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Effect of environmental conditions on perceived psychological restorativeness of coastal parks

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Abstract

We investigated the hypothesis that perception of psychological restorativeness during visits to coastal parks is modified by objective and perceived environmental conditions. Visitors (n=1,153) to California beaches completed a survey on perceived weather, environmental quality, and perceived restorativeness. We used generalized ordinal logistic models to estimate the association between environmental parameters and odds of perceiving higher levels of restorativeness. Visitors perceived greater restorativeness at beaches when ambient temperatures were at or below mean monthly temperatures and during low tides. The odds of perceiving the environment as more psychologically restorative were three times greater when visiting on days defined by government policy as having good air quality (OR=3.25; CI: 1.69–6.28). Visitors' perception of air (OR=1.56; CI: 1.14–2.18) and water quality (OR=1.78; CI: 1.28–2.49) also affected perceived restorativeness; with perceived healthy days more restorative. Warmer temperatures with less space due to sea level rise and poor environmental quality will restrict restorative experiences in recreational facilities designed for urban populations.

Keywords

Climate; air quality; environmental change; psychological restoration; mental health; coastal parks

1. Introduction

1.1. Psychological Restoration

The World Health Organization's (WHO) landmark assessment of the global burden of disease highlighted the growing impacts of mental health disorders on societies worldwide, with neuropsychiatric conditions accounting for approximately 13% of all Disability-Adjusted Life Years (DALYs), and accounting for 45% of the total number of years lived with disability (YLD) in those between the ages of 10 and 24 years (Collins et al., 2011; Gore et al., 2011). The knowledge gaps existing in preventive strategies against the development of mental health problems are alarming, and there is an increasing need to show that investment of societal resources into services and infrastructures that aid mental health are justifiably essential.

Public open spaces and natural parklands are increasingly receiving attention as salutogenic resources for psychological health (Bell et al., 2008; Morris, 2003; van den Berg, Hartig, & Staats, 2007). Psychologically restorative natural environments reduce stress (Velarde, Fry, & Tveit, 2007); elicit improvements in mood and concentration (Karmanov & Hamel, 2008; van den Berg, Koole, & van der Wulp, 2003); reduce heart rate (Chang, Hammitt, Chen, Machnik, & Su, 2008); correlate with self-reported health and quality of life (de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Ogunseitan, 2005); and outpace entertainment, built urban environments, and gymnasiums in perceived psychological and attention restoration quality (Bodin & Hartig, 2003; Herzog, Black, Fountaine, & Knotts, 1997; Hug, Hartig, Hansmann, Seeland, & Hornung, 2009). To date, studies in environmental health psychology have not typically incorporated gradients of physical environmental parameters as factors associated with public utilization and experiences of urban infrastructures and associated health outcomes (Hartig, Catalano, & Ong, 2007; Lafortezza, Carrus, Sanesi, & Davies, 2009). Few studies have examined the consequences of environmental change, i.e., changes in water/air quality and changes in climate, for the public utilization of psychologically restorative parks in heavily populated settlements (Cox, 2005; Scott, Jones, & Konopek, 2007).

Restorative environments are defined as places that afford visitors the opportunity to recover from stress and otherwise renew personal adaptive resources needed to meet the demands of everyday life, such as the ability to focus attention (Kaplan & Kaplan, 1989). Habitation of densely populated urban centers exerts stress on human psychological and physical resources, and the cumulative effects of exertion demands psychological restoration opportunities to avoid adverse health impacts (Hartig & Staats, 2006).

Natural environments have been demonstrated to support psychological restoration (Hartig, Evans, Jamner, Davis, & Garling, 2003; Herzog, Maguire, & Nebel, 2003; Kaplan, 1995), especially ‘blue spaces’ such as riversides and the seashore (Laumann, Garling, & Stormark, 2001; White et al., 2010). These natural environments are vulnerable to local and/or global environmental changes, including changes in air quality (e.g., photochemical smog), water quality (e.g., pollution of beaches with urban runoff or sewage), increases in ambient temperatures, extreme weather events, and in the case of coastal parks, sea level rise. Few urban parks have investigated or planned for vulnerabilities to potential climate change on existing infrastructures, much less the associated health effects to visitors (NPS, 2007).

Attention Restoration Theory (ART) posits that as one’s attention becomes fatigued their functioning declines to a point that restoration is necessary (Kaplan & Kaplan, 1989). Restorative environments must offer four factors to best facilitate restoration of attention fatigue; *being away, fascination, compatibility,* and *coherence* (Hartig, Korpela, Evans, & Garling, 1996; Kaplan, Kaplan, & Brown, 1989b). *Being away* refers to a geographical or psychological distance from demanding tasks and the associated ability to escape from distractions. *Fascination* refers to a soft, or effortless, intrigue into one's surroundings that allow a person to redirect attention from stressful demands. *Compatibility* is the factor that associates an individual's needs and desires with what the environment offers. Finally, *extent* indicates the ability to make sense of the structure, connectedness, and scope of the environment. Natural, park environments have been shown to consistently support human health (Kuo, 2010), including preference for restorative environments (Staats, Van Gemerden, & Hartig, 2010). Because changes in environmental quality and climate conditions have been shown to affect psychological health, it is hypothesized here that day-to-day changes will also affect the perceived restorativeness of coastal parks (Bullinger, 1989; Doherty & Clayton, 2011; Hartig et al., 2007; Stokols, Runnerstrum, Misra, & Hipp, 2009). Changes in environmental quality and climate may increase distractions, decrease fascination, and reduce perceived compatibility and coherence when visiting a natural environment.

