Do Climate or Institutional Factors Drive Seasonal Patterns of Tourism Visitation to Protected Areas Across Diverse Climate Zones in Eastern Australia?

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Abstract

Seasonality in tourism is a regular and predictable cycle of visitation across a year. Although seasonality in visitation is extremely common and is known, in principle, often to be driven by temporal changes in a range of natural and institutional factors, the relative importance of different individual pressures has yet to be quantified for any large-scale geographic areas. To assess the relative importance of natural versus institutional factors in driving tourism seasonality, data on visitation patterns were collated from 23 protected areas across six Koppen climate zones in eastern Australia. Analyses sought to determine the degree to which climate variables (such as mean monthly rainfall, and minimum and maximum temperatures) explained visitation patterns, and to understand how these relationships could assist in the prediction of tourism futures. Climate was the principal force driving seasonal patterns of visitation in equatorial, tropical, desert, grassland and temperate zones, whereas visitation to alpine/sub-alpine areas was driven by a complex array of natural and institutional factors. Tourism seasonality was driven mostly by institutional factors only in the sub-tropical climate zone. These analyses suggest that seasonal characteristics of current visitation could

be used to predict the degree to which changes in climate and/or institutional arrangements such as school holiday periods might influence tourism opportunities in protected areas in eastern Australia.

Keywords: Koppen climate zones, climate change, visitation, future tourism, management, adaptation

Introduction

Growth in demand for natural area tourism over the past two decades has seen annual visitor numbers rise in protected areas globally (Newsome et al. 2002). Patterns of visitation to many protected areas are typically highly seasonal, often with peak periods occurring in relatively narrow windows of time (Baum and Lundtorp 2001, Grindley 2005, Hadwen *et al.* 2008). Such strong temporal patterns in visitation (known as ‘tourism seasonality’) to natural areas are, however, not surprising, as seasonality is one of the most significant defining characteristics of tourism (Butler 2001, Scott and Lemieux 2009). Indeed, many researchers have highlighted the significant challenge that tourism seasonality poses for employment opportunities, visitor accommodation and the sustainable use of natural resources, especially in regional destinations (Ashworth and Thomas 1999; Adler and Adler 2003; Jang 2004).

Researchers have identified two main causes of seasonality in tourism: i) factors related to natural phenomena, such as climate, landforms and ecological characteristics, and ii) factors that are institutional and/or social (Butler 2001). Natural seasonality is largely driven by climatological conditions (e.g. temperature, rainfall) and other aspects of the natural world (such as migrations of iconic animal species, wildflower flowering times etc), whereas institutional seasonality is largely driven by societal practices and factors such as the timing of major holiday periods (Butler 2001). Depending on the destination and the sector of interest, different researchers have claimed that either natural or institutional factors have a greater influence on seasonality in tourism. For example, Nadal et al. (2004) and Parilla et al. (2007) indicated that economic and accommodation factors, respectively, determined seasonality in tourism in Spain. In contrast, Scott *et al.* (2008a) and Scott and Lemieux (2009) have recently highlighted the critical role that climate can play in driving holiday destination choice and tourism seasonality in North America.

Other studies have suggested that tourism seasonality in natural areas is influenced by both natural and institutional factors. For example, Grindley (2005) noted a pronounced temporal variability of visitation to Elgon National Park in Uganda, with peaks in July/August and December/January that

were closely tied both to anticipated weather patterns (a climatic, and thus natural, factor) and the annual holiday periods of the dominant overseas visitors from Europe and North America (an institutional factor). For many protected areas such as National Parks, it is not unreasonable to postulate that climate plays a strong role in explaining visitation patterns, as these sites often have few or limited facilities to provide visitors with respite from adverse weather events (such as heavy rain or high humidity, extreme cold or heat, and sand or snow storms), that could restrict visitation to particular times of year (Butler 2001). Moreover, it is the natural environment in protected areas that is attractive to tourists and its appeal will change with seasonal patterns in weather and critical ecological processes, such as animal migration and plant flowering. Indeed, many researchers have commented on the role of climate (and/or weather) in influencing tourism and recreation in natural areas (e.g. de Freitas 2003 and Keller et al. 2005). Given that both natural and institutional factors can, in principle, establish and maintain tourism seasonality in natural areas, planners require an understanding of the relative importance of these different sorts of factors to ensure future provision of facilities, accommodation and activities for visitors (Scott and Lemieux 2009).

While many studies have identified the types of natural and institutional drivers that drive seasonality in tourism for particular destinations over relatively small spatial scales (Ashworth and Thomas 1999, Nadal et al. 2004, Parilla et al. 2007), there have been few or no large-scale geographic analyses of patterns of tourism seasonality and the factors that control it, nor many analyses that span a large range or diversity of Koppen climate zones. For example, whilst studies in Canada by Jones and Scott (2006) and the United States by Hyslop (2007) have examined the role of climate (and climate change) in influencing visitation in National Parks across many different climate zones, neither of these studies incorporated investigations of institutional drivers of seasonality.

