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The Camping Climate Index (CCI): The development, validation, and application of a camping-sector tourism climate index

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ABSTRACT

Camping is a nature-based tourism activity where individuals spend one or more night away from home in an outdoor setting. Inherent in the definition are time and space, as well as exposure to natural elements such as weather or extremes. This study introduces the novel Camping Climate Index (CCI) to explore the impacts of weather and climatic variability on camping occupancy and optimal camping conditions. Daily meteorological data for 29 for-profit camping locations is analyzed and matched with daily camping occupancy data for the tent, recreational vehicle, and cabin categories. The CCI is empirically validated for camping behaviors compared to other tourism indices including the Tourism Climate Index and Holiday Climate Index. This study is the first to create an index using observed camping occupancy data for the three categories of camping matched with daily weather data that also captures the overriding effects of extreme/adverse weather events.

1. Introduction

Climate change has resulted in shifting seasonality, changing weather trends, and intensified extreme weather conditions (Reidmiller et al., 2018). Camping, the largest outdoor tourism sub-sector in the United States (Outdoor Industry Association, 2017), is particularly vulnerable to these changes warranting exploration. Researchers have examined the effects of weather and climatic variability for nature-based tourism across multiple activities including national park visitation (Hewer, Scott, & Gough, 2015), beach visitation (Lithgow, Martinz, GallegoSilva, & Ramirez-Vargas, 2019; Matthews, Scott, & Andrey, 2019), camping occupancy (Craig, 2019), and winter sports (Scott, Abegg, Pons, & Aall, 2017). Researchers have also used webcams to observe the effect of weather on nature-based tourism activities including park attendance during peak periods (Ibarra, 2011) and narrow periods during the day (Moreno, Amelung, & Santamarta, 2008). Nature-based tourism includes activities that occur in the natural environment away from one's home (Laarman & Durst, 1987; Tkaczynski, Rundle-Thiele, & Prebensen, 2015; Valentine, 1992). The consequences of climate change are expected to continue to have a considerable impact on outdoor tourism activities including camping and park visitation (Craig, 2019; Gössling, Hall, Peeters, & Scott, 2010; Katircioglu, Cizreliogullari, & Katircioglu, 2019; Koutroulis, Grillakis, Tsanis, & Jacob, 2018). While some climate change consequences can be catastrophic (e.g., natural disasters), others such as warming trends or shifts in seasonality create additional opportunities for outdoor activities, however. This is particularly true for the nature-based tourism activity camping (Craig, 2019; Hewer et al., 2015). Accordingly, we propose the empirical exploration of the temporal and spatial impacts of weather and climatic variability on the three categories of camping: tent, recreational vehicle (RV), and cabin.

The Camping Climate Index (CCI) is introduced, empirically tested, validated, and applied as a method to quantify the short- and long-term effects of weather and climatic variability for camping. Camping is an activity where individuals travel away from home to spend a night or more outdoors in a natural setting (Hewer et al., 2015). Camping is unique compared to other tourism activities because it is an outdoor activity itself, is an overnight accommodation, and is closely related to other outdoor activities including hiking, water sports, and site-seeing (Caim Consulting Group, 2019; Craig, 2019). In fact, a recent survey indicates that "campers are continuing to make strong connections between camping and other outdoor recreation activities, considering them to be one in the same" (Caim Consulting Group, 2019, p. 4). The number of active campers grew 4% from 2014 to 2018 to include 78.8

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million households (Caim Consulting Group, 2019), and camping has an annual economic impact of approximately $167 billion (Outdoor Industry Association, 2017). Considering the size and trajectory of the camping sector, the CCI can help camping organizations, both for-profit and non-profit, better understand the economic impacts of weather, climatic variability, and climate change.

Accordingly, the CCI addresses four gaps in the nature-based tourism literature by (1) introducing a camping sector index, (2) empirically testing relationships between weather variables and actual outcomes (i.e.., camping behaviors), (3) independently integrating extreme/adverse weather events into an index, and (4) empirically capturing seasonality using multiple methods. The remainder of this section will provide an overview of the relevant literature, followed by materials and methods, results and analysis, calculations, and discussion sections.

1.1. Climate change, weather, and camping

Climate change has altered the frequency and intensity of weather and extreme weather events, including heat waves, hurricanes, flooding, drought, tropical storms, and wildfires (Dutzik & Willcox, 2010; Easterling et al., 2000; Feng, Trnka, Hayes, & Zhang, 2017; Lithgow et al., 2019; Poumadère, Mays, Le Mer, & Blong, 2005; Tippett, Lepore, & Cohen, 2016). The term weather refers to short-term conditions (days to months), climatic variability to mid-term to long-term conditions (months to years), and climate change to long-term conditions (decades). The frequency and intensity of extremes in recent decades is linked to increasing economic losses in addition to the loss of lives (Mechler, , Bouwer, , Schinko, , Surminski, , & Linnerooth, 2019; Coronese, Lamperti, Keller, Chiaromonte, & Roventini, 2019; Hanewinkel, Cullmann, Schelhaas, Nabuurs, & Zimmermann, 2013; Tol, 2009). With the close spatial proximity to the natural environment, nature-based tourism activities are a vulnerable and highly sensitive economic sector (Dogru, Marchio, Bulut, & Suess, 2019; Hambira et al., 2020; Rutty & Scott, 2013; Verbos et al., 2018). Although weather conditions are only one of the factors linked to tourism destination choices, they are often the primary consideration.

Significant relationships between weather, climatic variability, climate change, and nature-based activities have been established by a number of researchers (e.g., Becken, 2010; Craig, 2019; Craig & Feng, 2018; Fisichelli, Schuurman, Monahan, & Ziesler, 2015; Hewer, Scott, & Fenech, 2016; Kim, Park, & Lee, 2017; Lithgow et al., 2019; Wilkins, de UriosteWeiskittel, & Gabe, 2017). Scott, Gössling, and Hall (2012) contended that warming trends may move climatically suitable areas for activities such as camping to higher latitudes or altitudes. Conversely, medium to low latitude destinations may see shifts because of individual preference for temperate regions and extreme weather avoidance. Shifting seasonality has also occurred, where conditions conducive to nature-based activities in the fall and spring meteorological seasons in the United States have increased (Monahan et al., 2016). Changing conditions are not inherently negative to camping, however. Shifting climate-derived weather and seasonality trends highlight the potential positive (i.e., opportunities) and negative (i.e., threats) impacts that changing conditions can have depending on spatial location.

1.2. Tourism resources and previous indices

Early work in tourism climatology was strongly influenced by Mieczkowski (1985) who developed the Tourism Climate Index (TCI) to investigate the impact of weather and climate on general tourism activities. The tourism index approach pioneered by Mieczkowski (1985) considered three climate resources: thermal, physical, and aesthetic. The thermal resource considers the perceived thermal sensations and comfort based on the atmospheric conditions including temperature and relative humidity. The physical resource considers the existence of specific meteorological elements such as precipitation and windspeed. The aesthetic resource considers the scenic comfort based on prevailing synoptic conditions such as sunshine hours. Through these three resources, weather conditions influence the demand for or satisfaction from nature-based activities (De Freitas, 2003). The development of the CCI builds on previous tourism indices – both general and activity-based – in Canada (Matthews et al., 2019), Europe (Perch-Nielsen, Amelung, & Knutti, 2010; Scott, Rutty, Amelung, & Tang, 2016), Mediterranean (Amelung & Viner, 2006; Ameglung et al., 2007), Australia (Amelung & Nicholls, 2014), Asia (Fang & Yin, 2015; Kubokawa, Inoue, & Satoh, 2014), the Middle East (Roshan, Yousefi, & Fitchett, 2016), and globally (Amelung & Viner, 2006; Mieczkowski, 1985). Specifically, the CCI will empirically and longitudinally evaluate weather, climatic variability, and camping occupancy relationships across the United States.

1.3. Tourism index gaps

As Matthews et al. (2019) and others have noted, the TCI and its variations are not without limitation thus creating gaps in the literature that need to be addressed. Several criticisms of tourism climatology studies using indices were they were too broad, lacked empirical testing with high resolution observational data, were reliant on subjective criteria, and were not validated against behaviors (Craig, 2019; De Freitas, 2003; Hewer et al., 2015; Matthews et al., 2019; Scott et al., 2016). This section highlights four key gaps in the literature that the CCI will address.

First, there is a need for indices that adapt more narrowly to tourism sectors (Matthews et al., 2019). It is not sufficient to assume consistency of desired climate resources across all tourism activities. For instance, (Grillakis, Koutroulis, Seiradakis, & Tsanis (2016)) noted that different nature-based tourism activities (e.g., camping versus alpine skiing) require different climatic conditions. Scott, Gossling, and De Freitas (2007) conducted a study supporting this assertion, finding that perceived optimal climatic conditions differed based on spatial location and activity. Statistical differences in climate preferences based on socio-demographic factors and place of origins across tourism sector have also been recorded (Rutty & Scott, 2015; Rutty & Scott, 2013). Despite a fairly wide body of research in tourism climatology related to nature-based tourism (Amelung & Nicholls, 2014; Amelung, Nicholls, & Viner, 2007; Fang & Yin, 2015; Lise & Tol, 2002; Perch-Nielsen, 2010; Roshan et al., 2016; Scott, McBoyle, & Schwartzentruber, 2004), however, the literature on camping is scarce (Brooker & Joppe, 2013). The CCI will address this gap by explicitly exploring camping by category.

Second, there has been insufficient empirical testing for indices using observed tourist behaviors (Craig, 2019; Hewer et al., 2016). For instance, the weather variable rating schemes of the TCI and its variations were subjective, as they were based on the authors' opinions and were not empirically tested using observed behaviors (De Freitas, Scott, & McBoyle, 2008; Gómez-Martín, 2007; Perch-Nielsen, 2010; Scott et al., 2016; Matthews et al., 2019). In and ex situ studies have assessed tourist perceived weather preferences to evaluate the importance of weather for outdoor tourism activities and to empirically validate indices (Denstadli, Jacobsen, & Lohmann, 2011; Dubois, Ceron, Gössling, & Hall, 2016; Jeuring, 2017; Rutty & Scott, 2010; Rutty & Scott, 2013; Scott, Gössling, & De Freitas, 2008). However, these studies and resultant indices did not empirically match individual perceptions and behaviors with observed weather conditions. Building on the work of Rutty and Scott (2010, 2013, 2015, & 2016), Scott et al. (2016) incorporating survey evidence from tourists into the ratings and weightings for the Holiday Tourism Index (HCI). This approach is rational, but the reliability of the surveys to determine the weather thresholds (i.e., conditions unsuitable for tourists) need to be further tested. For instance, recent camping studies found inconsistencies between self-reported weather thresholds and actual camping behaviors (Craig, 2019; Craig & Feng, 2018). Accordingly, this study will explore empirical relationships between camping occupancy behaviors and weather variables to assess the appropriate weather variable rating scheme and index rating for camping.