1.2. Environmental Quality and Climate

Approximately one-third of the world's population lives in coastal regions, defined as within 100km of the sea and an elevation of less than 50m (UNEP, 2006). In the United States (incorporating Great Lakes region), 53% of the population lives within coastal zones. This includes ten of the largest 15 urban areas (NOAA, 2004). The site of the present study in Orange County, CA, lies within the second largest US Census-defined urban area of Los Angeles – Long Beach – Santa Ana, CA (11.8 million residents), and borders the 15^{th} largest, San Diego, CA (2.7 million). Highly urbanized populaces have been a keen focus of environmental psychology due to every day stressors in crowded, urban environments and constraints on access to nature (van den Berg et al., 2007). Coastal cities offer access to linear parks along the seashore; outdoor, natural settings that can be used for restoration and exercise (Giles-Corti & Donovan, 2002; Hug et al., 2009). Coastal cities have been an understudied urban environment, though they are the most visited ecosystems in the world (Pendleton, Kildow, & Rote, 2006) and among the most vulnerable to natural disasters and climate change (Adger, Hughes, Folke, Carpenter, & Rockstrom, 2005; Heberger, Cooley, Herrera, Gleick, & Moore, 2009).

In 2008, there were 13 million visitors to the seven state beaches and parks within the Orange Coast District of California State Parks (Figure 1). These beaches face a variety of physical environment gradients including diurnal tides, variations in air and water temperature, fog via marine layer inversions, onshore and offshore winds, and qualitative variations in local water and air resources. The 17 miles of state beach coastline has a history of water quality problems. Between January 1999 and March 2009, at least some portion of beach within one of the seven state beaches was closed, for a cumulative total of 283 days (representing 7.6% of available days). Beyond natural variations, climate change projections of rising sea levels and temperatures could have devastating consequences for these coastal parks.

A 2006 report by the California Climate Change Center (CCCC) concluded that under a Lower Warming Range (3 – 5.5°F/1.9 – 2.8°C) scenario, California is projected to experience 6 – 14 inches (15.2 – 35.6cm) of sea level rise, 2 – 2.5 times as many heat wave days, 1.5 times more critically dry years, 25 – 35% increase in days conducive to ground-level ozone formation, and a 10 – 35% increase in large wildfire risk by 2070 – 2099, compared to 1961 – 1990 (Luers, Cayan, Franco, Hanemann, & Croes, 2006).

In this study we aimed to investigate the hypothesis that perceptions of psychological restorativeness are affected by gradients in measured environmental parameters and perceived quality of environmental conditions. We sought to determine if parameters associated with climate change projections will negatively affect the role these parks play in providing psychological restoration for urban populations. Through this work, we expect to contribute to a deeper understanding of the potential consequences of global climate change projections and variations in local environmental quality for mental health.

2. Methods

2.1. Location of Infrastructures Selected for the Study

The beaches of the Orange Coast District component of the California State Parks system were selected as the study site in part because they are located in a densely populated urban region, and are described by reliable historical records of physical environmental parameters and public accessibility (Figure 1). The average number of visitors to the beaches exceeds 1 million per month, although this is variable by season. The beaches represent a publically funded recreational resource for local residents and tourists, with the tacit justification of benefits to public health and wellness. In 2008, the state park system charged $10 per vehicle entrance fee, but the beaches are also available free of charge to visitors arriving by public transportation, on foot, or bicycle. Three representative coastal beach parks in the Orange Coast District were selected for further study in this research: Bolsa Chica State Beach (4.0 million visitors in 2008), Crystal Cove State Park (770,000); and Doheny State Beach (1.5 million).

2.2. Population Survey

We developed a questionnaire-based survey instrument to test the hypothesis that objective measures and perception of physical parameters indicative of environmental quality influences the experience of psychological restoration by visitors to the coastal parks. The questionnaire was used to solicit information on experiences associated with objective and perceived climatic and other environmental parameters. The University of California Irvine's Institutional Review Board approved all materials, methods, and questions.

We visited the study sites to recruit participants twice per month during calendar year 2008; once on a weekday and once on a weekend. During the heavy tourist month of July, we added one extra weekday visit to each beach. In all, there were 75 survey visits. All survey dates were randomly selected prior to the beginning of each month, with the criteria of having one high and one low tide date per month. This quasi-random survey date selection helped provide a diversity of survey dates, climatic conditions, and other parameters of environmental quality. Each survey visit included at least two research surveyors over a period of two hours: between one hour prior to and one hour following the designated high/low tide.

Prospective survey respondents were approached directly. Surveyors approached all visitors appearing to be over the age of 18 years old and asked for their voluntary participation. Those who agreed to participate were given the option of completing the questionnaire as self-administered or research surveyor-administered. Participants who opted for surveyor-administered questionnaire listened to questions read by the surveyors who offered no further insight or guidance on how participants responded. Overall, 1,153 respondents participated in the population survey. For each respondent, we collected information on duration of stay, frequency of visits to the location, residence zip code, and if not visiting alone, the number of people in the group.