Australia provides an excellent case study for which analyses of tourism seasonality can be elaborated, since the entire country (7 617 930 km²) is governed by a single Federal government (albeit with separate State and Territory governments) and therefore has relatively homogeneous institutional arrangements that fix the timing of school and public holidays. Furthermore, given its large size

Australia has climatic conditions that are extraordinarily diverse along a gradient of over 30° latitude (Colls and Whitaker 2001), with six Koppen climate zones stretching from the equatorial north (~10° S) to the cool temperate south of the country (~45° S) (Figure 1). These climate zones range latitudinally from monsoonal and wet-dry tropics in the north to alpine and cool temperate climate zones in the south. The diversity and climatic contrasts of the country support a wide variety of ecosystem types and biological phenomena across Australia, for example, bird-breeding events, wildflower seasons and fishing opportunities. Coupled with the demonstrated appeal of the natural environment for domestic and international travellers to Australia (Newsome *et al.* 2002), the diversity in climate and ecosystem types suggests that the drivers of tourism seasonality across Australia may vary considerably with location along the latitudinal gradient and related change in climatic zone.

In light of the appeal of natural area settings and the broad range of climates and ecosystems that occur across the country, it was predicted that natural, and especially climatic, variables would explain most of the seasonality of tourist visitation to natural areas in Australia, especially in the more climatologically extreme northern and arid inland parts of the country. Indeed, there is a general and somewhat intuitive understanding of climatic seasonality in Australia and its implications for tourism, as seen in the travel recommendations provided on the Australian Bureau of Meteorology website (www.bom.gov.au - site accessed on 4/7/2009). These state that:

“Most people will be more comfortable if they can visit northern and central Australia during the (southern) winter and go to the high country, the south coast and Tasmania during our summer. As an example, you could visit Tasmania (see [Hobart](#)) during summer or [Melbourne](#) in autumn, then travel north via [Sydney](#) as autumn continues. In winter, visit the Great Barrier Reef (see [Cairns](#) climate information), then go to [Ayers Rock/Uluru](#) and Kakadu national park (see [Jabiru](#)). If time permits, go on to Western Australia in the spring, to see the wildflowers (see [Morawa](#) climate information).”

Despite these general travel recommendations, which are based on Australia's climate and the anticipated visitor comfort associated with climate, there have been no detailed studies investigating relationships between climate and tourism seasonality across all six Koppen climate zones. To address this question and to examine relationships between natural (climatic) and institutional (holiday period) variables and the seasonality of visitation to protected areas, visitor statistics from 23 protected areas, spread across all six climate zones, were collated from eastern Australia. These data were used to assess the relative importance of climatic and institutional factors on tourism seasonality from sites ranging from those in the monsoon and wet-dry tropics in the northern parts of eastern Australia, to the arid interior, the coastal sub-tropics and the alpine and cool temperate zones of southeastern Australia.

Materials and Methods

Visitor data

To examine visitation variability for a range of protected areas throughout Australia, all Australian State and Territory government agencies responsible for protected-area management were contacted, with a request for access to visitor statistics from protected areas within their jurisdictions. This request specifically sought monthly (or shorter) duration visitor statistics, as the major aim of the analyses was to determine whether there were significant within-year relationships between visitation, climate and holiday periodicity, rather than to interrogate the data for long-term (i.e. inter-annual) trends in visitation.

Responses from government agencies for access to their visitation statistics were highly variable. Across most agencies and for most protected areas, generally very little suitable data were available to assess within-year temporal variation (i.e. monthly and seasonal patterns) in visitor numbers. This lack of suitable data is perhaps due, at least in part, to the fact that entry to natural areas is typically free in Australia and as a result, there are few opportunities for protected area managers to collect visitation statistics. As a result, the protected areas that were included in this study were dependent largely on whether appropriate visitor data were available with the necessary quality and temporal resolution. The availability of useable visitor data restricted our analyses to National Parks in Queensland and a

smaller number of National Parks and Reserves from New South Wales, Victoria and Tasmania, that is, eastern Australia (see Figure 1 and below for details). Although data was requested from agencies in the Northern Territory, Western Australia and South Australia, none were made available. In total, visitor information from 23 protected areas was collated. Fortunately, these sites spanned all of the six major Koppen climate zones in Australia (Figure 1).

In addition to the patchiness of visitor statistics across the jurisdictions, the quality and quantity of data from each of the four State agencies was variable (Table 1). Most importantly, the methods of data collection used by different natural-area managers differed, from ‘number of camping permits sold’ to ‘road counter estimates of visitor loads’ to ‘visitor counts in visitor information centres’. Even within a single protected area, these different recording methods are known to be subject to substantial error (Newsome *et al.* 2002, Cessford and Muhar 2003, Arnberger *et al.* 2005). Nevertheless, given the absence of better and/or more comparable data sources and the broad scale approach of our analysis, these data were deemed suitable for the study.