Third, the overriding effects of extreme/adverse thermal (i.e., minimum and maximum temperature) and physical factors (i.e., precipitation and windspeed) are poorly identified. Single weather factors can be pivotal to campers' decision making despite the desirability of other factors. For example, extremely unfavorable temperatures, either too hot or too cold, can overwhelmingly influence camping behaviors depending on camping category (i.e., tent, RV, cabin). Also, heavy rain and strong winds can impact camper occupancy decisions and duration of occupancy. The TCI represents weather conditions by integrating several weather factors into a single index, but it failed to explicitly take extreme/adverse weather events into account. De Freitas et al., (2008) recognized the potential overriding effect of weather extremes, and found from survey research that windspeed greater than or equal to 22 km/h or the duration of rainfall for more than half an hour adversely impacted tourism satisfaction. However, these findings were not incorporated into the calculation of the index from the study. The HCI (Scott et al., 2016) addressed overriding effects by assigning equal weights to the thermal and physical resources (both 40%) to lower the index score when extreme/adverse conditions occurred. This allowed the HCI to account for overriding effects within the index, but not independent of the index. Thus, the HCI may not precisely reflect the relative significance of each factors' impact on tourism activities (Hewer et al., 2015; Matthews et al., 2019) due in part to the possibility of favorable conditions that can skew the index score when extreme/adverse conditions occur. To address gaps related to overriding extreme/adverse thermal and physical factors, this study will integrate weather thresholds into the CCI independent of the index score calculation.

Fourth, indices have had difficulty capturing seasonality. The seasonal distribution of tourism climate indices and monthly changes in ratings has been analyzed in multiple regions around the world (Amelung & Nicholls, 2014; Amelung et al., 2007; Fang & Yin, 2015; Kubokawa et al., 2014; Perch-Nielsen et al., 2010; Scott et al., 2004), however, there remains a salient gap in addressing the change in length of the favorable tourism seasons (for exception see Monahan et al., 2016; Perch-Nielsen et al., 2010). We will address the gap in capturing favorable or unfavorable shifts in seasonality by using multiple methods to capture the number of optimal camping tourism days by season at 29 locations using the CCI.

In the following, the materials and methods as well as the results and analysis sections will outline the development of the CCI. The calculations section will validate the CCI and present climatic trends across the United States using the CCI.

2. Methods and materials

The CCI explores three weather resources: thermal, physical, and aesthetic. Thermal resources were operationalized using thermal comfort (TC), minimum temperature (Tmin), and maximum temperature (Tmax); physical resources were operationalized using precipitation (P) and windspeed (W); aesthetic forces were operationalized using daily hours of bright sunshine (S). The development of the CCI involves fives steps: (1) Retrieve daily weather variables; (2) Conduct iterative correlation to determine weather variable rating scores and thresholds; (3) Run regression analysis to identify the relative significance of individual weather variables; (4) Weight the CCI equation according to findings from regression analysis; and (5) Integrate weather thresholds into the final CCI equation.

2.1. CCI data

Daily camping occupancy data (tent, RV, and cabin) for 29 business locations throughout the United States between January 1, 2007 and November 11, 2016 (total 3603 days) were collected. The locations are owned by a large privately-held camping corporation. The data represented seven of the nine climate zones in the United States (Feng et al., 2014) including: Northeast, East Central, Central, Southeast, South, Southwest and West (Fig. 1). No other information is provided about the corporation to maintain confidentiality.

Daily meteorological data was retrieved from January 1, 1997 to December 31, 2017 for the 29 locations analyzed. Daily maximum temperature, minimum temperature, dew point temperature, and precipitation were obtained from Di Luzio, Johnson, Daly, Eischeid, and Arnold (2008) PRISM dataset. Windspeed, cloud cover, and solar radiation were retrieved from the North American Regional Reanalysis dataset (Mesinger et al., 2006). Daily minimum relative humidity was computed using daily mean dew point temperature and daily maximum air temperature, and daily mean relative humidity was computed using daily mean dew point temperature and daily mean air temperature (see Allen, Pereira, Raes, & Smith, 2006). Sunshine hours are an important parameter for camping, but there were no daily sunshine observations available for the focal locations. Therefore, sunshine hours were calculated based on daily incoming solar radiation values (Allen et al., 2006). Table 1 provides a list of variables used in the study and their units, and Table 2 the equations for the three tourism indices used to validate the CCI.

2.2. Weather variable rating scores

Iterative correlations were used to determine weather variable rating scores for thermal comfort, sunshine hours, precipitation, and windspeed (see Table 3). The iterative correlation method makes "the output error between the close-loop system and a reference model uncorrelated with [the] reference signal" (Karimi et al., 2002, p. 418) to maximize model fit. The iterative method can be applied to longitudinal data and has been successfully used to enhance model fit in a variety of contexts including statistics and natural science (Karimi et al., 2002; Saebo; Pulay, 1993). Rating scores were determined by dividing the range of correlations by 10, where high correlations corresponded to high ratings and low correlations to low ratings. The result was a weather variable rating system from unfavorable (0) to optimal (10). See Table 4 for comparative tourism index rating schemes.

2.3. Multivariate regression analysis

Weather variable rating scores were regressed on camping occupancy for each category (i.e., tent, RV, cabin). Dummy variables were included for holidays and weekends to detach potential institutional effects that were not weather-related. Dates were only included if the camping locations were open for business. The multivariate regression formula is expressed as:

$$Y_{it} = \alpha_{it} + \beta_1 {}^*TC_{it} + \beta_2 {}^*S_{it} + \beta_3 {}^*W_{it} + \beta_4 {}^*P_{it} + \beta_5 {}^*I_{it} + \varepsilon_{it} \tag{1}$$

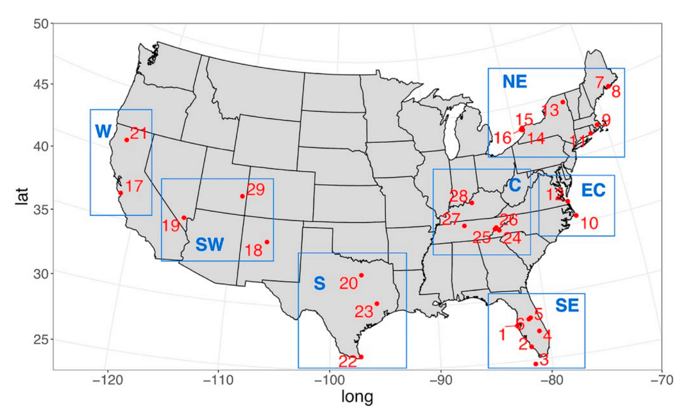

Fig. 1. Locations and climate zones for camping businesses. *Note. 29 privately-owned camping businesses throughout the United States in seven climate zones including: Northeast (NE); East Central (EC); Southeast (SE); Central (C); West (W); Southwest (SW); South (S).

Table 1
Study weather variables.

Sub-index variable	Initials	Climate Resource	Units	Index	Climate variable required
Daytime Comfort Index	CID	Thermal	Reported as °C	TCI	Maximum temperature (°C) Minimum RH
Daily Comfort Index	CIA	Thermal	Reported as °C	TCI	Mean temperature (°C) Mean RH
Thermal Comfort	TC	Thermal	Reported as °C	HCI, OPT, CCI	Mean temperature (°C) Mean dew point temperature (°C)
Precipitation	P	Physical	Millimeters (mm)	TCI, HCI, OPT, CCI	Precipitation (mm)
Windspeed	W	Physical	Kilometer per hour (km/hr)	TCI, HCI, OPT, CCI	Windspeed (km/hr)
Sunshine hours	S	Aesthetic	Hours (hr)	TCI, CCI	Solar radiation (w/m^2) Location coordinates
Cloud cover	A	Aesthetic	Cloud cover (%)	HCI, OPT	Cloud cover (%)

*Note. CID, CIA and TC are all dimensionless units, but are reported at °C values.
RH: relative humidity.
Location coordinates: Longitude and Latitude.
All recoded climate variables range from 0 to 10.

Table 2
Comparison tourism index formulas.

Index	Formula
TCI	40% CID +10% CIA +20% P + 20% S + 10% W
HCI	40% TC + 20% A + 30% P + 10% W
OPT	75% TC + 15% A + 5% P + 5% W

where Y_{it} represents the camping occupancy for three categories (i.e. $i =$ tent, RV and cabin) from January 1, 2006–November 11, 2017 denoted by t ($t = 3603$). TC_{it} represents the thermal comfort resources (°C); S_{it} represents aesthetic resources (hr); W_{it} and P_{it} represent physical resources (km/hr and mm, respectively); I_{it} is the institutional dummy that was coded one for weekend (Saturday, Sunday) and federal national holidays (United States Office of Personnel Management, 2019), and coded zero for workdays; α_{it} is a constant and ε_{it} is an error term.

The beta regression coefficients computed from equation (1) were used to assess the contributions of each weather variable on the regressed camping occupancy data. Only the beta values significant at $p < .01$ were considered for variable weightings. The percentage of each weather variables' beta value was then calculated to represent its relative significance. Regression results which achieved the highest r^2 values were used to determine the weather resources to include in the final CCI equation.

3. Results and analysis

3.1. Multivariate regression

The output in Table 5 shows the regression results with coefficient estimations (beta). The parameters indicate one unit increase in weather variable rating score led to a significant change in camping occupancy ($p < .01$ unless designated with ^{ns}). Institutional factors (i.e., weekends, holidays) also had a significant positive relationship with camping occupancy in all climate zones.