2.3. Assessment of Public Perception of Psychological Restorativeness

The psychological benefits of restorative environments are described by the Attention Restoration Theory (ART) which focuses on four components, namely, *being away*, *extent*, *fascination*, and *compatibility* (Kaplan & Kaplan, 1989; Kaplan, Kaplan, & Brown, 1989a). *Being away* allows the visitor to experience a sense of escape and change from the environment or occupation that had diminished the capacity for directed attention. *Extent* describes the temporal and spatial scope of the environment being visited; and extent is associated with concepts of connectedness and ease of comprehension of a location's dimensions. *Fascination* captures the level of engagement or interest in the environment, as visitors consider what they are viewing and experiencing without reaching the level of directed attention in a way that may exacerbate fatigue. The final construct is *compatibility*, or a person's inclinations and activities within the environment. *Compatibility* assesses the extent to which a person's needs are compatible with and supported by the environment.

Hartig and colleagues (1997) developed a *Perceived Restorativeness Scale* (PRS) based on ART. In PRS, the term *extent* was replaced by *coherence* to emphasize the importance of a coherent and understood connectedness to the environment. In addition, PRS includes the concept of l*egibility* to address issues of orientation as a visitor moves within an environment.

PRS presents questions and statements to which participants record their responses. For example, to the statement "Being here is an escape experience," respondents may select answers on a scale ranging from 0 to 6: 'Not at all' (0) to 'Completely' (6). There are 26 such statements, and the results of PRS assessment represents the means of aggregated responses, with appropriate reverse coding for negative-worded statements (e.g., "There is too much going on"). In the present research, we adopted the PRS and its associated definitions to assess respondents' self-report of perceived restorativeness in the environment. Confirmatory factor analysis supports the model of all five factors as the best fit. The RMSEA for one factor, four factor (compatibility and legibility combined, per findings in Hartig 1997), and five factor (compatibility and legibility separated), were 0.152, 0.092, 0.068, respectively.

2.4. Perception of Physical Environmental Conditions

Participants responded to questions about their perception of current weather and environmental conditions. Responses were ranked on Likert-type scales with six choices including a 'Don't Know' option. Responses to questions about air temperature and ocean (water) temperature ranged from "very cold" to "hot." Precipitation was ranked from "no rain" to "heavy rain." Perception of wind ranged from "no wind" to "strong wind." Cloud cover was recorded in quintiles, ranging from 0% to 100%. Air quality and water quality ranged from "very unhealthy" to "very healthy."

2.5. Ambient Physical Environmental Variables

Data from national and state monitoring stations were acquired for environmental parameters and climatic conditions. The data represented current tide conditions (low/high), maximum and minimum daily temperature, ambient temperature during each survey period, daily sum precipitation, wind, visibility, water quality, and air quality. Objective climatic and environmental quality data were recorded on the day of survey and represent recorded data closest to the time of the designated tidal visit.

Designated low/high tide were collected from NOAA (2008). Daily maximum/minimum temperature (^oC), precipitation (mm), and wind speed (mph) variables were recorded from the Western Regional Climate Center (2008). Weather Underground (2008) was used as the source of data on actual temperature at the time closest to the designated tide. Water quality data were provided by the Orange County Health Care Agency (2008), including total coliform bacteria in Colony Forming Units (CFUs)/100ml of water, and in Maximum Probably Number (MPNs)/100ml. Air quality data were from AIRNOW.gov (2008). This US government site categorically ranks ground-level ozone concentrations (Air Quality Index) into 'Good', 'Moderate', 'Unhealthy for Sensitive Groups', 'Unhealthy', 'Very Unhealthy,' and 'Hazardous.' Visibility in miles and relative humidity (%) were obtained from NOAA (2008).

As this research focused on the effect of environmental conditions on perceived restorativeness, we chose to measure both objective and perceived environmental quality and weather. Respondents in previous studies have shown an inability to accurately judge environmental quality and weather (Leslie, Sugiyama, Ierodiaconou, & Kremer, 2010; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007; Steinwender, Gundacker, & Wittmann, 2008). In addition, it was hypothesized that *perceived* environmental quality and *perceived* weather conditions would be associated with *perceived* restorativeness of the environment. This would be an intuitive result, but prior to the present study has not been tested. Objectively, various weather and environmental conditions have been statistically correlated with anti-depression medication prescriptions (Hartig et al., 2007), mood (Keller et al., 2005), and psychiatric emergency room visits (Briere, Downes, & Spensley, 1983), among other outcomes, but has not been associated with perceived environmental restorativeness.

2.6. Perceived Environmental Restorativeness Associated with Climate Change Scenarios

Based on low, medium, and high CO_2 emission scenarios, the California Climate Change Center projects temperature increases of 1.6-3.1^{o}C, 3.1-4.4^{o}C, or 4.4-5.5^{o}C, respectively, by the 30 year period of 2070-2099 (Luers et al., 2006). Based on these scenarios, the ambient temperatures during survey visits have been classified as average or plus 1.6^{o}C, plus 3.1^{o}C, or plus 4.4^{o}C.

Temperature anomalies were determined on the basis of historical trends compiled from average monthly maximum temperatures recorded between 1934 and 2006. The actual temperature on the survey date was subtracted from the average historical monthly maximum. For example, the average January maximum temperature for Crystal Cove State Park is 17.4^{o}C. The temperature at Crystal Cove at 11:30am on an actual survey day was 14.5^{o}C. The reported temperature anomaly for the study purposes is the difference of -2.9^{o}C.