Queensland

Monthly visitation data were available from the Queensland Environmental Protection Agency (Q EPA) for official camp sites within most of the State’s National Parks for the period 1996-2000. In total, information was available for 11 National Parks in Queensland (Table 1). Information was recorded via sales of camping permits and is likely to be relatively accurate. However, campers who did not buy permits or did not camp in designated camp sites within protected areas fall outside the range of these data. Furthermore, the data do not account for day visitors to protected areas, who can constitute a sizeable proportion of total visitors, particularly in protected areas close to major population centres where day trips are common (e.g. Dwyer and Edwards 2000). Although day-users of wilderness areas can be quite different from overnight campers in their perceptions, attitudes and activities (Cole 2001), their seasonal patterns of visitation are likely to be very similar to those of overnight campers. Therefore, for the purposes of the present study, data on the number of campers in any given park are suitable for the analysis of seasonal visitation patterns.

New South Wales

Data were obtained from the Visitor Data and Research Officer from the Parks and Wildlife Group within the New South Wales Department of Environment and Climate Change (NSW DECC). Visitor data were provided for four protected areas: two National Parks in central New South Wales, one Conservation Area in the western region, and one National Park on the south-coast (Table 1). All visitor data were recorded using road counters, which means that cars passing a given entrance point were counted rather than a direct quantification of actual visitor numbers. The raw data were then processed in different ways by NSW DECC for each of the four protected areas: in some cases, data were provided to us as raw vehicle numbers, whilst others were presented as ‘vehicle numbers multiplied by the average number of occupants’ to generate an estimate of total visitor numbers (Table 1). In addition to such differences in the available data, the timeframes for which data were available were highly variable across the four protected areas. They ranged from two to six years for each site between the years of 1999 and 2007 (Table 1). Nevertheless, the available data were suitable in that they provided the seasonal patterns in visitation that were critical for the analysis of tourism seasonality.

Victoria

Daily visitor data were made available by the Information Officer of Parks Victoria for the State’s Corporate Indicator Parks from September 2001 to August 2002. These data were collected by the agency by using a combination of visitor monitoring techniques and road counters (Table 1). Unlike most of the information available for other States, the original data for Victoria were highly resolved temporally, so the daily numbers were summed up to a monthly scale to make them consistent with the scale of data that was available from the other jurisdictions.

Tasmania

Access was granted by the Tasmanian Parks and Wildlife Service to monthly data from April 2004 to September 2005 for several well-known and heavily visited National Parks. To account for the fact

that different counting systems were in place in different sites within Tasmania (see Table 1), the raw data for each protected area were standardised to generate a set of data with the necessary spatial and temporal resolution for the seasonality analysis.

School holiday periods

An institutional factor that might explain much of the seasonality in visitation to protected areas is the timing of holiday periods. Specifically, it might be expected that visitation in some protected areas would rise and fall most strongly with school and/or public holidays in nearby population centres. Despite some minor differences across States and among schools, holidays for school children in Australia are usually 2-3 weeks in each of March, June and September, with a longer period of 4-6 weeks over the Christmas and New Year holiday period in December and January. There are also significant public holidays around Easter and Christmas and these are two times of the year when families traditionally travel and go on holidays (*sensu* Hadwen and Arthington 2003).

As it was possible that temporal accessibility to protected areas influenced the observed seasonality in visitation, a categorical index of holiday periodicity was developed which ranked each month of the year according to the occurrence and frequency of public and school holidays for the relevant State. A month with no designated public or school holidays was given a score of zero (e.g. November), a month with some public holidays was given a score of one (e.g. May), a month with school holidays was given a score of two (e.g. September) and a month with both school and public holidays was given a score of three (e.g. December). An additional benefit of this month-by-month scoring system is that it allows for a short period either side of the nominal school holiday period for families to visit protected areas; it is not uncommon for children to be withdrawn from school for brief periods either side of the formal holiday period. Although a monthly time-step scaling of holiday periods is not optimal in terms of capturing inter- and intra-regional differences in the timing and length of holidays, the fact that the climate and visitation data are available only as monthly averages meant that it would be inappropriate to develop a more refined index of holiday periods in the context of this study.

Climate data

Climate data for all protected areas were downloaded from the Australian Bureau of Meteorology's website and were calculated from records collected over long-term recording stations, with most data spanning the 1890s to the 1990s. Regional climate data were collated for each protected area for which visitor data were made available. Data on mean monthly rainfall (mm) and mean monthly maximum and mean monthly minimum temperatures (°C) were obtained for single locations within or nearby (within a 50 km radius) the 23 protected areas for which visitation data were available. These climatic variables were chosen specifically because temperature and rainfall (including snowfall) have been shown to influence the decision-making behaviours of visitors engaging in outdoor tourism and recreation (Kozak 2002, Hamilton and Lau 2005).

Although most tourist-comfort indices also include relative humidity as a variable (Mieczkowski 1985, de Freitas *et al.* 2008), humidity was not included in this study for two reasons. First, not all meteorological stations in Australia routinely record relative humidity, so monthly humidity records were not available for many of the protected areas studied. Second, for those sites that did have humidity data, the observable trends in mean monthly humidity did not vary sufficiently, either annually within a site or between sites, to be a useful climatic predictor in the subsequent analysis.

