather conditions, the variable measuring statewide tourism spending, month and year – explaining inflation-adjusted tourism-related spending (Elith, Leathwick, and Hastie 2008). To adjust for seasonality, three separate BRTs were estimated for each study area, resulting in a total of nine BRTs. The summer season covered the months of May to August, the fall season was September to November, and winter was defined as December to April. Therefore, the sample size for each location was 44 (summer), 33 (fall), and 55 (winter), since data was collected from 11 years.

BRTs were run using all of the weather variables, month, year, and total Maine taxable consumer spending (outside the region of interest) as the independent variables, and tourism-related spending as the dependent variable. The BRTs were used as a means to rank all of the weather conditions and other variables and their relationship with the dependent variable. Therefore, key assumptions about what independent variables might be influential did not have to be made as required in parametric models.

After the most influential variables were identified through the BRTs, linear mixed effects analysis of covariance (ANCOVA) was conducted for each location to statistically evaluate the relationships across year and season (Johnson and Wichern 2002). Because many of the temperature variables were correlated, mean maximum temperature was used since it had the highest rate of influence for temperature measures. The ANCOVA used mean monthly maximum temperature, days with precipitation, and total Maine consumer spending (minus the ESA being studied) as independent variables with fixed effects, and year as a random effects variable. Year is treated as random effect because there were multiple observations per year and the effect should have largely been captured by the total Maine consumer spending for that year. ANCOVAs were conducted for each location using all three independent variables, each variable individually without the others, and combinations of two variables. AICs were compared between the six model options for each location and season, and the model with the lowest AIC was chosen, unless adding another variable did not lower the AIC by ten or greater.

Finally, a mixed effects ANCOVA was then conducted by combining all locations, seasons, and years. In this combined model, location, season, and their interaction were included as covariates. Both linear and curvilinear models were evaluated by comparing AICs and residuals. The final model was then used to forecast tourism spending at higher mean monthly temperatures based on the entire span of the temperature data used to create the model from that season, plus projecting out to 1.7°C above the largest value. Projections spanned an additional 1.7°C warmer because IPCC models for Maine predict the average annual temperature will increase by 1.1 to 1.7 °C between 2015 and 2050 (Fernandez et al. 2015). All statistical analyses were performed using the statistical software R v 3.1.1 (R Development Core Team 2015).

3. RESULTS

3.1. Area Characteristics

Table 1 shows the mean monthly tourism-related spending, maximum temperature, and number of days with precipitation by location and season. Mount Desert Island and Millinocket have the greatest spending in the summer and least in the winter, while Bethel has the greatest spending in the winter and least in the fall. Furthermore, spending on MDI in the summer is over 13 times greater than spending in the winter. Temperature among the locations is comparable, with MDI being slightly cooler in the summer and warmer in the winter. All three locations have the greatest number of days per month with precipitation in the summer.

(TABLE 1)

3.2. Boosted Regression Trees

Of all variables used in the BRT, Table 2 shows the five most influential variables for each season and location. Total Maine consumer spending, which represents the general state of the economy, was influential in 66% of the cases. Although a few different measures of temperature returned as influential in each BRT, only mean maximum temperature was used for additional analyses since these variables were all highly correlated. Temperature variables were the most influential variable in 33% of the cases, and total Maine spending was the most influential in 44%. Precipitation variables only returned as influential for MDI in the winter and Bethel in the summer, and the level of influence was relatively low.

(TABLE 2)

3.3. ANCOVA by Location

Figure 2 shows the relationship between temperature and tourism-related spending across all seasons and locations from 2004-2014. Spending was transformed on a natural log scale to increase normality. During the summer and fall, spending tends to increase as mean maximum temperature increases. In the winter, mean maximum temperature has a negative relationship with spending in Bethel and Millinocket, but a positive relationship in MDI. The slope of the line is greatest in MDI for the fall and summer. Overall, there is more unexplained variation in the data for the winter models, particularly for Millinocket in the winter.

(FIGURE 2)

Results found that temperature was a statistically significant predictor of tourism-related spending in MDI for the summer and fall, in Bethel for the winter, and in Millinocket for the fall and winter. Precipitation was significant in the winter for MDI and Millinocket, and had a positive relationship with tourism spending in MDI, but a negative relationship in Millinocket. Maine consumer spending was significant in MDI in the winter, in Bethel in the summer and fall, and in Millinocket in the summer and winter.

3.4. ANCOVA Across Locations

Table 3 shows the regression results for this model, which includes Maine consumer spending, mean maximum temperature, days with precipitation, season, location, and the interaction of them as covariates. It also includes a term for mean maximum temperature + mean maximum temperature^2, which would suggest that the relationship is curvilinear rather than linear. AIC indicated that the curvilinear term significantly improved model fit.

Overall, this model explained 92.5% of the original variation in the spending data, and indicated that both mean maximum temperature (p=0.030) and Maine consumer spending (p=0.000) were significant.

(TABLE 3)

Figure 3 displays the regression model's predictions for tourism-related spending compared to the actual values. Overall, the residuals were normal and the model was not generally over or under-predicting. Residuals tended to be larger for greater values, which was likely because spending in MDI during the fall and summer seasons was much larger than every other location and season. Therefore, there were fewer data points at the upper end of the data.