Variability in camping occupancy explained by weather varied across climate zones. However, similar patterns emerged. Each of the four weather variables (i.e., thermal comfort, precipitation, windspeed, sunshine hours) that captured the three climate resources (i.e., thermal, physical, aesthetic) was rescaled to determine weights for the CCI equation (see Table 6). The aggregate of variables across all climate regions was included when rescaling the final CCI equation. Thermal comfort and sunshine hours were the two most salient contributors regardless of climate zone. The effects of precipitation and windspeed were negligible when relationships were aggregated across climate zones. Therefore, the initial CCI less extreme/adverse events is expressed as:

$$CCI = 0.5*TC + 0.5*S \tag{2}$$

Table 4
Tourism index values and categories.

CCI		TCI		HCI	
Value	Category	Value	Category	Value	Category
[7,10]	optimal	[80,100]	excellent	[80,100]	excellent; ideal
[5,7]	good	[60,80]	very good; good	[60,80]	very good; good
[3,5]	acceptable	[40,60]	acceptable	[20,60]	acceptable
[0,3]	unfavorable	[-20,39]	unfavorable	[0,20]	dangerous

Note. The OPT index does not provide index categories and thus was omitted from this table.

Table 3
Weather variable ranking scores.

Thermal comfort (TC)		Sunshine (S)		Precipitation (S)		Windspeed (W)	
°C	Rating	Hr	Rating	Mm	Rating	Km/hr	Rating
≥42	0	≥14	10	0	10	[0,2]	9
[34,42]	7	[12,14]	9	[0,0.03]	7	[2,5]	10
[28,34]	10	[9,12]	8	[0.03,4]	4	[5,10]	9
[24,28]	9	[6,9]	4	[4,8]	2	[10,15]	8
[20,24]	8	[4,6]	2	≥8	0	[15,20]	6
[16,20]	7	<4	0			[20,25]	4
[12,16]	6					[25,30]	3
[8,12]	5					[30,38]	1
[4,8]	4					≥38	0
[2,4]	3						
<4	0						

Table 5
Beta coefficients from multivariate regression results.

Climate Zones	SE	EC	NE	W	SW	C	S
TN	*n = 3603 days*						
TC	17.91	4.04	10.86	4.97	5.01	2.87	1.32
S	14.23	3.45	5.77	4.45	4.63	1.45	3.45
P	2.22	0^{ns}	1.27	0.24^{ns}	0.89	0^{ns}	0
W	3.28	1.18	2.36	0.75	0	0.25	0^{ns}
Institutional	18.79	4.57	5.75	3.08	1.12	0.94	1.25
R^2	0.42	0.46	0.66	0.53	0.69	0.61	0.25
RV	n = 3603 days						
TC	19.31	38.44	55.56	27.49	18.07	41.17	0^{ns}
S	29.73	37.15	26.03	28.57	13.24	22.67	7.64
P	0.61	2.52	5.73	0^{ns}	0	1.25^{ns}	0
W	6.45	5.44	9.18	0	5.79	5.22	0
Institutional	12.38	30.46	33.62	24.77	3.35	9.54	10.99
R^2	0.28	0.64	0.82	0.47	0.68	0.56	0.28
KB	n = 3603 days						
TC	1.87	18.17	20.74	8.33	5.89	9.06	1.06
S	5.74	11.37	6.27	8.18	3.9	7.14	9.74
P	0	0	1.56	0^{ns}	0	0^{ns}	0.34^{ns}
W	0	2.39	2.29	0	0^{ns}	0	0.3
Institutional	8.11	16.92	12.76	12.09	1.67	4.12	9.09
R^2	0.22	0.5	0.72	0.46	0.56	0.33	0.08

Note. All beta values significant at $p < .01$ unless designated with ^{ns}.

Table 6
Relative significance of climatic variables on camping activity.

TN	TC	Sunshine	Precipitation	Wind
SE	48%	38%	6%	9%
EC	47%	40%	0%	14%
NE	54%	28%	6%	12%
W	48%	43%	0%	7%
SW	48%	44%	8%	0%
C	63%	32%	0%	5%
S	28%	72%	0%	0%
US	48%	42%	3%	7%
RV	**TC**	**Sunshine**	**Precipitation**	**Wind**
SE	34%	53%	1%	11%
EC	47%	44%	3%	6%
NE	65%	22%	5%	9%
W	49%	51%	0%	0%
SW	49%	36%	0%	16%
C	59%	32%	2%	7%
S	0%	100%	0%	0%
US	43%	48%	1%	7%
KB	**TC**	**Sunshine**	**Precipitation**	**Wind**
SE	25%	75%	0%	0%
EC	57%	36%	0%	7%
NE	67%	20%	5%	7%
W	50%	50%	0%	0%
SW	60%	40%	0%	0%
C	56%	44%	0%	0%
S	9%	85%	3%	3%
US	46%	50%	1%	3%

3.2. Weather variable thresholds

Extreme/adverse weather events are rare, and the resolution of analysis described above may not be high enough to capture the true effects on occupancy. Therefore, weather variable thresholds were included to account for extreme/adverse weather events. The four threshold variables considered were minimum temperature, maximum temperature, precipitation, and windspeed. Threshold values were determined where the highest correlation between camping occupancy and unfavorable CCI occurred. The definition of "unfavorable" was empirically determined by optimizing the correlation coefficient. CCI was forced to a classification of "unfavorable" (CCI = 3) when extreme/adverse weather events were identified. If the calculated value of CCI from equation (2) was below three, the lower value was assigned. For example, if the CCI value calculated using equation (2) was two on a day when an extreme precipitation event occurred (CCI = 3), two would be assigned. Values for each of the four threshold values and the final CCI equation are presented in the remainder of this section.

3.2.1. Minimum temperature thresholds

Minimum temperatures ranged from $-5°C$ to $15°C$ and thresholds were considered using $0.5°C$ increments. Weather thresholds occurred at $11°C$ for tent camping, $8°C$ for RV camping, and $4°C$ for cabin camping. As minimum temperatures increased gradually from $-5°C$ to the thresholds, the correlation coefficient between camping occupancy and CCI from equation (2) increased, meaning the overriding effect for minimum temperature better explained the relationship than the CCI values using equation (2). The optimal minimum threshold value behaved slightly different among camping categories; tent dwellers were less tolerant to low temperatures than RV and cabin campers. The weather threshold value for overriding minimum temperature effects was set at $8°C$, the average of the three categories.

3.2.2. Maximum temperature thresholds

Maximum temperature and camping occupancy demonstrated a positive relationship. The correlation coefficient leveled at $34°C$ for all camping categories suggesting temperatures above $34°C$ may be considered too hot. This finding is consistent with previous observed temperature thresholds of $35°C$ (Hewer et al., 2015) for campers non-discriminant of camping category and from surveys where tourists had a perceived maximum temperature threshold of $32.2°C$ (Fisichelli et al., 2015). Thus, the weather threshold value for overriding maximum temperature effects was set at $34°C$.

3.2.3. Precipitation thresholds

Weather thresholds for precipitation were examined from 0 mm to 30 mm using 1 mm increments. Precipitation thresholds varied based on camping category. Tent camper thresholds occurred between 2 and 3 mm/day; RV camper thresholds occurred around 20 mm/day; cabin camper thresholds occurred around 12 mm/day. The aggregate of our results was slightly higher than the previously defined extreme precipitation level of 10 mm/day (Frich, Alexander, Della-Marta, Gleason, Haylock, Klein Tank & Peterson, 2002). The 10 mm/day level has also been used in past camping studies to significantly quantify the effects of precipitation (Craig, 2019; Craig & Feng, 2018). Accordingly, the weather threshold value for overriding precipitation effects was set at 10 mm/day.

3.2.4. Windspeed thresholds

Windspeed thresholds were explored ranging from 0 km/h to 40 km/h at 1 km/h increments. The correlation coefficients suggested that windspeed threshold values were about 20 km/h for tent campers, 23 km/h for RV campers, and 24 km/h for cabin campers. The quantitative results were consistent for all camping categories. The weather threshold value for overriding windspeed effects was set at 23 km/h, the average of the three categories.

Based on regression analysis and iteration correlations, the final CCI is expressed as:

$$CCI = \begin{cases} 0.5*TC + 0.5*S \\ \min(CCI, 3) \; if \; Tmin \langle 8°C, \; or \; Tmax \rangle 34°C, \\ \quad or \; P > 10mm, \; or \; W > 23km/h \end{cases} \tag{3}$$

3.3. CCI and camping occupancy

In general, three insights can be drawn from the observation of CCI and camping occupancy by climate zone depicted in Fig. 2. First, camping occupancy demonstrated seasonality no matter zone. Second, camping occupancy was closely linked to the climate resources (i.e., the CCI) in that zone. Third, regional differences existed in terms of the overall suitability for camping. Some zones had higher yearly average CCI (e.g. locations in the Southeast and South), while others had relative lower CCI except for the few peak seasons (e.g. locations in the Northeast).