2.7. Statistical Analyses

Descriptive univariate statistics were obtained for demographic data. Zero-order and non-parametric correlations were measured between potential confounders, independent variables of objective and perceived environmental quality and weather, and outcome variables of the PRS and its five separate constructs (Hipp, 2009). Based on correlation results, a series of t-tests were completed. For the t-tests, environmental parameters were transformed to binary variables, e.g. ‘Good’ air quality versus ‘Moderate’ or worse air quality.

The final analysis was a series of generalized ordinal logistic models (Norusis, 2010). The model relaxes the assumption of parallel lines. Individual means for the PRS and constructs were grouped into 6 ordinal categories. Means ≤1.50 = ordinal category 1; 1.51-2.50 = 2; 2.51-3.50 = 3; 3.51-4.50 = 4; 4.51-5.50 = 5; and means ≥5.51 = 6. Results are presented as exponential odds ratios estimating the association between environmental parameters and the odds of perceiving higher levels of restorativeness versus lower levels. The statistical package used was SPSS/PASW version 18.0.

3. Results

3.1. Demographic Information on Surveyed Population

The summary of the descriptive statistics of the surveyed population is presented in Table 1. All surveys were completed between 8:15am and 7:15pm, between January 16^{th}, 2008 and December 15^{th}, 2008. The survey methodology provided an even distribution of participants across the three parks, weekdays/weekends, and high/low tide. Overall, the response rate was 71.8%. Of those who refused to participate, 43.7% were female, 54.1% lived in Orange County, and their average age was 42.9 years. Compared to the 1,153 respondents, there were slightly more female participants (51%) and two-thirds of participants were Orange County residents. Caucasians were the majority race at 74% and 18% of all respondents self-identified as Hispanic/Spanish ethnicity. Participants were visiting the beaches with an average group size of four. Twenty-seven percent of respondents were California State Park annual pass holders, allowing for unlimited entrance during a 12-month period for the price of $100.00.

The average duration of visit was 2.9, just below the 2-4 hour interval (3 on the categorical scale of 1 – 4). Frequency of visitation was very high – 268 hours per year. This number was established by multiplying the self-reported number of yearly visits and the average length of visit per park. The frequency of visit to each of the seven coastal parks was summed to arrive at the average of 268 hours per year. The median frequency of visit was only 88 hours per year, or approximately 1.5 hours per week. Eight participants were removed from analysis due to the reporting of over 12 hours of beach visitation per day.

3.2. Objective Parameters of Environmental Quality on Scheduled Survey Dates

The ambient temperature on 14 out of the scheduled 74 survey dates (18.9%), for which we have temperature data, was at least 1.6^{o}C higher than the historical monthly average. The ambient temperature anomaly on 8 of these survey dates was higher than 3.1^{o}C, and on four dates, the anomaly was higher than 4.4^{o}C.

The tropospheric ozone concentration was rated as moderate or unhealthy for sensitive groups on three of the survey dates. Total coliform bacterial concentration in ocean water exceeded the regulatory standards of above 1,000 Colony Forming Units (CFU)/100ml of water on three dates. California's standard for ocean water contact is a single-sample of 10,000CFU/100ml and a geometric mean of 1,000CFU/100ml (CDPH, 2010; RWQCB, 1999; Santa Ana Regional Water Quality Control Board Water Quality Control Plan Attachment to Resolution No. 99-10," 1999). Rainfall occurred on only one date during the study period, and as such, precipitation was not included in the analyses.

3.3. Perceived Restorativeness of Coastal Parks

Visitors to the study sites perceived the locations to be psychologically restorative. The mean score on the *Perceived Restorativeness Scale* (PRS) was 4.8 out of 6.0, equivalent in narrative to between ‘Rather much’ and ‘Very much’ restorative (n = 1,053). In the PRS framework, *coherence* was rated highest with an average rating of 5.2 (between ‘Very much’ and ‘Completely’ restorative). The lowest rating (4.6) was associated with *being away*.

We included Cohen’s (1983) *Perceived Stress Scale* to test the relationship between stress and restorativeness. There was a positive correlation with higher perceived stress associated with higher perceived restorativeness ($R^2 = 0.04$, $p<0.001$). Thus, those most fatigued and stressed were reporting the environment as most restorative, on average. This result adds validity to the use of coastal parks as restorative environments.

A series of t-tests were performed to determine if there were significant variations in the perceived restorativeness of the coastal parks associated with objective and perceived environmental conditions (Tables 2 and 3). For the t-tests, all PRS data were square-adjusted to meet the assumption of normal distribution. Approximately 5% of all participants expressed complete agreement with each of the 26 statements on perceived restorativeness. The raw data showed significant negative skew, and several transformations were thus performed. Square-adjustments of all 26-items and the overall PRS score provided a normal fit to the data. Subsequently *coherence* was the only subscale with a skewness score of less than -0.04. As this step was exploratory, Bonferroni corrections were not performed.

Results for objective and perceived environmental parameters are presented in Tables 2 and 3, respectively. Non-significant environmental parameters are not reported. For objective environmental parameters this included water quality (i.e. bacterial Colony Forming Units), wind speed, water temperature, humidity, and visibility. For perceived environmental parameters this included ambient and water temperature and wind.