(FIGURE 3)

The combined model was then used to forecast tourism spending under a potential climate change scenario of higher temperatures. The number of days with precipitation was not used to model future spending under climate change scenarios since it was not a significant variable in the combined model. Results show tourism spending increasing as temperature increases across all locations for the summer and the fall (Figure 4). In winter, predicted spending has a parabolic relationship with temperature, increasing at higher and at lower temperatures, with 4.6°C having the lowest predicted spending for all three locations.

(FIGURE 4)

Table 4 shows example scenarios of how much tourism-related spending would be altered by having an increased mean maximum temperature. Examples show a temperature increase of 1.1°C and 1.7°C and corresponding predicted spending. The percent increase in spending with warmer temperatures is greatest in the summer across all locations. Bethel and Millinocket predictions show a slight decrease in spending during the winter months.

(TABLE 4)

4. DISCUSSION

Overall, results from the initial BRT analyses highlighted that temperature was an influential predictor of tourism-related spending, while other weather variables such as precipitation and snow depth, were largely non-influential. Of the four new variables created measuring stormy days and proportion on the month with snow, none were found to be influential. However, a variety of different temperature variables were influential (e.g., heating degree days, extreme minimum temperature, mean maximum temperature), but since they are generally highly correlated, only monthly mean maximum temperature was used in the parametric regression models.

Temperature had a positive effect on tourism spending in MDI, Bethel, and Millinocket in the summer and fall. As temperature increases, spending is projected to increase across all locations in the fall and summer, but decrease spending in some of the winter months as initially hypothesized. In the initial exploratory regression models by location, the winter models have greater variation in the data, particularly Millinocket in the winter. This likely makes sense because that area has such a wide variety of recreational activities possible in the winter (hiking, mountain biking, Nordic skiing, snowmobiling) that would have different temperature preferences. Therefore, the correlation between temperature and spending would not be expected to be as strong in this location and season. In contrast, Bethel is more straightforwardly an alpine ski location, so warmer temperatures would melt snow and deter that group from spending money in the area.

However, gains in the summer and fall are expected to be much greater than the losses in the winter, thus having an overall positive net effect for the state. In the winter, spending was predicted to be lowest at 4.6°C across all locations, but increase as it got warmer or cooler. Warming in the winter could decrease spending during colder months because warmer temperatures may not allow for snow and ice depth to be great enough for outdoor activities such as ice fishing, skiing, and snowmobiling. However, once it warms beyond 4.6°C, spending starts to increase again. This could be because activities requiring snow and ice are not possible at that temperature, and warming beyond 4.6°C would then allow other outdoor recreational activities, such as hiking and biking.

Results are consistent with findings from previous studies. When evaluating the impact of temperature on visitation to Acadia National Park, visitation was projected to increase under climate change scenarios (Fisichelli et al. 2015). It has also been expected that warmer temperatures would be beneficial to parts of the northern U.S., since regions that are cooler would have an extended warm season (Scott, McBoyle, and Schwartzentruber 2004). Other studies that assessed the impact of weather on tourism demand have often focused on temperature variables, as other climatic variables tend to be irrelevant in models (Rosselló-Nadal 2014). Our results also did not indicate non-temperature variables to be influential.

In our analysis, which differed from other studies, temperature and tourism spending exhibit a parabolic relationship in winter months. For example, Shih, Nicholls, and Holecek (2009) found increasing winter temperatures to have a negative impact on ski lift ticket sales. While this was consistent with our findings up until 4.6°C, the relationship between tourism spending and temperature was positive above this threshold. Since three locations in Maine were analyzed and only one had alpine skiing, results from the combined model cannot be directly compared to studies focusing only on alpine skiing. Nevertheless, we believe this is an important and interesting finding that deserves additional focus in future studies.

One reoccurring theme found in studies evaluating the impact of climate change on tourism is that often only temperature is considered, whereas climate change alters many weather variables in addition to temperature. This was ameliorated by first using a robust nonparametric method with all recorded weather data in order to eliminate more subjective approaches to determining influential variables. Regardless, temperature variables were the ones found to be most influential in the analysis, even though other climatic variables have been suggested to be important to tourism (Matzarakis 2006). Future studies may consider deriving climate variables on a daily scale to better understand small fluctuations in weather patterns.

Although it was originally hypothesized that precipitation would negatively impact spending in the summer and fall and positively impact spending in the winter, precipitation was only found to be significant in two of the study sites during the winter. In MDI, the relationship was positive, but it was negative in Millinocket. As expected, one possible explanation for the negative relationship found between tourism and winter precipitation in Millinocket is that although snow allows for more outdoor activities, it also makes travelling to a destination more dangerous and difficult. Therefore, visitors may forgo travelling by car to relatively remote areas, such as Millinocket. Further studies are needed to understand how non-temperature variables impact tourists' behavior and spending, and how their trip planning would change if increased precipitation became the new normal.

A previous study in Acadia found that among the tourists who believed climate change would impact tourism on the island, a majority believed it would have a negative effect (De Urioste-Stone, Scaccia, and Howe-Poteet 2015). Although results from that study contrast with our finding that climate change is predicted to have a positive effect on the MDI region, visitors' individual perceptions could be different than collective behavior. Additionally, visitors could perceive the negative impacts of indirect factors, such as species loss or sea level rise, that were not accounted for in the model.