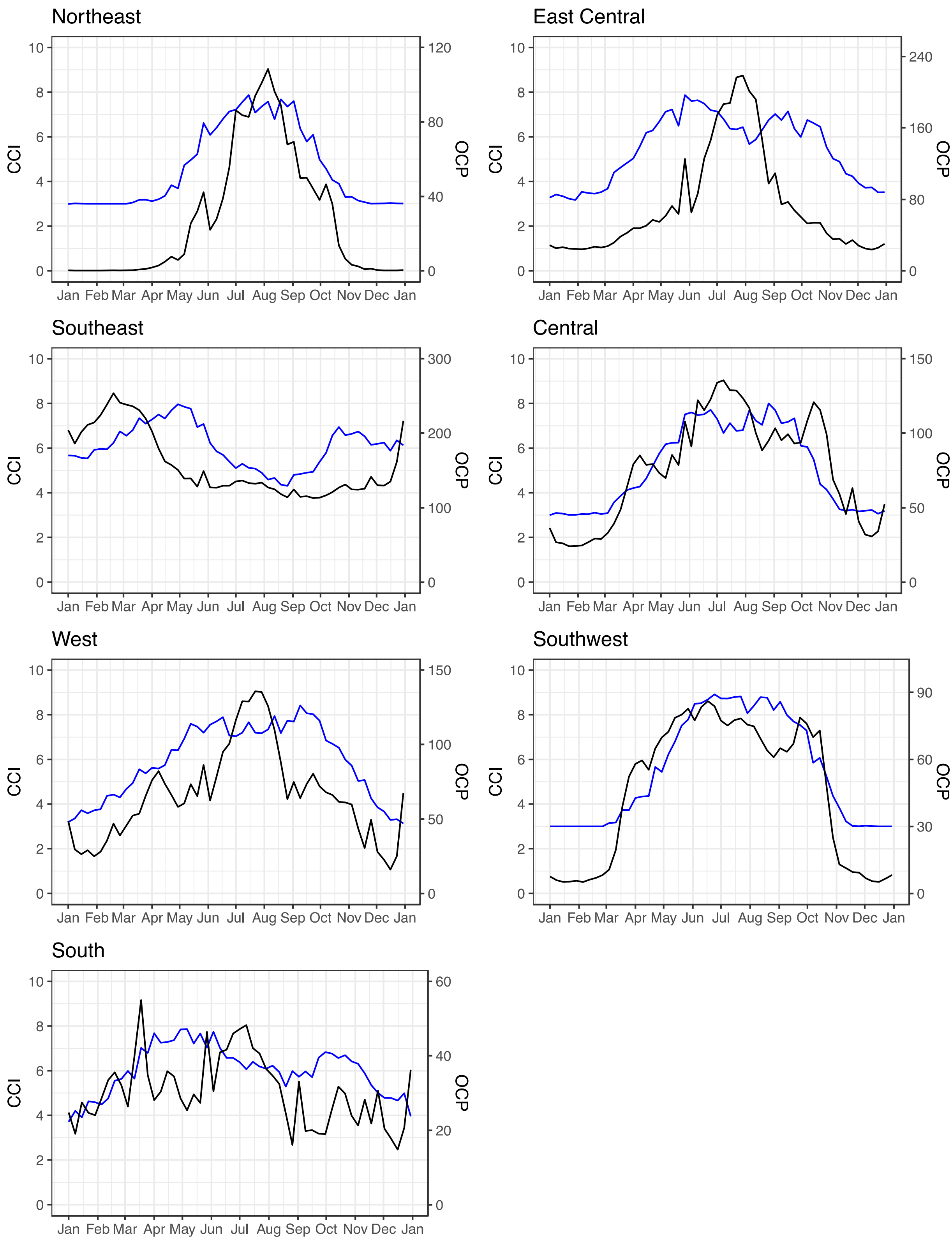

Fig. 2. Camping occupancy and seasonality. *Note. The black line is the weekly average camping occupancy for all camping categories (OCP) from January 1, 2007 – November 11, 2016. The blue line is the average CCI score. OCP and CCI used seven-day smoothed averages to alleviate impacts of institutional effects for occupancy and extreme weather events for CCI.

Specific to climate zones, the Northeast zone experienced peak CCI distributions in the summer season. The CCI scores were consistently higher in summer and lower in winter, a trend that camping occupancy followed. The East Central zone had more attractive CCI distributions for campers during summer months and into the shoulder seasons. The CCI in the Southeast climate zone was generally good or optimal, remaining above 5 for the majority of the year. In the West, the CCI was better in the spring and fall, but was not as variable from season-to-season or throughout the year as other zones. The Central zone demonstrated a similar pattern to the West and East Central zones. Conditions for camping were positive from the onset of spring and lasted until the end of fall in the Southwest zone. In the South zone, camping conditions were suitable throughout much of the year with optimal CCI conditions occurring at various times throughout the spring, summer, and fall seasons. The next section provides calculations relevant to validating the CCI, longer-term climatic trends, and seasonality of optimal camping days by climate zones.

4. Calculations

4.1. Validating the CCI

The CCI was validated by comparing it to two well established indices and a recent variation: the TCI (Mieczkowski, 1985), the HCI (Scott et al., 2016), and the OPT (Matthews et al., 2019). Table 2 provides the equations for each of the comparison indices. Scores for the three comparison indices and CCI were calculated daily then aggregated monthly to facilitate inter-comparisons. Annual data were subset into four seasons to explore the temporal differences among the indices. Multivariate regression analysis was conducted annually and within seasons, and the r^2 values were analyzed to determine variability explained in camping occupancy. As shown in Table 7, the CCI demonstrated an equal or stronger fit than the TCI, HCI, or OPT for 92.3% (12/13) of the significant annual observations. The CCI also demonstrated an equal or stronger fit for 88% (22/25) of the significant observations within season.

4.2. Long-term trends

To assess the impact of climatic variability on the suitability for camping tourism for the seven climate zones, the number of optimal days with CCI scores greater than or equal to 7 was calculated for the 29 focal locations between 1997 and 2017. The results are presented in Fig. 3. Overall, the climatic conditions for camping in the contiguous US improved between 1997 and 2017. Five of the seven zones experienced an increase in optimal camping days ranging from an annual increase of 32 days in the East Central zone to an annual increase of 6 days in the Southwest zone. Only the South and Southeast climate zones experienced a decrease in optimal days (18 and 4 days annually, respectively).

4.3. Seasonal impact

The climatic trends depicted in Fig. 3 indicated variability in optimal camping days throughout climate zones in the United States. Accordingly, the distribution of optimal camping days by season using the CCI was explored from 1997 to 2017. As depicted in Fig. 4, seasonal variations in climate zones were present.

Generally speaking, the CCI experienced positive changes between 1997 and 2017 as latitudes increased. This benefited locations within the more Northern and Western climate zones across all seasons. The intensified frequency of heat waves and heavy precipitation in the lower to middle latitudes was linked to the decreasing number of optimal days for camping.

A discussion with limitations and future research as well as conclusion sections is provided below.

5. Discussion

Changing climatic conditions will continue to influence opportunities and threats for camping organizations, both for-profit and non-profit. The CCI was developed to quantify these opportunities and threats using three climate resources upon which tourist activities are dependent: thermal, physical, and aesthetic. Specifically, the study developed, validated, and applied the CCI to address gaps in the literature that previous researchers identified pertaining to tourism indices and their respective methodologies (e.g., Craig, 2019; De Freitas et al., 2003; Hewer et al., 2015; Matthews et al., 2019). Encouragingly, the CCI was more predictive for the nature-based tourism activity camping compared to climate indices developed for other tourism sectors. The development of the CCI and findings from the study provide insights into the economic impact of weather, climatic variability, and climate change on the camping sector of tourism.

The CCI addresses the absence of a camping-sector climate index in the tourism climatology literature. Numerous studies have established that weather and climate are intrinsically important for tourism decision-making (Becken, 2010; Scott & Lemieux, 2010; Scott, Lemieux, & Malone, 2011) and that changes in weather patterns (Becken & Wilson, 2013; Wilkins et al., 2017; Falk, 2014; Olya & Alipour, 2015; Hübner & Gössling, 2012) or the redistribution of climate resources (Rosselló-Nadal, 2014; Amelung et al., 2007; Amelung & Nicholls, 2014; Fang, Yin, & Wu, 2017; Fang & Yin, 2015; Lise; Tol, 2002; Perch-Nielsen, 2010; Scott, 2011; Scott et al., 2004) will influence tourism demand. With few exceptions (e.g., Craig, 2019; Craig & Feng, 2018; Hewer et al., 2015; Hewer, Scott, & Gough, 2017; Hewer, Scott, & Gough, 2017b), however, limited research has empirically explored the relationships between camping, weather, climatic variability, and climate change. We addressed this gap by developing a camping-sector index that considered each of the three categories of camping. Furthermore, previous research involved limited locations (e.g., Hewer et al., 2015; Matthews et al., 2019) due in large part to the lack of available observed data. By including daily camping occupancy data for tent, RV, and cabin camping at 29 unique locations across seven climate zones, we were able to overcome this hurdle and provide empirical support for the application of the CCI.

Over the past 10 years researchers conducted in situ studies exploring tourist perceptions and preferences related to weather (e.g., Denstadli et al., 2011; Dubois et al., 2016; Jeuring, 2017; Hewer et al., 2015; Hewer et al., 2017; Hewer et al., 2017b; Matthews et al., 2019; Rutty & Scott, 2010, 2013, 2015, 2016; Scott et al., 2016). The CCI was able to support and extend these studies. For instance, our finding that thermal and aesthetic resources were the two most important resources for camping is consistent with Hewer et al.'s (2015) survey results that comfortable temperatures (i.e., thermal) and sunshine (i.e., aesthetic) are the two most salient contributors to camper satisfaction. We extended the work of Hewer et al. (2015, 2017, 2017b) by using longitudinal camping behavior data (i.e., camping occupancy) matched with observed weather data. We also built on the work of Scott et al. (2016) by validating the CCI with observed camping behaviors rather than surveys. This is important to highlight because recent research demonstrated that actual camping behaviors are not always consistent with perceived tourist perceptions about optimal or adverse conditions (Craig, 2019; Craig & Feng, 2018). For instance, maximum temperatures above previously self-reported acceptable thresholds can have non-significant or positive impacts on camping occupancy.

The use of observed longitudinal camping data was a strength of our study, but it also highlights a potential limitation. We were unable to quantify socio-demographic factors that may have influenced individual camper behaviors. In addition to the changing climatic conditions and weather patterns, socio-demographic factors as well as activity-related descriptives have previously influenced climate resource perceptions for nature-based tourists. For instance, Rutty and Scott (2015) found statistical differences for beach tourists' thermal preferences and

Table 7
Variability (r^2) in occupancy explained by CCI, TCI, HCI, and OPT by climate region.