Visitors to the state beaches perceived the environment as more restorative on days objectively cooler than climate change scenarios, during low tide, and on days with ‘Good’ ground-level ozone. This held true for the aggregate PRS measure, but there was variety within the constructs. *Fascination*, *compatibility*, and *legibility* were each rated significantly higher with cooler ambient temperatures. Only the constructs of *being away* and *fascination* were significantly higher at low tide. Each construct was rated significantly higher during days with good air quality.

Perceived restorativeness and perception of air quality followed a similar response to objective air quality measurements, with the exception that the construct of *being away* was not significantly different. Visitors to the state beaches perceived the environment to be more restorative when they also perceived the air and water quality to be “healthy” or “very healthy.” Cloud cover had a small, but statistically significant effect on perceived *fascination*, with less cloudy days rated more restorative.

The final step of analysis was the generalized ordinal logistic models to reveal potentially predictive relationships among environmental characteristics and perceived level of restorativeness (see Tables 4 and 5). For these models, we controlled for seven factors based on their significant correlation with overall PRS score. The individual factors were: gender, location of survey response, group size, duration of stay, time of visit, Orange County resident, surveyor-administered, and the fixed-effect of park.

The odds of perceiving the environment as more psychologically restorative were more than three times greater when visiting the state beach on a day with good air quality, holding all other variables constant. This relationship held true for all constructs. Conversely, the odds of perceiving the environment as more psychologically restorative were 30% less likely when visiting a state beach during a high tide. This result was consistent across constructs except *legibility*. Visitors on a day with ambient temperatures greater than 1.6^{o}C above the monthly mean were 30% less likely to perceive the environment as restorative compared to those visiting on days with average or below average temperatures. Though the direction of the relationship between ambient temperature and restorativeness was consistent across the constructs, none of the individual constructs revealed a significantly relationship with temperature.

Similar to objective environmental parameters, visitors who perceived the air quality to be healthier were more likely to perceive the environment as more psychologically restorative. Perceived water quality also had a positive association with perceived restorativeness of the environment. The odds of reporting the environment as more restorative increased by 78%, on average, if the respondent perceived the Pacific Ocean water quality as either "Healthy" or "Very healthy." Perceived cloud cover had a negative association with the constructs of *being away* and *legibility*. On average, visitors to the state beaches reported that their experience provided less of a novel setting for *being away* when there was greater cloud cover.

4. Discussion

Through this study, we investigated whether changes in objective and perceived environmental conditions constrained or accentuated the perceived restorativeness of coastal park environments. The gradation of climate and environmental parameters across the 75 survey dates provided a rich ecological context within the framework of localized scenarios of global climate change. Approximately one in five survey dates had ambient temperatures at least 1.6^{o}C above monthly average. This result allowed for the comparison and contrasting of perceived restorativeness below and above established ambient temperature for climate change scenarios projected for California.

To simulate the potential impact of climate-induced sea level rise, we implemented the surveys around known periods of high and low tides, with high tide used as an approximation of perceived restorativeness in a sea level rise scenario.

The variations in objective and perceived environmental quality parameters also presented the opportunity to discuss results in the context of global environmental change. Decreases in air and water quality are both projections of climate change, especially in coastal, urban communities such as Southern California (Luers et al., 2006).

To our knowledge, this is the first attempt to establish a link between *objective* and *perceived* parametric gradients in environmental quality and climate and their affect on perceptions of psychological restorativeness. The results reveal perceived psychological restorativeness within the natural environments is *significantly influenced by gradients in environmental parameters*. The perceived restorativeness of the coastal parks was inversely associated with ambient air temperatures above climate change scenarios ($\geq 1.6^{o}C$) during visitation. The warmer the temperature, the less the environment rated as psychologically restorative.

The lower level of perceived restorativeness in the parks under objective conditions of above average temperatures may be related to an associated loss of physical comfort (Thorsson, Honjo, Lindberg, Eliasson, & Lim, 2007; Zacharias, Stathopoulos, & Wu, 2004). A recent study by Park and colleagues (2011) found cooler summer thermal conditions to be associated with less psychological distress and a greater sense of the environment being enjoyable, friendly, and natural. If visitors cannot reach a physical and psychological comfort level due to warm temperatures, then they will be unable to restore directed attention and/or gain relief from psycho-physiological stress. Increased temperatures may reduce the ability to experience soft, undirected fascination, with the heat becoming a focus of attention. The perceived compatibility of the environment is also lessened. Interestingly, perceived ambient temperature was not significantly associated with PRS, even though participants who visited the beach on days that were $\geq 1.6^{o}$C above mean temperatures were more likely to rate the temperature as warm or hot ($\chi^2 = 73.4$, $p<0.001$).

The level of perceived restorativeness and associated responses decreased as air quality, both perceived and objective, and perceived water quality became less healthy. Visiting a state beach on a day with "good" air quality, as opposed to "moderate" or "unhealthy for sensitive groups," more than tripled the odds of increasing perceived restorativeness to at least the next highest ordinal category, a result significant for each construct as well. Though air quality is much improved from the 1970s and 1980s, Southern California is still susceptible to smog and on many survey dates a brown haze was noticeable on the horizon. Concerns about the environment and the air one is breathing may be directly related to perceptions of environmental restorativeness. Though a causal link cannot be made with the present study, the results do offer a strong association. The significant relationship between perceived environmental quality and perceived restorativeness is evident in regard to water quality as well.