Although results show tourism spending is expected to increase with climate change, some caution must be used in interpreting these results. Our results aim to predict potential changes to tourism spending by analyzing past weather conditions. However, the models do not take into consideration how changing climate will alter ecosystems, which could also impact visitation. For example, warming temperatures may correspond to the loss of species or the spread of vector-borne diseases (such as Lyme disease). These conditions may deter visitors from a destination, even if they prefer warmer temperatures. To understand ecological effects on tourism, future studies could survey visitors to see why they visit a particular area and what would prevent them from returning. Although this research only aimed to understand the impact of weather on future visitation under climate change, it would be helpful to see how weather, combined with other factors expected to change due to climate change, would impact future visitation. Coastal areas in particular could incorporate projected effects of sea level rise into models of future visitation. Visitor surveys could be administered to understand intended future visitation under various conditions, and that data could help inform which dependent variables to include in modeling. Additionally, future research could investigate the impacts of different conditions on visitation and spending based on what recreational activities the visitor enjoys.

5. CONCLUSION

As temperatures rise across the globe, a comparatively cooler climate, such as that in Maine, could draw larger crowds and boost the local economy in several months per year (Scott, McBoyle, and Schwartzentruber 2004). Temperature in Maine is expected to increase by 1.1 to 1.7 °C by 2050, which would change tourism spending and alter the local economy. If temperatures continue to rise as projected, the three locations are predicted to experience on average a 8.1 to 13.5% increase in summer tourism spending by 2050. In contrast, winter spending is forecasted to have a smaller change, decreasing by 0.6-1.4% in Bethel and Millinocket, and increasing by 0.2 to 0.5% in MDI. Overall, our findings show a net positive impact on spending associated with an increase in mean maximum temperature in Maine.

Findings from this study are useful for long-term tourism planning within these communities. Businesses in these regions could develop strategic plans to recognize spending is projected to increase with warmer temperatures in the future, assuming no changes in general tourism trends resulting from other factors. Potential long-term strategies to capitalize on this opportunity would be to increase infrastructure to accommodate more visitors and spending (or, alternatively, increase prices during peak season to reduce demand). Additionally, the results are useful for the parks and protected areas in the regions to better plan ahead for potentially larger crowds impacting the natural amenities. Finally, this study advances the current state of knowledge on how to assess the effect of weather on tourism by analyzing spending rather than visitation numbers, and by employing nonparametric methods to assess the impact of a multitude of highly correlated weather variables. Overall, this study indicates that climate change will positively influence tourism spending across three regions in Maine, but future studies should address how uncertainty and ecosystem change will impact tourism in order to more completely understand the relationship between climate change and tourism.

6. REFERENCES

Amelung, Bas, and Alvaro Moreno. 2011. "Costing the Impact of Climate Change on Tourism in Europe: Results of the PESETA Project." Climatic Change 112 (1): 83–100. doi:10.1007/s10584-011-0341-0.

Amelung, Bas, Sarah Nicholls, and David Viner. 2007. "Implications of Global Climate Change for Tourism Flows and Seasonality." Journal of Travel Research 45 (3): 285–96. doi:10.1177/0047287506295937.

Becken, Suzanne. 2012. "Measuring the Effect of Weather on Tourism: A Destination- and Activity-Based Analysis." Journal of Travel Research 52 (2): 156–67. doi:10.1177/0047287512461569.

Becken, Suzanne, and John E. Hay. 2007. Tourism and Climate Change: Risks and Opportunities. Clevedon: Channel View Publications.

Becken, Suzanne, and Jude Wilson. 2013. "The Impacts of Weather on Tourist Travel." Tourism Geographies 15 (4): 620-639. doi: 10.1080/14616688.2012.762541.

Bethel Area Chamber of Commerce. 2014. "Bethel: 2014 Visitor's Guide." http://www.bethelmaine.com/uploads/pdf/BethelVG2014-web.pdf.

Bigano, Andrea, Francesco Bosello, Roberto Roson, and Richard S. J. Tol. 2008. "Economy-wide Impacts of Climate Change: A Joint Analysis for Sea Level Rise and Tourism." Mitigation and Adaptation Strategies for Global Change 13: 765-791. doi: 10.1007/s11027-007-9139-9.

Black, Thomas R. 1999. Doing Quantitative Research in the Social Sciences: An Integrated Approach to Research Design, Measurement and Statistics. London: SAGE Publications.

Burakowski, Elizabeth, and Matthew Magnusson. 2012. “Climate Impacts on the Winter Tourism Economy in the United States.” https://www.nrdc.org/sites/default/files/climate-impacts-winter-tourism-report.pdf

Dawson, Jacky, and Daniel Scott. 2013. “Managing for Climate Change in the Alpine Ski Sector.” Tourism Management 35: 244–54. doi:10.1016/j.tourman.2012.07.009.

De Urioste-Stone, Sandra M., Lena Le, Matt D. Scaccia, and Emily Wilkins. 2016. “Nature-Based Tourism and Climate Change Risk: Visitors’ Perceptions in Mount Desert Island, Maine.” Journal of Outdoor Recreation and Tourism 13: 57-65. doi: 10.1016/j.jort.2016.01.003.