Climate zones	SE			EC			NE			W			SW			C			S		
Camping category	KB	TN	RV	KB	TN	RV	KB	TN	RV	KB	TN	RV	KB	TN	RV	KB	TN	RV	KB	TN	RV
Annual	n = 119 months (from January 2007 to November 2016)																				
CCI	0.04	0.06	0.1	0.58	**0.65**	**0.7**	**0.86**	**0.79**	**0.94**	0.59	**0.62**	0.48	**0.62**	**0.83**	**0.67**	0.34	**0.78**	**0.64**	0.29	0.21	0.07
TCI	0.01	0.1	0.2	0.27	0.24	0.31	**0.67**	0.58	**0.76**	0.24	0.5	0.2	0.55	**0.64**	**0.7**	0.12	0.35	0.42	0.27	0.03	0.13
HCI	0.01	0.05	0.1	0.46	0.52	0.58	**0.81**	**0.79**	**0.84**	0.57	0.4	0.34	0.25	0.35	0.21	0.22	**0.62**	0.39	0.06	0.07	0
OPT	0.01	0	0	0.54	0.54	**0.64**	**0.81**	**0.74**	**0.89**	**0.73**	0.47	0.51	0.54	**0.71**	0.57	0.26	**0.76**	0.51	0.1	0.13	0.01
Spring	n = 30 months																				
CCI	0.07	0.09	0.13	0.52	**0.86**	**0.83**	**0.80**	**0.84**	**0.87**	**0.62**	**0.89**	0.12	0.27	**0.60**	0.50	0.15	**0.68**	0.22	0.33	0.06	0.38
TCI	0.10	0.03	0.30	0.42	0.56	**0.76**	**0.74**	**0.77**	**0.82**	**0.52**	0.47	0.05	0.22	0.59	0.39	0.08	0.41	0.21	0.00	0.00	0.01
HCI	0.00	0.02	0.00	0.37	**0.63**	**0.70**	0.46	**0.50**	0.48	0.31	0.36	0.03	0.00	0.02	0.01	0.05	0.48	0.15	0.24	0.01	0.19
OPT	0.05	0.05	0.00	0.47	**0.70**	**0.75**	**0.79**	**0.80**	**0.87**	0.49	**0.67**	0.07	0.20	**0.62**	0.39	0.05	0.53	0.14	0.08	0.02	0.32
Summer	n = 30 months																				
CCI	0.07	0.12	0.24	0.13	0.21	0.45	**0.64**	**0.72**	**0.61**	0.02	0.10	0.11	0.01	0.02	0.01	0.08	0.26	0.12	0.16	0.35	0.15
TCI	0.04	0.02	0.10	0.08	0.13	0.26	0.36	0.40	0.35	0.24	0.45	0.45	0.00	0.11	0.02	0.00	0.00	0.03	0.21	0.14	0.14
HCI	0.06	0.02	0.20	0.17	0.10	0.17	0.59	**0.69**	**0.67**	0.24	0.12	0.12	0.00	0.08	0.03	0.01	0.25	0.06	0.02	0.02	0.01
OPT	0.08	0.04	0.20	0.19	0.18	0.31	**0.63**	**0.77**	**0.74**	0.25	0.13	0.12	0.00	0.08	0.04	0.01	0.01	0.00	0.04	0.06	0.20
Fall	n = 30 months																				
CCI	0.11	0.06	0.09	**0.62**	**0.64**	**0.76**	**0.83**	**0.79**	**0.93**	0.58	**0.67**	0.19	**0.73**	**0.84**	**0.82**	0.37	**0.79**	0.58	0.17	0.19	0.17
TCI	0.01	0.02	0.04	0.42	0.36	**0.65**	**0.73**	**0.72**	**0.85**	0.43	0.23	0.06	**0.61**	**0.71**	**0.74**	0.16	**0.68**	0.3	0.31	0	0.01
HCI	0.04	0.02	0.05	0.44	0.43	0.57	0.59	**0.61**	**0.6**	0.4	0.51	0.07	0.26	0.39	0.24	0.26	0.44	0.09	0.1	0.01	0
OPT	0.09	0.03	0.05	0.46	0.47	**0.66**	**0.75**	**0.74**	**0.87**	0.57	0.52	0.15	**0.6**	**0.76**	**0.63**	0.21	**0.62**	0.2	0.01	0.08	0.02
Winter	n = 29 months																				
CCI	0.12	0.19	0.19	0.31	0.04	0.07	–	–	–	**0.63**	**0.65**	0.03	0.02	0.09	0.03	0.11	0.14	0.28	0.14	0.23	0.20
TCI	0.20	0.10	0.09	0.00	0.03	0.02	–	–	–	0.28	0.30	0.03	0.02	0.02	0.11	0.00	0.09	0.02	0.21	0.20	0.05
HCI	0.07	0.07	0.14	0.09	0.06	0.03	–	–	–	0.03	0.05	0.04	0.02	0.05	0.03	0.12	0.01	0.00	0.09	0.11	0.01
OPT	0.10	0.11	0.14	0.28	0.00	0.04	–	–	–	0.50	**0.60**	0.06	0.02	0.02	0.07	0.07	0.11	0.21	0.16	0.11	0.01

*Note. Significant relationships ($p < .01$) are denoted by bolded values.

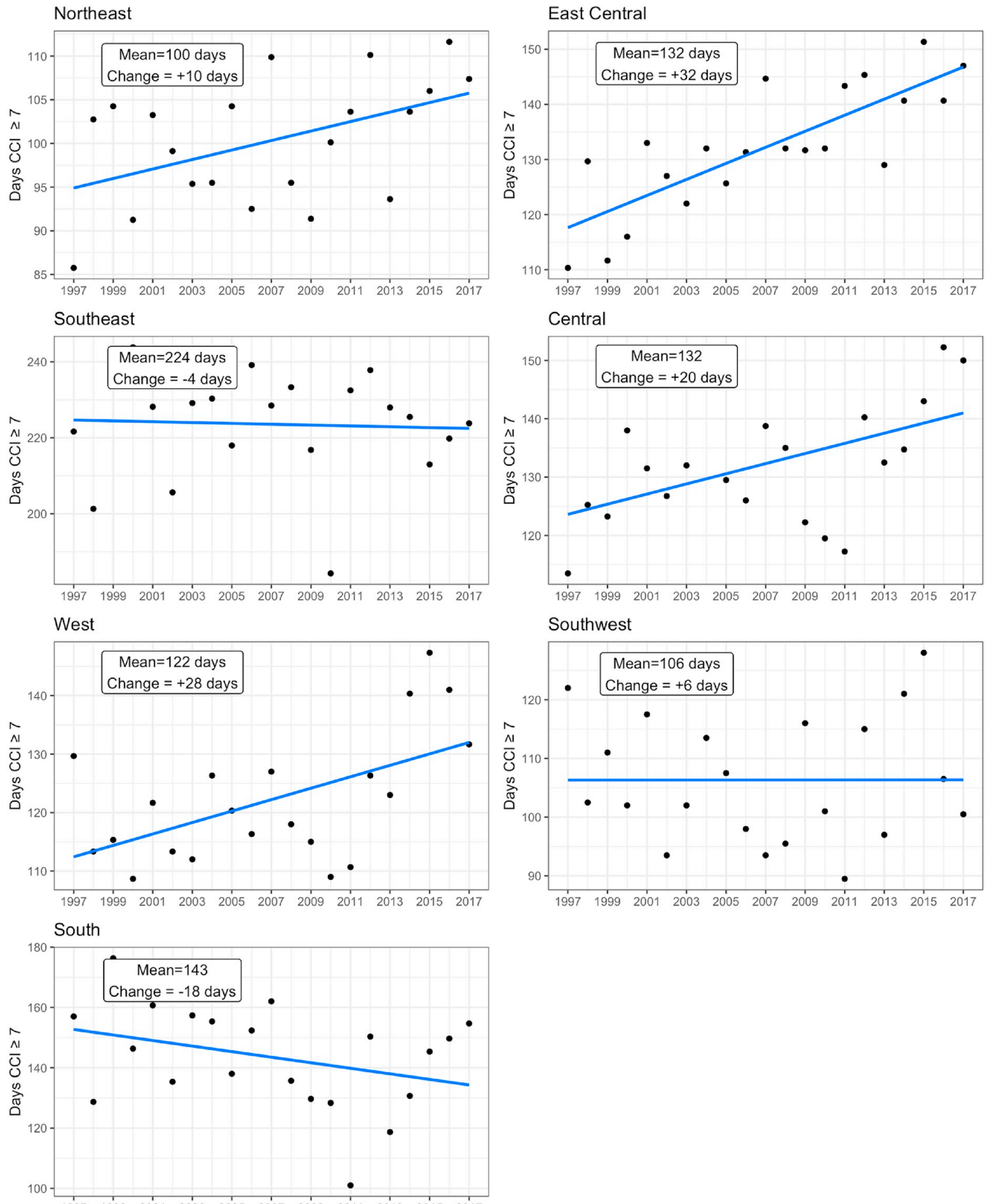

Fig. 3. Average ideal camping days and change in ideal camping days 1997–2017.*Note. Figures dictate that average numbers of ideal camping days 1997 – 2017 and the change in ideal camping days 1997 – 2017.

perceptions based on gender, age, experience-level, and location type. Specific to camping, Hewer et al. (2017) found statistical differences for perceived ideal and acceptable temperatures based on gender, age, camping experience, distance travelled, camping equipment, and recreational activities. Research has empirically demonstrated that younger individuals are more weather tolerant across tourism activities (e.g., Hewer et al., 2017; Rutty & Scott, 2015), which is an opportunity for camping tourism considering that the majority of new campers are under the age of 40 (Caim Consulting Group, 2019). Hewer et al. (2017) also found travel distance and camping duration were positively related to weather tolerance. Younger individuals are camping for longer durations; however, they tend to travel shorter distances to camp (Caim Consulting Group, 2019). Previous findings and current trends point to the need for future research that concurrently considers the role of socio-demographic factors, activity-related descriptives, observed behaviors, and observed weather conditions.