Analytical approach

Temporal variability in visitation patterns to protected areas across six climate zones in eastern Australia. The Koppen classification is widely used to delimit and describe climatic regions across Australia (www.bom.gov.au, Figure 1). There are six main Koppen climate zones across the country: equatorial, tropical, desert, subtropical, grassland and temperate. These climate zones were identified by the Australian Bureau of Meteorology using a modified Koeppen classification system, on the basis of a standard 30 year climatology record that covered the period 1961 to 1990. When combined with the visitation datasets described above, differences in protected area visitation across each of the six Koppen climate zones in Australia could be examined (Figure 1). The results are

principally presented in relation to the Koppen climate zones from here on, although some regional and State context is provided where necessary.

Variability in visitation patterns across Koppen climate zones. To examine the seasonality of visitation across all six Koppen climate zones data were collated from all 23 protected areas and mean monthly visitation statistics were calculated for each Koppen climate zone, as depicted in Figure 1.

Regression analyses examining drivers of seasonality in visitation. Mean monthly visitor numbers from the different sites were transformed from raw visitor numbers to percentages of total annual visitor numbers across each month, in order that the data could be compared across different protected areas that had large differences in total visitors but similar visitation seasonality. The transformed data were then regressed (using a separate linear mean squares regression for each variable) against the range of climate and holiday variables. As mentioned above, the climate variables used were mean monthly minimum temperatures, mean monthly maximum temperatures and mean monthly rainfall (which was also treated as a percentage of total annual rainfall). Visitation seasonality was also regressed against the categorical 'holiday periods' variable, in an attempt to examine the relative influence of domestic holiday periods on visitation variability. By regressing visitor statistics against categorical values for holiday periods, the relative importance of temporal accessibility (holiday periods) on visitor loads was determined for the protected areas assessed in each region. This approach accounted for potential visitation seasonality that was driven by the capacity of domestic travellers to visit the selected protected areas in any given month. To examine broad and local patterns in visitation, all regression analyses were conducted both at the Koppen climate zone scale ($n = 6$) and at the individual protected area scale ($n = 23$).

Results

Broad-scale temporal patterns in visitation to protected areas in different climate zones

There was substantial variability in the average timing and magnitude of visitor peaks and troughs to protected areas across the six Koppen climate zones (Figure 2). Patterns for the six protected area sites

in equatorial, tropical and desert climate zones (see Figure 1) revealed very strong peaks in visitation during two mid-year months, June and July, which represent the dry season in this part of the country (Figure 2). For example, visitation in the equatorial zone occurred in a very short peak in this dry season, with more than 55% of the annual visitor load in the region coming in just two months, July and August (Figure 2). In contrast, visitation to tropical and desert climatic zones tended to be spread over a wider period than that for the equatorial sites (Figure 2). Significantly, visitation in all three of these zones was very low (less than 5% of the total annual visitor numbers) in the hottest and wettest months of the year, which in northern Australia occur from November through to March.

In contrast to the strong mid-year peaks in climate zones in equatorial, tropical and desert climate zones, visitation seasonality was tri-modal for the four protected area sites in the subtropical zone (Figure 2). For protected areas in this climate type, which were all in southeast Queensland (Figure 1), distinct visitation peaks occur around the autumn (April), spring (September-October) and summer (December-January) school holiday periods. The month-by-month contribution to annual visitation is relatively similar across these three peaks, with each contributing about 12% of the total visitor numbers annually. Thus, with five months of the year each contributing around 12% of the annual load (thus together accounting for around 60% of the annual visitor numbers), this region displayed a greater spread in visitation across the year than any other climate zone examined in the study.

Peaks in visitation in autumn (April) and spring (September) were also evident in data for the grassland climate zone (data from protected areas in western Queensland and western New South Wales). However, unlike the subtropical (south-east Queensland) zone, the mid-summer (December-January) peak in visitation was absent for these grassland zone sites (Figure 2). For the grassland zone, it may be that higher summertime temperatures deter visitors during this period, as seems to be the case also for the equatorial, tropical and desert zones (Figure 2). Indeed, the shape of the seasonal visitation curve for the grassland zone seems to be a hybrid of the desert and subtropical zones. This result is perhaps not surprising given that the grassland zone sits geographically between the desert and subtropical zones, at least in the northern half of eastern Australia (Figure 1).

Protected areas in temperate zones in southern Australia displayed a seasonal trend in visitation that was characterised by a strong peak in numbers during the summer (December – March/April) and low visitation for the remainder of the year, particularly through the colder months (May – August) (Figure 2). In contrast, seasonality in the only alpine area examined in our study (Mt Buffalo National Park, in Victoria), which is also in the temperate Koppen climate zone but at considerably higher altitude and experiences winter-time snowfalls, showed both summertime and wintertime peaks (Figure 2). The possible reasons for this unusual bimodal pattern are considered in the Discussion.

Factors explaining visitation seasonality

The degree to which climatic and holiday period data explained temporal patterns in visitation varied considerably across the six different climate zones and, to some degree, with State or region within a State (Table 2). For protected area sites within the equatorial zone, the strongly seasonal visitation was best explained by mean monthly minimum temperatures. That variable explained 93% of the annual visitation variability, with higher minimum temperatures corresponding to lower visitation levels. Mean maximum temperatures and mean monthly rainfall explained considerably less of the visitation seasonality (less than 75%).