De Urioste-Stone, Sandra M., Matt D. Scaccia, and D. Howe-Poteet. 2015. “Exploring Visitor Perceptions of the Influence of Climate Change on Tourism at Acadia National Park, Maine.” Journal of Outdoor Recreation and Tourism 11 (October): 34–43. doi:10.1016/j.jort.2015.07.001.

Denstadli, Jon M., and Jens S. Jacobsen. 2014. “More Clouds on the Horizon? Polar Tourists' Weather Tolerances in the Context of Climate Change.” Scandinavian Journal of Hospitality and Tourism 14 (1): 80-99. doi: 10.1080/15022250.2014.886096

Denstadli, Jon M., Jens S. Jacobsen, and Martin Lohmann. 2011. “Tourist Perceptions of Summer Weather in Scandinavia.” Annals of Tourism Research 38 (3): 920–40. doi:10.1016/j.annals.2011.01.005.

Elith, J., J. R. Leathwick, and T. Hastie. 2008. "A Working Guide to Boosted Regression Trees." Journal of Animal Ecology 77: 802-813.

Falk, Martin. 2014. "Impact of Weather Conditions on Tourism Demand in the Peak Summer Season Over the Last 50 Years." Tourism Management Perspectives 9: 24–35. doi:10.1016/j.tmp.2013.11.001

Fernandez, I., C.V. Schmitt, S.D. Birkel, E. Stancioff, A.J. Pershing, J.T. Kelley, J.A. Runge, G.L. Jacobson, and P.A. Mayewski. 2015. "Maine's Climate Future: 2015 Update". Orono, ME: University of Maine.

Fisichelli, Nicholas A., Gregor W. Schuurman, William B. Monahan, and Pamela S. Ziesler. 2015. "Protected Area Tourism in a Changing Climate: Will Visitation at US National Parks Warm Up or Overheat?" PloS One 10 (6). doi:10.1371/journal.pone.0128226.

Forests for Maine's Future. 2011. "FAQ's about Maine's Forests." http://www.forestsformainesfuture.org/forest-facts/ (accessed August 4, 2015).

Gössling, Stefan, Daniel Scott, C. Michael Hall, Jean-Paul Ceron, and Ghislain Dubois. 2012. "Consumer Behaviour and Demand Response of Tourists to Climate Change." Annals of Tourism Research 39 (1). Elsevier Ltd: 36–58. doi:10.1016/j.annals.2011.11.002.

Henderson, Joan C. 2003. "Terrorism and Tourism Terrorism and Tourism : Managing the Consequences of the Bali Bombings." Journal of Travel & Tourism Marketing 15 (1):41-58. doi:10.1300/J073v15n01.

Johnson, Richard A. and Dean W. Wichern. 2002. Applied Multivariate Statistical Analysis. 5th ed. Singapore: Pearson Education.

Maine Office of Tourism, 2017. “Maine office of tourism visitor tracking research: 2016 calendar year annual report.” https://visitmaine.com/assets/downloads/2016-MOT-Annual-Report.pdf.

Matzarakis, Andreas. 2006. “Weather and Climate related Information for Tourism.” Tourism and Hospitality Planning & Development 3 (2): 99-115. doi: 10.1080/14790530600938279

Min, Jennifer C. H., Christine Lim, and Hsien-Hung Kung. 2011. “Intervention Analysis of SARS on Japanese Tourism Demand for Taiwan.” Quality & Quantity 45 (1): 91–102. doi:10.1007/s11135-010-9338-4.

Murray, Kyle B., Fabrizio Di Muro, Adam Finn, and Peter Popkowski Leszczyc. 2010. “The Effect of Weather on Consumer Spending.” Journal of Retailing and Consumer Services 17 (6): 512–20. doi:10.1016/j.jretconser.2010.08.006.

National Park Service. 2012. “A Guide’s Guide to Acadia National Park.” http://www.nps.gov/acad/upload/Guide-s-Guide-3-856-KB-2.pdf

National Park Service. 2017. “Acadia NP Recreation Visits.” https://irma.nps.gov/Stats/SSRSReports/Park%20Specific%20Reports/Visitation%20by%20Month?Park=ACAD.

NOAA. 2014. “National Climactic Data Center.” http://www.ncdc.noaa.gov/ (accessed January 8, 2015).

Pütz, Marco, David Gallati, Susanne Kytzia, Hans Elsasser, Corina Lardelli, Michaela Teich, Fabian Waltert, and Christian Rixen. 2011. “Winter Tourism, Climate Change, and Snowmaking in the Swiss Alps: Tourists’ Attitudes and Regional Economic Impacts.”

Mountain Research and Development 31 (4): 357–62. doi:10.1659/MRD-JOURNAL-D-11-00039.1.

Rauken, Trude, Ilan Kelman, Jens Kr. Steen Jacobsen, and Grete K. Hovelsrud. 2010. “Who Can Stop the Rain? Perceptions of Summer Weather Effects Among Small Tourism Businesses.” Anatolia 21 (2): 289–304. doi:10.1080/13032917.2010.9687104.

R Development Core Team 2008. “R: A Language and Environment for Statistical Computing.” R Foundation for Statistical Computing. http://www.R-project.org.

Raza, Syed Ali, and Syed Tehseen Jawaid. 2013. “Terrorism and Tourism: A Conjunction and Ramification in Pakistan.” Economic Modelling 33 (July): 65–70. doi:10.1016/j.econmod.2013.03.008.