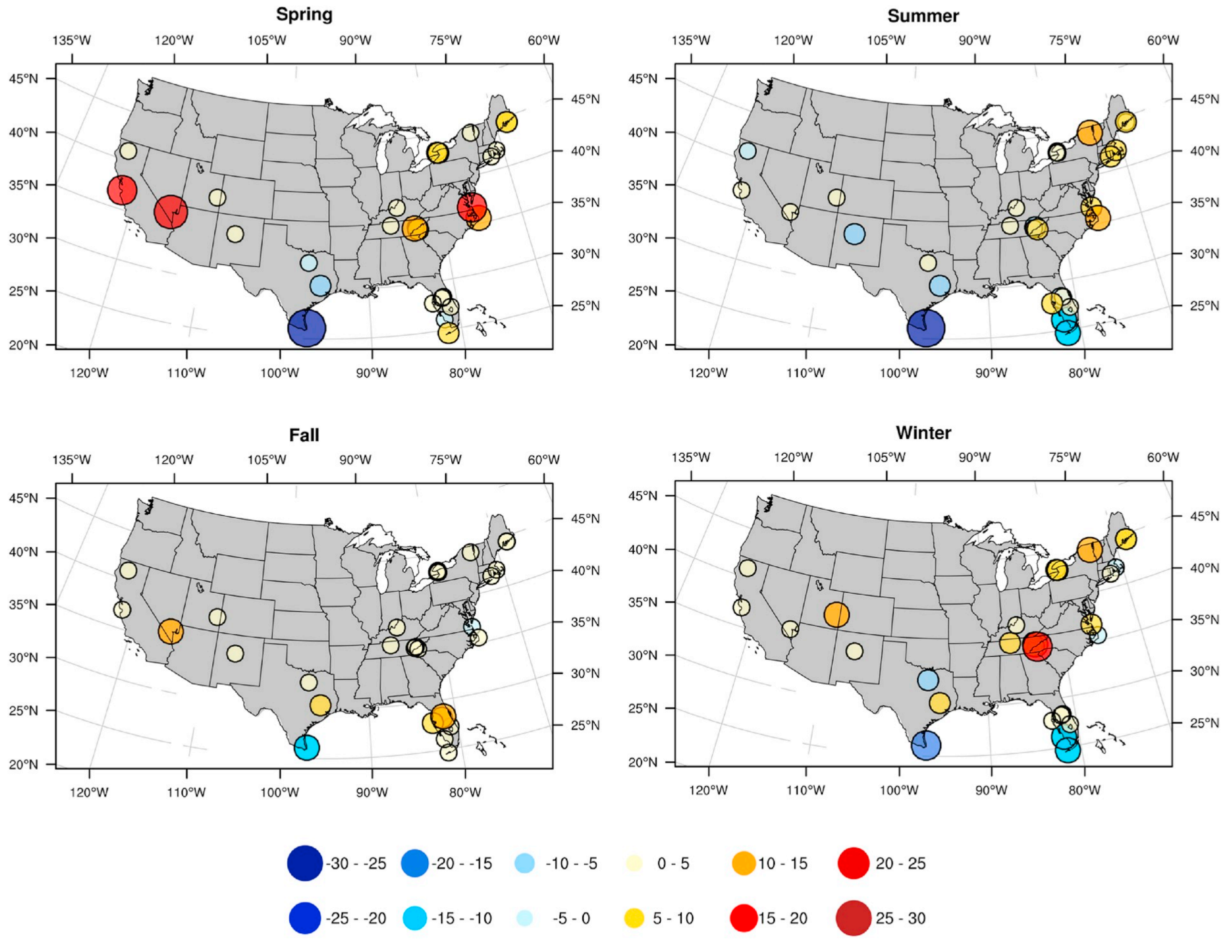

Fig. 4. Change in ideal camping days by season 1997–2017.*Note. Values indicate percentage change in ideal camping days 1997 – 2017 for the 29 camping locations.

There is evidence that changing climatic conditions are contributing to increasingly intense and frequent extreme weather events (Reidmiller et al., 2018) which in turn increase the number of costly and deadly disasters (NOAA, 2020). Weather extremes can adversely impact tourism demand (Becken & Wilson, 2013; Falk, 2014; Rosello, Becken, & Santana-Gallego, 2020) yet "empirical research that confirms or quantifies the relationship between disasters and tourism activity is scant" (Rosello et al., 2020, p. 2). Using retrospective time series forecasting, Craig and Feng (2018) found that extreme temperature and precipitation events could have an adverse impact on decisions to camp starting on the day of the event and up to 10 days prior to the event. Matthews et al. (2019) also used a data-driven approach for the OPT index using daily aggregate beach visitation data matched with daily weather data. The severity of extreme/adverse weather impact and previous high-resolution findings provide support for the consideration of daily data to examine camping and weather relationships.

Considering the large size of our dataset (from January 1, 2007 through November 11, 2016 for 29 unique locations) the occurrence of extreme/adverse conditions was comparatively rare. Statistical methods such as multivariate regression analysis for such a large dataset does not provide the resolution needed to capture the relationships between extreme/adverse conditions which necessitated the integration of the four thresholds in the final CCI equation, equation (3). This method allowed the CCI to integrate extreme/adverse weather into a scale without inadvertently introducing a cancelling effect.

We also quantified changing seasonality at the 29 camping locations to demonstrate temporal and spatial changes in CCI regionally throughout the United States (Fig. 4). In general, higher latitude locations saw an increase in optimal days regardless of season with three locations experiencing an over 20% increase in ideal days during the spring season. For researchers or practitioners interested in a single camping location or specific region, it may be necessary to explicitly integrate latitude in future studies. For instance, higher latitude (i.e., northern) regions in the study had stronger relationships with thermal climate resources whereas lower latitude (i.e., southern) regions had stronger relationships with aesthetic climate resources (see Table 5 for differences based on climate zone). The summer season saw the largest decrease in optimal days as well as the most modest percentage gains in optimal days. Combined our findings are consistent with Scott and colleagues' assertions that the number of cities in the United States with "excellent" conditions are likely to increase in the winter, decrease in the summer (Scott et al., 2004), and that warming trends will increase desirability of higher latitude locations (Scott et al., 2012). Our findings also support Monahan et al. (2016) research that demonstrated increasing favorable conditions in the spring and fall seasons across the United States.

Ideally, future research could build on this study by exploring the relationships between CCI and an even greater number of spatially diverse for-profit (i.e., business) and non-profit (i.e., governmental) campsites. Approximately 60% of camping nights in the United States occur at non-profit locations (Caim Consulting Group, 2019), yet in the peak summer season popular non-profit campsites have limited vacancies, higher latitude/altitude campsites have set schedules to close seasonally, and there is no price-response to high-demand holidays or weekends. In fact, campers can purchase an annual national park pass in the United States to book campsites at discounted rates up to six months in advance. For-profit campsites have much more flexibility with demand-based pricing and seasonal openings. Future research should compare the impact of the CCI on for-profit compared to non-profit locations and also explore the economic viability of later season camping in the fall and earlier season camping in the spring at non-profit locations.

The majority of significant relationships for the CCI occurred in the spring and fall seasons (see Table 7). The lack of significant relationships in the summer and winter months highlight there may be other factors influencing camping behaviors. Previous researchers suggested that institutional factors (e.g., weekends, holidays) can influence tourist behaviors (Hewer et al., 2016; Richardson & Loomis, 2004) in much the same manner as weather thresholds can have an overriding effect. Hewer et al. (2016) found that there were significantly more park visitors on the weekend than during the week, a trend that became even more pronounced during the shoulder seasons. For the entirety of our matched sample, we observed 31% more tent campers, 19% for more RV campers, and 88% more cabin campers on the weekend. Further, post-hoc correlation analysis demonstrated the CCI had a stronger relationship with weekend occupancy than weekday occupancy for all climate zones and camping types other than RV campers in the southwest (see Fig. 5). This finding highlights the importance of favorable weather conditions for campers making last-minute nature-based tourism decisions regardless of season. Future studies should attempt to capture factors that can influence camping behaviors including shifting weather trends (including desirability of conditions within and between seasons), types of holidays, weekend versus weekday occupancy, advanced reservations, cost of stay, cancellation policies, travel distance, and the length of occupancy (e.g., Brooker & Joppe, 2013; Craig, PetrunFeng, & Kinghorn, 2019; Hall, Gossling, & Scott, 2015; Hewer et al., 2017, 2017b).

Previous research in the United States shows that weather impacts campers differently based on occupancy type. A case study at two locations in the United States empirically demonstrated that weather impacts RV and cabin campers less in the warmer summer months than it does tent campers. Rutty and Scott (2014) discussed how beach tourists can change locations, or create their own micro-climate, at a resort when weather conditions become uncomfortable. RVs and cabins can create an opportunity for campers to create their own micro-climate when climate resources are either not ideal or exceed thresholds. Future research should consider the potential for campers to create micro-climates, and the relationship with this capability relative to weather conditions. Future research should also consider whether or not campsites are at maximum capacity. In the event there are limited vacancies to camp, this would mask the impact of weather on camping occupancy and also highlight the potential for extreme/adverse weather risks to campers.

5.1. Conclusion

Camping is the largest economic sub-sector of outdoor tourism and the characteristics of camping (e.g., overnight stays, natural settings, distance from one's home) make it particularly susceptible to extreme/adverse weather and changing climatic conditions. The CCI recognized the uniqueness of camping, and addressed a salient gap in the literature as the first camping-sector tourism climate index. The approach taken to create and validate the CCI matched daily weather data with daily camping behavior (i.e., occupancy) for the three categories of camping (i.e., tent, RV, cabin). Three key methodological advancements of the CCI include: (1) it was validated using daily camping observations at 29 geographically diverse locations across seven climate zones in the United States; (2) it captured adverse/extreme weather events without introducing a cancelling effect; and (3) it quantified camping climate resources seasonally throughout the United States. These advancements will be useful for those tasked with forecasting future outdoor tourism, weather, and climate change interactions. Missing from the methodology were market-based factors including socio-demographic factors and other activity-based descriptives such as distance travelled or duration of stay. Building on the CCI, future researchers should strive to integrate market-based factors and descriptives comparable to