Similar relationships existed for the tropical climate zone sites, where mean monthly minimum temperature, which was strongly negatively correlated to visitation numbers, again was the variable that best explained visitation patterns. Mean monthly maximum temperatures and mean monthly rainfall explained more than 88% of the variation in visitation statistics for this tropical climate type, which highlighted both the degree to which climate explained visitation and the auto-correlative nature of these two sets of measures in this region. Similarly, all three climate variables explained between 75-93% of the variation in visitor numbers to protected areas in the desert climate zone, although mean monthly rainfall (75%) explained less variation in the seasonality of visitation than the maximum and minimum temperature variables (Table 2).

In contrast to the protected areas in the extreme north of the country, visitation seasonality in the subtropical climate zone of southeast Queensland was best explained by holiday periodicity (31% of the visitation variability). None of the climatic variables explained more than 16% of temporal variation in visitation for this subtropical climate type. In the grassland climate zone (which lies to the west of the subtropical zone) however, climate variables explained most of the variation in visitation seasonality, with mean minimum temperatures and mean maximum temperatures both explaining around 55% of the variation in the dataset in the separate linear regressions.

For protected area sites in temperate climates in northern New South Wales, the three climatic variables each explained around 50% of the annual variation in visitation (Table 2). In contrast, in temperate climate zone sites in southern New South Wales, Victoria and Tasmania almost 90% of visitation variability could be explained by mean monthly maximum temperatures alone. Again, all three climatic variables explained a large proportion (> 85%) of the variability in visitation to protected areas in this zone. In the Victorian Alps (temperate Koppen zone but above the snowline) almost 20% of the annual variation in visitation was explained by mean monthly maximum temperatures. Overall, however, the seasonality in visitation to this particular protected area was poorly explained by the selected climatic and holiday period variables.

Discussion

Relative roles of natural and institutional factors in driving seasonality in visitation

Butler (2001) undertook a theoretical analysis of the range of factors that could drive visitation. His predictions have been broadly supported by empirical studies (e.g. Donatos and Zairis 1991, Koenig and Bischoff 2003, Grindley 2005) that have shown that seasonality in visitation can be driven by a range of both natural and institutional factors. Whilst very valuable locally, the findings from the existing empirical studies have typically been obtained from within only a single climate zone, which therefore limits the degree to which a more general understanding of the role of climate in influencing visitation seasonality can be developed. As identified by Scott and Lemieux (2009), there is a growing need for broad-scale analysis of tourism seasonality and the role of climate as a driver of large-scale

patterns of tourism seasonality to ensure that tourism planning can accommodate any future changes in climate. Although there have been some studies in North America that have examined tourism seasonality, visitor comfort and possible tourism futures in light of anticipated changes in climate in the future (Scott *et al.* 2004, Scott *et al.* 2008b), none have explicitly examined tourism seasonality and the relative role of natural and institutional variables across multiple and contrasting climate zones. As a result, of those published in the literature, only this current study has enabled a broader examination of the relative importance of natural and institutional factors in driving seasonality in visitation to protected areas across six major climate zones between latitudes $\sim 10^{\circ}$ S and $\sim 45^{\circ}$ S.

Climate variables strongly explained current visitation seasonality in many of the protected areas examined in this study across the climatically diverse parts of eastern Australia. This is not particularly surprising given that other climate-visitation analyses in National Parks across entire countries (Canada - Jones and Scott 2006 and the United States - Hyslop 2007) have identified similarly strong relationships between climate variables and visitation seasonality. However, the relative importance of climate as a whole and the role of individual climate variables in explaining the greatest percent of visitation seasonality differed substantially across the range of different geographical and climate types. Other than undertaking a meta analysis (which would require many studies having been undertaken previously), the only way that this spatial variation in the relationships between visitation, climate and geography could be detected is via a study like this one, which spanned a large number of climate zones.

The results of this study show convincingly that analysis of broad climate types alone can provide a strong predictive capacity to expected visitation seasonality across eastern Australia, especially in regions with marked variations in climate (e.g., substantial differences between summer and winter temperatures in alpine or temperate zones; the existence of a pronounced wet/dry dichotomy in the monsoonal tropics, etc). For such locations, climate explained up to 94% of the intra-annual variation in tourist visitation, whereas holiday periods explained, at best, only 2% of the seasonality in tourism (Table 2). Based on the strength of these explanatory relationships, predictions of visitation

seasonality across Koppen climate zones could be made with relatively high confidence. Furthermore, given the general paucity of reliable visitation data for many protected areas in Australia (Hadwen et al. 2007; Hadwen et al. 2008), predictions based on these types of relationships could certainly help protected area managers develop and implement visitor management plans.