Rosselló-Nadal, Jaume. 2014. “How to Evaluate the Effects of Climate Change on Tourism.” Tourism Management 42 (June): 334–340. doi:10.1016/j.tourman.2013.11.006.

Scott, Daniel, Jacky Dawson, and Brenda Jones. 2008. “Climate Change Vulnerability of the US Northeast Winter Recreation – Tourism Sector.” Mitigation and Adaptation Strategies for Global Change 13 (5-6): 577-596. doi: 10.1007/s11027-007-9136-z

Scott, Daniel, Brenda Jones, and Jasmina Konopek. 2007. “Implications of Climate and Environmental Change for Nature-Based Tourism in the Canadian Rocky Mountains: A Case Study of Waterton Lakes National Park.” Tourism Management 28 (2): 570–79. doi:10.1016/j.tourman.2006.04.020.

Scott, Daniel, Geoff McBoyle, and Michael Schwartzentruber. 2004. “Climate Change and the Distribution of Climatic Resources for Tourism in North America.” Climate Research 27: 105-117.

Shih, Charles, Sarah Nicholls, and Donald Holecek. 2009. "Impact of Weather on Downhill Ski Lift Ticket Sales." Journal of Travel Research 47 (3): 359–72. doi:10.1177/0047287508321207.

State of Maine Office of Policy and Management. 2014. "Maine Taxable Retail Sales." http://maine.gov/economist/retail/index.shtml

Strasser, Ulrich, Andreas Gobiet, Johann Stötter, Hannes Kleindienst, Friedrich Zimmermann, Karl Steininger, Franz Prettenthaler et al. 2013. "CC-Snow II: Effects of Future Snow Conditions on Tourism and Economy in Tyrol and Styria." http://www.klimafonds.gv.at/assets/Uploads/Projektberichte/ACRP-2009/20130627CC-Snow-IIEndberichtUlrich-Strasser.pdf

United States Census Bureau. 2010. "Census of Population and Housing." http://www.census.gov/prod/cen2010/cph-1-21.pdf

United States Environmental Protection Agency. 2013. "Glossary of Climate Change Terms." http://www.epa.gov/climatechange/glossary.html

Wilder-Smith, Annelies. 2006. "The Severe Acute Respiratory Syndrome: Impact on Travel and Tourism." Travel Medicine and Infectious Disease 4 (2): 53–60. doi:10.1016/j.tmaid.2005.04.004.

World Travel and Tourism Council. 2017. "Travel & Tourism: Economic Impact 2017 United States." https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2017/unitedstates2017.pdf.

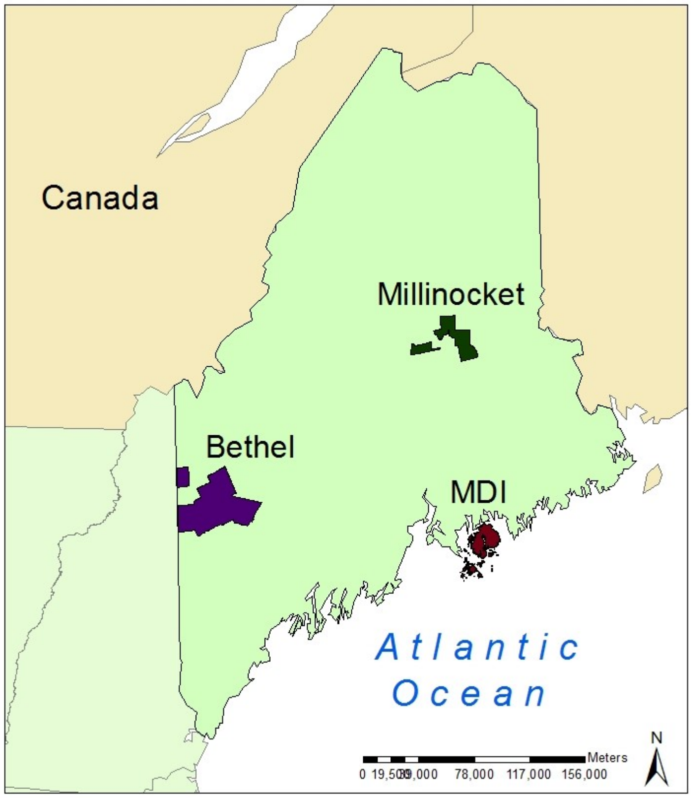

Figure 1. The three Economic Summary Areas (ESAs) studied within Maine. The western is the Bethel region, the northern is the Millinocket region, and the coastal is Mount Desert Island (MDI). The three study sites are spread throughout the state to create a better understanding of Maine tourism as a whole, and represent different climate regions.

Table 1. Mean monthly weather and spending variables and standard deviations for each of three study locations and three seasons.