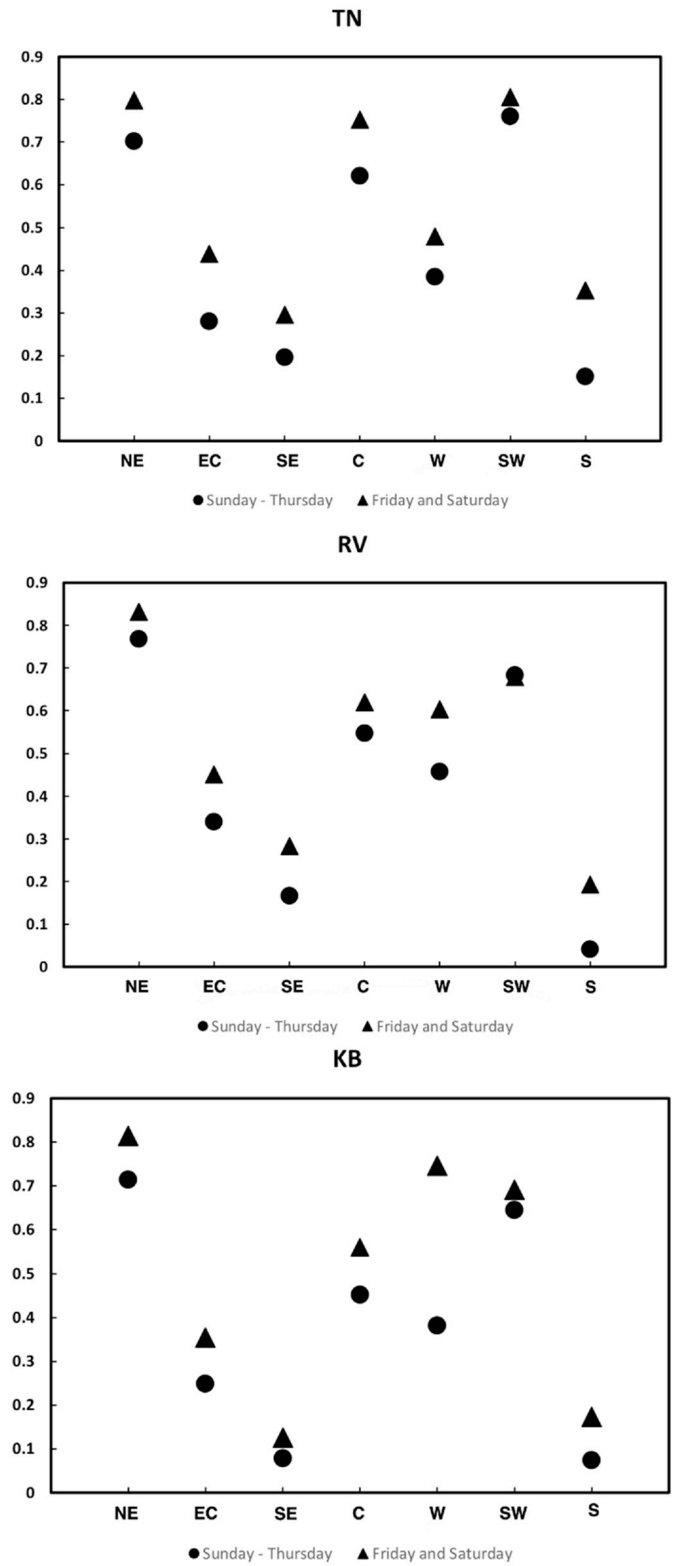

Fig. 5. Correlation between CCI and camping by category for weekends and weekdays. *Note. Average Friday and Saturday occupancy (TN = 8; RV: 65; KB: 13) and average Sunday through Thursday occupancy (TN = 6; RV = 55; KB = 7).

previously validated climate indices for other tourism sectors. In turn, more robust tourism indices will help nature-based tourism organizations, camping or otherwise, respond to changes in climate resources resulting from future climate change scenarios.

Declaration of competing interest

None.

CRediT authorship contribution statement

Siyao Ma: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft. **Christopher A. Craig:** Writing - original draft, Writing - review & editing, Investigation, Supervision, Project administration. **Song Feng:** Methodology, Investigation, Formal analysis, Resources, Supervision.

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References

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (2006). FAO irrigation and drainage paper: Crop evapotranspiration. *Irrigation and Drainage, 300*(56), 333.

Amelung, B., & Nicholls, S. (2014). Implications of climate change for tourism in Australia. *Tourism Management, 41*, 228–244. https://doi.org/10.1016/j.tourman.2013.10.002.

Amelung, B., Nicholls, S., & Viner, D. (2007). Implications of global climate change for tourism flows and seasonality. *Journal of Travel Research, 45*(3), 285–296.

Amelung, B., & Viner, D. (2006). Mediterranean tourism: Exploring the future with the tourism climatic index. *Journal of Sustainable Tourism, 14*(4), 349–366.

Becken, S. (2010). The importance of climate and weather for tourism. *Land Environ. People, 1–23*.

Becken, S., & Wilson, J. (2013). The impacts of weather on tourist travel. *Tourism Geographies, 15*(4), 620–639.

Brooker, E., & Joppe, M. (2013). Trends in camping and outdoor hospitality - an international review. *J. Outdoor Recreat. Tourism, 3*(4), 1–6.

Caim Consulting Group. (2019). *The 2019 North American camping report. Sponsored by kampgrounds of America*. Retrieved from https://koa.com/north-american-camping-report/.

Coronese, M., Lamperti, F., Keller, K., Chiaromonte, F., & Roventini, A. (2019). Evidence for sharp increase in the economic damages of extreme natural disasters. *Proceedings of the National Academy of Sciences of the United States of America, 116*(43), 21450–21455.

Craig, C. A. (2019). The weather-proximity-cognition (WPC) framework: A camping, weather, and climate change case. *Tourism Management, 75*, 340–352.

Craig, C. A., & Feng, S. (2018). A temporal and spatial analysis of climate change, weather events, and tourism businesses. *Tourism Management, 67*, 351–361.

Craig, C. A., Petrun Sayers, E. L., Feng, S., & Kinghorn, B. (2019). The impact of climate and weather on a small tourism business: A wSWOT case study. *Entrepreneurship Educ. Pedagog., 2*(3), 255–266.

De Freitas, C. R. (2003). Tourism climatology: Evaluating environmental information for decision making and business planning in the recreation and tourism sector. *International Journal of Biometeorology, 48*(1), 45–54.

De Freitas, C. R., Scott, D., & McBoyle, G. (2008). A second generation climate index for tourism (CIT): Specification and verification. *International Journal of Biometeorology, 52*(5), 399–407.

Denstadli, J. M., Jacobsen, J. K. S., & Lohmann, M. (2011). Tourist perceptions of summe weather in Scandinavia. *Annals of Tourism Research, 38*(3), 920–940.

Di Luzio, M., Johnson, G. L., Daly, C., Eischeid, J. K., & Arnold, J. G. (2008). Constructing retrospective gridded daily precipitation and temperature datasets for the conterminous United States. *Journal of Applied Meteorology and Climatology, 47*(2), 475–497.

Dogru, T., Marchio, E. A., Bulut, U., & Suess, C. (2019). Climate change: Vulnerability and resiliece of tourism and the entire economy. *Tourism Management, 72*, 292–305.

Dubois, G., Ceron, J. P., Gössling, S., & Hall, C. M. (2016). Weather preferences of French tourists: Lessons for climate change impact assessment. *Climatic Change, 136*(2), 339–351.

Dutzik, T., & Willcox, N. (2010). *Global warming and extreme weather*. Retrieved from www.frontiergroup.org.

Easterling, D. R., Meehl, G. A., Parmesan, C., Changnon, S. A., Karl, T. R., & Mearns, L. O. (2000). Climate extremes: Observations, modeling, and impacts. *Science, 289*, 2068–2075.

Falk, M. (2014). Impact of weather conditions on tourism demand in the peak summer season over the last 50 years. *Tourism Management Perspectives, 9*, 24–35.

Fang, Y., & Yin, J. (2015). National assessment of climate resources for tourism seasonality in China using the tourism climate index. *Atmosphere, 6*(2), 183–194.

Fang, Y., Yin, J., & Wu, B. (2017). Climate change and tourism: A scientometric analysis using CiteSpace. *Journal of Sustainable Tourism, 26*(1), 108–126.

Feng, S., Hu, Q., Huang, W., Ho, C. H., Li, R., & Tang, Z. (2014). Projected climate regime shift under future global warming from multi-model, multi-scenario CMIP5 simulations. *Global and Planetary Change, 112*, 41–52.

Feng, S., Trnka, M., Hayes, M., & Zhang, Y. (2017). Why do different drought indices show distinct future drought risk outcomes in the U.S. Great Plains? *Journal of Climate, 30*(1), 265–278.

Fisichelli, N. A., Schuurman, G. W., Monahan, W. B., & Ziesler, P. S. (2015). Protected area tourism in a changing climate: Will visitation at US National Parks warm up or overheat? *PloS One, 10*(6), 1–13.

Frich, P., Alexander, L. V., Della-Marta, P., Gleason, B., Haylock, M., Klein Tank, A., & Peterson, T. (2002). Observed coherent changes in climate extremes during the second half of the twentieth century. *Climate Research, 19*, 193–212.

Gómez-Martín, M. (2007). Climate potential and tourist demand in Catalonia (Spain) during the summer season. *Climate Research, 32*, 75–87.

Gössling, S., Hall, C. M., Peeters, P., & Scott, D. (2010). The future of tourism: Can tourism growth and climate policy be reconciled? A mitigation perspective. *Tourism Recreation Research, 35*(2), 119–130.

Grillakis, M. G., Koutroulis, A. G., Seiradakis, K. D., & Tsanis, I. K. (2016). Implications of 2C global warming in European summer tourism. *Climate Services, 1*, 30–38. https://doi.org/10.1016/j.cliser.2016.01.002.

Hall, C. M., Gossling, S., & Scott, D. (2015). The global effects and impacts of tourism. In *The routledge handbook of tourism and sustainability*. Abingdon: Routledge. https://www.routledgehandbooks.com/doi/10.4324/9780203072332.ch3.

Hambira, W. L., Saarinen, J., & Moses, O. (2020). Climate change policy in a world of uncertainty: Changing environment, knowledge, and tourism in Botswana. *African Geographical Review*. https://doi.org/10.1080/19376812.2020.1719366.

Hanewinkel, M., Cullmann, D. A., Schelhaas, M. J., Nabuurs, G. J., & Zimmermann, N. E. (2013). Climate change may cause severe loss in the economic value of European forest land. *Nature Climate Change, 3*(3), 203–207.

Hewer, M., Scott, D., & Fenech, A. (2016). Seasonal weather sensitivity, temperature thresholds, and climate change impacts for park visitation. *Tourism Geographies, 18*(3), 297–321.