In contrast to the strongly seasonal impact on visitation generated by climatic factors discussed above, a relatively small number of protected areas showed temporal peaks in visitor numbers that were strongly related to institutional factors, in this case holiday periodicity. These patterns occurred in regions with more stable climates (i.e. less strongly seasonal) and in climates that were more tolerable for people (i.e. less range in extreme temperature and rainfall and therefore less physiologically stressful conditions). For example, for the four protected area sites from the subtropical zone in southeast Queensland, 31% of the annual variation was explained by holiday periodicity. In contrast, each of the climate variables explained, at best, no more than 16% of the annual variation in visitation for these sites (Table 2). As all of the protected area sites in this sample are reasonably close (within 350 km) to Brisbane, the State's capital city, it is likely that the result is also partially driven by the fact that they are close to a significant population source of domestic visitors.

Whilst proximity to large population centres is undoubtedly an important factor in affecting the temporal variability in visitation to many protected areas in southern Australia and the more densely populated east coast, its converse is likely to be significant also in less populated areas of the country. For example, the population density in the Northern Territory, is <0.2 people km^{-2} and, for protected areas in northern Australia, such low local populations are likely to be a critical factor in explaining the small influence that holiday periodicity has on visitation. For these parts of the country, many visitors to protected areas will have travelled significant distances (> 1000 km) from population centres in the south or overseas and need to be assured that areas of interest will be accessible and comfortable when they do arrive. The strong wet-dry seasonality in climate in northern Australia means that peaks in visitor numbers should therefore occur during the dry season (June-July), when humidity is low and roads are still open; much of northern Australia is unpassable during the wet

summer months. In the wet ('rainy') season, most secondary roads are closed by floodwaters and the humidity is oppressive (e.g., > 70 % during January for much of northern Australia). These two factors would inhibit or discourage visitation. Moreover, this is the time of year when tropical cyclones pass across northern Australia (Colls and Whitaker 2001) and these large scale and potentially catastrophic climatic events are likely also to influence visitation as they increase both the uncertainty surrounding accessibility and the risk of dangerous (life-threatening) conditions. Accordingly, the observed seasonality in visitation to these more remote areas in northern Australia is predictably and strongly driven by climatic variables, which control not only human comfort, but also visitor safety and accessibility.

Climate appears also to strongly influence visitation to protected areas in inland regions of Australia (the desert region within the Koppen desert climate zone), with visitation statistics strongly and negatively related to mean monthly maximum temperatures. Maximum daytime temperatures in tourism centres in central Australia, such as Alice Springs, often exceed 40°C in summer and the highest shade temperature recorded in Australia (53.1°C) was recorded (at Cloncurry) in this part of the continent (Colls and Whittaker 2001). Tourism in these hot, dry periods is not only extremely unpleasant and physiologically stressful, but ventures to remote areas can be life threatening. As with the monsoonal and wet-dry tropics in the equatorial zone, a combination of personal comfort and safety perceptions thus drives visitation seasonality in the arid zone. Whilst heavy summer rainfall might be expected to deter visitors to the arid zone of inland Australia, its intermittency in these regions (Sheldon 2005) probably also explains why rainfall is less influential than maximum temperatures in explaining the recorded long-term trends in visitation seasonality in this climatic zone. However, rainfall itself might be a powerful positive influence on visitation to the arid zone when large wetlands such as Lake Eyre fill in response to high discharge in rivers (e.g. Cooper Creek and the Diamantina and Georgina Rivers). Floods along these river systems can generate spectacular growth in wildlife populations that serve as strong attractants for visitors (Larson 2006).

In cool temperate southern Australia (temperate climate zone), minimum temperatures and winter rainfall negatively influence visitor loads, resulting in visitation peaks in mid-summer (December-January). An interesting exception to this uni-modal peak in visitation to protected areas in southern Australia was seen with Mt Buffalo National Park, in the Victorian alpine region. Although snow is rare or unknown in most parts of Australia, wintertime tourism in the alpine regions of southeast Australia depends largely on snow-based activities and hence is contingent upon low mean temperatures and winter precipitation as snowfall (Whetton et al. 1996; Mules 2005). However, these alpine areas also attract summertime tourists for activities such as bushwalking, bird watching and viewing wildflowers. This type of summertime tourism in alpine and sub-alpine areas is reliant upon warm, dry conditions conducive to outdoor activities and the timing of critical ecological events such as flowering times and bird breeding. This divergence in climatic conditions and tourism activities across the seasons in Mt Buffalo National Park probably accounts for the complex temporal pattern observed in visitation and, overall, the weak explanatory power of the selected climatic variables for this region, despite the markedly seasonal patterns in temperature and rainfall. Furthermore, the period (2000-2001) for which the visitation data was available for this protected area was not only very limited but data were also collected over an exceptionally dry period colloquially referred to as ‘the Millenium drought’ (Bond *et al.* 2008). Wintertime visitation was most likely affected strongly by this drought and the lack of a strong wintertime peak most likely relates to the poor snowfall in the surveyed years. More than for any other region, it is likely that daily to weekly conditions (i.e. ‘weather’ as opposed to climate) in alpine regions influence short-term visitor decision making processes, because the success of their trip relies very heavily on climate (snowfall) as a resource (Scott and Lemieux 2009). Similar conclusions, regarding the importance of snow as a resource and as a condition, that will influence visitation, have been drawn from other studies examining climate and wintertime tourism in ski fields (Whetton *et al.* 1996, Scott et al. 2007).