	Season	Mean Monthly Tourism-Related Spending ($)	SD	Mean Monthly Maximum Temperature (°C)	SD	Mean Monthly Days with >0.254 cm Precipitation	SD
MDI	Summer	29,875,000	14,742,500	22.70	3.58	7.52	2.76
	Fall	17,273,500	12,137,800	14.96	5.18	7.06	2.37
	Winter	2,185,300	1,258,000	4.52	4.68	7.16	2.84
Bethel	Summer	3,549,900	802,200	23.51	3.31	9.41	3.19
	Fall	3,264,000	806,800	14.30	6.70	6.67	2.41
	Winter	6,083,000	1,905,800	2.56	5.82	6.20	2.61
Mill.	Summer	1,439,100	340,500	23.07	3.52	8.50	2.73
	Fall	1,126,200	429,700	13.54	6.16	7.27	3.01
	Winter	927,500	286,500	1.62	5.88	6.18	2.31

Table 2. A summary of the boosted regression trees' top five most influential variables to predict tourism-related spending for each location, adjusted for seasonality. Numbers indicate relative influence, out of a scale of 100 split between all influential variables.

	MDI		**Bethel**		**Millinocket**	
Summer	Heating degree days	57.6	Total Maine spending	52.9	Total Maine spending	52.3
	Mean monthly temperature	12.2	Month	13.2	Mean maximum temperature	18.1
	Total Maine spending	8.4	Days with a minimum temp. below freezing	10.5	Heating degree days	8.2
	Mean maximum temperature	6.3	Maximum daily precipitation	6.6	Extreme minimum temperature	6.0
	Month	3.9	Mean monthly temperature	6.1	Mean monthly temperature	5.1
Fall	Heating degree days	21.5	Total Maine spending	49.8	Mean maximum temperature	25.3
	Mean maximum temperature	21.0	Mean maximum temperature	24.2	Heating degree days	16.6
	Days with a minimum temp. below freezing	19.2	Mean minimum temperature	10.2	Cooling degree days	15.9
	Extreme minimum temperature	19.0	Cooling degree days	7.2	Days with a minimum temp. below freezing	15.2
	Extreme maximum temperature	7.9	Days with a minimum temp. below freezing	4.6	Extreme maximum temperature	10.9
Winter	Total Maine spending	47.9	Month	34.2	Month	49.5
	Month	44.3	Mean maximum temperature	19.2	Total Maine Spending	35.7
	Total precipitation	6.5	Heating degree days	16.4	Year	9.8
	Mean monthly temperature	0.5	Extreme maximum temperature	13.7	Days with a minimum temp. below freezing	5.0
	Extreme minimum temperature	0.4	Mean minimum temperature	10.7	NA	0.0

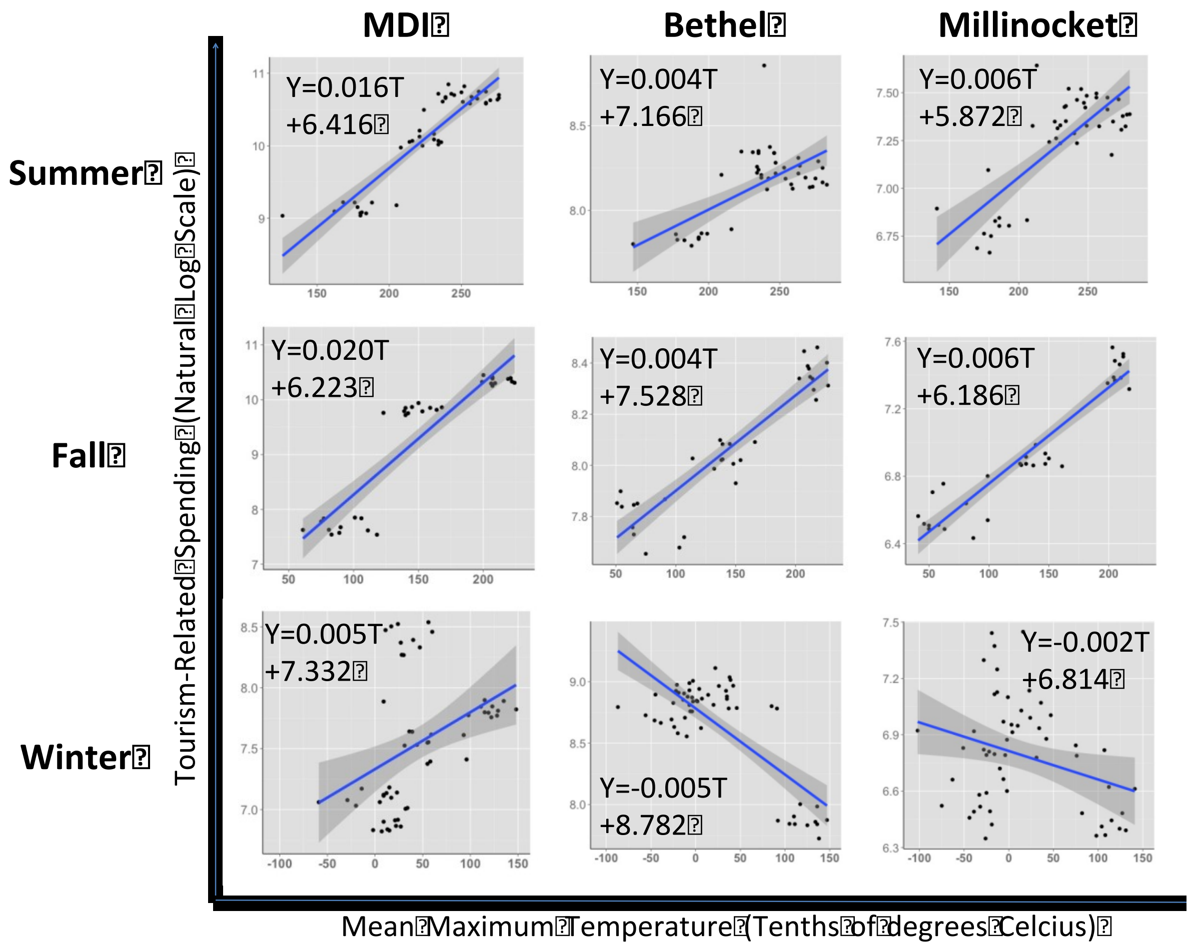

Figure 2. Scatter plots showing the relationship between monthly mean maximum temperature and tourism-related spending across all regions and seasons. The linear regression lines with degrees of uncertainty are also shown.