Hewer, M. J., Scott, D., & Gough, W. A. (2015). Tourism climatology for camping: A case study of two ontario parks (Canada). *Theoretical and Applied Climatology, 121*(3–4), 401–411.

Hewer, M. J., Scott, D. J., & Gough, W. A. (2017). Differential temperature preferences and thresholds among summer campers in ontario's southern provincial parks: A Canadian case study in tourism climatology. *Theoretical and Applied Climatology, 133*, 1163–1173.

Hewer, M. J., Scott, D. J., & Gough, W. A. (2017b). Difference sin the importance of weather and weaterhbased decisions among campers in Ontario Parks (Canada). *International Journal of Biometeorology, 61*, 1805–1818.

Hübner, A., & Gössling, S. (2012). Tourist perceptions of extreme weather events in Martinique. *Journal of Destination Marketing and Management, 1*(1–2), 47–55.

Ibarra, E. M. (2011). The use of webcam images to determine tourist-climate aptitude: Favourable weather types for sun and beach tourism on the Alicante coast (Spain). *International Journal of Biometeorology, 55*(3), 373–385.

Jeuring, J. H. G. (2017). Weather perceptions, holiday satisfaction and perceived attractiveness of domestic vacationing in The Netherlands. *Tourism Management*, (61), 70–81.

Karimi, A., Miskovic, L., & Bonvin, D. (2002). Convergence analysis of iterative correlation-based tuning method. *IFAC Proceedings Volumes, 35*(1), 413–418.

Katircioglu, S., Cizreliogullari, M. N., & Katircioglu, S. (2019). Estimating the role of climate changes on international tourist flows: Evidence from mediterranean island States. *Environmental Science and Pollution Research, 26*(14), 14393–14399.

Kim, S., Park, J. H., & Lee, D. K. (2017). Impact of climate change on the preferred season for outdoor water activities. *Sustainability, 9*(9), 1535. https://doi.org/10.3390/su9091535.

Koutroulis, A. G., Grillakis, M. G., Tsanis, I. K., & Jacob, D. (2018). Mapping the vulnerability of European summer tourism under 2 °C global warming. *Climatic Change, 151*(2), 157–171.

Kubokawa, H., Inoue, T., & Satoh, M. (2014). Evaluation of the tourism climate index over Japan in a future climate using a statistical downscaling method. *Journal of the Meteorological Society of Japan. Ser. II, 92*(1), 37–54.

Laarman, J. G., & Durst, B. (1987). Nature travel in the tropics. *Journal of Forestry, 85*(5), 43–46.

Lise, W., & Tol, R. S. J. (2002). Impact of climate on tourist demand. *Climatic Change, 55*(4), 429–449.

Lithgow, D., Martinz, M. L., Gallego-Fernandez, J. B., Silva, R., & Ramirez-Vargas, D. L. (2019). Exploring the co-occureence between coastal squeeze and coastal tourism in changing climate and its consequences. *Tourism Management, 74*, 43–54.

Matthews, L., Scott, D., & Andrey, J. (2019). Development of a data-driven weather index for beach parks tourism. *International Journal of Biometeorology*. https://doi.org/10.1007/s00484-019-01799-7.

Mechler, R., Bouwer, L. M., Schinko, T., Surminski, S., & Linnerooth-Bayer, J. (Eds.). (2019). *Loss and damage from climate change*. Switzerland: Springer.

Mesinger, F., DiMego, G., Kalnay, E., Mitchell, K., Shafran, P. C., Ebisuzaki, W., et al. (2006). North American regional reanalysis. *Bulletin of the American Meteorological Society, 87*(3), 343–360.

Mieczkowski, Z. (1985). The tourism climatic index: A method of evaluating world climates for tourism. *Canadian Geographer, 29*, 220–233.

Monahan, W. B., Rosemartin, A., Gerst, K. L., Fisichelli, N. A., Ault, T., Schwartz, M. D., et al. (2016). Climate change is advancing spring onset across the U.S. national park system. *Ecosphere, 7*(10), 1–17.

Moreno, A., Amelung, B., & Santamarta, L. (2008). Linking beach recreation to weather conditions: A case study in Zandvoort, Netherlands. *Tourism in Marine Environments, 5*(2–3), 111–119.
National Oceanic and Atmospheric Administration (NOAA). (2020). *Billion-dollar weather and climate disasters: Events*. Retrievable from https://www.ncdc.noaa.gov/billions/events.
Olya, H. G. T., & Alipour, H. (2015). Risk assessment of precipitation and the tourism climate index. *Tourism Management, 50*, 73–80.
Outdoor Industry Association. (2017). *Outdoor recreation economy report*. Retrievable from https://outdoorindustry.org/resource/2017-outdoor-recreation-economy-report/.
Perch-Nielsen, S. L. (2010). The vulnerability of beach tourism to climate change-an index approach. *Climatic Change, 100*(3), 579–606.
Perch-Nielsen, S. L., Amelung, B., & Knutti, R. (2010). Future climate resources for tourism in Europe based on the daily Tourism Climatic Index. *Climatic Change, 103*(3), 363–381.
Poumadère, M., Mays, C., Le Mer, S., & Blong, R. (2005). The 2003 heat wave in France: Dangerous climate change here and now. *Risk Analysis, 25*(6), 1483–1494.
Reidmiller, D. R., Avery, C. W., Easterling, D. R., Kunkel, K. E., Lewis, K. L. M., Maycock, T. K., et al. (Eds.). (2018), *Vol. II. 2018: Impacts, risks, and adaptation in the United States: Fourth national climate assessment*. Washington, D. C: U.S. Global Change Research Program.
Richardson, R. B., & Loomis, J. B. (2004). Adaptive recreation planning and climate change: A contingent visitation approach. *Ecological Economics, 50*(1–2), 83–99.
Rosello, J., Becken, S., & Santana-Gallego, M. (2020). The effects of natural disasters on international tourism: A global analysis. *Tourism Management, 79*, 104080. https://doi.org/10.1016/j.tourman.2020.104080.
Roshan, G., Yousefi, R., & Fitchett, J. M. (2016). Long-term trends in tourism climate index scores for 40 stations across Iran: The role of climate change and influence on tourism sustainability. *International Journal of Biometeorology, 60*(1), 33–52.
Rosselló-Nadal, J. (2014). How to evaluate the effects of climate change on tourism. *Tourism Management, 42*, 334–340.
Rutty, M., & Scott, D. (2010). Will the mediterranean become "too hot" for tourism? A reassessment. *Tourism and Hospitality, Planning and Development, 7*(3), 267–281.
Rutty, M., & Scott, D. (2013). Differential climate preferences of international beach tourists. *Climate Research, 57*(3), 259–269.
Rutty, M., & Scott, D. (2014). Thermal range of coastal tourism resort microclimates. *Tourism Geographies, 16*(3), 346–363.
Rutty, M., & Scott, D. (2015). Bioclimatic comfort and the thermal perceptions and preferences of beach tourists. *International Journal of Biometeorology, 59*(1), 37–45.
Rutty, M., & Scott, D. (2016). Comparison of climate preferences for domestic and intentional beach holidays: A case study of Canadian travelers. *Atmosphere, 7*(2), 30.
Saebo, S., & Pulay, P. (1993). Local treatment of electron correlation. *Annual Review of Physical Chemistry, 44*, 213–236.
Scott, D. (2011). Why sustainable tourism must address climate change. *Journal of Sustainable Tourism, 19*(1), 17–34.
Scott, D., Abegg, B., Pons, M., & Aall, C. (2017). A critical review of climate change risk for ski tourism. *Current Issues in Tourism, 22*(11), 1343–1379.
Scott, D., Gossling, S., & De Freitas, C. R. (2007). Climate preferences for tourism: An exploratory tri-nation comparison. In A. Matzarakis, CR, De Freitas, & D. Scott (Eds.), *Developments in tourism climatology* (pp. 18–23). Commision Climate, Tourism and Recration, International Society of Biometeorlogy.
Scott, D., Gössling, S., & De Freitas, C. R. (2008). Preferred climates for tourism: Case studies from Canada, New Zealand and Sweden. *Climate Research, 38*(1), 61–73.
Scott, D., Gössling, S., & Hall, C. M. (2012). International tourism and climate change. *Wiley Interdisciplinary Reviews: Climate Change, 3*(3), 213–232.
Scott, D., & Lemieux, C. (2010). Weather and climate information for tourism. *Procedia Environmental Sciences, 1*(1), 146–183.
Scott, D., Lemieux, C., & Malone, L. (2011). Climate services to support sustainable tourism and adaptation to climate change. *Climate Research, 47*(1–2), 111–122.
Scott, D., McBoyle, G., & Schwartzentruber, M. (2004). Climate change and the distribution of climatic resources for tourism in North America. *Climate Research, 27*(2), 105–117.
Scott, D., Rutty, M., Amelung, B., & Tang, M. (2016). An inter-comparison of the holiday climate index (HCI) and the tourism climate index (TCI) in Europe. *Atmosphere, 7*(6).
Tippett, M. K., Lepore, C., & Cohen, J. E. (2016). More tornadoes in the most extreme US tornado outbreaks. *Science, 354*, 1419–1423.
Tkaczynski, A., Rundle-Thiele, S. R., & Prebensen, N. K. (2015). Segmenting potential nature-based tourists based on temporal factors: The case of Norway. *Journal of Travel Research, 54*(2), 251–265.
Tol, R. S. (2009). The economic effects of climate change. *The Journal of Economic Perspectives, 23*(2), 29–51.
United States Office of Personnel Management. (2019). *Pay & leave federal holidays*. Retrieved from https://www.opm.gov/policy-data-oversight/pay-leave/federal-holidays/#url=2019.
Valentine, P. (1992). Review: Nature-based tourism. In B. Weiler, & C. M. Hall (Eds.), *Special interest tourism* (pp. 105–127). London: Belhaven Press.
Verbos, R. I., Altschuler, B., & Brownlee, M. T. J. (2018). Weather studies in outdoor recreation and nature-based tourism: A research synthesis and gap analysis. *Leisure Sciences, 40*(6), 533–556.
Wilkins, E., de Urioste-Stone, S., Weiskittel, A., & Gabe, T. (2017). Effects of weather conditions on tourism spending: Implications for future trends under climate change. *Journal of Travel Research, 57*(8), 1042–1053.

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