These are noteworthy results given climate change projections for Southern California include increases in the number of days with high levels of tropospheric ozone (Luers et al., 2006) and increased levels of surface water pollution due to increased urban runoff, flooding, and alterations in El Niño patterns (Boehm et al., 2002; Dwight, Semenza, Baker, & Olson, 2002; Murdoch, Baron, & Miller, 2000; Tibbetts, 2007; Trenberth & Hoar, 1997). Major health impacts of climate change are projected to be associated with poor air and water quality with increasing incidences of gastrointestinal disorders and respiratory diseases (USEPA, 2009). However, the psychological health effects that are expected to accompany deterioration of environmental quality have been difficult to pinpoint and quantify (Stokols, 1992; Stokols, Runnerstrom, Misra, & Hipp, 2009; van Kamp, Leidelmeijer, Marsman, & de Hollander, 2003).

The statistically significant association of oceanic tide levels and perception of psychological restorativeness is another important finding. That low tide is perceived as more restorative was an unexpected finding for the coastal parks given all three were favored surfing environments during high tide. Low tide conditions do offer tide pool exploration and wider sandy and rocky areas to explore, facts that may support higher ratings of *fascination* and *being away* during low tides. However, respondents reported participating in tide pool exploration less often than surfing (20% and 28% of respondents, respectively). We believe our findings are due to the negative effect of crowding during higher tides. Presumably, during high tides, crowding occurs because there is less physical space on the sand for restoration, social, and recreational activities. In urban environments such as Orange County with high seasonal beach visitation, higher tides may reduce the public benefits of parks and infrastructures designed to support beach visitation due to an accompanied increase in crowding.

Respondents to this survey revealed high incidence of beach visitation, with a median of 88 hours of visitation per year. Past research into preferred and favorite places reveal seaside environments as a significant choice (Korpela, Ylen, Tyrvainen, & Silvennoinen, 2010; Laumann et al., 2001; White et al., 2010). During 2000-2001, NOAA and California State University, Chico conducted a phone-based study to determine the number of beach-goers in

Southern California and the frequency of their visits. In a five county area of Southern California only 30.6% reported not being beach-goers. In a more detailed, diary-based study of beach-goers in Los Angeles and Orange Counties, respondents reported going to the beach an average of 5.6 times between February and July, 2000. Within this group there were individuals who reported visiting the beach at least 30 times in a two month diary period (NOAA, 2002). These findings support the strong preference for coastal park visitation by local residents.

The high frequency of beach visitation in the present study may hint at the possibility of future visitor adaptation to changing climatic conditions. One of the grand challenges in framing climate change projection work is addressing how populations might adapt and adjust as climate, on average, gradually changes. Colleagues in Italy and the UK compared preference for shade during summer green space visitation (Lafortezza et al., 2009). There was considerable preference for shade in both countries, but the preference for shade was significantly higher in the warmer Italian cities. The Italian users were also more likely to visit the green space in the evening to avoid the warmest part of the day. As climate changes it is reasonable to expect such adaptations as seeking shade and avoiding the park during extreme temperatures. We suspect extreme temperatures or the absence of sandy beach areas due to sea level will result in people seeking other opportunities for psychological restoration. It is up to governments to anticipate and plan for this, especially in urbanized regions. However, it is difficult to quantitatively predict the extent of adaptation if the baseline conditions change worldwide as predicted by climate change scenarios.

These results are based on self-selected participants who had already made the decision to visit the study sites. Our conclusions should be interpreted carefully within this context. However, Winkel et al. (2009) suggests congruence between selection of recreational environments and the health behavior outcomes, where, for example, certain locations support passive relaxation and others support active physical exercise. Changes to the quality of the environment may, as in this study, affect perceived restorativeness.

5. Conclusions

Our results provide evidence for the psychological effects of climate change with respect to mental restoration. The results also provide a strong rationale for proactive accommodation of the projected impact of global climate change through the design of urban parks to maintain benefits to the public and prevent possible impacts on mental health.

Through this research, we tested the hypothesis that the level of perceived psychological restorativeness of coastal parks is sensitive to gradients in environmental quality and climate that are associated with global climate change projections. Important results of this research are that *perception* of water and air quality, and objective measures of temperature difference from monthly mean, tide, and air quality are all significantly associated with perceived level of psychological restorativeness in the environment. Projections of global climate change impacts include deterioration of each of these environmental parameters.

The statistically significant contribution of both *perceived* and *objective* gradients in environmental parameters to the anticipation of psychological restoration in coastal parks has broad implications. Natural parks in urban and peri-urban regions have been shown to offer salutogenic health benefits to residents. The justification for resources expended by societies to maintain parks and access to natural areas is buttressed by arguments linking such resources to preventive strategies in mental health care at the population level.

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Table 1. Descriptive statistics of sampled population.