Table 3. Regression results for the combined model examining inflation-adjusted tourism-related spending (dependent variable). Total inflation-adjusted Maine spending, mean maximum temperature, days with precipitation, location, season, and the interaction of location and season are fixed covariates; year is a random variable. Data transformed on a natural log scale. R^2=0.9247.

	Value	**95% CI**	**df**	**t-value**	**p-value**
Intercept	439.484	317.47 – 608.39	373	37.425	<0.001
Total Maine spending	1.000	1.00 – 1.00	373	12.624	<0.001
Mean maximum temperature	0.998	0.99 – 1.00	373	-2.182	0.030
MMXT+MMXT^2	1.000	1.00 – 1.00	373	6.546	<0.001
Days with >0.254 cm inch precipitation	1.006	0.99 – 1.02	373	0.865	0.388
Location: MDI	4.415	3.74 – 5.21	373	17.967	<0.001
Location: Millinocket	0.355	0.30 – 0.42	373	-12.721	<0.001
Season: Summer	0.555	0.47 – 0.66	373	-6.923	<0.001
Season: Winter	2.454	2.01 – 3.00	373	9.008	<0.001
Location: MDI; Season: Summer	1.988	1.62 – 2.44	373	6.770	<0.001
Location: Millinocket; Season: Summer	1.176	0.97 – 1.43	373	1.639	0.102
Location: MDI; Season: Winter	0.104	0.08 – 0.13	373	-19.837	<0.001
Location: Millinocket; Season: Winter	0.480	0.38 – 0.60	373	-6.538	<0.001

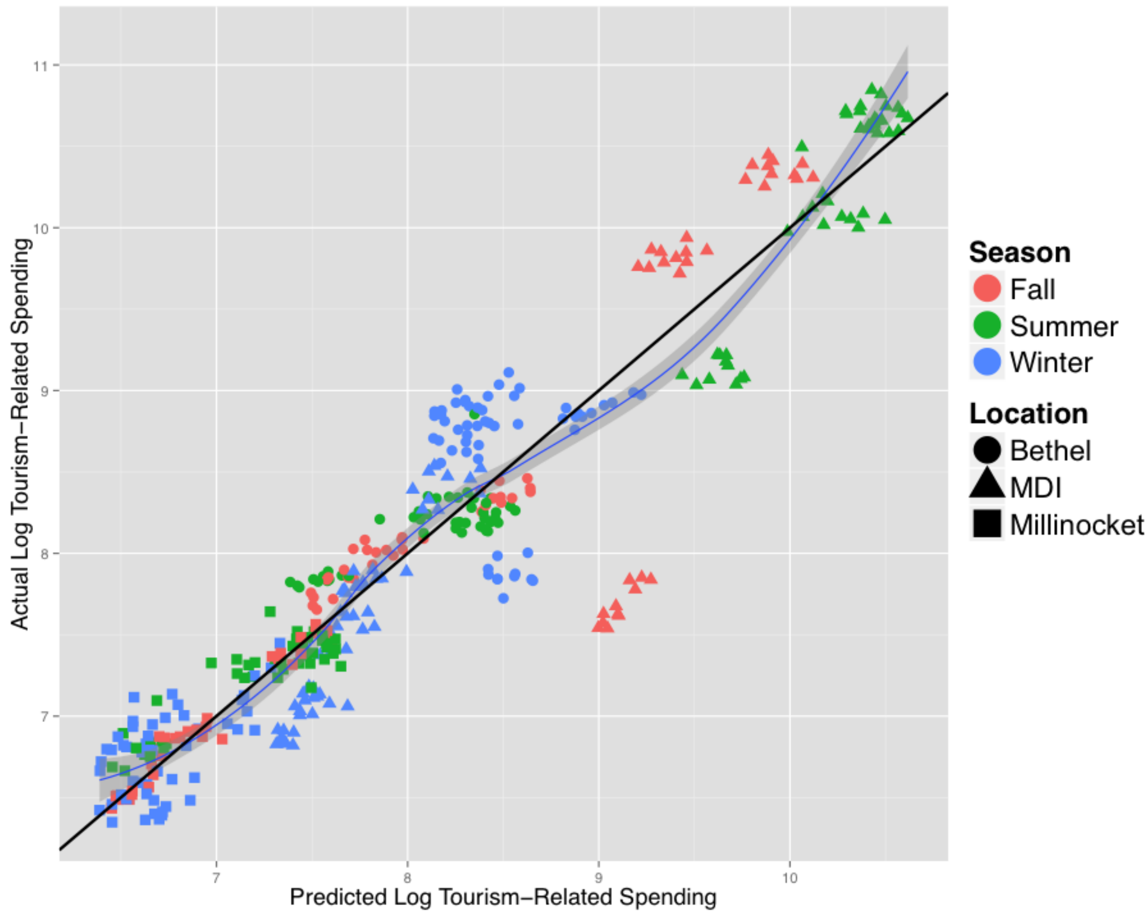

Figure 3. The predicted vs. actual tourism related-spending across all three regions and seasons transformed on a natural log scale. The straight line represents where predicted and actual spending are equal, and the curved line displays the data smoothed with a loess curve at α=0.05.