Impact of altered institutional or natural factors on visitation to Australian protected areas

Depending on the climate zone or bioregion in question, an understanding of the relative importance of institutional versus natural factors in influencing tourism seasonality can aid in the prediction of

tourism futures, particularly if one or both of these factors is likely to change over time. The findings from this study, for example, indicate that the timing of school holidays is the single most influential factor controlling seasonality in visitation to protected areas in subtropical southeast Queensland. As a result, the shape of annual visitation curves to these protected areas is to some extent buffered from changes in climate, at least in the short-medium term. Conversely, however, visitation to these areas is likely to be influenced strongly by social and or institutional factors, such as changes in the timing of school holidays, population growth or decline, visitation priorities by tourists from southern States, and changes to infrastructure (e.g. road, rail and airport links) in southeast Queensland. Similar findings, particularly in reference to factors influencing the seasonality in domestic tourism markets, have been reported elsewhere (Sindiga 1996).

A quite different set of conditions holds for tourism in the monsoonal wet-dry tropics and arid and semi-arid zones of Australia. Indeed, for most of the climate zones examined in this study, natural (climatic) factors explained far more of the variation in annual visitation patterns than did institutional factors. These findings are broadly consistent with other analyses of tourism seasonality (and anticipated responses to climate change) in natural destinations, such as those by Pickering *et al.* (2003) and Scott *et al.* (2007). For these protected areas, where climate strongly influences visitation, foreseeable changes in institutional factors are unlikely to re-shape the current seasonality in visitation. Instead, changes (including increased variability and extremes) in natural climatic and weather factors are more likely to modify the existing patterns in visitation.

Conclusions and *future directions*

These analyses have shown that in a country as large as Australia, with its wide variety of climatic zones and ecosystem types but rather uniform institutional systems, there are marked regional differences in the seasonality of visitation in protected natural areas. The relative importance of natural (climatic) and institutional (holiday periodicity) factors varies across the country (largely according to climate zone) and in most zones climate dominates as the main factor controlling visitation seasonality. However, population density and accessibility to protected areas is a likely covariate in

explaining visitation patterns. It appears that large population centres can dampen the degree to which climate drives visitation seasonality, especially in subtropical regions with their moderate weather patterns and reduced climatic seasonality.

These results suggest that for most of the climate zones examined in this study, changes to future climates has strong potential to influence spatial and temporal patterns of visitation in protected areas across much of the country. To inform further research activity in this area, these findings were used to generate a series of climate-related questions and issues of importance to the Australian tourism industry, as follows:

1. Is visitation to protected areas that have visitation patterns driven strongly by institutional factors, such as the timing of school holidays, 'buffered' from changes in climate?
2. Can investment in institutional factors (e.g. hard infrastructure and associated climate-change adaptation initiatives) buffer the expected impacts of altered climate on the seasonality of tourism in those protected areas where climate exerts a major control on visitation patterns? For example, will the provision of sealed roads alleviate problems with limited access to tropical and arid-zone protected areas?
3. Will protected areas in highly seasonal (and physiologically stressful) climate zones (e.g. monsoonal wet-dry tropics, arid zones) see a reduction in the peaks and length of tourism seasons as climate variability increases, maximum temperatures increase and rainfall decreases? And, how might changes in the frequency, intensity and perception of extreme climate events, such as tropical cyclones or extensive flooding, influence visitation, both over short and long time scales?
4. Will tourism opportunities increase in southern Australia because of possible local positive aspects of climate change (e.g. warmer and drier winters) and negative changes in northern Australia (e.g. more severe tropical storms and increased rainfall). In other words, could there be destination substitution at the national scale? If so, will there be a time lag and consequent dip in international visitor numbers to Australia as perceptions change about the suitability of particular areas for visitation?

These future research questions will need to couple the relationships generated in this current study to regional climate-change projections in order to develop robust predictions about the shape and possible shifts in tourism seasonality over the coming decades. These predictions could, in turn, form the basis of climate change adaptation responses both at the national and regional scale for protected area managers and tourism and hospitality businesses, especially those that service the needs of visitors seeking experiences in natural and protected areas.

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Table 1. Data characteristics and collection methods for visitor numbers from 23 protected areas in Queensland, New South Wales, Victoria and Tasmania.