Variable	N	Mean / %	SD
Response rate	1,153	71.8%	NA
Female	572	51.0%	NA
Age	1,107	42.9	14.0
Spanish/Hispanic origin	196	17.9%	NA
Caucasian	811	73.7%	NA
Orange County resident	631	63.4%	NA
Income[a]	1,041	3.2	0.9
State Park annual pass holder	182	27.0%	NA
Group size	1,103	4.0	6.5
Duration of visit[b]	1,145	2.9	0.9
Frequency of visit (hours/year)[c]	939	323.0	785.7
People per viewscape	1,124	60.1	148.4
High tide	539	46.7%	NA
Surveyor administered[d]	235	20.7%	NA
State Beach/Park			
Bolsa Chica	385	33.4%	NA
Crystal Cove	381	33.0%	NA
Doheny	387	33.6%	NA
Location of survey within state beach			
Beach/sand	791	68.6%	NA
Boardwalk	175	15.2%	NA
Other	187	16.2%	NA
PRS	1,032	4.8	0.8
Being away[e]	1,124	4.6	1.3
Fascination	1,132	4.8	1.0
Coherence	1,101	5.2	1.1
Compatibility	1,099	4.8	1.1
Legibility	1,098	4.7	1.1

[a] Ordinal variable: 1 = Under $20k annual; 2 = $20k - $60k; 3 = $60k - $100k; 4 = Greater than $100k
[b] Ordinal variable: 1 = Less than one hour; 2 = One to two hours; 3 = Two to four hours; 4 = Longer than four hours
[c] Calculated as the sum of mean annual visits multiplied by mean length of stay for all seven Orange Coast District State Beaches and Parks.
[d] All others completed as self-administered
[e] PRS, Being away, Fascination, Coherence, Compatibility, and Legibility. Mean of responses to comments on restorative aspects of the environment (ordinal variables): 0 = Not at all; 1 = Very little; 2 = Rather little; 3 = Neither little nor much; 4 = Rather much; 5 = Very much; 6 = Completely

Table 2. Summary of t-tests of relationship between objective environmental parameters and binary perception of psychological restorativeness.

		Mean (Standard Deviation)					
Objective environmental variable	N[a]	PRS	Being away	Fascination	Coherence	Compatibility	Legibility
Temperature during visit[b]							
< 1.6°C above monthly mean	868	24.0* (7.3)	23.1 (9.9)	24.0** (8.7)	28.6 (9.1)	24.7* (9.0)	23.7* (9.3)
≥ 1.6°C above monthly mean	214	22.8 (7.2)	23.2 (10.0)	22.0 (8.4)	27.4 (9.2)	22.2 (9.7)	22.2 (9.6)
Tide							
Low	578	24.3** (7.3)	23.7* (10.0)	24.4*** (8.5)	28.5 (9.1)	24.9 (9.1)	23.7 (9.4)
High	513	23.1 (7.3)	22.4 (9.8)	22.6 (8.7)	28.0 (9.2)	24.0 (9.3)	22.9 (9.4)
Actual air quality							
Moderate/unhealthy for sensitive groups	50	19.8*** (7.5)	19.1** (10.6)	19.5*** (8.9)	25.2* (10.5)	20.8** (10.4)	19.9** (9.0)
Good	1048	23.9 (7.3)	23.3 (9.9)	23.8 (8.6)	28.4 (9.1)	24.6 (9.1)	23.5 (9.4)

[a] N represents the smallest sample size across the five constructs
[b] Significant differences between groups are as follows: * p<0.05, ** p<0.01, **p<0.001

Table 3. Summary of t-tests of relationship between perceived environmental parameters and binary perception of psychological restorativeness.

		Mean (Standard Deviation)					
Perceived environmental variable	N[a]	PRS	Being Away	Fascination	Coherence	Compatibility	Legibility
Perceived air quality[b]							
Unhealthy or neither unhealthy/healthy	197	21.9*** (7.7)	22.9 (9.8)	21.5*** (21.5)	26.3** (10.3)	22.1*** (9.6)	21.1*** (9.8)
Healthy	777	24.2 (7.2)	23.1 (10.0)	23.9 (23.9)	28.8 (8.8)	25.2 (8.9)	24.2 (9.1)
Perceived water quality							
Unhealthy or neither unhealthy/healthy	342	22.3*** (7.0)	21.9*** (9.5)	21.6*** (8.5)	26.9* (9.6)	23.8*** (9.2)	22.3*** (9.2)
Healthy	318	25.3 (7.2)	24.5 (9.7)	25.2 (8.5)	28.4 (9.4)	26.5 (8.4)	25.5 (8.9)
Perceived cloud cover							
0 – 25%	839	23.9 (7.3)	23.6** (9.7)	23.5 (8.7)	28.5 (8.9)	24.7 (9.1)	23.6 (9.3)
50 – 100%	220	23.2 (7.3)	21.6 (10.2)	23.7 (8.4)	27.8 (10.0)	24.1 (9.1)	23.0 (9.3)

[a] N represents the smallest sample size across the five constructs
[b] Significant differences between groups are as follows: * $p<0.05$, ** $p<0.01$, **$p<0.001$

Table 4. Generalized ordinal logistic model for objective environmental parameters (results have been exponentiated; proportional odds ratios shown).

	OR (95% CI)					
	PRS	Being Away	Fascination	Coherence	Compatibility	Legibility
Temperature during visit						
<1.6°C above monthly mean[a]	1	1	1	1	1	1
≥1.6°C above monthly mean	0.70 (0.50, 0.98)	0.92 (0.67, 1.27)	0.79 (0.58, 1.09)	0.86 (0.61, 1.07)	0.95 (0.69, 1.32)	0.79 (0.57, 1.09)
Tide during visit						
Low	1	1	1	1	1	1
High	0.71 (0.56, 0.91)	0.69 (0.54, 0.88)	0.73 (0.57, 0.93)	0.76 (0.58, 0.98)	0.78 (0.61, 0.99)	0.80 (0.62, 1.02)
Air quality						
Moderate/ unhealthy for sensitive groups	1	1	1	1	1	1
Good	3.26 (1.69, 6.28)	2.02 (1.06, 3.84)	2.60 (1.40, 4.85)	2.26 (1.18, 4.31)	2.29 (1.17, 4.45)	2.35 (1.21, 4.57)