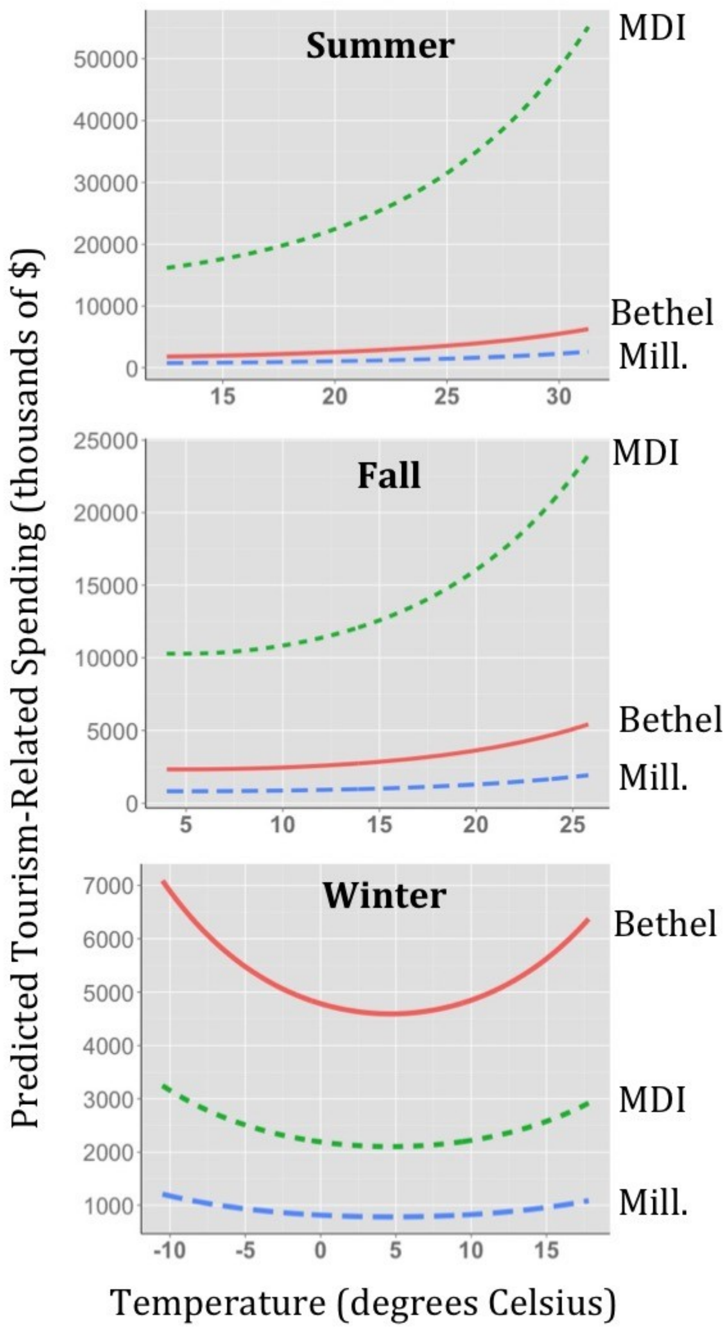

Figure 4. Predicted tourism-related spending in Bethel, MDI, and Millinocket across varying mean maximum temperatures.

Table 4. Tourism-related spending predicted from the combined model for the average mean maximum temperatures across seasons and locations, predicted spending at higher temperatures, and percent change in spending under higher average mean maximum temperature.

		Summer	**Fall**	**Winter**
MDI	Avg temp (°C)	22.7	15.0	4.5
	Spending ($)	26,650,885	12,585,588	2,104,499
	1.1°C increase ($)	28,796,466	13,227,384	2,108,047
	1.7°C increase ($)	30,096,744	13,526,096	2,114,060
	Low % change	8.1%	5.1%	0.2%
	High % change	12.9%	7.5%	0.5%
Bethel	Avg temp (°C)	23.5	14.3	2.6
	Spending ($)	3,211,413	2,776,174	4,629,649
	1.1°C increase ($)	3,481,527	2,896,619	4,600,929
	1.7°C increase ($)	3,645,346	2,970,231	4,594,194
	Low % change	8.4%	4.3%	-0.6%
	High % change	13.5%	7.0%	-0.8%
Millinocket	Avg temp (°C)	23.1	13.5	1.6
	Spending ($)	1,302,910	958,210	796,887
	1.1°C increase ($)	1,410,149	996,459	788,655
	1.7°C increase ($)	1,475,162	1,019,928	785,715
	Low % change	8.2%	4.0%	-1.0%
	High % change	13.2%	6.4%	-1.4%