State	Protected Areas (and corresponding number from Figure 1) for which suitable data were available	Data type	Data Collection Methods
Queensland	Jardine River National Park (1), Iron Range National Park (2), Lakefield National Park (3), Daintree National Park (4), Whitsunday Island National Park (5), Diamantina National Park (6), Carnarvon National Park (7), Bribie Island National Park (8), Bunya Mountains National Park (9), Girraween National Park (10), Great Sandy National Park (11)	Number of campers per month at camp sites within selected protected areas	Data collated from camping permit sales for each protected area
New South Wales	Warrumbungles National Park (12), Mimosa Rocks National Park (13)	Number of vehicles at one or more campsites	Vehicle counters on roads to campsites
New South Wales	Mungo National Park (14), Mount Canobolas State Conservation Area (15)	Vehicle counts multiplied by average number of occupants – estimate of number of visitors	Vehicle counters on roads to campsites
Victoria	Dandenong Ranges National Park (16), Grampians National Park (17), Mornington Peninsula National Park (18), Port Campbell National Park (19), Wilson's Promontory National Park (20), Mt Buffalo National Park (21)	Number of visitors	Visitor monitoring and vehicle road counts
Tasmania	Cradle Mountain-Lake St Clair National Park (Cradle Mountain Section) (22), Freycinet National Park (23)	Visits	Estimated through a combination of traffic and counts undertaken through visitor centres

Table 2. Summary of r^2 values for linear regressions of Koppen Climate Zone (and State/region) summaries of visitation data against holiday period scores (Holidays), mean monthly maximum temperatures (Mean Max), mean monthly minimum temperatures (Mean Min) and mean monthly rainfall (Mean Rain) for protected areas in eastern Australia. Regressions used mean visitation statistics (percentage of annual visitation for each month) calculated for each climate zone.

Koppen Climate Zone and State/region	Holidays	Mean Max	Mean Min	Mean Rain
Equatorial (Cape York, Queensland)	0.00	0.73	0.93	0.71
Tropical (far north Queensland)	0.00	0.89	0.94	0.89
Desert (far western Queensland)	0.09	0.90	0.93	0.75
Subtropical (southeast Queensland)	0.31	0.16	0.10	0.00
Grassland (western Queensland and NSW)	0.05	0.55	0.55	0.44
Temperate (northern NSW)	0.08	0.51	0.52	0.48
Temperate (southern NSW, Victoria and Tasmania)	0.03	0.90	0.87	0.86
Temperate (Victorian alps)	0.00	0.09	0.20	0.22
All temperate zone protected areas (mean $\pm$ SE)	0.04 (0.02)	0.50 (0.23)	0.53 (0.19)	0.52 (0.19)

Table 3. Summary of r^2 values for linear regressions of visitation data against holiday period scores (Holidays), mean monthly maximum temperatures (Mean Max), mean monthly minimum temperatures (Mean Min) and mean monthly rainfall (Mean Rain) for 23 protected areas across six Koppen climate zones in eastern Australia.

Protected Area Number	Koppen Climate Zone	State	Name of Protected Area	Holidays	Factors		
					Mean Max	Mean Min	Mean Rain
1	Equatorial	QLD	Jardine River National Park	0.00	0.36	0.81	0.72
2	Equatorial	QLD	Iron Range National Park	0.00	0.73	0.96	0.63
3	Tropical	QLD	Lakefield National Park	0.00	0.93	0.97	0.60
4	Tropical	QLD	Daintree National Park	0.00	0.75	0.84	0.90
5	Tropical	QLD	Whitsunday Is National Park	0.32	0.42	0.50	0.39
6	Desert	QLD	Diamantina National Park	0.00	0.84	0.89	0.58
7	Grassland	QLD	Carnarvon National Park	0.00	0.66	0.64	0.69
8	Sub-tropical	QLD	Bribie Island National Park	0.24	0.07	0.05	0.06
9	Sub-tropical	QLD	Bunya Mts National Park	0.20	0.23	0.18	0.07
10	Sub-tropical	QLD	Girraween National Park	0.24	0.06	0.03	0.00
11	Sub-tropical	QLD	Great Sandy National Park	0.32	0.18	0.15	0.01
12	Temperate	NSW	Warrumbungles National Park	0.00	0.51	0.52	0.47
13	Temperate	NSW	Mimosa Rocks National Park	0.05	0.82	0.80	0.06
14	Grassland	NSW	Mungo National Park	0.10	0.44	0.46	0.19
15	Temperate	NSW	Mount Canobolas Conservation Reserve	0.18	0.46	0.41	0.69
16	Temperate	VIC	Dandenong Ranges National Park	0.14	0.61	0.61	0.61
17	Temperate	VIC	Grampians National Park	0.04	0.71	0.74	0.67
18	Temperate	VIC	Mornington Peninsula National Park	0.00	0.73	0.64	0.88
19	Temperate	VIC	Port Campbell National Park	0.00	0.80	0.76	0.78
20	Temperate	VIC	Wilsons Prom National Park	0.00	0.87	0.77	0.80
21	Temperate	VIC	Mt Buffalo National Park	0.00	0.09	0.20	0.22
22	Temperate	TAS	Cradle Mountain-Lake St Clair National Park	0.00	0.89	0.90	0.87
23	Temperate	TAS	Freycinet National Park	0.00	0.74	0.74	0.14

Figure 1. Map of Australia showing modified Koppen climate zone classification (from the Australian Bureau of Meteorology - www.bom.gov.au) and the location (and identifying number) of each protected area for which monthly climatic and visitation data were available for this study.

Figure 2. Temporal patterns of variability in visitation to protected areas in Equatorial, Tropical, Desert, Subtropical, Grassland and Temperate Koppen climate zones. Data points represent the percentage of total annual visitor load for each month, calculated from mean visitor loads to protected areas within each climate zone.