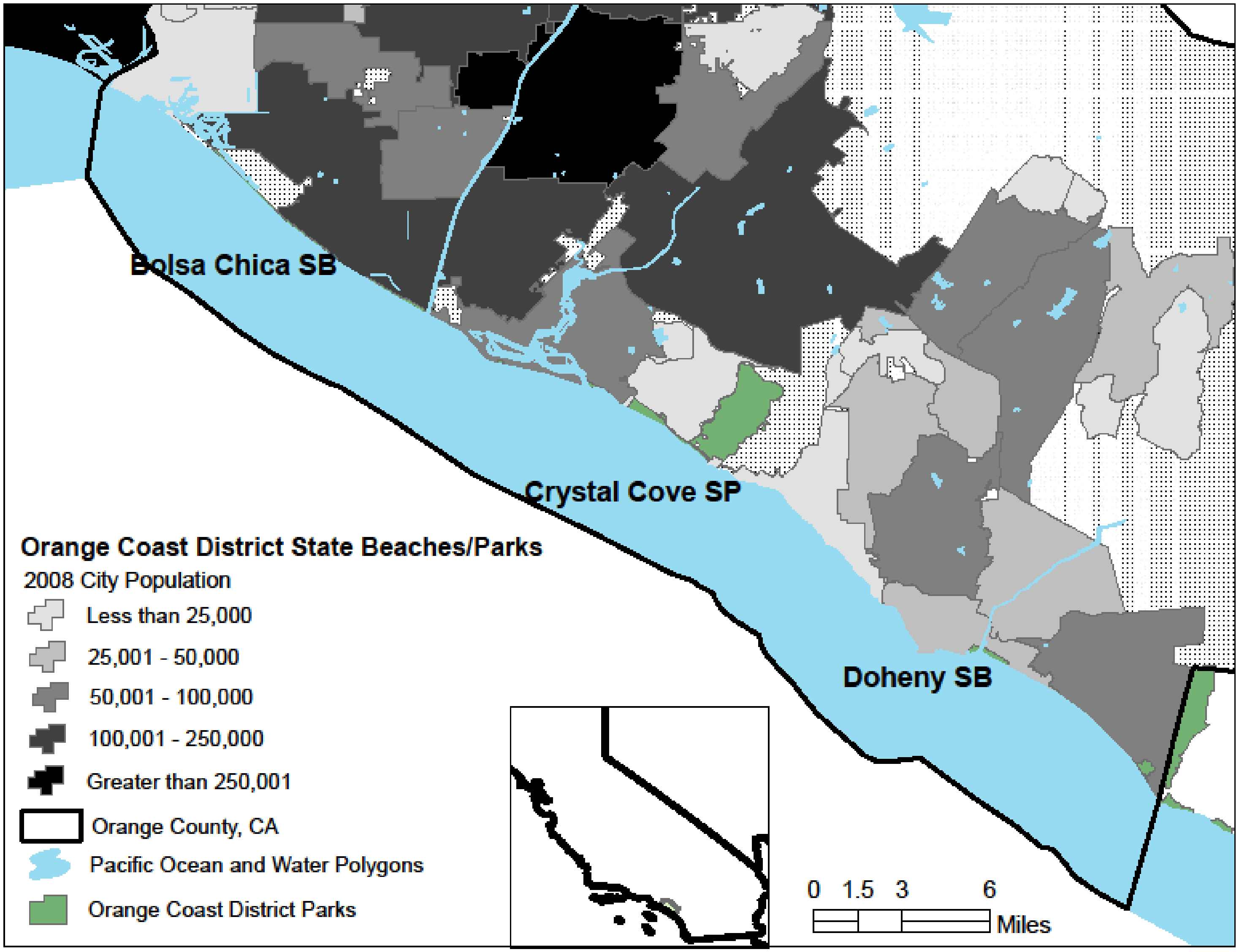
[a] Reference category.

Table 5. Generalized ordinal logistic model for perceived environmental parameters (results have been exponentiated; proportional odds ratios shown).

	OR (95% CI)					
	PRS	Being Away	Fascination	Coherence	Compatibility	Legibility
Perceived air quality						
Neither unhealthy, nor healthy to Very unhealthy[a]	1	1	1	1	1	1
Healthy or Very healthy	1.56 (1.14, 2.18)	1.04 (0.76, 1.43)	1.51 (1.10, 2.08)	1.60 (1.15, 2.24)	1.61 (1.17, 2.21)	1.49 (1.08, 2.07)
Perceived water quality						
Neither unhealthy, nor healthy to Very unhealthy	1	1	1	1	1	1
Healthy or Very healthy	1.78 (1.28, 2.49)	1.66 (1.21, 2.28)	1.98 (1.44, 2.73)	1.18 (0.84,1.66)	1.60 (1.16, 2.21)	1.87 (1.35, 2.59)
Perceived cloud cover						
< 25%	1	1	1	1	1	1
> 50%	0.75 (0.56, 1.02)	0.68 (0.50, 0.91)	0.82 (0.61, 1.10)	0.82 (0.60, 1.13)	0.76 (0.58, 1.04)	0.58 (0.43, 0.78)

[a] Reference category.

Figure 1. Map of study sites and Orange County population per city.



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